The Use of Ultrasound During Spinal Cord Surgery

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Intraoperative spinal ultrasonography is now considered an indispensable tool in many operations on the spine and spinal cord. Using ultrasonography, surgeons can now easily find and evaluate lesions within the spinal cord, dural sac, and along the ventral margin of the vertebral column during operations. Syrinxes, intra- and extramedullary tumors, hematomas, bone fragments, bullet fragments, cysts, and discs can be easily located and treated under ultrasonic guidance. In this article, we described the techniques used in performing this procedure, normal anatomy, and images of various types of pathologic lesions.

The accurate preoperative and intraoperative localization of lesions of the spine and spinal cord is vitally important for neurosurgeons. Because of the extreme delicacy of the spinal cord, the surgeon must be precisely aware of the position of the operative field, and where he/she is headed at all times.

Preoperative localization of spinal cord lesions has attained a high technological level with such tests as myelography, computed tomography (CT), and magnetic resonance imaging (MRI). MRI has recently become the diagnostic imaging technique of choice for imaging the spinal cord and spinal subarachnoid space [1-3]. It directly images the spinal cord with high contrast and detail, and it does not require the injection of contrast material, like CT and myelography, to achieve this visualization. Furthermore, unlike MRI, CT and myelographic examinations have been generally disappointing in the detail of the spinal cord they can display even with contrast material in the subarachnoid space [4-8].

Unfortunately, despite its exquisite detail of the spinal cord, MRI is worthless as an intraoperative tool. Once in the operating room, the neurosurgeon must use his/her best judgment in determining the location and extent of lesions based on the MRI displayed abnormalities. Furthermore, it is obvious that any manipulations performed during an operation will not be displayed on preoperative diagnostic scans. It is at this point that real-time ultrasonography has its greatest utility.

It turns out that real-time ultrasonography is almost the perfect intraoperative instrument. Once the bone has been surgically removed, ultrasonography is an excellent localizing device, since merely by pointing the scanhead at a lesion, all of the 3-dimensional coordinates defining the position of a lesion relative to the scanhead are defined [9, 10]. Since the neurosurgeon holds the scanhead, the position of a lesion is defined relative to the position of his/her hands, precisely the relationship a surgeon employs to define the location of lesions during an operation. The result is equivalent to literally pointing at an abnormality, exactly what one would want. Since the technique is performed in real-time and is safe, ultrasonography can be used repeatedly to evaluate the status of an operation. Not only can neurosurgeons localize spinal abnormalities, but they can...
Fig. 2. Normal transverse scan of a spinal cord. A fluid path (F) is present in the near field separating the scanhead from the posterior dura mater (curved arrows). (Posterior will always be positioned at the top of the images.) The posterior subarachnoid space is the clear space between the posterior dura mater and the spinal cord (s). The dentate ligaments (small arrows) are the small lines on each side of the spinal cord. The central canal (hollow arrow) is represented by a localized reflection in the ventral half of the spinal cord. In this scan, the anterior dura mater (middle-sized arrows) is resolved at about 5 o'clock and 8 o'clock. The dura mater cannot, however, be resolved along the posterior surface of the vertebral body (large arrow). The anterior subarachnoid space appears as an anechoic area between the spinal cord and vertebral body. Reprinted with permission of publisher [24].

Fig. 3. Normal cauda equina. Transverse scan through the cauda equina demonstrating individual nerve roots (small arrows') in cross-section. Two large groups of nerve roots (large arrows') are visible near the neural foramina. Reprinted with permission of publisher [24].

Fig. 4. Normal longitudinal scan of spinal cord. The posterior dura mater (solid arrows') is the first reflection beneath the scanhead. (On longitudinal scans, cephalad will always be on the left side of the image.) The spinal cord (s) appears as a long ribbon beneath the anechoic posterior subarachnoid space (p). The central canal (hollow arrows') is a line running through the ventral half of the spinal cord. The posterior surfaces of the vertebral bodies (v) are discontinuous reflections separated by disc spaces (curved arrows). The anterior subarachnoid space (a) lies between this line of discontinuous reflections and the spinal cord. Reprinted with permission of publisher [24].

Fig. 5. Normal conus medullaris. Longitudinal scan showing the conus medullaris narrowing into the filum terminale. The boundary of the spinal cord (small arrows') and the site of origin of the filum (large arrow) are visible. Multiple nerve roots (r) can be seen surrounding the conus and extending into the cauda equina. The central canal is again demonstrated on this scan (curved arrow).

also confirm immediately during an operation that a maneuver has actually produced the intended effect [9, 10].

Technique

All of the operations to be described were performed with the patients in the prone position. With a prone patient, the laminectomy can be filled with sterile saline providing a fluid path several centimeters deep through which scanning can be performed (Fig. 1). The fluid path has several functions: it keeps the near-field cap artifact of the scanhead from falling within the image of the spinal cord, it increases the amount of the spinal cord that can be imaged within a sector, and it allows scanning of the intraspinal contents without having to touch the intrathecal structures themselves [9, 10]. Finally, the scanhead can be positioned so that its area of best focus falls within the spinal cord.

The technique can be performed from an anterior approach through a corpectomy as well [11]. The procedure is identical. The space provided by the resected vertebral body is filled with saline producing a fluid path. The only difference is that now the more ventral anatomic structures are nearest to the scanhead.