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ORIGINAL ARTICLES

MAGNETIC RESONANCE IMAGING OF EXTRADURAL BLOOD PATCHES: APPEARANCES FROM 30 MIN TO 18 H

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SUMMARY

We have used magnetic resonance imaging to examine five patients treated with extradural blood patches for persistent post lumbar puncture headache. Images were obtained between 30 min and 18 h after patching. Extradural blood patch injection produced a focal haematoma mass around the injection site which initially compressed the thecal sac and nerve roots. The main bulk of the extradural clot extended only three to five spinal segments from the injection site, although small amounts of blood spread more distally. Spread from the injection site was principally cephalad. Mass effect was present at 30 min and 3 h, but clot resolution had occurred by 7 h, leaving a thick layer of mature clot over the dorsal part of the thecal sac. Eighteen hours after injection only small widely distributed clots, adherent to the thecal sac, were demonstrated. Extensive leakage of blood from the injection site into the subcutaneous tissues was present in all patients. (Br. J. Anaesth. 1993; **71**: 182–188)

KEY WORDS

Anaesthetic techniques: blood patch, extradural. Complications: post lumbar puncture headache.

Extradural blood patch is the treatment of choice for post lumbar puncture headache (PLPH) occurring as a complication of spinal or extradural anaesthesia [1–3]. The mechanism of action of the blood patch is incompletely understood, despite extensive clinical studies [2, 4–6]. We have recently presented the findings in a single patient investigated by magnetic resonance imaging (MRI) 30 min after injection of 20 ml of blood into the extradural space [7]. MRI demonstrated considerable mass effect from the extradural haematoma, with compression of the thecal sac and of exiting nerve roots. We have now had the opportunity to examine an additional four patients between 3 h and 18 h after patching. The findings from all five of these patients are presented here and include new observations on the original patient which were appreciated only after examination of later subjects.

PATIENTS AND METHODS

We studied five patients with severe PLPH resulting from accidental dural tap during extradural anaesthesia (two patients), after spinal anaesthesia (one patient) and after combined extradural and spinal anaesthesia (two patients). In the two patients with combined extradural and spinal punctures, there was no evidence of dural puncture by the Tuohy needle.

After local Ethics Committee approval, informed consent for MRI was obtained from each patient.

Extradural blood patches were performed after 24–84 h of unsuccessful conservative therapy (table I). Patching was performed with the patient in the sitting position. The technique of loss of resistance to air was used to locate the extradural space. All patches were performed using a 16-gauge Tuohy needle to inject 18–20 ml of autologous venous blood at the level of or adjacent to the original extradural puncture. Patches were performed by a senior registrar (three patients) or consultant in obstetric anaesthesia (two patients).

The dorsolumbar spine was imaged in each patient at a pre-determined interval (30 min–18 h) after patching. Imaging was performed using a 0.5 Tesla Max System (General Electric). Each patient was

TABLE I. *Basic clinical data for all patients. In patients Nos 1 and 4, two levels are indicated for the original procedure. In each, attempted extradural injection at the upper level was complicated by dural puncture. Successful extradural anaesthesia was subsequently established at the lower level*

Patient No.	Age (yr)	Weight (kg)	Procedure and level	Duration of headache (h)	Patch level	Time to MRI (h)
1	35	78	Extradural L2–3 +L3–4	36	L1–2	0.5
2	29	65	Spinal L2–3	36	T12–L1	3
3	44	81	Spinal+ extradural L3–4	24	L2–3	7
4	25	130	Extradural L1–2 +L2–3	84	T12–L1	9
5	24	93	Spinal+ extradural L2–3	72	L2–3	18

This article is accompanied by an Editorial.

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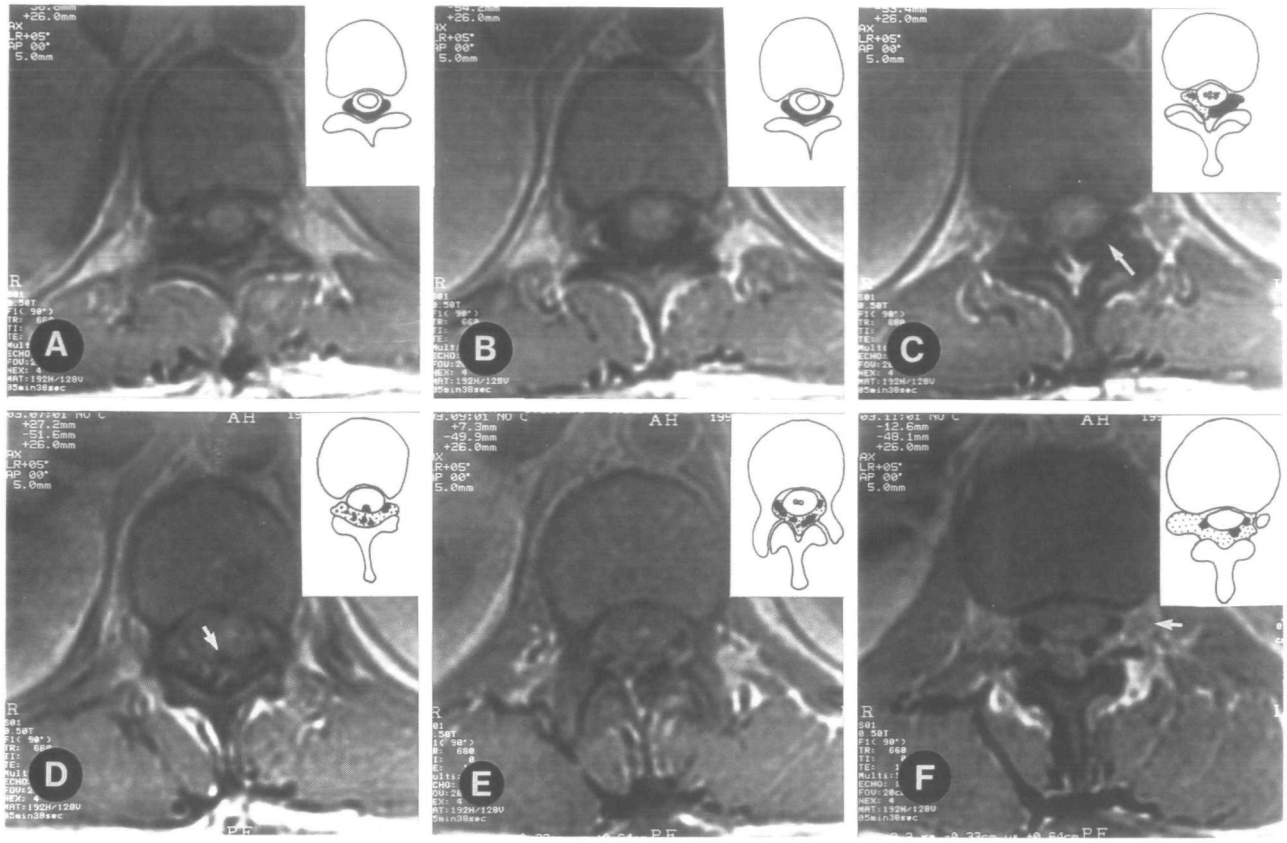

FIG. 1. A series of six axial T1 weighted GE images, demonstrating the distribution of blood within the extradural space in patient No. 2 (3 h after injection). The inset on each image shows the distribution of blood derived from both axial T1 and sagittal STIR images. Images are equidistantly spaced between T10 (A) and L3 (F). The arrow on C indicates clot extending out through the left neural outlet foramen. In D, the arrow indicates a small focus of clot lying within and adherent to the thecal sac. The arrow in F indicates the dorsal root ganglion displaced downwards and anteriorly by the extradural clot.

imaged in the sagittal plane using a T1 weighted gradient echo sequence (GE 300-480\14\90.8 Nex, 96*256 matrix, 42-cm field of view). The use of a large field of view allowed visualization of the extent of haematoma from the T6–7 vertebrae to the sacral recess. Axial T1 weighted images were obtained also throughout the visualized haematoma (GE 480-670\14\90.4 Nex, 192*128 matrix, 22-cm field of view) in all patients. In four patients additional sagittal plane images were obtained using a Short Tau Inversion Recovery (STIR) T1 weighted sequence (IR 1500/110, 4 Nex, 96*224-256 matrix, 42-cm field of view) to suppress the signal from extradural and subcutaneous fat.

Interpretation of MRI images

MRI provides a highly specific and sensitive demonstration of clotting blood [8]. During the first 2–10 h of clot development, haematoma appears as a markedly reduced signal on T1 weighted images. The presence of abundant fat within the extradural space provides clear contrast with larger areas of developing clot, but obscures smaller areas by swamping them with surrounding high signal. The use of STIR images specifically suppresses the high signal of fat and sensitively demonstrates fresh clot as areas of extreme high signal. The combination of axial T1 GE and sagittal STIR images allows demonstration of both the overall extent (STIR images) and the areas of greatest concentration (T1 GE images) of blood within the fat-containing extradural space. Delineation of haematoma from CSF is not a problem with each sequence, as the paramagnetic effect of the clot results in a signal intensity less than that of CSF on T1 weighted images and greater than that of CSF on T2 weighted images.

RESULTS

Clinical findings

All patients were suffering from severe PLPH at the time of patching. In patients Nos 4 and 5, potential technical problems caused by obesity led to a prolonged trial of conservative therapy before patching. There was a dramatic response to blood patch injection, with rapid relief of headache and postural symptoms within 30 min in all patients. There were no late recurrences of headache and repeat patching was not required in any patient. Three patients (Nos 1–3) complained of moderate local backache at the puncture site after patching; this resolved within 24 h in each.

Magnetic resonance findings

Patient No. 1, 30 min after patching. Imaging findings in this patient have been presented previously [7]. Parasagittal images demonstrated a sizeable blood clot in the posterior extradural space. The clot extended upwards from the puncture site to the T11–12 intervertebral space and down one

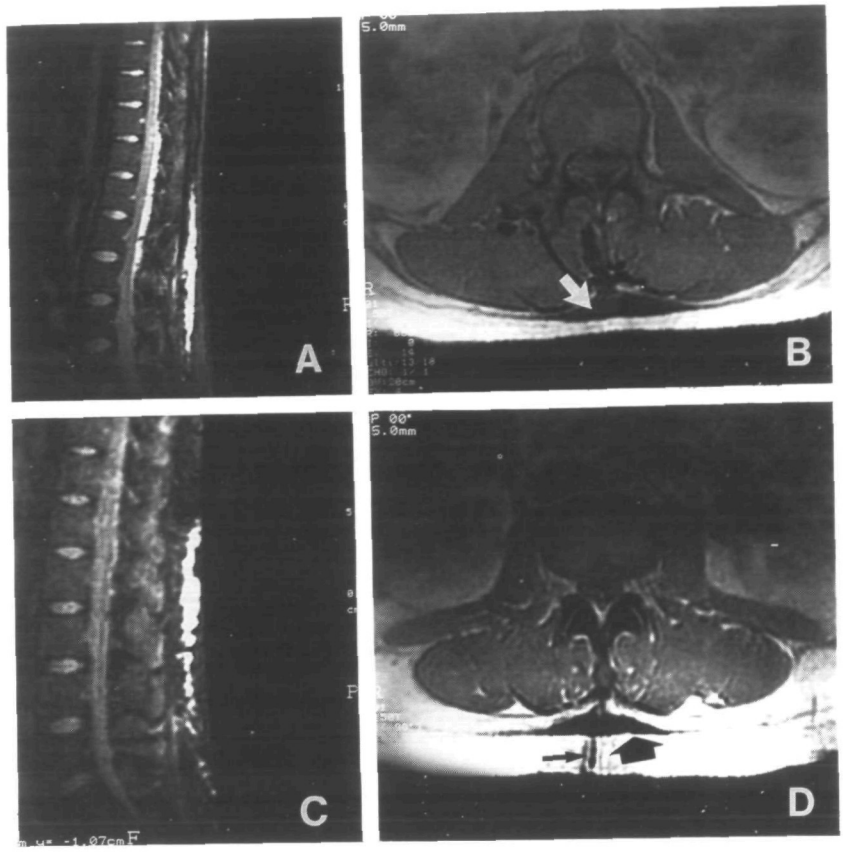

FIG. 2. A: Sagittal STIR image in patient No. 2 (3 h after injection), showing the distribution of extradural blood and extensive subcutaneous spread (clot appears white on this image). B: Axial T1 image in patient No. 2, showing extension of blood from the injection site into the fascial layers of the subcutaneous tissues (arrow; blood appears dark on this image). C: Sagittal STIR image in patient No. 5 (18 h after injection), showing a thin residual layer of extradural blood and extensive subcutaneous spread (blood appears white). D: Axial T1 image in patient No. 5, showing blood spread into the subcutaneous fat (large arrow; blood appears dark) at the level of the needle track (small arrow).

interspace to the L2–3 level. The clot was largest at the levels of the intervertebral discs where the sagittal diameter of the spinal canal is greatest. The clot was seen to compress the thecal sac and displace the conus medullaris and cauda equina anteriorly and to the right. Axial images demonstrated clot extending out through the intervertebral foramina at T11–12, T12–L1 and L1–2 with anterior displacement of the exiting nerve roots. In addition to the focal clot at the injection site, a thin layer of clot extended down the posterior aspect of the thecal sac to the level of the S1 vertebral body, upwards to the level of T9–10 and anteriorly into the anterior extradural space. An increase in the intensity of CSF signal on GE T1 weighted images indicated spread of blood into the subarachnoid space.

A review of the images in this patient demonstrated extensive spread of blood into the fascial planes in the subcutaneous fat overlying the puncture site. This finding was not appreciated initially and was not described when this case was originally reported.

Patient No. 2, 3 h after patching. Extensive clot was demonstrated extending from T7 to L4, with the main bulk of the clot lying between T10 and L3 (fig. 1). The clot was seen to surround the posterior aspect of the thecal sac and to conform to the outlines of the sac. There was generalized compression and anterior displacement of the thecal sac between T11 and L3. Focal clot was seen lying within the thecal sac at T12–L1 which appeared to be adherent to the theca (fig. 1D): the CSF signal was normal. Clot extended out through the neural outlet foramina at several levels (T11–12 to L2–3) and was seen to displace the nerve root at two levels (fig. 1F).

There was extensive spread of blood from the injection site into the fascial planes of the subcutaneous fat, which was well demonstrated on STIR images (fig. 2).

Patient No. 3, 7 h after patching. A thin layer of clot was demonstrated lying adjacent and adherent to the posterior aspect of the thecal sac (fig. 3). Clot extended from T8 to L4, but was most prominent between T11 and L3. There was no significant displacement of neural structures and no evidence of subarachnoid spread of blood. Extensive haematoma was seen to spread from the injection site into the fascial planes of the subcutaneous fat.

Patient No. 4, 9 h after patching. A thick layer of clot extended from T11 to L2 and closely conformed to the outline of the dural sac. A thinner layer of clot extended from T6 to L3. The clot was closely adherent to the thecal sac, forming a "saddle" of haematoma around the theca (fig. 4). There was no evidence of mass effect or subarachnoid blood and extensive spread of haematoma from the injection site into the fascial planes of the subcutaneous fat was again noted.

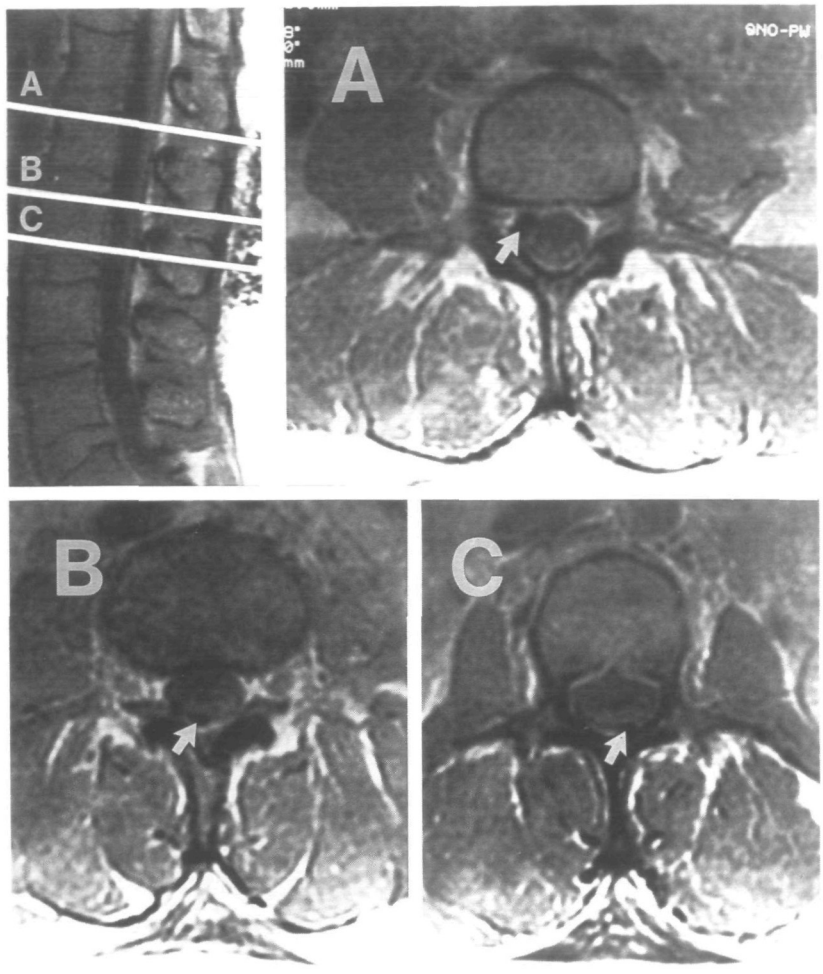

FIG. 3. Distribution of extradural blood in patient No. 3 (7 h after injection). Small foci of clot are seen adherent to the thecal sac at all levels (arrows; blood appears dark).

Patient No. 5, 18 h after patching. Minimal residual clot was seen extending from T12 to L2. The visualized clot was adherent to the thecal sac and had no mass effect. There was no evidence of subarachnoid spread of blood or mass effect. Extensive spread of haematoma into the fascial planes of the subcutaneous fat was again demonstrated (fig. 2).

DISCUSSION

Post lumbar puncture headache is usually a benign, self-limiting condition lasting for only a few days. In severe cases, however, the headache may be totally incapacitating and, without treatment, may last weeks or even months [2, 9].

The mechanism of PLPH is well described [2]. Its incidence and severity reflect the size of the subarachnoid–extradural fistula and are related closely to needle size [10]. PLPH is a particular problem after inadvertent puncture of the dura during attempted extradural anaesthesia. Although this complication occurs only in 1–2% of patients [2, 11] the combination of thecal puncture by a large-gauge Tuohy needle (16–18-gauge) and subsequent labour results in a 75–80% incidence of PLPH [1–3].

Gormley was the first to use injection of autologous blood into the extradural space to repair the thecal tear [12]. This technique has a high success rate, is relatively free of complications and is the method of choice for treatment of PLPH [2, 8, 13, 14]. The rapid response to patching cannot be explained by simple plugging of the thecal tear, as CSF production (0.5 ml min^{-1}) cannot make up the lost fluid within such a short time [2, 15]. Cook and Watkins-Pitchford demonstrated acceleration of the coagulation pathway in the presence of CSF and suggested that the almost instantaneous coagulation at the blood–CSF interface could explain the rapid therapeutic response [4]. Carrie disagreed with this conclusion, suggesting that the immediate response reflects displacement of CSF into the cranium by the injected volume within the spinal canal [15]. This suggestion is supported by the rapid response to bolus injections of saline into the extradural space [2, 3]. In the current study, the thecal sac was compressed markedly by the extradural clot at both 30 min and 3 h after injection, providing further evidence that this mechanism is responsible for the rapid increase in CSF pressure after blood patch injection. Later images (7 h onwards) demonstrated no residual thecal compression, indicating that this mechanism of pain relief is only short lived. The sustained therapeutic response to blood patches undoubtedly reflects sealing of the thecal tear by clot. A single postmortem examination in a patient

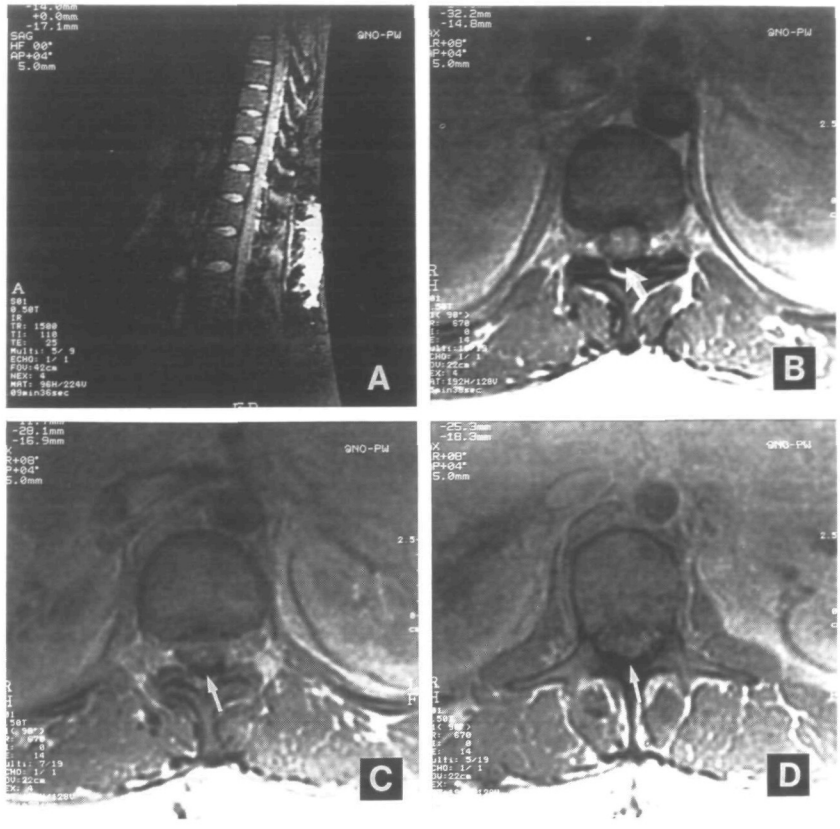

FIG. 4. A: Sagittal STIR image, showing the distribution of extradural blood and subcutaneous spread in patient No. 4 (9 h after injection; blood appears white). B–D: Distribution of extradural blood in patient No. 4. The blood forms a "saddle" of adherent clot along the dorsum of the thecal sac (arrows; blood appears dark).

who received a blood patch 2 days previously demonstrated many separate clots "adherent to the dura like a vulcanising rubber patch" [2]. The appearances in patients Nos 3, 4 and 5 in the current study (figs 2–4) confirm the wide distribution of clot adherent to the theca after resolution of mass effect, particularly in the region of the patch injection. The accelerated coagulation which occurs in the presence of CSF may favour formation of clot around the site of the thecal tear, and the finding of clot extending through the puncture site into the subarachnoid space in patient No. 2 provides an elegant demonstration of the ability of focal extradural blood to seal a thecal tear (fig. 1D). The combination of the initial thecal compression by the extradural clot and the tendency to accelerated clotting in the region of the CSF leak may explain in part why early workers had considerable success with injections of as little as 2 ml of blood [12].

Failure of extradural blood patching is often ascribed to inadequate injection volume [3, 9]. Although Gormley [12], in his original series of seven patients, had excellent results using only 2–3 ml of blood, later workers had failure rates as high as 25% for late blood patch injection using 6–10 ml [2, 6, 14, 16]. Crawford [3, 9] found that the use of increased volumes of blood was associated with a considerable increase in success and recommended routine use of injection volumes of 18–10 ml. Several groups have now examined the relationship between injection volume and success of blood patching and all recent studies have followed Crawford's recommendations for large injection volumes [1, 2, 17–19]. In the current study, all patients had a considerable volume of blood extending out from the site of insertion of the Tuohy needle into the fascial planes between the subcutaneous fat compartments. This observation has not been reported previously and raises important questions regarding the fate of the injected blood. It is impossible to estimate accurately the volume of blood within the extradural space in our patients, but it seems clear that it was much less than the overall injected volume. The blood patch injections in our patients were uncomplicated and it seems likely that this leakage of blood is a common occurrence.

The mechanism of this superficial leakage of blood is unclear. It is of interest that in Gormley's original report of successful patching with volumes of 2–3 ml [12], extradural puncture was performed using a standard, end-hole, spinal needle and the extradural space was localized by withdrawing the needle after initial subarachnoid spinal puncture. Later studies invariably used 16–18-gauge Tuohy needles and required considerably larger injection volumes. Although we can only speculate on the mechanism whereby blood enters the fascial planes, it seems possible that the use of the loss of resistance technique to locate the extradural space could result in the aperture of the Tuohy needle lying only partly within the extradural space during injection of blood. Alternatively, the presence of a relatively large defect in the ligamentum flavum may predispose to leakage of blood around the needle during injection or after

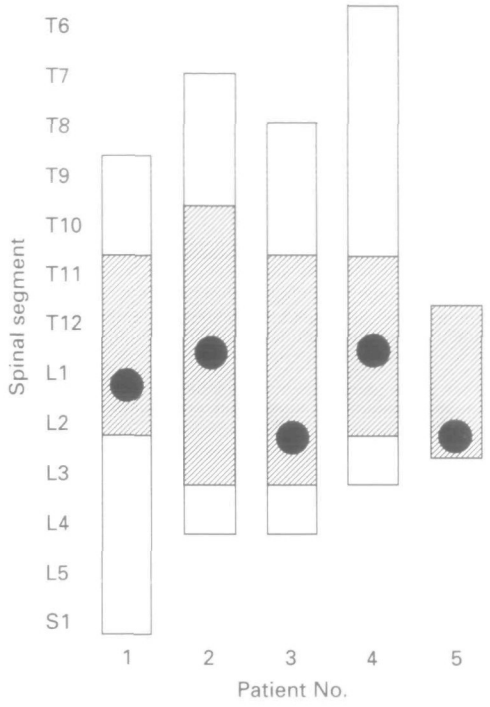

FIG. 5. Graphical demonstration of extradural blood distribution in all five patients. The patch injection level is indicated by a black dot. Hatched areas indicate the extent of clot contiguous with the injection site as demonstrated on T1 weighted GE images. Open boxes show the maximal spread as demonstrated on STIR images.

needle withdrawal. Whatever the mechanism of blood leakage, the current recommendations for optimal injection volumes probably relate poorly to the actual volume of blood injected into the spinal canal.

It is of interest that superficial leakage of blood was not demonstrated in the study of Szeinfeld and co-workers [19]. These workers used a gamma camera to document the spread of technetium-99m labelled blood in the extradural space during and after blood patch injections of 12–18 ml via a 17-gauge Tuohy needle. As no images were presented in this study, it is not possible to comment on whether or not the subcutaneous tissues were included within the collimated field which was examined. It is also of interest that only the first 10 ml of each injection was radiolabelled, so that leakage at the end of the injection may have been overlooked.

Another postulated cause for failure of blood patching is introduction of extradural clot at the wrong level [20]. This might result from alteration in the surface markings of the puncture site after delivery and has also been used to explain the relatively low success rate of extradural patching in some studies in which blood was introduced down the extradural catheter, the tip position being unpredictable [3, 20, 21]. In comparison, the study of Shah and Veness [18] had a success rate of 100% using 15–20 ml of blood injected via an extradural catheter introduced only 2–3 cm beyond the tip of a Tuohy needle. This is perhaps surprising, as the imaging study of Szeinfeld and co-workers [19] demonstrated wide spread of blood within the extradural space. Injections of 12–17 ml in this study resulted in spread over seven to 14 spinal segments and the extent of spread was directly related to the injection volume, with an average extent of one spinal segment per 1.6 ml of blood. This represents a slightly more extensive spread of blood than was seen in the current study, although this is not unexpected since radiolabelling studies are exquisitely sensitive to even small quantities of tracer and might be expected to demonstrate volumes of blood too small to be seen reliably on MRI [22]. The findings in the current study largely explain the apparent importance of the injection site despite the extensive spread of blood in the extradural space. Although our study demonstrated blood spread over nine to 10 spinal segments after injections of 18–20 ml, the majority of the clot and all the mass effect in patients Nos 1 and 2 was restricted to three to five segments around the injection site, with only small amounts of blood seen more distally. In common with Szeinfeld and co-workers, we found that the spread of clot was principally upwards from the injection site (fig. 5) and would therefore recommend that blood patch injections should be made at the level below the original spinal puncture.

Complications of blood patching are unusual and usually self-limiting. Backache is the most commonly reported complication, occurring in 20–35% of patients, with an average duration of 27 days [1]. The mechanism of backache remains unexplained, but the demonstration of extensive subcutaneous haematoma in the present study may be one causative factor. Short-lived radicular pain is a rarely reported complication [2, 23, 24] and the demonstration of nerve root displacement in patient No. 1 confirms the assumptions of previous workers that this results from nerve root compression by extradural clot. Spread of blood into the subarachnoid space has been suggested as a possible source of late arachnoiditis. Although the present study confirms the presence of subarachnoid spread, reports suggest that there is no reason to believe that this will give rise to late complications [2, 25].

On the basis of our findings, we would recommend that extradural blood patch be performed below the original site of puncture, but within one to two spinal segments. If the technique is performed via a Tuohy needle, gradual injection of up to 20 ml of blood is appropriate and smaller volumes should be used only when injection is limited by patient discomfort.

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