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A Comparative Evaluation Of Spinal Sonography And Magnetic Resonance In Children With Spinal Dysraphism.

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ABSTRACT

Background: Spinal dysraphism occurs due to failure of fusion of parts along dorsal aspect of midline structures lying along spinal axis from skin to vertebrae and spinal cord. Congenital spinal anomalies may be minimal and asymptomatic like spinal bifida occulta, or severe with marked neurological deficits like Arnold-Chiari malformation or caudal regression syndrome. Aim: To compare the results obtained from Ultrasonography and Magnetic Resonance Imaging in patients with spinal dysraphism. **Methods:** A total of 50 patients of age group new born to 06 months, who had signs of spinal dysraphism, were included. The patients were subjected to spinal USS and MR imaging after obtaining informed written consent from parents. All the images were reviewed by experienced radiologists who were blinded to the results of other investigative modalities. The findings of the MRI were compared with USS examination. **Results:** Out of 50 patients, 98 percent patient were detected to hydromyelia, 94 percent of tethering of cord, 92 percent of lumboacaral MMC and 88 percent cases were of Associated Arnold Chiari type II malformation (AC). Only 10% of patients had cervicothoracic meningomyelocele, diastematomyelia and intraspinal lipoma as their primary pathologies. Sensitivity and specificity of USS were 100 in diagnosing most of the spinal deformities. The mean time required for the MRI examination was 26.96 min; however in comparison ultrasonography took less mean time (10.62 min). **Conclusion:** Paediatric spinal dysraphism and associated malformations are accurately diagnosed on MRI scan. On the other hand, limited access to MR imaging together with high costs and the need for extensive preparation of the patients diminishes its suitability as a screening method for spinal dysraphism.

Keywords: Spinal dysraphism, Ultrasonography, MRI.

INTRODUCTION

Column of 33 vertebrae makes central axial skeleton of human body; which are separated by 23 intervertebral discs starting below the C2 vertebral body upto S1 vertebral body. They are associated with 31 pairs of spinal nerves – mainly supplying limbs.

Embryological basis

The defect of spinal dysraphism occurs in the first 8.5 weeks of fetal life. The neural tube develops from ectodermal cells, while mesoderm forms the bony elements, meninges, and muscle. The skin is separated from the neural tube by the mesoderm. Incomplete separation of ectoderm from the neural tube results in cord tethering, diastematomyelia, or a dermal sinus. Premature separation of the cutaneous ectoderm from the neural tube results in incorporation of mesenchymal elements between the neural tube and skin, which may result in the development of lipomas. If the neural tube fails to fuse in the midline posterior spinal abnormalities such as myelomeningoceles occur.[1]

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Spectrum of Spinal Dysraphism

Spinal dysraphism (SD), or neural tube defect (NTD), is a broad term encompassing a heterogeneous group of congenital spinal anomalies, which result from defective closure of the neural tube early in fetal life and anomalous development of the caudal cell mass.[1] These conditions are usually diagnosed at birth or in early infancy, but some may be discovered in older children or adults.

The estimated incidence of SD is about 1–3/1000 live births.[2] Some forms of spinal dysraphism can cause progressive neurologic deterioration. The anatomic features common to the entire group is an anomaly in the midline structures of the back, especially the absence of some of the neural arches, and defects of the skin, filum terminale, nerves, and spinal cord.

Congenital spinal anomalies have been classified into two broad categories – Open spinal dysraphism: It includes myelocele, meningocele, and myelomeningocele. These open forms are often associated with hydrocephalus and Arnold-Chiari malformation type II and may be classified as spina bifida aperta. Open NTDs (ONTDs) represents a serious congenital anomaly. If the neural tube fails to fuse at the skull, the result may be that of anencephalus or encephalocele. If the tube fails to fuse along the spine, the resulting defect is an open NTD such as meningomyelocele. Infants with NTDs frequently have additional serious neurologic, musculoskeletal, genitourinary, and bowel anomalies. Clinical symptoms of myelocele and myelomeningocele include severe neurologic disturbances mainly of the lower extremities such as paresis or paralysis and bladder or bowel dysfunction, as well as secondary development of hydrocephalus after repair. Occult spinal dysraphism: The closed form of spina bifida is also termed as spina bifida occulta. Spina bifida occulta consists of a defect in the vertebral arches not associated with an externally visible sac on the back. These lesions differ from spina bifida cystica in which the vertebral defect is associated with a cystic mass on the back.

Role of Radiological Investigations

Plain radiograph is screening modality for bony spinal anomalies. Ultrasound is good modality for evaluation of spinal anomalies in antenatal period; but in young infants, it can be used only as screening modality as it is sensitive to detect dysraphism with cystic component; but is less sensitive to MRI in closed spinal dysraphism.

Spinal USG

Spinal sonography was described in the early 1990s as a screening method for the detection of occult spinal dysraphism.[23-30] Since then the ultrasound examination of the spinal canal in newborns has become an established modality in pediatric imaging.[31,32] The relevance of spinal ultrasound in comparison to MRI has been demonstrated in depth.[33,35] Spinal sonography has consistently been shown to be a useful technique in the assessment of congenital anomalies of the lower spine and is recommended as the first-line examination in these patients.[33] In patients older than 4 months spinal ultrasound loses its relevance due to narrowing of the acoustic window caused by ossification of posterior elements of the spine. Panoramic ultrasound is the preferred method for the imaging of the longitudinal spine in the sagittal plane.[22,34] In newborn infants with cutaneous lesions overlying the lumbosacral spine who are at risk of clinically unrecognized cord tethering if the sonogram is positive, it could obviate the need for more costly and invasive diagnostic tests by identifying those patients who require surgical intervention.[75]

MRI Imaging

The Magnetic Resonance Imaging evolved from being a supplementary modality in diagnostic imaging complementing Computing Tomography in CNS investigations, to a superior modality, with the introduction of higher field magnets in mid 1980's and subsequently; resulting in ultrafast scanning time, down to milliseconds range and much improved Pulse Sequence techniques.[72] Soon the superiority of Magnetic Resonance Imaging over Computed Tomography was recognized. Magnetic Resonance Imaging today is considered the imaging modality of choice and has revolutionized the imaging of the brain, owing to its greater contrast resolution, multiplanar imaging capability, lack of artifacts and no radiation hazard.[72]

We conducted the study to determine the role of imaging in the evaluation of SDs, which would help in better management and prognostication of these patients

Aim

1. Evaluation of patients having spinal dysraphism with Ultrasonography and Magnetic Resonance Imaging.
2. Compilation and comparison of the results obtained from Ultrasonography and Magnetic Resonance Imaging in patients with spinal dysraphism.
3. Establishing the efficiency of chosen modality.

MATERIALS AND METHODS

The study was conducted in the department of Radio diagnosis and Imaging at Army Hospital (Research & Referral), Delhi Cantt., between Oct 2006 and Feb 2008. A total of 50 patients of age group new born to 06 months, who had signs of spinal dysraphism, were included. The patients were subjected to spinal USS and MR imaging after obtaining informed written consent from parents. All the images were reviewed by experienced radiologists who were blinded to the results of other investigative modalities. The findings of the MRI were compared with USS examination.

Spinal USG

The examination was performed on Philips HDI 5000 ATL Ultrasound system by using a 5 to 12 MHz multifrequency linear transducer in both the sagittal and axial planes along the whole of the spine with the patient in a prone position with their legs (hips and knees) slightly flexed during the US examination. When indicated, imaging was

performed with the patient erect to facilitate visualization of meningoceles, which only fill when dependently positioned.

Images in longitudinal and transverse section planes of the spinal canal were obtained. The region between conus medullaris and the coccyx was always displayed on a single composite image. In addition, specific areas of interest were demonstrated with magnification technique.

Magnetic Resonance

MRI was performed on 3.0 Tesla super conducting MR system (Trio - Seimens) with data matrix of 128 x 256. T1 fast spin echo sequences with TR of 650 to 750 ms and TE of 12 to 15 ms and T2 fast spin echo sequences with TR of 2000 to 3000 ms and TE of 60 to 120 ms with slice thickness of 3mm was performed. Myelogram scan was performed using TR 10000, TE 999 with a slice thickness of 60 mm and matrix of 320 x 320. Images were acquired in the sagittal, coronal and axial planes with field view of 25 cms. Total scan time was approximately 25 minutes.

RESULTS

Fifty five patients, who were detected clinically to have features of spinal dysraphism, were initially considered for this study. However five patients could not go through the modalities of study, so above five cases were not included in this study. Fifty patients subsequently underwent Ultrasonography and Magnetic Resonance Imaging.

Age & Sex Distribution

Amongst fifty patients studied, thirteen (26%) were in the age group of 01-02 months. The youngest patient was 30 days old and the oldest was 03 years old. The mean age in the study group was 4.04 months.

Table 3: Age wise distribution of cases in study group.

Age (Months)	No of cases	Percentage
1 – 2	13	26
2 – 3	11	22
3 – 4	12	24
4 – 5	9	18
5 & Above	5	10
Total	50	100

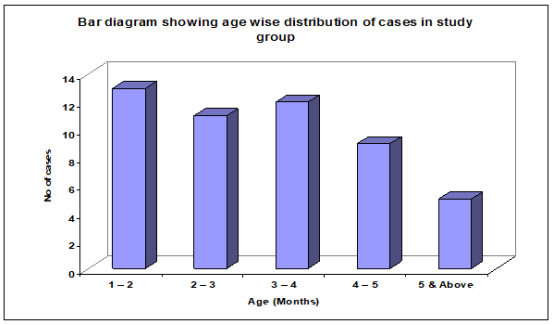
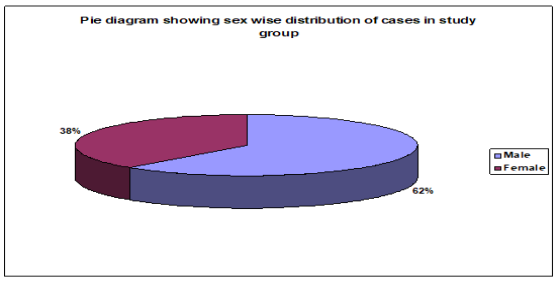


Table 4: Sex wise distribution of cases in study group.

Sex	No of cases	Percentage
Male	31	62
Female	19	38
Total	50	100

The study included 31 (62%) male patients and 19 (38%) female patients.

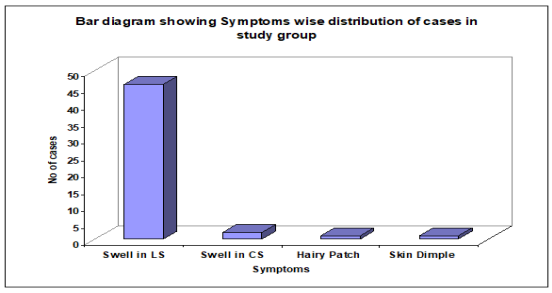


Clinical Presentation

The main clinical complaint in the study group was presence of swelling in the lumbosacral region. Few presented with other physical findings like lipoma, hairy patch and dermal sinus. Most patients had a combination of symptoms, while some patients had only lump as an incidental finding. The distribution on the basis of clinical symptom was as under

Table 5: Symptoms wise distribution of cases in study group.

Symptoms	No of cases	Percentage
Swelling in lumbosacral region	46	92
Swelling in cervicothoracic region with large head	02	4
Hairy Patch	01	2
Skin Dimple	01	2
Total	50	100



Pathologies Detected

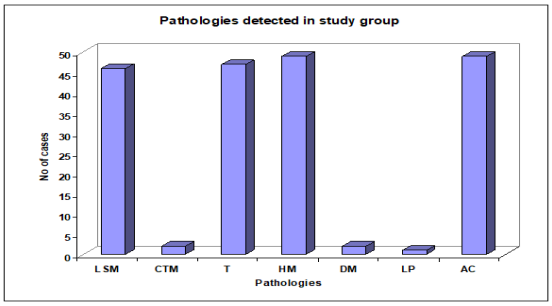
After all the 50 patients under study went through both the imaging modalities, following findings were revealed.

Table 6: Pathologies detected in study group.

Pathologies	No of cases (n=50)	Percentage
Lumbosacral MMC (LSM)	46	92
Cervicothoracic MMC (CTM)	02	04
Tethering of cord (T)	47	94
Hydromyelia (HM)	49	98
Diastematomyelia (DM)	02	04
Intraspinal lipoma (LP)	01	02
Associated Arnold Chiari type II malformation (AC)	44	88

Most patients were detected to have lumbosacral meningomyelocele. Only 10% of patients had

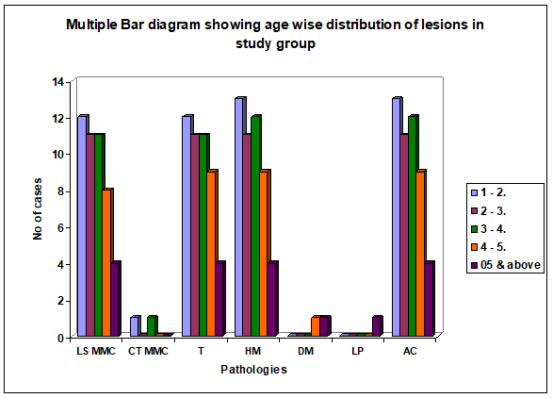
cervicothoracic meningomyelocele, diastematomyelia and intraspinal lipoma as their primary pathologies.



Age Distribution of Lesions

Table 7: Age wise distribution of lesions in study group.

Age (Months)	LSMMC	CTMMC	TC	HM	DM	LP	ACM
01-02	12	01	12	13	00	00	11
02-03	11	00	11	11	00	00	10
03-04	11	01	11	12	00	00	11
04-05	8	00	09	09	01	00	08
05 & above	04	00	04	04	01	01	04



Most lesions were found in initial days of newborns due to obvious cutaneous stigmata. Less obvious lesions like diastematomyelia and intraspinal lipoma were detected later during infancy when motor activities of child became prominent and obvious.

Ultrasonographic Features

The ultrasonographic findings suggested following observations

Table 8: Ultrasonographic findings in study group.

Ultrasonographic features	Number of cases	Sensitivity	Specificity	PPV	NPV
Lumbosacral MMC (LSM)	46 (n=46)	100	100	100	100
Cervicothoracic MMC (CTM)	02 (n=2)	100	100	100	100
Tethering of cord (T)	36 (n=47)	76	100	100	21
Hydromyelia (HM)	37 (n=49)	75	100	100	07
Diastematomyelia (DM)	02 (n=2)	100	100	100	100
Intraspinal lipoma (LP)	01 (n=1)	100	100	100	100

MRI Features

MRI was considered gold standard and its findings suggested following observations

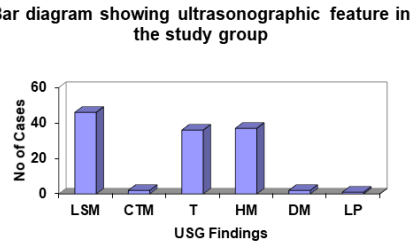


Table 9: MRI findings in study group.

MRI features	Number of cases
Lumbosacral MMC (LSM)	46 (n=46)
Cervicothoracic MMC (CTM)	02 (n=2)
Tethering of cord (T)	47 (n=47)
Hydromyelia (HM)	49 (n=49)
Diastematomyelia (DM)	02 (n=2)
Intraspinal lipoma (LP)	01 (n=1)
Arnold Chiari Malformation (ACM)	44 (n=44)

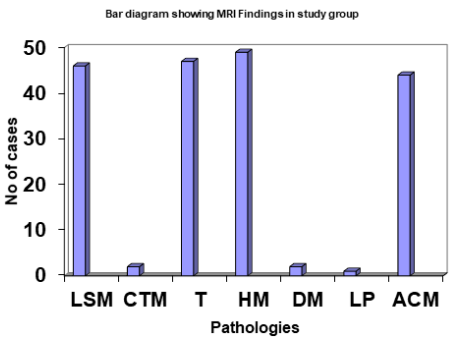
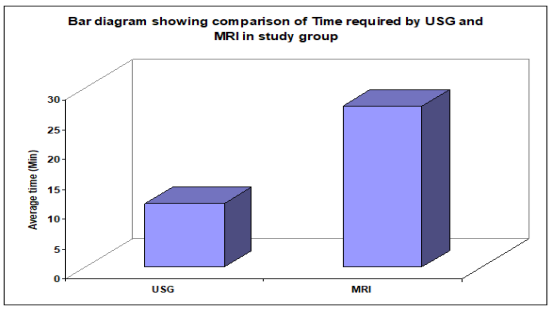


Table 10: Comparison of time required by USG and MRI in study group.

Particular	USG Mean ± SD	MRI Mean ± SD	Z Value	P Value
Time required (min)	10.62 ± 1.99	26.96 ± 5.99	18.29	<0.0001*

*Significant

The mean time required for the MRI examination was 26.96 min; however in comparison ultrasonography took less mean time (10.62 min).



DISCUSSION

At present, MR imaging is considered as the gold standard imaging modality in the evaluation of the pediatric spinal canal. Congenital anomalies as well as neoplastic, inflammatory, and traumatic disorders can be reliably evaluated with MR imaging.[1-4]

An indispensable condition for spinal ultrasonography is the presence of an acoustic window, which in infancy is provided by incomplete ossification of the dorsal elements. In spina bifida, the bone defect permits sonographic visualization of the spinal canal, and during or after spinal surgery, ultrasonography is possible through a limited window opened by the laminectomy.[30,31]

The majority of our patients were within the first 6 months of life. A few older children could be well studied because of nonfusion of arches.

In our study out of 50 patients the MRI revealed 46 cases of lumbosacral meningomyelocele. The ultrasonography demonstrated exactly same findings in all cases (Sensitivity = 100, specificity = 100, positive predictive value = 100, negative predictive value = 100). MRI demonstrated tethering and hydromyelia in 47 and 49 patients respectively. In comparison ultrasonography revealed tethering of cord and hydromyelia in 36 and 37 cases respectively. The sensitivity for ultrasonography was 76% for tethering of cord and 75% for hydromyelia. The specificity and positive predictive value were 100% for hydromyelia and tethering of cord each. The negative predictive value was 21% for tethering and 7% for hydromyelia. The sample size for cervicothoracic meningomyelocele, diastematomyelia and intraspinal lipoma was small. However ultrasonography revealed abnormality in all these patients.

While performing the MRI for spinal dysraphism scans for the brain were also included, this revealed Arnold Chiari malformations in majority of the patients with lumbosacral meningomyelocele. This additional information assisted the surgeons to decide regarding placement of the ventriculoperitoneal shunt. This feature could not be detected on ultrasonography due to unavailability of acoustic window.

In comparison the MRI was more time consuming (26.96 ± 5.99 min) as compared to ultrasonography (10.62 ± 1.99 min) {Z=18.29, P=<0.0001}.

We used Syrup Trichlophos for sedation in spinal ultrasonography as compared to general anaesthesia in MRI. However no adverse outcome was noted in general anaesthesia, the possibility of such eventuality was always considered during investigation.

In our series, most spinal disorder proved with MR imaging could be demonstrated with ultrasonography with satisfactory depiction of the complete pathologic condition in patients with multiple concurrent anomalies. Thus, spinal ultrasonography seems to represent an ideal screening test for congenital anomalies of the lower spine in infancy. However, US cannot replace MR imaging as the method of choice for this indication.

Rohrschneider Wk et al in their study in 1996 revealed the diagnostic yield of spinal ultrasonography was comparable to MRI findings in 38 examinations. MR imaging showed a normal spinal canal in 14, congenital anomalies in 22 and a neoplasm in 2 cases. In five examinations, the ultrasonography depicted the main abnormality, but MRI revealed additional findings. In one examination, no consensus was achieved. Whenever ultrasonography scans were normal, MRI also did not depict any spinal disorder. In all 24 examinations with abnormal MR findings, ultrasonography enabled detection of abnormality.[33]

Gercovich et al in their work in 1999 demonstrated the comparability in post operative patients of meningomyelocele. The findings were exactly same in most of the cases.[35]

The usefulness of spinal ultrasonography as an ideal screening test for congenital anomalies is generally emphasized in the current literature.[9,10,13-19] Even in patients with minor clinical signs, such as small cutaneous abnormalities, immediate exclusion of a malformation is important because early diagnosis and therapy correlate with favorable long-term results.[32,33] To be suitable as a screening method, an examination technique should be widely available, inexpensive, transportable, and easy to perform, as well as noninvasive and safe. All of these conditions are offered by ultrasonography. However, a screening method must also exhibit a high diagnostic sensitivity so that it reliably reveals pathologic cases among a large number of normal ones.

In the evaluation of spinal disorders, a clear advantage of MR imaging is the excellent tissue differentiation. Motion artifacts, which can considerably reduce the quality of MR images, play a minor mole during real-time ultrasonography. For two main reasons, dysraphism can be ideally evaluated with ultrasonography: First, it occurs in the neonate and young infant in which incomplete ossification of posterior elements provides an acoustic window, and second, the associated nonfusion of vertebral arches further improves sonographic visibility of intraspinal structures. Spinal ultrasonography in infancy seems to exhibit

good sensitivity concerning disorders situated below the mid thoracic level.

The limitations of the sonographic evaluation of intraspinal neoplasms are mainly due to the fact that this disease usually manifests beyond the 1st year of life.[9] MR imaging is clearly superior to ultrasonography in demonstrating the entire spinal canal, the extent of the lesions, and their anatomic relationship to surrounding structures. In addition, this method is independent from an acoustic window.

Spinal ultrasound and MRI are complementary imaging techniques in spina bifida cystica, whereas especially ultrasound allows a high resolution and benefits from fast availability. MRI should be performed to provide the surgeon with a comprehensive anatomic overview of the anomaly. When performed by an experienced examiner spinal ultrasound is a reliable method to rule out an occult dysraphism. In patients with normal findings, no further imaging examinations are necessary.[32] Spinal ultrasound should be performed as a useful first-line examination for the evaluation of the spinal cord in newborns. MRI allows a better tissue characterization as a better overview of the total spine from the thoracic segments to the coccygeal region. Using contrast-enhanced techniques it is possible to detect additional inflammatory changes in the meninges in patients with dermal sinus.

On the other hand only spinal ultrasound with additional M-mode-sonography enables the visualization of movement patterns of the cauda equina, especially useful in tethered cord syndrome.

In complex malformations such as the caudal regression syndrome or syndromes with spinal malformation, for instance Vacterl association or Currarino triad,[49] MRI is indispensable.

The classification of disease in complex dysraphic malformations with neurenteric cysts, diastematomyelia or even caudal agenesis and segmental spinal dysgenesis requires an MRI examination, and besides knowledge of embryology it calls for maximum cooperation between neurosurgeons and other specialists to provide the best patient care possible.[10]

CONCLUSION

Spinal ultrasound should always be used as a first-line examination for the evaluation of the spinal cord in newborns. Spinal ultrasound is also recommended in seriously ill patients because it takes less time to perform. On the other hand, limited access to MR imaging together with high costs and the need for extensive preparation of the patients diminishes its suitability as a screening method for spinal dysraphism. The ultrasonography can offer good alternative in these situations.

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