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ASNR 1988 Meeting Abstracts

The following are abstracts of papers and posters presented during the 26th annual meeting of the American Society of Neuroradiology held in Chicago, May 15-20, 1988. Only abstracts submitted in time for publication are included. The keynote lectures are not included. Abstracts of papers appear first, in the order in which they were presented. These are followed by abstracts of posters and alternate papers.

High Resolution MR Of The Fetal Spine And Spinal Cord: Kier EL, Lange RC, Holland SK, Trefelner EC (Yale Univ. School of Medicine, New Haven, CT 06510)

MR has rapidly become a leading modality in the evaluation of spinal and neural tube abnormalities in the infant. The correlation of anatomic material and diagnostic imaging techniques has resulted in major advances in neuroradiology.

At the last two meetings of our Society, techniques for the microdissection and photography of first and second trimester formalin fixed fetal spinal cord specimens were demonstrated. The accumulated experience in preparing and evaluating previously unavailable anatomic material paved the way to investigate the potential of MR in imaging the very small structures of the intact fetal spine and spinal cord.

MR imaging of intact formalin fixed fetal specimens was performed using the GE 1.5T Signa and the GE 2.0T CSI MR scanners. T1 weighted, proton density, T2 weighted spin echo images and gradient echo images were obtained using different size RF transceiver coils. 1mm to 3mm slices were performed using 80mm, 60mm and 40mm FOV. Sagittal and coronal images were correlated with dissected specimens. Specimens ranged in age from 10 to 30 weeks gestation.

The results of this continuing investigation will demonstrate the potential of MR in the study of the development of the spine and spinal cord in the intact fetus. The position of the conus, the size of the cord and subarachnoid space, the ossification patterns of the spine and the ganglia, nerve roots and filum terminale will be demonstrated.

Skeleton of Collagenous Structure in the Intervertebral Disc: Yu S, Haughton VM, Lynch KL, Ho KC, Ho PSP, Sether LA, Wagner M (Medical College of Wisconsin, Milwaukee, WI 53226)

We studied lumbar intervertebral discs in thirty cadavers with sagittal MR, CT, cryomicrotome anatomic sections and selective histologic or freeze-dried dehydrated sections. MR was sensitive to collagen in the intervertebral disc. Sharpey's fibers, which are essentially collagen, are effectively distinguished from the remainder of the anulus and nucleus which contain less collagen and more ground substance. Replacement of the nucleus pulposus by disorganized collagen is also readily detected by MR as a reduced signal intensity. The dark band in the intervertebral disc in MR images, previously called "intranuclear cleft," was also related to collagen. We found that with aging, the equator of the disc developed gradually more fiber which was mostly collagenous, but also elastic and reticular with little ground substance. The tissue appeared to develop in the periphery of the disc and proceed toward the center. In normal adults it forms a compact structure in the disc which appeared as a dark band in MR images. This dark band should be differentiated from the truncation artifact seen in the thoracic or narrowed lumbar discs.

MR in Non-Penetrating Spine Injuries: Use in Clinical Management:
Quencer RM, Beasley, RE, Cammisa FJ, Eismont FJ, Green BA, and Post MJD. (University of Miami School of Medicine, Miami, Florida 33101)

Forty-one medically stable patients who sustained non-penetrating spine injuries were evaluated with MR within three weeks of their injury in order to determine the role of MR in the surgical management of these patients. Eight patients with cervical fractures, 29 with thoracic and lumbar fractures and 4 patients with no fractures but with neurological deficits were examined. Clinical presentations varied and included transient cord dysfunction, central cord syndrome, and complete and incomplete neurological deficits. MR was used not only to help explain the patients' current neurological status but in instances where surgery was indicated, helped direct the operative management. Specifically, in 5 patients with cervical fracture/dislocation an associated herniated disc was found in 4, indicating the need for an anterior cervical decompression. In addition, MR was useful in explaining the cause of neurological dysfunction in patients with fractures uncommonly associated with deficits, such as Chance or Hangman's fracture. In seven such patients herniated discs were seen in 2, epidural hematoma in 1 and a Chiari malformation in 1. Other situations where MR was important in acute spine trauma included cases of progressive neurological deterioration, associated bony abnormalities and severe deficits in the face of normal routine radiographic studies. MR was not useful in thoracolumbar burst fractures, compression or wedge fractures, or in uncomplicated Chance or Hangman's fracture where no neurological deficit was noted. In conclusion , myelography and metrizamide CT is no longer required to help make clinical decisions in spine injured patients. MR is crucial in determining the underlying structural abnormalities in acute spine trauma and in certain injuries, can help direct surgical management.

The Role of CINE-MR in the Evaluation of the Pulsatile Characteristics of Post-Traumatic Spinal and Subarachnoid Cord Cysts: Post MJDP, Quencer RM, Green BA, Hinks RS, Horen M, Labus J (Univ. of Miami School of Medicine, Miami, FL 33101)

The purpose of this study was to determine the value of CINE-MR in assessing the flow characteristics of post-traumatic spinal cord (or subarachnoid) cysts (PTSCCs) both before and after shunt placement and to decide if the presence of pulsatility in these cysts correlated well with clinical deterioration and conversely, if the loss of pulsatility following cyst shunting correlated well with clinical improvement. Subarachnoid flow patterns were also assessed pre and postoperatively in these patients, who frequently also underwent bony decompression and adhesion lysis. The CINE-MR findings in these cyst patients (#17) were then contrasted with the flow characteristics in

patients with syringomyelia, cystic neoplasms, and non-traumatic subarachnoid cysts. The CINE-MR results were also correlated with operative findings (in 8), intraoperative spinal sonography, cyst fluid protein, and postoperative CINE-MR (in 4). MR techniques included cardiac gated sagittal (6 mm) field echo CINE-MR with a 9° flip angle and T1 and T2 weighted sagittal non-MAST and MAST scans on a Picker VISTA® operating at 1.5 Tesla. We conclude that (1) both large and multiple as well as small and single cysts can be pulsatile; (2) CINE-MR, being more physiological, is more convincing than non-MAST static MR in determining which cysts require shunting; (3) CINE-MR is critical in the preoperative detection of ball-valve mechanisms responsible for some expansile symptomatic PTSCCs; and (4) CINE-MR shows significant reduction in pulsatile flow within shunted PTSCCs and establishment of pulsatile flow in adjacent subarachnoid spaces following shunting, findings which correlate with clinical improvement. As a result of our study, we recommend CINE-MR in the pre - and postoperative evaluation of the majority of symptomatic patients with PTSCCs.

Spinal Cord Transection in Children: Diagnosis by MR : Mark AS, Berry I, Atlas S, Sanches J, Manelfe C, Dillon WP, Newton TH (Univ. of California, San Francisco, San Francisco, CA 94143)

Transection of the spinal cord is a rare entity which may occur in children as a complication of delivery or secondary to direct trauma to the spine. Eleven MR studies in 8 children (ages 2 months to 11 years) with suspected spinal cord transection (3 post-birth trauma, 5 post-motor vehicle accident) were studied with sagittal and axial T1WI (TR 500/600, TE 20/30 msec). Four patients were also studied using sagittal T2WI (TR 2000, TE 40/80). Proof of diagnosis was clinical examination (complete loss of cord function below the level of the injury) in 7 patients and autopsy in 1 patient. The level of the transection was at the cervicothoracic junction (5 patients), T6 (1 patient), conus (1 patient) and cervicomedullary junction (1 patient with atlanto-occipital dislocation). Sagittal images demonstrated severe loss of cord substance in all patients and complete separation of the cord in 3 patients. In 4 patients, a residual strand of soft tissue extended between the two segments of the cord. Progression of the injury from hemorrhagic cord contusion to almost complete transection was demonstrated in 2 patients. Arachnoid loculations (cysts) were seen in 2 patients. Our study shows MR can directly demonstrate cord transection in children. Because of its noninvasiveness, it is the imaging modality of choice in patients with severe spinal cord trauma once any unstable fractures have been stabilized.

Reduced Bandwidth Spin Echo MR Imaging of the Vertebral Spine at High Field: Ketonen L, Totterman S, Foster TH, Simon JH, Kido DK, Wicks AM (Univ. of Rochester, Rochester, NY 14642)

MR imaging using reduced bandwidth has been shown to improve S/N without degradation of spatial resolution.

An evaluation of the utility of reduced bandwidth spin echo (SE) imaging compared to a conventional SE technique was prospectively obtained in randomized fashion in 27 patients undergoing 50 MR examinations, including metastases, primary tumors, disc herniations, disc bulges and degenerative changes. The studies were conducted using a high field 1.5 Tesla MR imager (GE), and included both T1 (600/30) and T2-weighted (2000/30,90) SE series with flow compensation using a 16 KHz bandwidth, 3 mm slice thickness and 2 excitations. A comparison series (2000/46, 92) was obtained using a 8 KHz bandwidth, 3 mm slice thickness and one excitation, which decreased the scanning time by 50%.

Reduced bandwidth SE and conventional SE series were compared for lesion detection and chemical shift artifacts. The results of this study indicated that reduced bandwidth and conventional SE images were of equal diagnostic value. Chemical shift artifacts at the boundary between discs and vertebral bodies were seen in the lumbosacral area and were more prominent in reduced bandwidth images, but did not interfere with either lesion detection or interpretation of the images.

Reduced bandwidth SE imaging can replace the conventional SE technique without compromising lesion detection. The factor of two saving in imaging time means increased patient throughput and better image quality in pediatric and uncooperative patients.

Gradient Echo Volume Imaging Of The Cervical Spine: Hueftle MG, Tkach J, Ruggieri P, Masaryk TJ, Ross JS, Haacke EM, Modic MT (University Hospitals, Cleveland, OH 44106)

The purpose of this study was to develop a rapid gradient echo volume technique for the cervical spine utilizing a single acquisition which would provide thin reconstructions (2 mm sections). The following technique evolved from comparisons of pulse sequences and acquisition planes in 15 volunteers and represented a compromise of tissue contrast, spatial resolution, and exam time: 1) 1 or 1.5 Tesla superconductive magnet utilizing a surface coil, 2) sagittal plane anisotropic acquisition to reduce slab thickness (96-120 mm), 32-64 partitions (slice thickness 2-3 mm) covering the region from the foramen magnum to T2, 3) FLASH 5 degree flip angle for CSF myelogram effect, 4) TE 9-14 msec, 5) TR 50 msec and 6) multiplanar axial and oblique reconstructions. 120 consecutive cases referred for evaluation of extradural disease were studied with the above technique plus sagittal (3 mm) and axial (4 mm) T1 weighted (500/17) 2D spin echo sequences. Studies were interpreted blindly for purposes of this study. Results indicate that the 3D sequence provided 1) an adequate to good examination in 70% of patients compared to 90% of the T1 weighted images, 2) superior spatial resolution and characterization of extradural disease based on increased conspicuity (FLASH greater than spin echo in 41, FLASH = to spin echo in 48, FLASH less than spin echo in 8, and 23 normal) and decreased partial volume averaging, 3) shorter exam time (6.8-13.6 minutes vs 17-20 minutes), 4) coverage of a larger area in the axial plane. The technique was more sensitive to patient motion. Gradient echo techniques have been shown to be less sensitive to marrow changes and intradural disease (masked by high signal intensity of CSF) than 2D spin echo. Our results suggest that in the future, suspected extradural disease of the cervical spine may be adequately evaluated with a T1 weighted sagittal spin echo (for marrow changes and intradural lesions) and a volume gradient echo study with sagittal acquisition and axial reconstructions.

Comparison of Spin-Echo And Gradient-Echo Transaxial MR Imaging For Screening The Lumbar Spine: Watanabe AT, Teitelbaum GP, Lufkin RB, Kinkins JR, Tsuruda JT, Bradley WG (Huntington Medical Research Institutes, Pasadena, CA 91105)

Fifty MR examinations of the lumbar spine obtained at 1.5 Tesla were randomly chosen. The spin-echo (SE) and gradient-echo (GRE) transaxial images were reviewed in a blinded fashion by three radiologists. The clarity of visualization of the ligamentum flavum, facet joints, neural foramina, disk spaces, thecal sac, epidural fat, and herniated disk material, as well as overall image quality were quantitatively evaluated.

All anatomic structures were statistically better visualized on SE images. The most marked differences were observed for the neural foramina and epidural fat. SE was superior in delineating herniated disk material. However, GRE was confirmatory, and sometimes better, in diagnosing disk herniations in several instances.

GRE imaging is useful for diagnosing disk herniations in equivocal cases or in instances where motion artifact degrades the SE image. We recommend that transaxial GRE imaging of the lumbar spine be employed as an adjunct and not as a replacement for SE imaging.

MR Imaging of Discogenic Disease in the Lumbar Spine: Comparison of Gradient Echo with Spin-Echo Techniques: Tamura F, Mark AS, Fram EK, Atlas SW (Univ. of California, San Francisco, San Francisco, CA 94143)

The development of gradient echo images (GRE) allows the performance of images where the CSF is of high intensity ("MR myelogram") in a fraction of the time required for spin-echo images. Such sequences have been used successfully in the cervical spine to improve contrast between the bony canal and subarachnoid space. To assess the utility of GRE in the lumbar spine, we studied 63 disc levels in 21 symptomatic patients (ages 31-87 years) using axial multislice GRE (TR=600/700, TE=10/30 msec, theta 15), and spin-echo (TR=600/700, TE=20 msec) and compared the results with CT and clinical (in 13 patients) or surgical findings (in 8 patients). The sagittal short TR sequences were not reviewed. Ten levels had herniated discs, 11 had spinal stenosis, 16 foraminal and/or lateral recess stenosis, 16 had prior laminectomies, 7 post-operative scar, 10 central osteophytes and one post-operative infection. The

overall results indicate that axial GRE (using these parameters) do not add significant information in the study of lumbar disc disease, and in fact some information may be lost. The major limitations of GRE were due to the magnetic susceptibility effects which led to overestimation of the foraminal stenosis. The decreased contrast between epidural fat, disc, and thecal sac further limit the use of GRE in the lumbar spine. GRE were occasionally useful in selected cases of severe spinal stenosis, in distinguishing osteophytes from discs in differentiating bone from the thecal sac and in post-operative infection.

Gradient Refocused Echo Axial Images for Lumbar Disk Disease: Comparison with Spine Echo Images: Murayama S, Numaguchi Y, Robinson AE (Tulane University Medical Center, New Orleans, LA 70112)

Gradient echo (GRE) technique of MR has been promoted for evaluation of patients with cervical radiculopathy. Good results have been reported with the advantage that thecal sac-disc interface is clearly visualized. However, this technique has rarely been used for studies of the lumbar spine. We have evaluated GRE technique for axial MR of the lumbar spine in conjunction with a conventional spin echo (SE) technique.

One hundred patients were examined with a 1.5 Tesla MR unit. Axial GRE images of discs were obtained using T2* weighted technique (TR = 200-400, TE = 15 and flip angle of 15-30°) and comparison was made between GRE and proton-density weighted SE images. One hundred and sixty-seven disc spaces were evaluated including 75 bulging or herniated discs. Herniated discs were visualized as high intensity areas showing discographic effect on GRE images which were better demonstrated than SE images. Since bony margins were shown to be darker than the annulus fibrosus, diffuse bulging annulus are more accurately diagnosed by GRE images than by SE images.

GRE technique was also proven to be superior in imaging postoperative fibrosis as well as vacuum phenomenon in discs. Postoperative fibrosis was of intermediate signal intensity on proton-density weighted SE images, and of high signal intensity on GRE images. Post-laminectomy bone defects and postoperative epidural fibrosis in the lateral recesses were easily recognized with GRE images. Vacuum phenomenon was clearly visualized using GRE, because it was clearly outlined with hypointense rims on GRE images.

We conclude that axial GRE images are important adjuncts to SE images in MR of the lumbar spine.

The Differential Utility of Gradient-echo and Spin-echo Magnetic Resonance Imaging in Metastatic Disease to the Spine: Gusnard DA, Grossman RI, Hackney DB, Atlas SW, Goldberg HI, Zimmerman RA, Bilaniuk LT (Hosp. of the University of Pennsylvania, Phila., PA 19104)

The hypothesis underlying this study was that bony trabecular networks produce diagnostic susceptibility changes, which manifest hypointensity on long TR/long TE images. Given that gradient-echo imaging emphasizing T2* is intrinsically more sensitive to these susceptibility changes, it may be able to demonstrate lesions of the vertebrae, including metastatic disease. Magnetic resonance imaging with a 1.5 Tesla GE Signa scanner was performed on 14 patients aged 18-77, with metastatic disease to the spine. Gradient-echo (GE) and spin-echo (SE) sequences were employed in all cases and an unblinded, visual comparison made between them with regard to relative signal intensity changes within the vertebrae.

None of the techniques (T1 or T2-weighted GE or SE) were adequate for detecting all of the apparent metastatic lesions. GE imaging was more sensitive than SE imaging for detecting lytic metastases in 4 out of 14 patients (i.e. the youngest male patients), those expected to have the greatest bone density. GE T2* imaging was more sensitive than GE T1 imaging for detecting metastases in 3 middle-aged patients presumably due to its greater sensitivity to magnetic susceptibility differences and, thus, bone loss. GE T1 imaging was more sensitive than SE imaging for detecting sclerotic metastases in our 1 case of same.

Comparison of Strategies for CSF and Blood Flow Motion Artifact Suppression in T2-Weighted Spin Echo MR Imaging of the Spine: Citrin, CM, Sherman, JL, Gangarosa, R (Magnetic Imaging of Washington, Chevy Chase, MD 20815)

Cardiac gating effectively reduces physiologic motion artifact in CNS imaging. Both central and peripheral gating are costly in set-up time and are susceptible to arrhythmia induced artifacts. Motion artifact suppression technique (MAST) employs specially shaped read and select gradient wave forms which null the various temporal moments of motion, preventing their propagation as phase errors. This results in reduced motion artifact secondary to CSF pulsation. This suppression occurs within view motion (during data collection) but does not suppress view-to-view motion (between data acquisitions).

Comparison was made between gated, nongated, MAST gated, images in a series of volunteers with normal sinus rhythm (NSR) and were evaluated according to the following criteria: 1) Intensity of the CSF signal. 2) Homogeneity of the CSF signal. 3) Edge sharpness. 4) Visualization of normal anatomic structures. 5) Visualization of abnormalities. 6) Appearance of paraspinal soft tissues. Results of these studies indicate that cardiac gating alone will usually result in scans superior to those acquired without cardiac gating or MAST. Scans acquired using MAST will be superior to those acquired using cardiac gating only. Scans acquired using MAST and cardiac gating are generally superior to those acquired using MAST only. These results may not be valid in patients with cardiac arrthymias but adaptation of cardiac gating to reject out of synch beats might extend these results to such patients. The choice of the combination of strategies for motion artifact suppression must balance conflicting trade-offs for image quality, set-up time, acquisition time, and arrhythmia induced artifacts.

MR Of Sciatica: Evaluation Of Short TI Inversion Recovery Pulse Sequence: Schnapf D, Schellinger D, Frank J, Manz H, Paul R, Butler I, Wilson D, Boyle L (Georgetown Univ School of Medicine, National Institute of Health, York Imaging Center, York, PA 17403)

MR is proving to be an accurate and noninvasive technique to evaluate patients with sciatica. We performed over 400 examinations using the short TI inversion recovery (STIR) pulse sequence. The examinations were also compared with conventional T1 and T2 weighted spin echo, as well as gradient echo pulse sequences. STIR has several unique advantages. First, there is suppression of the fat signal and increased contrast between normal and pathologic tissue; secondly, there is less phase induced noise due to motion from subcutaneous fat. Next, the synergistic effects of prolonged T1 and T2 are additive and this is a major practical advantage of the STIR sequence. Finally, there is at least a 25% reduction in imaging time when compared to T2 spin echo sequences, while still preserving sensitivity to detection.

STIR (TR 1500, TI 100, TE 26) is extremely accurate in detecting metastatic disease to bone marrow. In addition, it is also sensitive in detecting intradural pathology. We will present a variety of intradural pathology such as lipoma, neurofibroma, meningioma, ependymoma fibrosarcoma, and dropped metastasis.

We have the ability to consistently visualize peripheral nerve roots of the lumbosacral plexus. We have a variety of cases demonstrating the relationship of the peripheral nerves of the lumbosacral plexus to a variety of pelvic pathologies such as neurofibromatosis, lymphoma, rectosigmoid carcinoma, and radiation fibrosis.

The sensitivity of STIR in detecting disease is at least equal to, and often greater than conventional spin echo pulse sequences. The STIR pulse sequence has the ability to visualize not only pathology of the lumbar spine and its contents, but the peripheral nerves of the lumbosacral nerve plexus as well, making this an important versatile technique in the evaluation of patients with sciatica.

3-D Imaging for the Post Surgical Failed Back Syndrome: Zinreich SJ, Wang H, Coe J, Quinn CB, Long DM, Davis R, McAfee PC, Rosenbaum AE (Johns Hopkins Medical Institutions, Baltimore, MD 21205

Two hundred patients with persistent symptoms after low back surgery were examined with direct axial computed tomography (CT), 2-D multiplanar and 3-Dimensional (3-D) imaging. One hundred of these patients had lumbar spinal fusion. 3-D images were found to best display the integrity of fusion (incomplete fusion, pseudoarthrosis, transitional syndrome) in 36/100 and showed additional fractures (pars interarticularis, articular facet, articular facet, and spinous process) in 11/100 patients. In 76/100 patients 3-D CT was found to augment information from the 2-D images. In the second group of 100 patients, without fusion, 3-D revealed additional fractures in 9/100 and disclaimed information on 2-D images in 6/100 patients. The 3-D images significantly improved the evaluation of the surgery performed and the magnitude of the lateral neural foramina in patients with and without spinal fusion. Our referring neuro- and orthopedic surgeons consider the 3-D examination routine when requesting an evaluation of the post surgical back.

Oblique Cross-Sectional MR of the Cervical Neural Canal: Larson TC III, Holloway H, Landman JA (Nashville Memorial Hospital, Vanderbilt Univ. Medical Center, Madison/Nashville, TN 37115/37232)

Fifty patients were evaluated with a high field MR unit to determine the presence of cervical neural canal stenosis as the cause for cervical radiculopathy. Oblique 3mm. thick partial saturation MR images were performed perpendicular to the neural canals on the symptomatic side. Presaturation techniques were employed. These were compared with plain films and CT with or without intrathecal contrast of the cervical spine. In only three instances were the oblique projections helpful in identifying pathology not otherwise visualized on MR studies using routine sagittal and angled axial sequences. The level of confidence on any of the MR studies to exclude neural canal stenosis was never superior to the evaluation provided on plain film or CT. Oblique cross-sectional MR imaging of the cervical spine suffered from inadvertent explicit prescription two plane image rotation, the inability to control the phase encoding gradient direction, flow generated artifact, inadequate visualization of the bony margins and contents of each neural canal and the lack of uniform orthogonal sections to each of the neural canals normally oriented at different obliquities.

Gadolinium DTPA: Use In the Unoperated Spine: Montanez J, Masaryk TJ, Ross JS, VanDyke C, Modic MT (Univ. Hospitals of Cleveland, Cleveland, Ohio 44106)

This pilot study was undertaken to evaluate the role of Gd-DTPA enhanced MR in the evaluation of herniated disk disease, with the hypothesis that it would increase the conspicuity of extradural disease on T1 weighted images. Ten patients with no history of prior surgery and symptoms of herniated disk disease formed the pilot group (cervical N=5, thoracic N=1, lumbar N=4). Pre- and post-gadolinium DTPA (0.1 mMol/kg, Berlex Laboratories, Inc.) MR studies were performed as follows: 1) sagittal and axial SE 500/17, 2) sagittal SE 2000/60, 3) sagittal and axial FLASH 200/13/60. Pre- and post-gadolinium studies were interpreted separately for evaluation of extradural disease, characterization by location, level, morphology, mass effect and enhancement. Myelographic and CT myelographic correlation was available in 6, and surgical confirmation in 6. Post Gd-DTPA diagnoses were: neoplasm N=1, disk herniation N=9. Post contrast examinations correctly changed the diagnosis in one case, and provided increased conspicuity and degree of confidence of disk herniations as follows: lumbar N=0/5, thoracic N=2/3, and cervical N=3/10. The value of Gd-DTPA is apparently related to two different types of enhancement. The first was enhancement of normal epidural venous structures outlining extradural defects with increased contrast on T1 weighted images, particularly in the cervical spine. The second was enhancement of vascular granulation tissue (confirmed histologically) surrounding lumbar disk herniations. Although the numbers are small, Gd-DTPA appears more helpful in evaluation of cervical and thoracic degenerative disease and may be a useful adjunct to unenhanced studies.

Comparative Study of the Neurotoxicity of Two Contrast Media Used for Myelography: Floras P, Deliac P, Caille JM (Department of Radiology and Laboratory of EEG, Groupe Hospitalier Pellegrin - 33076, Bordeaux, France)

Two hydrosoluble iodinated compounds, Iopamidol and Iohexol, were studied in 20 patients presenting with sciatica. The patients were randomized and the same procedures and amounts of iodine (15 ml Iopamidol containing 200 mg iodine, 12 ml Iohexol containing 240 mg iodine) were used for lumbar myelography.

Three types of criteria were used to analyze neurotoxicity: 1) Clinical examination, before, immediately after and 6 and 24 hours after injection for usual side effects. 2) CT scan to determine the product's brain penetration: before myelography, 6 and 24 hours after myelography. 3) In addition recheck EEG tracings were obtained in each case, before, 3,6 and 24 hours after examination with analysis of the amplitude and frequency spectrums during 30 min for each patient. Headache was the most frequent adverse reaction (3 cases) associated with nausea and vomiting, only when using Iopamidol, but the difference was not statistically significant. The most significant finding was the increase of sciatic pain after myelography (5 Iopamidol, 6 Iohexol) and the complete absence of neuropsychic symptoms. In cerebral computed tomography, important brain penetration was observed in 4 patients with Iopamidol and 6 patients with Iohexol. In 3 patients, brain penetration of contrast medium was present as soon as 2 or 3 hours after injection. In every case, penetration lasted around 24 hours. The study of EEG tracings revealed no electrical alterations in either group including those under intermittent light stimulation. Spectral analysis performed at the beginning, middle, end of registration either with open or closed eyes did not show any seizure disorder or focal abnormality. General hypovigilance was noted because of sleep.

In summary, the authors concluded that in spite of important brain penetration observed with Iopamidol and Iohexol, clinical and bioelectrical tolerance are excellent.

Percutaneous Lumbar Discectomy: A Canine Model: Chin JK[1], Pile-Spellman JMD[1], Onik G[2], Davis KR[1], Taveras JM[1] ([1]Massachusetts General Hospital, Boston, MA 02114 and [2]Allegheny-Singer Research Institute, Pittsburgh, PA 19104)

Percutaneous lumbar discectomy allows a relatively noninvasive method of disc decompression. Initial reported clinical experience is encouraging with approximately 75% of patients gaining relief. A canine model of percutaneous discectomy was used to obtain experience with this method, to assess the nature and amount of the decompression obtained, and to assess feasibility of using this in chondrodystrophoid dogs.

Seven cadaveric mongrel dogs (mean 20 kg) were used. A total of 23 discs were treated. A 2 mm Nucleotome® aspiration probe was used. The disc was entered as in humans at the posterolateral aspect of the disc space. Studies in selected animals included discography, myelography, and dissection.

It was possible to enter all the lumbar disc spaces from L1-2 to L5-6. L6-7 could not be entered with the straight cannula. Unlike humans, the lumbar disc spaces are small and uniform (16.0 mm +/- 1.0 mm by 3.1 mm +/- 0.1 mm by 24.3 mm +/- 0.5 mm). It is estimated that no more than 20% of the disc material is removed within the first 3 minutes, with little additional material being obtained by further aspiration. Myelography demonstrates that the disc can be entered without damage to the thecal sac. This method is technically feasible in dogs and may have a place in treating canine disc disease. This model offers an easy way of gaining experience with the method that is similar to the human situation.

Tears of the Anulus Fibrosus in the Cervical Spine: A Correlative Study by Cryomicrotomy and MR: Yu S, Sether LA, Haughton VM, Ho PSP, Ho KC, Wagner M (Medical College of Wisconsin, Milwaukee, WI 53226)

The cervical intervertebral discs have not been investigated as thoroughly as the lumbar. We studied the anulus fibrosus of cervical intervertebral discs in 18 cadavers with MR and anatomic sections. The MR images were obtained with a 1.5 T scanner in sagittal projection. The anatomic sections were obtained at exactly the same plane as MR images. The MR images were compared with their corresponding cryomicrotome sections. As in the lumbar spine, three types of anular tears were found in the cervical discs: concentric tear, radial tear and transverse tear. Radial tears occurred in older cadavers than did transverse or concentric tears. Concentric and transverse tears were common at all disc levels. Radial tears were much more prevalent at C4-5, C5-6 and C6-7. Radial tears appeared to be significant degenerative changes. The other two types of tear were incidental findings. MR could demonstrate the radial and transverse tears. Therefore, MR can be used to investigate tears of the anulus fibrosus in vivo.

Percutaneous Lumbar Discectomy: Correlation of Outcome With Multimodality Imaging Studies: Seigel RS, Brown CW, Tuerk K, Sadler KM (St. Anthony's Hospital Systems, Denver, CO 80201)

Clinical findings pre and post percutaneous lumbar discectomy (PLD) were correlated with CT, MR , myelography, and discography in 61 patients. 47 patients had CT, 49 MR , 28 myelography and 12 discography/CT. Outcome post PLD was graded: 0=no change,1=minimal improvement, 2=moderate improvement, 3=asymptomatic. CT indicated normal (9/51 disc levels) or bulging (35/51) disc more often than MR (normal 2/51,bulge 27/51). MR indicated degenerative disc (42/51) and herniation (17/51) more often than CT (degenerative disc 3/51, herniation 10/51). Myelography indicated bulge in 14/31 disc levels, herniation in 3/31 levels. Discography was utilized in multiple level disease; when

clinical findings did not correlate with imaging results; and to predict contained vs. extruded disc. Discography was predictive of clinical outcome in 5/12 patients.

Successful outcome (Grade 2 or 3) by MR criteria: Degenerative disc disease (DDD) or normal 20% (1/5), bulge 50% (12/24), and herniation 75% (15/20). Successful outcome was not effected by disc level: L3-4 (60%), L4-5 (54%), L5-S1 (56%). Grams of disc material removed did not correlate with outcome: Grade 0=1.46, Grade 1=1.22, Grade 2=1.64, Grade 3=1.52

Results indicate that focal disc herniations are more likely to improve (75%) than disc bulge (50%) or DDD (20%). MR appears more sensitive in demonstrating herniation and DDD than CT or myelography. Discography and grams of disc material removed do not correlate with outcome. Large disc herniations or extrusions are unlikely to improve s/p PLD. Good outcome is not effected by the level of PLD.

Sensitivity of MR and Discography for Radial Tears in the Anulus Fibrosus: Yu S, Sether LA, Haughton VM (Medical College of Wisconsin, Milwaukee, WI 53226)

Prior to the development of MR, discography was the only effective radiographic means for visualizing tears of the anulus fibrosus. We compared discography and MR in the detection of anular tears. Eight cadavers had MR of the lumbar spine, discography and then cryomicrotomy. MR images of the spine were obtained in sagittal projections with T1 and T2 weighted spin echo techniques. Each lumbar nucleus pulposus was cannulated with a 21 g spinal needle under fluoroscopic monitoring, injected with 0.5 to 1.0 ml of iodinated contrast medium mixed with green dye. The cryomicrotomic sectioning was performed in sagittal plane. Discography demonstrated 15 radial tears in 36 intervertebral discs. MR demonstrated 10 of the 15 as regions of high signal intensity in the anulus and Sharpey's fibers. The MR sensitivity was 67% for the radial tears of the anulus. The portions of the disc which were opacified at discography were consistently demonstrated in MR (T2-weighted images) as regions of bright signal intensity. The anular tear was a constant finding in degenerating discs with or without a nuclear herniation.

The Anatomic Basis of Vertebrogenic Pain in Lumbar Disc Extrusion: A Retrospective MR Study:
Jinkins JR, Whittemore AR, Bradley WG.
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INTRODUCTION: Extruded lumbar intervertebral discs have traditionally been categorized as posterior or postero-lateral in location (PDE), although occasional reports have addressed extrusions anteriorly (ADE) and centrally (CDE). The clinical state of radiating pain accompanying posterior extrusions is well understood, however the uncomplicated ADE and CDE may also be associated with a definite clinical syndrome, which includes both local and referred symptoms without specific lumbosacral root involvement.
METHODS: A detailed retrospective review of 250 MR examinations of the lumbar spine was performed utilizing single and dual respectively, on mid- and high field imagers. Extrusive abnormalities were sought along the periphery of the disc, anteriorly (ADE) or posteriorly (PDE), as well as centrally (CDE) into or through the vertebral body itself to include Schmorl's nodes and limbus vertebrae.
RESULTS: Out of the total of 250 examinations, 236 extrusions were identified in 145 subjects, leaving 105 negative studies (42%). Of these 236 extrusions, 69 (29%) were ADE's, 34 (14.5%) were CDE's, and 133 (56.5%) were PDE's.
DISCUSSION: The anatomic basis for the generation of pain within the disc and paradiscal structures rests with afferent sensory fibers from the two primary sources: 1) posterolateral neural branches emanating from the ventral ramus of the somatic spinal root, and 2) neural rami projecting directly to the paravertebral autonomic neural plexus. Thus, the conscious perception of pain originating in the vertebral column, although complex, has definite pathways represented in this dual peripheral innervation with common central ramifications. The directional differentiation of lumbar disc extrusions utilizing MR, together with a clarification of the accompanying clinical syndromes should contribute to the further elucidation of the specific causes of local and referred vertebrogenic pain engendered by these distinct organic lesions.

Gadolinium Complexes in MR Intraspinal Tumors: Gruselle JF, Kien P, Grenier N, Caille JM (Service de Neuroradiologie, Groupe Hospitalier Pellegrin - 33076, Bordeaux, France)

Fifty patients were examined during 1987 with routine and enhanced MR:2 complexes of gadolinium (Gd^{3+}), DTPA and DOTA Gd^{3+} were used, with Magniscan 0.5 Tesla. Beforehand, Gd T1 w (SE or GE) and T2 w sequences were performed. Then Gd T1 w sequences in two or three planes were performed.

1. Twenty-one patients with spinal-cord tumors were explored (11 astrocytomas, 5 ependymomas, 5 hemangioblastomas). In 20 cases, MR revealed a widening of the spinal cord. Complexes of Gd provide a better visualization and distinction of solid and cystic portions than T2 w sequences. In hemangioblastomas, these substances provide a better visualization of vascular area. They also differentiate simple reactive cysts from tumoral cysts (high signal of the walls of the latter).

MR with Gd complexes is more accurate in enumerating multiple lesions.

In one case of astrocytoma, MR did not show a widening of the spinal cord in T1 w sequences: a high signal in the posterior part of the spinal cord after Gd suggested the diagnosis.

2. Ten patients with extramedullar intradural tumors (6 meningiomas, 2 neurinomas, 1 metastasis, 1 mening. carcinomatosis) were explored. In 9 patients MR suggested the diagnosis of an extramedullary intradural lesion. The risk of confusion between intra- and extramedullary lesion is reduced by performing additional sections along different planes. However, gadolinium enhancement in one case distinguished normal spinal cord from the tumor, because of optimal contrast.

In multiple lesions, gadolinium complexes were used to detect small lesions with a diagnostic sensitivity approaching that of myelography.

3. Five extradural tumors were observed (3 chordomas, 1 chondroblastoma, 1 metastasis). In the three chordomas, the enhancement (homogenous or heterogenous) provided better images of tumoral extension especially in bone tissue.

4. Nine patients with epidural lesions were observed (7 metastatic, 2 infectious): myelography appears to be superior, but MR contributes by detailing the extension of intracanalicular lesions, except for the posterior localization, where the fat tissue signal is similar to that of these lesions in T1 w sequences.

5. Two cases of arachnoiditis were observed and we mention the risk of false positive diagnosis in the case of normally hypervascularized areas in the dura mater.

6. In three cases, MR was normal.

Gadolinium-DTPA: Intramedullary Lesions of the Spine: Sze G, Krol G, Zimmerman RD, Deck MDF (Memorial Sloan-Kettering Cancer Center, New York, NY 10021)

Gadolinium-DTPA was used in the evaluation of twenty-six patients with spinal cord lesions. Nine patients had primary cord tumors; six patients had benign syrinxes; three patients had multiple sclerosis with cord involvement; three patients had thrombosed vascular malformations; three patients had metastasis to the cord; two were normal. MR was performed on a 1.5 Tesla unit with surface coils. 3 mm. short and long TR sagittal scans were performed, as well as 5 mm. short TR axial scans. All cases were performed with cardiac gating and with gradient moment nulling techniques where appropriate.

Gadolinium-DTPA was able to enhance most neoplasms. In particular, the nidus of spinal cord hemangioblastomas and metastases enhanced markedly and were pinpointed for surgery or radiation therapy. All cases of primary gliomas, with the exception of one, also showed enhancement, although the enhancement varied considerably in intensity. Delineation of enhancement helped to differentiate benign, reactive cysts from tumor cysts. In addition, portions of the tumor that showed greater enhancement appeared to correlate with areas of more active neoplasm. Gadolinium was also of use in distinguishing post-operative change from recurrent tumor.

Even the lack of enhancement was of clinical use. Benign syrinxes failed to demonstrate enhancement, despite surrounding high intensity in the cord on the long TR images. Similarly, thrombosed vascular malformations also did not show enhancement. This helped to rule out associated tumor when the cord hematomas were detected. Finally, we did not see significant enhancement in any of our cases of multiple sclerosis, despite active disease in two cases, although subtle enhancement was present in one.

In conclusion, although most intramedullary lesions are detected without the use of contrast, gadolinium-DTPA was of benefit in the delineation and characterization of lesions. Specifically, gadolinium may help to: 1. Delineate the nidus of lesions, in cases of metastases or hemangioblastomas; 2. Show areas of more active tumor, in cases of gliomas; 3. Distinghish benign from neoplastic lesions, for example, in cases of complicated syrinxes and cord hematomas; and 4. Possibly differentiate active from inactive lesions, in cases of multiple sclerosis.

Gd-DOTA enhanced MR Imaging of Spinal Cord Tumors: Manelfe C, Berry I, Arrué Ph (Neuroradiology, CHU Purpan, Toulouse, France).

To assess the ability of Gd-DOTA to improve spinal cord tumor MR Imaging, 29 patients (17 females, 12 males) suspected for such pathology entered a clinical trial of this agent. 11 patients had already been treated for tumor with surgery and/or radiation therapy ; 5 were repeatedly imaged before and after treatment. Final diagnosis included 14 intraaxial tumors, 5 extraaxial tumors, 4 negative follow up, 2 dural fistula, 1 ischemia, 1 hematomyelia, 1 HNP, 3 arachnoid cysts, 1 normal, 2 pending.
MR Imaging was performed at 0.5 T (Magniscan*5000, Thomson-CGR, France) with the combination of T1 - and T2 - weighted techniques (spin-echo and gradient-echo) before and after injection of Gd-DOTA (Guerbet Lab., France), with one hour follow up.

Gd-DOTA enhancement was present in all tumors. It improved diagnosis of intraaxial tumors with the delineation of a nodule in 12/14 patients and additional cyst wall enhancement in 2 other, which were found invaded at surgery. Lack of enhancement after Gd-DOTA was reliable in ruling out tumor as in 2 cases with high signal intensity conus on T2-weighted images and dilated vessels posteriorly, which were confirmed not to be associated with tumor, but with dural fistula at angiography. Gd-DOTA enhancement proved extremely useful to improve the reliability of follow-up examination after treatment.

The reliability of Gd-DOTA enhancement of tumors might suggest that the combination of pre and post-contrast T1-weighted images only should be required and T2-weighted sequences could be performed only for non enhancing spinal cord lesions.

Gadopentetate Dimeglumine Enhanced MR of Spinal Neoplasms: Comparison with Unenhanced Spin-Echo and STIR: Stimac GK, Porter DO, Gerlach R, Genton M, (First Hill Diagnostic Imaging Center and Univ. of Washington, Seattle, WA 98104)

Unenhanced T1-and T2-weighted spin-echo (T1SE and T2SE), short TI inversion recovery (STIR) and gadopentetate dimeglumine (Gd-DTPA) enhanced spin-echo and STIR imaging techniques were employed in 20 patients to assess the safety and efficacy of Gd-DTPA in spinal imaging. Five patients had normal MR scans. Of those with lesions, both Gd-DTPA enhanced T1SE and unenhanced STIR scans improved detection and evaluation of spinal tumors over conventional SE methods, particularly T2SE, by providing higher tissue contrast in shorter imaging times. The Gd-DTPA enhanced T1SE scans were most helpful in evaluation of intradural tumors, whereas STIR was most effective for extradural tumors and bone metastases. In most cases, Gd-DTPA enhanced T1SE scans best delineated tumor margins, and the enhancement was helpful in suggesting a cellular or active nature of the lesions. In some cases the enhancement resulted in a more homogeneous and, therefore, less abnormal appearing marrow in spines involved by tumor; therefore, a precontrast T1SE scan is necessary in all patients who are to be studied with Gd-DTPA. A combined approach using T1SE, Gd-DTPA enhanced T1SE, and STIR images currently appears optimal for MR of spinal neoplasms. T2SE images added information only in selected cases.

Vertebral Metastases - Evaluation with Routine Spin Echo Sequences: Krol G, Ginsberg L, Sze G, (Memorial Sloan-Kettering Cancer Center, New York, NY 10021)

AIM: To define the role of T1 and T2 sequences in the assessment of metastatic lesions of the spine on MR.
MATERIAL AND METHODS: Eighty-seven patients with known primary neoplasms and proven spinal metastases were examined by MR. 39 patients were examined on .5 Tesla Technicare scanner, using body coil. 48 patients underwent study of the spine on GE 1.5 Tesla Signa scanner, with standard body coil (10) and rectangular 5 x 11" surface coil (38). TR/TE of 500/32 and 600/25 were typically used to obtain T1 information. Sequences with TR/TE intervals of 400-800/20-35, 800-1600/35-50 and 1600-2200/50-100 were used to gather T1, intermediate and T2 information. The intensity of metastatic bone lesions were assessed subjectively, as compared to the intensity of the normal vertebra on the same sequence.
Experiment: Five patients with single metastases of lumbar or thoracic vertebrae were examined using progressively increasing TR/TE intervals from TR/TE 600/20 to 2000/100 at 200/25 increments.
RESULTS: All metastatic lesions (blastic and lytic) displayed low signal intensity on T1 weighted images. The intensity difference between normal and abnormal vertebra became progressively obscured as balance was shifted towards T2.
CONCLUSION: All vertebral metastases regardless of type or origin of the primary neoplasm present as a low intensity on T1 weighted images. There is progressive increase of intensity of this lesion with prolongation of TE and TR parameters. The effect of loss of contrast between normal and abnormal bone is independent of the strength of magnetic fields and type of the coil used in examination and appears to be more obvious with increase of TE. The resulting isointensity with reference to normal vertebra renders the lesions undetectable on intermediate or long sequences in approximately 40 to 50% of cases. In 10% of cases the lesion is obscured on both intermediate and heavy T2 weighted imates. It is therefore recommended that routine evaluation of the spine for metastatic involvement should always include images with short TR/TE intervals, not exceeding 800/30 and preferably in the range of 400-600/20 msec. T2 weighted images are significantly less accurate in detection and assessment of spinal metastases.

False Negative and Positive MR Scans of Epidural Metastatic Disease: Sze G, Krol G, Shin J, Zimmerman RD, Deck MDF. Memorial Sloan-Kettering Cancer Center, New York, NY 10021

Both MR imaging and myelography were prospectively and retrospectively compared in 100 consecutive patients referred for evaluation of epidural metastasis. MR was performed on a 1.5 Tesla unit, using 3 or 5 mm. short TR sagittal sections and 5 mm. short TR axial sections through regions of interest. These scans were very rapid and were considered the basic examination for comparison with other modalities. In most cases, 3 or 5 mm. long TR sagittal scans, 5 mm short TI inversion recovery sagittal scans, or very short TR sagittal scans were also obtained.

MR provided information equivalent or superior to the traditional modalities in 92 of 100 cases. In 8 of 100 cases, MR provided less information. In five cases, short TR MR images, utilizing SE 600/20, did not detect vertebral body lesions clearly. However, the same lesions were generally easily visible on the additional sequences. Second, in three cases, exact determination of sites corresponding to the myelographically determined block was difficult. In these cases, diffuse metastatic involvement of the spine was present, superimposed on a narrow spinal canal. The diffusely narrow spinal canal did not allow adequate definition of significant epidural defects. Long TR spin echo images were extremely helpful, although interpretation was still problematic.

Conclusion: 1. Vertebral body metastases are best evaluated on short TR scans. Spin density scans, for example, those with a repetition time of 1000, may miss vertebral body metastases. If subtle but not definitive inhomogeneity is seen on the routine short TR sequences, the additional sequences mentioned above may prove complimentary.
2. In patients with diffuse vertebral body metastases, superimposed upon narrowed spinal canals, exact determination of significant epidural disease may be difficult by MR. In these cases, long TR sequences are extremely useful. However, given the extensive disease, the examination may prove extremely time consuming and this may be one area in which myelography is still appropriate.

MR of Intradural Extramedullary Spinal Metastases: Davis PC, Hoffman JC, Schwartzberg DG, Takei Y (Emory Univ. Sch. of Med., Atlanta, GA 30222)

Few reports describe MR abnormalities from intradural extramedullary spinal metastases. This report describes the variable appearances of intrathecal seeding in 11 patients compared to CSF and myelographic findings.

Diagnoses included medulloblastoma (6), ependymoma (2), ependymoblastoma (1), neuroblastoma (1), and multiple myeloma (1). T1 (10) and T2 (10) weighted studies were performed with 3-5 mm slices using a surface or head coil.

Ten of eleven patients had MR abnormalities; 1 with positive cytology had a normal MR. Two with extensive seeding by myelography (1) and autopsy (1), had a uniformly bright thecal sac on all pulse sequences which obscured drop metastases and cord compression. In 2, the thecal sac intensity distal to a spinal block was increased on T1-weighting possibly due to increased CSF protein and cellularity. In 4, metastases on the cord mimicked cord enlargement. An abrupt or shelf-like change in caliber of the cord helped to distinguish seeding from intramedullary disease. A thickened irregular appearance of the cauda equina and distal thecal sac post-surgically was difficult to distinguish from arachnoiditis. Only 1 patient had discrete well-defined drop metastases.

In summary, in our experience most patients suspected of seeding had recognizable abnormalities. More invasive techniques of myelography with CT, MR with Gadolinium, and CSF cytology remain the most sensitive techniques for identification of spinal seeding, and should be considered whenever the non-contrast MR findings are equivocal or fail to explain clinical findings. Problems with MR included localization of focal masses surrounded by abnormal CSF, and differentiation of seeding from arachnoiditis.

Pitfalls in the Neuroradiological Assessment of Spinal Cord: Cohen R, Zee CS, Bank W, Ahmadi J, Segall HD, Nelson M (Univ. of Southern California, Los Angeles, CA 90033)

The evaluation of spinal cord enlargement is a diagnostic challenge, even with the advent of MR. The appearance of spinal cord enlargement may be misleading on neuroradiological studies including MR. We present several interesting cases with unusual neuroradiological features. A few of the pitfalls we discuss will be familiar to more experienced neuroradiologists, but some of the cases shown have features that have been barely appreciated at all. Diagnostic pitfalls can be divided into the three following categories: 1) Unusual lesions simulating intramedullary neoplasms included seeding of medulloblastoma all around the cord; seeding of a glioblastoma into the central canal; a meningioma with cord invasion mimicking intramedullary lesion. 2) Exophytic cord tumor mimicking intramedullary lesion. A large exophytic cord tumor was attached to the cord by a narrow area at surgery. 3) Disadvantages of MR in the demonstration and evaluation of spinal cord enlargement. A conus medullaris ependymoma filling the entire distal thecal sac was not appreciated on MR due to the lack of contrast in signal intensity features within the canal. Difficulties in the MR diagnosis of cystic areas within cord neoplasms are being increasingly recognized.

Lumbar Dermal Sinuses: Naidich TP, Regenbogen V, Limauro D, McLone DG (Child. Mem. Hosp., Chicago IL 60614)

Analysis of imaging studies and surgery in 8 girls and 6 boys with lumbar dermal sinuses revealed: ages: 8 days - 15 years; cutaneous stigmata 100% (dimple and visible ostium 79%, hemangioma 50%, hypertrichosis 21%, atrophic skin zone 7%); midline site of ostium 71%; paramedian ostium with angled course of tract back to midline 29%; concurrent spinal lipoma 21%; extension of sinus as deep as lumbodorsal fascia 93%; ending of tract in epidural space 14%, at dura itself 7%, within the dural sac 71%; concurrent epidural (epi)dermoids 14%; concurrent intradural (epi)dermoids 57%; initial caudal descent of the tract from skin to lumbodorsal fascia 72%; horizontal course of tract 21%; caudocranial ascent of tract from skin to lumbodorsal fascia 21%; concurrent tethered cord 93%. Patients presented with cutaneous stigmata only (57%), orthopedic deformities of the foot 21%, meningitis (14%) or with pain resulting from prior infection and dense arachnoiditis (7%). One patient had concurrent diastematomyelia. No patient had scoliosis, hydromyelia, Chiari I or Chiari II deformity. Concurrence of spinal lipoma with dermal sinus suggests that focal derangements of disjunction of cutaneous from neural ectoderm may lead to contiguous or intermixed dermal sinus (incomplete disjunction) and spinal lipoma (premature disjunction). The differing craniocaudal courses of the tract suggest that the trajectory of the superficial part of the tract varies with patient position and posture and deepens as the patient assumes erect posture with associated increase in lumbar lordosis. A small midline posterior triangular outpouching of the arachnoid/dura analogous to a root sleeve marked the site of entry of the sinus tract.

Approach To a "Baseline" Brain and Spine MR Exam in Children After Meningomyelocele Repair: Protocol and Utility: Boyer RS, Pattispau J, Walker ML (Primary Children's Medical Center, Salt Lake City, UT 84103).

Magnetic resonance (MR) provides an unparalleled opportunity to exam the brain and spine in children after meningomyelocele (MMC)repair to better understand the broad spectrum of associated abnormalities. During a 9 month period (5/87 - 1/88), we performed a "baseline" brain and spine MR exam at 1.5 T on 50 children with MMC repair, age 3 weeks to 18 years (mean 6.8 years). We developed an MR protocol that allows acquisition of maximum anatomical information in a one-hour examination period. All sequences employed short TR and short TE for optimum anatomic visualization.

Brain malformations included: Chiari II (44), dysplastic corpus callosum (33), shunted hydrocephalus (39), "beaked tectum (43), falx hypoplasia (41) and stenogyria (33). Level of spinal dysraphism ranged from T6 to S1. After MMC repair, the distal spinal cord tapers gently to the level of repair where it appears to be scarred to the dorsal aspect of the expanded thecal sac in virtually every case. Other spinal findings included: syringohydromyelia (11), scoliosis (14) and fat in filum (4). We could not predict from the appearance of the distal cord which patients might respond to surgical release, which has been performed in 11 patients. Indications for surgery included: increasing spasticity, incontinence, scoliosis, weakness and/or pain.

Anatomic CNS information not previously available can be noninvasively acquired in a one-hour MR exam of children with MMC. Clinical correlation is necessary to identify children who may benefit from release of the scarred distal cord.

The "Interrupted Cord" : Three Cases Of An Unusual Malformation Of The Spinal Cord : Raybaud CA, Couailler JF, Choux M, Binnert D (Univs. of Marseille and Dijon, Marseille and Dijon, France)

Three cases of a previously undescribed malformation of the spinal cord have been observed in infants between 1975 and 1987. The upper, neuroectodermal, neurulated portion of the cord was separated from its lower, lumbosacral portion (each with its sets of nerve roots) by an intermediate portion devoid of roots and constituted presumably by white matter only. Other morphological features included tethering of the conus, segmentation disorders of the spine (including sacral agenesis), and in one case a true neuroenteric canal. The clinical features included neurogenic bladder in all three cases and arthrogriposis with partial impairment of sensory motor function of the lower limbs. The morphogenesis of this type of malformation is not known. A mechanical disruption of the cord is unlikely. Since the functional segmentation of the cord which fits the metameric (somitic) segmentation of the body is induced by the sensory ganglion cells from the neural crest, it can be hypothetized that faulty connections were established either because of delay of induction, or through a process of lesion and secondary repair.

MR Imaging of Extrinsic Compression of the Neuraxis in Skeletal Dysplasia: Sherman JL, Kopits SE, Citrin CM (Washington Imaging Center, Kensington, MD 20895 and Uniformed Services Univ. of The Health Sciences, Bethesda MD 20814 and International Center for Skeletal Dysplasia, Towson MD 21204)

Thirty-six patients (4-27 years old) with skeletal dysplasia underwent MR imaging of the cervical spine and craniocervical junction. Eighteen patients had Morquio's syndrome (MPS-IV), 10 had spondyloepiphyseal dysplasia (SED) congenita and 8 had achondroplasia (ACP). Sagittal images were obtained in all patients in neutral, flexion and extension positions using T1-weighted spin-echo or field-echo pulse sequences. Other imaging planes and sequences supplemented most exams. Both dynamic and static compression of the spinal cord or cervicomedullary junction (CMJ) was determined. Patients were evaluated for severity of dysplasia (especially at C1-2), presence of instability and presence of spinal cord deformity (myelopathy).

Typical dysplastic vertebrae were more easily recognized on the radiographs but MR was superior for evaluation of the odontoid. The odontoid was dysplastic in 24 patients with MPS-IV or SED. None of the patients with ACP had odontoid dysplasia or C1-2 instability. Instability was present in 12 patients with MPS-IV or SED. Twenty-five patients exhibited compression of the cord or CMJ. Images in the neutral position underestimated the severity of cord deformity in 11 patients and missed cord deformity in 2 patients. Foramen magnum stenosis was present in 7 patients with ACP.

MR evaluation of patients with skeletal dysplasia is advocated since it provides non-invasive evaluation of the neuraxis and can be used as a screening procedure. Flexion and extension images are necessary for complete evaluation. The optimum time to surgically intervene in the care of these patients is determined by correlation of MR and clinical findings.

Observation on Thrombus Formation, Structure and Evolution in Intracranial Aneurysms Treated by Balloon Occlusion: Strother CM, Kikuchi Y, Graves VM, Eldivik P, Partington C (University of Wisconsin, Madison, WI 53711)

Over a three year period we have performed serial MR on 9 patients having endovascular occlusions for treatment of intracranial aneurysms. Using these studies we have analyzed the formation, structure and evolution of both spontaneous and induced thrombus.

A thrombus differs significantly from a hematoma. Spontaneous arterial thrombi are comprised primarily of platelets and fibrin while thrombi induced in aneurysms by balloon occlusion more closely resemble venous thrombi and have more of their bulk comprised of erythrocytes.

Spontaneous thrombus in incompletely thrombosed aneurysms appears as laminated, inhomogeneous tissue which is quite dark on both T1 and T2 weighted images. Within 9 days of aneurysm thrombosis, spontaneous thrombus becomes bright on T2 weighted images.

Following occlusion of the lumen of an aneurysm the isolated blood retains the MR characteristics of stagnant blood containing oxyhemoglobin. (Short T1 and long T2) As clotting occurs there is a shortening of the T2 of the clot; as degradation of RBC's and hemoglobin occurs the T2 again lengthens.

Reduction of mass effects is common after complete aneurysm thrombosis and was observed in all of our patients where followup of over 3 months was available.

Thrombus formation and dissolution is a complex, dynamic process. Induced thrombus in intracranial aneurysms serves as a good model of its evolution.

Therapeutic approach in management of head and neck pseudoaneurysms: Kwan ES, Higashida RT, Halbach VV, Hieshima GB, Hardin CW (UCSF Medical Center, San Francisco, CA 94143)

A series of 39 carotid and vertebral pseudoaneurysms (extracranial and intracranial) were treated with endovascular occlusive techniques. Symptoms and therapeutic implications depend on etiologies, location, vascular anatomy, associated fistula, vessel transection and age of pseudoaneurysm. Etiologies include trauma (28), spontaneous dissection (3), tumor erosion (4), sequela to treatment of fistula (4). Clinical presentations include transient ischemic attacks, cranial nerve palsies, headache, epistaxis, hematomas, and bruit. Detachment of balloons within acute pseudoaneurysms is not indicated due to thin wall and fresh mural thrombi; thereby risking vessel rupture and distal embolization, proximal occlusion is treatment of choice. Chronic pseudoaneurysms with organized mural thrombi and definable necks are amenable to balloon therapy with preservation of flow in parent vessels. In pseudoaneurysms with wide necks the detachable balloons must maintain volume indefinitely; otherwise the balloons may migrate distally and the pseudoaneurysm recannalizes. Medially directed cavernous carotid pseudoaneurysms or those extending into the subarachnoid space should be treated urgently due to high risk of life-threatening epistaxis and subarachnoid hemorrhage. Pseudoaneurysms with associated fistulae may require a trapping procedure and/or transvenous embolization. Pseudoaneurysm and dilated varix in association with fistula must be distinguished because of different therapeutic implication. The benefits of systemic heparinization during embolization should be weighted against life-threatening hemorrhage in patients with vessel transection. There were 4 complications: 2 were delayed stroke following proximal carotid occlusion, 2 were thromboembolism to middle cerebral territory.

Direct Percutaneous Embolization in Arterial and High Flow Arteriovenous Lesions: Berenstein, A, Choi IS (New York University Medical Center, New York, NY 10016)

We have previously reported the use of direct puncture and embolization in venous lesions. We are now reporting our experience of direct puncture and embolization in arterial or high flow arterial venous lesions, in whom for one reason or others (ligations, etc.), the transfemoral approach is not possible. The use of fluoroscopy, compressive techniques in conjunction with tissue adhesives or 95% ethanol will be described. We have used this technique in 7 patients in 10 separate procedures. The technique was successful in all cases. There were no complications. After direct puncture of the nidus one can reflux into the feeding pedicle and obtain complete devascularization. The technique may offer a new approach for arterial and high flow lesions in the head and neck which cannot be catheterized by conventional techniques.

Transvenous Embolization of Direct Carotid Cavernous Fistulas: Halbach VV, Higashida RT, Hieshima GB, Hardin CW, Yang PJ (UCSF Medical Center, San Francisco, CA 94143)

Of the 165 direct carotid cavernous fistula patients (CCFs) treated by the authors, fourteen (8.5 %) were treated from a transvenous approach. Twelve of these were treated through the inferior petrosal sinus (IPS) and one through the superior ophthalmic vein (SOV). One patient underwent both IPS and SOV approaches.

The embolic agents were as follows: five patients had balloons only, four patients had minicoils alone, three patients had coils and liquid adhesives, one had balloons and coils, and one had balloons and liquid adhesives. The reasons for transvenous treatment were as follows: three patients had an occluded carotid artery secondary to trauma, nine failed transarterial balloon attempts, and one had a prior trapping procedure. In the remaining patient with Ehlers-Danlos syndrome, a transarterial approach was judged to be too dangerous. This patient suffered a fatal pontine hemorrhage following subtotal transvenous occlusion of the CCF with diversion of flow into cortical veins. Another complication occurred when the IPS was perforated during catheterization resulting in a small SAH. The tear was immediately closed with minicoils and surgical exposure and embolization resulted in complete cure.

Of the remaining twelve patients treated, there was complete cure in eleven, and angiographic and clinical improvement in the remaining case. Transarterial balloon embolization remains the procedure of choice in the treatment of symptomatic CCFs, however transvenous embolization is an alternative when the arterial route fails.

Transvenous Embolization of Dural Fistulas Involving the Transverse and Sigmoid Sinuses: Halbach VV, Higashida RT, Hieshima GB, Mehringer CM, Hardin CW (UCSF Medical Center, San Francisco, CA 94143)

Eleven patients with dural fistulas involving the transverse and sigmoid sinuses were treated by transvenous embolization with coils or liquid adhesives. Seven patients underwent preoperative embolization of the external supply followed by direct surgical exposure of the sinus: liquid adhesives were used in four and coils in the remaining three patients. Four of these patients had complete obliteration of their fistula and there was 95% reduction in the remaining three. Four patients had transvenous placement of coils from a transfemoral approach. In three, the ipsilateral sigmoid sinus was thrombosed and a contralateral approach across the torcula was utilized. Coils were used in all four patients; one patient also had liquid adhesives placed within the sinus. Complete cure was achieved in one patient, 95% reduction in another, and 50 and 40% reduction in the remaining two. There were two transient complications in this series, one related to venous occlusion secondary to liquid adhesives, and another related to transient occlusion of the vestibular aqueduct. Obliteration of dural fistulas involving the transverse and sigmoid sinuses can be achieved by placement of embolic material within the involved sinus from a transvenous approach; both coils and liquid adhesives can achieve this goal.

Embolization of Dural Arteriovenous Fistulae (DAVF) of the Cavernous Sinus Region by Venous Approach: Goto K (Fukuoka Univ., Fukuoka 814, Japan)

Preface Embolization of DAVF of the cavernous sinus region is now being performed by venous approach in selected cases. This approach is utilized when transarterial approach becomes very difficult or impossible by recurrence after embolization of the external carotid branches or when there are too many feeding arteries.

Materials and Methods 1. Catheter: Tracker 18 catheter (Target therapeutics). Guide wire: 0.014" Hi-torque floppy coil guide wire (ACS) or 0.014" Radifocus low-friction plastic guide wire (Terumo Japan). 2. Case Material : 10 cases with DAVF. Approaches: via inferior petrosal sinus -- 6 cases, via superior ophthalmic vein -- 4 cases.

Results Clinical improvement: Complete cure -- 7 cases, Marked improvement -- 3 cases, Obliteration of DAVF on angiography: Complete in 6 cases, Marked in 4 cases. Complication: Transient 6th cranial nerve palsy -- 2 cases, Visual disturbance -- 1 case.

Discussion The authors prefer to approach the cavernous sinus via the inferior petrosal sinus by transfemoral catheterization, however, the inferior petrosal sinus is quite hypoplastic or obliterated in many cases. In these instances, we are obliged to place catheters into the superior ophthalmic vein via either the frontal or angular vein, which is exposed by surgery, to reach the cavernous sinus. In order to prevent intraorbital or intracranial hemorrhages by rupturing veins, we have to wait until the veins arterialize. Also selection of catheters and guide wires, and gentle manipulation of them are of prime importance. Transient 6th cranial nerve palsy was regarded as ischemic neuropathy related to progression of thrombosis within the cavernous sinus after embolization, and visual disturbance was considered to be caused by migration of liquid emboli or thrombi from the cavernous sinus to the central retinal arteries. Steel mini-coils are preferred to liquid adhesives to reduce complications.

Preoperative Balloon Embolization Of The Inferior Petrosal Sinus: Hecht ST, Jungreis CA, Sekhar LN, Janecka IP (Univ. of Pittsburgh, Pittsburgh, PA 15213)

Surgery of the skullbase is treacherous, owing to the close proximity of numerous neural and vascular structures. Vascular control is of paramount importance for safe skullbase surgery. In particular, temporal bone resection is fraught with the danger of excessive blood loss due to venous bleeding. To improve hemostasis, we have begun embolizing the inferior petrosal sinuses of patients prior to temporal bone resection for carcinoma of the temporal bone. HEMA filled detachable balloons are the embolic agents. The emboli are introduced via femoral venous approach. Presurgical embolization results in both reduction of surgical blood loss and reduction of the duration of surgery.

Endovascular Embolization in Eight Cases of Vein of Galen Aneurysms: Lylyk P, Vinuela F, Casasco A, Dion JW, Peacock D, Lufkin R, Bentson J (Fleni, Bs. As., Argentina; and UCLA Medical Center, LA, CA 90024)

A vein of Galen aneurysm is a rare vascular abnormality. It tends to present in stereotype patterns depending upon the age of the patient. From September 1986 to March 1988 the authors investigated and treated eight patients with V. of Galen aneurysms. Their ages ranged from 24-hr. newborn to 10 y.o. boy, (4 neonates, 3 infants, 1 older child). The technique used to catheterize and embolize the V. of Galen aneurysms was based upon the work reported by Mickle and Quisling. In two cases a combination of detachable balloons and the Gianturco spring emboli was used. In 5 pts. therapy was performed in two stages. In 3, one procedure was carried out and in one pt. the transtorculor approach was complemented with intra-arterial embolization. A total occlusion of the Vein of Galen aneurysm was obtained in 5/8 cases, subtotal in 3/8.

Ve-pe shunt was placed in 6 cases, 3 prior and 3 after the embolization was done. Seven of these patients are alive and 6 of them are neurologically normal. In two cases intraventricular hemorrhage occurred, one of these full recovery and the other death after 10 days. A therapeutic choice has to be made in each given case depending upon the age and the hemodynamics of the vascular malformation and the cardiac status. Choices are surgical, endovascular or combined. The transtorcular approach is safe, quick and may be the first choice in neonates and in groups 1,2, and 3 of Yasargill's classification.

Thrombogenicity of Teflon Versus Copolymer Coated Guidewires: Evaluation with Scanning Electron Microscopy: Pinto RS, Robbins E, Seidenwurm D (NYU Medical Center, 560 First Avenue New York, N.Y. 10016)

Utilizing the scanning electron microscope, a new guidewire with a copolymer coating was compared to standard Teflon coated coiled spring guidewires both in clinical and in vitro settings.

Intense thrombogenicity was observed with the teflon coated guidewires with formed thrombi ranging in size of 50-100 microns.

No formed thrombus was noted on any of the specimens of the copolymer guidewire. Isolated clumps of platelets and erythrocytes without fibrin strands were seen infrequently.

We conclude that the copolymer guidewire is markedly less thrombogenic than teflon coated guidewires.

MR of Postoperative Cerebral Aneurysm: Brothers MF, Fox AJ, Lee DH, Pelz DM, Deveikis JP (Univ. of Western Ontario, London, Ontario Canada N6A 5A5)

Twenty patients underwent 24 MR scans following clipping of cerebral aneurysm. Eighteen posterior and 6 anterior with a mean postoperative interval of 8.7 days. Mean preoperative aneurysm size was 21.5 mm with 9 giants (> 2.5 cm) and 8 large (> 1.5 cm). Sugita non-magnetic clips were used. No ill effect due to the scan occurred.

Clip artifact had complete signal void of variable shape, rimmed by high signal along the frequency encoded axis margin. Artifact size averaged 31.2 mm. It was much less obtrusive than in CT scans. In 14 MR scans the aneurysm could be partially imaged next to the clip artifact, mainly in very large aneurysms or those treated by clipping the parent vessel. Of these, 4 revealed residual lumen on MR and 10 looked completely thrombosed. Postoperative angiography showed that 6 of the latter had a missed residual lumen, with a mean diameter of 10.8 mm.

Evolution of the signal intensity of new aneurysm thrombus, in those minimally or not obscured by artifact, coincides with patterns previously described for hemoglobin in intracerebral hematoma. Earliest hyperintensity could be seen in either the periphery or the center of the new thrombus.

All 17 scans performed for postoperative deficits showed appropriate lesions, mainly small brainstem infarcts. Postoperative CT missed over 60% of these lesions, mainly due to artifact from clip or bone.

In conclusion, MR is significantly better than CT in postoperative assessment of aneurysm patients, particularly in detecting significant small infarcts. Scanning is safe if non-magnetic surgical clips are used. MR is not accurate in assessment of the residual lumen. The clip artifact is considerably less than that seen on CT.

Comparison of MR and CT in Patients with Intracranial Aneurysm Metal Clips: Larsson EM, Holtås S, Olsson M, Romner B, Säveland H, Brandt L (University Hospital, S-221 85 Lund, Sweden)

CT and MR of the brain were performed without complications in 16 patients operated upon for ruptured aneurysms using Yasargil (316) and Sugita (Elgiloy) clips. These clips were found to be nonferromagnetic and did not move when introduced into our scanner (0.3 T Fonar β-3000 M) in a previous experimental study. The artifacts caused by the clips were smaller on MR than on CT and anatomical structures such as brain stem and temporal lobe were therefore better visualized on MR. Brain tissue lesions corresponding to the frontotemporal surgical approach were revealed by MR in seven patients and by CT in six patients. In three patients temporal lobe lesions seen on MR were not visualized on CT because of beam hardening artifacts. Lesions unrelated to the region of surgery were seen in nine patients on MR and in five on CT.

In conclusion, our study shows that patients with nonferromagnetic Yasargil and Sugita clips can safely be examined in a 0.3 T Fonar MR scanner. MR provides more information than CT because of less disturbance of the image by metal artifacts and superior soft tissue discrimination. Thus, MR can be performed in patients with intracranial aneurysm clips when CT does not adequately demonstrate the suspected pathology, if it is certain that the clips are nonferromagnetic.

Xenon/CT Cerebral Blood Flow Studies in the Assessment of Location, Timing, and Severity of Clinical Vasospasm: Fukui MB, Johnson DW, Yonas H, Sekhar L, Latchaw RE, Gur D, Pentheny S (University of Pittsburgh, Pittsburgh, PA 15213)

The current understanding of clinical vasospasm secondary to subarachnoid hemorrhage (SAH) is that the greatest impact of spasm is upon the vessel of aneurysm origin, is less severe remotely, with a gradual onset of symptoms, and can be responsive to hypertensive measures . At the University of

Pittsburgh Health Center we use the stable Xe/CT CBF method to follow SAH. We have identified a group of 14 patients with delayed neurologic deficits taken from a population of 66 patients with SAH due to aneurysm rupture. We have found several whose syndrome did not follow the typical pattern of clinical vasospasm. In some, aggresive medical management failed to reverse the deficits and local infarction or brain death resulted. In 10 of 14, noncontrast CT did not identify a cause for deterioration while the accompanying CBF study demonstrated locally or globally reduced blood flow. In 4, the noncontrast CT scan revealed ischemic and/or hemorrhagic infarcts while the CBF study revealed a significantly larger area of flow compromise. In 5, reduction of CBF related closely to the vessel of origin. Three had only reductions of CBF unrelated to the vessel of origin. Another 6 had reductions of CBF related closely to and unrelated to the vessel of origin. In 6 of our 14 patients, neurological deterioration due to vasospasm was sudden and devastating associated with CBF <15cc/100gm/min and resulted in local infarction or brain death despite aggressive medical management. Six had surgery, pre and postop CBF studies. Two had normal pre and postop CBF. Four had preop focal ischemia. Postop, 1 showed no change and 3 became worse. Both the vessel of origin and remote vessels can be severely affected. One or more vascular territories can rapidly infarct despite aggressive intervention. Preop evaluation can identify ischemia that may complicate the postoperative course.

Cerebral Blood Flow Study Using Stable Xenon-CT in Sickle Cell Cerebrovascular Disease: Correlation with CT and MR : Numaguchi Y, Haller JS, Humbert JR, Murayama S, Robinson AE, Lindstrom WW, Gruenauer LM (Tulane University Medical Center, New Orleans, LA 70112)

Many children with Hemoglobin-SS disease develop strokes following occlusion of intracranial arteries. Repetitive hypertransfusion of such patients can prevent recurrence of strokes and is sometimes followed by reparative changes of the affected vessels. Serial cerebral blood flow (CBF) measurements can be helpful in assessing progress during hypertransfusion, as well as after discontinuance of transfusions in selected cases. Previous study indicated that Xenon-133 CBF studies could demonstrate impaired flow in Hemoglobin-SS children.

We evaluated the usefulness of CBF studies using stable Xenon with CT flow map imaging (Picker 1200SX System) in 19 children with sickle cell disease who presented with strokes or other cerebral symptoms. Five slice areas of the brain were examined following 5 minutes inhalation of 30% Xenon, balanced with oxygen and room air. All patients were also examined with brain CT and MR , and findings were correlated with Xenon-CT flow studies.

Our results indicate that (1) Xenon-CT is a safe and reliable method of measuring CBF of Hb-SS children; (2) cortical rCBF is often abnormal when MR shows infarctions either in the cortex or in the watershed zones regardless of their sizes; and (3) abnormal rCBF may be seen in patients whose MR is normal. Structural asymmetry may account for this and, correlation with CT and MR is important. Such flow abnormality can truly be ischemic lesions which may develop infarction. Repeat study seems necessary before transfusion therapy.

Mini-Fiberscope for a New Imaging Technique in Neuroradiology---It's Apparatus and Clinical Applications : Machida T, Yamakawa K, Aoki S, Sasaki Y

(Univ. of Tokyo, Tokyo, Japan 113)

The marked development of a flexible fiberscope in recent years allows direct visualization of the vessel lumina by angioscopy and subarachnoid space by spinalscopy during the traditional neuroradiological procedures such as cerebral angiography, venography or myelography. Our flexible fiberscope devised in Japan consists largely of optic guides and image guides. Optic guides are served by xenon cold light as the light source. Image guides, which are conduit-type fused image bundles, have more than 2000 picture elements. Various types of fiberscopes are available as endoscopy, but we should choose a smaller type (0.35-0.75 mm) as angioscopy in neuroradiology. Because percutaneous transluminal angioscopy must be performed through a relatively long and tortuous route, while transfemoral approach is adopted, a guiding catheter is needed, which makes it possible to introduce the fiberscope and simultaneously to occlude the vessel and to flush during the investigation. A double lumen balloon catheter is desirable to avoid streaming blood in the visual field of the fiberscope. A fiberscope fixed in a tip-deflected catheter is also available as spinalscopy. It is inserted through a spinal needle (18G) into the subarachnoid space. It can be controlled carefully under fluoloscopy and videomonitoring using the tip-articulation catheter in order to put a fiberscope in the desired position. We could obtain color images of morphologic changes of the carotid artery, jugular vein and spinal subarachnoid space.

Color Doppler Imaging of the Extracranial Carotid Arteries: O'Leary DH, Polak JF, Dobkin GR, Wang AM, LoGerfo FW (Harvard Medical School, Boston, MA 02115)

Color Doppler imaging was performed on 47 vessels prior to angiography for possible extracranial carotid atherosclerosis. The normal carotid bifuration consistently demonstrated a region of flow reversal along the posterior wall. The size and shape of this zone varied within the cardiac cycle and among patients. In vitro studies using a geometrically correct clear plastic model showed that the size and shape of this zone of flow reversal varied with the ratio of external to common carotid flow. The finding of this area of flow reversal is thought to be a function of the geometric design of the normal human carotid bifurcation. With stenosis, flow reversal is lost and regions of high velocity flow are readily identifiable. One case of atheromatous pseudo-occlusion, previously misdiagnosed as total occlusion by standard Duplex sonography, was correctly diagnosed using color Doppler imaging. In one instance, a complex swirl pattern of flow within a proximal vertebral aneurysm was easily demonstrated. Color Doppler imaging permits rapid and accurate assessment of the normal and abnormal carotid bifurcation and promises to be useful in the study of certain neck masses.

Color Doppler Imaging of Neonatal Intracranial Vessels: Wong WS, Tsuruda JS, Liberman RL, Chirino A, Vogt JF, Gangitano E (Huntington Memorial Hospital and Huntington Medical Research Institutes, Pasadena, CA 91105)

Color Doppler imaging (CDI) is a recent innovation which provides a visual display of the flow pattern of vascular structures. Being non-invasive, it is ideally suited to study neonatal intracranial vasculature. This study was conducted in two parts. First, 14 neonates were examined with an ACUSON 128 color Doppler scanner using a standard approach through the anterior fontanel. Whenever possible, approaches through the posterior fontanel and the temporal bone were taken. The spatial peak temporal average (SPTA) of the equipment estimated in situ was maintained at all times below 94 mW/cm^2. Of the major intracranial arteries, the anterior cerebral, M1 segment of the middle cerebral, distal internal carotid and basilar arteries were consistently demonstrated. Portions of the vertebral, distal middle cerebral and posterior cerebral arteries were frequently visualized. In the second part of the study, we examined 10 neonates who had undergone extracorporeal membrane oxygenation (ECMO). In this procedure, the right common carotid artery was cannulated with a large caliber catheter and ligated distally. CDI was able to demonstrate the occlusion of the right internal carotid artery and the reversal of flow through the ipsilateral A1 segment. Increased flow on the contralateral side and in the basilar artery was observed in several patients. Although the accuracy and clinical usefulness of CDI is yet to be fully evaluated, our preliminary results show that neonatal intracranial vessels can be readily examined for normal and abnormal flow patterns by CDI.

Transient Blindness, Ophthalmalgia, and Vascular Spasm during Cerebral Arteriography of Patients with History of Migraine Headaches: Suojanen JN, Wang AM, Schick RM, Li K, Lin JCT (Brigham and Women's Hospital, Boston, MA; Chung-Hua Hospital, Taipei, Taiwan; Mackay Memorial Hospital, Taipei, Taiwan)

The role of cerebral angiography in the evaluation of complicated migraine headache is controversial. Some authors report an increased incidence of complications with little yield, while others report a relatively high diagnostic yield with a few significant complications.

We report three female patients ages 21 to 56 years old with histories of migraine headaches who underwent cerebral angiography. Upon ionic contrast injection into the carotid artery, all three developed pain and blindness in the ipsilateral eye. Angiograms and fluoroscopy showed slow flow and narrowing of intracranial vessels. All three patients' symptoms resolved over 20 minutes, though one patient's vision returned to completely normal after one week.

These findings have not been previously reported; several mechanisms are possible. Although we observed only three patients and they all recovered, our observations were quite striking and support the view that migraine patients are at increased risk for complications from cerebral arteriography.

Neuroradiology of Cocaine Abuse: Rowley, HA, Olsen WL (University of California San Francisco, CA 94143 and San Francisco General Hospital, San Francisco, CA 94110).

The clinical records and radiographic studies of 16 patients with cocaine-related strokes were reviewed for the period 1982-88. Our findings were compared to a review of all the previously reported cases. In our experience, cocaine-related complications were independent of drug route (12 nasal, 3 intravenous, 1 aerosol), were confirmed by toxicology screens in 12/16 and were increasingly frequent, with 13/16 seen during 1986-88. All 16 had CT scans, 11 had cerebral angiography and 4 had MR imaging. There were 12 hemorrhages; 5 secondary to aneurysm rupture, 2 from AVM rupture and 5 parenchymal hematomas without known source. In 2 patients there was non-hemorrhagic infarction of the upper midbrain and bilateral thalami. One of these patients had posterior cerebral artery narrowing suggestive of vasculitis on arteriography. Another patient developed sagittal sinus thrombosis with secondary venous infarctions. A comprehensive review of the world literature revealed only 26 reported cases of cocaine-related strokes, of which 17 had hemorrhages (5 aneurysm, 2 AVM, 7 parenchymal, 2 not specified and 1 astrocytoma) and 9 had presumed infarctions (5 confirmed radiographically). Only one of these 26 cases had arteriography suggestive of vasculitis. Our results are in accord with these previously reported cases. Since it appears that the incidence of these complications is increasing, radiologists should be familiar with the neuroradiologic manifestations of cocaine-related strokes.

Incremental and Synergetic Effects of Cocaine and Methamphetamine on Cerebral Vasculature: Experimental Study: Wang AM, Suojanen J, Rumbaugh CL, Brooks ML, Colucci V. (Brigham and Women's Hospital, Harvard Medical School, Boston, MA 02115)

Left vertebral arteriography via transfemoral approach was performed after intravenous administration of cocaine, methamphetamine or both, to evaluate the cerebral vascular changes in 12 New Zealand white rabbits. In the cocaine group of 4 animals, 3 received incremental doses every 10 minutes, starting at 0.1 mg/kg and progressing to 7.0 mg/kg; one received a single high dose of 12 mg/kg. The methamphetamine and combination groups similarly consisted of 3 animals receiving incremental dosages and a single animal receiving a single high dose.

Cerebral vascular spasm was seen only in the group receiving both drugs at high incremental dosages; the effect appeared non-additive. Blood gas measurements remained stable. The observed cerebral vascular spasm was reversed with high dose IV ketanserin. Cerebral vascular spasm produced by incremental administration and synergistic effects of cocaine and methamphetamine can be accurately evaluated by vertebral angiography in rabbits.

To our knowledge, these effects have not been reported and the mechanisms are unknown. Further experimental studies are necessary to explain these effects, as well as possible pharmacologic manipulations to reverse the cerebral vascular spasm.

Cerebral Micro-Arteriovenous Malformations: Review of 13 Cases: Willinsky R, Lasjaunias P, Comoy J, Pruvost P, TerBrugge K (Hopital Bicetre, Le Kremlin-Bicetre, France, 94270, and Univ. of Toronto, Toronto, Canada)

From the authors' series of 178 cerebral vascular malformations, 13 patients had arteriovenous malformations with a small nidus (less than 1 cm) or fistula, a single, pial normal-sized feeding artery and an early draining cortical vein. We call these micro-arteriovenous malformations (mAVMs). All 13 patients presented with an intracranial hematoma. Ten of the 13 patients had no previous symptoms related to the malformation. One patient had a previous bleed in the same location. In 11 patients the mAVM could be demonstrated angiographically; however, the hematoma represented a transient cause for the mAVM being occult in 2. In 2 patients, the malformations were only evident at surgery. All the mAVMs were superficial and 10 of the 13 were cortical. Since the nidus is small and the feeding artery and draining vein is normal-sized, mAVMs are by nature CT and MR occult. Nine of the 13 patients were treated surgically with no peri-operative morbidity. These malformations are not reachable by an endovascular approach. Patients presenting with mAVM constitute a remarkable subgroup within the cerebral arteriovenous malformations, with a favorable prognosis following surgery. Micro AVMs have previously been unrecognized due to poor quality studies or studies done in the presence of the hematoma. They likely represent part of the group of lesions previously called occult or cryptic.

Assessment of Steal Phenomenon by I-123 Iodoamphetamine SPECT Imaging in Patients with Intracranial AVMs:

Johnson M H, Winer J W, Rosenwasser, R H, Maurer A H, Brooks K M, Kenning J A, Liu T H, Richterman R L, Adler L P (Temple Univ. Hospital, Philadelphia, PA 19140)

Traditionally arteriography has been the primary imaging modality in patients with cerebral AVM. The perfusion of normal tissue or lack thereof is assessed poorly by angiography alone because of the inability to assess the microvasculature which provides the nutrient tissue perfusion. The phenomenon of "cerebral steal" refers to the reduction in tissue perfusion in normal brain adjacent to an AVM.

Ten patients with AVMs have been studied using I-123 Iodoamphetamine. These studies were correlated with angiography, CT and MR. Following surgical therapy in five cases, and in two cases post-embolization, evidence of increased perfusion in these areas was demonstrated. There was complete correlation between angiography and early IMP-SPECT in the diagnosis of steal. Steal was detected in 5/9 patients. Delayed IMP-SPECT was performed in 6 occasions and revealed improved activity in ischemic territories, as defined by early SPECT, confirming ischemia due to steal. In all 5 patients studies following embolization, surgery or both, improvement in the normal parenchymal perfusion was demonstrated.

An area of decreased parenchymal activity on early SPECT images beyond that which conforms to an anatomic lesion on CT or MR (AVM/clot), represents cerebral steal. This reduced activity may be adjacent to or distant from the lesion. Delayed SPECT images confirm this by demonstrating improved activity in these early ischemic areas. The demonstration of significant steal by SPECT in patients with cerebral AVMs is predictive of the reversibility of parenchymal ischemia post therapy. Prominent vascular steal may suggest the need for staging the AVM treatment to avoid capillary breakthrough, edema, and hemorrhage, which may be associated with normalization of perfusion in nutrient vessels subjected to chronic vasodilatation and secondarily impaired autoregulation. Serial early SPECT images following staged therapeutic procedures are a useful adjunct in following the reduction of steal post-embolization or post-surgery.

MR Pre- and Post-gamma Knife Radiosurgery of Intracranial Pathology: Kanal E, Lunsford LD, Latchaw RE, Wolf GL (Pittsburgh NMR Institute, Univ. of Pittsburgh, Department of Radiology, Pittsburgh, PA 15213)

Stereotactic "gamma knife" radiosurgery entails focusing 201 ^{60}Cobalt beams onto a specific, computer defined area. This enables a single treatment delivery of a very high dose of radiation to the target tissue while keeping the dosage to the adjacent parenchyma at relatively minimal levels. The temporal changes pursuant to such treatments are not clearly defined. To this end, 14 patients undergoing gamma knife radiosurgery of

varied intracranial pathology prospectively underwent MR examinations of the head within 24 hours preceding the procedure. This served as the baseline examination for comparative purposes. Subsequent to gamma knife radiosurgery 8 patients underwent a follow-up MR examination within 24 hours post-treatment. Additional follow-up scanning was performed out to 7 months in 2 of these patients. The remaining 6 patients underwent follow-up MR study from 4.5 - 8 months following their radiosurgery. The examinations demonstrated a relatively prolonged (weeks to months or greater) latency between gamma knife irradiation and the development of MR visible alteration in the signal intensity pattern of either the pathology itself or the surrounding, adjacent parenchymal structures. Studies utilizing Gadolinium-DTPA injections before and after gamma knife irradiation of the brain of a baboon confirm the delayed nature of the blood brain barrier breakdown which was evident at 6 weeks post-irradiation. MR and contrast-enhanced MR imaging may prove quite helpful in the investigation of the temporal changes associated with normal and pathologic tissues in patients undergoing gamma knife radiosurgery.

Tumor Versus Edema: Thallium-201 and SPECT Imaging in Comparison to MR in the Follow-up of Intracranial Gliomas: Boyko OB, Djang WT, Coleman RE, Burger PC, Schold SC, Friedman HS (Duke Univ., Durham, NC 27710)

In the follow-up of therapy for intracranial gliomas, distinguishing progression of tumor from vasogenic edema or radiation change can become a diagnostic dilemma. Recent reports have suggested that planar thallium-201 (Tl-201) imaging is superior to computed tomography (CT) in distinguishing tumor from edema because of a presumed preferential ability of the Na-ATPase cell membrane pump of glioma cells to localize intracellularly this potassium analog. To date we know of no studies comparing magnetic resonance imaging (MR) with single photon emission computed tomography (SPECT) and planar imaging of Tl-201 localization in gliomas.

Three patients underwent planar and SPECT Tl-201 imaging (3.0-5.2 mCI) of their biopsy proven gliomas [supratentorial (2) and brainstem (1)]. Their previous therapy included chemo- and/or radiotherapy. High field (1.5 Tesla) MR was performed using Tl (SE 500/20), intermediate (SE 2500/30,40) and T2 (SE 2500/70,80) weighted sequences. Follow-up MR in all three patients demonstrated extensive abnormal increased T2 signal from tumor and edema which were not distinguishable. Tl-201 localized to a significantly smaller area and was best demonstrated by SPECT. Autopsy correlation in one case (brainstem glioma) confirmed better delineation of tumor bulk by Tl-201 imaging than MR or CT. Areas of abnormal hyperintense T2 signal on MR where Tl-201 did not localize, pathologically showed vasogenic edema/radiation change.

In conclusion our preliminary results suggest the potential clinical adjunct utility of Tl-201 SPECT imaging in the follow-up of intracranial gliomas, specifically when a question arises of distinguishing tumor bulk from edema.

A Theory for Edema Development in Meningiomas Based on MR Observations of the Tumor-Brain Interface: Valavanis A, Wichmann W, Schubiger O (Univ. Hospital of Zurich, 8091 Zurich, Switzerland)

It is an accepted fact that edema in meningiomas is produced from intratumoral vessels and is localized in the white matter. Since meningiomas are extraaxial tumors, edema must pass through cortex in order to reach the white matter. In order to evaluate the role of cortex in edema development in meningiomas, we retrospectively analyzed the brain-tumor interface on Tl-weighted gadolinium enhanced and on T2-weighted, high-field MR images of 44 surgically proven cases of supratentorial meningiomas.

In 25 cases (57%), variable degrees of edema were present. In these cases the underlying cortex was highly compressed and either appeared as a very thin strip (5 cases) or was even invisible (20 cases). In 19 cases (43%), no edema was present. In these cases the underlying cortex was either of normal thickness (14 cases) or only slightly compressed (5 cases). 74% of meningiomas with edema were located over areas characterized by a primarily thin cortex (1.5-3 mm), while 64% of meningiomas without edema were located over areas characterized by a primarily thick cortex (3-4.5 mm).

It is concluded that an intact or an only slightly compressed cortex appear to represent a barrier against propagation of edema from the meningioma into the white matter while a highly compressed cortex appears to be the main promoting factor in edema development with meningiomas. Significant cortex compression and, therefore, peritumoral white matter edema will rather occur with meningiomas located over those brain areas which are normally characterized by a thin cortex. This MR theory further supports a CT based hypothesis on edema development in meningiomas formulated in 1983 by Stevens, et al.

Animal Trials With Gd-DO3A - A Nonionic MR Contrast Agent: Runge VM, Kaufman DM, Wood ML, Jacobson S, Tweedle MF, Wolpert SM (Tufts University-New England Medical Center Hospitals, Boston, MA 02111)

Gd-DO3A, a new nonionic IV contrast agent for MR , was evaluated and compared with the sodium salts of Gd-DTPA and Gd-DOTA in two experimental models.

T1 weighted images (TR/TE=.5/25) were acquired prior to and following contrast injection in 39 Fisher rats. Enhancement of renal cortex and medulla was evaluated in 15 animals with normal renal function following a dosage of 0.05 mmol/kg. A dosage of 0.25 mmol/kg was used for contrast enhancement in 24 animals studied with an intracerebral glioma. The brain tumor model was created by stereotactic implantation of gliosarcoma cells from tissue culture (250,000 cells in 5 microliters). These animals were studied upon development of neurological signs. This typically occurred 7-14 days following implantation and equated with tumor growth to a 5 mm. diameter. The MR studies were conducted with a specially designed saddle type coil using a 1.0 Tesla Siemens system. Contrast media were supplied by Squibb.

The enhancement of renal medulla with DO3A peaked by 19 minutes (105 ± 25%), compared with DTPA which peaked at 6 minutes (85 ± 23%). Enhancement of the intracerebral glioma was comparable with Gd-DTPA and Gd-DO3A (62 ± 29% vs. 59 ± 41%). Enhancement with Gd-DOTA was inferior in this model (32 ± 6%).

Enhancement with Gd-DO3A in this model of intracranial neoplastic disease was equivalent or superior to two previously described agents, Gd-DTPA and Gd-DOTA. Gd-DO3A is the first suitable nonionic paramagnetic metal ion chelate to be developed for use in MR . Because of its chemical structure, synthetic derivatives can also be developed with relative ease, unlike Gd-DTPA and Gd-DOTA.

Absence of Gd-DTPA Enhancement in Cerebral Gliomas: Correlation with Absence of Iodinated Contrast Material Enhancement on CT: Kuhn MJ, Mikulis DJ, Davis KR (Massachusetts General Hospital, Harvard Medical School, Boston, MA 02114)

Twelve patients with suspected cerebral gliomas were evaluated by intra-venous administration of iodinated contrast material (300 cc, Urovist meglumine) for computed tomography and Gd-DTPA (0.1 mmole/kg) for MR imaging. All patients subsequently underwent biopsy, confirming the presence of astrocytomas of various grades.

Six of the tumors demonstrated no contrast enhancement on CT. These lesions also failed to show any Gd-DTPA enhancement. The six gliomas that did show enhancement on CT also enhanced with Gd-DTPA on MR images.

Enhancement mechanisms of lesions by iodinated contrast and Gd-DTPA both depend on blood brain barrier disruption. The findings suggest that there is limited use for Gd-DTPA in MR imaging when a neoplasm has been shown not to enhance with iodinated contrast on CT. This may result in reduced costs and better time utilization.

Gadolinium-DTPA Enhanced MR Imaging of Meningeal Pathology at 1.5 Tesla: Kanal E, Kemp S, Latchaw RE, Wolf GL (Pittsburgh NMR Institute, Univ. of Pittsburgh, Department of Radiology, Pittsburgh, PA 15213)

Magnetic resonance imaging has allowed for marked advances in the diagnostic capabilities of the neuroradiologist for the evaluation of intracranial diseases by contrasting the effects

of differing T1, T2, and relative proton densities (RPD) of normal and pathologic tissues. Certain conditions exist, however, wherein the intrinsic tissue characteristics of the pathology are sufficiently similar to those of the background tissue that diagnostically sufficient contrast and accurate diagnoses may be virtually unattainable. Meningeal pathology, especially when diffuse or plaque-like in nature, is one such entity that is quite difficult to adequately examine with routine imaging methods. This is due to similarities between the T1, T2, and RPD values of CSF and those of the abnormal meningeal membranes, as well as the spatial characteristics of the meninges. With the natural affinity of Gadolinium-DTPA for the meningeal membranes, however, the resultant considerably shortened T1 allows for markedly increased contrast between the abnormal meningeal membranes and the surrounding non-enhancing CSF and/or brain parenchyma. We present four patients with meningeal pathology prospectively examined before and after intravenous administration of Gadolinium-DTPA. Neoplastic as well as inflammatory conditions were studied. All demonstrated markedly increased perceptibility of the meningeal disease in the examination performed after the contrast agent was administered. In most instances, the pathology was identified as foci of considerably increased relative signal intensity compared to cerebrospinal fluid or gray matter on short TR and TE spin echo images due to a decreased T1. Although of apparently low specificity, Gadolinium-DTPA seems to be an excellent contrast agent for increased sensitivity for meningeal pathology.

MR of CNS Lymphoma: Shapiro M, Sze G*, Charles J, Cross B, Chyatte D, Duberg A, Post, J**, Deck M* (Yale Univ. School of Medicine, New Haven, CT 06510; Cornell Univ. Medical School*; and Univ. of Miami Medical School**)

Twenty-three cases of documented CNS lymphoma (22 intracranial, 1 spinal) were reviewed for signal intensity on T1 and T2 WIs, location, and number of lesions per patient. In addition patient charts, CT scans, and histologies were also reviewed in order to evaluate the following: 1) Disparities between aids and non-aids patients; 2) Correlation between signal intensity and cell type; and, 3) If MR was superior to CT in sensitivity and/or specificity.

The results of the study were: 1) 17 of 20 biopsied lesions were hypo or isointense on T2 WIs compared to grey matter, and three were hyperintense; (Three of the 23 patients were not included because excessive blood from the biopsy precluded interpretation of initial signal intensity). All lesions were hypo or isointense on T1 WIs. 2) Patients with aids are more likely than non-aids to have multiple foci. In the supratentorial region basal ganglia, periventricular region, and frontal lobes were the favored sites. In the infratentorial compartment the cerebellar lesions predominated (4 hemispheric, 1 vermian). Fifteen patients had a single focus while 8 had 2 or more lesions. Five cases were extra-axial. MR was superior to CT in both sensitivity and specificity.

In intraparenchymal lesions which are iso or hypointense on T2 weighted images, lymphoma should be a primary diagnostic consideration. Lymphoma should also be considered in the differential diagnosis of extra-axial lesions which on T2 WIs, are iso or hypointense to grey matter.

In one case angiography could not differentiate between extra-axial lymphoma and meningoma.

MR of Metastatic Adenocarcinoma to the Brain: Hinshaw DB, Leon JM, Peckham N, Hasso AN, Thompson JR, Holshouser BA (Loma Linda Univ., Loma Linda, CA 92354)

A retrospective study was conducted to evaluate the MR appearance of metastatic adenocarcinoma of the brain. The patients were examined with either 0.5T or 1.0T MR systems using T-1, spin density and T-2 weighted sequences. Ten patients with pathologically confirmed metastatic adenocarcinoma of the brain were examined with MR . Two additional patients with documented primary adenocarcinomas elsewhere in the body and apparent metastatic adenocarcinoma to the brain without pathologic confirmation were also studied with MR . All of these tumors showed characteristic findings of intermediate intensity with T-1 weighted images and decreasing signal with greater T-2 weighting (ie. T-2 shortening). These findings indicate an element of magnetic susceptibility in the tumor bed. This may be related to small hemorrhagic areas with hemosiderin deposits as was confirmed with pathologic examination using iron stains.

High Resolution 3DFT Imaging of the Pituitary Gland: Schwartzberg DG, Brummer ME, Davis PC, Hoffman JC (Emory Univ. Sch. of Med., Atlanta, Georgia 30322)

Although MR is useful for evaluating large pituitary adenomas (PA), small PA are frequently missed with current imaging techniques. For such small lesions, three-dimensional Fourier Transform (3DFT) has theoretical advantages over the standard 2DFT technique, including uniformly very thin slices, absence of interslice gap or "cross-talk", and increased phase angle uniformity. Magnification images obtainable with small field of view (FOV) should also allow better PA detection. Consequently we have applied magnification 3DFT in the evaluation of the pituitary gland.

Images were acquired on a Philips 1.5 T scanner with 10 mT/m gradients and standard head coil. Using a 3DFT sequence (TR 600-700, TE 30, FOV 150, matrix 256^2 with 80% acquisition, N=2), 9-10 1.1 mm slices were generated with a total imaging time of less than 40 min. The resultant pixels were linearly interpolated to cubic 0.6 mm elements and reformatted in sagittal and coronal planes. These images were compared to our standard 2DFT protocol (TR 500, TE 20, FOV 200, matrix 256^2 with 100% acquisition, N=6) which required 13 min.

A total of 18 volunteers and patients with PA were studied. A phantom was used to compare techniques using identical TR, TE, FOV and imaging time per slice. As compared to standard 2DFT technique, high resolution 3DFT technique better demonstrates normal pituitary anatomy, has improved tissue contrast, and offers improved detectability and definition of PA, and phantom structure. Reformatting offers additional useful information without any increase in imaging time. Work is currently underway to determine the sensitivity of 3DFT in the detection of PA.

Gadolinium-DTPA MR Imaging of the Pituitary: Newton DR, Dillon WP, Norman D, Newton TH, Wilson CB (Univ. of California, San Francisco, San Francisco, CA 94143)

Eleven patients with suspected pituitary microadenomas were scanned on a 1.5 T Signa system prior to and following administration of I.V. Gadolinium-DTPA (0.1mmol/kg). Eight of these patients had Cushing's disease, 5 had hyperprolactinemia and 1 had acromegaly. Surgical confirmation was available in all cases. Results were correlated with results of CT and venous sampling when available. The normal pituitary gland, infundibulum and cavernous sinuses enhance immediately after the administration of Gadolinium-DTPA, allowing contrast between the enhancing normal glandular tissue and low intensity microadenomas. In 5 patients, contrast-enhanced MR detected a lesion not seen on the unenhanced images. Tumor delineation was improved with Gadolinium administration in 2 additional cases. In 4 patients, administration of Gadolinium did not significantly alter the pre-contrast interpretation. Tumor localization was accurate in 6 and incorrect in 1 of the patients in whom adenomas were found at surgery. Exploratory surgery was negative in one patient with a suspected lesion, but subsequent venous sampling correlated with the MR findings. In 2 patients with focal lesions suspected on MR, no adenoma was found but the anterior lobe showed histologic evidence of hyperplasia and/or inflammation. Delayed scans did not improve the differentiation of pituitary gland from microadenoma. Gadolinium-enhanced MR of the sella is helpful in evaluating patients with suspected microadenomas in whom noncontrast studies are not definitive. The diagnostic accuracy may improve in the future by the use of faster scanning techniques to maximize the immediate post-contrast interface between normal gland and tumor.

Correlation of MR Signal Intensity, Surgical Findings and Pathologic Features of Large Pituitary Adenomas: Differentiation of Soft Cellular and Firm Fibrotic Tumors. Johnson CE, Snow RB, Morgello S, Zimmerman RD, Lavyne MH, Deck MDF. (The New York Hospital-Cornell Univ Medical Center, New York, NY 10021)

The MR signal intensity of pituitary adenomas with suprasellar extension was correlated with tumor consistency found at surgery and degree of fibrosis found on histologic exam in 34 cases. MR of the sella was performed at .6T(21 cases) or 1.5T(13 cases) using

both short and long TR sequences. Tumors were surgically classified as soft(easily removed by suction or curettage) or firm(resectable only be laser or sharp dissection). MR signal intensity predicted tumor consistency with a high degree of accuracy. The 26 adenomas which were hyperintense to white matter on long TR images were found to be soft tumors at surgery. In 8 cases, the tumors were isointense to white matter. Seven of these were found to be firm. In the one instance in which an isointense tumor was found to be soft, a fine calcium matrix was present which readily collapsed with suction. Histologic examination without knowledge of MR or operative findings demonstrated that the 26 hyperintense soft tumors had fibrosis that was insignificant in 13 cases, mild in 10, and marked in 2. One contained large amounts of collagen. Of the 7 firm(isointense) tumors, the amount of fibrosis was insignificant in 1, mild in 3, and marked in 3. Imperfect correlation between the tumor consistency and amount of fibrosis found on histologic exam may be related to sampling error with overestimation of the degree of fibrosis, since the surgical specimens represented only portions of the pituitary masses. Since firm or fibrous tumors may be difficult to remove without direct surgical visualization, evaluation with MR may help in determining if a large pituitary adenoma can be resected via a transphenoidal approach or whether a craniotomy will be necessary.

Hypothalamic Bright Signal: Manifestation of Posterior Pituitary Regeneration: El Gammal TA, Brooks BS, Hoffman WH (Medical College of Georgia, Augusta, GA 30912)

An ectopic location of the posterior pituitary bright signal was observed in 7 cases out of 1500 cranial MR studies. These included two cases where the bright signal was noted in the developmental abnormality of a sellar fossa, one where the bright signal was seen in the median eminence of the hypothalamus, one in relation to the superior surface of the pituitary gland, and three where the bright signal was in the middle of the pituitary gland.

In 13 other pathologic cases with sellar and/or parasellar tumors, an aberrant location of the bright signal was found in the hypothalamus in 7 and in relation to the infundibulum in 6. Five of these were MR studies of non-operated patients with pituitary adenomas producing compression and/or destruction of the posterior lobe. In the other 8, the aberrant bright signal occurred after hypophysectomy in 7 and after removal of a craniopharyngioma in the eighth.

Accumulation of neurosecretory material and regeneration of pituitary tissue in these locations has been documented previously in animal experiments and in a few reports in humans after hypophysectomy. MR now provides further corroborative evidence in vivo of this process of formation of a "miniature posterior lobe".

Absence of the Posterior Pituitary "Bright Spot": Possible Associated Extra- and Intrasellar Causes and Its Correlation with Diabetes Insipidus: Boyko OB, Curnes JT, Heinz ER, Djang WT, Burger PC (Duke University, Durham, NC 27710)

It has been established that on T1 weighted magnetic resonance imaging (MR) the posterior lobe of the pituitary can have a high signal intensity. Although some authors have implied that the absence of this "bright spot" indicates a disturbance in the hypothalamohypophyseal tract, others have suggested that its absence can be a normal variation or associated with sellar pathology but not have any association with diabetes insipidus (DI).

We retrospectively reviewed the clinical information and sagittal T1 (SE 500/20) weighted images (1.5 Tesla) of 50 patients with absence of the posterior pituitary "bright spot." The age of the patients ranged from 1 to 70 years. Four patients (8%) had documented hormonal dysfunction. One patient had a selective growth hormone disturbance. Three pediatric patients (6%) had associated (DI) and in two (4%) the DI was idiopathic and acute. The third patient was on ADH replacement therapy and had a past history of cranial irradiation for Histiocytosis X.

Eight other patients in this series also had a history of cranial irradiation as well as chemotherapy. Autopsy findings in one patient who had "lost" the "bright spot" on a follow-up MR, without developing DI, showed no fibrosis of the gland. The patient had received radio- and chemotherapy for a brainstem glioma. Sellar changes associated with the absence of the "bright spot" included pituitary neoplasm (11), empty sella (5), clival metastasis (1) and 30 patients without any sellar changes (normal variation [27], SIADH [1], other [2]).

We conclude that the absence of the posterior pituitary "bright spot" can be associated with DI but is not diagnostic for DI. The posterior pituitary bright spot absence can be associated with intrasellar causes as well as a wide variety of extrasellar processes including suprasellar and clival masses, as well as possibly radiation/chemotherapy.

The Role of Clot Formation in MR of Blood: Hayman, LA, Taber KH, McCardle C, Kirkpatrick JB, Bryan RN (Baylor College of Medicine, Houston, TX 77030)

The decrease in signal as compared to brain on magnetic resonance (MR) in acute intracerebral hemorrhage has been attributed by Gomori, et al., to the state of the hemoglobin in red blood cells. This paper presents a series of in vitro experiments which demonstrate that the formation of a mature retracted clot matrix (and the secondary rise in hematocrit this creates) are factors which can cause this MR appearance. MR images of retracted clots which do not contain red blood cells at 0.3, 0.5, 1.0, 1.5 and 2.4T were isointense or hypointense compared to brain. NMR spectroscopic measurements of T2 at .23 and 4.7T were done on deoxygenated blood samples (43%-73% O_2 saturation) with hematocrits (Hct) of 18-100%. Increasing the Hct produced a marked reduction in T2 at both field strengths. Cell lysis moderated but did not abolish the T2 effect at either field strength. The authors conclude that both the formation of the retracted clot and the increase in hemoglobin concentration which occurs are factors which contribute to the hypointense signal of acute blood on T2 weighted clinical scans. These factors are particularly important on low field strength (.4-.6T) systems which theoretically are only one ninth as sensitive to the T2 shortening effects of paramagnetic intracellular deoxyhemoglobin.

This data has 2 important implications. First, T2-weighted scans may be a useful tool for noninvasive monitoring of the clotting process. This information may have prognostic value in the clinical setting. The data also indicates that blood may not be specifically identified by T2 weighted spin echo MR if the scans are done while unclotted blood is accumulating or if fibrinolytic enzymes in CSF and/or dura rapidly lyse the blood clot. In addition, diseases or medications which prevent retracted clot formation may interfere with the specificity of MR in detecting acute hemorrhage.

Quantitation of Intracellular Methemoglobin: Hayman LA, Taber KH, Ford JJ, Miglorie P, McLaurin T, Bryan RN (Baylor College of Medicine, Houston, TX 77030)

Spin echo T1 and spin density (SD) weighted images were done to compare clotted and heparinized (Hct 45 and 90-100%) whole blood with and without methemoglobin at 4 field strengths (0.3, 0.5, 0.1, 1.5 Tesla). There were no significant SD changes. On T1 weighted images only the methemoglobin samples were markedly hyperintense compared to the rat brain. The authors conclude that the hyperintense signal identified on T1 weighted scans of acute hematomas (0-7 days) represents the accumulation of intracellular methemoglobin. It is not a "pseudodensity" caused by changes in SD (Radiology 1987, 165:199-202).

The rate of methemoglobin formation in vitro is too low to account the hyperintense T1 signal reported in clinical hematomas at 15-24 hours. (AJNR 1988, 9:47-57). Serial measurements of normal whole blood (anaerobic conditions at 37°C) resulted in a change of only .05%/hr for heparinized samples and .25%/hr for samples stored in EDTA. However, blood injected into cat brain, which subsequently became ischemic, is acutely hyperintense to brain on 3 hour old T1 weighted scans at 1.5T. Hence, the presence of intracellular methemoglobin appears to be related to the biochemistry of the surrounding tissues. The isointense T1 signal at 24-49 hours in clinical cases would then be due to the rapid clearance of intracellular methemoglobin. Serial measurements of normal whole blood with 100% concentrations of methemoglobin (anaerobic conditions at 37°C) indicate that complete clearance of this

maximal level could occur in 24-36 hours (rate constant=0.0698±0.0001/hr). The reappearance of T1 signal intensity at the rim of clinical hematomas at 3-7 days does not indicate the presence of extracellular hemoglobin from cell lysis (Mag Res Ann 1987, 79) because red cell lysis occurs centrally in hematomas at 15 days (Am J Path 1988, 130(1):44-58).

The MR Appearance of Subdural Hematomas and Hygromas: Fobben ES, Grossman RI, Hackney DB, Goldberg HI, Zimmerman RA, Bilaniuk LT. (Univ of Pennsylvania, Philadelphia, PA 19104)

Twenty-five patients with known subdural collections on MR were retrospectively reviewed to appreciate the spectrum of MR findings associated with such lesions. The lesions were dated by history and CT when available. Hematomas were grouped according to MR intensity changes described by Gomori et. al. as follows: acute 3, early subacute 3, late subacute 7 and chronic 7. There were 3 cases of chronic SDH and rebleeding with multiple phases of hemorrhage and 2 cases of acute CSF subdural hygromas. Serial MR was available in 7 cases. Chemical analysis confirmed the presence of methemoglobin in 3 cases of subacute SDH.

Subdural hematomas evolved in a pattern similar to intracerebral hemmorrhage with the exception of chronic hematomas where isointensity to gray matter was observed on short TR/TE images, in contrast to the persistant very high signal intensity present in chronic parenchymal hematomas. It can be speculated from our serial MR images that this signal intensity is secondary to dilution and absorption of free methemoglobin. Hemosiderin was rarely seen in simple chronic hematomas. Both of these findings are most likely the result of the absence of a blood-brain barrier permitting clearance and dilution of blood products.

SDH with rebleed demonstrated loculations, hemosiderin deposition, dilutional effects and layering phenomenon. The presence of hemosiderin in these cases may be due to bleeding occuring at a faster rate than clearance and/or deposition of hemosiderin on internal loculations. The persistance of high signal from methemoglobin in a hematoma that is expected to be in the chronic phase also suggests rebleeding.

Two cases of acute pure CSF subdural hygromas had signal intensities identical to CSF without evidence of blood products. At surgery clear fluid under pressure was found. An arachnoid tear is the presumed etiology.

MR provides excellent characterization of subdural hematomas and hygromas. SDH differ from parenchymal hematomas in the chronic phase where there is clearance and dilution of methemoglobin and hemosiderin. Rebleeding can also be more accurately evaluated and followed.

The Effect of Hemoglobin Oxygenation on the MR Intensity of Experimentally Produced Intracerebral Hematomas at 0.6T and 1.5T: Weingarten K, Zimmerman RD, Markisz J, Cahill P, Sze G, Deck MDF (New York Hospital-Cornell Medical Center, New York, NY 10021)

The complex intensity changes known to occur in acute (<1 week) intracerebral hematomas(AIH) are dependent on multiple parameters. This study was undertaken to determine the effect of hemoglobin oxygenation on the in vivo appearance of AIH. Autologous blood was injected into 7 dog brains, using venous blood in 4 and arterial blood in 3. Serial MR scans were performed during the initial week at 0.6T and 1.5T using spin echo(SE) short TR/short TE, long TR/long TE, and long TR/multiecho TE and gradient echo(GE) sequences.

On long TR SE scans, hypointensity developed more rapidly at 1.5T than at 0.6T, regardless of the source of hemorrhage. In venous hematomas, maximum hypointensity was seen before 12 hours at 1.5T and between 24-48 hours at 0.6T. In arterial hematomas, the development of maximum hypointensity was delayed, appearing after 24 hours at both field strengths. By contrast, hyperintensity on short TR SE scans(T1 shortening) appeared simultaneously at both field strengths and was seen earlier in arterial and intraventricular hemorrhage than in venous hemorrhage. These phenomena are probably due to differences in deoxyhemoglobin concentration and rate of formation of methemoglobin. Of note is that gradient echo sequences at both field strengths and both sources of hemorrhage demonstrated hypointensity at all times, suggesting that this appearance is not dependent on deoxyhemoglobin concentration.

The MR Evaluation of Pachygyria and Associated Syndromes: Byrd SE, Osborn RE, Radkowski MA, McArdle CB, Prenger EC (Children's Memorial Hospital, Chicago, IL 60614)

Pachygyria refers to a cerebral cortex with too few gyri which are thickened, coarse and broad based. It is a congenital malformation of the brain and is typically associated with the lissencephalic syndromes (patients with brains composed of areas of agyria and pachygyria). However, pachygyria can occur as a separate entity or in combination with other pathological states besides lissencephaly. We studied 30 patients with some form of pachygyria with magnetic resonance (MR) imaging. Our patients ranged in age from newborn to 17 years with equal sex distribution. They presented with a variety of symptoms, the most common of which were seizures, delayed development, focal neurologic deficits, failure to thrive and severe mental retardation. The pachygyria was seen most commonly with (1) lissencephaly (2) as an isolated form and (3) in combination with dysmorphic facial syndromes especially with a variant form of the Miller-Dieker syndrome. We will emphasize (1) the MR findings of pachygyria which consists of thickened, coarse, broad based gyri with an increased in gray matter and abnormal smooth gray-white matter interface (2) the syndromes associated with isolated pachygyria and dysmorphic facies and (3) the differentiation of pachygyria from migrational disorders caused by cytomegalic virus and toxoplasmosis in which the MR findings simulate pachygyria but in actuality are due to polymicrogyria.

The Clinical Significance of Hindbrain Herniation and Deformity as Shown on MR in Patients With Chiari II Malformation: Wolpert SM, Scott RM, Platenberg RC, Runge VM (New England Medical Center Hospital, Boston, MA 02111)

The purpose of this study was to investigate whether the degree of brainstem herniation and the nature of the cervico-medullary deformity seen on sagittal plane MR correlates with the clinical syndrome in patients with the Chiari II malformation. Thirty-eight patients with the malformation were studied with a 1 T magnet. The amount of brainstem herniation was assessed by relating the position of the midbrain and pons to the sella turcica and the anterior lip of the foramen magnum respectively. The cervico-medullary deformity was graded into degrees of increasing severity. We found that the neurologic status of these children was not affected by either the amount of herniation nor by the characteristics of the cervico-medullary deformities. We concluded and confirmed the impression of others that other factors such as disorganization of the brainstem nuclei are probably the likely cause for the breathing and swallowing difficulties experienced by children with the Chiari II malformation.

Imaging of Posterior Fossa Cystic Malformations: Pre- and Post- Shunting: Gusnard DA, Bilaniuk LT, Zimmerman RA, Sutton LN, Hackney DB, Goldberg HI, Grossman RI, Atlas SW, Schut L (Univ. of Pennsylvania, Philadelphia, PA 19104)

Cystic malformations of the posterior fossa represent a most interesting and challenging group of lesions. Characterization of these anomalies can be very difficult and yet it is important for it can influence management (whether to shunt or not) and can indicate prognosis. Retrospective review of 14 cases of posterior fossa cystic malformations, both before (14 CT and 1 MR study) and after shunting procedures (5 CT and 9 MR studies), reveals that MR offers a major advantage over CT by providing a more precise delineation of not only the spectrum of infratentorial abnormalities related to the cyst, but also associated supratentorial abnormalities. In addition to identification of arachnoid cysts, true Dandy Walker cysts, and Dandy Walker variants, cysts were demonstrated that communicated with the fourth ventricle superiorly by thin clefts. In those patients with good response to shunting, follow-up revealed cerebellar hemispheres of normal size. In contrast, in those that had extensive parenchymal abnormalities, there was lack of significant response indicating true cerebellar dysgenesis. Another factor that influenced response to shunting was the age of the patient at the time of shunting. Correlation of the imaging results with clinical course demonstrated a relationship between poor outcome and presence of supratentorial abnormality rather than with type of infratentorial abnormality. In summary, MR has demonstrated value in evaluation of patients with posterior fossa cystic malformations.

New Concepts in Posterior Fossa Cysts in Children: Barkovich AJ, Kjos BO, Edwards MSB, Norman D (Univ. of California, San Francisco, San Francisco, CA 94143)

MR and clinical data on 29 patients with posterior fossa CSF collections were analyzed. A clear separation of these patients into classical categories was not possible because of new information obtained from the MR images. We present a new classification of these disorders. The Dandy-Walker malformation, Dandy-Walker variant, and mega cisterna magna seem to represent a continuum of developmental anomalies of the posterior fossa. It is suggested that these terms be abandoned and replaced by the term Type I posterior fossa cystic disorders. A possible embryologic basis for this continuum is suggested. Discrete posterior fossa CSF collections that are clearly separate from the fourth ventricle and vallecula are classified as Type II disorders. Posterior fossa CSF collections that communicate with the fourth ventricle and are associated with cerebellar atrophy are classified as Type III disorders. Both Type I and Type II disorders can cause enlargement of the posterior fossa and scalloping of the inner table of the occipital bone. Type I disorders present with seizures, developmental delay and enlarging head size; they require CSF diversion when associated with hydrocephalus. Type II disorders present with symptoms of a posterior fossa mass; they generally require surgical resection. Type III disorders are a result of degenerative disorders and require no surgical therapy. This new classification facilitates both diagnosis and therapy of these disorders.

Tectal Key to Aqueductal Pathology: Barkovich AJ, Norman D (Univ. of California, San Francisco, San Francisco, CA 94143)

Magnetic resonance scans of 21 patients with non-tumoral aqueductal stenosis and 6 patients with neoplastic stenosis of the aqueduct were reviewed. One patient had an aqueductal web. The results indicate that stenosis beginning at the level of the superior colliculi is usually a consequence of pre-existing hydrocephalus rather than a cause of hydrocephalus. Stenosis beginning at the level of the intercollicular sulcus is most commonly a cause of hydrocephalus. The mesencephalic tectum is often distorted in patients with benign aqueductal narrowing. This distortion results in a number of different MR appearances ranging from an elongated and thin to a short and broad tectum. When compressed by a dilated suprapineal recess, the distorted tectum is sometimes difficult to differentiate from the bulbous enlargement caused by a tectal glioma. It is important to recognize the patient in whom this distortion is the result of hydrocephalus and aqueductal stenosis in order to avoid unnecessary diagnostic procedures, and/or error in diagnosis.

Multiple Sclerosis in Adolescents: High Resolution CT and MR Findings: Osborn AG, Harnsberger HR, Smoker WRKS, Boyer RS (Univ. of Utah, Salt Lake City, UT 84132)

Multiple sclerosis (MS) is a rare disorder in children and adolescents, accounting for less than 1% of all cases. Vague symptoms and erratic clinical course of the disease make establishing a definitive diagnosis difficult. Scattered case reports have appeared in the literature but no series has delineated the findings on high resolution CT and MR. We describe the imaging spectrum derived from a series of 10 documented cases.

All ten patients were female; mean onset of symptoms was 16.3 years with the first MR scans obtained at an average of nearly 3 years after symptom onset. Only two patients had a clinical diagnosis of MS prior to MR imaging. Four patients cord scans with single or multiple foci of intramedullary increased signal; MR brain scans were normal in 3 of 4. Seven of the ten cases with brain scans had severe disease with multiple confluent periventricular, cerebellar, and brainstem plaques seen as hyperintense foci on T2WI. Lesions were iso- or hypodense on NECT and showed varying degrees of contrast enhancement.

Differences between MS in adults and adolescents in our series are: 1)Even more striking female predominance; 2)all had severe disease; 3)all had brainstem/cerebellar disease vs. 15-33% in adults; 4)cortical and/or white matter atrophy was uncommon in adolescents. Similarities include lack of correlation between severity of symptoms and disease extent or location on MR as well as increased sensitivity of MR compared to CT in both age groups.

Xenon-CT Cerebral Blood Flow Evaluation of Ischemic Disease of the Brain in Children and Young Adults: Stringer WA, Hasso AN, Thompson JR, Hinshaw DB Jr, Vu LH (Loma Linda Univ. School of Medicine, Loma Linda, CA 92354)

We retrospectively reviewed our experience with Xenon-CT cerebral blood flow (CBF) evaluation in seventeen children and young adults presenting with symptoms of cerebral ischemia. A total of twenty-four Xenon-CT CBF studies were performed in these patients. In twelve studies, Xenon-CT flow maps showed more extensive evidence of ischemic disease than the baseline non-contrast conventional CT images obtained simultaneously. In twelve studies, the baseline and flow images were equivalent. Comparison with a complete conventional CT examination with contrast was available in thirteen cases. Xenon-CT CBF showed more extensive evidence of ischemic disease than conventional CT in six cases and less extensive disease in one. The studies were equivalent in six cases. Comparison with complete conventional CT without contrast was available in fifteen cases. Xenon-CT CBF showed more extensive disease in seven cases, and in the remaining eight cases the studies were equivalent. Comparison with MRI was available in eleven cases. Xenon-CT CBF showed more extensive disease in five patients and less extensive disease in two. The studies were equivalent in four patients. Overall, in comparison to either a complete conventional CT study or baseline images obtained during Xenon-CT examination, Xenon-CT flow maps provided superior delineation of the extent of ischemic cerebral disease in fourteen of seventeen patients. Complete conventional CT proved superior in one. We conclude that Xenon-CT more reliably shows the extent of cerebral ischemia in this patient population than conventional CT and appears to be complimentary to MR .

MELAS Syndrome, Multiple Recurrent Strokes in Children with Diagnostic Muscle Mitochondrial Findings: Haas DK, Chuang S, Harwood-Nash D, Barkovich J, Becker L, Laidley J, Coates R (Department of Radiology, Fitzsimons Army Medical Center, Aurora, CO 80045-5001 and Hospital for Sick Children, Toronto, Ontario, Canada)

Three pediatric patients with mitochondrial myopathy, encephalopathy, lactic acidosis and recurrent cerebral insults that resemble strokes (MELAS) were imaged with computed tomography. Examination demonstrated low density lesions consistent with stroke in all three patients without any demonstrable etiology. The patients experienced recurrent stroke-like symptoms and low density lesions on CT. All patients had normal early development, seizures and alternating hemiparesis. MELAS represents a distinctive syndrome, and is possibly transmitted by maternal inheritance. The key to diagnosis depends on the clinical, radiographic, and laboratory findings. These include lactic acidosis and ragged red fibers evident on muscle biopsy.

Primary Meningeal Tumors in Children (CT Findings): Hope A, Armstrong D, Chuang H, Babyn P, Harwood-Nash D. (Hospital for Sick Children, Univ. of Toronto, Toronto, Canada)

Primary meningeal tumors are rare in children. We retrospectively reviewed skull radiographs and CT findings in 19 pathologically proven cases consisting of 2 bilateral optic sheath meningiomas, and 17 intracranial tumors including 10 meningiomas, 4 sarcomas, 2 leptomeningeal melanomas and 1 primitive neuro-ectodermal tumor.

Intracranial meningiomas (10) showed features similar to those seen in adults: a hyperdense or isodense mass, homogenous enhancement with well defined margins and variable amounts of edema, calcification and hyperostosis. The 2 malignant meningiomas were indistinguishable on CT from benign meningiomas ; both, however, showed evidence of raised intracranial pressure on skull radiograph, not seen in the benign tumors.

The 4 meningeal sarcomas were distinguishable from meningiomas by clinical and CT features, pre-

senting at an earlier age (2 vs. 13 yrs. average) with shorter symptom duration and presence of a palpable mass in two. CT showed bone lysis in 3, heterogenous enhancement in 3, and cyst formation in 2.

Compared to adults, children show a male predominance (14:5), and a higher incidence of: malignancy (9/19), non-dural origin (2/19), diffuse lesions (2/19) and a wider histologic variety.

MR and CT of Primary CNS Neuroblastoma: Davis PC, Wichman RD, Takei Y, Hoffman JC (Emory Univ. Sch. of Med., Atlanta, GA 30322)

Primary cerebral neuroblastoma is an uncommon neoplasia which has typically been described as a large intraparenchymal supratentorial mass with cysts, calcification, and hemorrhage in children. The MR appearance is largely unknown.

This report describes initial and follow-up experience in 13 patients (aged 15 days - 52 years) with proven primary cerebral neuroblastoma.

Seven had typical large supratentorial masses with cysts in 6, calcifications in 2, and spontaneous hemorrhage in 3. Mass effect with little associated edema was characteristic.

Six had peri or intraventricular masses. Of these, 4 contained calcifications and none hemorrhaged spontaneously.

Follow-up ranged from 2 days - 8 years (mean 2 9/12 years). Five patients are deceased, 7 are living with residual or recurrent tumor, and 5 patients developed subarachnoid seeding by cytology and/or myelography.

CT was superior to MR for detection of calcification, neoplasia at surgical sites and around cysts, and subarachnoid seeding. Multiplanar MR aided localization of intraventricular lesions.

This lesion is more variable in presentation, location, and appearance than previously described. At present, CT is preferable to MR for evaluation of these lesions, although Gadolinium may alter the role of MR for imaging of neuroblastoma.

Tumefactive Fibroinflammatory Disease: Curran JG, Williams JP, Rettig KR, Iyer R, Cooper SD, Weissmann J (Univ. of So. Alabama, Mobile, AL 36617)

Isolated forms of fibrosclerosing disease involving the Orbits, Thyroid, Mediastinum, and Retroperitoneum are well described. Less well known are instances of multifocal involvement.

We describe the case of a seven year old girl, who presented with abnormal growth velocity, bilateral proptosis and a left sixth nerve palsy. Laboratory investigations indicated abnormal Growth Hormone regulation and Diabetes Insipidus. Radiological work-up showed delayed bone age, left hydronephrosis, and abnormality of the orbits on CT scan. MR demonstrated abnormal soft tissue in the superior orbits bilaterally, enlargement of the pituitary stalk, a mass in the pineal region, and a left infra-renal, retroperitoneal soft tissue infiltration. High signal white matter abnormality was demonstrated bilaterally in the cerebellar hemispheres.

Histology revealed a diffuse fibroblastic proliferation, with an inflammatory cell infiltrate. Following death from steroid-related side effects, confirmation of histological involvement at the various sites was obtained.

This case of a rare multifocal condition demonstrates the value of MR in identifying all of the involved sites, even though the disease may, as in this case, appear to be solely confined to the head. Of the various names given in the literature to this condition, we have elected to use the term " Tumefactive Fibroinflammatory Disease ".

Primitive Neuroectodermal Tumor in a 55 Year Old Female: Artiles C, Bronen R, Lidov M, Hufnagel TJ, Piepmier J (Yale Univ. School of Medicine, New Haven, CT 06510)

A 55 year old female presented with a three-week history of headaches, seizures and right-sided weakness. Physical exam demonstrated a left third nerve palsy and a mild right hemiparesis.

CT revealed a densely enhancing suprasellar mass with possible involvement of the left temporal lobe. MRI showed an unusual mass extensively involving the temporal lobe with a large exophytic component. Angiography demonstrated a mild tumor blush and no supply from the external circulation. Subtotal resection was performed and the histology was typical of a primitive neuroectodermal tumor (PNET). Following treatment with radiation to the entire neuroaxis and chemotherapy, the patient has done well.

PNET is a highly malignant, rare neoplasm of childhood and young adulthood. Past the third decade of life only two other cases have been reported. The actual number is certainly higher, however, since there has been difficulty in classifying this tumor, which is histologically similar to the more common extracranial neuroblastoma. Despite this, even if we include cases previously classified as cerebral neuroblastoma, very few cases have been reported in adulthood.

The CT findings of PNET's have been well-described. The tumor presents as a large mass, most often involving the frontal and temporal lobes, with coarse calcification occurring in about half of the cases. There is usually relatively little edema and 10% demonstrate intratumoral hemmorhage. All cases show enchancement, which may be solid, inhomogeneous or ringlike.

In addition to the extreme rarity of this lesion in adults, our case is interesting in that on CT it mimicked an extraaxial lesion, such as meningioma. MR , however, defined the lesion much better and demonstrated a large intraparenchymal component not seen on CT.

An Unusual Supraclinoid Carotid-Cavernous Sinus Fistula: Pelz DM, Deveikis JP, Fox AJ, Lee DH (Univ. of Western Ontario, London, Ontario, Canada N6A 5A5)

A 23 year old male was involved in an MVA four years prior to this hospitalization. Shortly afterwards he noticed the onset of a right retroorbital bruit with mild right proptosis. The diagnosis of carotid-cavernous fistula was not made until several weeks prior to referral for balloon occlusion.

Cerebral angiography with compression studies demonstrated a large right carotid-cavernous fistula. The origin was initially difficult to visualize and after various manoeuvers it was finally found to originate from the supraclinoid internal carotid artery near the posterior communicating artery. Attempts to embolize the lesion using detachable balloons and the Tracker catheter were unsuccessful. A subsequent MRI demonstrated the fistula between the supraclinoid internal carotid artery and the superior cavernous sinus, surrounded by CSF. The fistula was easily clipped at surgery.

To our knowledge only one untreated case of supraclinoid carotid cavernous fistula has been previously noted. MR was invaluable to verify the subarachnoid location of this fistula which made surgical treatment feasible.

Pitfalls in the Diagnosis of Deep Cerebral Vein Thrombosis: A Case Report of Misleading MR Findings: Deveikis JP, Lavenstein B, Schellinger D, Patronas NJ (Georgetown Univ. Hospital, Washington, DC 20007)

After a prodromal viral illness, this 12 month old girl developed lethargy, irritability, and the inability to sit unsupported. On examination she was febrile, showed little spontaneous movement, and appeared to have a left hemiplegia. Computed tomography (CT) showed bilateral thalamic hypodensities, somewhat larger on the right, as well as very dense thalamostriate and internal cerebral veins, vein of Galen, and straight sinus, with no significant contrast enhancement of the thalamic lesions or of the above-mentioned venous structures. On the basis of the CT findings, the diagnosis of deep cerebral venous thrombosis with bilateral thalamic infarcts was made. Magnetic resonance imaging (MR) was then performed to confirm the diagnosis. This again showed the thalamic

infarcts, but the deep venous system appeared to be patent, with signal void in these structures. To resolve the diagnostic dilemma, cerebral angiography was performed and confirmed the diagnosis of deep cerebral vein thrombosis.

Prior reports have shown that MR is quite useful in the diagnosis of cerebral vein occlusion. However, care must be taken in the choice of imaging sequences and in the interpretation of the images obtained, since low signal in vessels on long TR sequences does not necessarily indicate patency of that vessel. This case illustrates that there continues to be a role for CT and angiography in diagnosing this disorder.

Intravascular Balloon Embolization of a Large Basilar Tip Aneurysm: Campos J, Antones JL (Hospital Santa Maria, University of Lisboa, Lisboa, Portugal)

46 year old man presented with a subarachnoid hemorrhage. Four vessel cerebral angiography confirmed the presence of a large basilar tip aneurysm, 20 mm in diameter. A craniotomy was done but it was not possible to clip the aneurysm. One week later, due to the progressive deterioration of the patient's clinical status, it was decided to use an endovascular approach to treat the aneurysm. A 7.3 French polyethylene catheter was placed from a transfemoral approach at the C2 level of the left vertebral artery. Heparin was given (2.5 cc I.V.). A silicone detachable balloon 1.5 M was attached to a Tracker 18 microcatheter. Advancing the coaxial system and also using the flow, the balloon was guided through the basilar artery and successfully placed directly into the aneurysm. As we did not have any HEMA, we decided to fill the balloon with 0.5 ml of metrizamide. After waiting for twenty minutes, the patient was well and the balloon was detached. The size of the aneurysm did not warrant a second balloon. A check angiogram was done 10 days later showing obliteration of the aneurysm. After the embolization procedure, the patient improved neurologically and was discharged in good condition two weeks after the procedure. It seems that this technique may offer an alternative to the therapy for the management of some unclippable cerebral aneurysms, namely in the basilar tip artery.

CHLOROMA: CT and MR Appearance of an Iron Laden Lesion: Kochan JP, Peyster RG, Hershey BH, Hoover ED (Hahnemann University Hospital, Philadelphia Pa 19102)

A case of intracerebral chloroma imaged by computed tomography (CT) and magnetic resonance imaging (MR) is presented. A patient with myelogenous leukemia presents with an initial noncontrast CT (NCCT) demonstrating a homogeneous area of increased density, slightly lower than that of acute hemorrhage in the right temporal lobe. Contrast enhanced CT (CECT) showed a uniform enhancement of the lesion. MR examination revealed a lesion nearly isointense to cortex on T1 weighted images, with progressively decreasing signal intensity on proton density and T2 weighted images.

Open biopsy showed a greenish lesion without evidence of hemorrhage, but with abundant immature myelocytes. The diagnosis was leukemic infiltrate, or chloroma. The patient died after a course of radiation and chemo therapy. The intact, fixed brain specimen was rescanned by MR and showed the lesion to be of even lower signal. Microscopic exam revealed few myeloid cells, but abundant hemosiderin laden macrophages.

Chloroma, more recently refered to as granulocytic sarcoma, is a rare lesion of the CNS, which contains high levels of myeloperoxidase, an iron containing enzyme normally found in white blood cells. This enzyme, a derivative of the heme group, is what gives the lesion its typical green color. An infiltrate of leukemic cells containing high levels of iron, offers a possible explanation of its increased density on NCCT with enhancement of the underlying viable tissue on CECT. This also offers a satisfactory explanation of its low signal on MR . MR and microscopic evaluation of pre and post mortem specimens demonstrate the different appearance of the iron of myeloperoxidase and that of hemosiderin.

Edema Of The Corpus Callosum Secondary To Ependymitis Mimicking Glioma On MR : Kochan JP, Peyster RG, Hershey BH, Hoover ED (Hahnemann University Hospital, Philadelphia, Pa 19102)

A case of edema of the corpus callosum secondary to ependymitis mimicking glioma on MR is presented. The patient, with a history of hydrocephalus, presents with an initial noncontrast CT showing hydrocephalus secondary to aqueductal stenosis. A VP shunt was noted in the right lateral ventricle. MR examination confirmed the presence of aqueductal stenosis, but with a diffusely thickened, irregular corpus callosum. A mild increased signal intensity was noted on T1 weighted images, while a markedly increased signal intensity was noted on proton density and T2 weighted images. In addition, increased signal was noted in the ependyma of both lateral ventricles. The overall appearance was suggestive of a glioma of the corpus callosum, although, given the history and period of evolution of this finding, inflammatory change secondary to infected shunt was the most probable diagnosis. A followup contrast enhanced CT study showed a nonenhancing low density in the anterior corpus callosum with edema extending into the white matter bilaterally. There was also enhancement of the ependymal lining of the lateral ventricles. This is the typical finding of ependymitis, but with a considerable amount of callosal edema. Subsequent cultures of the CSF obtained from the shunt tube were positive for staph aureus.

MR of Lipomatous Meningiomas: Arrington JA, Kumar AJ, Ahn HS, Zinreich SJ, Sexton CC, Brem H, Bryan RN (The Johns Hopkins Medical Institutions, Baltimore, MD 21205)

MR images of three lipomatous intracranial meningiomas are presented with CT and pathologic correlation. A prominent chemical shift misregistration artifact is visualized at the periphery of the lesions on MR because of the fat-water interface between the meningiomas and brain parenchyma. Lipomatous meningiomas are uncommon and their MR appearance has not been previously reported to our knowledge. Diagnostic images as well as a discussion of the chemical shift artifact and its diagnostic applications are presented.

Hematoma Of The Nasal Septum: CT Appearance: Johnson JE, Seeger JF, Carmody RF (Univ. of Arizona, Tucson, AZ 85724)

Hematoma of the nasal septum is usually a clinical diagnosis when preceded by facial trauma. Plain films are of little or no value due to limited soft tissue contrast resolution. CT, however, can provide valuable morphologic information. We have recently seen two children with no history of antecedent trauma who presented with masses in the anterior nasal cavity which proved to be septal hematomas. The diagnosis was suggested by the CT findings.

The first patient was an 11 mo. old who presented with otitis media, septicemia, and respiratory arrest. The second patient was a 7 year old with a recent URI who complained of difficulty breathing. Obstructing midline masses were seen in the nasal cavity of both patients. CT revealed a well defined mass centered on the anterior nasal septum with no associated bony abnormality.

Nasal septal hematoma develops from subperichondrial hemorrhage, which strips the perichondrium and overlying mucosa from the cartilagenous septum. Necrosis of the septum can occur rapidly. Secondary infection can complicate a septal hematoma, particularly if the mucosa is disrupted. Treatment consists of immediate surgical drainage, often with antibiotic therapy.

The differential diagnosis of anterior nasal masses includes granulomatous processes, lymphoma, encephalocele, dermoid, septal hematoma, metastases, and primary tumors. If a discrete midline mass involves the nasal septum without bone destruction, septal hematoma should always be considered, even in the absence of trauma.

Unusual Etiology of Ophthalmoplegia: Suojanen JN, Barnes PD (Brigham and Women's Hospital, Boston, MA; Children's Hospital, Boston, MA 02115)

A five year old male fell into a pile of leaves and became stuporous with left third and sixth cranial nerve palsies. Head CT's showed a large left middle cranial fossa arachnoid cyst; a normally enhancing left cavernous sinus; and an apparently pneumatized left sphenoid wing. The patient regained consciousness quickly. The cranial nerve palsies were attributed to the arachnoid cyst, so it was operatively fenestrated several days later. The cranial nerve abnormalities persisted postoperatively.

He presented again four weeks later with a red and swollen left eye with purulent discharge. Contrast-enhanced orbital CT showed a 3 cm long linear low attenuation mass in the left orbit with a soft tissue mass around it. The "pneumatized" left sphenoid wing now had soft tissue density. Although the cavernous sinus appeared enlarged, there was sufficient enhancement to exclude thrombosis. A twig was removed from the orbit and purulent material drained from the wound.

Although arachnoid cysts can cause visual disturbances, associated cranial nerve abnormalities are rare. The low attenuation adjacent to the left cavernous sinus on the first series of CT scans was not pneumatization, but probably the twig. It must have pierced the lateral wall of the cavernous sinus, injured the cranial nerves, and just missed the vascular channels. This case reiterates the difficulty of imaging orbital wooden foreign bodies and the importance of imaging the entire course of cranial nerves when abnormalities are present.

CNS Involvement As Primary Manifestation of Whipple's Disease: Azar-Kia B, Fine M, Naheedy MH (Loyola Univ. Medical Center, Maywood, IL 60153)

Central nervous system presentation in Whipple's disease without systemic or gastrointestinal symptoms is extremely rare. To our knowledge only six such cases have been published.

Our case is a 27 year old white female who presented with progressive dementia and lethargy, resulting in coma. CT showed multiple bilateral, small and large hemispheric lucencies, primarily involving the white matter of the frontal and parietal lobes. Some of these lesions extended laterally into the gray matter and the others medially abutting on the ependyma of the lateral ventricles. The pathology was confined to the supratentorial space, sparing the occipital and temporal lobes. The posterior fossa was normal. The lateral ventricles were compressed, and the supratentorial subarachnoid spaces were obliterated. After infusion of contrast media there was a very faint ring-like enhancement around some of the lesions. MR confirmed the white matter origin and the extent of the lesions. T_1 weighted image of the lesions showed low intensity, and T_2 weighted images demonstrated high intensity in the white matter without cystic changes.

Biopsy of the left frontal lesion showed characteristic PAS positive particles in astrocytes. Using heavy antibiotic therapy, the patient regained consciousness and continues to show very slow clinical improvement.

We conclude that Whipple's disease should be considered in the differential diagnosis of white matter disease, especially if primary clinical presentation is dementia and lethargy. Early diagnosis and antibiotic treatment is of utmost importance in prognosis of Whipple's disease.

Unusual Manifestation of Metastatic Hypernephroma: Azar-Kia B, Fine M, Naheedy MH (Loyola Univ. Medical Center, Maywood, IL 60153)

We are presenting a 65 year old white female with a history of recurrent epistaxis who is otherwise in good health. Radiological examination showed a mass in the left nasal cavity with thinning of the medial wall of the left maxillary sinus. This lobulated nasal soft tissue mass was projecting into the maxillary sinus and superiorly extending into the ethmoid sinus. The nasal septum was deviated to the right. There was also a small rounded density on the lateral wall of the left maxillary sinus. Paranasal sinuses were otherwise clear. Biopsy showed metastatic hypernephroma. Subsequent radiological studies revealed a renal mass which proved to be a hypernephroma. This case presents an unusual manifestation of metastatic hypernephroma, with the nasal cavity being the only site of metastasis and also epistaxis being the first clinical manifestation of a hypernephroma.

Dural Sarcoidosis Presenting as Dementia: Blaser SE, Berns DH, Ross JS, Roessman U, Tucker T (University Hospitals, Cleveland, OH 44106)

A previously well 52 year old black female presented with a several week history of progressive memory and cognitive decline. Unenhanced CT revealed subtle hyperostosis of the left frontal and parietal calvarium with a suggestion of an underlying soft tissue density. The extra-axial density was seen to enhance following intravenous administration of contrast material. Primary differential consideration at this time included meningioma, dural metastases and chronic subdural membrane formation.

MR imaging was performed in axial and coronal planes with T1 (500/15) and T2 (2200/22-90) weighting. The lesion was isointense with grey matter on both T1 and proton density images, and was hyperintense on T2 weighted images. There was marked and homogeneous enhancement of the lesion after intravenous administration of Gadolinium DTPA. Post enhancement coronal images revealed that the lesion extended along or involved the leptomeninges from the falx to the anterior and middle fossa. Mild mass effect was present without evidence of edema. MR imaging in the coronal plane demonstrated greater extent of the lesion than CT. Gd-DTPA enhancement revealed even more extensive involvement than suspected on either contrast enhanced CT or unenhanced MR imaging.

Subsequent craniotomy and biopsy disclosed a markedly thickened dura with multiple non-caseating granuloma consistent with sarcoidosis, strains for acid fast bacilli are negative. A trial of prednisone was begun. The patient's symptoms improved and a repeat MR with gadolinium enhancement was performed demonstrating partial resolution of leptomeningeal involvement.

This case represents an unusual presentation of sarcoidosis as well as the advantages of MR and specifically Gd-DTPA enhanced MR imaging in the initial evaluation of neurosarcoidosis and in the evaluation of the course of the disease and response to therapy.

Melanocytoma: Unusual Tumor, Unusual Presentation: Berns DH, Blaser SE, Masaryk TJ, Selman W Roessmann U. (University Hospitals, Cleveland, OH 44106)

This previously healthy 19 year old female was G1 PO with an estimated gestational age of 20 weeks. She suddenly awoke from sleep with a severe pancephalic headache, nausea and vomiting. Physical examination was remarkable for nuchal rigidity and decreased pin sensation in the left V2 distribution.

An initial CT revealed an ovoid area of increased attenuation on the left perimesencephalic cistern. Angiography showed mild prominence of the left meningohypophyseal artery. Postcontrast CT revealed diffuse lesion enhancement.

MR revealed an ovoid area of homogeneous increased intensity on the T1 weighted images with marked decreased intensity on T2. The lesion was felt to represent either a thrombosed aneurysm or hemorrhagic meningioma.

Subtotal resection was achieved via a left temporal craniotomy. Pathology revealed a cellular tumor with deposits of melanin without evidence for hemorrhage. Diagnosis was a melanocytoma.

Melanocytomas are rare intracranial extraaxial neoplasms with distinct histologic and clinical features. Intracranially all cases reported in the literature are associated with the trigeminal nerve. Its biologic behavior is variable without the severe prognosis of primary melanoma. Surgical removal may lead to cure or prolonged patient survival. This case demonstrates that the paramagnetic properties of melanin may be confused with hematoma in preoperative radiologic evaluation.

Radiologic-Pathologic Correlation in Gliomatosis Cerebri: A Case Report: Koslow S, Hirsch W, Claassen D, Johnson D, Latchaw R (Univ. of Pittsburgh, Department of Radiology, Pittsburgh, PA 15213)

A 41 year old woman had a few week history of headache, blurred vision, and dizziness. She had focal left corticospinal and left cerebellar signs. CT showed a 3cm area of minimal contrast enhancement in the right occipital lobe. MR showed the enhancing region to have low T1 and high T2 signal and also showed enlargement of the splenium of the corpus callosum. In addition, there was subtle loss of gray-white demarcation throughout the right cerebral hemisphere. The left cerebral hemisphere and cerebellum appeared normal. The patient died unexpectedly 13 days after the MR scan. The areas of absent gray-white demarcation on MR were diffusly infiltrated by neoplasm. In addition, several areas which

appeared normal by MR (including cerebellar hemispheres) were also infiltrated by neoplastic cells. The short interval between the MR and autopsy provided an opportunity for radiologic-pathologic correlation in this rare entity. We observed that while superior to CT, MR greatly underestimated the extent of the pathologic process.

Rapid Spontaneous Resolution of an Epidural Hematoma: Babbel RW, Kelly WM (David Grant USAF Medical Center, Travis AFB CA 94535)

A 19-year old male with a deteriorating mental status underwent non-contrast head CT two hours following blunt head trauma. The initial study revealed a lentiform occipital/cerebellar epidural hematoma bridging the left lateral sinus and displacing the sinus away from the inner table of the skull. A subsequent CT examination approximately 10 hours later, without intervening surgery, demonstrated complete resolution of the epidural hematoma. Coincidentally, a delayed post-traumatic hematoma became apparent in the right frontal lobe.

This case is unique in that a typical epidural hematoma spontaneously resolved on CT images within 10 hours. Spontaneous external drainage of the hematoma through a skull fracture was clinically not apparent and no fracture was visible on CT. Traditionally, resorption of an epidural hematoma treated conservatively evolves over one to several weeks. Our experience with this trauma patient suggests that anatomic or physiologic circumstances might rarely occur to allow for accelerated bulk removal of an epidural hematoma in the acute phase. We postulate that spontaneous evacuation may have occurred into the adjacent dural sinus. The potential for such a pathway would also imply that some epidural hematomas evolving in this manner over a similar time frame may not be imaged at all if there is a significant delay between the inciting trauma and subsequent CT scanning.

Chordoma of the Petrous Bone: Lipper MH (Univ. of Virginia, Charlottesville, VA 22908)

A 44-year-old male presented with complaints of mild headache and double vision gradually increasing in severity over one month. Clinical examination revealed a left XII cranial nerve palsy only. CT of the temporal bones showed a large, expansile, sharply marginated lesion with mild non-homogeneous contrast enhancement, involving the left petrous bone. MR demonstrated a lobulated mass arising within the left petrous bone and extending postero-inferiorly, with low signal intensity on T1 weighted images and non-homogeneous high signal intensity on T2 weighted images. Cerebral angiography revealed narrowing of the intrapetrous left internal carotid artery and occlusion of the left internal jugular vein without evidence of neovascularity. Partial surgical excision was performed.

A second patient, a 49-year-old female presented with headache and rapidly decreasing level of consciousness over one day. Physical examination revealed an obtunded female with pinpoint, constricted, non-reactive pupils without spontaneous eye movements. CT demonstrated a right pontine hemorrhage with a lytic lesion of the right petrous bone seen only in retrospect. Surgery was performed for evacuation of the hematoma and the patient died without any further investigations being performed.

The differential diagnosis in the first case included neuroma and primary or metastatic malignancy because of the CT and MR findings. The second patient was diagnosed as having a pontine hemorrhage of unknown etiology. In both cases, the histological diagnosis was a chordoma. This diagnosis was totally unexpected as it was thought that chordomas occurred exclusively in areas where notochordal remnants may persist, such as the clivus, sphenoid bone and spine.

Malignant Intravascular Lymphoma: Pre and Post Mortem CT and MR Imaging with Autopsy Correlation - An Addition to the Gamut for Deep White Matter Infarction: Goldblatt D., Minieka M, Russell EJ, Brody BA, Lazar R (Northwestern Memorial Hospital, Chicago, IL 60611)

A 57 year old man presented to our institution following a blackout leading to a motor vehicle accident, which resulted in paraparesis. Upon admission he was noted to have cognitive defects and after questioning it became apparent that he had undergone a progressive personality change over several months prior to admission. CT scan of the brain revealed a focal non-enhancing low attenuation region in deep white matter of right temporoparietal region. The patient became progressively demented over the next week: MR study demonstrated additional lesions within subcortical and deep hemispheric white matter (prolonged T2). Considering occult infection as a diagnostic possibility, a brain biopsy was done; this revealed malignant lymphoma cells confined to the intravascular (luminal) region within leptomeningeal and deep white matter penetrating arteries. The cells packed the vessels, and in concert with superimposed fibrin clot resulted in vascular occlusion. The changes accounted for the pattern of deep white matter infarction shown by CT and MR studies. Malignant intravascular large cell lymphoma (MIL) may therefore mimic other processes, such as hypertension, atherosclerosis, and infection which result in this pattern. MIL often presents as a progressive dementia, and cases with slower progression than in our case may clinically resemble more benign processes. Therefore, in the appropriate clinical setting, MIL should be considered as a potential cause of solitary or multifocal hemispheric white matter disease.

Intraspinal Extension of a Bronchogenic Cyst: A Case Report: Weingarten K, Haimes AB, Gamache FA, Deck MDF (New York Hospital-Cornell Medical Center, New York, NY 10021)

A 33 year-old female was discovered to have a right T10 paraspinal mass on a chest film obtained prior to minor orthopedic surgery. Past medical history was noncontributory. Noncontrast CT and MR demonstrated an extradural, intraforaminal, and paraspinal cystic mass with smooth neural foraminal widening. No mass was present in the prevertebral space. The mass measured 3-10 Hounsfield units and was mildly hyperintense to cerebrospinal fluid(CSF) on short TR sequences and moderately hyperintense to CSF on long TR sequences. The MR intensities were attributed to increased protein(70 mg% vs. 40% of CSF) and decreased pulsations in the cyst as compared with CSF. The subarachnoid space and cystic mass were isolated from each other, since neither intrathecal nor intracystic installation of water-soluble contrast demonstrated a communication. Surgery revealed a peduncular bronchogenic cyst arising from the pleura and extending into the extradural space. Hyperinflation of the mass with application of positive pressure ventilation and collapse with expiration demonstrated its communication with the respiratory tree. To our knowledge, this appears to be the first reported case of a bronchogenic cyst causing epidural compression of the spinal cord.

A Case of Carotid Dissection in a Child. Contribution of MR in Early Diagnosis and Management: Kien P, Greselle JF, Dautheribes M, Guerin J, Caille JM (Service de Neuroradiologie - Groupe Hospitalier Pellegrin-33076 Bordeaux, France)

The clinical course began with a temporo-frontal headache followed by an abrupt hemiplegia in a seven year old child after a violent effort. CT scans obtained 2 and 12 hours after onset were normal. Ten hours after onset, MR was performed, T_1-weighted (TE = 8 msec, TR = 500 msec) and T_2-weighted (TE = 50 msec, TR = 2000 msec, 3 echoes). MR images showed a moderate hypersignal from the basal ganglia and the insula region that evoked stroke. Associated obstruction of the intra-cavernous portion of the internal carotid artery and a poor visualization of the M1-M2 segment of the middle cerebral artery in the coronal slices. The diagnosis of dissection was confirmed by arteriography. Follow-up MR examinations on days 5, 20 and 45 showed the stroke developing into a large zone of malacia. In connection with this case, the authors point out:
-the rarity of stroke in young children and the demonstration of its exceptional character of their etiology by dissection,
-the often traumatic nature of these dissections and the frequency of headaches or neck pain in the clinical history.
-the negativity of CT during the first few hours and the advantages presented by MR which permits a very early diagnosis and guides management by showing the absence of carotid flow.

Gadolinium Enhanced MR Imaging of Experimental Bacterial Meningitis: Evaluation and Comparison with CT: Mathews VP, Kuharik MA, Edwards MK, D'Amour PG, Azzarelli B, Dreesen RG (Indiana Univ., Indianapolis, IN 46223)

The evaluation of gadolinium-DTPA (Gd) enhanced magnetic resonance (MR) imaging of experimental bacterial meningitis was performed after the direct inoculation of Staphylococcus aureus into the cisterna magna of four dogs. Each animal was then

studied with both unenhanced and enhanced MR imaging and computed tomography (CT) utilizing Gd and meglumine iothalamate, respectively. The enhancement patterns of these modalities were compared and images were correlated with histopathology. All animals demonstrated abnormal leptomeningeal enhancement on MR with Gd, but only one of four dogs exhibited abnormal contrast enhancement on CT. In these animals Gd enhanced MR also identified complications of meningitis such as ventriculitis and cerebritis more effectively than CT. Unenhanced MR was not helpful in identifying meningitis. Histologic evaluation demonstrated that the abnormal areas of contrast enhancement on MR and CT correlated with inflammatory cell infiltration. However, some regions of mild leptomeningitis, ependymitis, and cerebritis identified histologically did not demonstrate abnormal enhancement. Since the animal model used was clinically and pathologically similar to human meningitis, we propose that Gd enhanced MR will subsequently be found more effective than unenhanced MR and contrasted CT for demonstrating meningitis and its complications in humans.

MR of Temporomandibular Joint Disorders: Palacios E, Valvassori G, Guzman M, Dobben G, Reed C (Berwyn Magnetic Resonance Center, Berwyn, Il 60402, MacNeal Hospital, Berwyn, Il 60402)

A study was carried out on 20 asymptomatic volunteers and 12 fresh cadavers to assess anatomy and MR imaging techniques. Five hundred and six patients (1012 joints) with signs and symptoms related to the TMJ were studied in two and a half years. The results of our studies indicate that MR is a good non-invasive alternative to other imaging modalities, mainly to detect internal derangement.

The study demonstrated that 13% of the patients had a morphologically normal TMJ, 87% had internal derangement and degenerative changes and 2% had other disorders. The average age was 32 years with a female to male ratio of 18:1. Of the internal derangement cases, 44% were bilateral and 56% were unilateral.

A group of patients was studied before and after treatment for internal derangement. The morphology, position of the discs and bony structures were correlated with clinical, surgical and arthroscopic findings. The results indicate that the physiopathology and management of TMJ disorders is still controversial.

The Temporomandibular Joint: Two-Compartment Arthrography and Magnetic Resonance Imaging: Schellhas KP, Wilkes CH, Omlie MR, Peterson C, Fritts HM, Heithoff KB (Center for Diagnostic Imaging, St. Louis Park, MN 55416)

The reliability and accuracy of two-compartment temporomandibular joint (TMJ) arthrography was compared to magnetic resonance (MR) imaging based upon the analysis of surgical findings obtained from joints which had been preoperatively studied with either arthrography or MR and, in some cases, both procedures. 743 consecutive TMJ arthrograms were successfully performed in a total of 443 patients using a single 27-gauge needle and a two-compartment technique including videofluoroscopy on each joint. There was 100% correlation with surgical findings in 218 radiologically abnormal joints operated upon within 90 days of arthrography with respect to the presence or absence of meniscus displacement and normal or abnormal disc morphology and function. 1,052 TMJ's (604 patients) were studied with high field strength surface coil MR using T1-, T2-weighted or partial flip angle technique. Surgical findings are available in 170 of the joints studied. 43 joints were studied with both two-compartment arthrography and MR. Arthrography was superior to MR in detecting capsular adhesions and the presence or absence of perforation of the disc or meniscus attachments. Joint effusions, failed TMJ implants and avascular necrosis (AVN) are best demonstrated with MR. Soft tissue lesions, including intrinsic degeneration of the meniscus, anomalous muscle development, muscle atrophy, tendonitis and injuries, such as contusions and hematomas, are only demonstrated with MR. The authors recommend MR as the procedure of choice for diagnosis of uncomplicated internal derangements of the TMJ. Two-compartment arthrography should be considered whenever capsular adhesions or perforations are suspected and not demonstrated with MR, and in all cases where MR proves inconclusive.

Temporomandibular Joint Derangements: MR Fast Scanning Compared to T1- and T2-weighted Imaging Techniques: Schellhas KP, Fritts HM, Heithoff KB, Jahn JA, Wilkes CH, Omlie MR (Center for Diagnostic Imaging, St. Louis Park, MN 55416)

100 temporomandibular joints (TMJ) (58 patients) were studied with high field surface coil MR using combined T1-, T2-weighted and partial flip angle or GRASS (gradient recalled acquisition in the steady state) imaging techniques in closed-mouth position for purposes of comparison. T1- and T2-weighted images were obtained with the mouth closed only, while GRASS scans were obtained with the mouth closed, partially opened and fully opened. T1-weighted images were obtained with TR=600 milliseconds, TE=20, 256 x 256 matrix, 12 cm field of view (FOV) with 3 mm thickness and 2 excitations (5 minutes, 8 seconds). T2-weighted images were obtained with TR=2000-2500, TE=20, 80-100, 1 excitation (8 minutes, 24 seconds - 11 minutes, 13 seconds). GRASS images were obtained with TR=25, TE=13, flip angle=30 degrees, 16 cm FOV, 5 mm thickness, 1 or 2 excitations (6-13 seconds, respectively). T2-weighted images were the most sensitive to fluid detection in the joint bursas and within the muscles of mastication and fascial spaces near the joints. GRASS images were highly sensitive to fluid within the joints and fascial spaces, although the thicker scan section and local artifacts associated with these techniques resulted in lower accuracy compared to the T2-weighted images. The authors recommend either a combination of T1-weighted closed-mouth sagittal images and GRASS closed- and open-mouth images or multiecho proton density and T2-weighted closed-mouth images combined with GRASS open-mouth views for evaluation of mechanical TMJ symptoms. Both methods provide excellent anatomic definition. Multiecho T2-weighted images are recommended whenever inflammatory disease or early avascular necrosis is suspected.

Magnetic Imaging of the Temporomandibular Joint: Assessment of Splint Therapy: Manzione JV, Katzberg RW, Tallents RH, Kido DK, Ekholm SE (Univ. of Rochester Med. Ctr., Rochester NY 14642)

Temporomandibular repositioning splint therapy is often utilized to treat patients with joint noises clinically felt to represent anterior meniscus displacement with reduction. The goal of this type of splint therapy is to reposition the anteriorly displaced meniscus back onto the condylar surface. The purpose of this study is to determine the role of magnetic resonance imaging in (1) detecting the presence of meniscus displacement with reduction in patients with temporomandibular joint symptoms, and (2) to determine if splints fabricated for such patients have restored or maintained normal meniscal condylar relationships.

The MR scans in 190 temporomandibular joints were reviewed. 58 joints representing bilateral scans in 29 patients had been performed with the mouth in the closed, open, and splinted jaw position. All scans were performed utilizing a 3" surface coil and a 1.5 Tesla imaging system.

The results indicated that 43% of the scans were normal. Anterior meniscus displacement with reduction (MDR) and anterior meniscus displacement without reduction (MD) were found in 24% and 33% of the scans. Evaluation of these scans with the jaw in an anteriorly splinted position indicated that there was restoration of normal meniscal condylar relationships in 57% of the patients with MDR. None of the patient with MD were shown to have normal condylar meniscus relationship while wearing the repositioning splint.

We conclude that magnetic resonance imaging of the temporomandibular joints in symptomatic patients is a useful noninvasive means (1) to determine the presence, type and stage of an internal derangement (normal vs. MD vs. MDR), (2) to determine which patients are most suited for protrusive splint therapy (i.e. patients with MDR), and (3) to assess the accuracy of splint therapy at its initiation and during treatment. Because of the high incidence of bilateral temporomandibular joint derangements, bilateral examinations is suggested in all patients. This can regularly be performed utilizing the bilateral surface coil technique in the sagittal and coronal planes.

Muscles of Mastication: MR Imaging of Abnormal Structure and Physiology: Schellhas KP, Heithoff KB, Fritts HM, Wilkes CH (Center for Diagnostic Imaging, 5775 Wayzata Blvd., Suite 190, St. Louis Park, MN 55416; Park Place Center, 5775 Wayzata Blvd., Suite 990, St. Louis Park, MN 55416)

Normal and abnormal muscles of mastication may be studied and defined with MR. Specific structural and physiological alterations may be defined using either T1-weighted or combined multiecho T1- and T2-weighted MR imaging techniques. Specific pathological alterations which may be demonstrated include anomalies of development, muscle atrophy (disuse and denervation),

contracture, inflammatory changes, injuries (including contusions, hematomas, tears, and rupture) and muscular dystrophies, including reflex sympathetic dystrophy. Pathologic changes within the lateral pterygoid muscles may accompany or cause clinical symptoms suggesting internal derangement of the temporomandibular joint (TMJ). Cases presented were selected from over 1300 surface coil MR studies of the TMJ performed between 2/1/87 and 1/10/88.

The Impact of Gadolinium-DTPA on the MR Evaluation of Benign and Malignant Tumors of the Extracranial Head and Neck: Crawford SC, Harnsberger HR, Teresi L, Lufkin RB, Osborn AG, Smoker WRK (Univ of Utah, Salt Lake City, UT 84132)

Sixteen patients with known benign or malignant tumors of the extracranial head and/or neck were imaged before and after intravenous administration of Gadolinium-DTPA at 0.1 millimoles per kilogram. Imaging was performed on a 1.5 Tesla unit. Pre-injection imaging included axial T1 and T2 sequences. Post-injection imaging employed only T1 sequences, obtained at 3,15, and 30 minutes after injection. The Gadolinium enhanced images were compared to the unenhanced images for degree of lesion conspicuity, degree of enhancement at different time intervals, and detection of additional abnormalities with Gadolinium.

Gadolinium enhanced images provided improved lesion conspicuity over T1 images in 15 of 16 cases, and in 5 of 16 when compared to T2 images. Three minute images showed the greatest amount of enhancement among those lesions that accumulated Gadolinium. One of the 16 did not enhance. Additional information provided included perineural tumor spread, meningeal tumor involvement, and inhomogeneous enhancement of malignant nodes. This delineation of internal nodal architecture may help in the MR diagnosis of malignant adenopathy.

CYSTIC LESIONS OF THE HEAD AND NECK: ROLE OF MRI: Mafee MF, Tan CS, Johnson G, Chow J, Friedman M, Tan WS (University of Illinois at Chicago, Chicago, IL 60612)

This paper reports on MR and CT examinations of patients who had various cystic lesions of the head and neck. Included are 3 cystic hygromas, 3 branchial cleft cysts, 3 plunging ranulas, 4 thyroglossal duct cysts, 5 thyroid cysts, 1 large duplication cyst of the cervical esophagus, 1 lymphangioma of oropharynx, 1 cavernous hemangioma of pharynx and larynx, 1 epidermoid cyst of the anterior neck, 3 odontogenic cysts, 3 ameloblastomas, 1 extensive extracranial craniopharyngioma, and one unusual extensive cystic extracranial pituitary adenoma. All cystic lesions demonstrated a high signal intensity on T2-weighted (T2W) images and intermediate signal intensity on proton weighted (PW) images, and low to intermediate signal on T1-weighted (T1W) images. Two of cystic hygromas and one ranula appeared relatively hyperintense in T1W images. This MR characteristic was thought to be due to high protein content of the lesions. In one case of cystic hygroma fluid-fluid level with areas of dependent hypointensity was noticed. A case of lymphangioma and cavernous hemangioma of the upper aerodigestive tract had similar MR signal intensity as proteinaceous cystic lesion. The odontogenic cysts, except one, appeared as uniform signal intensity with a tooth identified within the cyst. In one cyst the heterogeneity was due to old hemorrhage. The solid and cystic components of ameloblastomas, craniopharyngioma and pituitary adenoma were differentiated because of different signals. The gradient echo "GRASS" fast MRI was performed in 5 patients (branchial cleft cysts, ranulas, cavernous hemangioma). The branchial cysts and ranulas appeared as slight to moderate increased signal intensity on gradient echo images. The cavernous hemangioma appeared as isointense to adjacent tonsillar tissue on these images. Although MR proved superior to CT for defining the cyst/normal tissue interface, however, some solid lesions may have similar MR characteristics and therefore CT may provide more information than MR regarding the cystic nature of lesion. In our study the reliability of using the high signal intensity of T2W images for defining the edge of the cysts and tumors was demonstrated through histopathologic correlation.

MR Imaging of Recurrent or Residual Tumor in the Postoperative Head and Neck Patient: Sandy AD, Hesselink JR, Brahme FJ, Press GA (Univ. of California, San Diego, CA 92103)

The presence of recurrent or residual disease is frequently of clinical concern in patients who are status post surgical resection of neoplasms of the head and neck. The utility of MR imaging in post therapy evaluation of patients with a variety of diseases from the oropharynx to the sternoclavicular junction has been described. To further define the role of MR imaging in the evaluation of the postoperative head and neck patient, the examinations of seven patients with biopsy-proven recurrent or residual tumor located between the oropharynx and the base of the skull were reviewed.

The superior contrast resolution provided by MR imaging facilitated the detection of recurrent or residual disease in all cases. In the nasal cavity and paranasal sinuses, MR clearly differentiated tumor from inflammatory disease in most cases. On T2-weighted images, tumor was significantly hypointense relative to adjacent inflammatory disease in six of seven cases, and approximately isointense in one. Tumor could also be distinguished from normal adjacent muscle which was hypointense to tumor in six of seven cases. T1- and proton-density weighted images showed tumor infiltration of fat/tissue planes within the infratemporal fossa, parapharyngeal space and orbit.

Images obtained in coronal and sagittal planes were most helpful in the evaluation of extension of disease through the base of the skull and into adjacent compartments of the face. Bone erosion could be detected when abnormal soft tissue was present on both sides of a bony wall.

MR promises to be a useful tool in the evaluation of the postoperative head and neck patient. The ability to differentiate between recurrent tumor and adjacent inflammation, in most cases, will allow for more accurate determination of extent of recurrent disease. It may also facilitate earlier detection of recurrent disease.

Sinonasal Tumors and Inflammatory Tissues: Their MR Differentiation: Som P, Shapiro M, Biller H*, Sasaki C, Lawson W* (Mt. Sinai Hospital*, New York 10029 and Yale Univ. School of Medicine, New Haven, CT 06510)

In the head and neck region accurate mapping of tumor margin is extremely important. It often determines whether curative surgery or palliative radiation and/or chemotherapy will be the treatment modality of choice. If surgery is considered, tumor mapping may determine the appropriate surgical approach. If radiation therapy is utilized, accurate tumor margins may modify the radiation fields and if chemotherapy is employed, identification of the precise tumor contours permits optimal evaluation of tumor response. The MR and CT scans of 53 patients with sinonasal tumors were analyzed and compared for accuracy of tumor mapping. The findings were confirmed by either surgery or biopsy. In addition, the MR scans on 60 patients with inflammatory disease were also studied and their findings were confirmed by surgery. Another 47 MR studies on tumors occurring elsewhere in the head and neck but, with similar histology to those found in the sinonasal tumor group, were examined. Also reviewed were 50 MR scans of routine inflammatory disease, 6 cases of extensive polyposis, 3 cases of aspergillosis and one case of chronic granulomatous disease (benign). This study demonstrated the following: 1) Approximately 95% of all sinonasal tumors have low to intermediate signal on T2 weighted images. About 5% have a bright signal on T2 WIs. This group is comprised almost exclusively of minor salivary gland tumors and rarely some neuromas. All routine inflammatory disease and polyposis yielded bright signals on T2 weighted images. Fibrosis, mycetomas, and chronic granulomatous disease yielded lower signals on long TR long TE sequences. 2) MR is superior to contrast enhanced CT in differentiating sinonasal tumors from adjacent inflammatory tissue. 3) MR is the modality of choice for follow-up evaluation neoplasms (post surgical and/or radiation).

In Vitro Imaging of Laryngeal Perichondrium With MR at 2.35T: Kikinis R, Wolfensberger M, Boesch Ch, Martin E (Medical School Univ. of Zuerich, Zurich, Switzerland)

Because of insufficient spatial resolution present imaging techniques cannot reliably detect perichondrial infiltration or early cartilage involvement by laryngeal carcinoma.

The present study was undertaken to determine how much the spatial resolution of MR will have to be increased to allow us to see the laryngeal perichondrium. For this purpose eight lar-

ynges (3 without and 5 with tumor) were examined using different imaging parameters. Stepwise histological sections were used for comparison.

Using a conventional spin echo sequence with a TR of 2000ms and a TE of 80ms and a pixel size of .3x.3x2.0 millimeter the best results were obtained.

With this setting a detailed analysis of the thyroid cartilage becomes possible. The marrow of the ossified cartilage has a greyish appearance. Next to it comes a thin hypointense line corresponding to calcified cartilage and bone. This is followed by another grey line corresponding to uncalcified cartilage. And finally, there is a second hypointense line which is the perichondrium.

MR with this kind of spatial resolution will become clinically avilable in the near future. The presence or absence of even minimal cartilage invasion and the amount of soft tissue involvement should then become reliably predictable.

The Radiographic Assessment of Trigeminal Neuropathy: HUTCHINS LG, HARDIN CW, HARNSBERGER HR, DILLON WP, SMOKER WRK, OSBORN AO (Univ. of Utah, Salt Lake City, UT 84132 and Univ. of California-San Francisco, San Francisco, CA 94143)

Seventy-five patients with trigeminal neuropathy and an abnormal imaging study (CT and/or MR) had their clinical and radiographic records retrospectively analyzed. The trigeminal nerve was divided into proximal (brainstem, preganglionic, gasserian ganglion, and cavernous sinus) and peripheral (extracranial V1, V2, and V3) segments. The purpose of the study was to 1) Determine the efficacy of clinical localization of CN V lesions, 2) Compare CT and MR for CN V imaging, and 3) Develop an MR protocol for effective CN V imaging.

Thirty-five percent of the patients had CT, 44% MR, and 21% CT and MR. Forty-nine percent of lesions were peripheral, 19% in the preganglionic segment, 17% brainstem, 8% gasserian ganglion, and 5% cavernous sinus.

Clinical localization was found to be extremely inaccurate. For example, less than half of patients with brainstem lesions had three division clinical involvement and over one third of patients with peripheral lesions showed more than one division clinical involvement. CT missed three gasserian ganglion lesions and will not detect the most common brainstem lesions (small infarcts and MS plaques). The ideal MR protocol must image the entire course of clinically involved segments and should include T2 axial images of the brain and brainstem, as well as T1 axial and coronal images through the brainstem and globe. When V3 is involved, axial images should extend through the inferior mandible.

Precise Localization of Cerebrospinal Fluid Leaks by MR : Sibbitt RR, King JN, Orrison WW, Wicks J, Janke R (Univ. of New Mexico, Albuquerque, NM 87131)

Thirteen patients were evaluated for potential cranial CSF leakage in 20 separate MR examinations. Twelve patients had rhinorrhea and one had otorrhea. Fourteen examinations were unequivocally positive, with a bridge of CSF/tissue signal connecting the basilar CSF cisterns with the CSF-filled air spaces. Three were unequivocally negative. Variable combinations of surgery, radionuclide cisternography, and clinical follow-up confirmed MR findings, and there were no false negative or false positive exams. Dural defects were accurately localized in all of the positive exams. MR provides accurate and clinically useful information in the evaluation of CSF rhinorrhea and otorrhea.

MR of the Nasal Cycle: Zinreich SJ, Kennedy DW, Kumar AJ, Johns ME, Rosenbaum AE (Johns Hopkins Medical Institutions, Baltimore, Maryland 21205)

Magnetic resonance studies frequently demonstrate increased signal T2 weighted images in the nasal area. To further evaluate this phenomenon, several MR examinations of the nasal cavity were performed within an 8-12 hour period. The study demonstrated that the changes alternated from side to side and were interrupted by the administration of topical vasoconstriction, confirming imaging of the normal nasal cycle. The changes were also observed within the ethmoid sinuses. Signal intensity of T2 weighted images during the congested phase was similar to inflammatory mucosa. Occasionally, these changes make interpretation of the extent of pathology difficult in patients with sinus disease, and raise the possibility of inflammatory pathology in asymptomatic patients. Awareness of MR imaging of nasal cycle should reduce the likelihood of diagnostic errors and provide another method for study of this physiologic phenomenon.

Magnetic Resonance Imaging of the Temporal Bones: Comparison of Bilateral Surface Coil and Head Coil Techniques: Manzione JV, Plewes, DB, Kido, DK, Totterman S, Ekholm SE, Simon JH (Univ. of Rochester Medical Center, Rochester, NY 14642)

Unilateral MR surface coil imaging of the temporal bones has been used to improve signal-to-noise ratios and, therefore, improve geometric resolution. The disadvantages of unilateral surface coil imaging are (1) additional scan time is required to visualize the contralateral temporal bone if indicated, (2) additional head coil scans are required to evaluate the brain stem for lesions which may mimic 7th-8th nerve complex diseases. The purpose of this study is to (1) report a bilateral surface coil technique in which both temporal bones as well as the contents within the posterior fossa may be imaged simultaneously, (2) compare the relative signal-to-noise ratio of bilateral surface coil and head techniques.

The bilateral surface coil described utilizes two 4" diameter circular surface coils as receivers in a paired configuration with the coils oriented so that the MR signal currents add. The coils are tuned and matched as a pair when loaded with the head with active detuning used to decouple the coils from the B1 pulse.

Relative signal-to-noise ratios measured in this study indicated that the bilateral 4" surface coil technique had a better relative signal-to-noise ratio compared to the head coil measurements at distances of approximately 4.5 cm or less from the surface coil. At distances approximately greater than 4.5 cm, the head coil provided better relative signal-to-noise ratios. We conclude that for (1) peripheral structures (i.e. the temporomandibular joint, parotid gland, and portions of the facial nerve) the bilateral surface coil technique is preferred to improved signal-to-noise ratio at the levels of these structures; (2) at the level of the internal auditory canal and cerebellopontine angle, there did not appear to be a major difference in signal-to-noise ratio and therefore for evaluation of these structures, the head coil was adequate. Utilizing the head coil (with a small field of view) when evaluating these structures has the advantage of also providing optimal views of the brain stem and posterior fossa.

Temporal Bone Fractures Revisited: Johnson GT, Mafee MF, Girgis I, Raju S, Espinosa G, Valvassori G (Univ. of Illinois, Chicago, IL 60612)

The clinical, CT, and surgical findings in 31 patients with 35 temporal bone fractures were reviewed. Most of the fractures were due to assault, MVA or fall with a small group due to iatrogenic causes(4 cases). 86% patients were male. Average age = 28 yrs. In 10 cases direct sagittal imaging was done; in 5 patients with CSF-otorrhea positive contrast cisternography was done. 52% of fractures were longitudinal, 14% transverse, 34% atypical or isolated. Findings in longitudinal fractures: ossicles involved (80%), labyrinth spared (80%), facial nerve (FN) paralysis (57%). Findings in transverse fractures: labyrinth involved (80%), ossicles dislocated (60%), FN paralysis (40%). The isolated or atypical fractures included: isolated fracture of EAC (2), tegmen (2), mastoid (1), scutum and pyramidal eminence (1), hypoglossal canal-cochlear aqueduct (1), round window-cochlear aqueduct (1), stapes footplate (1), and temporal bone injury related to TMJ arthroscopy (3). The sites of injury to the FN in patients with FN paralysis were evenly distributed along the course of the FN. The number of patients with FN paralysis and longitudinal fracture is notably higher than the percentages previously cited. Direct sagittal imaging proved superior to, or an important complement to axial and coronal imaging in assessment of the FN canal, EAC, tegmen, and in ossicular dislocation. In three cases fractures in the region of the cochlear aqueduct and round window were seen in patients with CSF-otorrhea, recurrent meningitis or pneumocephalus illustrating the role of the cochlear aqueduct as potential pathway between subarachnoid space of brain and scala tympani. Pneumocephalus (3) and pneumolabyrinth (3) were important CT findings

as clues to temporal bone fracture in total of 6 cases. In 1 case, pneumolabyrinth was seen in iatrogenic fracture of the stapes footplate in mastoid surgery. Finally, temporal bone CT detected injury to the temporal bone in 3 patients presenting with hearing loss and FN paralysis after inadvertent entry of the middle ear during TMJ arthroscopy.

ROLE OF CT AND MR IN THE EVALUATION OF INTRATYMPANIC MASSES: Mafee MF, Valvassori GE, Raju S, Johnson GT, Tan WS, Espinosa G (Univ. of Illinois at Chicago, Chicago, IL 60612)

In this paper we describe the role of CT and MR in the evaluation of 112 patients with various intratympanic masses. Glomus tumors (32 cases) are the most common intratympanic tumors. CT in combination with dynamic CT was more specific for the diagnosis of glomus tympanicum. MR was superior to CT in large glomus tumors for exact delineation of tumor mass and its relationship to vascular and adjacent soft tissues. Vascular anomalies of the middle ear including ectopic carotid (4 cases) and bulging exposed jugular bulb (11 cases) could be accurately diagnosed by CT. Facial nerve neuromas (7 cases) were best diagnosed by CT. Extratemporal components of facial neuromas were accurately diagnosed by both CT and MR . Facial neuromas were hypointense in T1-weighted and hyperintense in T2-weighted MR images. Perineural extension due to parotid tumors (5 cases) could not be differentiated from primary facial nerve tumors by CT and MR characteristics. The presence of a mass in the parotid detected on CT or MR is a clue in these cases. Extension of CP angle meningioma (5 cases) and extension of primary cholesteatoma of the petrous apex (6 cases) and cholesteral granuloma of the petrous apex into the middle ear (2 cases) were shown on CT. We report also a case of extramedullary hematopoiesis in a sickle patient, presenting as a cyst in the middle ear and two patients with labyrinthine schwannoma, presenting as a mass in the middle ear. The presence of a mass in the round window niche in a patient with significant sensorineural hearing loss should raise the question of labyrinthine schwannoma. A case of intratympanic ectopic meningioma had identical otoscopic and CT findings as an attic cholesteatoma. In general, bone involvement due to middle ear disease was better delineated by CT. In glomus tumors, facial nerve tumors and large lesions, the combination of CT and MR was most useful.

The Clinical Efficacy of the 7th-8th Nerve Complex Sign in the Diagnosis of Acoustic Neuromas and the Influence of Gd-DTPA Enhanced Scans on Patient Management: Manzione JV, Kido DK, Dutcher P, Nelson C, Joy S, Ketonen L (Univ. of Rochester Medical Center, Rochester, NY 14642)

Pre- and post gadolinium - DTPA (Gd-DTPA) enhanced MR scans were performed on 6 patients clinically suspected of having pathology of the 7th-8th nerve complex, in order to determine (1) if seeing a central linear area of low signal intensity within the IAC on the noncontrasted MR scans represented normalcy (nerve bundles separated by CSF), (2) if Gd-DTPA enhanced studies influenced the clinical decision making in the management of these patients.

In 4 patients, the noncontrasted study showed a central linear area of low signal intensity within the IAC mimicking normal anatomic landmarks. The contrast MR scans in 3 patients clearly defined enhancing lesions which led to the decision for surgery without an air contrast CT cisternogram or further work-up. In the 4th patient the contrasted MR study confirmed that the noncontrasted study was normal. In the other 2 patients the central area of lucency was not seen on the noncontrasted study. On the contrast scan one of the patients had a large primarily extra-canalicular lesion and the 2nd patient had an intracanalicular lesion the extent of which was underestimated on the noncontrasted scan. The Gd-DTPA enhanced MR scans were efficacious in altering the clinical course and therapaeutic decision making in 5 of the 6 patients. We have found that the presence or absence of a central linear area of low signal within the IAC is an unreliable sign of predictor of the presence, absence, or extent of small intracanalicular lesions. This preliminary study suggests that GD-DTPA enhanced MR scans (1) may be more sensitive than noncontrasted MR scans in detecting small lesions thus eliminating the need for the more invasive air contrast CT cisternogram and (2) can better define the extent of a lesion, potentially altering the surgical approach.

The Significance of Asymmetry of the Foramen of Vesalius: Lanzieri CF, Duchesneau PM, Rosenbloom SA, Rosenbaum AE (Cleveland Clinic Foundation, Cleveland, OH 44195-5103)

The foramen of Vesalius is a small, variable but consistently symmetrical structure located anteromedial to the foramen ovale, and lateral to the foramen rotundum and vidian canal. It transmits an emissary vein through which the cavernous sinus and pterygoid plexus communicate. Fifty high resolution CT scans of the skull base and two 3-D (Cemax) reconstructions were reviewed to determine criteria for the normal appearance of this structure. Three normal types were classified; 1) well formed foramen 1-2mm in size (N=32); 2) nonvisualization (N=11); 3) partial assimilation with foramen ovale (N=7). There was remarkable symmetry in a large number of cases (N=48).

Asymmetry signified abnormality in 4 of the 6 cases. Abnormal causes of asymmetry included invasion by nasopharyngeal melanoma, angiofibroma, carotid cavernous fistula with drainage through the emissary vein and neurofibromatosis. Thus, for these usually symmetric foramina of Vesalius, asymmetry is more likely due to a pathologic process than a normal variant.

MR of the Hypoglossal Canal - Normal and Pathologic: Shapiro M, Som P*, Cross R, Peyster R**, Charles J, Sasaki C (Yale Univ. School of Medicine, New Haven, CT 06510; Mt. Sinai Hospital*; and Hahnemann Univ. Hospital**)

The 12th cranial nerve exits from the ventrolateral sulcus of the medulla as two discrete bundles which enter the hypoglossal canal (between the jugular tubercle superiorly and the occipital condyle inferiorly). Within the hypoglossal canal, proper, the two separate bundles usually fuse into one discrete nerve. The primary function of the 12th cranial nerve is motor supply to muscles of the tongue.

A retrospective study of 145 MR examinations was performed in order to delineate the normal dimensions, anatomic variations and optimal viewing plane of the hypoglossal canal. Sixty studies in the axial projection (T1, P.D., and T2 WIs, 3-5 mm sections), 60 studies in the coronal projection (T1 WIs, 3 mm) and 25 exams in the sagittal plane, (T1, P.D., T2 WIs, 3-5 mm) were reviewed. From this review, data concerning the optimal viewing plane, normal dimensions and anatomic variations (including compartmentalization of the canal into two sections by a bony spicule and a persistent hypoglossal artery) were obtained. In addition, T1 weighted coronal and axial images were reviewed for delineation of the proximal course of the hypoglossal nerve. All diameters obtained from this study were measured from medullary bone to medullary bone. The average sagittal diameter was 5.9 mm, vertical height 7 mm, and the coronal transverse diameter 5.4 mm.

Three mm thick contiguous sequences, T1 or P.D. (axial plane), best demonstrated the proximal portion of the hypoglossal nerve in a single image. T1 WIs (3 mm contiguous) in the coronal or axial projection best delineated the canal itself. Pathologic processes of the canal included 9th and 12th nerve neuromas, chordoma, paragangliomas (glomus jugulare and glomus vagale), metastatic disease and Pagets disease.

Because of its superb contrast resolution, MR is the modality of choice for visualizing normal anatomy and imaging pathology involving the hypoglossal canal and/or nerve. The excellent signal disparity between fat and normal muscle, readily demonstrates the effects of denervation of the tongue with loss of muscle volume and increase in signal intensity (fatty degeneration).

Gradient Recalled Echo MR Imaging of the Jugular Foramen: Daniels DL, Czervionke LF, Pech P, Hendrix LE, Mark LP, Smith DF, Haughton VM, Williams AL (Medical College of Wisconsin, Milwaukee, WI 53226)

Axial T1-weighted spin echo MR images have not proven to be effective in identifying normal structures in the jugular foramen. By correlating cryomicrotomic sections and axial T1-weighted gradient recalled echo (GRE) images, we identified the neural and vascular contents of the jugular foramen in normal volunteers. Also demonstrated in GRE images were small tumors in the jugular foramina of patients with glomus tumors and neurofibromas. Further work with GRE images is needed to determine the signal characteristics of a large series of jugular foraminal lesions.

Pre-Operative Localization of the Sensory-Motor Cortex: Cohen WA, Berger MS, Ojemann GA (Univ. of Washington, Seattle, WA 98104)

Pre-operative localization of the sensory-motor cortex is often a critical issue for neurosurgical management. We have correlated intraoperative physiologic monitoring with MR examinations in order to derive a set of standard anatomic references to predict the location of these important areas. We retrospectively reviewed the scans of eight patients with tumors located in or near the sensory-motor cortex. All patients underwent MR examinations in sagittal and axial planes using multiple pulse sequences. All patients had intraoperative electrophysiologic mapping with motor cortex stimulation and electrocortography.

MR images were compared with intraoperative photographs of the mapped cortex. Careful correlation of normal anatomic landmarks as well as of tumor margins was made. Central sulcus, which was best defined on axial images near the vertex, was identified by a pair of prominent, symmetrical sulci extending from side to side. On mid-sagittal images the motor cortex was always seen anterior to the posterior-superior continuation of the cingulate sulcus. Location of sensory cortex was more variable, being found either anterior or posterior to this structure. On parasagittal MR images, motor cortex was immediately anterior to a line based on and perpendicular to the posterior-superior Sylvian triangle (posterior insular roof). At least one of these landmarks correlated with the location of Rolandic cortex in all patients. A landmark did not correlate if tumor was not visible on the pertinent slice. We feel that these landmarks will enable more precise preoperative prediction of the location of sensory-motor cortex.

Anatomic Localization of Cortical Function by Magnetoencephalography, Magnetic Resonance Imaging, and Computed Tomography: Orrison WW, Davis LE, Sullivan GW, Mettler Jr, FA, Flynn ER (Univ. of New Mexico, Albuquerque, NM 87131)

Magnetoencephalography (MEG) monitors magnetic field amplitudes which are time averages of evoked neuron responses, and can detect, characterize, and localize two separate magnetic fields emanating from the brain. The localizing ability of EEG-evoked potentials is 15-20 mm compared to the MEG potential to localize the source of a physiologic magnetic field to approximately 3 mm^3. The location of somatosensory magnetic field sources for voluntary right thumb and right index finger flexions were determined using a seven sensor neuromagnetometer inside a magnetically shielded room. These magnetic field sources were then identified on the individual's respective CT or MR, and correlation was accomplished by geometric calculations, direct skull measurement, and surface marker identification. Specific functional magnetic fields were located over the appropriate sensorimotor cortex, however there was considerable variation in the exact site. These preliminary results indicate that the traditional "homunculus" for the sensory and motor cortex may have significant anatomic variation. Clinical localization of normal and abnormal neurologic functions may require evaluation by both anatomic and physiologic neurodiagnostic modalities.

Magnetic Resonance Imaging of Compact White Matter Pathways: Curnes JT, Burger PC, Djang WT, Boyko OB (Duke Univ. Medical Center, Durham, NC 27710)

A prominent decreased signal intensity can be seen in many of the heavily myelinated, compact fiber pathways of the brain on T2 weighted magnetic resonance (MR) images (SE 2500/80). These areas include the anterior commissure, internal capsule, optic tract and radiations, fornix, mammillothalamic tract, superior frontooccipital fasciculus, cingulum, corpus callosum, uncinate fasciculus, and superior longitudinal fasciculus. All of these pathways could be identified in normal subjects age three and older, based on review of axial and coronal images at 1.5T in 50 adults and 15 children. Correlation of the in vivo and postmortem MR appearance of two brains with Perls' and luxol fast blue stained human brain sections indicates that the short T2 reflects heavy myelination and fiber density, not iron deposition. This is in contrast to the decreased T2 signal seen in the subcortical "U" fibers and deep nuclei of the brain that results from iron deposition. These pathways also differ from areas of brain iron accumulation in that 1) they may appear as areas of decreased T1 on partial saturation pulse sequences, 2) and they can be seen with regularity in all patients older than the age of three years. It is important to distinguish between the effect of the myelin sheath and the effect of brain iron on the T2 relaxation values seen in the normal brain since both result in shortened T2 relaxation. The normal MR appearance of the above named fiber pathways will be demonstrated and correlated with myelin stained sections.

The Vermis in Sagittal Plane: MR Anatomic Correlation: Press GA, Courchesne E, Murakami J, Berthoty DP, Wiley CA, Hesselink JR (Univ. of California, San Diego, CA 92103)

PURPOSE AND METHODS: To establish a detailed MR atlas of the cerebellum, 3 formalin-fixed brains and 10 normal volunteers were scanned in the sagittal plane on a 1.5-T imager. Multislice, multiecho, spin-echo pulse sequences were used to acquire 5 mm thick proton-density and T2-weighted images. The fixed brains were then sectioned sagittally. Each sagittal MR image was carefully compared with the corresponding labelled anatomic brain section.

RESULTS: The branching pattern of the main fiber tracts that extend from the cerebellar peduncles to the lobules of the hemispheres and the vermis is remarkably constant, and best delineated (in vivo) using cardiac-gated proton density (long TR/short TE) sequences with flow compensating gradient pulses. These fiber tracts serve as reliable markers for determining the identity of the major lobules (central, anterior and posterior quadrangular, superior and inferior semilunar, gracilis, biventral, tonsillar) and fissures (preculminate, primary, superior-posterior, horizontal, prepyramidal, secondary, posterolateral) that appear on any sagittal image. There is, however, definite variability in the branching pattern of the fiber tracts as they extend distally into the individual folia of the lobules. The ratio of white matter to grey matter within the vermis (WM/GM=0.29) is significantly smaller than in the hemispheres (WM/GM=0.42). The relative size and morphology of the major lobules appear to be constant. Precise mapping and quantification of normal cerebellar anatomic structures on MR images provide a useful tool for the comparison of various patient groups.

MR of Brainstem Corticospinal Tract Wallerian Degeneration: Schrodt JF, Edwards MK, Bognanno JR, Mulry CC, Rippe DJ, Lucas DE, Kuharik MA (Indiana Univ., Indianapolis, IN 46223)

Five hundred and seventy-eight high field MR studies of the brain were retrospectively examined for evidence of corticospinal tract Wallerian degeneration within the brainstem. Of these, 11 exams revealed abnormalities within the brainstem in patients with hemispheric encephalomalacia and chronic infarction. Both the signal characteristics and bilateral symmetry of the brainstem were examined and graded. A correlation between the size and location of the hemispheric lesions and the presence or absence of brainstem abnormalities was found. Ipsilateral brainstem atrophy was present in all cases when the areas of infarction and encephalomalacia involved the anterior division of the middle cerebral artery in the region of the primary motor cortex or the region of the posterior limb of the internal capsule. Only four cases demonstrated ipsilateral areas of increased signal on T2 weighted images within the brainstem suggesting gliosis. In these, the abnormal signal areas were small, scattered, and discontinuous. In no case was there a continuous, long segmental band of abnormal signal corresponding to the pathway of the corticospinal tract. The absence of this finding probably relates to the age and chronicity of the hemispheric lesions and to the histochemical stage of Wallerian degeneration within the fiber tract.

Magnetic Resonance Imaging an Animal Model of CNS Wallerian Degeneration: Rafto SE, Wallace SF, Grossman RI, Rosenquist AC, Kundel HL (Univ. of Pennsylvania School of Medicine, Philadelphia PA. 19104)

The central visual connections of the cat are among the best documented of any mammalian central nervous system. The corticofugal visual pathway of the cat is being used as a model for studying Wallerian degeneration with MR. A method has been developed to reliably and accurately position each cat in our 1.9T magnet in exactly the same stereotaxic plane used in neuroanatomical studies. This facilitates comparison between multiple imaging sessions on each animal, and with histologic tissue. Imaging is

performed with a modified double saddle receive-only cat head coil, 256 x 256 matrix over a 4.95 cm field of view, and 2.5 mm slice thickness.

We have studied 9 animals following unilateral visual cortical aspiration. These animals demonstrate an area of well defined hypointensity on long TR/TE (3500/20 & 80 msec) spin echo (SE) images remote from the surgical site and along the course of corticofugal fibers from the lesion. This abnormal signal has a definite time dependence. In 5/5 animals imaged between 2 and 6 weeks following surgery it is prominent, but has not been demonstrated before 2 weeks (3/3 animals). In addition, it is not a permanent signal change. In 6/6 animals it is again inapparent by 12 to 15 weeks post-op. Histology in 3/3 animals has confirmed that the area of signal abnormality corresponds to degenerating axons and glial proliferation in the visual corticofugal fiber tract. No parenchymal signal abnormality has been noted at any time on short TR/TE (600/20) SE images, and no alteration of the blood brain barrier along the degenerating fiber tract using Gadolinium DTPA (Berlex; 0.1 mmol/kg) has been noted (2/2 animals). One animal used as a surgical control (craniotomy and durectomy) has retained normal parenchymal appearance.

We are continuing our studies to improve imaging of the degenerative process, better document its time course in this fiber system, and identify which cellular or chemical component of Wallerian degeneration is responsible for the signal alteration now seen.

Wallerian Degeneration and Inflammation in the Rat Peripheral Nerve Detected by in vivo MR Imaging: Titelbaum DS, Frazier JL, Grossman RI, Joseph PM, Yu LT, Kassab EA, Hickey WF, Brown MJ (Univ. of Pennsylvania, Philadelphia, PA 19104)

An animal model of peripheral nerve injury was studied by in vivo MR imaging. Proximal tibial nerves in Brown Norway rats (BN) were either crushed, transected (neurotomy), or transected and grafted with Lewis rat (allograft) or BN (isograft donor nerves. The nerves distal to the site of transection or crush were imaged at varying time intervals from 0-54 days following surgery. Subsequent histologic analysis was obtained and correlated with MR findings. On long TR/TE sequences, allograft and isograft rats (followed to 30 days) showed similar discrete high signal intensity along the course of the tibial nerve corresponding to edema and demyelination from Wallerian degeneration. Pathology of allografts also revealed intense inflammation. Neurotomy rats (followed to 54 days) showed similar high signal along the nerve which resolved between 45-54 days, when a quiescent degenerated nerve was seen at pathology. Animals with crush injury showed maximal high signal at 15 days, with resolution by 30 days, corresponding to clearing of myelin debris. These changes were not seen in sham operated rats. Our findings suggest that MR is capable of identifying peripheral nerve traumatic neuropathy with subsequent Wallerian degeneration, and that the severity of injury appears to correspond to duration of signal abnormality. MR may not be able to distinguish inflammatory from traumatic neuropathy.

Neuroanatomic Mapping of Corticofugal Tracts in the Internal Capsule and Brainstem on MR Images by Wallerian Degeneration: Kuhn MJ, New PFJ, Davis KR (Massachusetts General Hospital, Harvard Medical School, Boston, MA 02114)

Precise localization of the corticospinal, corticopontine and corticobulbar tracts and their subdivisions may be achieved by MR imaging. Signal change in these tracts can be clearly identified through Wallerian degeneration, thus allowing for MR mapping of axonal pathways. The MR images of thirty patients who demonstrated Wallerian degeneration in the brain were coupled with clinical and pathologic findings to produce functional topographic representations of the corticofugal pathways as they course through the internal capsule and brainstem. Although large infarcts in the motor cortex tend to cause degeneration in the entire corticospinal (pyramidal) tract, smaller lesions often result in degeneration confined to a specific functional portion of this tract. For example, a small infarct confined to the medial portion of the precentral gyrus causes signal change only in the portion of the corticospinal tract containing axons to the lower extremity. In this manner, functional units of the entire corticospinal tract may be separately identified.

Since they lie on opposite sides of the crus cerebri, the frontal corticopontine tract can be readily distinguished from the parieto-temporo-occipital corticopontine tract. The regular and aberrant corticobulbar tracts can also be separately identified by Wallerian degeneration.

Experimental Carotid Angiography and the Blood-Brain Barrier: A Histological Assessment Using HRP: Wilson AJ, Sage MR (Flinders Univ., Bedford Park, South Australia 5042)

Intracarotid injection of contrast media may result in blood-brain barrier (BBB) breakdown. Previous methods of demonstrating BBB breakdown as a consequence of carotid angiography have either been relatively insensitive, or have tended to underestimate the degree of breakdown. In this study, a histological technique was used to compare the effects on the BBB of carotid angiography with methylglucamine iothalamate (MGI) and iopamidol. The protein horseradish peroxidase (HRP) was used as a vascular tracer, and this was visualized histochemically for both light microscopy (LM) and electron microscopy (EM).

MGI, iopamidol (both 280mgI/ml) or physiological saline were infused via a catheter, into the left internal carotid artery of rabbits at 5ml/min for 30 sec., followed immediately by an infusion of HRP. Seventy seconds later, the brain was perfused with fixative, also via the catheter. Coronal Vibratome sections were cut at regular intervals through the rostral left hemisphere, HRP was visualized, and sections were processed for LM or EM.

By LM, HRP extravasation in saline-injected brains was confined to small amounts in the walls of rare, large, penetrating vessels. In MGI-injected brains, extravasated HRP was seen mostly in the walls of numerous short, branching segments of vessels, and occasionally in large, dense, circular fields. In iopamidol-injected brains there was an appearance similar to that after MGI, except that the frequency of disrupted vessels was lower. Morphometric analysis of equivalent regions of the parietal cortex from 5 MGI-, 5 iopamidol-, and 2 saline-injected brains yielded disrupted vessel densities of 6.14mm^2, 2.73/mm^2 and 0.17/mm^2 respectively. By EM, HRP was found in the basement membrane of disrupted vessels, but was not found within endothelial cells or in interendothelial spaces. Frequent enlarged interendothelial spaces were seen, suggesting a paracellular rather than a transcellular route for HRP extravasation.

This study shows that, although iopamidol causes less BBB damage than does MGI after experimental carotid angiography, it nevertheless produces a measurable degree of BBB breakdown under the conditions employed.

The Effect of Contrast Medium Viscosity on the Blood-Brain Barrier Following Intracarotid Injection in the Rabbit: Wilson AJ, Sage MR, Evill CA, Wilcox J (Flinders Univ., Bedford Park, South Australia 5042)

Contrast medium (CM) viscosity has been proposed as a possible factor in blood-brain barrier (BBB) disruption following carotid angiography.

In this study, test solutions were injected into the internal carotid arteries of rabbits and the degree of BBB disruption was assessed using 99mTc-pertechnetate and Evans blue as quantitative and qualitative markers, respectively. The seven test solutions consisted of basic solutions of physiological saline, iopromide, or meglumine iothalamate (MGI) plus solutions derived from these by the addition of sufficient gelatine to augment their viscosities considerably. Each solution was injected into the left internal carotid artery of a group of 10 rabbits, at a rate just sufficient to clear an exposed pial vessel for 30 seconds, resulting in injection volumes which varied inversely with viscosity. The high viscosity MGI solution was also injected into a further group of 10 rabbits as a fixed dose, equal to the mean injection volume of the low viscosity MGI group, without regard to the time taken. The mean injection time of this eighth group was 52 seconds. Immediately after the test solution injection, Evans blue and 99mTc-pertechnetate were injected intravenously. Thirty minutes later, animals were killed, their brains removed and assessed for Evans blue staining and pertechnetate uptake in the left hemisphere.

Analysis of variance indicated no significant differences ($p > 0.05$) between the three saline groups, between the two iopromide groups or between the two MGI groups injected over 30 seconds, on the basis of pertechnetate uptake. The lack of

significant difference between these groups was also found with Evans blue staining. A significant difference ($p < 0.05$) was found between the MGI group and the group injected with the fixed dose of high viscosity MGI.

These results indicate that, under the study conditions, CM viscosity, either by itself or as a consequence of its association with hyperosmolality, has no significant effect on the BBB. However, under conditions of constant injection volume, higher viscosity solutions may require increased injection times, and this may lead to increased BBB disruption.

3DFT MR Angiography of Carotid Artery Disease: Waqle WA, Dumoulin CL, Souza SP, Cline HE, Eames FA, Hart HR. (Albany Medical Center, Albany, NY 12208 and General Electric Corporate Research & Development Center, Schenectady, NY 12301)

Magnetic resonance phase contrast and three dimensional Fourier transform (3DFT) angiography were performed on 6 normal volunteers and 10 patients with known carotid artery stenosis, occlusion or dissection. Following localization of the carotid artery bifurcation using phase contrast angiography, 2 sets of 64 contiguous 1.25 mm axial images are obtained in 20 minutes. In the first of the two data sets, no saturation pulse is applied and both arteries and veins appear bright, in the second set, a saturation pulse is applied and the arteries appear black. By subtracting data from these 2 sets, only the arteries are contrasted. The flow data can be retrospectively used to calculate 3D images of the luminal surfaces of the carotid arteries, giving a "dye-cast" appearance. A study of the cervical carotid arteries can be completed in less than 1 hour, is totally non-invasive and uses a 1.5 Tesla magnet (Signa, GE).

In the non-saturation technique, areas of stenosis appear hypointense relative to the residual lumen, and in the cases of total occlusion the entire lumen is hypointense and the cross-sectional diameter is decreased due to absent flow. In the saturation technique, areas of stenosis are hyperintense relative to the residual lumen and in a case of spontaneous bilateral carotid artery dissection the thickened artery wall appeared hyperintense and followed a helical course while the lumen was circumferentially narrowed.

Limitations include the relatively small field of view (20 cm) and a large data set which occupies at least 140 image spaces on the disk. All of the cervical carotid artery lesions present on angiography could be detected with the 3DFT technique.

MR Angiography of Carotid Artery Stenoses: Wright AM, Sayre J, Enzman D (Stanford Univ. Medical Center, Stanford CA 94305)

Several techniques have been described for obtaining angiographic images of blood vessels with MR. All of these methods depend on receiving a coherent signal from the moving blood within a vessel. As long as the flow through the vessel is well-behaved, standard techniques for flow compensation of the gradient waveforms may be employed to minimize signal loss due to phase shift. However, with turbulent flow through stenoses, these techniques are not adequate and signal loss occurs.

We have developed a method for imaging with extremely short TE pulse sequences, with TE in the range of 2-5 msec. A gradient-recalled echo is used, with the echo occurring very early in the read gradient, instead of at the center. Compared with a standard velocity-compensated sequence, this results in a reduction in the second moment of the read gradient by a factor of approximately 500. Theoretical analysis using published data on velocity distributions downstream from stenoses suggests that this sequence will successfully image even severely disturbed flow. Phantom experiments have been performed which confirm the theoretical predictions, and we have successfully imaged highly turbulent flow through stenoses at velocities > 4m/sec. Using a pre-saturation technique, projection images of carotid bifurcation stenoses in humans have been obtained, demonstrating that signal loss due to turbulence can be virtually eliminated.

MR Angiography Of The Intracranial Circulation: Ruggieri P, Laub G, Masaryk TJ, Lenz G, Ross JS, Tkach J, Haacke EM, Modic MT (Univ. Hospitals of Cleveland, Cleveland, Ohio 44106)

The purpose of this study was to devise and test a 3D MR angiography technique for evaluation of the intracranial vessels. Evolution of the technique was based on comparative studies of various pulse sequence parameters and normal volunteers. The following represents an acceptable compromise of tissue contrast, spatial resolution, and exam time: 1) transmit and receive head coil (flow related enhancement); 2) TE 10-14msec (time for compensation gradients vs decreased phase dispersion); 3) TR25-50msec (exam time vs signal-to-noise and flow related enhancement); 4) a flip angle 15 degrees (vascular vs soft tissue contrast); 5) axial volume acquisition 32-64 partitions 1.0-1.25mm partition thickness (exam time and flow related enhancement vs spatial resolution and signal-to-noise); 6) data processing utilizing a ray tracing algorithm and threshold technique (multiple views without subtraction). Methodology was then kept constant to define applicability and limitations in both normals (n=8) and clinical cases (Aneurysms n=9, AVM n=5, Arterial Occlusion n=5, Dolichoectasia n=2, Neoplasm n=2, and Hydranencephaly n=1). Good visualization of the vertebrobasilar system, circle of Willis, and first order arterial branches was obtained in 74% of patients. Limitations included patient motion, limited field of view, persistent phase dispersion (higher order of motion, magnetic susceptibility), and inadequate flow related enhancement (slow flow secondary to dilated vessels or poor cardiac output). Nevertheless, the initial results of this ongoing study indicate that 3D MR angiography of the intracranial circulation is reproducible in normal subjects as well as patients. Potential applications include screening studies for intracranial aneurysms, preoperative planning, and potentially monitoring of vasospasm secondary to subarachnoid hemorrhage. Additionally, changes in signal intensity due to variability in cardiac output or blood velocity may be solved with improvements in gradient refocusing, shorter echo times, or an intravascular paramagnetic contrast agent.

Pre-Saturation Techniques in Vascular Thrombosis: Evaluation in a Flow Phantom and in a Clinical Series: Sze G, Johnson CE, Krol G, Deck MDF (Memorial Sloan-Kettering Cancer Center, New York, NY 10021)

The effect of pre-saturation techniques in the evaluation of vascular thrombosis was examined in a flow phantom and in a clinical series. All imaging was performed on a 1.5 T unit. Pre-saturation or similar sequences to eliminate flow-related enhancement (FRE) were performed in addition to routine short TR sequences. A flow phantom was constructed by imaging liquid ($Cu\text{-}SO_4$ treated water) pumped through tubing at various speeds. Clinical correlation was obtained by imaging fifteen cases of suspected vascular thrombosis, especially dural sinus thrombosis.

In the flow phantom the specialized sequences eliminated FRE, replacing artifact with slightly hypointense signal but not with signal void. In the clinical cases, the success of pre-saturation techniques in evaluating suspected thrombosis depended on whether the clot was hyperintense or hypointense, perhaps related to the chronicity of the thrombus. The specialized sequences could differentiate hyperintense clot from FRE. However, clot was often slightly hypointense or isointense. In these cases, pre-saturation techniques did not help since elimination of FRE resulted in the intravascular signal similar to that of clot.

Conclusion: In cases of suspected vascular thrombosis, pre-saturation techniques will only help exclude hyperintense thrombosis. In cases with hypointense or isointense thrombus, other methods, such as gradient echo imaging or phase reconstructions, will be necessary.

Differential Flip Angle (DFA) CSF Flow Imaging: Rubin JB, Wright A, Enzmann DR (Stanford Univ. Medical Center, Stanford, CA 94305)

Two new approaches to rapid CSF flow imaging are described. The first method (sagittal DFA) provides a qualitative flow map of CSF in the sagittal projection sensitive to pulsation amplitudes as small as a fraction of one millimeter. In this technique, acquisition of two short TR gradient echo (GRASS) images with different flip angles provides a motion insensitive and motion sensitive pair from which

a normalized subtraction yields a CSF flow map of in-plane CSF motion. The second method (axial DFA) provides a quantitative flow map of CSF in the axial projection accurate over the wide range of physiological CSF motion. In this technique, acquisition of two or three GRASS images with different flip angles permits calculation of "effective TR prolongation" and average pulsation amplitude from either regions of interest or entire images. Both techniques are based on a mathematical model of GRASS imaging which incorporates flow effects, relaxation parameters, imaging parameters, and physiological parameters. These techniques were validated in a CSF flow phantom and 8 normal volunteer cervical spines. Preliminary clinical evaluation of CSF motion has been performed in 23 patients in the normal spinal and cranial CSF pathways and in a variety of pathological conditions including spinal block secondary to herniated disk, syrinx cavity, arachnoid cyst, normal pressure hydrocephalus, and obstructed cerebral acqueduct.

Hyperdynamic Intraventricular CSF Flow States: A Consequence of Dilation of the Cerebral Aqueduct. Whittemore AR, Bradley WG, Jinkins JR (Huntington Medical Research Institutes, Pasadena, California 91105)

In some cases of communicating hydrocephalus, MR images demonstrate CSF flow void sign covering the dilated third and fourth ventricles as well as the aqueduct, indicating that there is more than the usual amount of pulsatile, intraventricular CSF flow. This has led to speculation over the significance of this finding. To better understand the dynamics of pulsatile CSF flow and to determine the cause of hyperdynamic intraventricular CSF flow states, we constructed conceptual and mathematical models. Four physiological parameters affecting the amplitude of CSF pulsations were identified: (1) resistance to flow through the ventricles, (2) the ratio of arterial and venous resistances of the brain, (3) mechanical compliance of the brain, and (4) the arterial pulse magnitude. A semiquantitative analysis of these parameters shows that variations in (2) - (4) are unlikely to produce a significant effect. However, resistance to flow through the ventricles is an important factor and is primarily determined by the aqueduct, the resistance of which decreases rapidly as its dimensions increase. We analyzed MR images of 5 patients with hyperdynamic intraventricular CSF flow and found an important common feature, dilation of the aqueduct. By applying the laws of hydrodynamics to aqueductal dimensions extracted from these images, we estimated the aqueductal resistance to be reduced to 1/12-1/44 of normal. This reduction explains the observed increase in pulsatile intraventricular CSF flow. We conclude that the hyperdynamic intraventricular CSF flow associated with some cases of advanced communicating hydrocephalus is secondary to dilation of the aqueduct.

Effects of Field Strength on CSF Motion Artifacts: Rubin JB, Solomon MA, Enzmann DR (Stanford Univ. Medical Center, Stanford, CA 94305)

The purpose of this study was to evaluate the dependence, if any, of CSF motion artifacts on MR field strength. A normal volunteer's cervical spine and an oscillatory CSF flow phantom were imaged at three field strengths: 0.35T, 0.38T, and 1.5T. Conventional spin-echo T2 weighted images were compared with motion compensated spin-echo T2 weighted images using either cardiac gating, flow compensated pulse sequences, or a combination of the two on each imager. The CSF flow phanton simulated CSF motion within the cervical spine (pulsation amplitude: 10 mm, pulsation period 1060 msec), providing an objective comparision of the effects of this type of motion at each field strength. The volunteer's cervical spine allowed the clinical significance of the flow effects and the efficacy of motion compensation at each field strength to be determined. No field strength dependence of CSF motion artifacts was observed on phantom images which revealed prominent flow effects at each field strength. Similar findings were observed on the clinical images at each field strength. Furthermore, the application of CSF motion compensation techniques at 0.35T and 0.38T reduced CSF motion artifacts and markedly improved T2 weighted image quality. These data suggest that CSF motion artifacts are prominent enough at all the field strengths studied (0.35T - 1.5T) to warrant application of CSF motion compensation techniques (cardiac gating and flow compensated pulse sequences).

Difficult Clinical Pituitary Lesions Evaluated by Gd-DTPA MR Imaging: Joy SE, Kido DK, Woolf PD, Nelson CN, Plewes DB, Manzione JV (Univ. of Rochester Med. Ctr., Rochester, NY 14642)

Gd-DTPA MR imaging of the pituitary gland was performed in the following situations: (1) patients with normal and inconclusive CT scans but with abnormal serum hormonal assays, (2) patients with previous transphenoidal surgery in whom tumor recurrence is suspected and, (3) patients with possible cavernous sinus invasion. High resolution contrast CT imaging failed to address these concerns conclusively. A total of six patients in whom pituitary tumors were suspected (evenly divided with respect to the absence or presence of prior surgery) were entered into the study. All patients had immediate pre- and post-gadolinium T_1 weighted 3 mm coronal and sagittal images using 16 cm field of view (standard technique). A comparison of the standard technique with imaging obtained using bilateral surface coils and high resolution imaging was performed as an adjunct in three other patients.

In three of six patients with suspected pituitary tumor gadolinium-MR (G-MR) was better than contrast CT (C-CT) with respect to delineating the tumor. In one patient G-MR identified cavernous sinus invasion, which was not identified by C-CT. In no instance was C-CT better in delineating the tumor. The standard technique for imaging of the pituitary was preferred over the other methods.

Efficacy and Safety of Gd-DOTA Used In Neuroradiological MR: Kien P, Allard M, Bonnemain B, Caille JM (Service de Neuroradiologie - Groupe Hospitalier Pellegrin - 33076 Bordeaux, France)

The safety and efficacy of Gd-DOTA enhanced magnetic resonance were evaluated in nineteen patients with central nervous system lesions with the following incidence: 9 intraspinal tumors with 5 intramedullar and 4 extramedullar intradural; 10 intracranial diseases with 4 neurinomas, 4 meningiomas, 1 glioma and 1 ischemic accident. All MR studies were done at 0.5 Tesla, before and after injection of 0.1 mmole/kg of Gd-DOTA. No premedication was given. The pre-contrast images were both T1 and T2 weighted (T1:26/500; T2:50/2000, 3 echoes). The post-contrast T1 weighted sequences were performed in the three spatial planes (26/500). Neural tolerance was assessed by analysis of spontaneous and hyperpnea-activated electrical brain activity (EEG recorded on an 8-channel portable electroencephalography with bipolar derivation). Recordings were performed before and 1 hour after administration of Gd-DOTA. Coagulation studies were repeated 2 and 12 hours after injection of Gd-DOTA. Patients were observed during the MR scan and questioned about side effects at the end of the MR scan and 24-48 hours later.

Contrast enhanced MR with Gd-DOTA in all patients who took part in this clinical trial significantly improved the visualization of CNS pathologies. After administration of contrast medium, EEG recordings did not show any modication; in particular, there appeared neither slow waves nor paroxysmal events. There was no significant change in blood coagulation and no side effects were encountered. In conclusion, this study demonstrated the excellent tolerability and clinical efficacy of Gd-DOTA in neuroradiological MR.

Gd-DTPA Enhanced 3-D FLASH of the Brain: Runge VM, Nelson KL, Wood ML, Traill MR, Kaufman DM, Wolpert SM (Tufts Univ.-New England Medical Center Hospitals, Boston, MA 02111)

Gd-DTPA enhanced 3-D FLASH examination was performed in 24 patients with intracranial space occupying lesions. Seven meningiomas, 2 acoustic neuromas, 1 glomus tumor, 1 juvenile angiofibroma, 1 chordoma, and 4 presumed metastases were included. Scan time varied between 5 and 15 minutes, with a slice thickness of 1.0-2.0 mm. The flip angle was set at 40-50 degrees to maximize T1 contrast. Imaging was performed on a Siemens 1.0 Tesla Magnetom with data processing on a KONTRON Mipron workstation.

Gd-DTPA enhancement on 3-D FLASH is at least equal to that observed on short spin echo techniques (TR/TE=0.6/20). Enhancement of arterial and venous structures has markedly improved with a combination of Gd-DTPA and 3-D FLASH. For example, the vertebral basilar system and internal carotid arteries were consistently enhanced on post Gd-DTPA 3-D FLASH. Acquisition of 1 mm. contiguous slices through the entire brain permits reformatting of equal resolution images in any arbitrary plane. Experimental work is currently being pursued in tissue segmentation and surface modelling. For ease of viewing 10 mm. thick sections can also be created by addition of 10 contiguous 1 mm. reformatted images.

3-D FLASH with Gd DTPA enhancement is being developed to replace routine T1 weighted spin echo scans. Thin (1 mm.) high resolution scans can be obtained in any arbitrary plane from a single 10 min. acquisition. This obviates the problem of localization of intracranial masses and identification of their precise relationship with nearby anatomical structures.

Effects of Gadolinium Complexes on Spinal Cord Cell Cultures: Allard M, Simonnet G, Dupouy B, Doucet D, Caille JM (Service de Neuroradiologie-- Groupe Hospitalier Pellegrin - 33076f Bordeaux - France)

In various tissues, gadolinium (Gd^{3+}) has been shown to modify calcium-influx-related metabolic functions and to block the binding of calcium to the plasma membrane. The question arises as to whether magnetic resonance (MR) contrast media are able to interact with plasma-membrane calcium binding sites or calcium channels. The object of this study was to investigate the possibility of a fixation of gadolinium at the neuronal cell surface and/or its penetration inside the cell. To distinguish the effect of ionic gadolinium from that of complexed gadolinium and to improve sensitivity, we used radioactive compounds: MR contrast media were labeled with gadolinium 153 (γ) or carbon 14 (β). In all experiments cultured mouse spinal cord cells were used. The techniques of preparing dissociated cell cultures have been previously described by Allard et al (J Neurochem 1987, 48:1553-1559). Cells were plated in falcon plastic tissue culture dishes 3.5 mm diameter at a density of 2 x 10^6 cells/dish in 1.5 ml of nutrient medium at 37° C. After 8 days, cell cultures were incubated for 5 days in 0.5 ml of nutrient medium containing 0.3 μ Ci of DTPA (153) Gd or DOTA (153) Gd (at a final concentration of 50 nM) or 0.4 μ Ci of (^{14}C) DTPA Gd or (^{14}C) DOTA Gd (at a final concentration of 50 nM). Then, the supernatant was transferred into vials to quantify radioactivity. Each well was rinsed twice with 200 μ l of medium, then the radioactivity of the pellet was measured.

The structural integrity of the cells was assessed by a morphological criterium and the leakage of cytoplasmic lactate dehydrogenase. After incubation in the presence of Gd complexes in these conditions, the cell morphology was maintained.

About 1% of the total radioactivity (β and γ) was found in the cellular pellet. In the presence of Ouabaïne, a cellular uptake inhibitor, the radioactivity found in the pellet is unchanged.

This result shows that gadolinium complexes do not penetrate the cell. So, in these conditions, gadolinium complexes interact with the membrane of spinal-cord cells, but they do not penetrate these cells.

N-Butyl Cyanoacrylate for Embolization: Comparisons In Vitro and In Vivo with Isobutyl cyanoacrylate: Brothers MF, Fox AJ, Deveikis JP, Kaufmann JCE, Lee DH, Pelz DM (Univ. of Western Ontario, London, Ontario, Canada NoA 5A5)

Despite the development of new alternative embolic agents, the endovascular treatment of brain AVM continues to require frequently the use of cyanoacrylic glue, especially in situations where particulate or sclerosing agents are ineffective such as when flow is very rapid or fistulous. Because isobutyl-cyanoacrylate (IBCA), the most commonly used embolic glue, is no longer available or manufactured, a real need for an alternative fast polymerizing agent exists.

In vivo and in vitro studies were performed to compare IBCA with n-butyl cyanoacrylate (NBCA, supplied as Histoacryl Blue), a tissue adhesive approved for surgical use in some countries. Polymerization time in static plasma was compared and the effect of the addition of iophendylate oil or glacial acetic acid on polymerization was assessed. Polymerization time in vivo was compared following intraarterial injection of the internal carotid artery in pigs using a standardized technique. The histopathologic reaction to each glue in the embolized pig rete was assessed and compared from 0-60 days postembolization.

Our results show that while NBCA polymerization is demonstrably faster than IBCA in vitro, intraarterial injections of a standardized ratio mixture of glue with iophendylate show no significant difference in "effective" polymerization time. Like IBCA, NBCA polymerization can be predictably prolonged by addition of glacial acetic acid. Iophendylate had little effect on NBCA polymerization, compared with its marked effect on IBCA. Histopathologic reactions were similar. We therefore conclude that NBCA should be an acceptable alternative to IBCA for intravascular use, with certain modifications in technique.

A Thrombotic Mixture as a "Polymerizing" Agent: Fox AJ, Lee DH, Pelz DM, Brothers MF, Deveikis JP (Univ. of Western Ontario, London, Ontario, Canada N6A 5A5)

Avitene, a microparticle collagen material, mixed with Ivalon (PVA) and suspended in a solution of ethanol and contrast has properties that are promising as an embolization material. As a rationale, the Avitene is a thombotic agent that acts similar to a polymerizing substance; the Ivalon can act as a template for scarring; the ethanol is a sclerosing agent; the contrast medium allows it to be seen radiographically.

This mixture can "polymerize" in a nidus being embolized and won't block the feeder like acrylic glues. Multiple injections are possible through the same catheter without clogging. The catheter cannot be glued to the artery. However this mixture cannot block some rapid arteriovenous shunts which can be blocked by glue.

We have treated 39 patients at University Hospital in London, Ontario with various lesions for embolization using Avitene with one or more of the other additives, performing 53 embolization procedures. This material is an ideal embolization substance to be used with microcatheters without leak balloons such as the Tracker catheter system. The discipline of embolization using this material, especially in the brain, is much more relaxed and efficient than embolization with acrylic glues, except where rapid arteriovenous shunts predominate. Our case material includes brain AVM cases with late follow up angiography showing partial recanalization of nidus as we have seen with acrylic glue. This suggests that for brain AVMs surgery should promptly follow embolization.

Ivalon-33% Ethanol-Avitene Embolic Mixture: Clinical Experience With Neuroradiological Endovascular Therapy In 40 Arteriovenous Malformations: Dion JE, Vinuela FV, Lylyk P, Lufkin R, Bentson J (Univ. of California, Los Angeles, CA 90024)

A mixture of particles of polyvinyl alcohol foam (Ivalon) (140-250 microns), 33% ethanol and microfibrillar collagen (Avitene) was shown by Lylyk, et al to be an effective and permanent embolic agent in the internal carotid rete mirabile of the swine; it is easily embolized through micro catheters such as the Tracker catheter.

Following these experiments, the authors performed 60 embolization procedures in 40 patients using this same mixture, or at least 2 of its elements (sodium sotradecol was substituted for 33% ethanol in 6 instances). Case material included 16 brain AVMs, 6 dural AVMs, 15 facial, head and neck AVMs, 1 epistaxis, and 2 venous hemangiomas. This mixture produces thrombosis of medium and small size vessels reaching the nidus of AVMs, shown histologically to be permanent up to 7 weeks in the case of brain AVMs operated after that delay. Intermediate follow-up (3-6 months) on lesions of the face and neck which were not treated by surgery showed that some recanalization occurred in a small percentage of cases, especially when all 3 component of the mixture were not used. Long term results are not yet available. In facial venous hemangiomas, substitution of ethanol for sotradecol was effective and painless.

The advantages of this mixture include: readily available ingredients which are technically easy to prepare and use; well controlled gradual embolization, repeatable many times via the same catheter without gluing it in place; ability to use other embolic agents through the same catheter; decreased risk of venous outlet and pulmonary embolization.

The authors conclude the following: in brain AVMs, no recanalization occurred on short and intermediate follow-up; there was a need to use IBCA in conjunction with the mixture in approximately 1/3 of cases because of the presence of fistulas or inability to inject the mixture through catheters less than 2.2F; in the external carotid system, some recanalization occurred on intermediate and long follow-up especially when all 3 agents were not used together. This mixture is superior to either agent alone and is a useful and versatile addition to the endovascular therapy armamentarium.

Cryoprecipitate Admixtures : In vitro testing as an embolic agent: Luedke MD, Pile-Spellman JMD, Huggins CE, Davis KR, Chin JK, (Depts. of Radiology and Surgery, Massachusetts General Hospital, Boston, MA 02114)

An ideal embolic agent would be biocompatable, easy to use, permanent or lysable, and universally available. We believe that cryoprecipitate admixtures may be such an agent. Cryoprecipitate is a blood product high in factor VIII and fibrinogen. Typically it has been used in hemophiliacs and more recently as a surgical tissue adhesive. When mixed with thrombin, cryoprecipitate forms a clot. As an embolic agent we must be able to alter the clotting time, clot density, radiodensity, thrombin excess, permanence and lysability of this compound. In vitro testing of the cryoprecipitate was performed which included: clotting time vs: thrombin concentration, fibrinogen concentration, ionic and non-ionic contrast concentration; as well as additives (GAX, Avitene, PVA). Solubility of the clot with Urokinase was also tested.

It was found that clotting time could be altered from less than one second to greater than ten minutes by altering the thrombin concentration. The density of the clot also varied dependent upon the thrombin concentration. Fibrinogen dilution changed the nature of the clot but did not alter the clotting time over a dilutional range to the second order. An ionic contrast agent (Iothalamate Meglumine 60%) shortened the clotting time, whereas a non-ionic contrast agent (Iopamidol 61%) markedly lengthened clotting time with respect to the fibrinogen vs thrombin dilution curve. Collagen admixtures were made which included GAX (a non-antigenic collagen) and Avitene. Avitene seemed to produce a slightly denser clot whereas GAX and PVA, (a plastic polymer) did not seem to alter clot density. Lysability of the clot was possible with Urokinase which was dependent upon clot size and density. Thrombin excess was evaluated by mixing the residual supernatant of the clot with fresh cryoprecipitate. This demonstrated that the presence of residual thrombin was only a problem at higher thrombin concentrations.

Platinum Wire: A New Transvascular Embolic Agent: Yang PJ, Halbach VV, Higashida RT, Hieshima GB, Seigel RS (Univ. of California at San Francisco, San Francisco, CA 94143)

Super-selective catheterization has been facilitated by the development of new microcatheter systems. Standard Gianturco or "mini" coils cannot be utilized with these systems. However occasions arise in which metallic coils would be an ideal embolic agent in a vascular structure accessible only to a tracker (Target Therapeutics) catheter system.

We have performed ten embolization procedures in nine patients with arteriovenous fistulas utilizing platinum wires as an embolic agent. The wire is obtained from the tips of .014-.016 steerable guidewires. Complete occlusion of the fistula occurred in six of ten cases. In several cases, platinum wire embolization was augmented with other agents. Complications occurred in two cases, neither resulting in permanent neurological deficits.

Advantages of using platinum coils include availability, radiopacity, thrombogenicity, and most importantly, the ability to deliver the embolic agent through present microcatheter systems.

Synthetic Fiber-coated Platinum Coils Successfully Used for the Endovascular Treatment of Arteriovenous Malformations, Aneursyms and Direct Arteriovenous Fistulas of the CNS: Hilal SK, Khandji AG, Chi TL, Stein BM, Bello JA, Silver AJ (Neurological Institute, New York, NY 10032)

Platinum coils coated with synthetic fibers were used to embolize vascular lesions through a "Tracker" catheter system to treat 56 patients with the following lesions: a) large supratentorial convexity AVMs; b) AVMs of the basal ganglia with selective embolization of the distal anterior choroidal artery and distal lenticulostriate arteries; c) deep arterial aneurysms of the lenticulostriate arteries; d) arteriovenous malformations of the posterior fossa with distal embolization of the ICA and superior cerebellar arteries; e) spinal cord arteriovenous fistulas with two lesions distal to the conus; f) aneurysms of the anterior spinal artery; g) venous aneurysms supratentorially; h) vertebro-venous fistulas in the neck. The exceptional and somewhat unexpected success of this work and its safety has prompted this report. A large number of the cases were followed by surgical exploration, a factor which gave us the opportunity to study the thrombogenecity of a variety of coil materials such as stainless steel, gold, bare platinum coils and the fiber-coated platinum coils. The correlation of the surgical findings on the thrombogenecity of these coils and the histological confirmation will be presented. The pattern of clot formation was primarily around the synthetic fiber. Bare coils produced little clots and the adjacent vessel wall remaining histologically uncompromised. The practical advantage of these coils is that they don't migrate, they do not reflux back into the main artery as may happen with liquid embolic material and when deposited in an aneurysm they don't deflate. They can be deposited with excellent control forming a "platinum cast" of the abnormal vessels. They represent an excellent preoperative treatment for most cases and even the only treatment for others.

An Analysis of Technical Failures and Complications in Endovascular Intra-aneurysmal Balloon Embolization Therapy: Deveikis JP, Fox AJ, Pelz DM, Lee DH, Brothers MF (Univ. of Western Ontario, London, Ontario, Canada N6A 5A5)

Recent reports have shown that endovascular intra-aneurysmal balloon embolization is a safe and effective method for treating certain intracranial aneurysms. Advances in the development of a water-soluble polymerizing agent, 2-hydroxyethyl-methacrylate (HEMA), have revolutionized the field, ushering in a new era for this technique. In our experience with intra-aneurysmal balloon embolization therapy pre-HEMA and in our early experience with the technique using HEMA, we encountered a number of technical difficulties and complications. Selected cases illustrating the technical failures and complications encountered in our experience with this technique are analyzed.

In our experience we encountered such difficulties as the inability to position the balloons within the aneurysm, as well as persistant patency of portions of the aneurysm lumen. Various complications, most commonly transient neurological deficits, were seen. Less commonly, we encountered such serious complications as aneurysm rupture, persistent neurological deficits, and even death in one case. The likely causes of these technical problems and complications are discussed. Modifications and improvements in technique are suggested.

Preoperative Embolization of Cerebellar and Spinal Hemangioblastomas: Eskridge JM, Scott JA (Univ. of Washington, Seattle, WA 98195)

Hemangioblastomas are difficult to resect due to their hypervascularity. Preoperative embolization of two cerebellar and two spinal hemangioblastomas was performed to see if this would facilitate surgical removal. Embolization was performed using the Tracker™ catheter from Target and polyvinyl alcohol (PVA) particles. In all four cases we devascularized the tumor niduses without obliterating adjacent normal vessels. Superior cerebellar, posterior inferior cerebellar and posterior spinal arteries were embolized. All four lesions were resected in a short period of time with minimal blood loss. In all cases the surgeons stated that devascularization had markedly facilitated surgical removal. One of the spinal cord lesions had been operated on, in the past, without embolization and this lesion could not be resected. Following embolization, it was completely resected without complication. There was only one minor

complication in our series and it was acute hydrocephalus that developed following embolization of a large hemangioblastoma in the cerebellar hemisphere. The patient was taken to surgery immediately and the tumor was completely resected and the patient recovered without adverse sequelae. Our initial experience suggests that preoperative embolization of hemangioblastomas may facilitate surgical removal of these otherwise difficult lesions.

Three-Dimensional Computed Tomography of Intracranial Lesions: Gholkar A, Isherwood I (Univ. of Manchester, Manchester, England)

Three dimensional Computed Tomographic (3DCT) reformations have been employed successfully as an adjunct to standard axial CT for the examination of complex bony structures of the craniofacial and pelvic regions. 3DCT has been less successful when applied to soft tissues.

AIMS - to investigate the potential role of 3DCT in the investigation of intracranial lesions.

METHOD - 3DCT examinations have been performed in a variety of conditions including 37 tumours (19 sellar and parasellar), 8 arterio-venous malformations, 4 aneurysms and 4 other primary vascular lesions. All patients were examined on a GE CT 9800 in the University Department of Diagnostic Radiology. Multiple 1.5/3 mm sections were obtained during intravenous injection of 100 mls of Omnipaque 350 using a Medrad Mark IV CT injector. A low dose technique (1) was employed using 200 mAs and 120 kVp and dynamic scan mode. 3D images were obtained using computer software 3D 98.

RESULTS & DISCUSSION - Clinically useful information was obtained in all cases and there were no technical failures. The advantages of the method as observed in this preliminary study include the opportunity to optimise, as a post processing option, the angle of display to match the surgical approach and the facility to communicate complex anatomical information.

The results of these preliminary observations are encouraging and a prospective comparative study with conventional angiography has been established in conjunction with the University Department of Neurosurgery to identify objectively the role of this technique in surgical management.

Surface Resolution of Three Dimensional Serial CT Reconstructions of Bone.: *Stevens JK,Terbrugge KG,(Playfair, and Dept. of Radiology, Toronto Western Hospital, Toronto, Ontario. M5T 2S8)

Three dimensional reconstruction from serial CT scans has become an important new tool to the neuroradiologists and the neurosurgeon. We and many others have found 3D to be of great value as a surgical planning tool for spinal fractures, as well as a valuable teaching tool. While the resolution of 2D CT images has been quantified, very little is known about surface resolution of 3D CT imaging.

We have taken bovine bones, and via a 1200 watt Argon laser etched gratings (1.23mm - 0.125mm in 6 steps) on the surface at three different angles. These standards were CT scanned on a GE9800, using 1.5mm x .25mm x .25mm pixels on serial, adjacent slices at 80KV and 120Ma. Reconstructions were carried out on a reconstruction workstation, (ISG technologies) as well as custom hardware and software used for electron microscopic reconstruction (Stevens et al. 1980,1980,1984,1986). The serial CT scans were reconstructed using conventional window and threshold segmentation methods. The final images were displayed using three different surface display algorithms – simple coined surfaces (SC), linear interpolated coined surfaces (LIC) and voxel based surface (V).

Results demonstrate a highly astigmatic surface resolution. The gratings normal to the scan provided the best detail. The Voxel based surface had the highest resolution (0.125mm) and the other two methods were slightly worse (0.375mm). The 45 degree gratings, were almost as resolvable. Again, the highest resolution was obtained with the voxel based surface (0.125 mm V,and 0.375mm SC, LIC). Finally all three methods had dramatically lower resolvability for the 90 degree gratings (V, SC,LIC > > 1.25 mm).

These data show that a voxel based surface produces the best surface resolution of the methods tested. Additionally, all methods show that while it is possible to obtain solid body images which *appear* to have uniform surface detail, caution must be exercised since some of this detail may be artificial.

Three Dimensional Surface Rendering of Nasal Anatomy: Lanzieri CF, Levine HL, Rosenbloom SA, Duchesneau PM, Rosenbaum AE (Cleveland Clinic Foundation, Cleveland, OH 44195-5103)

Current advances in endoscopic nasal and paranasal sinus surgery have challenged head and neck radiologists to produce more graphic and complete depictions of intranasal anatomy and pathology. The purpose of this paper is to investigate the potential of utilizing three dimensional surface rendered CT reconstructions for demonstrating normal, pathologic, and post-operative intranasal anatomy. Three dimensional surface renderings of the intranasal structures were generated in twenty-four patients from axial or coronal high resolution CT images utilizing a CEMAX-1500 (Philips Medical Systems, Shelton, CT). Excellent images were obtained in all cases. Because of the complicated anatomy, three dimensional images were felt to be more useful for surgical planning than standard two dimensional images in all cases. Further manipulation including "electronic surgery" to "remove" the middle turbinate resulted in excellent visualization of the uncinate process and hiatus semilunaris. There is good correlation between the size and shape of the uncinate process and hiatus semilunaris. There is good correlation between the size and shape of the uncinate process (blade type or mezzaluna type) and the incidence of ipsilateral sinusitis. Simulation of anterior and posterior "electronic nasal endoscopy" could also be performed.

In summary, we believe that three dimensional CT reformatting will be a vital adjunct to endoscopic nasal surgery.

Temporal and Cross Modality Image Matching for Patient Realignment: Du Boulay G, Dalton B, Durrani T, Marshall S, Saeed N (Institute of Neurology, Hirst Research, GEC, and Strathclyde University, Huntingdon, Cambridgeshire, England)

The goal of repeating a scan with an accuracy of 1 mm in all directions, without head fixation or any form of stereotactic frame in order to measure the progress of disease requires answers to several problems: (1) image variability--we have scanned two volunteers and a phantom 3 times in a day, every 3 months for 18 months and a comparison of these images shows distortions of boundaries of less than 3 pixels; (2) segmentation routines can extract the brain image; (3) knowledge-based systems can extract internal markers such as the inner scalp boundary; (4) orthogonal and angular realignment to superimpose the new scout views on stored images is automatic; (5) and brain feature extraction for fine-tuning the match is a remaining significant problem.

MR Diffusion Imaging - Preliminary CLinical Experience: Mikulis D, Chien D, Kwong K, Buxton R, Davis K, Brady T, Rosen B (Harvard Medical School and Massachusetts General Hospital, Boston, MA. 02114)

Diffusion MR, which is sensitive to the microscopic motion of water in tissues, was performed in 6 patients to assess diffusion parameters in various pathologic states and to gain insight into the clinical application of this method. Diffusion imaging was performed by modification of a standard spin echo technique. Two images were acquired (TR 800, TE 180, NEX 4) differing in the duration of the frequency encoding (read) gradient and its compensatory gradient. Calculation of the diffusion coefficient at each pixel was based on the signal attenuation between the two images. Standard T1 and T2 weighted acquisitions were performed in each case to provide a comparison with diffusion maps. Average diffusion coefficients ($x10^{-5}$ cm^2/sec) in 18 normals were 1.1 for gray matter, 0.7 for white matter, and 2.4 in pure water. Average diffusion coefficients in the 6 patients studied were: venous infarction/hypertension 2.1, meningioma 1.3 and surrounding edema 2.2, oligodendroglioma 1.1, astrocytoma (grade II-III/III) 2.3, microangiiopathic leukoencephalopathy 2.2, and multiple sclerosis plaque (on steroids) 0.9 with adjacent normal white matter 0.9. Abnormal diffusion matching the extent of T2 signal abnormality was present in of 3 of 6 cases. The exceptions include the meningioma which demonstrated abnormal diffusion but normal T2 signal (isointense to cortex), and the M.S. plaque and the oligodendroglioma both of which which demonstrated normal diffusion but abnormal T2

signal. These preliminary findings indicate that: 1) diffusion abnormalities are present in diverse pathologic states with certain lesions distinguishable from normal tissues by altered diffusion coefficients, 2) increased T2 signal does not necessarily correlate with increased water diffusion indicating that there are differences in the biophysical mechanisms responsible for T2 relaxation and the molecular self diffusion of water.

Improved Magnetic Resonance Images of the Brain Using a Variable Bandwidth Pulse Sequence: Curnes JT, Boyko OB, Yeates AE, Pelc NJ, Shimakawa A (Duke Univ., Durham, NC 27710)

Signal to noise (S/N) ratios are of critical importance in MR. The diagnostic information in T2 weighted images obtained at longer TE intervals is based on decay (spin-spin relaxation) differences at a point in time when the signal intensity from all tissues has become quite low (decreased S/N ratio). In an effort to improve image quality by increasing the S/N ratio, a narrow bandwidth may be selected to increase the sampling time, thereby reducing noise. The disadvantages of this, however, include a lengthening of the first echo to a TE longer than one would prefer, as well as a predictable increase of the chemical shift artifact along the frequency encoded direction.

A variable bandwidth (VB) pulse sequence was developed which combined a standard 16kHz bandwidth on the first echo (TE=20 or 30) with a 5.3kHz bandwidth on the second echo (TE 70-80). This combination preserves an early first echo with minimal chemical shift artifact while reducing statistical noise on the second echo by $\sqrt{3}$. Chemical shift effects on the second echo are felt to be often acceptable due to the short T2 of fat.

Twenty patients (both normal and abnormal) and 10 post-mortem specimens underwent cranial MR with both a standard sequence and a prototype variable bandwidth (VB) sequence using a GE Signa 1.5 T system. Three independent observers agreed that in each case, S/N ratio and lesion conspicuity were improved on the second echo of the VB sequences as compared to a standard 16kHz image without (1) the additional time required to increase S/N ratio by increasing the number of excitations (nex), or (2) increasing the field of view, and (3) the attendant degradation of early echo images by inherent chemical shift and TE limitations of narrow bandwidth imaging. Areas of noticeable improvement include 1) discrimination of adjacent areas of increased T2, 2) identification of areas of T2 as perivascular spaces versus ischemia or demyelination, 3) gray/white differentiation, 4) detection of myelinated pathways, and 5) detection of normal brain iron.

Intra-Voxel Incoherent Motion (IVIM*) MR Imaging of Wallerian Degeneration: Berry I, Manelfe C, Demonet JF, Arrue Ph (Neuroradiology Service, CHU Purpan, Toulouse, France)

T2-weighted imaging techniques have proved an excellent screening method in clinical brain MR. Indeed most of the pathological processes include either brain edema or brain demyelinization and gliosis, which induce T2 prolongation, depicted on T2-weighted images. Although those techniques are very sensitive they cannot separate the two processes. IVIM imaging showing diffusion and perfusion proton motions should have this ability, which was confirmed with the comparison of edema in acute stages of brain ischemia and Wallerian degeneration of the corticospinal tract.

MR imaging was performed at 0.5 T (Magniscan* 5000) (Thomson-CGR, France) in 4 patients (3 males, 1 female; 30,35,50,57 years old) with Wallerian degeneration (4 months to 5 years). T2-weighted spin echo (TR1000/TE 140 msec) and IVIM techniques were assessed for their ability to image edema and Wallerian degeneration. On T2-weighted sequence both processes exhibited bright signal intensity. With IVIM imaging, edema was characterized with elevated apparent diffusion coefficient (ADC) as compared to normal grey and white matter while Wallerian degeneration had the same ADC as normal brain. This new imaging technique seems therefore to be useful in the differentiation of pathologic lesions.

Identification of Calcified Intracranial Lesions By Fast Small Flip Angle Proton Density Imaging: Albert S, Leeds NE (Beth Israel Medical Center, New York, NY 10003)

Identification of calcified intracranial lesions by proton MR requires proton density images (very short TE and TR longer than 4000ms) in addition to the more common T_1 and T_2 weighted images as proton density images represent the signal from all the protons within the section examined. However, the acquisition of proton density images prolongs the imaging time compared to that of T_2-weighted images. It has been shown recently that reliable proton density images can be obtained using small flip angle fast gradient echo imaging techniques.

We have used fast proton density (FPD) imaging in combination with T_1 and T_2-weighted images for identifying calcified intracranial lesions. Fast proton density images have been obtained with very small flip angle and short TE values, 6-15° and 9-13ms, respectively. TR of 75-200ms was utilized. The MR examinations were carried out at a field strength of 1.5T (GE SIGNA) with a variant of the pulse sequence GRASS (Gradient Recalled Acquisition in the Steady State). Patients with and without intracranial calcification as diagnosed by CT were selected for our study.

Our results demonstrate that: 1) Most calcified intracranial lesions can be identified in an MR examination; 2) FPD images are very useful in identifying calcific zones; 3) FPD images are obtained in relatively short acquisition time; and 4) FPD images can be used to differentiate between calcific zones and hemorrhage.

In Search Of An Effective Screening System For Intraocular Metallic Foreign Bodies Prior To MR - An Important Issue Of Patient Safety: Mani RL (Providence Hospital, Oakland, CA 94609)

Patients placed in high strength magnetic fields with undetected intraocular ferromagnetic foreign bodies (IFFB) are at risk for severe eye injury. At present there is no consensus system to detect IFFB for lack of specific answers to the following questions:

1. What are the directly observed behavior characteristics of metallic foreign bodies in ocular vitreous when exposed to 1.5 Tesla? Over time? Over a range of decreasing sizes?
2. What detection system with what parameters is capable of finding all of these small IFFB?

We initiated a series of experiments geared to answer these questions and provide a scientific rationale to choose an appropriate screening system. The results of these experiments can be summarized:

1. Sixteen IFFB's (size: 0.15-2.0mm) were placed in bovine vitreous and exposed to 1.5/0.5T. All reacted identically, but in proportion to mass: a) vibration, b) torque, c) sudden projectile motion. All fragments exposed for 30-45 minutes demonstrated dramatically enhanced reactions.
2. Plain film detection tests of 19 iron fragments (size: 0.15-2.0mm) employed every available state-of-the-art film/screen/focal spot combination to produce a total of 86 radiographs. Analysis of the best 36 films demonstrated that plain film radiography cannot resolve fragments smaller than 1.2mm. Literature indicates, however, that IFFB's are frequently found in sizes approaching 0.5 mm (Neubauer, et al 1975).
3. CT (9800) with 3.0mm slice, FOV 13-18cm, bone algorithm, detected 100% of 21 IFFB's (size: 0.15-2.0mm) down to 0.1mm.
4. CT appears to be the detection system of choice in the search for retained IFFB.

Xenon/CT Cerebral Blood Flow Studies Prior To and During Continuous Depth Electrode Monitoring in Epilepsy Patients: Initial Report of Observations: Hogg JP, Johnson DW, Dasheiff R, Badour AS, Yonas H, Pentheny S, Jumao-as A, Latchaw RE (University of Pittsburgh, Pittsburgh, PA 15213)

At the University of Pittsburgh Epilepsy Center, presurgical evaluation of patients with medically intractable seizures include noninvasive imaging including CT, MR, Xe133 CBF, and Xe/CT CBF. Later, more invasive testing is done including stereotactic placement of bitemporal and bifrontal intracranial depth electrodes allowing continuous depth electroencephalography (CDEEG). There were 27 scans unmonitored by CDEEG, 7 were later found to have bilateral temporal or frontal seizure foci and 10 had unilateral seizure foci. Ten are still awaiting depth electrode placement. Six of 7 with bilateral foci demonstrated asymmetric regional cerebral blood flow (rCBF) in regions of seizure foci subsequently documented by CDEEG. One study was degraded by motion. Three of 10 with unilateral seizure foci had symmetrical, normal rCBF, and 1 had global symmetrically decreased CBF. Two had decreased rCBF and 2 had increased rCBF in the area of the later documented seizure focus. Two scans were degraded by motion.

A subgroup had depth electrode stimulation of seizure activity and were found to manifest only electrographic seizures, some occasionally manifesting mild symptoms. Each received a CDEEG monitored baseline exam prior to depth electrode stimulation and at least 1 temporal lobe stimulation followed by another Xe/CT CBF scan 20 minutes later. Of these, 4 patients

had 7 temporal lobe stimulations. There were 4 seizures by CDEEG which showed increased CBF in the lobe of the focus. In 3, stimulation failed to cause a seizure and in 1 there was no change in CBF and in the other 2 there was increase in CBF in the lobe of stimulation. One of these 2 reported an aura. We also found in those who had more than 1 temporal lobe stimulation that elevated CBF returned to normal levels in 20-30 minutes.

Relative Accuracy of MR and CT in Radiological Evaluation of Patients with Seizure: Mikhael MA, Trommer BL (Evanston Hospital-McGaw Medical Center of Northwestern Univ., Evanston, IL 60201)

Three hundred and sixty-eight cases presenting with seizure disorder were studied with CT and MR. CT showed a primary brain tumor in 36 cases (21-78 yrs), ischemic and hemorrhagic infarctions in 42 cases (24-78 yrs), metastases to the brain in 42 cases (38-78 yrs), arteriovenous malformations and aneurysms proven by angiogram and/or surgery in 6 cases (15-42 yrs), old scars from infarctions and/or trauma in 10 cases (38-71 yrs), acute small posttraumatic hematoma in 2 cases (10 and 19 yrs), and was negative in the remaining 230 cases.

MR studies missed the small acute cerebral hemorrhages, which were clearly shown on CT scans (2 cases), but detected all the other lesions. The 2 cases of small hemorrhagic areas missed on early MRs were clearly shown on later MR scans (10 days after the ictus).

Moreover, MR studies showed brain tumors in 6 cases proven by surgery to be: astrocytoma in 4 cases (4-13 yrs), 1 case of multiple lymphoma masses (21 yrs) and 1 case of temporal lobe metastases (52 yrs); posttraumatic infiltrating gliosis in 2 cases (12 and 18 yrs); hamartoma of the temporal lobe in 2 cases (5 and 11 yrs); temporal lobe sclerosis in 3 cases (9-15 yrs); 3 cases of occult vascular malformation (21-28 yrs); and 2 cases of vanishing temporal lobe lesions (6 and 18 yrs), out of the 230 cases with negative CT scans. Thus, the CT scan was positive in 138 cases and was negative in 230 cases, missing 18 cases with radiological abnormalities detected only by MR. Some of these lesions were surgically curable (hamartoma and temporal lobe sclerosis) and others were helped by medical treatment. In 2 cases the lesions detected on MR disappeared on follow-up MR studies (6-8 wks) and were assumed to be post-seizure changes.

We feel that CT and MR scans are complementary studies for the diagnosis of cases presenting with seizures and the neuroradiological work-up to study these cases is not complete without an optimum MR study. Lesions shown on MR studies done shortly after seizure should be followed-up before considering surgical intervention because some of these, in our series, disappeared on follow-up MR studies and were presumed to be post-seizure changes of the brain.

MR Evaluation of Intractable Partial Complex Seizures: Pathologic and Electroencephalographic Correlation: Dowd CF, Dillon WP, Laxer KD, Barbaro N (Univ. of California, San Francisco, San Francisco, CA 94143)

We prospectively reviewed the MR studies of 24 patients with intractable partial complex seizures, who later underwent resection of EEG proven seizure foci. Nineteen patients were imaged at 1.5T, four at 0.35T, and one at 0.5T. Correlation was obtained on all patients with EEG and surgical pathology.

Of 13 patients with mesial temporal sclerosis (MTS), 8 exhibited an MR abnormality at the site of pathology as determined by EEG and surgery. Abnormalities included increased (5) or decreased (1) signal intensity, distortion of gray-white interface (1) and temporal lobe atrophy (1). Five patients had no abnormalities at the site of the diseased focus.

MR was more sensitive in patients with other structural lesions which included tumor, encephalitis, polymicrogyria, cryptic vascular malformation, and tuberous sclerosis.

Prior studies indicate some usefulness of MR in intractable seizure patients, but many report relative insensitivity of MR in defining an abnormality (as low as 11%). Our results demonstrate the usefulness of high resolution thin section multiplanar MR using cardiac gating or flow compensation techniques in this patient population.

MR Imaging Prior to and Following Electroconvulsive Therapy in Patients with Major Affective Disorders : Braffman BH, Grossman RI, Shah A, McCallister T, Price TPR, Gyulai L, Atlas SW, Hackney DB, Goldberg HI, Bilaniuk LT, Zimmerman RA (Hospital of the Univ. of Pennsylvania, Philadelphia, PA 19104)

Electroconvulsive therapy (ECT) is an effective treatment for depression and other psychiatric disorders. However, the use of ECT is controversial. Animal research, human autopsy studies, and neuroimaging studies suggest the possibility that ECT may result in cerebral pathology. This includes possible accelerated neuronal dropout of aging, neuronal and hippocampal cell loss and gliosis, atrophy, petechial hemorrhages, and transient disruption of the blood brain barrier. Because of these possible sequelae, we designed this study in which MR imaging was performed in 14 patients with major affective disorders prior to and following their courses of ECT. Pre- and post-ECT MR scans were evaluated by visual analysis by at least two neuroradiologists.

MR imaging following ECT revealed no changes when compared to the pre-ECT MR scans. However, it is possible that subtle changes of cell loss and gliosis may not be detected by MR. These possible sequelae of ECT cannot be excluded on the basis of this study.

Large Virchow-Robin Spaces: MR-Clinical Correlation: Heier LA, Bauer C, Schwartz L, Zimmerman RD, Deck MDF (New York Hospital-Cornell Medical Center, New York New York 10021)

1.5T MR scans routinely demonstrate small foci of CSF signal on all pulse sequences about the base of the brain. These lesions conform to the path of the lenticulostriate(LS) arteries as they enter the basal ganglia through the anterior perforated substance and represent large Virchow-Robin(VR) spaces which accompany the vessel as it penetrates the brain from the subarachnoid space. Rarely these perforations have been seen in the high convexity(HC) extending into the centrum semiovale. A retrospective review of 816 MR scans was undertaken to determine the clinical significance and associations(if any) of this anatomy. The VR spaces were graded as were the non-specific white matter(WM) lesions. The presence of atrophy, infarction, hydrocephalus and miscellaneous pathology was noted. 314 cases of large VR spaces were identified. A study sample was created consisting of a positive group containing all the grade 2 and 3 VR spaces(67 patients) and a negative or control group of 109 randomly selected patients from the original 502 who did not have large VR spaces. This study sample had their charts reviewed and the following variables were noted: age, sex, incidental WM lesions, infarction, dementia, hypertension and atrophy. For each patient variable, the proportion of patients who were positive for that variable was calculated for each of the two groups and compared across groups using a Fisher exact test. Multiple logistic regression analysis was used to determine whether any of these variables were jointly associated with being "positive" or "negative" for large VR spaces. The following variables were significantly associated with being positive for large VR spaces: age, hypertension, dementia, incidental WM lesions and male gender. Logistic regression analysis revealed that when all these variables are considered jointly, only age remains significant. In conclusion, large VR spaces are another phenomenon of the aging brain.

Significance of Virchow-Robin Spaces in Magnetic Resonance Images of the Brain: Muraki A, Glass-Royal M, Manz H, Smirniotopoulos J, Carvlin M, Schellinger D (Georgetown Univ. Hospital, Washington DC, 20007)

Small, multiple foci of increased signal intensity (T2 weighted images) in the centrum semiovale are frequently observed on magnetic resonance (MR) images of the brain. Often, these findings are of doubtful significance with respect to the patient's clinical state. Several explanations for this phenomenon have been advanced and much controversy surrounds this issue. We correlated images of 5 fixed brains obtained at 1.5T and 4.7T and of 30 fixed brains obtained at 1.5T with pathologic analysis of these brains. An evaluation of the perivascular spaces in fixed brain specimens from the Yakovlev collection of the Armed Forces Institute of Pathology (AFIP) were reviewed. These foci of hyperintensity in part correlated with the location of the deep penetrating arteries and probably represent extracellular water in the perivascular (Virchow-Robin) spaces. These spaces

typically enlarge with aging and with various systemic disorders such as hypertension. We then retrospectively reviewed 150 MR scans of patients with various clinical/pathologic conditions and found that these hyperintense foci were frequent findings. It is our conclusion that many of the small hyperintense foci in the centrum semiovale represent extracellular water in the Virchow-Robin spaces.

Cribriform State of Brain: MR Appearance of Supratentorial Perivascular Spaces at High Field: Boyko OB, Djang WT, Yeates AE, Burger PC, Heinz ER (Duke Univ., Durham NC 27710)

Magnetic resonance imaging (MR) is an extremely sensitive technique for detecting white matter lesions. Typically lesions have increased water content and are best identified on T2 weighted images as areas of relative signal hyperintensity. Areas of high signal intensity in white matter are usually assumed to represent pathologic processes such as infarction, gliosis, edema or demyelination.

We have encountered 15 adult and pediatric patients in whom there have been multiple discrete, symmetrical, round or elliptical foci of high signal intensity within the supratentorial white matter as seen on T2 weighted images. All studies were performed at 1.5 Tesla using spin echo T1, intermediate and T2 weighted sequences. T1 and intermediate images demonstrated these foci to be isointense or near isointense to cerebrospinal fluid (CSF). Although one patient had a clinical diagnosis of moya moya and another of neurofibromatosis, these MR findings were found in normal non-hyperintense individuals, and thus could not be directly associated with a specific disease process.

The conspicuity of these spaces is improved using a prototype variable bandwidth pulse sequence. A standard 16 kHz bandwidth is used on the first echo and a 5.3 kHz bandwidth on the second echo. The sampling time is thus increased with a reduction of statistical noise on the second echo.

After reviewing the neuropathy literature and the autopsy material at our own institution, it became clear that the perivascular spaces surrounding penetrating arteries of the cerebral hemispheres can become quite prominent in some patients, especially those with hypertension. The appearance of these dilated perivascular spaces has been referred to as the "cribiform state." These foci of increased signal can be distinguished from MS or SAE by the fact that these foci have less signal intensity on intermediate T2 weighted echoes.

MR Quantitation of Gray, White and CSF Volumes of the Brain in Alzheimer Disease: Kowalski HM, George AE, Rusinek H, de Leon MJ, Stylopoulos LS, Mourino M, (NY Univ. Med. Center NY, NY 10016)

We used two MR inversion recovery sequences: for CSF (5000/490/50 and 100) and for white matter (1400/425/30). The CSF sequence highlights the CSF and suppresses the gray and white matter signal. The white matter sequence highlights the white matter and suppresses both gray and CSF signals. Using references to samples of pure gray, white matter and CSF in histogram analyses, the 3 tissue distributions are differentiated and tissue volumes quantitated.

We studied 10 patients with Alzheimer disease (AD) and 12 age matched normal controls. All subjects met diagnostic criteria consistent with NINCDS-ADRDA recommendations. AD patients showed a significant decrease selectively in the amount of temporal lobe gray matter ($p < .05$). There was no difference in the temporal lobe white matter volumes between the normals and AD patients. No group differences were found for either gray or white matter volumes in the parietal, frontal and occipital lobes. This study is the first in vivo evidence that the early changes of Alzeimer's disease involve a selective loss of temporal lobe gray matter.

The Normal Echogenicity of The Corpus Callosum: Tominaga S, Pilc-Spellman J, Kushner D, Mikulis D (Massachusetts General Hospital, Boston, MA 02114)

The corpus callosum is an easily identifiable structure sonographically since it is significantly more echolucent than adjacent white matter, and is silhouetted by surrounding structures. A retrospective study was performed to assess the echo pattern in infants and adults undergoing transfontanelle and intraoperative ultrasonography. We reviewed 45 adult intraoperative ultrasound examinations (ages 17-72) and 138 infant transfontanelle examinations (from 23 weeks gestation to 6 months of age). The corpus callosum could be well seen and was normal on 16 of the intraoperative studies and 68 of the transfontanelle examinations. The echogenicity of the CC was assigned to one of three groups; group I - echogenicity of the CC equivalent to adjacent whitematter, group II - less than adjacent whitematter, group III - similar to CSF in the lateral ventricle.

Transfontanelle studies revealed the following case distribution: Group I - 23.5%, Group II - 67.7%, Group III - 8.8%. Intraoperative studies revealed the following case distribution: Group I- 12.5%, Group II - 31.3%, Group III - 56.2%. These findings indicate decreasing echogenicity of the corpus callosum with age most likely due to progression of myelination occurring during the normal maturation of the CNS.

Periventricular Hyperintensities: MR-Pathologic Correlations Between Subcortical and Subependymal Hyperintensities: Heier LA, Morgello S, Farrar JT, Zimmerman RD, Deck MDF (New York Hospital-Cornell Medical Center, New York, NY 10021)

Subependymal periventricular hyperintensity(PVH) is commonly encountered on T2 MR in adults and increases with age. While the pathologic basis of subcortical white matter(WM) hyperintensities has been investigated, the source of subependymal PVH has not been identified. We correlated pathologic, postmortem magnetic resonance(MR), and clinical findings in 19 patients between the ages of 40 and 91. MR scans were assessed for location and extent of hyperintensities in both the subcortical and subependymal WM. Histologic sections of subependymal WM were graded for ependymal denudation, pallor, atherosclerosis, gliosis and rosettes. Sections of the subcortical WM were graded for both vascular and WM abnormalities. The following observations were made: 1.Subependymal PVH did not correlate with pathologic changes in the subependymal WM. 2. Subependymal PVH had a strong association with pathologic and MR lesions in the subcortical WM. 3. There was a moderate association between the vascular abnormalities in the subependymal and subcortical WM. 4. Subcortical pathology and subependymal PVH strongly correlated with age. We conclude that subependymal PVH represents a physiologic change rather than a structural one. It is postulated that subependymal PVH is due to extravascular water arriving at the ventricles(15% normal CSF production). Subcortical WM pathology may increase the amount of extravascular water traveling to the ventricles thus increasing the size of the subependymal PVH. Subependymal PVH does correlate with pathologic lesions in the subcortical WM and may be an index of vascular and WM disease in the adjacent subcortical WM.

Chronic Acquired Hepatic Failure: MR Imaging Of The Brain: Brunberg JA, Kanal E, Hirsch W, Davis PL, Van Thiel DH (Pittsburgh NMR Institute and Univ. of Pittsburgh, Pittsburgh,PA 15213)

1.5T MR images of the head and upper abdomen were obtained in a prospective series of 42 adults with non-Wilsonian chronic hepatic failure. Imaging sequences with T1 contrast weighting (T1CW) (TR 500-600msec/TE 20msec) demonstrated markedly increased signal intensity in the globus pallidus in 27/42, in the putamen in 20/42, in the subthalamic region and surrounding the red nucleus in 15/42, in the quadrigeminal plate in 5/42 and in the anterior pituitary in 10/31. T2CW (2500/100) images demonstrated the globus pallidus to be of normal low intensity in all 27. A region of markedly low intensity was seen within the globus pallidus on T1CW and T2CW images in 3 patients and was demonstrated to represent calcification in the 2 patients on whom CT studies were obtained. Gradient reversal images (200/50/θ=10°) demonstrated low signal intensity in the regions seen to have increased intensity on T1CW images. Increased intensity in the basal ganglia on T1CW images was seen more frequently in patients with cholestatic hepatic failure (11/14) than in patients with chronic active hepatitis (12/20) or ethanol associated hepatic failure (4/8). Three of 42 patients demonstrated increased intensity in the pons with T2CW images, compatible with central pontine myelinolysis.

MR findings in the CNS and pituitary did not correlate with liver or spleen morphology or MR intensity patterns, and did not correlate with clinical neurologic status or laboratory indices of hepatic function. Alterations in intensity were not

demonstrated in the cerebral cortex or in cerebellar regions which, like the basal ganglion in patients with chronic hepatic encephalopathy, are demonstrated to have characteristic histopathologic changes, including proliferation of Alzheimer type II astrocytes, microcavitation, and neuronal degeneration. Deposition of an as yet unidentified paramagnetic substance is postulated as a mechanism for this previously undescribed MR manifestation of chronic hepatic acquired failure.

MR Imaging in One-Side-Dominant Parkinsonism: Tsuchiya K, Makita K, Furui S, Takenaka E, Nakajima S (National Defense Medical College, Tokorozawa, Saitama, 359 Japan)

High-field MR imaging provides an opportunity for the evaluation of iron distribution in the brain. In disorders affecting the extrapyramidal system, abnormal accumulation or distribution of iron has been described on T2-weighted MR imaging.

We reviewed T2-weighted MR images(SE, TR 1800ms, TE 80-100ms)obtained at 1.5T in 14 patients (seven males, seven females, 44-78 years old) with clinically one-side-dominant Parkinsonism (idiopathic Parkinson disease). In eight cases, hypointensity was more prominent and/or extensive in the putamen on the side contralateral to the dominant side. In addition, more prominent hypointensity was noted in the contralateral midbrain in two cases.

These findings may reflect changes in dopamine metabolism in the nigro-striatal pathway resulting in abnormal iron or pigmentary accumulation. We consider these findings to be noteworthy in the evaluation of MR images of patients with Parkinsonism which is known to be frequently one-side dominant.

MR of the Basal Ganglia in Typical and Atypical Parkinson's disease: Discrimination using Spin-echo and Gradient Echo techniques: DeLaPaz RL and Langston JW (Stanford Univ. Medical Center, Stanford, CA 94305)

Parkinson's disease was studied with SE (20/600 and 40,80/2000) and variable flip angle gradient echo (GRASS, TR 400, TE 60, 30 degree flip) techniques at 1.5T (GE Signa). Patients included early typical ("classic") Parkinson's (11 cases, mean age 64) and atypical cases ("Parkinson Plus" with poor response to dopamine replacement; 17 cases, mean age 66). Signal in the posterior-lateral putamen (PLP), relative to the globus pallidus (GP), on the T2-weighted SE and GRASS images, was tested as a discriminator between these groups. Background-corrected intensity ratios (PLP/GP) were defined as follows: <0.9 as "PLP<GP"; >0.9 and <1.1 as "PLP=GP"; >1.1 and <2.0 as "PLP>GP"; and >2.0 as "PLP>>GP". These ratios correspond to visual assessment of the PLP as "darker" than, "equal" to, "normal", and "much brighter" than the GP, respectively. In typical Parkinson's, results were PLP=GP in 2 and PLP>GP in 9 cases. In atypical Parkinson's, results were PLP<GP in 5, PLP=GP in 7, PLP>GP in 4, and PLP>>GP in 1 case. In 3 atypical cases with clinical Striato-nigral degeneration (SND), marked low signal was seen in the putamen (PLP<GP). One was studied post-mortem and showed typical changes of SND with profound neuronal loss, fibrillary gliosis, and dense pigment staining (iron and non-iron containing). A fourth SND case showed very high signal in the entire putamen (PLP>>GP), suggesting gliosis and minimal pigmentation. A survey of 500 consecutive SE studies revealed PLP<GP in 4 (0.8%, mean age 64, range 60 to 70) and P=GP in 12 patients (2.4%, mean age 61, range 37 to 76) with diagnoses unrelated to Parkinson's disease. With clinically suspected Parkinson's disease, very low signal in the putamen on T2-weighted SE and GRASS images (PLP<GP) is useful for identifying atypical disease, especially SND, but is not a specific finding and may be seen in non-Parkinsonian patients.

Interactive Education in Neuroradiology: Mezrich RS, Schonfeld S, Keller I, Safer J, Amorosa J (Robert Wood Johnson Medical School, New Brunswick, NJ 08901)

The constant improvements in modern imaging techniques have provided great benefits to diagnostic radiology and have increased the challenge to those involved in medical education. For students to take advantage of the new radiologic tools they must learn to understand anatomy and its change with disease in ever increasing detail. Computer-aided instruction has been proposed as a device to help improve medical training however its cost has often been too high and its operation too complex to be effectively used by most radiologists. Recent advances in personal computers have produced systems sophisticated enough to store and manipulate large data bases of radiologic images on devices cheap enough to have in the home, using software simple enough that even non-programmers can design sophisticated educational tools. We will demonstrate a program designed to teach principles and methods of neuroradiology that runs on Macintosh computers using Hypercard software. We will demonstrate the system with an image data base of CT, MR, Angio and Plain X-ray images stored on a hard disk. The program provides a simple mechanism to construct linkages between text and images that allows the student to learn about any detail by simply pointing at it. The same basic types of linkages can be used to test the student's factual knowledge. Interactive scenarios that let the student pursue a clinical problem in a simulation of actual practice are easily constructed without the need for special programming skills.

MR Imaging In Patients With Intracranial Aneurysm Clips: Becker RL, Norfray JF, Teitelbaum GP, Bradley WG, Jacobs JB, Wacaser L, Rieman RL (Department of Diagnostic Radiology, Torrance Memorial Hospital Medical Center, 3330 W. Lomita Blvd. Torrance, CA 90509)

Four patients with intracranial aneurysm clips made from a variety of alloys were studied by magnetic resonance imaging (MR) at field strengths ranging from 0.35 T to 0.6 T without incident. Knowledge of the type of alloy used in the manufacturing of an aneurysm clip is important in determining whether the clip will or will not deflect in a magnetic field. Ferromagnetic clips show deflection and torque in a magnetic field and have the potential to dislodge from an aneurysm. Non-ferromagnetic or weakly ferromagnetic aneurysm clips such as the Sugita (Elgiloy), Yasargil (316 LVM stainless steel), Heifetz (Elgiloy), Yasargil (Phynox) and Vari-Angle McFadden (MP35N) do not deflect or deflect weakly in the magnetic field and therefore would not be expected to dislodge during MR.

Intracranial Chemical Shift Artifacts - At High Field - Effects of Altering Bandwidth: Smith AS, Weinstein MA, DeRemer DR, Cole RA, Barr RG, Duchesneau PM, Lanzieri CF, Rosenbloom SA (Cleveland Metropolitan General Hospital, Cleveland, Ohio 44109)

Chemical shift artifacts were noted to have variable occurrence in higher field strength systems of various manufacturers. Seventy-seven examinations performed on a 1.4 Tesla Technicare Unit were reviewed. The artifacts were 1) apparent extra-axial fluid collection due to shift of subcutaneous or diploic fat signal, 2) apparent location shifts of intracranial lipomas 3) artifactual vessels or calcification associated with lipomas. Shift of the fat signal from diploic or subcutaneous fat in the apparent fluid collections depended on skull size and therefore related to age and biparietal diameter. Shift of fat across the inner table of the thin skulls without yellow marrow resulted in apparent subdural hematomas in patients less than eight years old. In adults, the diploic fat shifted across the inner table onto the brain while subcutaneous fat signal overlapped the thicker medullary cavity and outer table. Analysis and examples of changes in bandwidth for several manufacturers and other machine parameters are presented. Calculations for the linear dimension of the expected chemical shift artifact are outlined.

Orbital and Intracranial Findings in Pseudotumor Cerebri: A CT Study with Clinical Correlation: Gibby WA, Goldberg HI, Cohen M, Sergott RC (Univ. of Pennsylvania, Philadelphia, PA 19104)

A retrospective, blinded study of 17 patients with pseudotumor cerebri was performed. Criteria

for inclusion within the study included clinical and CSF pressure evidence of pseudotumor cerebri, no space occupying intracerebral lesion on CT or other pathology causing non-localized increased intracranial pressure, and availability of thin section axial and coronal CT through the orbits. Twenty age and sex matched individuals referred for orbital study in which there was no evidence for pseudotumor cerebri, visual impairment or evident ocular pathology by either radiographic or clinical investigation were utilized as controls.

The CT's were graded for degree of ventricular and sulcal enlargement (0-2+) based upon expected size for the patient's age, degree of empty sella (0-3+), and for optic nerve head reversal (0-2+). The optic nerve sheath diameters were measured in both the coronal and axial planes. Correlation was made with the patient's visual deficit and outcome, opening CSF pressures and weight.

Contrary to prior reports, no significant difference in the pseudotumor cerebri group and the controls were found regarding ventricular and sulcal size. Sixteen of seventeen pseudotumor patients had some degree of empty sella versus seven of twenty in the control patients. The degree of empty sella was also significantly different. Optic nerve head reversal was present in one or both optic nerves in 12 of 17 pseudotumor patients and in only one of 20 controls. Nerve sheath diameters (6.5 + .8mm for the pseudotumor group and 5.4 + .7 in the controls) were also significantly different. Patients with severe visual loss had greater degree of optic nerve head reversal.

Inversion Recovery MR Scanning of Multiple Sclerosis: Edwards MK, Duerk JL, Farlow MR, Rippe DJ, Kuharik MA (Indiana Univ., Indianapolis, IN 46223)

A prospective study was performed comparing inversion recovery scans to spin echo scans of 48 consecutive patients with suspected multiple sclerosis. A prolonged inversion recovery scan sequence (TR=3000, TI=600) and a motion suppressed spin echo scan sequence (TR=2000, TE=80) were performed on each patient using a Picker 1.5 T scanner. Lesions were detected in the white matter or brain stem in 27 of the patients using the inversion recovery sequence, and in 25 patients using the spin echo sequence. No evidence of multiple sclerosis was found on either sequence in 21 patients. Inversion recovery sequences were much more sensitive to detection of small lesions in the immediate periventricular region where the bright signal from cerebral spinal fluid may shield a small periventricular lesion on spin echo sequences. Inversion recovery sequences were also superior to spin echo sequences in the detection of lesions in the brain stem, cerebellar peduncles, and corpus callosum.

The same scan sequences were also performed on 20 patients with a variety of other disease processes including infarction, tumor, arteritis, hemorrhage, and elderly "normal" patients with white matter lesions on spin echo scans. In these patients the appearance of the lesions differed from those of multiple sclerosis on inversion recovery sequences. The lesions of chronic MS appeared darker than those of edema, infarction, or white matter abnormalities in elderly patients. The use of the inversion recovery scan sequence appears to provide significant improvement in both the sensitivity and specificity of the diagnosis of MS.

Cerebral Parenchymal Neurocysticercosis: Comparison of CT and MR:

Begley MG, Dwyer A, Nash TE (National Institutes of Health, Bethesda, MD 20892)

Eight patients presenting with seizures, serologic (Western Blot Specific) and radiologic evidence of Parenchymal Cerebral Neurocysticercosis (PCN) were examined with CT and MR prior to, during and after praziquantel therapy. The compared CT (pre- and post- contrast) and MR (SE TR500/TE 30, TR 2000/TE 30, and STIR sequences at 0.5T) were performed on the same day or within 72 hours. The scans were interpreted in a double-blind fashion and a lesion by lesion comparison performed. A total of 110 lesions were seen: 41 cystic-target, 36 partially calcified with peripheral edema, and 39 totally calcified. All the active lesions (cystic-target and partially calcified/edematous lesions) were seen equally well with both MR and CT. These lesions appeared as scattered foci of abnormal signal on MR exams. However, CT demonstrated the character of the active lesions, especially the cystic-target lesions while MR did not. CT was thereby more valuable in initial evaluation of patients as the cystic-target lesion created by encapsulation of the cysticercal larva is conclusive radiologic evidence of the presence of cysticercosis. Only two patients had definite evidence of cyst formation on their initial MR scan. In these, the cyst was demonstrated by a halo of inflammatory edema surrounding the cyst. CT and MR exams showed transient perilesional edema during the first week of therapy in two patients. All lesions diminished in size after therapy, most becoming totally calcified. CT appeared better than MR in initial evaluation of patients with PCN and documentation of response to therapy and progression of calcification.

High Field MR of Brain Abscess: Goldberg HI, Titelbaum DS, Grossman, RI, Hackney DB, Bilaniuk LT, Zimmerman RA (Hospital of the University of Pennsylvania, Philadelphia, PA 19104)

The MR characteristics of 9 bacterial brain abscesses in 8 patients in various phases of evolution (acute, subacute and chronic) were evaluated with particular emphasis on the appearance of the capsule and center of the lesion. Fourteen MR examinations were performed with serial studies obtained in five patients.

The walls of 5 of 7 acute and all 3 subacute abscesses were hyperintense on T1 weighted images (WI). In the acute phase, the wall was thicker and more irregular than in the subacute phase. One cerebritis phase abscess revealed heterogeneous hyperintensity throughout. On T2WI, the abscess wall was generally hypointense in the acute phase and became hyperintense in the subacute phase. A partial rim of hypointensity was frequently present in the outer portion of the wall in the subacute phase. In the chronic phase the wall was isointense on T1WI and similarly hypointense on T2WI. The abscess cavity was uniformly hypointense on T1WI in the subacute phase while in the acute phase it was mildly hypointense and heterogeneous with foci of hyperintensity. On T2WI in the acute phase the center was only slightly hyperintense and also heterogeneous with foci of lower intensity. In the subacute phase the center was uniformly hyperintense on T2WI being similar to CSF. In the chronic phase the abscess center on T1WI was iso to hypointense and hyperintense on T2WI.

The MR findings of early abscesses suggest a consistent hemorrhagic component in the wall and progressing central necrosis. In chronic abscesses MR suggests collagen in the capsule.

Meningeal Fibrosis Following Chronic Ventricular Shunting: Destian S, Heier LA, Zimmerman RD, Morgello S, Deck MDF (New York Hospital-Cornell Medical Center, New York, NY 10021)

Four patients, aged 20 to 77 years, with long-standing ventricular shunts (present for at least two years) had unenhanced CT scans which demonstrated small ventricles and bilateral low density extra-axial collections indistinguishable from chronic subdural hematomas. Following contrast administration, however, there was marked enhancement of the convexity collections as well as prominent paratentorial and parafalcine enhancement. Follow-up CT scans obtained up to thirteen months later demonstrated no change in the collections. MR scans were performed in three of the patients. On STR/STE sequences, the bilateral subdural collections appeared mildly hyperintense relative to CSF but hypointense relative to brain. On LTR/ITE sequences, the subdural collections appeared hyperintense relative to CSF and brain, and on LTR/LTE sequences they appeared hyperintense relative to CSF and brain in two patients. In the third patient, the collections were isointense relative to CSF and hyperintense relative to brain. The extent of the collections was better demonstrated on MR, but as with

unenhanced CT the collections could not be distinguished from chronic subdural hematomas. Two of the patients were biopsied, and pathology demonstrated fibrosis of the meninges characterized by granulation tissue and collagen deposition.

Meningeal fibrosis is a rare post-shunt phenomenon which may mimic chronic subdural hematoma on unenhanced CT and MR. Recognition of this entity is important, particularly if therapeutic intervention is being contemplated. Therefore, an enhanced CT scan should be obtained in chronically shunted patients to differentiate between chronic subdural hematoma and meningeal fibrosis.

MR-Pathologic Correlation in CNS AIDS: Olsen WL, Lempert TE, Longo FM (University of California, San Francisco, CA 94143, San Francisco General Hospital, San Francisco, CA 94110).

We reviewed the brain MR scans of 39 AIDS patients in whom there was pathologic correlation: 29 by brain biopsy and 10 by autopsy. There were 12 cases of primary CNS lymphoma, 10 cases of progressive multifocal leukoencephalopathy (PML), 8 cases of toxoplasmosis, 4 cases of human immunodeficiency virus (HIV) encephalitis, 2 cases of cytomegalovirus (CMV) encephalitis, 2 cases of nonspecific gliosis and one normal biopsy. There was significant overlap in the MR appearance of the various lesions. For instance, focal areas of high signal on T2 weighted images in the deep white matter were seen in cases of PML, lymphoma and toxoplasmosis. However, some distinguishing features were found: Most cases of lymphoma were solitary lesions which often had heterogeneous signal on T2 weighted images with large portions isointense with white matter. Toxoplasmosis was usually multiple, frequently with rings of low signal and central high signal on T2-weighting. However 4 cases of lymphoma also had a ring appearance. All cases of PML showed homogeneous high signal on T2-weighted images without mass effect. Most PML lesions were focal or multifocal, while all 4 cases of HIV encephalitis had diffuse areas of high signal in the central white matter. One patient with CMV had a small mass lesion of high signal in the cerebellum. The other patient with CMV had a normal MR scan.

MR of Progressive Multifocal Leukoencephalopathy in AIDS Patients: Mark AS, Olsen WL, Atlas SW, Lempert TE, Newton D (University of California San Francisco, CA 94143 and San Francisco General Hospital, San Francisco, CA 94110)

Progressive multifocal leukoencephalopathy (PML) is a demyelinating disease caused by a papova virus. This disease afflicts only immunosuppressed patients, especially AIDS patients. We reviewed the MR scans of 10 AIDS patients with biopsy proven PML. A variety of field strengths ranging from 0.35T to 1.5T were used and there were no significant differences in the appearance of the PML lesions at different field strengths. The lesions were solitary in 6 patients, and multiple in 4 patients (bilateral in all 4). The lesions involved the white matter in all 10 patients, but in 9 extended to the cortical grey-white junction. In 4 of these patients the cortical grey matter appeared to be involved. The lobar distribution of the lesions was as follows: parietal 8; occipital 4, frontal 4, temporal 4. The corpus callosum was involved in 2 patients and in 2 others the internal capsule was abnormal. Basal ganglia and posterior fossa involvement were seen in one patient each. On T1 weighted images the lesions were hypointense to grey matter in 9 patients. In the 10th patient the lesion was isointense with grey matter. In one patient, there was a focus of high signal in the middle of the low intensity lesion consistent with hemorrhage (methemoglobin). On T2 weighted images, all 10 patients had homogeneously high signal lesions. The lesions appeared well defined and focal in 8 patients and in the other 2 there was marked asymmetry in the diffuse abnormality. None of the lesions had mass effect. Seven patients had contrast enhanced CT scans and no lesions enhanced. We conclude that PML in AIDS patients typically exhibits focal or multifocal lesions that have high signal on T2 weighted images and low signal on T1 weighted images. There is a parietal predilection, but more important, the peripheral grey-white matter junction are involved. The lesions do not exhibit mass effect and do not enhance with CT scanning.

Dense MCA Sign in Experimental Drug Treatment: Tomsick TA, Brott T, Olinger C, Barsan W, Masters J, Reed R, Spilker J (Univ. of Cincinnati Medical Center, Cincinnati, Ohio 45267-0742)

Dense Middle Cerebral Artery Sign (DMCAS) was detected by early CT in 6 of 50 patients (12%) entered into studies of drug treatment for acute cerebral infarction. Thirty patients were treated with naloxone and 20 patients were randomized to treatment with ancrod or to placebo. The 6 DMCAS patients developed large-volume infarcts (range: 38-303cm3; mean: 192cm3). Two became hemorrhagic. In none was the infarct limited to the basal ganglia and internal capsule. All developed cortical involvement.

Of the 44 patients without the DMCAS, only 7 developed infarcts of volume (mean:179cm3) similar to those of the 6 DMCAS+ patients. The time from symptom onset to the CT was not significantly different in the DMCAS- and DMCAS+ groups.

This study indicates that the DMCAS is more common than previous retrospective studies suggest and its presence predicts development of a large infarct.

We are examining the implications of the DMCAS in acute stroke patients examined by CT and treated with tissue plasminogen activator (TPA) within 90 minutes of ictus in a Phase I dose-escalation study. Five of 17 have exhibited the DMCAS. Mean infarct volume at 7 days in this group has been 125cm3. No hemorrhagic transformations have occurred in the DMCAS+ group.

These very preliminary results suggest the possibility that ultra-early thrombolytic therapy for acute stroke patients may decrease the volume of cerebral infarction without increasing hemorrhagic transformation in DMCAS+ patients.

The Cerebral Vascular Pattern: Anatomic Features That Predict Vulnerability to Profusion or Oxygenation Deficiency: Moody DM, Bell MA, Challa VR (Bowman Gray School of Medicine of the Wake Forest Univ., Winston-Salem, NC 27103)

We have been studying the brain vascular system in human autopsy material histochemically utilizing the action of an endothelial membrane enzyme, alkaline phosphatase (Bell MA, Scarrow WG, Microvasc. Res., 1984; 27:189). Not only does gray matter have a greater rate of metabolism than white, but various regions of the brain have vastly different types of blood supply. A critical study will enable the observer to predict the susceptibility of the brain to hypoxia (e.g. anesthesia accident) on the one hand and hypoperfusion states (e.g. carotid stenosis or overtreatment for hypertension) on the other.

Cortex: Short arterioles 6 mm long--high metabolic rate.
Corpus callosum: Short arterioles 8 mm long--low metabolic rate.
Subcortical "U" fibers: Short arteries and arterioles, often from separate pial arteries (dual blood supply)--low metabolic rate.
Extreme capsule: Short arteries and arterioles from pial plexus over insular cortex. Additional blood supply from lateral branches of lenticulostriate arteries (triple blood supply).
Centrum semiovale: Long penetrating arteries and long resistance arterioles 20-50 mm in length--low metabolic rate.
Basal ganglia and thalamus: Long penetrating arteries and resistance arterioles 20-50 mm in length--medium-to-high metabolic rate.

The pial arteries and arterioles over the brain surface are richly interconnected with anastomoses. In the brain parenchyma a few capillaries from adjoining arteriolar systems anastomose with each other; arteriolar-to-arteriolar anastomoses don't occur normally, we believe, but can occur in response to insult.

Gray matter (high metabolism) is most vulnerable to hypoxia. Deep gray and white regions (long single source arterioles) are most vulnerable to hypoperfusion resulting from increased vascular resistance in the long penetrating vessels. Hypoperfusion is due to arteriosclerosis and atherosclerotic narrowing (in parenchymal arteries and extending down to 50 μm diameter arterioles), and is exacerbated by the vascular spirals, loops, and tortuosities of aging. The corpus callosum, subcortical "U" fibers, and extreme capsule are least susceptible to either of these vascular challenges.

MR of Acute Cerebral Ischemia: Correlation With Histopathology in the Rabbit: DeLaPaz R, Shibata D, Zarnegar R, Steinberg G (Stanford Univ. Medical Center, Stanford, CA 94305)

Within cerebral ischemic lesions there are wide regional variations in neuronal injury, neuropil (glial) disruption and edema. This study was undertaken to assess the MR correlates of these regional changes. Twenty male New Zealand rabbits underwent unilateral transorbital occlusion of the anterior cerebral and internal carotid arteries: permanent in 14 with MR images obtained at 12 hours after occlusion; and transient for 1 hour in 6 animals followed by reperfusion until MR imaging 4 hours later. Histopathologic analysis (40 micron H & E stain) was spatially correlated with MR of premortem and post-mortem brains (3-5 days of formalin-fixation). Brain images were obtained with two systems: Resonex RX-4000 (0.38 Tesla, 3 inch diameter solenoidal imaging coil, 3.6 mm slice thickness, TR=400, TE=35 ms; and TR=1500, TE=35 & 70 ms) and General Electric Signa (1.5

Tesla, 6 inch diameter saddle coil, 5 mm slice thickness, TR=800, 1200, 2000 TE=25,50,75,100 ms). MR abnormality (high signal on T2-weighted images) was most consistently correlated with regions of neuropil disruption and interstitial edema. MR abnormality was less consistently associated with histologic signs of neuronal ischemia, especially low grade injury. Both low and high grade neuronal injury were seen in regions of normal MR signal (false negative MR), most frequently in the basal ganglia. Conversely, abnormal MR was seen where neuropil injury and edema were accompanied by minimal or no ischemic neuronal changes (false positive MR). High signal on T2-weighted proton MR primarily represents neuropil (glial) change and interstitial edema but is not a good predictor of neuronal injury, especially low-grade changes.

Angiographic Findings In The Very Early Phase (6 Hours) of Acute Ischemic Stroke: Bozzao L,Fantozzi LM, Bastianello S, Bozzao A, (Neuroradiology Section) Argentino C, Lenzi GL, Fieschi C (III cattedra di Clinica Neurologica) (Dept. Neurological Sciences, Univ. of Rome "La Sapienza")

Over a period of 14 months, 80 patients with supratentorial ischemic stroke seen four hours from the onset of symptoms and who did not show serious alteration of consciousness or important general diseases were studied with angiography.

A CT scan was performed in advance to rule out the possibility of intracerebral hemorrhages or tumors.The cerebral angiography carried out with digital equipment was, as a rule, limited to the vascular territory responsible for the neurological deficit. In 12/19 patients with carotid occlusions the contralateral side was studied as well.Arterial pathology was classified as: internal carotid artery (ICA) non-stenosing plaque, ICA stenosing plaque, ICA ulcerated plaque, ICA occlusion (bifurcation or cervical), syphon occlusion, middle cerebral artery (MCA) trunk occlusion, peripheral branch occlusion.

A relevant lesion in the symptomatic artery was found in 72/80 patients, extra-cranial in 19, intra-cranial in 22, and tandem extra and intra-cranial in 31. In 8 patients angiography was normal. In 8 of 19 patients with ICA carotid occlusions, lesion was located in the cervical segment. An intra-cranial occlusion, isolated or associated, was found in 53/80 of our patients.In 3 of them the MCA occlusion was no longer evident when angiography was repeated after a week.

Our results show 1) a high incidence of occlusive pathology of the intracranial arteries, with a significant presence of a potential embolic source, 2)a high frequency of carotid occlusion located at the cervical segment, 3) a lack of isolated ICA stenosis significant enough to explain the clinical deficit on a hemodynamic basis.

Imaging Cerebral Ischemia: Stable Xenon-enhanced CT Cerebral Blood Flow Mapping In The Acute Period: Hecht ST, Yonas H, Johnson DW, Latchaw RE, Gur D (Univ. of Pittsburgh, Pittsburgh, PA 15213)

24 patients with brain ischemia due to either acute stroke (10), trauma (4) or vasospasm secondary to subarachnoid hemorrhage (10) have been studied with CT and stable xenon-enhanced CT within 24 hours of becoming symptomatic. Four of the studies were performed within the first 2 hours and another 18 were performed within the first 6 hours. Initial cerebral blood flow (CBF) maps demonstrated localized or generalized blood flow values less than 15 ml/100 gm/min. The minimum local CBF was less than 4 in 17 patients, 5 - 9 in 5 patients, 10 - 14 in 2 patients. No patients had minimum local CBF values of 15 ml/100 gm/min or higher. Due to methodologic constraints, values of 1 ml/100 gm/min or less are not recorded. All patients developed cerebral infarctions in the areas of severely decreased CBF, apparent both clinically and on follow-up CT examinations, when available. Experience based on more than 2500 stable xenon-enhanced CT CBF studies suggests the threshold CBF for irreversible brain tissue damage is 14 ml/100gm/min. Stable xenon-enhanced CT CBF mapping is diagnostic of cerebral infarction in its earliest stages. Early diagnosis is useful for clinical decision making during the acute period.

An Open Multicenter Study of the Radiologic Changes Seen After Various Doses of r-TPA in Patients With Acute Stroke: Preliminary Results: Wolpert SM (The TPA-Acute Stroke Study Group, New England Medical Center Hospital, Boston, MA 02111)

To test the safety and efficacy of fibrinolytic therapy in acute stroke, an open multicenter dose-range finding study of r-TPA given intravenously following angiography to patients within 8 hours of the onset of acute thromboembolic stroke has been undertaken at 8 centers: Aachen RFG; Boston, MA (3); Cleveland, OH; New York, NY and San Diego/LaJolla, CA (2). Following initial clinical assessment, CT-scan and angiography, each patient with a documented cerebral artery occlusion appropriate to the clinical syndrome received a preassigned dose of r-TPA intravenously over 60 minutes. Repeat angiography and CT, serial neurological examinations, and laboratory studies were then performed. The primary positive (efficacy) outcome was angiographically demonstrated reperfusion of the previously documented cerebral artery occlusion. The primary negative (safety) outcome is central nervous system hemorrhage with clinical/neurological deterioration. Three dose levels of r-TPA have been employed to date. In 6 of 15 patients reperfusion through branch occlusions of the middle cerebral artery were seen; no "angiographic" responses were seen in the remaining 9 patients. One patient suffered a fatal intracerebral hemorrhage. Hemorrhagic infarcts occurred in 4 patients. One of these 4 patients died.

Intra-arterial Urokinase Therapy in Progressive Cerebral Infarct: Tsai FY, Shah DC, Matovich VB, Ashraf A, Alfieri A (Truman Medical Center, Kansas City, MO 64108)

Thrombolic agents are potentially able to increase blood supply to ischemic areas of the brain by lysis of thromboembolic occluding the focal arterial supply. Furthermore, the thrombolytic agents might inhibit proliferation of the thrombus and prevent the potential progression of cerebral infarcts.

The systemic intravenous administration of thrombolytic agent urokinase is reported to have a significant risk of cerebral hemorrhage and the results of thrombolytic effect on occluded arteries are poor. However, superselection arterial thrombolytic treatment is superior to systemic application. Urokinase has a very minimal systemic reaction with maximal local effect with intra-arterial injection. Our approach is to treat the acute thromboemboli by superselective intra-arterial injection of urokinase by means of tracker catheter. In the past two years, we have treated five patients with intra-arterial urokinase infusion (40,000 IU/kg) with four successes and one failure.

A Prospective Study of MR In Posterior Circulation Infarction: Tress BM, Davis SM, Dowling R, Donnan G, Keirs L, Rossiter S (Univ. of Melbourne, The Royal Melbourne Hospital, Victoria, Australia, 3050).

This study was designed to prospectively compare the ability of CT and MR to detect relevant abnormalities in patients presenting with a clinical diagnosis of posterior circulation infarction and to determine whether MR had any direct effect on the management of any of these patients. 26 consecutive patients presenting with a clinical diagnosis of posterior circulation infarction and 25 age and sex matched control patients had CT and MR on a 0.3 Tesla iron shielded resistive scanner within 3 weeks of their initial neurological symptoms. 6 of the subjects had intra-arterial digital subtraction angiograms. The MR and CT hard copies of the subjects and controls were mixed and evaluated in blinded fashion by a neuroradiologist. The results were compared with the clinical data which had been separately evaluated by two neurologists. In 19 patients (70%) MR showed relevant lesions not seen on CT, with normal CT scans in 13 (48%) and more extensive lesions on MR in 6 (22%), chiefly in the brain stem. In 8 of 27 patients (30%) MR showed evidence of abnormal vertebro-basilar blood flow not accounted for by flow related artifacts. Angiography showed vertebral artery occlusion in 3 cases, predicted by MR in 2. MR altered the presumed pathogenesis and hence the management in 3 cases. In 4 of the 27 cases (15%) neither MR nor CT showed a relevant lesion. In the 25 control subjects only 2 infratentorial lesions indistinguishable from brain stem infarcts and 1 flow abnormality were detected. This study suggests that in addition to providing more information than CT regarding infarct site, extent, and pathogenesis in patients presenting with clinical posterior circulation infarction, MR can detect flow abnormalities indicating large or medium size vessel disease. This in turn may aid selection of patients for angiography and full anticoagulation.

PRESENTED AT POSTER SESSIONS:

CT and MR of Primary CNS Lymphoma: Goldstein SM, Belkin RI, Neuwelt EA, Howieson JL (Oregon Health Sciences Univ., Portland, OR 97201)

Primary CNS lymphoma is an uncommon primary brain neoplasm. Twenty-six patients with pathologically proven CNS lymphoma and no evidence of acquired immunodeficiency syndrome were treated with osmotic blood brain barrier disruption and intra-arterial chemotherapy since 1982. All patients had computed tomography scans and 28 magnetic resonance scans were obtained in 14 patients.

The CT scans showed 47 enhancing lesions present with 12 patients showing multiple enhancing masses. All of these lesions abutted a CSF space with 89% showing solid enhancement while the rest exhibited ring enhancement. 96% of the lesions showed marked enhancement.

On T2 weighted MR the enhancing area was minimally hyperintense with surrounding markedly hyperintense edema in half the cases while in the other half there was a diffuse area of marked hyperintensity. One patient had Gadolinium enhanced MR and 2 more enhancing lesions were noted than on the corresponding enhanced CT.

Contrast enhanced CT and MR are equivalent modalities for imaging primary CNS lymphoma. Gadolinium DTPA enhanced MR may prove to be the optimal study.

Evaluation of Osseous Compressive Disorders at the Craniocervical Junction: MR vs. CT Myelography: Zollars LE, Wang H, Uematsu S, Kopits S, Kumar AJ, Ahn HS, Zinreich SJ (Johns Hopkins Medical Institutions, Baltimore, MD 21205)

Twenty patients (ages 5 months to 75 years) with osseous compressive disorders of the cranio-cervical junction were examined by CT (with or without intrathecal contrast) and/or MR (.5T or 1.5T superconductive magnets). General indications for a scan included constrictive bony disorders involving the foramen magnum or compression of the upper cervical cord or pontomedullary region. The spectrum of patients examined included: achondroplasia (5), rheumatoid arthritis (4), fracture of the dens (2), Morquio's disease (2), post-traumatic atlanto-axial subluxation (2), Hurler's disease (1), Paget's disease (1), Klippel Feil deformity (1), Arnold Chiari malformation (1), and Down's syndrome (1).

While CT remains superior to MR in demonstrating precise bony detail, MR adequately evaluates the cortical margins. Sagittal MR of the craniocervical junction revealed C1-2 subluxation, fractures, basilar invagination, bony erosion and platybasia. MR has the advantage over CT in demonstrating cervical medullary compression and tonsillar herniation. CT myelography may miss cord deformity. Syringohydromyelia and cord atrophy are better illustrated with MR than CT myelography. Subarachnoid space effacement is beautifully visualized on GRASS MR images and is less invasive than CT myelography. Plain film exam in conjunction with MR may be the most efficacious means of evaluating the craniocervical junction unless precise bone detail is required or the patient is unsuitable for MR examination.

MR and CT Correlation of Severity of Degenerative Changes in Lumbar Facet Disease: Murtagh FR, Weisman P, Arrington JA, Silbiger ML, Vaum RC (University of South Florida, Tampa, FL 33612)

Sixty-six lumbar facet complexes were evaluated by both axial CT and axial MR by three independent observers and the results correlated to determine the accuracy of MR for assessment of severity of bone involvement in degenerative facet disease. Using CT of the facet joints as a "Gold Standard", and dividing facet disease into 3 categories of severity (mild, moderate, and severe), we found 86% agreement of MR with CT in mild facet degenerative disease (joint asymmetry, periarticular calcifications), 78% agreement in moderate disease (minimal body overgrowth, subchondral erosions and hyaline cartilage destruction) and 100% agreement in severe disease (extensive bony overgrowth). We conclude that MR is in fact a fairly accurate assessor of facet disease but that CT is probably a better overall modality for fine bone detailed analysis.

The MR Characteristics of Low versus High Grade Gliomas: Fobben ES, Hackney DB, Zimmerman RA, Goldberg HI, Grossman RI, Bilaniuk LT (Univ of Pennsylvania, Philadelphia, PA 19104)

CT criteria for distinguishing low grade versus malignant gliomas have been well described. Since MR is replacing CT for initial evaluation and follow up of these neoplasms similar MR critieria are needed. This study was undertaken with the goal of determining MR characteristics which distinguish low and high grade gliomas. In addition since radiation therapy planning is presently dependent upon enhanced CT for definition of tumor margins we compared the MR images to enhanced CT, when available, to determine if MRI provides useful information relevent to radiation therapy.

Preoperative MR images of 24 patients with proven gliomas were reviewed. Grade was determined by biopsy and biologic behavior on follow up. Spin-echo images were obtained with TR 600, TE 20-30 and TR 2000-3000 and two echoes at 20-40 and 60-80 msec. The images were evaluated with attention to the following features: mass effect, apparent tumor vascularity, hemorrhage, heterogeneity of signal intensity within the tumor, extent and pattern of edema and infiltration. Since edematous tissue with infiltration by isolated tumor cells is indistinguishable from tumor-free edematous tissue the terms "edema" &" infiltration" are used to represent two different imaging patterns. Edema = high signal intensity extending along white matter tracts in a vasogenic pattern. Infiltration which may also have white matter hyperintensity requires one of the following: gray matter involvement; extension across the corpus callosum; marked expansion of the infiltrating region or signal intensities suggesting hemorrhage,calcification or cyst formation.

MR Characteristics	Low grade	High grade
Edema	3/11	11/13
Infiltration	3/11	10/13
Mass effect	8/11	13/13
Hemorrhage	4/11	5/13
Heterogeneity	9/11	10/13
Vascularity	2/11	1/11

Preliminary results indicate that, as with CT, the finding of extensive edema in a vasogenic pattern is a good indicator of malignancy. Because MR is more sensitive than CT for detecting old hemorrhage, minor amounts of hemorrhage could be detected even in low grade tumors making it a poor predictor of malignancy. The presence of tumor heterogeneity alone was a poor predictor as there are numerous causes of heterogeneity such as calcification, hemorrhage, necrosis and tumor cysts. Vascularity could not be assessed with confidence on MR. MR at the present time, without contrast enhancement, suffers from serious limitations with regard to deliniation of tumor margins relevent to radiation therapy planning.

MR of Tethered Spinal Cord Syndrome: New Findings: Raghavan N, Barkovich AJ, Norman D (Univ. of California, San Francisco, San Francisco CA 94143)

Accurate diagnostic imaging is required to evaluate the nature of the tethered cord, the operative approach and associated abnormalities. Twenty-five patients with tethered spinal cord syndrome were studied prior to surgery with magnetic resonance imaging (MR). There were 14 men and 11 women with an age range of 0 to 65 years and an average age of 18 years. The tethering was clearly identified in all cases. The conus was actually normal in position in 16% of patients. The filum was abnormally thickened in all but one patient. Etiology of the tethering was spinal lipoma in 18 patients, thickened filum in three patients, diastematomyelia in two patients and myelomeningocele in two patients. Syringohydromyelia/ myelomalacia of the conus or the cord adjacent to the tethering lesion was identified in nine of 20 patients with appropriate images. This finding has not been described previously in the presurgical cases of tethered spinal cord syndrome in the absence of Chiari malformations. MR is the most appropriate technique for imaging tethered spinal cord syndrome.

Transvenous Embolization of Dural Fistulas Involving the Cavernous Sinus: Halbach VV, Higashida RT, Hieshima GB, Hardin CW, Pribram H (UCSF Medical Center, San Francisco, CA 94143)

Because of the risks associated with arterial embolization of cavernous dural fistulas, we have sought an alternative method to promote fistula closure. Thirteen patients underwent transvenous embolization as a treatment for symptomatic cavernous dural fistulas. All procedures were performed from a femoral vein access through the inferior petrosal sinus (IPS) or basilar plexus. In five patients an IPS was not angiographically demonstrable, however embolization was still possible through this route in two. The embolic agents used were: detachable balloons in one, coils alone in five, coils and liquid adhesives in four, coils and silk sutures in one, silk sutures in one, and liquid adhesives alone in one. Nine patients had follow-up angiograms with complete obliteration of the fistula and complete resolution of related symptoms. One patient had complete resolution of clinical symptoms but refused follow-up angiography. Another patient had 50%

decrease in fistula flow on the follow-up angiogram and improvement in clinical symptoms. Two patients had complete fistula obliteration following embolization and progressive improvement in symptoms but have not yet had follow-up angiograms. The follow-ups range from one month to ninety-seven months with a mean of fifteen months. There were two complications related to this treatment. An embolic stroke followed transient placement of a balloon in the internal carotid and a second patient developed transient visual loss when the venous outflow pathways were occluded prior to fistula closure. The fistula was immediately closed with complete recovery of vision. With recent advances in microcatheters and embolic agent technology, transvenous closure of cavernous dural fistulas is now possible. We now utilize this method as the primary treatment of symptomatic cavernous dural fistulas requiring treatment.

Cerebral and Cranial Artery Navigation Without Using a Leak Balloon--A New Combination of a Low-Friction High Torque Guide Wire and a Thin Supple Catheter: Goto K (Fukuoka University, Fukuoka 814, Japan)

PREFACE: Calibrated leak balloons have long been used for the purpose of embolization of AVM and chemotherapeutic agent infusion of malignant neoplasm. However, these are time-consuming procedures because of the complexity of the systems and lack of maneuverability. This is a report on a new combination of a guide wire and a catheter to do these procedures quickly and safely.

MATERIALS AND METHODS: 1) Guide Wire: 0.014" Radiofocus Guide Wire (Terumo Japan). Friction coefficient of this guide wire is extremely low, as this is a plastic guide wire with hydrophilic polymer coating. High torque control is generated by superelastic alloy used as a core material. 2) Catheter: Tracker 18 catheter (Target Therapeutics). This catheter is characterized by a relatively stiff proximal and supple distal end. 3) Case Materials: 8 Pial AVM cases, 17 dural AVM cases, 5 AV fistula cases and 5 angioma cases. Super-selective cannulation into the arterial feeders was done in all cases. High torque floppy coil guide wires were used in conjunction with the Radiofocus Guide Wire M and comparisons were made. Particles of PVA and dura, and liquid adhesives were used as emboli.

RESULTS: Smoothness in guide wire and catheter manipulation: good in all cases; Torque control: excellent in 24, good in 11 cases. Average time needed to place tip of catheter to the optimal point: 15 minutes. Complication: none.

DISCUSSION: This high torque plastic guide wire with hydrophilic polymer coating enabled to place a catheter into thin tortuous cerebral and cranial arteries spending much less time, compared with coil guide wires. A new instrument consisting of this guide wire and a thin catheter with hydrophilic polymer coating has just been completed, and this is expected to make navigation of intracranial arteries much easier. A detachable balloon could be mounted on the tip.

Visual Pathway Gliomas in Neurofibromatosis: MR Characteristics: Dowd CF, Atlas SW, Hoyt WF, Newton DR (Univ. of California, San Francisco, San Francisco CA 94143)

Approximately one-third of neurofibromatosis (NF) patients have visual pathway gliomas. CT data suggests that less than one-fourth of these lesions extend into the retrochiasmal visual pathways. Thirteen patients (ages 2-27) with NF and chiasm gliomas underwent MR evaluation (11 at 1.5T, 2 at 0.35T) to define signal characteristics and extent of visual pathway lesions by MR.

Chiasm masses demonstrated high signal intensity on long TR sequences in 12/13 cases. Extension of high signal into the optic tracts was seen in 8/13 cases, usually bilateral and involving the lateral geniculate bodies. The retrogeniculate optic radiations were spared in 11/13 cases. Optic nerve enlargement was seen in 10/13 cases, five of which were bilateral. Optic nerve lesions differed from chiasm/retrochiasmal lesions in that their signal intensity was isointense to normal white matter on all sequences. 12/13 cases showed MR abnormalities outside of the visual pathways. Extent of MR abnormalities did not correlate with clinical neuro-ophthalmologic status.

The sparing of the optic radiations suggests that the geniculate region somehow limits posterior extent of disease. Also, the differences in signal intensity patterns of involved optic nerves and chiasm/retrochiasmal pathways suggests separate pathologic processes. With its inherent contrast sensitivity and anatomic detail, MR may provide understanding of the natural history and prognosis of this poorly understood lesion.

MR Imaging of Brain Anomalies with Absence to the Septum Pellucidum: Osborn RE, Byrd SE (Naval Hospital, San Diego, CA 92134)

We evaluated 18 patients with MR who had absence of the septum pellucidum (ASP). These patients included three with holoprosencephaly (HPE), two with septo-optic dysplasia (SOD), four with schizencephaly, and nine with absence of the corpus callosum (ACC).

The septum pellucidum (SP) is a double layered structure which lies between the corpus callosum and the fornix and separates the bodies of the lateral ventricles. It develops via neuronal migration from the ventromedial hemispheric wall or anterior wall of the diencephalon at about 8 weeks gestation. The region in which the septum forms also includes the lamina reuniens which is the precursor to the corpus callosum and is adjacent to the chiasmatic plate.

Structures with important relationships to the septum region which may have associated anomalies are the hypothalamus, pituitary gland and the anterior visual apparatus. A defect involving the anterior diencephalon results in various abnormalities including diencephalon results in various abnormalities including ACC, SOD, pituitary anomalies, and variants of these anomalies.

HPE results from an embryological abnormality which occurs at 4-5 weeks gestation. The prosencephalon fails to properly differentiate into the telencephalon and diencephalon and therefore the SP is not induced.

Schizencephaly is a neuronal migrational disorder which results in hemispheric clefts which commonly involve the Sylvian areas and are frequently bilateral. The ASP is probably another manifestation of faulty migration. The corpus callosum may also be absent in these patients and optic nerve hyhpoplasia has also been reported. These associations suggest that the septal anomalies in schizencephaly patients may share a common origin with other anomalies with ASP.

Isolated ASP represents a finding without other identifiable anomalies or sufficient chemical findings to secure a specific diagnosis.

MR Study of the Early Myelination of the Brain: Raybaud CA, Sevely A, Salinas M, Berry I, Girard N, Manelfe C (Univs. of Marseille and Toulouse, Marseille and Toulouse, France)

Myelination of the brain begins during the late fetal period. Yet the number of myelinated fibers at birth are too small to allow recognition by MR, and the infant brain presents an unusual appearance. On T1W images one sees no contrast between the structures, because the water (90%) is uniformly distributed. On T2W images, the signal is high in the white matter, low in the central ganglia, and the cortex. Myelin replaces water; its signal is high on T1W images, low on T2W images. During maturation, myelination proceeds sequentially. At birth, the pons, arbor vitae and middle part of the posterior limb of the internal capsule are myelinated. Then follow the corona radiata and the optic radiations (3 months), the posterior (6 months) and the anterior (8-10 months) portions of the corpus callosum, and finally, the centrum semiovale (early second year). The T1W sequences are more sensitive in detecting early changes, but do not differentiate the pyramidal tracts from adjacent ganglia. The contrast between the cortex, central ganglia and white matter (with the various tracts) is shown best by T2W sequences. Those also are especially valuable in showing the focal cortical maturation which parallels that of the tracts. This study was made from a series of 74 neurologically normal and abnormal neonates and infants, the normality of the features being deduced from the consistency of the findngs. No correlation has been done with the degree of psychomotor development as yet.

Magnetic Resonance Imaging in Adrenoleukodystrophy and Adrenomyeloneuropathy: Orrison WW, King JN, Snyder RD, Keck GM (Univ. of New Mexico, Albuquerque, NM 87131)

Twenty-five patients identified as having a family history of adrenoleukodystrophy (ALD) or adrenomyeloneuropathy (AMN) were examined with MR at 1.5 Tesla. Twenty-three patients had a technically satisfactory MR and were identified to have carrier status by pedigree analysis and/or evaluation of serum very-long-chain fatty acids. Adrenoleukodystrophy is a sex-linked recessive disorder with childhood onset and clinical features of seizures, cortical blindness, incoordination, and mental deterioration. CT and MR are known to demonstrate white matter changes, particularly in the occipital regions. AMN may occur with a similar inheritance pattern to ALD and in the same families. Onset is in

adulthood and is primarily a peripheral neuropathy with spastic paraparesis.

In addition to the expected white matter changes for this disorder, decreased spinal cord diameter was found in 8 of 23 (35%) of patients with the ALD-AMN complex. The finding of decreased spinal cord diameter on MR in heterozygotes of ALD-AMN, in AMN, and in pre-symptomatic or asymptomatic ALD-AMN patients may represent a new anatomic marker for the variable clinical presentations of this condition. In addition to the cranial MR or CT examination in patients with suspected ALD or AMN, MR of the spine also appears indicated.

MR of Hindbrain Deformity in Chiari II Patients With and Without Symptoms of Brainstem Compression: Curnes JT, Oakes WJ, Boyko OB (Duke Univ., Durham, North Carolina 27710)

We examined the MR appearance of the hindbrain deformity, including the upper cervical spinal canal and craniovertebral junction, in 33 patients with the Chiari II malformation.

At birth, there is impaction of the medulla and cerebellar vermis into the upper cervical spine which results in obliteration of the subarachnoid space and scalloping of the dens. Spinal canal enlargement during the child's growth, combined with dorsal displacement of the neural tissue, results in eventual marked widening of the precervical subarachnoid space. This enlargement may simulate an intradural mass. Our series documents the changes seen at birth and the progression of the widened precervical space through the first and second decades.

Twelve patients (36%) had brainstem symptomatology, and eleven (33%) required surgery. This group was compared to the other 21 asymptomatic children (64%) to identify MR features associated with clinical deterioration. The level of descent of the hindbrain hernia was critical; eight of twelve symptomatic cases had a cervicomedullary kink at C4 or lower, while no asymptomatic patients had a fourth ventricle, medulla, or kink below C3-C4. The precervical cord subarachnoid space was slightly wider in asymptomatic patients, though great overlap existed. In four patients with follow-up scans, this space was documented to increase in width following laminectomy. A CSF flow void was present in the precervical space in about 25% of patients in both groups. In nine of 12 symptomatic patients, C1 arch indentation of the dura causing significant compression was confirmed surgically. However, 33% of asymptomatic patients (7/21) also had this appearance. Absolute measurement of the AP diameter of the canal at C1 ranged between 11 and 25 millimeters in both groups. Retrocollis which persisted despite sedation for the MR exam was seen in two patients, both symptomatic.

Recognition of the vermis, medullary kink, cervical cord, C1 arch, fourth ventricle, and precervical space in Chiari II patients is fundamental to the analysis of symptoms in these patients, and is important for preoperative evaluation.

CT Volumetrics of Malignant Brain Tumors for Evaluation of Chemotherapeutic Response: Ahn HS, Zinreich SJ, Wang H, Kumar AJ, Grossman SA (The Johns Hopkins Medical Institutions, Baltimore, MD 21205)

CT volumetric analysis was employed to evaluate response of primary brain tumors (Grade III & IV astrocytoma) to continuous intravenous infusion of BCNU and Cisplatin. All patients had contrast enhanced CT scan prior to the initiation of chemotherapy and follow-up examination every 6 weeks thereafter. All CT scans were performed with a Siemens Somatom DR 3 scanner following the injection of 150cc Angiovist 60 (or the equivalent). Contiguous 4mm slice thickness through tumor and edema were obtained to reduce partial volume averaging effect. Using the standard Siemens software program, tumor volume was measured by manually tracing the area of enhancing tumor, including the area of central lucency and cystic component when present. Over 1000 CT images were evaluated and serial volumes were recorded as a function of time following the initiation of chemotherapy. The CT volumetric changes in tumor volume correlated well with the patient's clinical status. Patients with a tumor volume reduction of more than 50% had a statistically significant increase in survival ($P < 0.01$). To evaluate the accuracy of visual inspection in assessing tumor volume change, a total of 30 CT examinations from 7 patients were randomly selected and evaluated by the 3 neuroradiologists. A group of scans reported as "no significant interval change" by the 3 neuroradiologists had a mean tumor volume change of 28%. Precise tumor volume assessment is important in the management of patients with brain tumor since it may afford a prognostic indication of the patient's clinical course and may provide a more accurate means of determing the optimal therapeutic approach. CT volumetric proved its superiority over the conventional means in assessing tumor volume change.

The Effect of Gradient Moment Nulling on the MR Appearance In-Plane Vascular Flow: Evaluation With a Flow Phantom: Johnson CE, Sze G, Zimmerman RD (The New York Hospital-Cornell Univ. Medical Center and Memorial Sloan-Kettering Cancer Center, New York, NY 10021)

The effect of gradient moment nulling(GMN) on the MR signal intensity of in-plane vascular flow was examined in an experimental model using a flow phantom and in clinical settings including chronic sagittal sinus thrombosis. GMN is a flow motion reduction technique whose purpose is to rephase spins which have undergone phase shifts resulting from movement through magnetic field gradients. GMN typically produces increased in-plane vascular signal. To evaluate the effect of GMN on the intensity of in-plane flow, a flow phantom was constructed of ordinary plastic tubing forming a U-shaped flow loop connected to a stable velocity pump. Ten flow velocities were used ranging from 1.0 to 22.4 cm/sec. Long TR images parellel to the in-flow and out-flow arms of the flow loop were obtained both without and with flow rephasing gradients. The intensity of the flowing liquid with GMN relative to that obtained without flow compensation gradients increased with increasing velocities up to a flow rate of 17.9 cm/sec. Above this velocity there was rapid decrease in intensity differences, possibly related to turbulent dephasing of spins. Clinically, increased intensity was often observed in vessels parallel to the imaging plane, most consistently seen in the transverse sinuses. With chronic sagittal sinus thrombosis, no significant signal increase was observed in the sinus as would be expected if flow were present. Increased sagittal sinus intensity with use of GMN was identified in a normal volunteer. While the use of GMN reduces some flow motion related artifacts, it is important to recognize its effects on the appearance of vascular structures so that normal vascular hyperintensity is not misinterpreted as a lesion.

MR of Mesial Temporal Lobe Fissural Cysts: Subarachnoid Cysts Simulating Intra-axial Lesions: Sherman JL, Citrin CM, Borke R (Washington Imaging Center, Kensington, MD 20895 and Uniformed Services Univ. of The Health Sciences, Bethesda MD 20814)

Transaxial CT and MR imaging of the brain occasionally reveals focal cystic lesions of the mesial temporal lobe that appear to be intra-axial. We retrospectively reviewed the CT and MR images of 11 patients (ages 5-50 years) with cystic mesial temporal lobe lesions. The images were compared to corresponding coronal formalin-fixed sections of the brain and neuroanatomical texts. Axial and coronal images were available in all cases and sagittal images were available in seven patients. At least three MR spin-echo pulse sequences were employed providing T1-weighted, T2-weighted and proton density information on all the patients.

The determination that a lesion was cystic was made by noting isointensity with respect to CSF on all sequences and isodensity compared to CSF on CT. Nine were right-sided and two were on the left. They varied from 4 mm to 20 mm (average = 10 mm) in anteroposterior diameter and were located medial to the temporal tip of the lateral ventricle. There was no evidence of surrounding edema or gliosis. Coronal MR images were most useful, revealing the cysts as focal CSF intensity lesions expanding the choroidal fissure (parahippocampal sulcus) of the temporal lobe.

Three of the patients had seizure disorders. EEGs in these patients revealed no focal temporal lobe abnormality. The other eight patients were evaluated for unrelated complaints. Six month follow-up examinations in three patients were unchanged and in two patients there was no change over a three-year period.

The typical MR characteristics of choroidal fissure cysts allow differentiation from cystic tumor, inflammatory cysts, porencephalic cysts and cystic encephalomalacia. They are benign lesions that most likely develop along the invagination of pia mater in the choroidal fissure.

"Disappearing Infarcts": Signs of Apparently Reversible Ischemic Changes on Serial CT and MR Scans: Deveikis JP, Fox AJ, Pelz DM, Brothers MF, Drake CG (Univ. of Western Ontario, London, Ontario, Canada N6A 5A5)

Apparently reversible ischemic changes were seen on serial computed tomographic (CT) and magnetic

resonance imaging (MR) scans of five patients developing neurological deficits following subarachnoid hemorrhage and craniotomy for repair of intracranial aneuryms. Two patients had CT and MR evidence of resolving ischemic changes, with a corresponding degree of improvement in their clinical findings. These changes were most likely related to small vessel arterial vasospasm, which gradually resolved. Three other patients were followed with CT scans for various neurological deficits, and low density lesions compatible with infarcts were seen at anatomical sites appropriate for the clinically observed deficits. Serial scans showed an apparent dramatic improvement in the appearance of the brain, with return of the density of these ischemic regions to normal, although the patients continued to have significant neurological deficits. Days to months later these regions again became hypodense, suggesting that the ischemic changes were masked by petechial hemorrhage into an area of infarction, raising the density of the tissue to a normal level. This was confirmed in one patient when an MR scan of the "disappearing infarct" showed petechial hemorrhage into the area of infarction that had been previously seen on CT.

The literature on the topic of reversible ischemic changes is reviewed. It is suggested that MR or followup CT scans may be useful to rule out the presence of hemorrhage into an area of infarction in patients in whom the apparent resolution of an area of ischemia is not accompanied by a corresponding improvement in clinical signs and symptoms.

CT and MR Findings in Hepatic Encephalopathy: Herrera L, Hahn F (Univ. of Nebraska, Omaha, NE 68105)

Central nervous system dysfunction is commonly seen in progressive liver disease. Hepatic encephalopathy is a recurrent, reversible, and often terminal event. A few studies have described cranial CT findings in stable patients following acute hepatic failure or with chronic progressive disease. CT findings have also been described after liver transplants. Cranial radiographic findings of patients at the end stage of liver disease (ESLD) and prior to transplant are rare.

A retrospective study of thirty-eight (38) patient records admitted with hepatic encephalopathy found cerebral cortical atrophy, subcortical white matter changes and hemorrhage to be the most common abnormalities present on head CT and/or MR imaging. Thirty-one (31) patients were medically treated and seven (7) received an orthotrophic liver transplant. We describe the clinical, radiographic, and neuropathologic findings in four (4) representative patients with ESLD.

We conclude that white matter lesions are common in hepatic encephalopathy and may reflect blood brain barrier disruption secondary to metabolic factors as well as edema. MR may be the imaging choice in patients with hepatic encephalopathy prior to transplantation.

MR Imaging of Gerstmann-Straussler-Scheinker Disease: Another Cause of Increased Brain Iron: Kuharik MA, Farlow MR, Edwards MK, Ghetti B, Mathews V, D'Amour PG (Indiana University School of Medicine, Indianapolis, IN 46223)

Gerstmann-Straussler-Scheinker (GSS) disease is a rare entity characterized by adult onset cerebellar ataxia, progressive dementia, and decreased reflexes in the lower extremities. Rigidity and bradykinesis occur late in the syndrome with death generally within one year of onset of the extrapyramidal symptomes. The disease appears to be inherited in an autosomal dominant manner, yet in several cases evidence exists that the cause is a transmissable agent. Seven patients with GSS in an Indiana family were recently evaluated. High field cranial MR examinations were performed on 5 of the most symptomatic. Of these 5 patients, 3 exhibited extrapyramidal symptoms as well as severe dementia and ataxia. MR images in all 3 demonstrated mild cerebellar atrophy with abnormal low signal on T2-WI in the putamen and globus pallidus. Signal loss was also present in the thalamus and caudate in one of these patients. This loss of signal on the T2-WI indicates an abnormal accumulation of iron in these areas. This has been confirmed by the autopsy histopathological finding of abnormal increased iron deposition in the basal ganglia in one of these patients with GSS. The remaining 2 of the 5 patients clinically had ataxia and mild dementia without any extrapyramidal findings. Cranial MR examinations of these patients were generally unremarkable without evidence of abnormal iron deposition. Increased iron content in the basal ganglia has previously been described in a number of neurodegenerative movement disorders, including Parkinson's disease, Parkinson Plus syndrome, Huntington's chorea, Hallevorden-Spatz, multiple sclerosis, and Shy-Drager syndrome.

A Comparison of Symmetric and Asymmetric Long TR Multi-echo Scans in the Evaluation of Intracranial Pathology: Watts A, Haimes AB, Kelly AB, Sze G, Deck MDF, Zimmerman RD(New York Hospital-Cornell Medical Center, New York, NY 10021)

A long TR asymmetric echo technique(AET) has been used as an alternative to a combination of short TR and long TR symmetric technique(SET), offering the advantage of shorter scanning times. To compare the efficacies of these two protocols, scans of 178 patients imaged at 0.6T with 500/32 and 2150/32, 64, 96, 128 sequences were reviewed. 2150/32& 96 or 128 scans were used to simulate AET and the 500/32 and 2150/64& 96 or 128 scans to simulate SET. (The 4th echo was often degraded and the third echo was usually employed.) In the majority of cases, AET and SET both adequately evaluated lesions. Overall, however, SET was superior. AET alone failed to detect one or more demyelinating lesions(primarily corticomedullary or paraventricular) in 22% of 65 cases due to low contrast with adjacent white matter on 2150/32(1st echo AET) and CSF on 2150/96(2nd echo AET) scans. They were well seen on the 2150/64 scan(1st echo SET) where CSF and brain were isointense (gray) and white matter lesions were bright. Confident diagnosis of small areas of subacute hemorrhage required STR and LTR images through the region of pathology. With subdural hematomas, maximal contrast was achieved on the 1st echo of the SET. In 15 of 17 infarcts, both protocols were equally useful; 2 small cortical infarcts were identified only with SET, again due to poor contrast. SET and AET were equivalent in the detection of intraaxial tumors in 65% of 49 cases. In 25%, SET was superior, including 3 cases where small lesions were not identified by AET. In 10% of cases, the 1st AET echo showed greater intralesional detail than the SET. In conclusion, while both AET and SET characterized most intracranial pathology, SET proved more valuable in the identification of small lesions, especially those near the cortical or ventricular surfaces.

DEMENTIA: POST-MORTEM MR PATHOLOGIC CORRELATION: Weissmann JR, Williams JP, Harp DL, Curran JG (Univ. of South Alabama, Mobile, Al 36617)

The current interest in Alzheimer's disease as well as the conflicting information in its MR status prompted a study to determine if Alzheimer specific changes could be identified and correlated with the pathologic findings.

8 brains were obtained from the Alzheimer Disease and related Disorders of Mobile. All the brains were fixed in formalin and scanned in a Picker Vista 0.5 Tesla magnet. The brains were then examined grossly and microscopically and correlated with the MR findings.

No abnormal MR white matter or periventricular signal changes were identified in the 4 brains that had histologically proven Alzheimer's disease. The only consistent MR feature was atrophy of the temporal lobe and hippocampal regions.

Increased T2 white matter changes were seen in 2 of the brains with no histologic changes of Alzheimer's disease and in a 3rd brain which had Alzheimer's disease. However, all the MR white matter lesions correlated with the gross and microscopic changes of vascular infarcts. The remaining brain had histologic changes compatible with Parkinson's disease.

In conclusion the initial 8 brains of the study indicated no MR specific Alzheimer white matter changes. It also substantiated the quoted literature percentages for dementia; 50% Alzheimer's (4), 20% multi-infarct(2), 15-20% mixed (1) and 10% other(1).

MR of the Cerebellar Vermis with Anatomic Correlation: Arrington JA, SchnitzleinN, Kumar AJ, Zinreich SJ, Hain T, Zee DS, Wang H, Ahn HS (Johns Hopkins Medical Institutions, Baltimore, MD 21205)

The cerebellar cortex, including the hemispheres and vermis, is divided transversely by fissures into an anterior, posterior and florculonodular lobe. The anterior and posterior lobes are further subdivided into lobules by fissures. The vermis is commonly divided into 9 lobules. MR has vastly improved the evaluation of the cerebellum and particularly the vermis. The anatomy of the cerebellar vermis is reviewed with gross anatomic sections and correlative MR images in the sagittal, axial, and coronal planes.

Preoperative Evaluation Of The Inferior Alveolar Nerve Prior To Dental Implant Surgery: Rothman SLG, Chafetz N, Schwarz MS, Rhodes ML (MPDI Medical Science Center, Torrance, CA 90505)

Osseointegrated dental implantation is rapidly becoming one of the most commonly performed oral surgical procedures. Its goal is to implant a set of dentures permanently. The proper positioning of the titanium implant, and anchoring of its tip into compact mandibular bone, require precise knowledge of the course of the inferior alveolar nerve.

Employing a special computer algorithm designed for optimal visualization of this structure, the normal anatomy of the inferior alveolar neurovascular bundle of 150 patients and 2 mandibular specimens was depicted on cross-sectional oblique and panoramic reformations generated from axial CT scans.

There are 3 patterns of ossification surrounding the inferior alveolar nerve. The first is dense bone. The second is a fine rim of bone surrounded by a medullary lucency. The third is marked demineralization with no visualized bone. The extent of ossification and the height and contour of the alveolar ridge is best evaluated on the cross-sectional oblique reformations. This allows the surgeon to operate on some patients who would otherwise have been excluded from surgery.

Direct Comparison of Intermediate And High Field MR : Hemorrhagic Lesions Examined With Spin Echo And Gradient Echo Techniques at 0.5 T And 1.5 T :
Seidenwurm D, Kowalski H, Meng TK, Schlesinger S, Kricheff II (New York University, New York, NY 10016)

Recent work has described the MR appearance of intracranial hemorrhage at 0.5T and 1.5 T. Imaging features thought to be field strength dependent have been described. No direct comparison of intermediate and high field MR of the same clinical lesions has been undertaken to date.

MR examinations of 20 patients with intracranial hemorrhage were performedat 0.5T and 1.5T. Examinations were performed within 2 hours for lesions less than 30 days old ; within 24 hours for lesions greater than 30 days old. MR examination included T1 and T2 weighted spin echo and T2* weighted gradient echo images at each field strength. The number and characteristics (i.e. signal intensity of the margin, body and core) of each hemorrhagic lesion were assessed and compared using the three pulse sequences at each field strength.

Seven lesions were under 7 days old, 12 were 8-30 days old, 14 were 31 to 300 days old and 17 were more than 301 days old.

Lesion detection and characterization were superior ($p < .01$) at 1.5T when T1W and T2W spin echo sequences were employed. Improved detection and characterization in lesions > 301 days old at 1.5T ($p < .01$) accounted for this observation. When gradient echo techniques were employed detection and characterization were similar at both field strengths. Gradient echo techniques did not provide significant additional information about hemorrhage at 1.5T in this series. Gradient echo techniques improved detection and characterization of hemorrhage at 0.5T.

Brain Arteriovenous Malformations: Analysis of the Angioarchitecture in Relationship to Hemorrhage: Willinsky R, Lasjaunias P, TerBrugge K, Pruvost P (Hopital Bicetre, Le Kremlin-Bicetre, France 94270 and University of Toronto, Toronto, Canada)

The authors studied the charts and angiograms of 178 patients with cerebral vascular lesions explored and/or treated at The Hopital Bicetre between 1981 and 1986. The angiographic features of the arteriovenous malformations (AVMs) could be grouped into: arterial variations, arterial aneurysms, arterial infundibulum, arterial stenosis, venous variation, venous stenosis, venous ectasia, arteriovenous fistula, trans-cerebral vascularization and external carotid supply. 25 patients were discarded due to incomplete information and 26 patients with lesions related to the venous system were eliminated. 56/127 or 44% had bled. Approximately 50% of patients in the 3rd (22/41) and 5th decades (8/17) bled whereas a lower percentage bled in the other decades. Deep (12/17) and posterior fossa (9/14) lesions bled more often than cortical (17/50) and cortical-ventricular (18/46). In the cortical lesions, 12 of the 17 that had bled were micro-arteriovenous malformations (nidus < 1cm). After excluding micro-AVMs we found that temporal (11/25) insular (2/3) and callosal (6/9) topographies bled more often than frontal (1/15), parietal (2/18) and occipital (1/13) lesions. Arterial aneurysms (18/24) and venous stenosis (23/43) were the commonest features associated with hemorrhage. Furthermore, we found that older males (40-50) with associated aneurysms and younger females (20-30) with venous stenosis were more likely to have bled. Analysis of the angioarchitecture of brain AVMs may be helpful for understanding symptoms, predicting clinical outcome and thus directing treatment decisions.

ACCEPTED AS ALTERNATE PAPERS:

Angiography of Spinal Dural Arteriovenous Fistula: Application of the Venous Phase: Willinsky R, Lasjaunias P, TerBrugge K, Hurth M (Hopital Bicetre, Le Kremlin-Bicetre, France 94270 and University of Toronto, Toronto, Canada)

The authors present their protocol for spinal angiography in their investigation of dural arteriovenous fistula (DAVF). The protocol has been used in approximately 120 patients from 1983 to present at Bicetre Hospital. To visualize the normal venous phase in a spinal angiogram requires a selective high quality study in the intercostal artery where Adamkiewicz originates. We achieve such a high resolution study by using conventional filming with magnification and subtraction during apnea (under general anaesthesia). The filming must last 24 seconds and we inject 1cc/second for 9cc of Hexabrix.

The myelopathy of DAVF is produced by a venous congestion. In the 20 patients with proven DAVF investigated at Bicetre, all had stasis in the spinal circulation evident on the angiogram. When a diagnosis of DAVF is entertained, demonstration of a normal venous phase in spinal angiography rules out a venous congestion and thus eliminates the necessity for a complete evaluation of the spinal axis. In these circumstances, normal veins can be seen to correspond to defects seen on the myelogram. Demonstration of stasis in the spinal cord circulation is consistent with a DAVF, and thus complete spinal angiography must be done. This must include selective injections of all intercostal arteries, including the lateral sacrals, as well as the supply to the cervical cord and posterior fossa.

In summary, the venous phase of a spinal angiogram can either support the suspicion of a spinal DAVF or rule out its diagnosis.

MR Angiography Of The Carotid Vessels: 2D Projective Techniques vs Gradient Echo Volume Reconstructions: Masaryk TJ, Lenz G, Ruggieri P, laub G, Ross JS, Haacke EM, Modic MT (Univ. Hospitals of Cleveland, Cleveland, Ohio 44106)

The purpose of this study was to compare motion compensated gradient echo acquisitions vs 2D projective spin echo MR of the carotid bifurcation in normals and pathologic cases. 2D projective techniques were obtained using a gated spin echo TE 24msec, velocity and acceleration compensated sequence with 15-20mm slice thickness acquired at systole and diastole in the sagittal plane with subsequent subtraction. 15 normals and 12 pathologic cases were studied. The volume technique consisted of: sagittally acquired ungated gradient echo, TE 13 velocity compensated (slice and read), TR 25-100msec, flip angle of 25-40 degrees, 32 partitions, 1-1.5mm slice thickness with thresholding and ray tracing algorithms for reconstruction in any plane without the need for subtraction. 12 normals and 8 pathologic cases were studied using this technique.

The projection 2D technique demonstrated good visualization of the carotid bifurcation in 13/15 normals and 2/12 pathologic cases. In contrast, the gradient echo

volume technique provide good visualization of the carotid bifurcation in 11/12 normals and in 5/9 of the pathologic cases. Patient motion, and variable signal intensity distal to the stenoses were major problems, but less so with the volume than projective techniques. Rarely, the gradient echo method appeared to suffer from lack of contrast which was thought to be related to poor cardiac output or slow flow distal to stenoses. Advantages of the gradient echo volume sequence included: 1) ease of application to patients which included lack of cardiac gating, shorter exam time, and the lack of dependence upon subtraction study, 2) exclusion of the jugular vein, 3) multiple projective reconstructions, 4) improved characterization of stenoses, 5) minimization of phase dispersion with shorter TE's, gradient refocusing, and diminished voxel size. Additional improvements may be possible with refinement of the gradient refocusing pulses or shorter echo times.

Improvement of Signal-to-Noise and Contrast-to-Noise Ratios in MR Employing Mixed Bandwidth Pulse Sequences: Lipper MH, Cail WS, Brookeman JR, Mugler JP, Chason DP, Beskin RR, Ferguson RD (Univ. of Virginia, Charlottesville, Va 22908)

It is well known that MR signal-to-noise (SNR) and contrast-to-noise (CNR) ratios deteriorate with increasing echo times. In order to improve SNR and CNR in the second echo of a double echo sequence performed on a 1.0 T Siemens Magnetom unit, we are currently employing a mixed bandwidth technique for data reception. We use a relatively wide bandwidth, resulting in a short data sampling period (Ts), for the first echo, to achieve a short minimum echo time thus reducing the effects of T2 decay, enabling one to maintain a "proton density" image. For the second echo, we utilize a narrow bandwidth, resulting in a long data sampling period to improve SNR and CNR. This requires lowpass filters with different bandwidths for the two echoes. On patient images the background noise level on the second echo is approximately 60% of that on the first echo.

We have compared mixed bandwith sequences with standard sequences employing the same bandwidth and Ts for both echoes of a double echo sequence. We have shown a definite improvement in SNR and CNR for the second echo with the mixed bandwidth technique. Additional improvement has been achieved by using gradient motion rephasing (GMR) for the second echo. The drawbacks of the technique are an increased chemical shift artifact, which does not appear to exert an undue influence on the diagnostic quality of brain images, as well as some increase in artifacts from motion, T2 decay, field inhomogeneities and susceptibility interface.

Magnetic Resonance Imaging Of The Spinal Cord In Patients With Suspected Multiple Sclerosis: Hershey, BL, Peyster RG, Haskin ME (Hahnemann University, Philadelphia, PA 19102)

We retrospectively reviewed magnetic resonance (MR) scans of 119 patients performed from November 1985 to March 1988 who were referred with symptoms suggesting multiple sclerosis (MS) involving the spinal cord. There were 103 studies of the cervical cord, 40 studies of the thoracic cord and 11 studies of the conus and lumbar region. Brain imaging was obtained in 97 patients. All studies were performed on a GE Signa 2.0 T magnet operating at 1.5 T. Sagittal T1 weighted, proton density, and T2 weighted images were obtained for all spine studies. We found MS plaques in the spinal cord in 15 patients (12.6%), 11 cervical and 6 thoracic. Brain studies were available in all of these patients and in 6 were diagnostic of MS. Of the five other patients, two had negative brain studies, one had a single white matter lesion, and two had a few white matter lesions. Alternative diagnoses were encounted in 34 patients, including sternosis or disc herniation, sarcoid and prior cord hemorrhage. In 13 patients with symptoms of spinal cord MS, brain imaging was positive while cord imaging was negative. We conclude that spinal cord imaging is useful in addition to brain MR in patients with clinical symptoms of MS involving the cord. Spine MR is also useful in identifying other types of pathology in patients suspected of having cord MS.