Radicular avulsion resulting from spinal injury: assessment of diagnostic modalities

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Summary. The diagnostic utility of imaging techniques in injuries to the intramedullary and subarachnoid portions of the brachial plexus, with possibly complete avulsion of one or more nerve roots from the spinal cord and extra-medullary meningocoele was compared in 18 patients studied by unenhanced computed tomography (CT), cervical myelography, myelographic CT (MCT) and magnetic resonance imaging (MRI). Emphasis was placed on the lesions of the subarachnoid roots. CM was the only diagnostic modality to show avulsion of 18 nerve roots and their levels in 8 patients (100% = gold standard), and to verify 2 incomplete avulsions. MCT reliably revealed 8 of 18 (45%) and MRI 1 out of 18 (6%) avulsions. Myelography with MCT showed intact subarachnoid nerve roots in 10 additional patients. MRI and MCT (16 out of 16 = 100%) were superior to myelography (14/16 = 88%) for demonstrating 16 traumatic meningocoeles in 8 patients; follow-up MRI (6–24 months) showed no increase in their size. We recommend a subsequent CT to rule out fracture to the spinal column; MRI should provide significant information concerning oedema or haemorrhage in the spinal cord. Myelography with segmental MCT is performed to differentiate pre- from post-ganglionic lesions, data which are essential for deciding whether exploration of the plexus or a motor substitution operation is indicated.

Key words: Spinal cord, injuries – Spinal cord, MR studies – Nerve root avulsion – Contrast media – Cervical myelography

Cervical nerve root avulsion injuries occur typically in young men involved in motorcycle, automobile or skiing accidents, or who fall from heights. It is critical to differentiate between complete avulsion of nerve roots and a postganglionic lesion in order to determine management and prognosis [1–3]. Reflex arc studies can help establish whether the injury is pre- or postganglionic, although they have limitations [1, 4]. Cervical myelography plays an important role in determining if a preganglionic lesion has been sustained. Since the initial report [5] describing the myelographic appearance of a traumatic meningocoele with possible cervical nerve root avulsion, there have been numerous limited investigations confirming the original observations, many based on myelography with oily contrast media [4, 6–9]. Cervical myelography with water-soluble media injected via lumbar puncture was initiated in young babies by Neuenschwander et al. [10]. Myelographic computed tomography (MCT) has been performed predominantly after lumbar injection [11, 12]. The initial report placed emphasis on the changes of the roots themselves rather than on traumatic meningocoeles as had been the case [13] in cervical myelography with water-soluble contrast medium. Magnetic resonance imaging (MRI) studies clearly demonstrate distal brachial plexopathy not visualized by other imaging modalities, in addition to traumatic meningocoeles [14, 15]. This is a prospective study to determine the degree of accuracy with which nerve root avulsion can be demonstrated. The results of myelography were compared with the diagnostic findings of MCT and MRI studies. Cervical myelography using iotrolan 300 introduced by lateral C1–2 puncture provided good visualization of all portions of the intrathecal nerve roots. The contrast medium has been previously shown to have an excellent neural tolerance [16]. Even at the high iodine concentration of 300 mg/ml it remains isotonic with cerebrospinal fluid, which is not the case with any other water-soluble contrast medium.

Methods

From July 1988 to July 1990, 18 patients with suspected subarachnoid nerve damage underwent unenhanced computed tomography (CT) and MRI, as well as cervical myelography followed by segmental MCT of the cervical spine (3–5 weeks after the initial trauma) and a follow-up MRI 6–24 months after the injury. The patients, 15 men and 3 women, were aged between 18 and 53 years, with an average age of 29 years. All patients had suffered acci-
dents, 6 with motorcycles, 5 in automobiles, 5 falling from a height and 2 skiing. The following imaging procedures were performed.

1. Conventional radiographs of the cervical spine, shoulder and chest were obtained immediately following the accident, together with any further regions indicated by the patients' injuries.

2. Neurological findings, especially paralysis of individual upper and lower arm or hand muscles, were the indications for CT studies. CT was obtained from C4 to T2 on the 1st day. Examinations were performed on 3rd or 4th generation scanners with 2-mm-thick contiguous slices; kv: 120, mA 160, a 512 x 512 matrix and secondary on axis reformations.

3. Prior to surgical treatment of fractures, MRI was performed (in 12 patients 1–3 days and in 6 3–5 weeks after the injury) using a 1.0 T unit in 12 acute and 12 follow-up studies. The sequences comprised T1-weighted (TR 500, TE 20 ms) and T2-weighted (TR 2000, TE 100 ms) images and partial saturation images (TR 500, TE 10.04 ms as phase contrast), STIR images were performed with motion artefact suppression techniques (MAST). TR 2000, TI 125 ms STIR and T2-weighted SE images were obtained with two excitations, PS and T1-weighted images with four excitations. T1-weighted or PS images were obtained in two planes, with a total time of 21 min; T2-weighted or STIR images added 17 min. Slice thickness was 5 mm and we produced coronal and transverse images. A 1.5 T unit with a Helmholz cervical coil and a 256 x 256 matrix was used in the other 6 patients. Sagittal (T1 localizer), axial (T1-weighted) and coronal (T1- and T2-weighted) images with 4-mm sections were obtained. The sequences were weighted for T1 (TR 700–900, TE 17–34 ms), proton density (TR 2000, TE 28 ms), T2 (TR 2000, TE 90 ms); a 2D FLASH sequence (TR 510, TE 12 ms) with three acquisitions was also used. Initial MRI did not include images with gadolinium, but this was used in the follow-up studies 6–24 months after trauma. The total average examination time was 80 min. In order to avoid any effect of the myelographic contrast medium on the MR images the examination was always performed prior to myelography [17].

4. Following treatment of the fractured limbs and after stabilization of the patient's general condition (3–5 weeks) a myelography was performed through a C1–2 level puncture under fluoroscopic control using an image intensifier with the patients prone and a 20 G needle [18–20]. We injected 8–10 ml iotrolan at 20–22 °C, at which temperature (16) its viscosity is about 16 cP, which is twice that at body temperature of 37 °C [21] but still clinically acceptable. No sedation was required. Contrast was excel-