A Comparison of MR Myelography of Brachial Plexus Injury with CT Myelography and Conventional Myelography

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Abstract : **The purpose of this study is to assess the accuracy of magnetic resonance myelography (MRM) of cervical spines in patients with preganglionic brachial plexus injury (BPI) using CT myelography as the gold standard and comparing this with routine conventional myelography. Patients with a clinically diagnosis of BPI were studied (9 males, 1 female; aged 16-42 years old; mean age = 25.4 years). All patients had undergone clinical evaluation by an orthopedic surgeon and five patients had had additional somatosensory evoked potentials performed. All patients were investigated by conventional myelography, computed tomography myelography (CTM) and magnetic resonance myelography (MRM). We used CTM as the gold standard and the accuracy of MRM and conventional myelography were assessed in relative to this. The sensitivity in detecting a pseudomeningocele by MRM was 100% and the sensitivity in detecting nerve root abnormality was 90% at the levels of C5, C6 roots and 100% for C7, C8, T1 roots. MRM had many advantages over conventional myelography and CTM which included the absence of radiation and the lack of need for intrathecal injection of contrast medium.**

เรื่องย่อ : การตรวจ MR Myelography ในผู้ป่วย Brachial Plexus Injury เปรียบเทียบกับ CT Myelography และ Conventional Myelography

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สารศิริราช 2545; 54: 87-95.

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เป็นการศึกษาเพื่อประเมินประสิทธิภาพของการตรวจวินิจฉัยด้วย MR myelography ในผู้ป่วย brachial plexus injury โดยใช้ CT myelography เป็นการตรวจวินิจฉัยมาตรฐาน และเปรียบเทียบกับการตรวจด้วย conventional myelography ศึกษาในผู้ป่วย brachial plexus injury จำนวน 10 ราย เป็นเพศชาย 9 ราย เพศหญิง 1 ราย อายุ 16-42 ปี เฉลี่ย 25.4 ปี ผู้ป่วยทุกรายได้รับการตรวจ conventional myelogram, CT myelogram, และ MR myelography โดยใช้ CT myelography เป็น gold standard พบว่าการตรวจด้วย MR myelography ให้ค่า sensitivity ในการวินิจฉัย pseudomeningocele 100% ให้ค่า sensitivity ในการวินิจฉัย nerve root abnormality ที่ระดับ C5, C6 90% และที่ระดับ C7, C8 และ T1 100% สรุปได้ว่าการตรวจด้วย MR myelography ให้ค่า sensitivity สูงในการวินิจฉัย pseudomeningocele และ nerve root abnormality และการตรวจด้วย MR myelography ไม่จำเป็นต้องอาศัย intrathecal contrast medium

INTRODUCTION

Brachial plexus injury (BPI) may be a result of trauma to the neck, shoulder or upper extremity. A potential mechanism is direct traction on the plexus by shoulder compression or dislocation with fixation of the plexus between the clavicle and first rib. Knowledge of the precise type and level of injury is needed for early operative intervention to avoid muscle degeneration and to achieve the best outcome. Myelography and CT myelography have been the neuroradiological examinations of choice for evaluation of brachial plexus injuries.[1-4] They have also been used for imaging both preganglionic and postganglionic injuries to the brachial plexus. Both, however involve considerable exposure to radiation, a possible reaction to the contrast material, and the surgical risk of lumbar puncture.[5,6,10] CT is of limited value in the axial plane because of the density of scapula/clavicle and the poor contrast from axillary vessels after bolus of contrast material has been injected. MR imaging has also been useful in assessment of brachial plexus injuries. Recently, a new MRI technique, utilizing three-dimensional fast spin echo volume acquisition, with maximum intensity projection (MIP) has been published.[6,8-10] The MIP algorithm creates a three dimensional myelogram - like image (MR myelogram). The two purposes of this study were 1) to compare the sensitivity in detecting nerve root injury in BPI patients with conventional myelography, 2) to evaluate which kind of pathology in BPI is more sensitive to detection by MRM.

MATERIALS AND METHODS

Between September and December 1999, we studied 10 patients who had clinical and somatosensory evoked potential evidences of traumatic brachial plexus injury. There were nine men and one woman, aged 16 to 42 years with mean age of 25.4 years. All of them had a history of motorvehicle accident. The injury occurred on the right side in 4 /10 patients and in 6/10 patients the injury was on the left side.

All patients underwent conventional cervical myelography by means of fluoroscopy-guided lumbar puncture. The study was performed using 10 ml of water-soluble, non-ionic contrast medium and standard radiographic projections were obtained. There after, the patients were transferred to the computed tomography (CT) Unit for CT myelography of the cervical spine within one hour of conventional myelography. The CT study was tailored to each nerve root from C5 to T1 with three slices and a slice gap of 3 mm for each cervical level. All patients underwent MR myelography of the cervical spines by 1.5 tesla MR machine (Philips), with a cervical surface coil. We obtained the MR myelogram using a three- dimensional fast spin-echo sequence (TR = 8,000 ms ; TE = 300 ms ; slice thickness 5 mm, field of view 16 cm, 512 X 256 matrix ; no slice gap), total 12 images (total time = 10 min) compressed into a composite image using the MIP algorithm. Normal myelography (N) was considered with both symmetrical radiolucent nerve

root sleeves as well as the paraspinal gutters (Figure1). We considered the nerve roots to be abnormal (A) when it showed either asymmetrical, distortion, or absence of the normal radiolucent nerve roots or narrowing of the associated paraspinal gutters (Figure1). The pseudomeningocele (M) (Figure1) showed an accumulation of contrast medium in the direction of the nerve root pathway or even adjacent to the nerve root origin. The criteria for the evaluation of MR myelography (MRM) were similar to the principles of evaluation of myelography (Figure 4). The evaluation of CT myelography (Figure 2A, 2B, 2C) was considered normal (N) when normal radiodensity of the nerve root and symmetry of paraspinal gutter was seen on the axial scan. An abnormality of the nerve root (A) was considered to be present when there was no demonstrable radiodensity of a nerve root. A pseudomeningocele (M) was considered to be present when the contrast medium extended along the nerve root sleeve. Myelography, CTM, MRM were assessed separately without knowing of the clinical information. Thereafter, we compared the sensitivity of myelography and MRM using CT M as the reference.

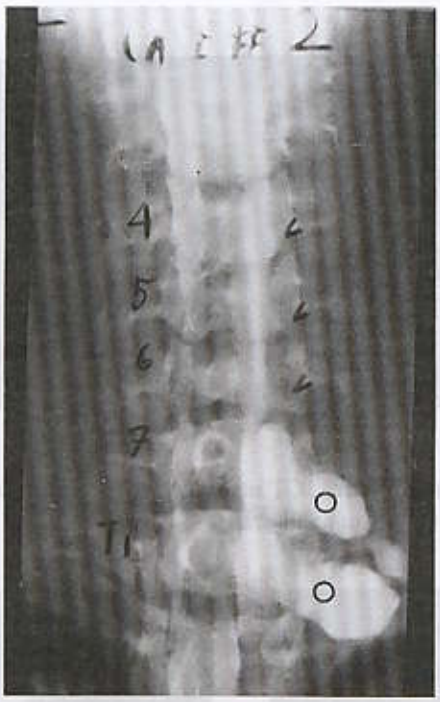

Figure 1. Cervical myelography of a 22 year-old man who had a motorcycle accident with left brachial plexus injury. There are three levels of left C5, C6, C7 nerve roots avulsion, showing asymmetrical blunting (arrowheads) and absence of normal radiolucency of the nerve root sleeves. Additional two levels of pseudomeningocele (circle) are shown in left C8, T1 roots.

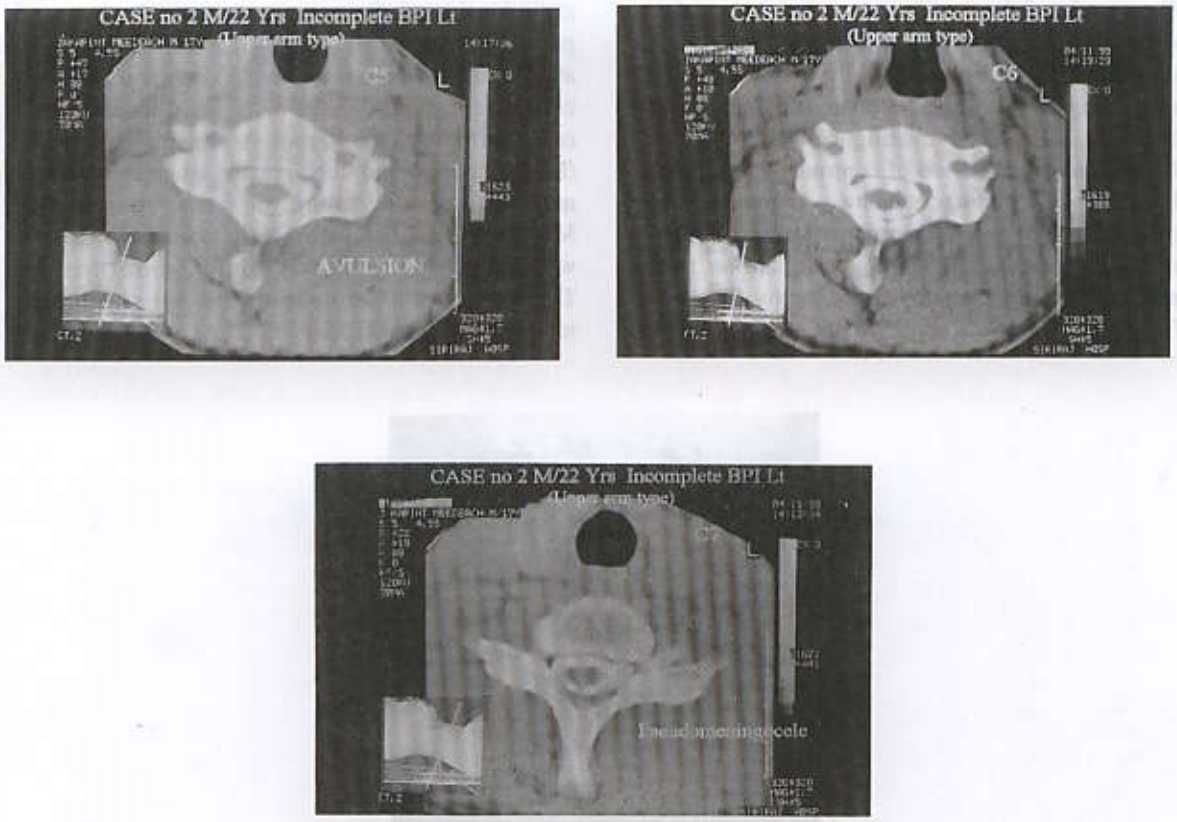

Figure 2A,B,C. The same patient as in Figure1, CT myelography reveals absence of dorsal / ventral roots of the left C5, C6 and C7 on an axial scan.

Figure 3A,B. The same patient as Figure1,2 showing asymmetry of the left paraspinal gutter at the origin of C6 (Figure 3A) and C7 (Figure 3B) in axial view with conventional MRI which was difficult to evaluate.

Figure 4. The same patient as Figure1,2,3 studied by MR myelography reveals clearly demonstrable asymmetrical avulsion of the left C5, C6, C7 root origins as well as an easily detectable pseudomeningocele of the left C8 and T1 roots. In addition, normal signal of the contralateral non-injured brachial plexus is also observed.

RESULTS

There were 10 patients, 9 men and 1 woman who had history of motorvehicle accident. Four patients had clinical signs of right brachial plexus injury and another six patients had a left-sided injury (Table 1).

By dividing the appearance of each nerve roots of brachial plexus into normal (N), abnormal (A) and pseudomeningocele (M), the results of study are shown in Table 2.

This study showed that all patients were in the teenage to young adult group and most of them were male. All the patients had a history of motorvehicle accident. Most of the patients had a "total arm type" of brachial plexus injury (C5-T1 levels). The sensitivity of nerve root origin on MRM (Table 3) and on myelography are shown in Table 4. Myelography had a sensitivity of 100% while MRM had a sensitivity of 90-100% depending on the level of nerve root injury.

Table 1. The 10 brachial plexus injury patients in this study.

Case	Age (years)	Sex	Injured side	Clinical assessment of injured levels
1	26	M	R	C5 - T1
2	22	M	L	C5 - C7
3	28	M	L	C5 - T1
4	22	M	L	C5 - C7
5	42	M	R	C5 - T1
6	19	M	R	C5 - T1
7	29	M	L	C5 - T1
8	18	M	L	C5 - T1
9	27	F	R	C5 - C7
10	16	M	L	C5 - T1

Table 2. Results of Myelography, CT Myelography, MR Myelography, Clinical finding and / or SEP.

Case	C5				C6				C7				C8				T1			
No.	Myl	CTM	MRM	Clinical / SEP	Myl	CTM	MRM	Clinical / SEP	Myl	CTM	MRM	Clinical / SEP	Myl	CTM	MRM	Clinical / SEP	Myl	CTM	MRM	Clinical / SEP
1	A	A	N	+ / -	A	A	N	+ / -	A	A	A	+ / -	A	A	A	+ / -	A	A	A	+ / -
2	A	A	A	+ / -	A	A	A	+ / -	A	M	M	+ / -	M	M	M	X / -	M	M	M	X / -
3	A	A	A	+ / -	A	A	A	+ / -	M	M	M	+ / -	M	M	M	+ / -	A	M	M	+ / -
4	A	A	A	+ / -	A	A	A	+ / -	M	M	M	+ / -	A	A	A	X / -	N	N	N	X / -
5	A	A	A	+ / -	A	A	A	+ / -	M	M	M	+ / -	A	A	A	+ / -	N	N	N	+ / -
6	A	A	A	+ / +	A	A	A	+ / +	M	M	M	+ / +	M	M	M	+ / +	A	N	N	+ / +
7	A	A	A	+ / +	A	A	A	+ / +	A	A	A	+ / +	A	A	A	+ / +	N	N	N	+ / +
8	A	A	A	+ / +	A	A	A	+ / +	M	M	M	+ / +	M	M	M	+ / +	N	N	N	+ / +
9	A	A	A	+ / +	A	A	A	+ / +	A	A	A	+ / +	A	A	A	X / +	N	N	N	X / +
10	A	A	A	+ / +	A	A	A	+ / +	A	A	A	+ / +	A	A	A	+ / +	M	M	M	+ / +

N = Normal
A = Abnormal
M = Traumatic Pseudomeningocele
X = Normal clinical of this nerve root

Myl = Myelography
CTM = CT Myelography
MRM = Magnetic Resonance Myelography

SEP = Sensory evoked potenital
\+ = SEP was performed
\- = SEP was not performed

Table 3. The sensitivity of MR myelography in detecting an abnormality of the nerve root at levels of C5, C6, C7, C8 and T1. (The CT myelography of cervical spines is the gold standard)

Level of spine	Sensitivity
C5	90%
C6	90%
C7	100%
C8	100%
T1	100%

Table 4. The sensitivity of myelography in detection of nerve root abnormality or pseudomeningocele of C5, C6, C7, C8 and T1. (The CT myelography of cervical spines is the gold standard)

Level of spine	Sensitivity
C5	100%
C6	100%
C7	100%
C8	100%
T1	100%

Table 5. CT myelography compared with conventional myelography and MR myelography for the detection of pseudomeningocele and avulsion.

Investigation	CT myelography (N = 50)			Clinical (N = 50)
	Pseudomeningocele (N = 13)	Avulsion (N = 31)	Normal (N = 6)	
Myelography				
Pseudomeningocele	11	-	-	Abnormal = 44
Avulsion	2	31	1	
Normal	-	-	5	
MR myelography				
Pseudomeningocele	13	-	-	Normal = 6
Avulsion	-	29	-	
Normal	-	2	6	

When the results were subdivided into avulsion and pseudomeningocele, it was found that MR myelography was superior to conventional myelo-graphy with a sensitivity of 100%, i.e., in all cases that appeared normal on CT myelography. The sensitivity of MR myelography in detecting avulsion of the nerve root was about 93.5% (29/31). Conventional myelography provided good correlation with CT myelography in detecting avulsion of the nerve root (100%) but only a fair result in the detection of pseudomeningocele (11/13), 84.6% (Table 5).

DISCUSSION

Brachial plexus injury is not an uncommon condition. It occurs as a result of severe trauma with traction on the brachial plexus usually in a road traffic accident. It can occur at a pre-ganglionic or post ganglionic level of the brachial plexus. Previous studies suggest that myelography and CTM should be used for imaging of brachial plexus injury[4,11]. Thus a combination of myelography and CTM may be the standard imaging used for the injury of brachial plexus[11]. In this study we used CTM as the standard

imaging for brachial plexus injury and compared the sensitivity of myelography and MR myelography in detection of brachial plexus injury, particularly nerve root avulsion and pseudomeningocele.

By observation of the asymmetrical filling of contrast medium in each nerve root, distortion, absence of the nerve root sleeve on myelography and CT myelography including an abnormality bright signal, asymmetry and blunting of each nerve root levels on MR myelography were utilized in the interpretation of nerve root abnormalities (injury)[3,4,7,8]. Even though myelography and CT myelography are less expensive and can be performed everywhere, there are some drawbacks to cervical myelography and CT myelography. It is occasionally difficult to perform a lumbar puncture, especially in small infants and in those with acute multisystem injuries. There may be poor opacification of contrast medium at the cervical level and a risk of contrast medium allergy. Thus, MRI (Figure 3A, 3B) is a non-invasive diagnostic study to investigate injury of the brachial plexus[5,6,12]. Evaluation of the signal intensity is useful in defining both normal and abnormal brachial plexus. Fat has a high signal intensity on first echo images and a moderate signal intensity on second echo images. The brachial plexus has low signal intensity on all sequences except when the nerve is injured when it gives a bright signal in T2w images. Nerve roots are therefore difficult to differentiate from fat and the CSF signal nearby. The detection of nerve root avulsion by MRI has been reported to have a sensitivity of 88.9%[8].

Because the acquisition time for conventional MRI is long, the injury is not always clearly visible[3]. Artifacts may be due to CSF pulsation or patients movement, and may be confused with the signal intensity of vertebral arteries and spinal venous plexus. MR myelography is a new modality for generating myelography-like images of CSF by MRI by using a cervical surface coil, with a heavy T2 weight and a thin slice gap in three dimensions. This technique does not need lumbar puncture, radiation or contrast medium administration. The detection rate of pseudomeningocele by MR myelography in this study was similar to a previous study of Nakamura et al.[7], in which MR myelography was better than myelography in detecting pseudomeningocele and had the advantages of not producing non ionizing radiation and did not need intrathecal contrast medium. The detection rate by MR myelography of nerve root avulsion was less than myelography and CT myelography at C5 and C6 levels which might need experience in interpretation and high resolution MR myelography. The limitations of MR imaging are patient's movement, and difficulty in determining the level of injury since there is no bony landmarks. These drawbacks could be decreased by good communication with patients and more experience. In conclusion, MR myelography is an alternative imaging modality for investigating brachial plexus injury which is noninvasive and better for detecting pseudomeningocele, and has a fair result in detecting avulsion of the nerve root particularly at C5 and C6 levels. Therefore, patients at risk of contrast medium allergy, with multisystem injuries, or who are unsuitable for myelography and CT myelography may undergo MR myelography.

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