Head Trauma

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ACR APPROPRIATENESS CRITERIA

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Patricia C. Davis, for the Expert Panel on Neurologic Imaging

Craniocerebral injuries are a common cause of hospital admission following trauma, and are associated with significant long-term morbidity and mortality. CT remains essential for detecting lesions that require immediate neurosurgical intervention as well as those that require in-hospital observation and medical management.[1] For patients with minor head injury (Glasgow Coma Scale [GSG] score of 13–15), the New Orleans Criteria[2] and the Canadian CT Head Rule[3] are clinical guidelines with high sensitivity for detecting injuries that require neurosurgical intervention and offer a potential reduction in unnecessary CT scans.[4-6]

Other imaging modalities such as MR imaging depict nonsurgical pathology not visible on CT. Cervical spine imaging is indicated for patients with head injury who have signs, symptoms, or a mechanism of injury that might result in spinal injury, and in those who are neurologically impaired (see the ACR Appropriateness Criteria for Spine Trauma).

Skull Radiography

Masters et al[7] developed and tested a management strategy that shifted the focus of neuroimaging of head trauma away from skull radiography and toward CT scanning. Skull radiography is useful for imaging of calvarial fractures, penetrating injuries, and radiopaque foreign bodies.

CT

CT advantages for evaluation of the head-injured patient include its sensitivity for demonstrating mass effect, ventricular size and configuration, bone injuries, and acute hemorrhage. CT offers widespread availability, rapidity of scanning, and compatibility with medical devices. Its limitations include insensitivity in detecting small and nonhemorrhagic lesions such as contusion, particularly adjacent to bony surfaces. Likewise, diffuse axonal injuries (DAIs) that result in small brain lesions go undetected on CT. CT is relatively insensitive for detecting increased intracranial pressure or cerebral edema and for early demonstration of hypoxic-ischemic encephalopathy (HIE) that may accompany head injury. Potential risks of exposure to ionizing radiation warrant judicious patient selection for CT scanning as well as radiation dose management.[8]

There is a consensus that patients identified as moderate-risk or high-risk for intracranial injury should undergo early noncontrast CT for evidence of intracerebral hematoma, midline shift, or increased intracranial pressure. There is an inverse relationship between declining clinical or neurologic status as described by the GCS[9] and the incidence and severity of CT abnormalities related to head injury.[10-12]

Clinical selection criteria for CT scanning of patients with minor or mild injury (ie, GCS score >12) who harbor significant intracranial pathology and/or require acute surgical intervention have been problematic. Rapid CT scanning is readily available in most hospitals that treat head injured patients; thus CT has value as a screening tool to triage minor or mild head-injured patients who require hospital admission or surgery from those who can be safely discharged without hospital admission.[13-15] Although this approach offers reduced inpatient services and reduced cost, the result is greater CT use in the emergency setting.[11,13-15] In the minor head injury setting with a GCS score of 15, the New Orleans Criteria[2] found 100% sensitivity for CT identification of an acute trauma lesion by using risk factors of headache, vomiting, drug or alcohol intoxication, older than age 60, short-term memory deficit, physical findings of supraclavicular trauma, and/or seizure. Stiell et al[3] reported 100% sensitivity for detecting neurosurgical and/or clinically important brain injury in subjects with a GCS score of 13–15 based on high-risk factors of failure to reach a GCS score of 15 within 2 hours, suspected open skull fracture, 2 or more vomiting episodes, sign of basal skull fracture, or age ≥65.

Clinical criteria for scanning of children with head injury have been less reliable than those for adults, particularly for children younger than age 2.[16,17] For this reason, more liberal use of CT scanning has been suggested for pediatric patients. This must be balanced with the higher risk of radiation exposure in childhood via judicious patient selection for scanning as well as management of radiation dose.[8,18,19] Noncontrast head CT plays an essential role in the evaluation of children with suspected physical injury from child abuse (see the ACR Appropriateness Criteria for Suspected Physical Abuse—Child).

Early and repeated CT scanning may be required for deterioration, especially in the first 72 hours after head injury, to detect delayed hematoma, hypoxic-ischemic lesions, or cerebral edema.[20] CT has a role in subacute or chronic head injury for depicting atrophy, focal encephalomalacia, hydrocephalus, and chronic subdural hematoma.

Cerebral Angiography, CTA, MRA

Cerebral angiography has a role in diagnosis and management of traumatic vascular injuries such as pseudoaneurysm, dissection, or uncontrolled hemorrhage. Vascular injuries typically occur with penetrating trauma, basal skull fracture, or trauma to the neck.[21-23]

CT angiography (CTA) and MR angiography (MRA) have a role as less invasive screening tools for detection of traumatic

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ACR CRITERIA

Clinical condition—head trauma	CT, head, without contrast	MRI, brain, without contrast	X-ray and/or CT, cervical spine†	CT, head, without and with contrast	MRI, brain, without and with contrast	CTA, head and neck	MRA, head and neck	Angiography, cerebral	X-ray, skull
Minor or mild acute closed head injury (GCS ≥13), without risk factors or neurologic deficit	7[a]	4	5	3	2	3[b]	3[b]	1	1
Minor or mild acute closed head injury, focal neurologic deficit and/or risk factors	9	6[c]	6	2	3	5[cd]	5[cd]	1	1
Moderate or severe acute closed head injury	9	6	8	2	2	5	5	1	2
Mild or moderate acute closed head injury, child <2 years old	9	7[e]	7	2	4[f]	4[d]	4[d]	1	5
Subacute or chronic closed head injury with cognitive and/or neurologic deficit(s)[g]	6	8	2[h]	2	3	4[i]	4[i]	1	2
Closed head injury; rule out carotid or vertebral artery dissection‡	8	8[e]	5	6[j]	6	8	8[k]	6[c]	2
Penetrating injury, stable, neurologically intact	9	5[l]	8[m]	4[j]	4[l]	7	6[l]	5[d]	8[n]
Skull fracture	9	6[l]	6	4	4[lo]	7[d]	4[l]	1	5[i]

Note:—Appropriateness criteria scale from 1 to 9; 1 indicates least appropriate; 9, most appropriate; [a], known to be low yield; [b], rarely indicated with mild trauma; [c], for problem solving; [d], if vascular injury suspected; [e], include diffusion-weighted images; [f], potentially useful in suspected non-accidental trauma; [g], PET or SPECT for brain = 4−used for selected cases; [h], assuming there are no spinal neurologic deficits; [i], for selected cases; [j] consider perfusion; [k], add T1 images; [l], if MRI is safe; [m], if neck or C-spine is site of injury; [n], if calvarium is site of injury; [o], useful if infection is suspected. †, see the ACR Appropriateness Criteria on Spine Trauma; ‡, see the ACR Appropriateness Criteria on Cerebrovascular Disease.

vascular lesions. MRA and fat-suppressed T1-weighted MR[22] or CTA may reveal carotid or vertebral dissection, although angiography remains the gold standard for dissection depiction.

MR Imaging

MR imaging is hindered by its limited availability in the acute trauma setting, long imaging times, sensitivity to patient motion, incompatibility with various medical devices, and relative insensitivity to subarachnoid hemorrhage. Other factors include the need for MR imaging-specific monitoring equipment and ventilators, and the risk of scanning patients with certain indwelling devices (eg, cardiac pacemaker, cerebral aneurysm clip) or foreign bodies. In part, these limitations can be overcome by situating MR imaging scanners close to emergency care areas with appropriate design and equipment for managing acutely injured patients.[24,25] Open bore geometry, faster imaging sequences, and improved patient monitoring equipment allow a greater role for MR imaging in closed head injuries.

MR imaging is sensitive for detecting and characterizing subacute and chronic brain injuries. MR abnormalities in subacute head injury have been used to predict the recovery outcome of posttraumatic vegetative state.[26] While CT is sensitive for detecting of injuries requiring a change in treatment,[27] MR imaging also is used for acute head-injured patients with nonsurgical, medically stable pathology. Hemosiderin-sensitive T2-weighted gradient echo sequences reveal small subacute or chronic hemorrhages. Diffusion sequences improve detection of acute infarction associated with head injury. Fluid-attenuated inversion recovery (FLAIR) images are more sensitive than conventional MR imaging sequences for depicting of subarachnoid hemorrhage and for lesions bordered by CSF.[28]

The soft tissue detail offered by MR imaging is superior to that of CT for depicting nonhemorrhagic primary lesions such as contusions, for secondary effects of trauma such as edema and hypoxic-ischemic encephalopathy, and for imaging of DAI.[29-31] DAI results in characteristic lesions in increasing order of injury severity in the: 1) cerebral white matter and gray-white matter junction, 2) corpus callosum, particularly the splenium, and 3) dorsal upper brain stem and cerebellum.[29,32]

Superior depiction of nonsurgical lesions with MR imaging may affect medical management and predict the degree of neurologic recovery.[29,33] Diffusion-weighted MR imaging and apparent diffusion coefficient (ADC) mapping depict cytotoxic injury almost immediately. In acute brain trauma, focal contusion and DAI may show restricted diffusion and evolve over time to atrophy / encephalomalacia.[34,35] Perfusion imaging with CT or MR imaging may prove helpful for disorders of vascular autoregulation or ischemia.[36]

Other Imaging Modalities

A few reports suggest a role for functional imaging techniques (SPECT, PET, xenon-enhanced CT, functional MR imaging) to assess cognitive and neuropsychologic disturbances as well as recovery following head trauma.[37-40]

Review Information

This guideline was originally developed in 1996. The last review and update was completed in 2006.

Appendix

Expert Panel on Neurologic Imaging: Patricia C. Davis, MD, Principal Author, Northwest Radiology Consultants, Atlanta, Ga; David J. Seidenwurm, MD, Panel Chair; James A. Brunberg, MD; Robert Louis De La Paz, MD; Pr. Didier Dormont; David B. Hackney, MD; John E. Jordan, MD; John P. Karis, MD; Suresh Kumar Mukherji, MD; Patrick A Turski, MD; Franz J. Wippold II, MD; Robert D Zimmerman, MD; Michael W. McDermott, MD, American Association of Neurologic Surgeons; Michael A. Sloan, MD, MS, American Academy of Neurology.

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