The frequency of anterior cervical decompression surgery continues to grow as the rate of cervical spinal disease increases and spine surgeons become more experienced with this technique. In addition, this surgery generally has excellent clinical outcomes and a low morbidity rate.\(^1,2\) However, the rare but potentially troublesome and occasionally catastrophic complication after anterior cervical decompression surgery. There is limited literature describing this complication, and the management of CSF leak varies. The aim of this study was to retrospectively review the treatment of cases with CSF leak and develop a management algorithm. A series of 14 patients with CSF leak from January 2011 to May 2016 were included in this study. Their characteristics, management of CSF leak, and outcomes were documented. There were 5 male and 9 female patients. Mean age at surgery was 57.1±9.9 years (range, 37-76 years). All instances of CSF leak, except 1 noted postoperatively, were indirectly repaired intraoperatively. A closed straight wound drain was placed for all patients. A lumbar subarachnoid drain was placed immediately after surgery in 4 patients and postoperatively in 7 patients. In 1 patient, lumbar drain placement was unsuccessful. In 2 additional patients, the surgeon decided not to place a lumbar drain. One patient developed meningitis and recovered after antibiotic therapy with meropenem and vancomycin. Another patient had a deep wound infection and required a revision surgery. Wound drains and lumbar drains should be immediately considered when CSF leak is identified. Antibiotics also should be considered to prevent intradural infection. [Orthopedics. 2018; 41(2):e283-e288.]

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**Materials and Methods**

This retrospective review of patients undergoing anterior cervical decompression surgery from January 2011 to May 2016 received institutional review board approval. All of the patients but 1 underwent primary surgery. That 1 patient underwent posterior laminectomy 11 years earlier. Patients identified as having CSF leak were included in this study. Age, sex, type of procedure, Japanese Orthopaedic Association score, reason for the CSF leak, and intraoperative and postoperative management of the CSF leak were noted from medical records. The patients were seen regularly in the outpatient clinic, where outcomes and complications were documented.

The management of the CSF leak and the prophylactic use of antibiotics were at the surgeon’s discretion. The dural defects were repaired with an onlay graft of muscle/fascia, collagen dural substitute (DuraMax; Beijing Tianxinfu Medical Appliance Co Ltd, Beijing, China), Surgicel (Ethicon Inc, Somerville, New Jersey), or Gelfoam (Jinling Pharmaceutical Co Ltd, Nanjing, China). A closed straight wound drain was placed for all patients. A lumbar subarachnoid drain was placed immediately if the dural defect was larger than 2 mm. When a CSF leak was noted postoperatively or the amount of wound drainage with CSF was more than 100 mL per 24 hours, a lumbar subarachnoid drain was connected to a 1000-mL bag with a tubing set to establish a closed drainage system. The collection bag was positioned to titrate CSF drainage at 10 to 15 mL/h. Cerebrospinal fluid cultures were performed daily. The wound drain was removed when the amount of drainage was 0 mL after clipping for 24 hours. After 24 hours, the lumbar drain was assessed for discontinuation if the patient remained clinically asymptomatic (no positional spinal headaches, swelling under the wound, and/or dysphagia) in bed and with mobilization.

**Results**

A total of 578 patients underwent anterior cervical decompression surgery. Fourteen (2.4%) had a CSF leak, with the diagnosis being cervical spondylosis in 6 patients and ossification of the posterior longitudinal ligament in 8 patients. There were 5 male and 9 female patients in this study. Mean age at surgery was 57.1±9.9 years (range, 37-76 years). Three patients underwent anterior cervical discectomy and fusion, and 7 had anterior cervical corpectomy and fusion. Three patients underwent a combined technique with anterior cervical discectomy and fusion and anterior cervical corpectomy and fusion. The hybrid technique (anterior cervical corpectomy and fusion and artificial disk replacement) was performed in 1 patient.

Cerebrospinal fluid leak occurred at the time of dissection of the adherent posterior longitudinal ligament in 7 patients, and 5 patients presented at the time of dissection of the ossified posterior longitudinal ligament. One patient had a CSF leak under unintended dural injury. One CSF leak was noted postoperatively. All of the cases of CSF leak, except 1 noted postoperatively, were repaired intraoperatively. Collagen dural substitute and Gelfoam were used for 6 patients, Surgicel and Gelfoam for 6 patients, and muscle/fascia and Surgicel for 1 patient. A lumbar subarachnoid drain was placed immediately after surgery in 4 patients (dural defect greater than 2 mm). For the remaining 10 patients, the lumbar drain was not placed immediately because the dural defect was less than 2 mm and there was adequate closure of the durotomy. Seven patients had a lumbar drain placed postoperatively under local anesthesia because of the continuous leakage of more than 100 mL per day. In 1 case (patient 9), lumbar drain placement was unsuccessful. In 2 additional patients, the CSF leakage was less than 100 mL per day, so a lumbar drain was not placed. The average time that wound drains and lumbar drains were left in place was 7.8±3.6 days (range, 4-16 days) and 6.4±2.2 days (range, 4-12 days), respectively. All except 2 patients had prophylactic use of antibiotics until removal of the lumbar drain.

Neurological deficits increased in 2 cases (patients 9 and 14), with the Japanese Orthopaedic Association score decreasing from 2 preoperatively to 1 postoperatively and from 14 preoperatively to 4 postoperatively, respectively. These 2 patients were lost to follow-up owing to dissatisfaction with outcome. The remaining 12 patients had a mean follow-up of 38.7±22.5 months (range, 3-68 months) and an average hospital stay of 16.6±5.7 days (range, 7-25 days). The average Japanese Orthopaedic Association score improved from 13.6 preoperatively to 16.0 postoperatively.

One patient (patient 10) developed meningitis and recovered after antibiotic therapy with meropenem and vancomycin. Another patient (patient 9) had a deep wound infection. In this case, revision surgery was performed to repair the dura because of the failure of placement of the lumbar drain. Patient data are presented in the Table.

**Discussion**

Cerebrospinal fluid leak is rare after cervical decompression surgery. In this study, the rate was 2.4%, which is consistent with that reported by previous studies. Various methods have been described to manage this complication, including bed rest, direct pressure of the wound, repair of the dural tears, and placement of a lumbar drain.4,5

Bed rest or direct pressure of the wound alone does not lead to a favorable outcome in most patients.4,8,9 Direct repair is optimal in most cases of CSF leak. However, the leaks can be difficult to manage, given the limited field of view and the lack of deep access to facilitate direct repair. Various methods and materials have been described for indirectly repairing dural tears, including gelatin foam, fibrin glue, collagen matrix, muscle and fascia graft, biological graft, synthetic materials, and
blood patch.\textsuperscript{4,5,10-13} The reported failure rate is 5% to 10% for anterior cervical decompression surgery.\textsuperscript{4} However, there are no studies comparing the success rates of different methods. The method used in this study—involving an onlay technique with dural substitutes, muscle/fascia graft, Surgicel, or Gelfoam—was similar to that reported in previous studies. However, the failure rate was high (80%; 8 of 10). There are 2 possible reasons for this higher failure rate. First, in this study, the definition of failure was transfer for placement of a lumbar drain, which is different from that of previous studies. Second, a more active management protocol—placement of a lumbar drain—was undertaken in this study to decrease the risk of severe complications. This increased the failure rate of indirect repair.

Placement of a lumbar subarachnoid drain is another common method for treating a CSF leak. In this study, some surgeons placed the lumbar drain immediately after the surgery, whereas others placed it when the dural defect was large or the CSF leak persisted postoperatively. In a retrospective study by Elder et al\textsuperscript{14} of 14 patients with CSF leak, 4 patients had lumbar drains placed immediately postoperatively and recovered uneventfully. Lumbar drains were not placed immediately postoperatively for the other 10

<table>
<thead>
<tr>
<th>Patient No./ Sex/Age, y</th>
<th>Diagnosis</th>
<th>Surgical Procedure</th>
<th>Reason for Leak</th>
<th>Repair Method</th>
<th>Wound Drain, da</th>
<th>Lumbar Drain, db</th>
<th>Prolongation of Antibiotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/76</td>
<td>Spondylosis</td>
<td>C3-5 ACDF</td>
<td>Dissection of adherent PLL</td>
<td>Collagen dural substitute</td>
<td>0-13</td>
<td>10-15</td>
<td>None</td>
</tr>
<tr>
<td>2/F/65</td>
<td>Spondylosis</td>
<td>C5 ACCF+C3-4 ACDF</td>
<td>Dissection of adherent PLL</td>
<td>Surgicel\textsuperscript{c} and Gelfoam\textsuperscript{d}</td>
<td>0-15</td>
<td>12-17</td>
<td>Yes</td>
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<tr>
<td>3/F/49</td>
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<td>C5 and C6 ACCF</td>
<td>Dissection of adherent PLL</td>
<td>Muscle/fascia and Surgicel</td>
<td>0-7</td>
<td>4-10</td>
<td>Yes</td>
</tr>
<tr>
<td>4/F/60</td>
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<td>C5 and C6 ACCF</td>
<td>Dissection of adherent PLL and dura</td>
<td>Collagen dural substitute</td>
<td>0-8</td>
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<td>None</td>
</tr>
<tr>
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<td>C6-7 ACDF</td>
<td>Dissection of adherent PLL</td>
<td>Surgicel and Gelfoam</td>
<td>0-4</td>
<td>0-5</td>
<td>Yes</td>
</tr>
<tr>
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<td>OPLL</td>
<td>C4 and C5 ACCF</td>
<td>Dissection of adherent PLL</td>
<td>Surgicel</td>
<td>0-6</td>
<td>2-7</td>
<td>Yes</td>
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<td>7/F/54</td>
<td>Spondylosis</td>
<td>C5 ACCF+C6-7 ACDF</td>
<td>Noted postoperatively by wound drainage</td>
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<td>0-5</td>
<td>0-7</td>
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<td>8/F/64</td>
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<td>C6 ACCF\textsuperscript{7}</td>
<td>Dissection of ossified PLL</td>
<td>Collagen dural substitute and Gelfoam</td>
<td>0-8</td>
<td>5-10</td>
<td>Yes</td>
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<td>C4 and C5 ACCF</td>
<td>Dissection of ossified PLL and dura</td>
<td>Collagen dural substitute and surgical</td>
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<td>Unsuccessful</td>
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<td>10/F/51</td>
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<td>C6 ACCF+C3-4 ADR</td>
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<td>Surgicel and Gelfoam</td>
<td>0-11</td>
<td>7-17</td>
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<td>Collagen dural substitute and Gelfoam</td>
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<tr>
<td>12/F/48</td>
<td>OPLL</td>
<td>C5 ACCF+C6-7 ACDF</td>
<td>Dissection of ossified PLL</td>
<td>Collagen dural substitute and Gelfoam</td>
<td>0-5</td>
<td>None</td>
<td>Yes</td>
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<tr>
<td>13/M/62</td>
<td>OPLL</td>
<td>C5 and C6 ACCF</td>
<td>Dissection of ossified PLL</td>
<td>Surgicel and Gelfoam</td>
<td>0-6</td>
<td>0-8</td>
<td>Yes</td>
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<tr>
<td>14/F/62</td>
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<td>C5 ACCF</td>
<td>Unintended dural trauma</td>
<td>Gelfoam</td>
<td>0-4</td>
<td>0-5</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Abbreviations: ACCF, anterior cervical corpectomy and fusion; ACDF, anterior cervical diskectomy and fusion; ADR, artificial disk replacement; OPLL, ossification of the posterior longitudinal ligament; PLL, posterior longitudinal ligament.*

\textsuperscript{a}From day of surgery to postoperative day.

\textsuperscript{b}Postoperative days.

\textsuperscript{c}Ethicon Inc, Somerville, New Jersey.

\textsuperscript{d}Jinling Pharmaceutical Co Ltd, Nanjing, China.
patients because it was thought that there was adequate closure of the durotomy. However, 1 (10%) of these patients was readmitted for severe dysphagia, neck discomfort, positional headache, and a CSF collection at the surgical site. A lumbar drain was ultimately placed for this patient. Smith et al.15 also did not routinely immediately place a lumbar drain in their patients with intraoperative dural tears. However, at the end of their experience with 7 patients with intraoperative dural tears, they recommended insertion of a lumbar drain when the dural defect was first recognized, thinking that this probably would decrease the overall morbidity.

Some dural defects are small and will seal off with the use of an onlay technique without a lumbar drain.16 However, small dural tears can sometimes behave as a “one-way valve,” with CSF egressing out and failing to reenter the subarachnoid space.5 Placement of a lumbar drain will immediately diminish the egress of CSF and help the adjuncts adhere to the dura, especially in the first few days postoperatively before the chemical seal forms and the graft becomes established.4,17 In 8 of 10 patients in the current study, the dural defects were thought to be small, so a lumbar drain was not placed immediately after the surgery but rather later postoperatively. Thus, the authors recommend placement of a lumbar drain for all dural defects—small or large—at first identification. In the authors’ experience, this strategy has yielded good results without the need for reoperation for a persistent dural fistula or pseudomeningocele. The failure of insertion of a lumbar drain may increase the risk of reoperation for a persistent dural fistula,4,5 as in patient 9 of the current study. In a review of CSF leak management, Mazur et al4 found that none of the patients who received a lumbar drain developed a CSF fistula or pseudomeningocele or required reoperation. Further, insertion of a closed lumbar drain can prevent the development of serious, life-threatening airway obstruction or infections.3,5,7,18,19

Lumbar drains are generally kept in place for 4 to 5 days, based on histological evidence indicating that dural sealing takes approximately 4 days.4,15 However, not all dural tears heal after 5 days of lumbar drainage, and success rates range from 83% to 100%.4 The current authors prefer to remove the lumbar drain after the wound drain to ensure that the dura mater has healed. The average length of lumbar drain placement in this study was 6.4 days, with a success rate of 100%.

Although lumbar drains are effective in the treatment of CSF leaks, the rate of infection after their placement is reported to be approximately 5%,20,21 In a study by Kitchel et al,22 antibiotics were not used prophylactically for 19 patients who had a CSF leak and were treated with a lumbar drain. Two of them had an intradural infection. However, the use of antibiotics has seldom been reported for patients in whom a lumbar drain has been placed. In a study of 11 patients with a CSF leak, Fengbin et al23 used antibiotics for all of the patients; 1 patient had an intracranial infection. In the current study, 1 patient had meningitis even with the administration of antibiotics prophylactically. Considering that lumbar drains will remain in place for at least approximately 4 to 5 days4,15 and that central nervous system infection could potentially be catastrophic, the current authors suggest the use of antibiotics with lumbar drains.

Wound drain use and length of placement in patients with CSF leaks is controversial. Elder et al14 placed wound drains in only 3 (21%) of their patients. A closed suction wound drain was placed for only 1 day in the study by Joseph et al.5 Both of these studies did not address the indication for and the length of placement of wound drains. Some have argued against the use of drains because of the risk of durocutaneous fistulas.8 However, most studies have found no associated increase in the rate of durocutaneous fistulas with wound drains.4

There is the possibility of accumulation of CSF, blood, or serous fluid if a wound drain is not placed. When the arachnoid membrane is intact or a dural tear is small, occult CSF leaks might occur and induce fluid leakage from the

Figure: The suggested management algorithm for cerebrospinal fluid (CSF) leak after anterior cervical decompression surgery.
The incidence of postoperative wound hematoma varies from 1% to 11%, with it being the second most common complication. It presents mainly as a neck mass associated with dysphagia and occasionally as respiratory distress, which can be life-threatening. A wound and occasionally as respiratory distress, is a common complication. It presents mainly in 1% to 11%, with it being the second most common complication. It presents mainly in operative wound hematoma varies from rate of associated complications. Further, an occult CSF leak could be identified and whether dural tears had healed determined according to the amount of wound drainage. Wound drains were routinely placed in this study, and neck mass and hematoma did not occur.

The Figure shows the suggested management algorithm for a CSF leak after anterior cervical decompression surgery based on the authors’ experience and review of the literature. If a leak is recognized intraoperatively, the dural tears should be repaired with an onlay graft of muscle/fascia, collagen dural substitute, Surgicel, or Gelfoam. A submuscular wound drain and a lumbar drain should be placed immediately at the conclusion of the operation, regardless of dural defect size. The wound drain should be removed when the amount of drainage is 0 mL after clipping for 24 hours. The patient should be kept on bed rest for another 24 hours. When there is no further leakage, the lumbar drain should be removed. Prophylactic antibiotics are continued until both the wound and the lumbar drains are removed. If there is no CSF leak during the operation, a wound drain should be placed. However, if a CSF leak is noted postoperatively, the patient should have a lumbar drain placed and be given antibiotics for prevention of infection.

**Limitations**

In addition to the inherent limitations of a retrospective study, this study had a small number of cases, which underpowers its recommendations. Study results could not be statistically analyzed because of sample size. However, this study had relatively more CSF leaks than most other studies. Studies involving multiple large centers and larger samples are necessary to explore the efficiency of the authors’ treatment algorithm.

**Conclusion**

Cerebrospinal fluid leak after anterior cervical decompression surgery is rare. Indirect repair of dural tears with onlay graft is the common method for treating a CSF leak. However, the success rate in this study was much lower than that of previous studies. Wound drains and lumbar drains should be immediately considered when a CSF leak is confirmed. The prophylactic use of antibiotics is recommended to prevent intradural infection.

**References**


