Use of Intraoperative Ultrasonography During the Surgical Repair of Pediatric Cystic Spinal Dysraphism

—Technical Note—

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Abstract

The present study investigated the benefits of intraoperative ultrasonographic guidance during the surgical repair of congenital cystic spinal dysraphic lesions. Twenty-one children with cystic spinal dysraphism who underwent surgical repair were examined by real-time ultrasonography during the surgical intervention. Five children had meningoceles, six had myelomeningoceles, four had open neural plaques, three had lipomyelomeningoceles, and three had diastematomyelia. Visualization of the cystic compartments, identification of the neural structures, and identification and localization of the associated lesions were all reliably achieved in all cases. Intraoperative ultrasonographic guidance could determine the type of lesion and the associated lipomas, ectopic tissues, dermoid and epidermoid cysts, and doubling of the spinal cord, and locate diastematomyelic spurs, bands, and adhesions. Components filled with cerebrospinal fluid appeared as anechoic areas, and lipomas as hyperechoic. Intraoperative ultrasonographic guidance allowed the surgeon to correlate the complex anatomy identified on preoperative computed tomography and magnetic resonance imaging to the surgical site during the operation. Better orientation to the defect allows appropriate repair of the lesion with optimal preservation of neural tissues.

Key words: spina bifida, cystic spinal dysraphism, intraoperative ultrasonography

Introduction

Spinal dysraphism is a relatively common congenital anomaly of the central nervous system encountered in pediatric neurosurgical practice. The term cystic spinal dysraphism is used to describe congenital posterior midline lesions affecting the vertebra, spinal cord, and skin, and includes meningocele, myelomeningocele, open neural plaque, and lipomyelomeningocele. These congenital lesions can include many associated lesions beyond the primary anomaly. Congenital spinal dysraphic lesions are devastating for both family members and the affected child. Appropriate neurosurgical intervention may offer the patients a better quality of life. Surgical repair of the cystic spinal dysraphism with layer by layer closure is the optimum treatment, and removal of the tethered portion is essential for successful treatment.

Magnetic resonance (MR) imaging can demonstrate the anatomy and associated problems in and around the lesions. However, preoperative computed tomography (CT) and MR imaging may not show the precise localization, type, and anatomy of associated lesions beyond the cystic lesion. Real-time image guidance may be helpful for the localization of associated anomalies and identification of pathology during surgical intervention.

Ultrasonography has been successfully used as a diagnostic tool during many types of neurosurgical operations for several years. Ultrasonography is safe, simple to use, inexpensive, and mobile in the operating room. Comparison of preoperative neuroimaging findings and intraoperative sonographic data is extremely important for the localization and identification of pathology during surgical intervention.
The present study assessed the use of intraoperative ultrasonography during the surgical repair of cystic spinal dysraphism for real-time image guidance.

Materials and Methods

Twenty-one patients, 12 females and nine males aged from 2 months to 2 years, underwent ultrasonography-assisted repair of cystic spinal dysraphism at the Neurosurgical Department, Faculty Of Medicine, Ondokuzmayis University in 2000–2001. Five of the 21 lesions were meningoceles, six were myelomeningoceles, four were open neural plaques, three were lipomyelomeningoceles, and three were diastematomyelia.

All lesions were evaluated by one of the authors (C.Ç.) using a Tosbee real-time ultrasound scanner (Tosbee; Toshiba Inc., Tokyo). A 7.5 MHz transducer was used to enhance the imaging of the solid, cystic, and neural portions of the defects, and the spinal canal. The tip of the transducer head was covered with sterile gel to maximize the sonographic images. The transducer and cord were then covered with a sterile, translucent, disposable plastic sheath to maintain sterile surgical conditions. The tip of the transducer was touched gently to the cranial border of the lesion and moved in the caudal direction in the transverse and longitudinal planes. Images were selected on the monitor screen and hard copies were printed.

The first step in the sonographic evaluation is identifying the posterior bony structures of the spine. This examination provides the border of the spina bifida defect and the level of the kyphotic segment. Evaluation of the neural network should then start at the normal level and move in the direction of the defect. Finally, the cystic mass should be examined from the plane of the base to the top of the midline surface. The dissection plane, the most suitable site for entry into the cyst, the border of the lipoma, the bony spur, cystic cavities, and septa should be distinguished and marked as required using a sterile pen.

The upper and lower parts of the spina bifida, the course of spinal cord into the lesion, and the location and extent of the lipomatous and other solid parts were visualized. The ultrasonographic images were compared with the preoperative images obtained by radiography, CT, and MR imaging.

The results of the intraoperative ultrasonography were evaluated according to the following criteria: type of the lesion, determination of associated lesions, visualization of the neural structures underlying the skin surface, identification of doubling of the spinal cord, and accuracy of localization of the diastematomyelic spur and lipoma.

Results

Ultrasonography could easily identify the type of lesion, and easily delineated the upper and lower parts of the spina bifida in all patients. The findings of ultrasonography and MR imaging showed good correlation for the course of the spinal cord in the normal spinal canal and in the lesion, as well as associated anomalies. Ultrasonography could identify the location and extent of the lipomatous and other solid components of the lesion, as well as components filled with cerebrospinal fluid.

The lamina, spinous processes, and boundary bony structures around the spina bifida appeared as hyperechoic structures. The spinal dura mater was shown as a circular hyperechoic thin membrane around the hyperechoic cylindrical spinal cord. The epidural space appeared as hyperechoic. The components of the lesions filled with cerebrospinal fluid were anechoic. Lipomatous and solid components of the lesions were hyperechoic.

The axial T2-weighted MR image of a normal segment of an illustrative case is shown in Fig. 1A. The intraoperative ultrasonographic image in the axial plane of this case is also shown in Fig. 1B. Another
illustrative case shows the diastematomyelic spur and the doubling of the spinal cord (Fig. 2). Sagittal T2-weighted MR and intraoperative ultrasonographic images of the proximal segment of the cystic spinal dysraphism are shown in Fig. 3. Preoperative and intraoperative neuroradiological images of the malformation area are shown in Fig. 4.

Discussion

The primary goal of the present study was to evaluate the benefits of intraoperative ultrasonographic examination during the surgical treatment of cystic spinal dysraphism. These types of congenital anomalies may demonstrate complex structural and neuronal organization. Neurosurgeons need to understand the relationship between the malformation and neural tissue in the defect. Better orientation to the lesion will allow appropriate repair of the lesion with optimal preservation of the neural tissues. Information about the type of the lesion (myelocele, myelomeningocele, or lipomyelomenigocele), the position of neural structures in the cyst, lipoma, ectopic renal and intestinal tissues, epidermoid or dermoid cyst, band and adhesions, presence or absence of diastematomyelic spur, and doubling of the spinal cord is necessary for orientation and planning of the surgical repair.

The intraoperative ultrasonographic examination should be started at the normal level of the dorsal side in the axial plane moving from superior to inferior, and in the sagittal plane from right to left. We found that intraoperative ultrasonography was...
excellent for the localization of the diastematomyelic spur, lipoma, and cerebrospinal fluid compartments in the lesions (Figs. 2 and 4). Intraoperative real-time ultrasonography could also show the depth, course, and location of neural tissues, and associated anomalies in the cystic mass (Figs. 3 and 4). Hidden tethering lesions can also be visualized by ultrasonography during surgical intervention.\textsuperscript{6,9,10,12} The ultrasonographic findings should be correlated with clinical examination, and the preoperative MR images and CT scans. Intraoperative ultrasonography did not always provide information about the associated lesions beyond the anomaly such as ectopic renal and intestinal tissues, epidermoid or dermoid cyst, band, and adhesions.

Intraoperative ultrasonography is a useful diagnostic tool during the surgical treatment of pediatric cystic spinal dysraphic lesions, especially for establishing the orientation of malformed lesions and the presence of associated anomalies, and may enhance surgical success.

References


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Commentary on this paper appears on the next page.
Commentary

The authors described a novel technique to facilitate surgical treatment of congenital cystic spinal dysraphic lesions. Although MRI is the diagnostic gold standard in the cases with spinal dysraphism, intraoperative ultrasonography allows the surgeon to correlate the complex anatomy of the lesion identified preoperatively to the surgical field during the operation. The use of ultrasonography for spinal surgery is not new, but can be a useful diagnostic tool during the surgical treatment of congenital cystic spinal dysraphic lesions.

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Ultrasonography has several advantages over MRI, including real-time data acquisition, mobility, cost-efficiency, and freedom from problems with the use of magnetic materials. The authors investigated the benefits of intraoperative ultrasonographic guidance during surgical repair of congenital cystic spinal dysraphic lesions in 21 cases, and confirmed that ultrasonography is a reliable tool for visualization of cystic components, identification of normal structures, and identification and localization of associated lesions. Although the image quality of ultrasonography is far worse than that of MRI, as shown in the figures in this paper, the authors made up for this disadvantage of ultrasonography by systematic examination of the correlation of the complex anatomy identified on preoperative CT and MRI with intraoperative ultrasonographic findings. MRI- and CT-guided neuronavigation, which are commonly used, do not provide anatomical findings over the course of operation. Their disadvantage of non-real-time data acquisition might lead surgeons to inappropriate judgements regarding surgical procedures due to intraoperative shift of the brain, spinal cord, and other structures, especially in the case of cystic lesions and mass lesions. In this paper, authors successfully demonstrate the usefulness of ultrasonography in spinal surgery in infants.

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