Short report

The posterior sacral foramina: an anatomical study

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ABSTRACT

The vascular and nervous structures and their relations with the spinal nerve roots were examined in the 2nd, 3rd and 4th posterior sacral foramina in relation to percutaneous needle insertion for neuromodulation. A foraminal branch provided by the lateral sacral artery to each foramen entered the inferior lateral quadrant of each foramen, adjacent to the nerve root medially. Facing the posterior sacral aperture and around the sacral nerves, there was no venous plexus. A venous plexus was sometimes present near the median line, and always around the proximal part of the spinal ganglion. The sacral nerve roots, especially the 3rd, had a long extradural course in the foramen, presenting a potential risk of nerve lesions during procedures involving needle insertion.

Key words: Sacral nerves; vesical dysfunction; neuromodulation.

INTRODUCTION

Electrical stimulation of sacral nerve roots can modulate neural reflex behaviour with respect to the lower urinary tract in patients with urinary symptoms refractory to conventional treatment after carrying out peripheral nerve evaluation in order to establish the integrity of the sacral nerves (Schmidt et al. 1989; Thon et al. 1991) and employing stimulation of different modalities (Ohlsson et al. 1989). In addition, electrical stimulation can be used for the management of pain, particularly perineal pain, with meticulous titration of pulse width to allow more selective stimulation of motor and/or sensory fibres (Barolat, 1991).

Only limited literature exists on the anatomy of the posterior sacral foramina and the relationships between the nervous and vascular structures that they transmit. This has highlighted some potential risk factors associated with needle insertion. We have therefore undertaken an anatomical study to establish the nature of the vascular and nervous structures and their relations in the posterior sacral foramina as they may influence percutaneous needle insertion for neuromodulation.

MATERIALS AND METHODS

An anatomical study was undertaken on 6 human cadavers, 3 male and 3 female, with a mean age of 75 y. There was no previous history of spinal injury, congenital defects or gross bony pathology. Within 48 h of death, the cadavers were injected and embalmed with 10% formalin. Eosin was added to the infusion into the arterial system to improve contrast during dissection and photography. The cadavers were placed in a prone position. A midline posterior incision was made from L4 to the coccyx. The L5 spinous process and the posterior face of the sacrum were cleared of all soft tissues. The insertions of the gluteus maximus muscle and its superficial fascia were cut off so that the posterior sacral foramina became apparent. The dissection was then continued under an operating microscope (Zeiss OPMI6). The L5 spinous process and the posterior face of the sacrum were cleared of all soft tissues. The insertions of the gluteus maximus muscle and its superficial fascia were cut off so that the posterior sacral foramina became apparent. The dissection was then continued under an operating microscope (Zeiss OPMI6). The 2nd, 3rd and 4th posterior sacral foramina were dissected following which bone drilling of the superior and medial edges of the foramina was undertaken.

RESULTS

When the posterior sacral foramina became apparent, a fibrous membrane was observed which closed each
of these posterior apertures; this was probably analogous to the ligamenta flava of the mobile vertebral column (Fig. 1). By carefully dissecting across this membrane, the dorsal branches of the sacral nerves were individualised. These filiform branches, with a variable arrangement and destined both to muscular and subcutaneous structures, intermingled with the insertions of gluteus maximus. Adipose tissue was abundant, particularly at the level of the 3rd and 4th posterior sacral foramina, enclosing the nerve roots. The 2nd posterior sacral foramen was nearly half filled by its nerve root along with its ganglion which partially plugged the foramen. The 3rd and 4th nerve roots occupied a relatively smaller proportion of their respective foramina.

As observed through the posterior sacral foramina, each nerve root had an oblique course from upper to lower, from internally to externally. A foraminal arterial branch was present, always lateral to the ventral nerve root, close to the inferolateral edge of each posterior sacral foramen. There was no venous plexus around the nerve root at the level of the posterior sacral aperture, but after drilling the medial bony edge of the foramen, a venous plexus was observed near the midline in two thirds of the foramina (Fig. 2). The arrangement was often asymmetric between the right and left sides, with the presence of a venous plexus on one side and none on the other. For a same side, a venous plexus was not
always noted in the 3 foramina. After drilling the superior bony edge of the foramen, a venous plexus was regularly observed around the proximal part of the spinal ganglion (Fig. 3).

It was noted that, in the distal half of its course through the sacral foramen, the anterior nerve root had an extradural course, and individual fasciculi of nerve fibres were readily identifiable.

DISCUSSION

Some authors have suggested methods for identifying the surface markings of the posterior sacral foramina and they described paths for needles inserted into the respective foramina. The posterior foramina are much shorter than the anterior. They may be partially visible on an anteroposterior 15° cranial tilt stereoradiograph (Jackson & Burke, 1984). The incidence of nerve root or vascular penetration increases with increasing angle of needle entry in the vertical plane.

Also, the incidence of nerve root penetration is higher with a medial approach as compared with lateral entry in the transverse plane (Hasan et al. 1996).

Other authors (Xu et al. 1996), in order to avoid injury to the sacral nerve roots associated with posterior sacral screw placement during internal fixation and fusion procedures extending to the sacrum, have tried to determine qualitatively the location of the anterior sacral foramen on the posterior aspect of the sacrum from plain radiographs. The approximate boundaries of the anterior sacral projection of the foramen were 6 mm superior, 10 mm lateral, 3 mm inferior and 3 mm medial to the corresponding margins of the posterior foramen. This is in accordance with the oblique course of the nerve root observed through the posterior foramen.

A foraminal branch has been described arising from the lateral sacral artery to each foramen, entering mainly the upper medial quadrant of the respective foramen (Hasan et al. 1996). In our study, however, in all cases this arterial branch entered the inferior lateral quadrant of the foramen, occupied by the nerve root medially and the sacral bone edge laterally.

The nerve roots are not surrounded by venous plexuses, as it is usually reported in the literature. Facing the posterior sacral aperture, there is no venous plexus, but there often are venous plexuses near the midline and there are always venous plexuses around the proximal part of the spinal ganglia. These plexuses communicate with the presacral venous plexus, formed by the medial and lateral sacral veins. In addition, the sacral nerve roots have a long extradural course in the foramina, even though the dura mater accompanies other spinal nerves as far as the edges of the intervertebral foramina. This presents a greater potential source of nerve lesions during procedures involving needle insertion.

What are the solutions for avoiding root penetration and haemorrhage? Authors have insisted on the angle of needle entry in the transverse and vertical planes (Thon et al. 1991; Mersdorf et al. 1993; Hasan et al. 1996; Bosch & Groen, 1998). In some foramina, the nerve roots leave a window at their inferior medial quadrant, but it needs to be mentioned that venous plexuses are frequent at that site.

Although CT could be useful, it cannot readily distinguish the nerves from adjacent structures. The higher resolution provided by MR imaging allows this region to be examined in greater detail (Gierada et al. 1993). Each sacral nerve, particularly the 3rd and 4th, is surrounded by fat and signal flow void in numerous small vessels. If necessary, gradient-echo imaging can be used to distinguish neural from vascular structures.
more effectively. In an oblique coronal plane (posterior to anterior), the 3 sacral foramina can be imaged simultaneously. Sacral coronal images must be parallel to the long axis of the sacrum (Blake et al. 1996). This coronal plane provides the best visualisation of the bony sacrum, sacral foramina and proximal nerve roots.

CONCLUSIONS

Knowledge of anatomical detail concerning the posterior sacral foramina and the course of the anterior nerve roots is important for avoiding nerve root penetration and haemorrhage. If the needle is inserted at an optimal angle from the superior lateral edge of the posterior sacral foramina, the chances of any adverse structural penetration can be minimised. Nevertheless, needle insertion under MR imaging control for electrical stimulation constitutes best procedure.

REFERENCES


