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Diagnostic value of ultrasonography in spinal abnormalities among children with neurogenic bladder

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Abstract

Background: Nowadays, magnetic resonance imaging (MRI) is the gold standard for evaluation and diagnosis of spinal cord abnormalities, which are considered among the leading causes of neurogenic bladder; however, MRI is a costly imaging method and is not available at all health centers. Sporadic studies have shown the alignment of MRI with ultrasonography results in diagnosis of spinal abnormalities; although none of these studies has expressed the diagnostic value of ultrasonography.

Objective: The aim of this study was to evaluate the diagnostic value of ultrasonography in detection of spinal abnormalities in children with neurogenic bladder.

Methods: This is a cross-sectional study carried out from January 2014 to November 2015 on patients with neurogenic bladder referred to Department of Radiology, Dr. Sheikh Hospital, Mashhad University of Medical Sciences, Mashhad, Iran. All patients underwent sonography of the spinal cord and soft-tissue masses; also, a spinal MRI scan was performed. The existence of spina bifida, sacral agenesis, posterior vertebral arch defects, mass, tethered cord, myelomeningocele, lipoma and fatty infiltration, dural ectasia, hydromyelia and syringomyelia, and diastomatomyelia was recorded during each imaging scan. Chi-square and Fisher's tests were used for data analysis using SPSS 19.0 software, and the sensitivity and specificity of ultrasonography findings were calculated by MedCale 26 software.

Results: Forty patients with neurogenic bladder (22 males/18 females), with an average of 25.73±19.15 months, were enrolled. The most common abnormality was found in patients' MRI was tethered cord syndrome (70%). There was a significant relationship between ultrasonographic and MRI findings in spina bifida abnormalities (p=0.016), sacral agenesis (p=0.00), tethered cord (p=0.00), myelomeningocele (p=0.00), and lipoma and fatty infiltration (p=0.01). Ultrasonography had a sensitivity of 20.0%-100% and a specificity of 85.7%–100% depending on the detected type of abnormality.

Conclusion: It seems that ultrasonography has an acceptable and desirable sensitivity and specificity in the diagnosis of most of the spinal cord abnormalities except for dural ectasia, hydromyelia and syringomyelia, diastomatomyelia, and the spinal cord masses in children with a neurogenic bladder.

Keywords: Neurogenic bladder, Ultrasonography, Magnetic resonance imaging

1. Introduction

Neurogenic bladder is a term applied to a malfunctioning urinary bladder, which occurs due to abnormalities of the central or peripheral nervous system and leads to loss of urine control (1, 2). Open spinal dysraphism, including meningocele, myelomeningocele, lipo myelomeningocele, occult spinal dysraphism (tethered cord syndrome), sacral

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and anorectal agenesis, spinal trauma, spinal cord tumors and transverse myelitis are some of the most common causes of neurogenic bladder in children (1, 2). Prevalence of these disorder varies from 0.5 to 5 per thousand births and is more prevalent in females and the poor (3). To evaluate and diagnose neurological causes of neurogenic bladder, the anatomy of the spinal canal is performed using CT scan, tomography, myelography, and magnetic resonance imaging (MRI). However, the gold standard imaging to evaluate the spinal cord is T1 MRI sections (4). However, MRI is a costly imaging method and is not available in all health centers. On the other hand, sporadic studies over recent decades have shown the alignment of MRI with ultrasonography results in the diagnosis of spinal disorders. Studies have demonstrated that high-resolution ultrasonography also can provide useful anatomical and pathological information from the spinal cord and soft tissue structure. Moreover, ultrasound is a simple, noninvasive, cheap, safe, and reliable and safe diagnostic tool compared with other imaging methods. Also, the ultrasound can be used as a valuable method to screen people at risk for lumbar spinal disorders (5). On the other hand, the presence of cartilage tissues in the posterior arch of the vertebral column in children and due to visibility spaces, which are better than intervertebral interlaminar spaces in children, causes a high-quality examination of the spinal canal by ultrasonography. In these cases, ultrasound can provide useful information on the status of the spinal canal with lower costs (2, 6). Sporadic studies have already compared ultrasonography findings with MRI in different types of spinal cord injuries. However, so far no study has evaluated the diagnostic value of ultrasonography in the study of spinal cord abnormalities in patients with urinary incontinence due to neurogenic bladder. The aim of this study was to evaluate the diagnostic value of ultrasonography in detection of spinal abnormalities in children with a neurogenic bladder.

2. Material and Methods

2.1. Research Design and Setting

This is a cross-sectional study carried out from January 2014 to November 2015 on patients with a neurogenic bladder referred to Department of Radiology, Dr. Sheikh Hospital, Mashhad University of Medical Sciences, Mashhad, Iran. In this study, patients aged less than 12 years diagnosed with neurogenic bladder dysfunction by a pediatric neurologist/subspecialty, according to diagnostic measures, entered the study; patients with a known history of myelomeningocele or brain lesions and those older than 12 years were excluded. The sampling method was a census, and all patients referred to the imaging center during the study period with inclusion criteria and without exclusion criteria were evaluated.

2.2. Measurement Tool

2.2.1. *Checklist*

A checklist including age, sex, and abnormal findings on ultrasonography and MRI were recorded for all patients. Ultrasound and MRI abnormalities included spina bifida, sacral agenesis, posterior vertebral arch defects, mass, tethered cord, myelomeningocele, lipoma and fatty infiltration, dural ectasia, hydromyelia and syringomyelia, and diastomatomyelia. All patients first underwent spinal sonography of the spine, spinal cord, and soft-tissue masses and then spinal MRI was performed for all of them.

2.2.2. *Ultrasound and MRI Protocol*

Spinal ultrasonography in lateral recumbent with knees-to-chest position was performed by a pediatric radiologist using multifrequency surface probes (7 to 12 MHz). Lumbosacral spinal cord MRI (1.5 Tesla) was carried out in children aged less than 6 years with a sedative and, if necessary, anesthetic drugs and sagittal and transverse T1 and T2 images of spine and, if necessary, coronal were prepared, and ultrasonography and MRI results were prepared and recorded based on the research variables in checklist.

2.3. Ethical Consideration

This study was approved by the Ethics Committee of Mashhad University of Medical Sciences (922870). Before the inclusion of children to study, the research project, along with its advantages and disadvantages, was explained to parents, and they signed the written consent form. Patients' privacy and dignity were maintained during the implementation of the project, and their coded information was entered into the analysis program.

2.4. Statistical Analyses

Findings of this study were statistically analyzed using SPSS 19.0 for Windows (SSPS Inc., Chicago, IL, USA). To examine the relationship between the results of ultrasonography and MRI, the chi-square test and, if necessary, Fisher's exact test were used. Moreover, sensitivity and specificity of ultrasonography findings were calculated on MRI using Medcalc 16.1 software.

3. Results

This study included 40 patients with a neurogenic bladder (22 males/18 females) with an average of 19.15±25.73 years. Based on the results, the most common abnormalities found in patients with a neurogenic bladder were regarding ultrasonography and an MRI tethered cord as much as 60% and 70%, respectively. After that and according to the ultrasound, myelomeningocele (30%) and sacral agenesis (25%) had the highest prevalence. However, according to the MRI, the most common anomaly found after tethered cord was dural ectasia (30%); then, myelomeningocele, sacral agenesis, and hydromyelia and syringomyelia had the highest prevalence (each 25%). Figure 1 shows ultrasound findings of four spinal cord anomalies.

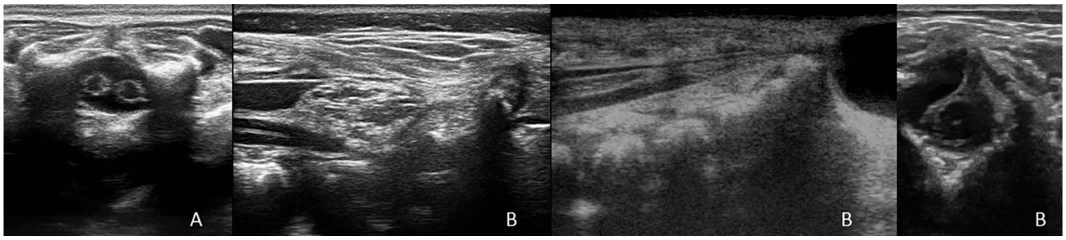

Figure 1. A) Typical feature of diastomatomyelia; B) Intra-spinal mass with tethered cord and sacral hypoplasia; C) Tethered cord with distal meningocele; D) Dermal sinus tract attached to dorsal surface of cord.

Table 1. Relationship between anomalies found on ultrasonography, magnetic resonance imaging (MRI) of the spine, spinal cord, and soft-tissue masses in children with neurogenic bladder

Variables,	Ultrasonography; n (%)	MRI; n (%)	p-value
Spina Bifida	2 (10)	3 (15)	0.016
Sacrum Agenesis	5 (25)	5 (25)	0.00
Defect of the Posterior Vertebral Arch	2 (10)	1 (5)	0.10
Mass	1 (5)	3 (15)	0.150
Tethered Cord	12 (60)	14 (70)	0.001
Myelomeningocele	6 (30)	5 (25)	0.00
Lipoma and Fatty Infiltration	3 (15)	2 (10)	0.016
Dural Ectasia	4 (20)	6 (30)	0.541
Hydromyelia and Syringomyelia	1 (5)	5 (25)	0.250
Diastomatomyelia	2 (10)	3 (15)	0.284

Table 2. Diagnostic Power of Ultrasonography in the Diagnosis of Spinal Dysraphism in Children with Neurogenic Bladder

	Variables	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
Ultrasonography of the lumbar spine (n=20)	Spina Bifida	66.6%	100%	100%	94%
	Sacrum Agenesis	100%	100%	100%	100%
	Defects of the Posterior Vertebral Arch	100%	94.7%	50%	100%
Ultrasonography of cord and soft tissue (n=20)	Mass	33.3%	100%	100%	89.4%
	Tethered Cord	85.7%	100%	100%	75%
	Myelomeningocele	100%	93.3%	83.3%	100%
	Lipoma and Fatty Infiltration	100%	94.4%	66.6%	100%
	Dural Ectasia	33.3%	85.7%	50%	75%
	Hydromyelia and Syringomyelia	20.%	100%	100%	78.9%
	Diastomatomyelia	33.3%	94.1%	50%	88.8%

According to Fisher's test, a statistically significant relationship was observed between ultrasonographic and MRI findings in spina bifida anomalies, sacral agenesis, tethered cord, myelomeningocele, and lipoma and fatty infiltration (Table 1). In examining the diagnostic power of ultrasonography in the diagnosis of spinal cord abnormalities in children with neurogenic bladder, results showed that ultrasonography of the lumbar spine has a sensitivity of 66.6%-100% and specificity of 94.7% to 100% depending on the type of injury (Table 2). Besides, the ultrasonography of spinal cord and soft-tissue masses has a sensitivity of 20.0% to 100% and a specificity of 85.7% to 100% depending on the type of injury. In ultrasonography of the lumbar spine, the lowest sensitivity is associated with diagnosing spina bifida (66.6%), and the lowest specificity is for the posterior vertebral arch defect (94.7%). Besides, in ultrasonography of spinal cord and soft-tissue masses, the lowest specificity and sensitivity are related to hydromyelia and syringomyelia diagnosis (20.0%), and the lowest specificity was related to dural ectasia (85.7%).

4. Discussion

This study aimed to evaluate the diagnostic value of ultrasonography in the diagnosis of spinal disorders in children with a neurogenic bladder; the results showed that ultrasonography has high specificity for the diagnosis of most spinal cord injuries, although it does not have high sensitivity in diagnosis of some disorders such as mass, dural ectasia, hydromyelia and syringomyelia, and diastomyelia. One of the most common causes of neurological bladder is a congenital spinal cord lesion. Thus, diagnosis and treatment of the underlying disorder causing nervous bladder is of utmost importance. In this study, disorders such as simple occult spinal dysraphisms such as tethered cord, hydromyelia, and syringomyelia, occult spinal dysraphisms such as diastomyelia, spinal dysraphisms covered with skin coverage such as myelomeningocele, dysraphism of the vertebral column such as spina bifida and sacral agenesis were evaluated by ultrasonography and MRI, and the results were compared. So far, MRI has been the gold standard to evaluate and diagnose spinal abnormalities; however, high cost and the lack of availability of MRI in all treatment centers has prevented this method to be pervasive for treating all patients. Moreover, ultrasonography is an affordable, noninvasive imaging method, which is readily available in most health centers. However, for the use of ultrasonography in the diagnosis of spinal cord injuries, many studies are needed, and our study is among the first to evaluate the diagnostic value of ultrasonography. High specificity of ultrasonography in the diagnosis of spinal cord abnormalities in patients with a neurogenic bladder is highly remarkable in the analysis, so that, in five of 10 analyzed injuries, ultrasonography specificity is 100%; except for one of 10 cases, it is 93.3%–94.7%, which is highly desirable as a diagnostic tool.

This study is distinct from other studies because it has investigated the ultrasonography diagnosis power in most spinal cord abnormalities because, in most conducted studies, the diagnostic power of ultrasonography has just been discussed in a particular injury. On the other hand, despite sporadic studies comparing the results of ultrasonography and MRI, there has been no systematic comparison between these two methods. In the research of Gerscovich et al., which was among the first studies that compared the results of ultrasonography and MRI, it has been demonstrated that the results only in 20% of cases failed to reach a successful diagnosis of myelomeningocele. (7) However, in this study, there is no report of the diagnostic value of ultrasonography against MRI and the patients under study were also those with myelomeningocele. Moreover, in the Chern et al. study, an adaptation of ultrasonography of the lumbar spine and MRI in patients suspected to occult spinal dysraphism, the sensitivity of ultrasonography for detecting an abnormal conical surface was obtained as 76.9% (8). In another study conducted by Sasani et al., (9) the relationship between skin lesions with radiological, clinical, and urodynamic findings were examined; ultimately, the results showed no diagnostic discrepancy between ultrasonographic and MRI findings. Moreover, according to this group of researchers, MRI is still the most reliable diagnostic procedure of spinal cord injuries. However, the Lode et al. studies in 2008, after Rohrschneider et al. results in 1996, have reconsidered ultrasonography in the diagnosis of spinal cord injuries, although this study has been reported in statistically low volume (10). In this study, six children with skin disorders of the lumbosacral region were subject to spinal ultrasonography and MRI, and ultrasonography was able to diagnose occult spinal dysraphism and tethered cord in all patients (10). In the Rohrschneider et al. study, spinal disorder findings diagnosed in ultrasonography of 30 babies with a mean age of 5.5 months were consistent with MRI findings; in all cases of abnormalities, the diagnoses were the same (11) Also, in Sattar’s study, the use of prenatal ultrasonography in diagnosis of spina bifida led to favorable results in post-natal follow-up by MRI, so that in all eight infants under study, ultrasonography had diagnosed prenatal spina bifida (12). In the latest studies in 2015, the Hondel et al. study showed that ultrasonography had a sensitivity of 80% and specificity of 89% in diagnosing tethered cord (13). One of the other items not mentioned in other studies, which has been examined for the first time in this study, is the relationship between spinal cord abnormalities findings in patients with neurogenic bladder on MRI with ultrasonography. In this study, there was a significant relationship among ultrasonographic findings of spina bifida, sacral agenesis, tethered cord, myelomeningocele, lipoma and fatty infiltration and MRI findings, while a significant relationship was not found in the dural ectasia items, hydromyelia and syringomyelia and diastomatomyelia.

Apart from discussing the low sample size under study in this group of lesions, which can be influential in the presence or absence of this relationship, other issues also involved in finding this association will be discussed in the following with raising the diagnostic power of ultrasonography in the differentiation of hydromyelia and syringomyelia. Among the results obtained in the present study, the lowest possible sensitivity of ultrasonography occurred in the diagnosis of hydromyelia and syringomyelia in a way that ultrasonography showed a detection sensitivity as much as 20%, which is consistent with Gerscovich's study. In Gerscovich's study, ultrasonography was less sensitive in diagnosing hydromyelia–syringomyelia compared with MRI. It seems that this can be attributed to the position of hydromyelia–syringomyelia, so that the exposure of injury at higher levels of the spinal cord is associated with reduced detection sensitivity. However, unfortunately, the situation of hydromyelia–syringomyelia lesions to the spine was not discussed in the study to enable us to judge further in regards to this analysis. However, what is not mentioned in the study, but is considered as investigators' experiments, was that ultrasonography can detect masses of the spinal canal in small sizes in a few millimeters to centimeters, and more masses were detected in a well-defined round or oval contour. Perhaps one of the possible reasons for the different results obtained in the present study compared with other studies is the difference in the ultrasonography operator in the studies. In our study, all ultrasonography were performed by an experienced pediatric radiologist; therefore the probability of diagnostic success in ultrasonography is at the lowest level compared with other studies, although the ultrasonographer's characteristics have not been properly mentioned in all studies. On the other hand, the success of an ultrasonographic evaluation of spinal dysraphism is significantly associated with the presence of enough inter-laminar space or bone defect in posterior elements to achieve enough vision from spinal canals, and its difference in different patients in various studies can be among the other reasons for different obtained results.

5. Study limitations

The conducted study also faced some limitations. The sample size of cases is from significant cases that should be considered in future studies, and the studies with higher sample size should be carried out. In the present study, due to student researcher's time constraints in this project, collecting more samples was not possible, while it was possible that, by increasing the sample size, analyzing the relationship between more variables of our study will encounter more significant results. On the other hand, this single-center study was carried out in a subspecialty pediatric imaging center. However, to achieve more generalizable results, this study should be performed as a multicenter research by people with different skill levels. It is suggested that, in future studies, in addition to taking into account the limitations of the current study, the relationship between physical examination findings and clinical manifestations should be examined with ultrasonographic and MRI findings.

6. Conclusions

Based on the results obtained in this study, ultrasonography has a favorable and acceptable sensitivity and specificity for the diagnosis of most spinal cord abnormalities in children with neurogenic bladder and can be used as a valuable preliminary diagnosis in patients suspected of having neurogenic bladder dysfunction. However, due to low sample size, the results of this study need more replications in higher sample size for more generalizability.

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Conflict of Interest:

There is no conflict of interest to be declared.

Authors' contributions:

All authors contributed to this project and article equally. All authors read and approved the final manuscript.

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