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BACKGROUND AND PURPOSE: Cervical transforaminal blocks are frequently performed to treat cervical radicular pain. These blocks are performed mostly under fluoroscopy, but a CT-guided technique has also been described. The aim of this study was to review the results of CT-guided CSNRB by using a dorsal approach, to describe the contrast patterns achieved with this injection technique, and to estimate the degree of specificity and sensitivity.

MATERIALS AND METHODS: We used a CT-guided technique with a dorsal approach leading to a more extra-than transforaminal but a selective nerve root block as well. Of 53 blocks, we performed 38 for diagnostic and 15 for therapeutic indications. Pain relief was measured hourly on a VAS. The distribution of contrast and the angle of the trajectory of the injection needle were analyzed as well as the degree of pain relief.

RESULTS: Contrast was found in the intraforaminal region in 8 (15%) blocks, extraforaminally in 40 (78%) blocks, and intraspinally in 3 (6%) blocks. The mean angle between the needle and the sagittal plane was 26.6° (range, from 1° to 50°). The mean distance between needle tip and nerve root was 4.43 mm (range, 0–20 mm). Twenty-six (68.4%) of the 38 diagnostic blocks led to a decrease in the pain rating of >50%. There were no complications or unintended side effects, apart from occasional local puncture pain.

CONCLUSIONS: We conclude that CT-guided CSNRBs using a dorsal approach are feasible and that they are sensitive and specific.

ABBREVIATIONS: CSNRB = cervical selective nerve root block; VAS = Visual Analog Scale

CSNRBs are commonly performed under fluoroscopic guidance,[1-7] but CT guidance is also possible and has been described.[8] CT guidance offers the advantage of enhanced anatomic resolution with a more precise needle-tip positioning.[9] It is, however, seen as more time-consuming and likely to involve more radiation exposure. In both fluoroscopic and CT-guided CSNRBs, the aim is to block the root in the foramen. The patient is, therefore, placed in a supine position, and the foramen is reached from a lateral approach in a nearly horizontal plane.

In recent years, there have been several reports of catastrophic complications of CSNRB under fluoroscopic guidance, including cerebral edema[10]; cerebellar infarction[11-13]; infarction of the cervical spinal cord[14,15]; and hemorrhagic infarction of the pons, midbrain, cerebellum, and thalami with intraventricular extension, subarachnoid hemorrhage, and hydrocephalus.[16-18] There are similar reports of CT-guided CSNRB complications of cerebellar and brain stem infarction[19] and spinal cord infarction.[20] In all these cases, the probable mechanism was arterial puncture leading to infarction. Live fluoroscopy has been advocated to detect vascular uptake, but 2 of the above-mentioned cases were performed with this technique.[12,15]

There is a need, therefore, to modify the conventional technique to minimize the risks of the procedure.

We used a modification of the CT-guided technique in which the patient is prone and the foramen is accessed from the dorsal aspect, with the tip of the needle aimed at the outer confines of the foramen. This technique leads to an extraforaminal but still selective nerve root block. It might involve a smaller risk of devastating complications, such as spinal cord infarction or cerebellar infarction.

The aim of the study was to review the results of CT-guided CSNRB by using the dorsal approach, to describe the contrast patterns achieved with this injection technique, and to estimate the degree of specificity and sensitivity.

Materials and Methods

Patients

Between January 1, 2007, and December 31, 2007, thirty-one patients underwent CT-guided CSNRB involving 53 blocks. The indication was diagnostic in 38 blocks and therapeutic in 15 blocks. Eighteen patients had only 1 diagnostic block, 7 patients had 2 blocks, 4 patients had 3 blocks, 1 patient had 4 blocks, and 1 patient had 5 blocks. If patients had >1 block, the blocks were usually performed at intervals of 1 week and were typically done for therapeutic purposes.

Technique

Informed consent was obtained before the intervention. The procedure, its benefits, and its risks were discussed with the patient. Risks included infection, bleeding, and allergic reaction as well as a small risk of a severe neurologic impairment, such as spinal cord stroke or even death.

For the procedure, the patient was placed in the prone position. The patient's head was in a straight position with the forehead on a pillow. After a lateral scout image was obtained, the designated level was marked and images were obtained through the desired cervical

Number of different nerve root blocks[a]								
	All Indications			Diagnostic Indication			Therapeutic Indication		
Nerve Root	No.	+	−	No.	+	−	No.	+	−
C3	1	1	0	1	1	0	0	0	0
C4	4	3	1	3	2	1	1	1	0
C5	3	1	2	3	1	2	0	0	0
C6	22	16	6	14	9	5	8	7	1
C7	13	10	2	12	9	3	1	1	0
C8	10	9	1	5	4	1	5	5	0
Σ	53	40	13	38	26	12	15	14	1

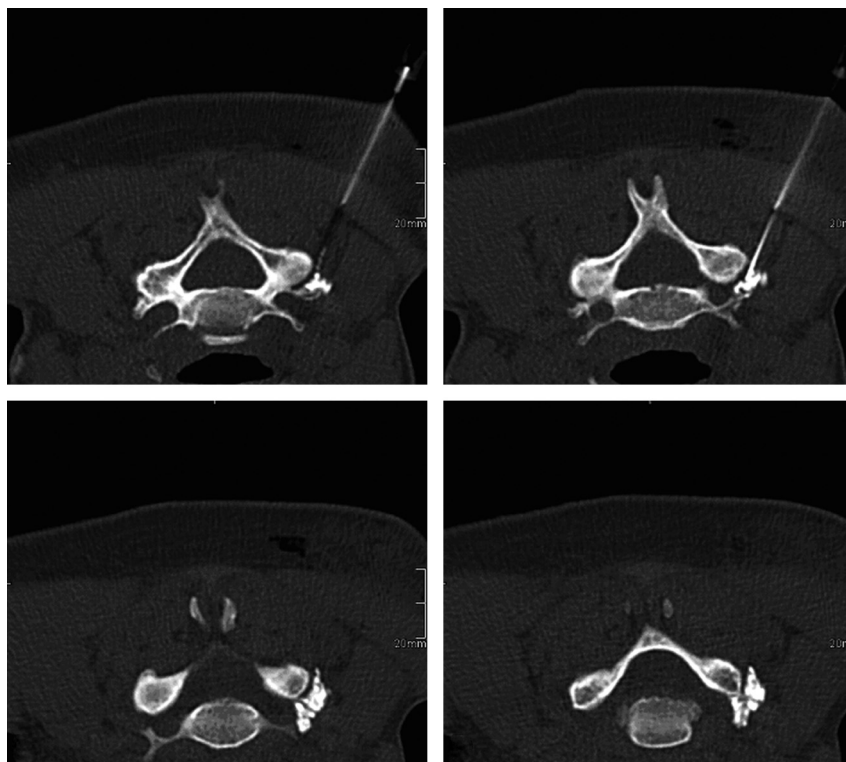[a] + indicates evaluated as a positive block; −, evaluated as a negative block.

Fig 1. Extraforaminal contrast distribution after CSNRB of the right C6 nerve root.

neural foramen. An appropriate needle-entry point was calculated before it was identified and marked on the skin prior to its sterilization. The entry site was chosen to avoid the carotid and jugular vessels and to gain access to the outer foramen. Usually, the needle was placed in a 10°–45° angle to the sagittal plane (a 45°–80° lateral angle to the table).

Once the site was sterilized and the skin and subcutaneous tissue were anesthetized, a 22-ga 10-cm straight spinal needle (Seibelneedle; William Cook Europe, Bjaeverskov, Denmark) was partially inserted through a 19-ga 4-cm introducer needle, and an initial image was obtained by using the minimum exposure the CT scanner could provide. The straight spinal needle had marks to control the depth of introduction.

After the initial image was obtained, the needle was adjusted and advanced toward the posterior aspect of the neural foramen by using an intermittent CT imaging technique. A multisection technique with 6 images per acquisition and a section thickness of 3 mm was used, which could display the entire course of the needle and the surrounding anatomy. Usually 1 or 2 acquisitions were sufficient. The optimal placement of the needle tip was at the outer edge of the posterior aspect of the foramen, which was reached from the dorsal approach

typically at a 10°–45° angle (range, 1°–50°) between the needle and the sagittal plane (Figs 1 and 2). The facet joint capsule served as a confine for the needle. The patients sometimes described reproduction of their pain when the needle was in the correct position. Once the needle was in the desired position, 0.5 mL of a 1:1 mixture of iopamidol (Solutrast 300; Bracco Altana Pharma, Konstanz, Germany) and bupivacaine 0.75% (Bucain; Delta Select, Dreieich, Germany) was injected. After the injection, an acquisition with 6 images was used again, which then displayed the entire distribution of the contrast. When the contrast was in an appropriate distribution, the nerve root block was performed with 1 mL of bupivacaine. If no or an inappropriately small amount of contrast was detected, the procedure would have been stopped. This, however, was never the case.

For therapeutic blocks, 8 mg (2 mL) of dexamethasone (Fortecortin Inject; Merck, Darmstadt, Germany) was added.

Patient Assessment

Usually in our department, the patient's history and a pain analysis are recorded at the first presentation, a physical (neurologic) examination is conducted, and the CT/MR imaging scans of the cervical
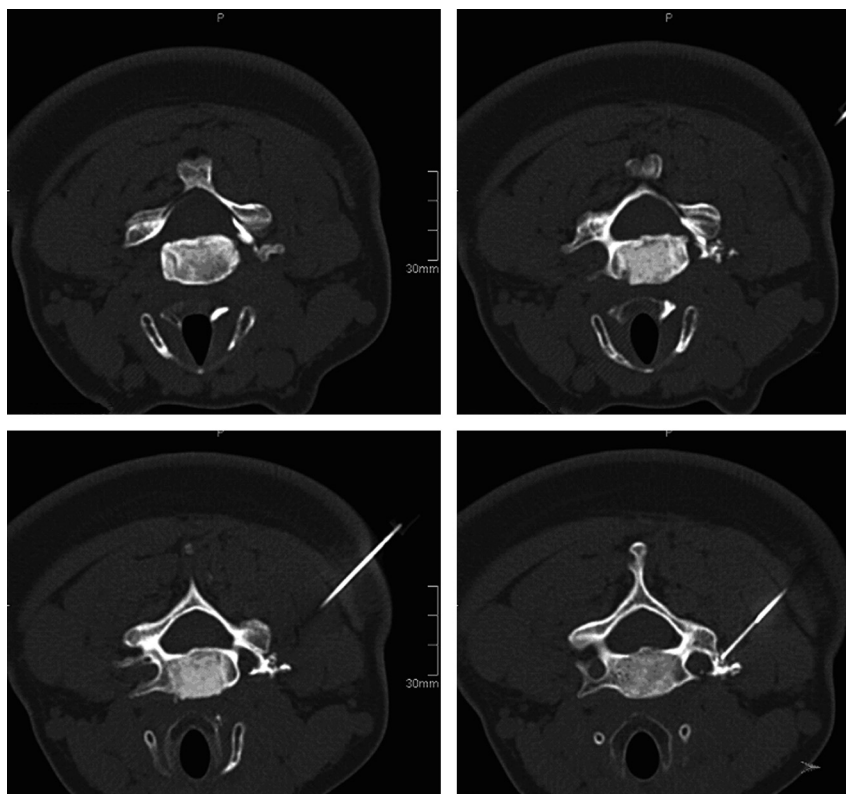
Fig 2. Extra- and intraforaminal contrast distribution after CSNRB of the right C6 nerve root.

spine are evaluated. When the assumed diagnosis is cervical radicular pain, a cervical nerve root block is planned.

For this retrospective study, patients' charts were assessed to ascertain the nerve root and pathology involved. Furthermore, the patients' charts were reviewed to discover whether, following a positive diagnostic block, an operative intervention or subsequent therapeutic blocks were performed and their effect on pain intensity.

Outcome Measurement

At our institution, all patients receive a standard form to fill in their pain scores on the VAS before the block and after the block for 6 hours in hourly intervals. Later, these standard forms were analyzed. The block was regarded as positive if the following criteria were met: 1) the pain level decreased >50%, 2) the duration of the response was ≥4 hours, and 3) the pain in the arm decreased if one of the nerve roots from C5 to C8 were blocked.

Neuroradiologic Analysis

Contrast patterns were analyzed to assess whether the spread of the contrast agent was extraforaminal, intraforaminal, or intraspinal. To this end, we analyzed each block by means of 6 axial sections in 3-mm sections centered on the foramen.

Needle angulation was measured as the angle between the needle and the sagittal plane. The distance between the needle tip and the nerve root was measured, as well as the distance between the needle tip and the entrance of the foramen. The foramen was defined as being situated posteromedial to a line from the anterior confine of the zygapophyseal joint to the anterior part of the uncinate process (Fig 3).
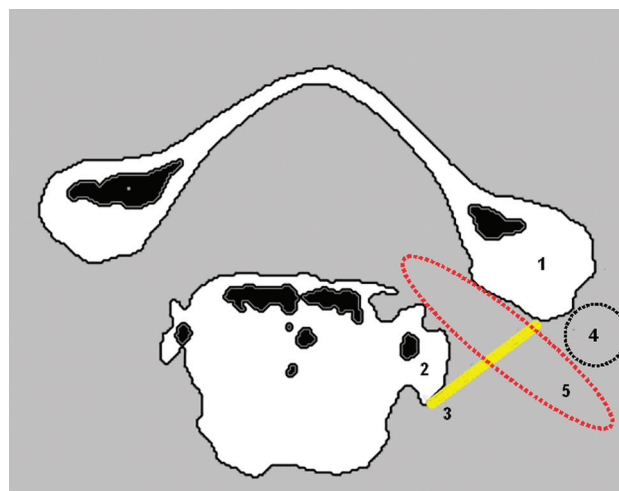

Fig 3. Schematic illustration of the needle tip and entrance of the foramen. 1 indicates the facet joint; 2, the uncinate process; 3, the line reaching from the anterior part of the uncinate process to the anterior part of the zygapophyseal joint; 4, the area in which the needle tip in the dorsal-approach technique is expected; and 5, the area in which the nerve root and nerve supplying the artery are expected.

Statistical Analysis

For statistical analysis, a computer software package (GraphPad Prism, Version 5.01; GraphPad Software, La Jolla, California) was used. A P value < .05 indicated a significant difference. For calculation of the statistical significance of the differences of mean VAS scores, the Mann Whitney U test was used. An unpaired t test was also used to determine if there were statistical differences in the distance from the needle tip to the nerve root or to the foramen between the group of positive and negative blocks. Angulation of the needle was

correlated to the distance from the needle tip to the foramen and to the nerve root by means of the Wilcoxon matched-pairs test. The χ^2 test was used to compare extra-/intraforaminal contrast patterns with the results of the blocks.

Ethics Committee Approval
This retrospective study was approved by the Ethics Committee of the University Hospital, Freiburg, Germany.

Results

Outcome Measurement
Overall 40 blocks fulfilled the criteria for positive blocks and 13 blocks were classified as negative. The positive blocks were 1 C3 block, 3 C4 blocks, 1 C5 block, 16 C6 blocks, 10 C7 blocks, and 9 C8 blocks.

With 1 exception, the blocks that were considered negative were performed for diagnostic indications. Among these blocks, there were 1 C4 block, 2 C5 blocks, 6 C6 blocks, 3 C7 blocks, and 1 C8 block.

In those blocks not affecting pain relief, another pain source, either radicular pain emerging from another level or a different pathology (such as cervical facet joint pain or peripheral neuropathy) was later found.

Thirty-eight blocks were performed with diagnostic and 15 blocks with therapeutic indications (Table). Overall mean VAS scores decreased from 5.57 ± 1.57 (range, 2.5–10.0) preintervention to 1.52 ± 2.29 (range, 0.0–7.0) postintervention.

In patients with positive blocks, mean VAS scores decreased from 5.42 ± 1.57 (range, 2.5–10) to 0.52 ± 1.04 (range, 0–4.5). In negative blocks, mean VAS scores were 6.08 ± 1.44 preintervention (range, 5.0–10.0) and 5.25 ± 1.48 postintervention (range, 3.0–7.0), respectively. No statistically significant difference was found between the preinterventional VAS scores in positive and in negative blocks ($P = .14$). Postinterventional VAS scores clearly differed in the 2 groups of blocks ($P < .0001$).

Twenty patients had osseous pathology (foraminal stenosis due to osteophytes), 4 patients had a soft disk prolapse, and 6 patients had a combined pathology in the level of interest. One patient who underwent 2 CSNRBs had a soft disk prolapse at the C5–6 level and osseous pathology in the C4–5 level. Overall 5, 37, and 11 CSNRBs were performed for osseous, soft disk, and combined pathology, respectively.

Fourteen patients had subsequent surgery. Nine patients had ventral spondylodesis. This was performed with bone cement in 7 patients, autologous bone grafts and ventral osteosynthesis in 1 patient, and a cage in another patient. Five patients had cervical foraminotomy as described by Frykholm.[21] All patients who underwent ventral fusion had a complete resolution of the radicular pain, but 1 patient who had a single-level fusion with Palacos had neck pain 3 months after the operation. Those patients who underwent dorsal decompression had complete pain relief directly after the operation, but after 3 months, 1 patient had radicular pain once again.

Most patients who had >1 block had similar results each time. One patient had the same level block performed 3 times for therapeutic indications, and 5 patients had the same level block performed twice.

In 1 patient, a C7 block and a C8 block were performed. He had complete pain relief (VAS score, from 4.5 to 0) after the C7 block and partial pain relief after the C8 block (VAS score, from 2.5 to 1), which was rated positive. After dorsal decompression of the C7 nerve root foramen, the patient remained pain-free.

One patient had a C6 block leading to complete pain relief and subsequently underwent dorsal decompression, which initially led to complete pain reduction. Three months later, the patient once more had cervicobrachialgia, which now irradiated into the C7 dermatome. A C7 block led to complete pain relief, and a second therapeutic C7 block had a long-lasting effect.

Neuroradiologic Analysis
The mean angle between the needle and the sagittal plane was 26.61° (range, 1°-50°). The mean distance between the needle tip and the confines of the foramen was 10.02 mm (range, 1–20 mm). The mean distance between the needle tip and the nerve root was 4.43 mm (range, 0–20 mm).

The angle of the needle and the distance between the needle and the nerve root did not correlate to the effect of the block ($P = .4915$ and $P = .2591$). However, the distance between the needle and the foramen was significantly higher in those blocks that were rated positive ($P = .007$).

Angulation of the needle correlated with the distance between the needle tip and the foramen ($P = .0009$) and the distance between the needle tip and the nerve root ($P = .0132$).

Contrast had an extraforaminal distribution pattern in 40 blocks. In 3 blocks, contrast was found intraspinally (epidurally), and in 8 blocks, the distribution of contrast was both intra- and extraforaminal. Unfortunately in 2 blocks, the contrast scans were not archived. There were no correlations between extra- or intraforaminal distribution of contrast and a positive or negative response to the block (χ^2: extraforaminal, 34 of 40 positive blocks, 8 of 13 negative blocks; $P = .12$).

In 10 blocks (3 therapeutic and 7 diagnostic), no clear contact between the contrast agent and the nerve root was found, due to difficulty in identifying the exact position of the nerve root in its extraspinal course. Nevertheless, 9 of these blocks were positive. No correlation was seen between contrast in clear contact with the nerve root and a positive or negative response to the block.

Discussion
CSNRB is a technique frequently used in case of cervical radicular pain, with estimates ranging in the magnitude of >30,000 per year in the United States.[22] It can be used as a diagnostic tool, but more often, it is performed therapeutically with local application of corticosteroids as an alternative to medical treatment or operative decompression of the nerve root. Indications for a diagnostic cervical block revolve around clinical and MR imaging findings.[23]

Lately, there is a growing awareness of possible devastating complications of the procedure, such as spinal cord infarction or cerebellar infarction. Also vertebral artery puncture has been described.[16] In a recent survey conducted among pain physicians about complications following cervical transforaminal epidural steroid injections, 78 complications including 16 vertebrobasilar brain infarcts, 12 cervical spinal cord infarcts, and 2 combined brain and spinal cord infarcts were

reported.[24] However, there is likely to be under-reporting of complications.[25] Some complications have not been published because they are still before the court or because lawyers and patients refused to have their case records released into the medical literature.[5] Among the published cases, there are 2 in which CSNRB was performed under CT guidance,[19,20] both with a transforaminal access.

It is assumed that most complications involve an embolic mechanism, with inadvertent injection of high-particulate material into a nerve root artery.[26] Recently, after the known adverse events were analyzed, the use of real-time fluoroscopy to detect vascular uptake, a nonparticulate corticosteroid such as dexamethasone, and microbore extension tubing (pigtail) to minimize needle manipulation while changing syringes have been proposed to reduce the probability of these adverse events.[24]

CT guidance with dorsal access offers the possibility of performing a selective block, as the contrast distribution pattern demonstrates. For the therapeutic efficiency of corticosteroids, it is not important if the target point is located slightly more distally because there is a strong axonal transport of corticoids.[27] If, however, an intraspinal epidural (less selective) distribution of the steroid is intended, the conventional or even a translaminar approach is more suitable.

In our opinion, the technique we describe minimizes the danger of inadvertent puncture of the nerve root artery because the target point of the needle tip lies posterior to the region in which the radicular artery can be expected to run.

Recently, the technique has been described in a technical note, but no information was supplied regarding the patterns of contrast distribution, the angle of the trajectory, the distance between the needle tip and the nerve root, and pain relief after the block.[9] In the present study, the angle of the needle toward the sagittal plane correlated with the distance between the needle tip and the foramen and the distance between the needle tip and the nerve root but not with the distribution of contrast. The pattern of contrast distribution did not correlate with either a positive or negative response to the nerve block. This indicates that intraforaminal distribution of the local anesthetic is not necessary for anesthesia of the nerve root. The volumes used in our studies are within the ranges described in the literature.[3,23,28]

It is believed that posterior needle placement in the foramen might minimize the risk of intravascular injection by avoiding the vertebral artery.[29] In a large series of 1036 extraforaminal nerve root blocks, the posterior access was significantly safer than the anterior.[30] This finding may be because the radicular artery normally runs anterior to the radicular nerve. Nevertheless, Huntoon[31] could demonstrate that branches of the deep cervical and ascending artery can enter the foramen posteriorly and can supply the spinal cord. He described the anatomy of the deep cervical arteries after examination of the cervical foramina of 10 embalmed cadavers and found that of 95 intervertebral foramina dissected, 21 had an arterial vessel proximal to the posterior aspect of the foraminal opening and 7 of these 21 cases were spinal branches potentially forming radicular or segmental medullary vessels to the spinal cord. He concluded that these arteries may be vulnerable to injection or injury during transforaminal epidural steroid injection. This might explain why, in some published

cases of complications, the needle position was in the posterior part of the foramen.[11,14,17]

It is difficult to compare the CT technique with the fluoroscopic technique in terms of contrast use. First, vascular uptake in the dorsal approach appears to be much more unlikely because the final needle position is not in the region of the suspected course of the radicular artery. Second, applying a small volume of contrast as an initial step makes it possible to correct the needle position in cases of insufficient contrast distribution. Although the final volume of local anesthetic injected is larger than the initial contrast volume, this difference has a lower impact on the specificity of the block than the position of the needle tip. By obtaining a block of 6 CT acquisitions with 3-mm section thicknesses after contrast injection, we could rule out contrast distribution to the adjacent nerve root.

Because the complications stated above seem to occur at a frequency of <0.1%, the present study of 53 is insufficiently powered to assess the risks associated with our technique. For similar reasons, the sensitivity and specificity of the technique when used for diagnostic purposes cannot be determined with certainty. However, to our knowledge, precise estimates of the sensitivity and specificity of other techniques of cervical nerve root block studies do not exist; nevertheless, these techniques are widely used. For methodologic and ethical reasons, a study that would produce this information seems virtually impossible to perform. First, it would require that a precise diagnosis for the pain be achieved by another method; this, however, could make a diagnostic block unnecessary and could expose the patient to an unnecessary risk. Second, the study design would have to negate the possibility of a false-positive response due to the patient's expectations (placebo response; for lumbar back pain, this issue has been reviewed by Saal[32]).

The only way to draw limited conclusions regarding specificity and sensitivity is to compare the results of serial (therapeutic) injections or to correlate them to the outcome of nerve root decompression. We did this and found that blocks of the same nerve root produced similar outcomes, with a low level of variability in changes in pain scores, and that surgical decompression of the nerve root identified led to pain relief in all except 1 case.

The technique is simple and not very time-consuming. It induces a relatively low radiation dose, particularly if in the future, dose-reduction strategies published recently[33,34] can also be applied for intermittent CT acquisition.

Conclusions

CT-guided CSNRB by using a dorsal approach is feasible, seems to have the same predictive value as other commonly used techniques for cervical blocks, and, on the basis of technical considerations, can be assumed to have a higher degree of safety.

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