Leakage of cement in percutaneous transpedicular vertebroplasty for painful osteoporotic compression fractures


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We analysed the CT scans and radiographs of 76 vertebrae in 49 patients who underwent vertebroplasty for painful osteoporotic compression fractures. Leaks of cement were classified into three types: those via the basivertebral vein (type B), via the segmental vein (type S), and through a cortical defect (type C).

More leaks were identified on CT scans than on radiographs by a factor of 1.5 (74/49). Most type-B (93%) and type-S (86%) leaks were missed or underestimated on a lateral radiograph which is usually the only view used during the injection of cement. Of the leaks into the spinal canal, only 7% (2/28) were correctly identified on radiographs. The areas on lateral radiographs where this type of leak may be observed were divided into four zones, and their diagnostic value in predicting a leak into the spinal canal was evaluated. The results showed that cement in the neural foramina had the highest positive predictive value (86%).

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Leakage of cement after vertebroplasty has been reported in between 38% and 72.5% of cases. 1-5 It may cause pulmonary embolism and neurological complications including myelopathy and radiculopathy. In order to prevent these, it is important to understand the patterns of leakage. Our aim therefore in this study was to classify the patterns of leakage, to evaluate the accuracy of plain radiographs in detecting leaks and to find and assess signs on a lateral radiograph which could predict leaks into the spinal canal.

Patients and Methods

Between June 1999 and October 2001, 118 patients underwent percutaneous transpedicular vertebroplasty for the treatment of painful osteoporotic compression fractures. All had had severe back pain and tenderness for more than two months which did not respond to conservative treatment for more than two weeks. The levels of vertebroplasty were selected on the basis of the MR findings and the site of local tenderness. Only the levels showing localised fluid collection, haemorrhage or oedema and/or an intravertebral vacuum phenomenon, were selected. Levels with healed fractures were excluded even when there was gross collapse of the vertebral bodies. The primary reason for vertebroplasty was to obtain relief from pain, allowing patients to be

Fig. 1

Diagram showing the classification of patterns of cement leakage. Type B is a leakage via the basivertebral vein, type S via the segmental vein, and type C through a cortical defect.
more mobile, to have a better quality of life and to improve the management of their osteoporosis.

We selected 76 vertebrae in 49 consecutive patients who had postoperative CT with 1 mm of reconstruction increment. There were six men and 43 women with a mean age of 70.7 years (55 to 82). Of the 76 vertebrae, 47 were thoracic and 29 were lumbar.

**Operative technique.** All patients underwent vertebroplasty with fluoroscopic control and local anaesthesia in an operating theatre. Intraosseous venography was performed before the injection of cement, and tungsten powder and barium sulphate were mixed with the cement. When a thin toothpaste consistency was achieved, trans- and bipedicu- lar injection was carried out. The amount of cement which was injected was 5.1 ± 1.8 ml (2 to 9).

**Methods of analysis.** Postoperative spiral CT was performed with a Somatom plus 4 scanner (Siemens Medical, Germany) on the first postoperative day. The thickness of the slice was set at 3 mm, the pitch was 1.0, and the reconstruction increment 1.0 mm. The images were transformed to the DICOM (digital imaging and communication in medicine) 3.0 format, and transferred to a personal computer. Multiplanar reconstruction of the images was carried out on V-works v3.5 (Clinic3D Inc, Seoul, Korea) personal compu-
Any leakages of cement were classified into three types as follows: B, via the basivertebral vein, S, via the segmental vein and C, through a cortical defect (Fig. 1). The accuracy of plain radiography in detecting leaks was then evaluated. Two orthopaedic surgeons (JWK, WJK), who were blinded to the CT scans, reviewed the radiographs simultaneously to identify leaks. The results were compared with those which had been obtained by the first author (JSY) from the radiographs and CT scans. The former results were grouped into correct interpretation, misinterpretation of the type of leak and misinterpretation of the presence of a leak. The ability to identify each type of leak on radiographs was evaluated.

Finally, in an attempt to determine and assess some signs on the lateral radiograph which could be of help in the early
detection of leaks into the spinal canal in the operating theatre, the lateral radiographs were analysed and the areas where a leak might be observed were divided into four zones as follows: zone I, the neural foramina; zone II, the portion of the vertebral body just anterior to the neural foramina in the posterior one-fifth of the vertebral body; zone III, the pedicles; and zone IV, the portion just anterior to the pedicles in the posterior one-fifth of the vertebral body.

Results

Patterns of leakage of cement. Leaks via venous channels such as type-B (28, 38%) and type-S leaks (29, 39%) were more common than type-C leaks (17, 23%).

Type-B leaks involve intrusion of cement into the spinal canal. They proceed via the vascular foramen and in the spinal canal they spread along the epidural venous plexus (Fig. 2). Type-S leaks (Fig. 3) usually proceed horizontally, along the segmental veins. They therefore often resemble a small paravertebral leak on anteroposterior (AP) radiographs. They are, however, actually long leaks in many cases, and may reach the neural foramina (Fig. 3b). Sometimes they take a vertical or oblique course (Fig. 3c). Type-C leaks occur via a cortical defect around a vertebral body, including the spinal canal (Fig. 4).

Leaks into the spinal canal therefore may be type-B or type-C. All 28 leaks involving the spinal canal in our series were type-B characterised by their distribution within the epidural plexus. The distribution of the cement is relatively symmetrical, and is anterior to the dura mater. It does not occur more than one part of the spinal canal, although it may extend proximally and distally (Fig. 2c) or laterally to the neural foramina (Fig. 5). This contrasts with type-C leaks involving the spinal canal which have an asymmetrical distribution, and can occupy any corner of the spinal canal (Fig. 4b). They are, however, uncommon.

The accuracy of plain radiographs in detecting leaks. Review of the CT scans and radiographs of the 76 vertebrae by the first author (JSY) identified 74 leaks in 48 vertebrae (63%). Simultaneous review, however, of the lateral radiographs by two other orthopaedic surgeons (JWK, WJK) identified only 35 leaks (47%), and of these 12 (16%) type-C leaks by two other orthopaedic surgeons (JWK, WJK) (63%). Simultaneous review, however, of the lateral radiographs by the first author (JSY) identified 74 leaks in 48 vertebrae (63%).

The types of leak identified in all four zones of the lateral radiographs, by number and percentage

Table I.

<table>
<thead>
<tr>
<th>Zones</th>
<th>Type B</th>
<th>Type S</th>
<th>Type C</th>
<th>No leak</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I†</td>
<td>12 (86)</td>
<td>1* (7)</td>
<td>1* (7)</td>
<td>0 (0)</td>
<td>14</td>
</tr>
<tr>
<td>II‡</td>
<td>8 (59)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (20)</td>
<td>10</td>
</tr>
<tr>
<td>III</td>
<td>9 (69)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>4 (31)</td>
<td>13</td>
</tr>
<tr>
<td>IV§</td>
<td>14 (67)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>7 (33)</td>
<td>21</td>
</tr>
</tbody>
</table>

*foraminal leaks
†vertebrae showing cement in both zones I and II were excluded
‡vertebrae showing cement in both zones III and IV were excluded

Table II.

<table>
<thead>
<tr>
<th>Zones</th>
<th>Type B</th>
<th>Type S</th>
<th>Type C</th>
<th>No leak</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>28 (100)</td>
<td>14 (50)</td>
<td>14 (48)</td>
<td>25 (86)</td>
<td>6 (33)</td>
</tr>
<tr>
<td>II</td>
<td>0 (0)</td>
<td>12 (43)*</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>III</td>
<td>0 (0)</td>
<td>2 (7)</td>
<td>15 (52)</td>
<td>4 (14)</td>
<td>11 (65)</td>
</tr>
<tr>
<td>IV‡</td>
<td>29 (100)</td>
<td>29 (100)</td>
<td>17 (100)</td>
<td>17 (100)</td>
<td></td>
</tr>
</tbody>
</table>

*misinterpretation of type-B leak as foraminal leak

The types of leak identified by number and percentage

<table>
<thead>
<tr>
<th>Radiograph reading</th>
<th>Type B</th>
<th>Type S</th>
<th>Type C</th>
<th>No leak</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Misinterpretation as no leak</td>
<td>28 (100)</td>
<td>14 (50)</td>
<td>14 (48)</td>
<td>25 (86)</td>
<td>6 (33)</td>
</tr>
<tr>
<td>Misinterpretation as incorrect type of leak</td>
<td>0 (0)</td>
<td>12 (43)*</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Correct interpretation</td>
<td>0 (0)</td>
<td>2 (7)</td>
<td>15 (52)</td>
<td>4 (14)</td>
<td>11 (65)</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>29</td>
<td>29</td>
<td>17</td>
<td>74</td>
</tr>
</tbody>
</table>

Misinterpretation as incorrect type of leak

Table II gives the details of the results. Although there were 28 vertebrae with type-B leaks, none was identified on the AP views. On the lateral views, in 12 vertebrae (43%) the leak was misinterpreted as a simple foraminal leak (Fig. 5) and in 14 vertebrae (50%) it was not identified (Figs 6 to 8). Thus, in only two vertebrae (7%) were the leaks correctly interpreted.

There were 29 vertebrae with type-S leaks. When only the lateral view was reviewed, 25 (86%) were missed and only four (14%) were correctly interpreted. On the AP views, 14 (48%) were missed and 15 (52%) correctly interpreted.

All 17 vertebrae having type-C leaks were correctly interpreted on the lateral radiographs. On AP views, six (35%) were missed and 11 (65%) correctly interpreted.

Leaks were therefore identified more commonly on CT scans than on plain radiographs by a factor of 1.5 (74/49). When only the lateral view was used most of type-B (93%) and type-S (86%) leaks were not identified or misinterpreted.

Diagnostic value of cement in the four zones on the lateral view in predicting leaks into the spinal canal. All leaks involving the spinal canal showed cement in at least one of the four zones on lateral radiographs.

The types of leak in each zone are summarised in Table II. Of the 14 vertebrae in which cement was seen in zone I, 12 (86%) were type-B leaks. Thus, the positive predictive value of cement in zone I in detecting a leak into the spinal canal was 86%. Only two of the 14 vertebrae (14%) had pure foraminal leaks (types C and S). Of the ten vertebrae in which cement was seen in zone II, eight (80%) were type-B (Fig. 6), in zone III 9 (69%) were type-B (Fig. 7), and in
zone IV, 14 (67%) (Fig. 8). Thus, cement in zone I had the highest positive predictive value in indicating leaks into the spinal canal.

**Discussion**

Our study has shown that leakage of cement is more common than may be appreciated on plain radiographs. In particular, of 28 leaks into the spinal canal, only two (7%) were correctly interpreted on plain radiographs. Since the posterior portion of most vertebral bodies is concave in the axial plane, early detection of a leak, especially of type B, is difficult on the lateral radiographs. Furthermore, since most patients who undergo vertebroplasty for compression fracture are overweight, the level of fracture is often at the thoracolumbar junction, and all patients have severe osteo-

Lateral radiograph (a) and CT scan (b) of a leak into the spinal canal. On the lateral view cement seems to be in the neural foramen (zone I), but the CT scan shows that it is a type-B leak.

Lateral radiograph (a) and CT scan (b) of a leak into the spinal canal. On the lateral view the cement seems to be in the vertebral body just anterior to the neural foramen (zone II), but the CT scan shows that it is a type-B leak.
porosis, the quality of the lateral radiograph is usually poor. In addition, the quality of the images using C-arm fluoroscopy is usually worse than that of plain radiographs. Thus, leaks into the spinal canal may be easily overlooked.

Unfortunately, however, C-arm fluoroscopy is the only means of monitoring leakage of cement during injection. Furthermore, for the detection of leaks into the spinal canal only the lateral radiographs can be used since the leaks are not seen on the AP view. Therefore, any signs which are suggestive of this type of leak on the lateral radiograph may be very useful.

This led us to assess the diagnostic value of identifying cement in four zones on the lateral views in predicting pos-
sible leaks into the spinal canal. The overall sensitivity was 100%, as all the leaks into the spinal canal had cement in at least one zone. Thus the positive predictive value (PPV) of each zone, which is the probability that there is a true leak into the spinal canal when cement is observed in that zone on the lateral radiograph, may help in deciding whether to stop or continue the injection of cement during vertebroplasty. At the level of the pedicle, in zones III and IV, which are nearer to the tract of the needle, the PPVs were 69% and 67%, respectively. In these zones, no leak was identified in 11 of 34 (32%), and cement was actually in the pedicle(s) or in the vertebral body anteriorly, as shown in Figure 3a. By contrast, at the level of the neural foramen, zones I and II, the overall PPV was 83% (20/24), and if the neural foraminal leaks (2/24) were included it became 92% (22/24). Thus, cement in zones I and II seems to be more dangerous than that in zones III and IV. In zone I, there was a leak in 14 vertebrae; most (12/14, 86%) were into the spinal canal and only two (14%) were foraminal leaks. Thus, careful attention must be paid to identifying cement in the neural foramina which are not well imaged by fluoroscopy, and injection should be stopped when and preferably before, cement is seen in this site.

Although there were 28 vertebrae with leaks into the spinal canal and in some cases the cement occupied about 25% of the spinal canal, there were no neurological complications; all these leaks were type-B, and it seems that this type of leak does not cause such complications since the distribution of cement resembles that of normal local venous engorgement. We examined three separate cases of postoperative paralysis which were not included in this study. Two patients had been referred from elsewhere (Fig. 4b), and one has been described in a case report.7 They all had type-C leaks. While type-B leaks are contained in the epidural veins, there is no barrier in type-C and the cement can extend without restriction. In addition, it is presumed that if a type-C leak entraps a nerve root and proceeds into the spinal canal, the dura and its contents will also be involved because of a decreased mobility. Thus a type-C leak into the spinal canal can be more dangerous than a type-B leak.

Type-C leaks into the spinal canal may occur as a result of two types of cortical defect. One is a pre-existing defect such as fracture gap and the other is the defect produced during insertion of the needle. We do not undertake vertebroplasty on patients with acute fractures since they usually respond to conservative treatment. This may be one of the reasons why we did not have type-C leaks into the spinal canal. Great care must be taken during insertion of the needle. Once the wall of the pedicle is perforated by the needle, its repositioning may unseal the cortical defect and cause a type-C leak into the spinal canal.

Type-B leaks also should be avoided although they seem to be less dangerous than type-C leaks. The spinal canal may already be compromised. Furthermore, the vertebral body may collapse further after vertebroplasty, and under these circumstances a type-B leak may lead to delayed paralysis.

Of type-S leaks, only 14% (4/29) were identified on lateral radiographs and 52% (15/29) on AP views. Since many surgeons only use lateral views during the injection of cement, type-S leaks may be easily missed. This type of leak may cause embolism more commonly than type-B leaks because the segmental veins are closer to the large veins than the epidural veins. Although there were no cases of symptomatic pulmonary embolism associated with the type-S leaks, there may have been subclinical embolisms. Correlation between this type of leak and pulmonary embolism, whether subclinical or clinical, requires further study.

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No benefits have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


