Elmesallamy *Egyptian Journal of Neurosurgery* (2019) 34:39
https://doi.org/10.1186/s41984-019-0061-8

Egyptian Journal of Neurosurgery

RESEARCH Open Access

Perioperative ultrasound imaging versus magnetic resonance imaging in management of lumbosacral spinal dysraphisms

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Abstract

Objectives: The purpose of this study was to correlate lumbosacral spinal ultrasound (LUS) and magnetic resonance imaging (MRI) findings in patients with lumbosacral spinal dysraphisms to evaluate the value of LUS in diagnosis, intraoperative use, and during follow-up of those patients.

Methods: A total of 24 patients aged up to 6 years old were operated for lumbosacral spinal dysraphisms at the Neurosurgery Department of Zagazig University hospitals during the period from January 2017 to August 2018. All patients were investigated preoperatively, intraoperatively, and on follow-up by LUS to compare the data with preoperative and follow-up MRI of the spine.

Results: The median age was 11 months at the time of surgery. The most common anatomical description from the LUS study was thickened filum (18 cases). Using MRI findings as the standard reference, the sensitivity of LUS in detecting a thickened filum was 77.8% preoperatively and 62.5% postoperatively, with a specificity of 100%. The sensitivity and specificity of detecting conus level, solid masses, and cystic masses were 100%.

Conclusions: Lumbosacral spinal dysraphisms can be evaluated well by ultrasound imaging in age group up to 6 years old with 100% specificity (true negative) in comparison with MRI.

Keywords: Lumbosacral ultrasound, Spinal dysraphisms, Myelomeningocele, Tethered cord

Introduction

Spinal dysraphism is an umbrella term that describes any anomaly of the spinal cord, cauda equina, or overlying tissues such as the muscles and skin. The nervous system abnormalities may or may not associate with mesenchymal or dermal changes. Spinal dysraphism is one of the most common congenital disorders associated with significant morbidity and mortality [1].

Spinal dysraphisms are categorized into open spinal dysraphisms (OSD) and closed spinal dysraphisms (CSDs). Open spinal dysraphisms basically include myelomeningocele and other rare abnormalities such as myelocele and hemi-myelomeningocele. Closed spinal dysraphisms are further categorized based on the association with low-back subcutaneous masses. Closed spinal dysraphisms with mass are represented by lipomyelocele, lipomyelomeningocele, meningocele, and myelocystocele. Closed spinal dysraphisms without mass comprise simple dysraphic states (tight filum terminale, filar and intradural lipomas, persistent terminal ventricle, and dermal sinuses) [2].

Sonography is a good method for investigating the spinal canal, cord, and meningeal coverings and for characterizing nearly all spinal anomalies with high geometric resolution in the neonatal and infantile age groups. Relative advantages of sonography over MRI include wide and cheap availability, no need for sedation or general anesthesia, and lack of vulnerability

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to artefacts due to patient movement, cerebrospinal fluid (CSF) pulsation, and vascular flow which can adversely affect MR image quality [3].

This work aims to study the role of ultrasonography in lumbosacral spinal dysraphism evaluation to identify and classify the different spectrum of lesions in comparison with MRI data (preoperative and postoperative) besides intraoperative usage.

Patients and methods

A prospective study on patients with lumbosacral spinal dysraphisms was carried out at Neurosurgery Department, Faculty of Medicine, Zagazig University hospitals, during the period from January 2017 to August 2018 after approval from the local ethical committee and Zagazig University institutional review board (Zu-IRB). Written informed consent according to the criteria set by the local research ethics committee in our center was obtained from the parents before surgery. A total of 24 cases were included in the study. Inclusion criteria were children up to 6 years old of both sexes with lumbosacral spinal dysraphisms.

Evaluation of the patients was done to determine the presenting symptoms and signs by history and examination with stress on cutaneous manifestations (lumps, nevi, lipoma, hair tuft, hemangioma, dermal sinus), deformities (spina bifida, scoliosis), and other congenital anomalies as (club foot, pes cavus, claw toes, leg or foot length discrepancy). Spinal ultrasonography was done for all patients preoperatively, intraoperatively, and postoperatively after 6 months during follow-up, and MRI was done for all patients preoperatively and postoperatively after 6 months during follow-up. Ultrasonography of the spine was done with a high-frequency linear transducer (7–12 MHz) in both axial and sagittal plane scanning. The quality of

Table 1 Demographic data of the studied group

Variables	*N* = 24	Percentage
Age (months)		
Mean ± SD	13.25 ± 7.58	
Median and range	11 months, (1 day–68 months)	
Sex		
Male	15	62.5
Female	9	37.5
Clinical presentation		
Lower limbs weakness	9	37.5
Lower limbs deformities	3	12.5
Patulous anus	4	16.7
Swelling on the back	18	75
Normal skin	3	12.5
Skin stigmata	–	–
Hair tuft	1	4.2
Hemangioma	2	8.3
Dimple	3	12.5

Table 2 Comparison between ultrasonographic and MRI imaging in the diagnosis of spinal dysraphism

SUS	MRI				
	Negative *N*	Positive *N*	Sensitivity %	Specificity %	Accuracy
Presence of syringohydromylia					
Negative	23	0	100%	100%	100%
Positive	0	1			
Thickened film					
Negative	6	4	77.8%	100%	83.34%
Positive	0	14			
Soft tissue mass					
Negative	10	0	100%	100%	100%
Positive	0	14			
Cystic tissue mass					
Negative	16	0	100%	100%	100%
Positive	0	8			
Conus level					
Positive	0	24	100%	100%	100%

The MRI findings were used as the standard reference for the sensitivity and specificity of LUS

Table 3 Comparison between LUS and MRI imaging after 6 months from surgery

SUS	MRI				
	Negative *N*	Positive *N*	Sensitivity %	Specificity %	Accuracy
Presence of syringohydromylia					
Negative	24	0	100%	100%	100%
Positive	0	0			
Thickened film					
Negative	16	3	62.5%	100%	87.5%
Positive	0	5			
Soft tissue mass residual					
Negative	18	0	100%	100%	100%
Positive	0	6			
Cystic tissue mass residual					
Negative	22	0	100%	100%	100%
Positive	0	2			
Conus level change					
Negative	20	0	100%	100%	100%
Positive	0	4			

The MRI findings were used as the standard reference for the sensitivity and specificity of LUS ultrasound decreases after the first 4 months of life as posterior spinous elements ossify, and in most children, LUS is not possible beyond 6 months of age except persisting window in children with posterior spinal defects which enables ultrasound to be performed at any age. Localization of the conus medullaris is crucial for the detection of low-lying cord. Location of conus should be interpreted in relation to the lumbar vertebral bodies. Sagittal scanning should be performed both in the median and paramedian planes. The data of ultrasonography of all patients were collected as follows:

Preoperative:

1. Assessment of the level of the conus medullaris
2. Appearance of the spinal cord and cauda equine
3. Presence or absence of syringohydromylia
4. Thickened filum (2 mm or more)
5. Soft tissue mass, cyst, or subcutaneous tract

Intraoperative:

1. Adequacy of surgical exposure
2. Confirming preoperative diagnosis
3. Section of filum (thickened filum, fatty filum, tethering cord)
4. Relationship between the tethered cord and surrounding tissue through echogenicity differentiation between normal spinal cord and other tissues (plane of demarcation)

Postoperative follow-up

Evaluation of untethering and repair by detecting cord regression and postoperative presence of any lesion or fistula.

Follow-up is done after 6 months from surgery by clinical evaluation to determine any change in neurological status and imaging evaluation by LUS and MRI spine to determine the location of the conus medullaris and any lesion.

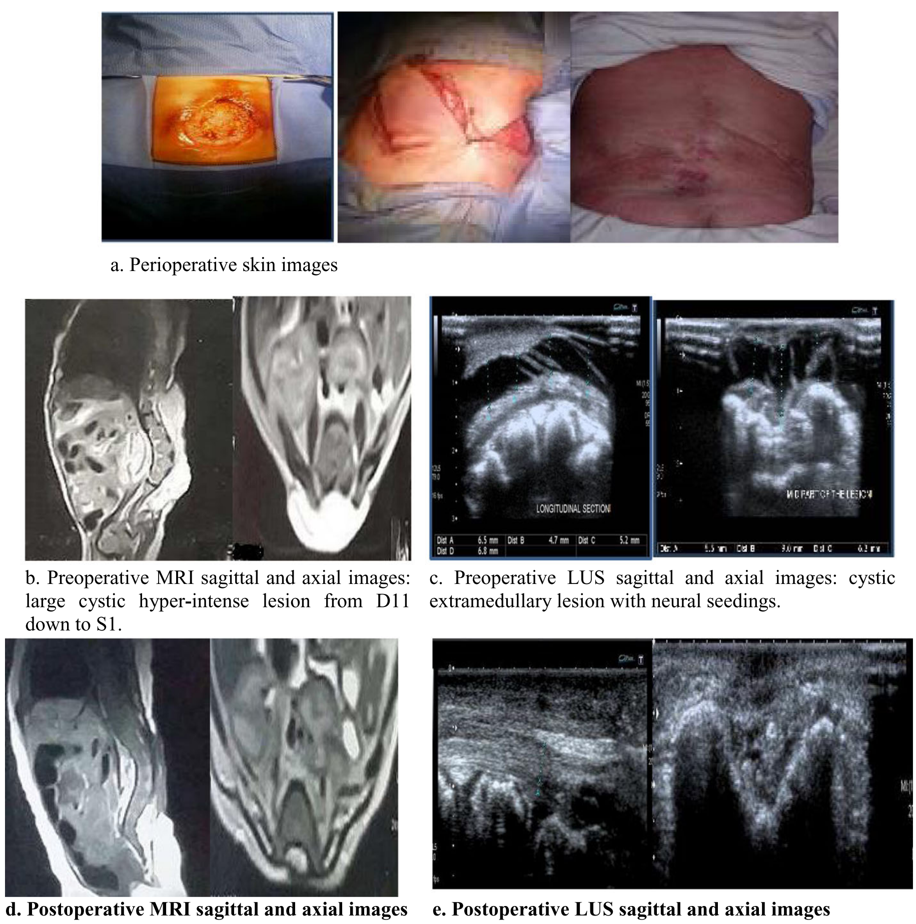


Fig. 1 Large, defined extramedullary cystic lesion about 1.3 × 3.2 × 12 cm seen opposite D11 down to S1 vertebrae with neural element component seen within the cyst and lower dorsal scoliosis. **a** Perioperative skin images. **b** Preoperative MRI sagittal and axial images: large cystic hyper-intense lesion from D11 down to S1. **c** Preoperative LUS sagittal and axial images: cystic extramedullary lesion with neural seedings. **d** Postoperative MRI sagittal and axial images. **e** Postoperative LUS sagittal and axial images

Data were collected and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) software for analysis.

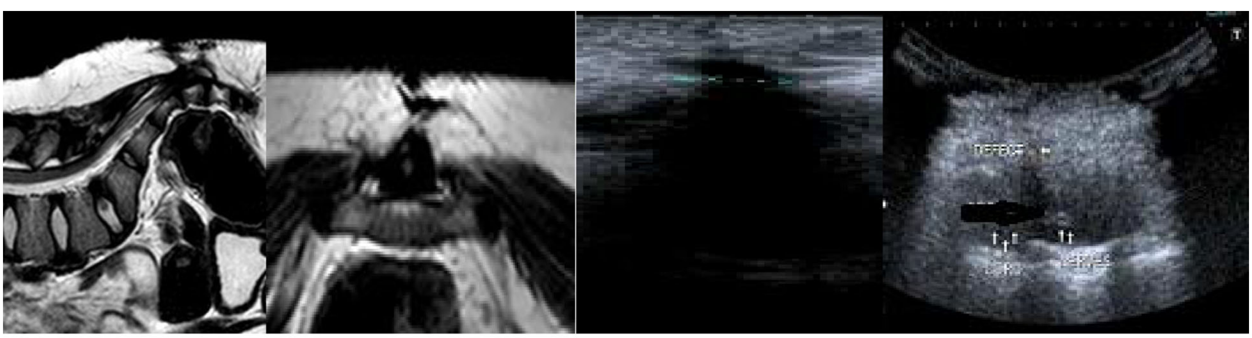
Results

There are 24 patients in this study: 15 males and 9 females with a mean age of 11 months, the youngest aged 1 day and the oldest 68 months. The main clinical presentation is shown in Table 1. Using the MRI findings as the standard reference for sensitivity and specificity of LUS, Table 2 shows the analyzed preoperative relation, while Table 3 shows the analyzed postoperative relation after 6 months from surgery. During surgery, the LUS imaging was used as a guide for surgical exposure adequacy, confirmation of preoperative diagnosis and tissue differentiation. Figures 1, 2, and 3 show the demonstration of operated patients.

Discussion

This study evaluated the sensitivity and specificity of LUS in the management of lumbosacral spinal dysraphisms by using the MRI as the standard reference. The sensitivity of LUS in detecting a thickened filum was 77.8% preoperatively and 62.5% postoperatively, with a specificity of 100%. The sensitivity and specificity of detecting conus level, solid masses, and cystic masses were 100%.

Azzoni et al. found LUS in comparison with MRI was highly specific but not very sensitive. The images were similar, easily comparable, and often identical to the MRI results, although MRI was certainly more sensitive. The advantages of sonography are non-invasiveness, lower cost, availability, simplicity, rapidity of the examination, and its specificity. Indications for its use are lumbosacral skin abnormalities and neurological disorders caused by malformations [4]. Chern et al. found the sensitivity of LUS in comparison with MRI 76.9% in detecting low-lying tethered cord. The diagnostic value of SUS has been shown to be equal to MRI [5]. Rohrschneider et al. found that LUS exactly correlated with MRI in 32 of 38 cases. In five cases, LUS detected the main abnormality but MRI gave additional information. Wherever LUS is normal, MRI is also normal. LUS had a sensitivity of 100%. Therefore, LUS may be used as a primary screening tool, with MRI being performed in any case where LUS revealed abnormalities [6]. Dhingani et al. reported that 79.31% of cases showed full agreement between LUS and MRI examinations and 20.69% partial



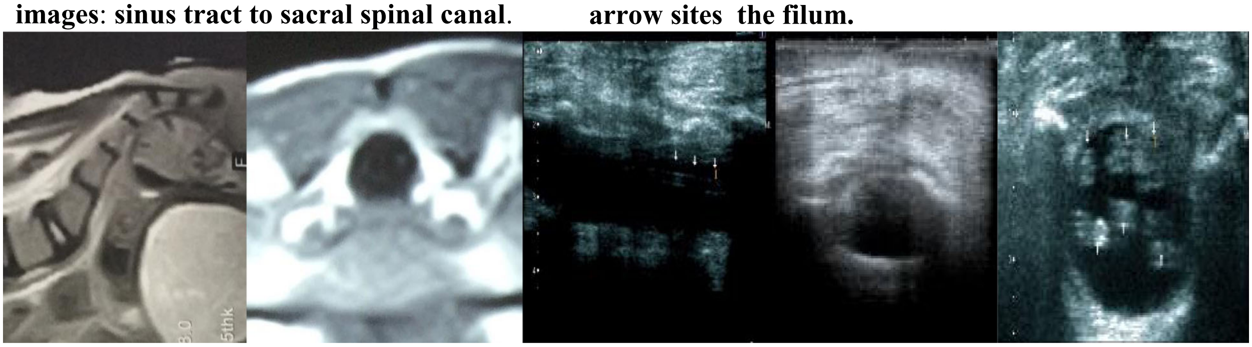


Fig. 2 Skin dimple at the lower back. **a** Preoperative MRI sagittal and axial images: sinus tract to sacral spinal canal. **b** Preoperative LUS sagittal and axial image: black arrow sites the filum. **c** Postoperative MRI and LUS (sagittal and axial images): normal central echo complex (small white arrows)

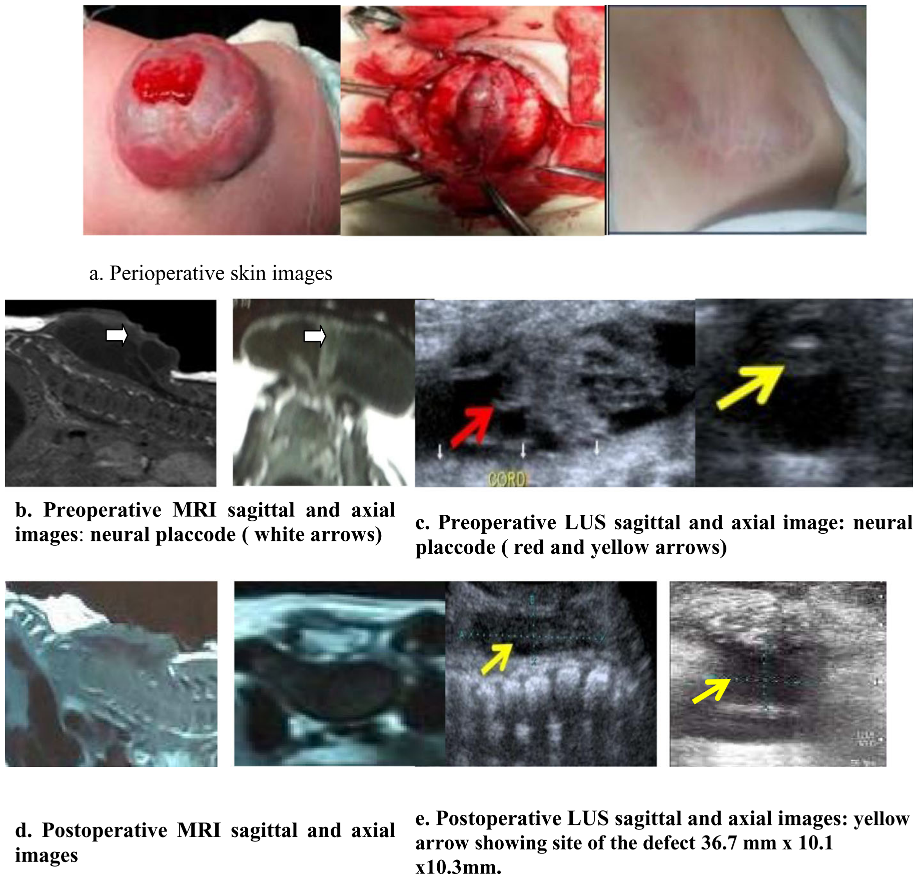


Fig. 3 Meningomyelocele. **a** Perioperative skin images. **b** Preoperative MRI sagittal and axial images: neural placode (white arrows). **c** Preoperative LUS sagittal and axial image: neural placode (red and yellow arrows). **d** Postoperative MRI sagittal and axial images. **e** Postoperative LUS sagittal and axial images: yellow arrow showing site of the defect 36.7 mm × 10.1 × 10.3 mm

agreement. LUS can be used as the initial modality for evaluation of spinal dysraphism as well as for screening of suspected cases [7]. Hughes et al. reported 40% full agreement between LUS and MRI examinations, 47% partial agreement, 13% no agreement, and 90% agreement in low-lying cord location [2]. Kommana et al. concluded that ultrasound and MRI are adjuvant in the evaluation of spinal dysraphism. MRI is excellent in characterizing the soft tissue spinal anomalies of dysraphism, whereas ultrasound is an excellent initial imaging modality in infants for evaluation of dysraphism [8].

Ultrasound is used in this study not only as a preoperative screening but also as an intraoperative screening for adequacy of surgical exposure, confirming preoperative diagnosis and detection of the relationship between the tethered cord and the surrounding tissue through echogenicity differentiation between the spinal cord and other tissues (plane of demarcation). Also, ultrasound was used on the postoperative follow-up evaluation of untethering and repair by detecting cord regression and postoperative presence of any lesion. Gerscovich et al. concluded that in patients who have a spinal defect or interlaminar space allowing visualization of the lumbosacral spinal canal, ultrasound can provide similar information to that obtained with magnetic resonance imaging with no need for sedation and at a low cost. Ultrasound seems more sensitive than magnetic resonance imaging in the detection of cord adhesions, which is particularly relevant in the diagnosis of tethering [9].

In this study, in post-operative follow-up, three cases presented with wound healing problems (two cases with erythema on either side of the incision, in areas of tension, one case with subcutaneous collection). Two cases presented with CSF leak managed conservatively.

Conclusion

Ultrasonography use in lumbosacral spinal dysraphism management in this study gained important findings which encourage neurosurgeons to use it as a tool during diagnosis, intraoperative period, and during follow-up tool instead of MRI:

1. Ultrasonography is a well-established method for investigating the spinal canal, cord, and meningeal coverings and for characterizing nearly all spinal

anomalies with high geometric resolution in the neonatal and infantile age groups, and wherever a bone defect.

2. In neonates and infants with suspected spinal and paraspinal anomalies, ultrasound scanners have brought its diagnostic value on par with that of MRI. LUS has good sensitivity and specificity at detecting anomalies and abnormal findings consistent with MRI either during the preoperative period or on follow-up.
3. Relative advantages of sonography over MRI include wide and cheap availability, no need for sedation or general anesthesia, and lack of vulnerability to artefacts due to patient movement, cerebrospinal fluid (CSF) pulsation, and vascular flow which can adversely affect MR image quality
4. Ultrasonography can be used intraoperatively with many advantages for tissue differentiation.

Abbreviations
LUS: Lumbosacral ultrasonography; MRI: Magnetic resonance imaging

Acknowledgements
It is lucky to work with the neurosurgery team at Zagazig University Hospital for their great help and support.

Authors' contributions
The author contributed to the study conception, design, most surgical works, data collection, and drafting of the manuscript. The author read and approved the final manuscript.

Funding
All patients operated at Zagazig University Hospitals Neurosurgery Department for free.

Availability of data and materials
All data that support the findings of this study are available from the Neurosurgery Department at Zagazig University Hospital. Data are however available from the author when requested with permission.

Ethics approval and consent to participate
A research committee approval has been granted for this study by the medical ethics committee, Faculty of Medicine, Zagazig University on December 18, 2016. Written informed consent according to the criteria set by the local research ethics committee in our center obtained from the parents before surgery.

Consent for publication
Informed consents were obtained from all patients, and no personal data were included in this study.

Competing interests
The authors declare that they have no competing interests.

Received: 3 June 2019 Accepted: 16 October 2019
Published online: 29 November 2019

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