RESIN INJECTION STUDIES OF THE LUMBAR EXTRADURAL SPACE

G. R. HARRISON, I. G. PARKIN AND J. L. SHAH

A previous resin injection study of the lumbar extradural space (Husemeyer and White, 1980) suggested that the dural sac was triangular with a posterior midline fold, and implied that the extradural space was quite broad in the dorsolateral and anterior regions. This did not agree with the picture of the extradural space in many textbooks of anatomy, where it is shown as a thin layer situated between the dura mater and the vertebral canal, containing fat and blood vessels. It is possible that the lack of cerebrospinal fluid (CSF) pressure in the cadaver (Barrison, 1933) affected the shape of the resin casts. Therefore, resin injection studies were performed in which attempts were made, in the cadaver, to compensate for these postmortem changes.

MATERIALS AND METHODS

The studies were performed upon two groups of 10 cadavers, aged at death between 65 and 95 yr. The cadavers used, donated to the anatomy department for teaching and research, were at least 48 h postmortem, to comply with the regulations of the Anatomy Act (1832 and 1871).

In both groups a 16-gauge Tuohy needle was inserted to the extradural space at the 2nd or 3rd lumbar space, and an 18-gauge spinal needle, connected to a lumbar puncture manometer via a three-way tap, was inserted to the cisterna magna. Water 100–200 ml was injected to the cisterna magna to create a pressure in the subarachnoid space of 15–20 cm H2O as measured by the manometer.

In group 1, 15 ml of resin was injected to the extradural space.

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SUMMARY

Two resin injection studies of the lumbar extradural space were performed to elucidate its size and shape. To counteract the lack of cerebrospinal fluid pressure in the cadaver, the subarachnoid space was filled with water. In group 1, the extradural injection of resin caused an immediate increase in subarachnoid pressure. The casts produced varied in thickness, but were situated predominantly in the dorsomedial and dorsolateral regions of the spinal canal. Thin anterior spread occurred in 40% of cases. In group 2, resin was injected to the subarachnoid space before the extradural injection of dyed resin. The resulting extradural casts were thinner than in group 1, but the distribution of resin was similar. The problems of interpreting resin casts are discussed in relation to the results obtained, with reasons for suggesting that the extradural space is only potential.

In group 2, 60 ml of resin was injected to the lumbar subarachnoid space through a 16-gauge needle, allowing the displaced intrathecal water to overflow from the cisternal manometer. Following this 15 ml of resin was injected through the needle in the extradural space. This resin had been coloured with a blue dye to distinguish it from that in the subarachnoid space.

The resin used was of low viscosity, suitable for the preparation of anatomical corrosion casts (Trylon Ltd, Wollaston, Northants, NN9 7QJ). When mixed, it had a pot life of 25 min, and it was injected 15 min before gelling occurred. The cadavers were then embalmed. Ten days later, the lumbar vertebrae were removed and transversely sectioned with a bandsaw. The casts were examined and measured in situ. The specimens were decalcified using concent-
Results

Group 1

In all cases, during the injection of the extradural resin, there was an immediate increase in pressure at the cisterna magna, and water overflowed from the manometer until the injection of resin was complete.

In all 10 cadavers, resin was seen only in the extradural space, predominantly in the dorsomedial or the dorsolateral region, or both (fig. 1). The maximum depth of the casts varied from 1 to 9 mm. In those cases in which the maximum depth was greater than 3 mm, there was local inward bulging of the dura mater as a result of the presence of a large globule of resin, from which a thin layer of resin spread out on either side (fig. 2). In these lateral projections the resin tended to be fragile, and often broke during dissection.

In four cases the resin had spread in a very thin layer, less than 1 mm thick, in the region between the anterior dura mater and the posterior longitudinal ligament. On dissection this anterior layer was found to be incomplete, forming a network on the outside of the dura mater.

In none of the cases examined was the dural sac triangular, as previously described (Husemeyer and White, 1980), but it tended to conform to the shape of the resin injection cast. All casts had an undulated surface on the dural aspect, and none showed a dorsomedian fold of dura mater.

Group 2

All 10 cadavers contained clear resin in the subarachnoid space. The extradural space contained a thin layer of coloured resin which varied between 1.5 and 4 mm in depth (fig. 3), and was found in the region posterior to the intervertebral foramina. The maximum thickness of the resin tended to be in the midline posteriorly, spreading out and thinning laterally. In only four instances was there any spread into the anterior compartment, and again this was found to form an incomplete layer, as in group 1. In one case, the resin in the extradural space formed a bulge, as described in group 1. A dorsomedian fold of dura mater, 1 mm in depth, was found in one cadaver. The dural sac tended to conform to the shape of the spinal canal, and in no instance was the dural sac found to be triangular.

Discussion

Whenever resin is injected to a closed space within the body, there will be some distortion of the tissues, which will be preserved in the form of a cast. By definition, casts are artefacts, but this does not necessarily imply inherent error, as it is merely a description of something that is introduced during preparation or investigation.

Various factors which affect the shape of the cast must be considered in interpreting the results; they include the area to which the injection is made, the compliance of the tissues, the viscosity of the resin and the volume of resin injected. Wherever resin is injected, it will flow along the lines of least resistance. If it is injected to an open area, such as a blood vessel, it will fill up the available space, but if it is injected to an area where there is no existing space, it will create one by causing distortion in the most compliant tissues. In the extradural region this is the dural sac, which is supported in vivo by CSF pressure, but is unsupported in the cadaver. It is possible...
for the injection of resin to cause distortion of only
the inner border of the extradural space, as the outer
border is composed of bones and ligaments, and is
effectively non-compliant. The spread of resin will
also be affected by its viscosity. When tissue disfor
the injection of resin to cause distortion of only
tion occurs, local forces may be created which will
cause the resin to be redistributed to an extent
related to its viscosity, which is a major factor in
determining the flow of resin in response to an
applied force. In addition, the viscosity increases as
gelling progresses, so that there is only a limited time
in which redistribution can occur. Finally, the
amount of resin is important, as injecting an
inadequate amount to a space will not fill up the
available area, whereas injecting an excess to a
potential space will cause considerable distortion of
the tissues.

In the cadaver there is no CSF pressure (Barrison,
1933) and resin injected to the extradural space will
collapse the dura mater. No local pressures will be
created to cause redistribution of the resin, and the
cast would be expected to show little more than the
result of compressing the dura mater against the
contents of the dural sac. When water was injected
to the subarachnoid space of cadavers, creating a
pressure of 15–20 cm H₂O, the compliance of the
dura mater approached that found in vivo. Under
these conditions the extrudal injection of resin
immediately caused water to flow out of the needle
in the cisterna magna. This was an important obser-
vation, as it implied immediate dural distortion, and
suggested that the extradural space was only poten-
tial. Were a space to have existed around the dura
mater, it is unlikely that the immediate increase in
pressure would have occurred, as there would have
been room to accommodate the resin without dis-
torting the dura.

Dural distortion will allow the formation of a
depot of resin which will be subject to the effects of
local forces (arising from the pressure of fluid in the
subarachnoid space) tending to reform the original
shape of the dura mater, and the resin will spread
into a more even layer around it. However, if the
time between the injection of resin and the point of
gelling is short (as recommended by Tompsett
(1970)), there will be little opportunity for the resin
to spread. Both of these factors will tend to maintain
distortion, and may explain the shape of the cast in
figure 2. If resin is injected to the subarachnoid
space, the compliance of the dura mater will be
reduced, and the distortion produced by the sub-
sequent extradural injection of resin will also be
reduced. In this situation the final shape of the cast
will depend, not only upon the above factors, but
also upon the relative time of injection of the sub-
arachnoid and extradural resins. If the extradural
resin is injected when the subarachnoid resin has
gelled, it will not distort the dura mater, but if the
resin is injected to the extradural space when the
subarachnoid resin is still pliable, as occurred
during these studies, it will produce a distortion of the
dura mater. This may be redressed by the effect of
local forces as described above, but only until the
subarachnoid resin has gelled.
FIG. 3. Transverse section of resin casts. The resin in the extradural space is seen as a thin layer on the posterior aspect of the subarachnoid resin. (Bar = 1 cm).

The infrequent spread of resin into the region between the anterior dura mater and posterior longitudinal ligament further supports the suggestion that the extradural space is potential. In those cases in which there was no anterior spread, the dura mater was found to be closely applied to the posterior longitudinal ligament, and in the eight cases in which the resin had spread into the anterior compartment, it was very thin and incomplete. It is possible that this was the result of using too little resin. Determining the correct volume of resin to inject to the extradural space is difficult. Too little will not fill the space should it exist, but too much will cause excessive distortion of the tissues. Fifteen millilitre was chosen in these experiments, as it is similar to the volume of local anaesthetic used in extradural anaesthesia. Filling the subarachnoid space itself also may cause distortion, from within rather than from without. In the first group, distortion from within seems unlikely as the water-derived subarachnoid pressure was similar to that found in vivo. In the second group, in which resin contributed to the subarachnoid pressure, the argument for distortion from within is much stronger. In either case, it would be impossible for more resin to be accommodated by forcing the dura mater any further against the walls of the vertebral canal, if the extradural space is only potential.

It is not easy to reach any definite conclusions about the shape of the extradural space from the casts produced, as it was not possible to quantify the extent of distortion. However, the authors support the hypothesis that the extradural space is potential on the basis of two observations: (1) the extradural injection of resin caused water to flow out immediately from the needle in the cisterna magna (group 1); and (2) the paucity (or absence) of resin in the anterior compartment.

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REFERENCES

