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Postoperative Cerebrospinal Fluid Leaks of the Lumbosacral Spine: Management with Percutaneous Fibrin Glue

Mahesh R. Patel, William Louie, and Jacob Rachlin

PURPOSE: To assess CT-guided injection of fibrin glue for the management of lumbosacral cerebrospinal fluid (CSF) leaks. **METHODS:** Six consecutive patients with postoperative CSF leaks were treated after CSF aspiration under CT guidance. A solution of cryoprecipitate was simultaneously injected with a 10% calcium chloride solution containing 2000 units of thrombin per milliliter. In one patient, 0.5 mL of iopamidol was added to the calcium chloride/thrombin mixture before injection. Placement of the fibrin glue aggregate was confirmed by CT imaging. To determine outcomes we reviewed the patients' records, postprocedure imaging studies, and physical findings, and we interviewed the patients directly. **RESULTS:** In three patients with postoperative CSF leaks, symptoms resolved after treatment. Despite imaging evidence of successful plug deployment, two other patients still had severe symptoms, and they underwent surgery after 2 and 18 hours, respectively. One patient had a continued CSF leak and a headache after 12 hours; follow-up surgery repaired an unsuspected dural tear just distal to the site of original surgery underneath the lamina and not covered by the fibrin glue. After one of the successful procedures, the patient had a fever and a headache, probably because of aseptic meningitis, which resolved after 2 days. **CONCLUSION:** Percutaneous CT-guided placement of fibrin glue may provide nonsurgical treatment for postoperative CSF leaks, potentially avoiding a major and technically difficult surgical procedure.

Index terms: Aspiration, computed tomography guidance; Cerebrospinal fluid, leakage; Computed tomography, postoperative; Spine, special procedures

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Cerebrospinal fluid (CSF) leaks involving the lumbosacral spine can occur as a result of surgery or trauma; rarely, these leaks occur after diagnostic or therapeutic lumbar puncture. These leaks represent serious problems because of persistent headaches and the possibility of meningitis. Surgical management requires repeat surgery with meticulous direct closure of the dura or closure by means of a fascial graft (1). A previous study (2) has evaluated the direct application of fibrin glue with or without muscle packing to achieve closure. Other re-

searchers (3) have described a percutaneous transnasal and transsphenoidal approach under fluoroscopic guidance to manage CSF rhinorrhea after pituitary surgery.

We introduce a simple, percutaneous, computed tomography (CT)-guided method of placing a two-component fibrin glue into the extradural space to seal postoperative spinal CSF leaks, potentially avoiding a major surgical procedure with its associated cost and morbidity.

Subjects and Methods

Six consecutive patients (age range, 32 to 74 years) with spinal surgery for either degenerative disease ($n = 4$) or tumor resection ($n = 2$) had CSF leaks 10 days to 14 weeks after surgery. These patients presented with postural headaches, palpable soft tissue fluid collection, or persistent CSF wound drainage. All patients had magnetic resonance (MR) imaging either immediately or within 1 week of the fibrin glue placement to assess accurately the relationship of the fluid to the dura.

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MR studies of the lumbar spine were done on a 1.0-T Magnetom Impact scanner (Siemens, Iselin, NJ). For each patient, sagittal T1-weighted images were obtained, with the following parameters: 556/20/1 (repetition time/echo time/excitations); section thickness, 4 mm (1-mm gap between sections); matrix size, 192×256 ; and field of view (FOV), 300 mm. This sequence was followed by an asymmetric, dual-echo, fast spin-echo axial T2-weighted sequence with the following parameters: 5000/22,90/1; section thickness, 4 mm; matrix size, 250×256 ; and FOV, 230 mm. Axial T1-weighted images were also obtained with the following parameters: 600/20/1; matrix size, 250×256 ; section thickness, 4 mm; and FOV, 240 mm.

After informed consent had been obtained, the patient was placed in the prone position on a 9800 CT scanner (General Electric, Milwaukee, Wisc), and 5-mm contiguous (120 kV, 140 mA, 25-cm FOV) scans were obtained through the CSF collection. The spinal CSF leak was located with 10-mm-thick and then 5-mm-thick contiguous CT scans, and the overlying skin was marked. With the patient under local lidocaine anesthesia, an 18- to 20-gauge spinal needle was placed into the largest part of the CSF leak adjacent to the location of the dural tear as indicated by MR imaging. The maximal amount of CSF was drained, and repositioning of the spinal needle and reaspiration were performed as needed. The spinal CSF leaks were aspirated slowly to avoid aspiration of a nerve root through the dural defect. The patient was continuously monitored for associated neurologic symptoms by either a nurse or a neurosurgeon, and the aspiration was titrated accordingly. The needle was repositioned at least once (and often three or four times) to drain maximally the CSF adjacent to the suspected leak. The subcutaneous CSF collection was not necessarily drained unless it was in direct communication with the deeper collection adjacent to the thecal sac.

The formation of a fibrin plug required the combination of two components. The first component comprised cryoprecipitate containing concentrated fibrinogen. This part was prepared either from the patient's own blood (4, 5) or from donor blood/plasma (in emergency situations or in patients who had severe anemia, a blood dyscrasia, or some other contraindication to autologous blood use). The cryoprecipitate was allowed to thaw and placed in 3-mL syringes. Once thawed, the cryoprecipitate was used within 4 hours. The second component of the fibrin plug was made by mixing 20 000 U of lyophilized thrombin with 10 mL of a 10% calcium chloride solution. This combined solution, with a concentration of 2000 U of thrombin per milliliter, was placed in 3-mL syringes. To increase the conspicuity of the fibrin plug, we later added a small amount (0.5 mL) of iopamidol to the thrombin/calcium chloride solution.

A syringe containing 3 mL of cryoprecipitate was connected to one port of a three-way stopcock. The combined thrombin/calcium chloride solution syringe was connected to a second port of the three-way stopcock. Both syringes were connected, via the three-way stopcock, to the hub of

the spinal needle that had been placed in the extradural space under CT guidance.

Equal volumes of the cryoprecipitate and thrombin/calcium chloride solution were injected simultaneously. During the injection, the patient was monitored carefully for any adverse symptoms. When the two solutions aggregated, the fibrin plug was formed in vivo. Separate assemblies were used for repeat deployments of fibrin plugs (when needed) because of the accumulation of fibrin within both the stopcock and the syringe (from reflux). The total volume instilled ranged from 4 to 18 mL. The end point was either adequate coverage by the fibrin plug adjacent to the suspected side of dural leak or appreciable mass effect higher than or equal to the mass effect seen on imaging studies before the intervention. The position of the fibrin plug was documented with postprocedure CT scans. After the procedure, the patient was restricted to overnight bed rest.

The success of the procedure was determined by chart review, direct patient interview, and physical examination, with the follow-up interval ranging from 2 hours to 1.5 years. In one patient, follow-up MR imaging included additional axial and sagittal contrast-enhanced T1-weighted images, from which the residual collection size and enhancement pattern were evaluated.

Results

In three of six patients (patients 1 through 3) with persistent postoperative spinal CSF leaks, the symptoms either resolved or decreased markedly after the procedure. These three patients did not require repeat surgery (see Table). Figure 1 shows a successful fibrin plug placement. In patients 4 and 5, CT scans indicated that the fibrin plug deployment had been successful, but these two had severe but persistent symptoms and underwent repeat surgeries within 2 and 18 hours, respectively, after the procedure. In patient 6, the fibrin plug treatment was unsuccessful, and he still had CSF wound drainage after 12 hours of bed rest. He required an extensive S-1 laminectomy; the dural tear, which was not covered by fibrin glue, was identified under the lamina. Therapy with direct placement of fibrin/gelatin sponge was successful.

At the time of fibrin glue placement, patient 3 had fever, headache, and CSF cultures positive for *Staphylococcus epidermis* (considered most likely to be a skin contaminant). Although this patient's condition improved when he received intravenous injections of antibiotics, the symptoms were probably caused by aseptic meningitis. He subsequently did well, and follow-up lumbar MR images 1 month later showed a

Data for patients with symptomatic postoperative lumbosacral cerebrospinal fluid leaks

| Patient | Age, y/Sex | Reason for Surgery | Laminectomy | Presentation, wk | Symptoms | Follow-up from Plug Placement | Outcome |
|---------|------------|---------------------------------|----------------------|------------------|-------------------------------------|-------------------------------|--|
| 1 | 74/M | Large neurofibroma (L2-3) | L-1 to L-4 | 10 | Soft tissue collection | 12 mo | Successful |
| 2 | 59/F | Conus ependymoma | T-12 to L-1 | 5 | Soft tissue collection | 3 mo | Successful |
| 3 | 53/M | Disk herniation (L4-5) | L-5 and inferior L-4 | 1.5 | Wound leak, headache | 4 mo | 2 d of aseptic meningitis, follow-up MR in 1 mo with small residual collection |
| 4 | 59/F | Spinal stenosis | L2-3 and L3-4 | 2 | Severe postural headache, back pain | 2 h | Imaging with good placement, severe symptoms resulting in repeat surgery |
| 5 | 53/M | Right L-4 and L-5 radiculopathy | R L-4 and L-5 | 2 | Soft tissue collection | 18 h | Surgery caused by continued leak with fibrin plug placed over dural rent but nonadherent because of granulations |
| 6 | 32/M | Right L5-S1 disk herniation | R L-5 and S-1 | 2 | Wound leak, headache | 12 h | Unsuccessful; dural tear under S-1 lamina repaired at repeat surgery |

small residual CSF collection with an enhancing surrounding fibrin plug (Fig 2). The fibrin plug is slightly hyperintense on T1-weighted images and shows enhancement with gadopentetate dimeglumine. In patient 5, the technique was modified by adding contrast material to the glue (Fig 3); this patient underwent surgery 12 hours later for persistent severe headaches. At surgery, the fibrin plug was seen to be well positioned but not completely adherent to the dura.

Discussion

The goal of surgical repair of postoperative dural tears with associated CSF leaks is to pro-

duce an adequate seal that can withstand CSF pressure during the healing period. Prompt repeat surgery is recommended to prevent the complications of meningitis, CSF fistulas, and pseudocyst formation with potential nerve compression. Previous methods included meticulous primary surgical closure for small defects and the interposition of fascial, muscle, or fat grafts over the defect.

More recently, direct fibrin glue placement over the defect has been attempted, with or without associated graft placement. Siedentop et al (5) have suggested that placement of a fibrin plug can create adhesion at the site of a dural tear; this adhesion can promote healing,

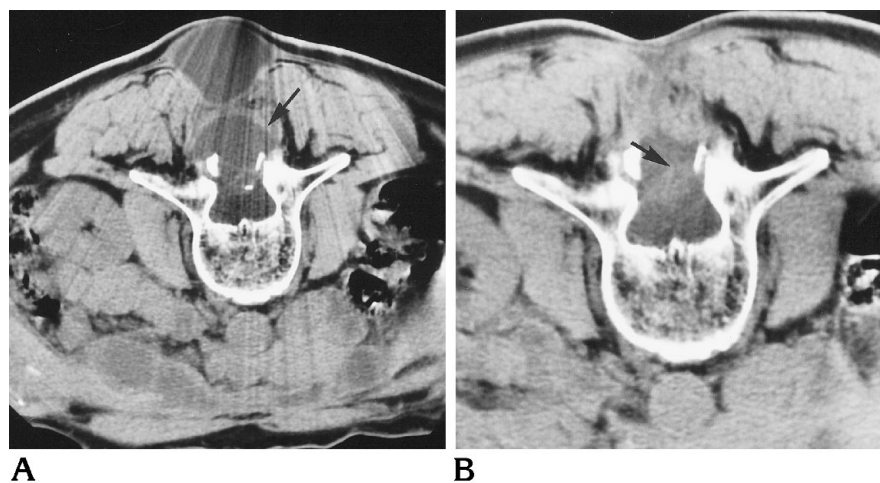


Fig 1. Patient 1. CSF leak with successful fibrin plug.

A, Axial CT scan before procedure shows CSF collection (arrow) posterior to thecal sac and a more superficial CSF collection.

B, CT scan after placement of high-attenuation fibrin glue plug (arrow), which sealed the dural leak.

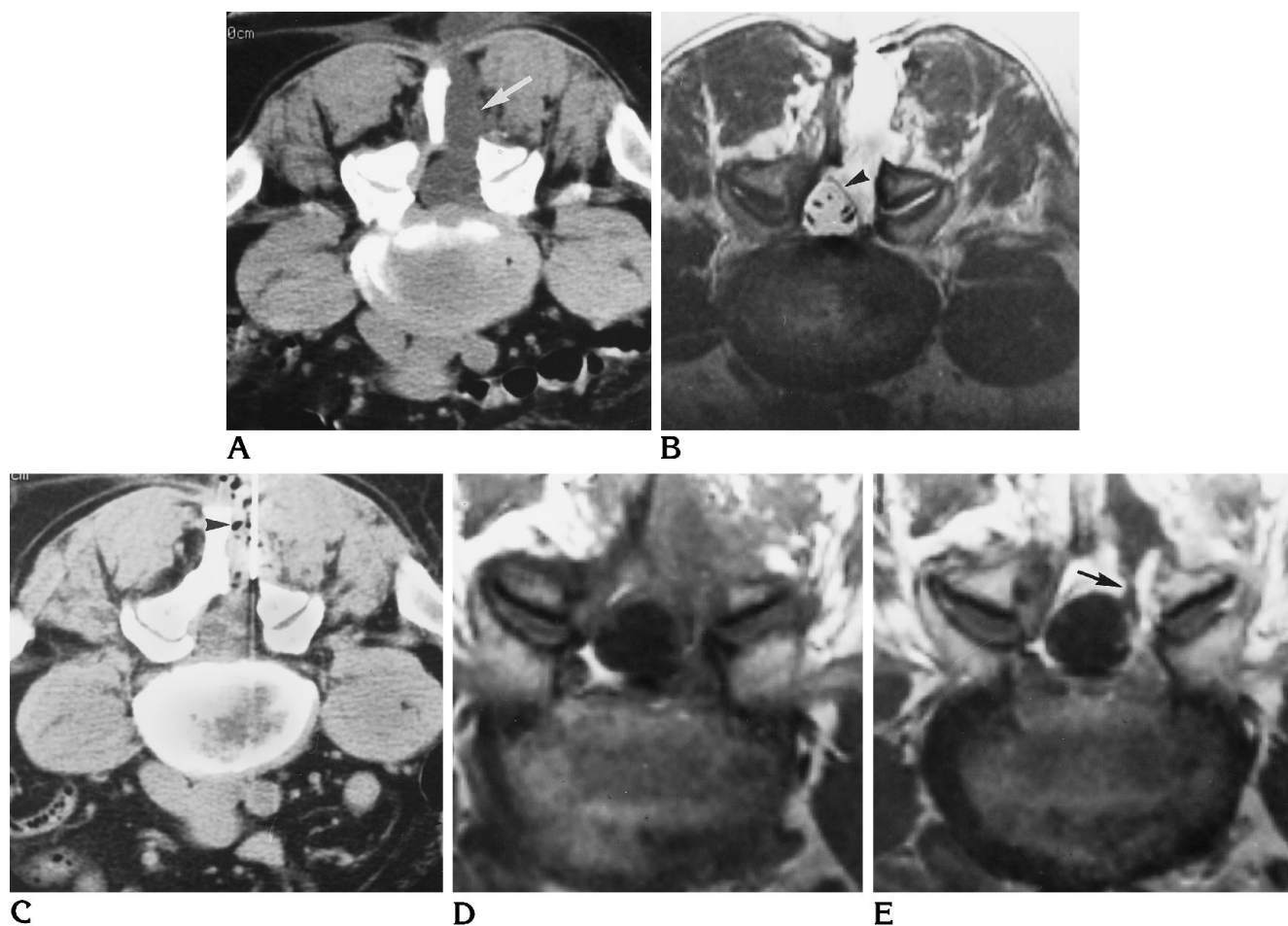


Fig 2. Patient 3. Successful fibrin plug. Patient's recovery was complicated by meningitis. Follow-up MR study showed decreased size of cerebrospinal fluid (CSF) collection.

A, Axial CT scan shows CSF leak indistinguishable from thecal sac (arrow).

B, Axial T2-weighted MR image before placement of fibrin plug shows leak. Dura is clearly defined (arrowhead), which is essential to appropriate planning for fibrin glue placement.

C, Axial CT scan shows high-attenuation fibrin plug (arrowhead) introduced through a spinal needle with the patient in the prone position.

D, Axial T1-weighted MR image shows the difficulty in separating CSF from postoperative changes.

E, Axial, contrast-enhanced T1-weighted MR image shows small residual CSF collection (arrow). The enhancing granulation tissue surrounding the CSF is probably the fibrin plug.

with its maximal bonding effect reached within 30 to 90 minutes (70% of the bonding effect is achieved within 2 minutes of the mixing of the two adhesive components). Subsequent granulation tissue and fibrosis probably result in a more definitive repair (6). It has also been postulated that the fibrin adhesive is completely absorbed so that the process of wound healing is not disturbed; in fact, that wound healing is promoted by the immediate stimulation of fibroblasts (5). However, a small amount of the fibrin glue may be introduced intrathecally and may result in an aseptic meningitis, as probably occurred in our patient 3. Although fibrin glue may

serve as a nidus for infection, this was not observed in our study. In our small sample, neither arachnoiditis nor fibrous adhesions occurred.

We think that a preprocedure MR study is essential to locate the site of potential CSF leak and to delineate the thecal sac from the extradural CSF collection; this step may prevent inadvertent introduction of the fibrin glue into the thecal sac. Intrathecal contrast-enhanced CT scans could provide similar information, but we found MR imaging to be adequate.

In our study, three of six CSF leaks were cured by percutaneous therapy. In one of the three cases classified as "failures," the patient



Fig 3. Patient 5. Contrast material was included in the fibrin plug. This axial CT scan shows good position of fibrin plug mixture containing contrast material (arrow). Surgery for repair revealed that the fibrin plug was placed over the dural tear but did not adhere.

had repeat surgery only 2 hours after the procedure, which we think is not enough time to assess the effectiveness of the fibrin plug. We advocate conservative assessment up to 14 days, because a small amount of continued drainage from nonaspirated sites may persist. In patient 6, the dural leak was underneath the lamina; in patient 5, the leak was covered by the plug but the plug did not adhere because of granulations. Our 50% success rate is similar to that found by Nishihara and McCaffrey (2): in their study, 56% of rats with experimentally induced CSF rhinorrhea were successfully treated with direct application of fibrin glue alone.

In summary, in 50% of our patients, a major surgical procedure was avoided, along with its associated risks and costs. Therefore, we now use this fibrin plug procedure as the first treatment option for a spinal CSF leak.

We also recommend that autologous cryoprecipitate be used whenever possible; this avoids the risks of blood-borne pathogens, including hepatitis C. If this procedure is being considered, we recommend harvesting the patient's blood ahead of time (if there are no contraindications to using autologous blood). The preparation of cryoprecipitate from autologous blood requires 3 days; 500 mL of whole blood is harvested and centrifuged, and the plasma is then extracted and frozen at -80°C for 24 hours. The plasma is then thawed gradually over 24 hours at 6°C , once again centrifuged with the liquid precipitate harvested, and frozen for 24 hours. Approximately 20 to 25 mL of cryoprecipitate is produced. This product needs

to be thawed 30 to 45 minutes before use and must be used within 4 hours once it is thawed. The cost at our institution is \$110 to harvest the cryoprecipitate, and we charge \$77 for its administration.

Other potential therapies proposed for CSF leaks include epidural blood patches (7–9) and persistent lumbosacral drainage (10). Complications that occur as a result of the epidural blood patch include persistent headache, neurologic deterioration, and subdural hematoma (11, 12). The intrathecal introduction of red blood cells can cause severe headaches. Complications associated with continuous lumbar drainage include coma, persistent CSF leaks, and injury to soft tissue nerve roots (13). In addition, a 14- to 16-gauge tear in the dura is created above the site of the leak, which may not heal spontaneously. Continuous bed rest for at least 3 days necessitates a prolonged hospital stay, and there is a potential for infection. Consequently, our first-line therapy for CSF leaks is placement of a fibrin glue plug (unless the patient is going to have surgery immediately). Although the media might be a nidus for infection, this problem did not occur in our small series.

In summary, this simple fibrin plug procedure for the management of postoperative lumbosacral CSF leaks may help patients avoid a major surgical procedure and its associated costs and morbidity. With refinements in technique and improved selection of patients, our success rate will probably improve. This approach could be expanded to treat CSF leaks elsewhere in the spine, as well as cranial CSF leaks that are accessible to a percutaneous approach.

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