Management of cerebrospinal fluid leaks after anterior decompression for ossification of the posterior longitudinal ligament: a review of the literature

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Object. Anterior decompression is an effective way to treat cervical myelopathy associated with ossification of the posterior longitudinal ligament (OPLL); however, this approach is associated with an increased risk of a dural tear and resultant CSF leak because fusion of the dura with the ossified PLL is common in these cases. The authors review the literature and present an algorithm for treatment of CSF leaks in these patients.

Methods. A MEDLINE review was performed to identify papers related to CSF leak after anterior decompression for OPLL, and data were summarized to identify treatment options for various situations. A treatment algorithm was identified based on these findings and the experience of the authors.

Results. Eleven studies were identified that presented data on intra- and postoperative management of a CSF leak during ventral surgery for OPLL. The incidence of cervical dural tears and CSF leaks after anterior decompression procedures for OPLL ranged from 4.3% to 32%. Techniques including preventative measures, intraoperative dural repair with various materials, and postoperative drainage or shunt placement have all been used.

Conclusions. Although direct dural repair is the preferred treatment for CSF leak, this technique is not always technically possible. In these cases, intraoperative adjuncts in combination with postoperative measures can be used to decrease the pressure gradient across the dural tear. (DOI: 10.3171/2010.12.FOCUS10255)

Key Words • ossification of the posterior longitudinal ligament • cerebrospinal fluid leak • anterior cervical decompression

OSSIFICATION of the posterior longitudinal ligament (OPLL) is a known cause of cervical stenosis resulting in myelopathy and/or radiculopathy. Various operative procedures, including anterior, posterior, and combined approaches, have been used for treating this disease.29 Although posterior approaches such as multilevel laminoplasty or laminectomy with or without fusion provide a straightforward albeit indirect approach to treat OPLL, anterior decompression with direct resection of the OPLL is often necessary because the anchoring effect of the dentate ligaments, nerve roots, and anteriorly attached root sleeves may preclude sufficient decompression of the spinal cord with a posterior approach. In cases of OPLL, however, the dura mater often becomes ossified or calcified and fuses with the PLL, thereby increasing the chance for CSF leak and spinal cord or nerve root injury during surgical manipulation for removal of the ossified mass. The possibility for traumatic manipulation increases the risk of a CSF leak during anterior decompression in comparison with a posterior approach,21,54 because laminoplasty or laminectomy obviates direct manipulation of OPLL. Hence, although anterior decompression of the spinal cord by resection of the ossified ligament combined with anterior fusion can achieve more satisfactory results than a posterior approach,33,45,54,56 the surgeon must take into account the risk of a CSF leak. Additionally, when choosing an anterior approach, the surgeon must be aware of intra- and postoperative management strategies to treat a CSF leak and minimize manipulation of the thecal sac to avoid any spinal cord damage.20,36,52 In this article, we review the literature on intra- and postoperative management of cervical dural tears during surgery for OPLL and suggest a treatment algorithm.

Abbreviations used in this paper: LP = lumbar-peritoneal; OPLL = ossification of the PLL; PLL = posterior longitudinal ligament; WP = wound–peritoneal cavity.
Methods

To identify the relevant publications on this subject, we searched the PubMed database (http://www.ncbi.nlm.nih.gov/PubMed/) for the keywords “ossification of the posterior longitudinal ligament,” “cerebrospinal fluid leak,” and “dural tear.” We also performed a search using the MeSH terms “ossification of the posterior longitudinal ligament” and “decompression, surgical” and “cervical vertebrae.” The “Related Articles” feature in PubMed was also used to search for relevant citations, and the reference lists of other articles were checked for further publications. The online archives of key publications, including Journal of Neurosurgery, Neurosurgery, and Spine, were searched using the same terms. All articles were initially screened for relevance by title and abstract. Articles in languages other than English and articles without an abstract were excluded. All suitable reports and important cross-references were obtained as full-text copies for review. Publications were scrutinized for the following information: incidence of CSF leaks after anterior surgical decompression of the cervical spine for OPLL; primary intraoperative strategies and success rates; postoperative management modalities and success rates; and dural repair techniques. Inclusion criteria were publication date between January 1, 1970, and July 31, 2010; English language; and either 1) documentation of the incidence of CSF leak after anterior decompression to treat OPLL, 2) description of the management of CSF leaks encountered during spine surgery, or 3) laboratory investigations, technical reports, or retrospective case series focused on the repair of dural tears. Using these findings and the experience of the senior author, a treatment algorithm was developed to guide management of a dural tear with CSF leak after anterior decompression and resection of OPLL.

Results

Literature Review

The current evidence on intra- and postoperative management of a CSF leak during surgery for OPLL consists of retrospective case series, experimental investigations of dural repair, and technical case reports. To our knowledge, there are no randomized trials available. The details of the literature search are outlined in Fig. 1. Eighty-four full-text articles were identified for further analysis. Six were excluded because the full-text version could not be located. Eight were published in a non-English language. Thirteen did not address the topic of CSF leaks or dural tears. Fifty-seven papers were reviewed, including 39 articles describing management strategies for CSF leaks, 11 of which were case series reporting data on the use of intra- and postoperative adjuncts for treatment of a CSF leak after anterior decompression for OPLL (Table 1). In 26 articles, dating from 1981 to 2009, surgical management of OPLL was the major topic.

![Fig. 1. Selection of articles for review.](image-url)
Management of CSF leaks in surgery for OPLL

Incidence

The incidence of cervical dural tears and CSF leaks after anterior decompression procedures has ranged from 0.5% to 3%.4,9,16,21,22,25,26,28,36,35 For OPLL, the incidence is much higher, ranging from 4.3% to 32%.1,3,11,12,17,27,33,42,43,52 In a review of 1994 cases, Hannallah et al.26 reported that the presence of OPLL was the greatest risk factor for the development of a CSF leak after anterior decompression surgery and that patients with OPLL were 13.7 times more likely to have a leak than were patients without this condition.

Secondary Complications

Technical reports have described various secondary complications associated with a CSF leak after cervical operations, including meningitis,41 delayed wound healing, airway obstruction,2,10 cutaneous CSF fistula,52 and pseudomeningocele.2,15,34 Life-threatening CSF leaks in the immediate postoperative period are uncommon but require early identification and prompt intervention. Evidence on the long-term sequelae of CSF leaks that are managed adequately, however, is optimistic. Whereas Saxler et al.48 found that patients with incidental dural tears had poorer outcomes (they underwent more reoperations and experienced more pain and pain-related functional limitations), other authors have reported that the long-term deleterious effects of CSF leaks may be limited. Hannallah et al.26 reported no long-term sequelae, such as wound infection, pseudomeningocele, sinus tract formation, or meningitis, in 20 patients with CSF leaks with an average follow-up of 5.4 years. Cammisa et al.9 reported that when CSF leaks were recognized and treated appropriately, patients experienced no complications such as persistent recurrent headaches, meningitis, pseudomeningocele, cutaneous fistula, or neurological deficit after an average follow-up of 22.4 months. Similarly, Wang et al.57 found that a dural tear did not increase the risk of postoperative infection, neural damage, or arachnoiditis.

Treatment of CSF Leaks

Various techniques, reviewed below in further detail, have been described to manage dural tears and CSF leaks. These include repair with gelatin foam, fibrin glue, collagen matrix,20,46 fat and fascia graft,5,47 biological graft,19 synthetic materials,14,61 or blood patch;7,48 insertion of a lumbar drain26,35 or LP16 and WP (wound-peritoneal cavity) shunts;2,19 ventriculostomy;34,41 laser techniques;23 insertion of a lumbar drain26,35 or LP16 and WP (wound-peritoneal cavity) shunts;2,19 ventriculostomy;34,41 laser techniques;23 and microdural stapling.7,7

Intraoperative Strategies

Primary Dural Repair. Although direct repair is optimal management in most cases of dural tear with a resultant CSF leak in all spinal regions, when this situation is encountered during anterior cervical surgery for OPLL, exposure is often inadequate to facilitate direct repair. Hannallah et al.26 reported that only 5 of 20 intraoperative ventral CSF leaks in their series were accessible for direct repair. Primary repair techniques aim to provide a watertight seal of the dural tear. If it is technically possible, direct repair with suturing is preferable. Still, the reported failure rate is 5%–10% with this technique.5,6,9,15,32,50 Dural tears are likely to occur when the dura becomes ossified and adheres to the PLL and cannot be dissected off.43 Such dural tears create tissue gaps that are not amenable to primary repair. Ossified dura may be diagnosed on preoperative CT as either a single homogeneous ossified mass of dura adhered to the PLL or a double-layer sign in which anterior and posterior ossified rims are separated by a hypodense area of hypertrophied PLL.43 Another reason primary repair may fail may be the pinhole-sized tears from suture needles that allow CSF to leak through the dura.8,29,46 The potential risk of using primary suture closure for small incidental dural tears is conversion of a low-pressure defect to high-pressure pinholes from suture needles.46

Chemical Sealants and Dural Grafting. The addition of a chemical seal has been proposed as a mechanism to overcome the problem of CSF leak from the suture holes.46 Fibrin glue has been shown to be a useful adjunct to prevent leaks in conjunction with direct repair.50 Laboratory data demonstrate that dural defects repaired by suture alone leak at physiological pressures, whereas repairs supplemented by sealants, such as fibrin glue, withstood higher pressures in the postoperative period.7,8,50 Nakajima et al.44 demonstrated the importance of fibrin glue for sealing the suture holes at the repair site to prevent CSF leaks. Smith et al.52 reported a series in which 7 patients with dural defects received a patch without fibrin glue, using either an autogenous fascia graft or synthetic materials such as gelatin foam. Five of these patients developed durocutaneous fistulas and 3 required reoperation to repair the dura. Because fibrin sealant remains in situ for only 5–7 days before being resorbed, it should be supplemented with dural grafting to form a watertight closure in the immediate postoperative period.

Narotam et al.46 reported the successful use of a collagen matrix onlay sutureless graft during primary repair of dural tears. The onlay graft is placed over the defect and attaches via surface tension to the dura, where it provides a low-pressure absorptive surface to diffuse any CSF and acts as a site for biological dural repair. The hemostatic properties of collagen initiate clot formation, resulting in an immediate chemical seal. The collagen matrix is a chemoattractant and provides a scaffold for fibroblasts to infiltrate and deposit new collagen, thereby reconstituting new dura. In this series of 110 patients with intraoperative anterior/posterior spinal dural fistulas, including 10 anterior cervical dural lacerations, the application of microfibrillar collagen matrix (in 100% of cases), combined with subfascial drains (in 82%), fibrin glue (in 7.3%), lumbar drains (in 2.7%), or other adjunct including suture (in 8%), resolved the dural fistulas 95% of the time.

Epstein17,74 described a technique of suturing or using microdural staples to secure a pericardial graft over the dural defect. This is followed by application of fibrin sealant and dural graft matrix and a WP or LP shunt. In many cases of OPLL, however, direct repair is not possible because of location or size of the dural defect. Furthermore, not all dural tears can be recognized and repaired primarily, and the need for postoperative treatment strategies persists.
<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Cases</th>
<th>No. of CSF Leaks &amp; Dural Tears (%)</th>
<th>No. of Cases w/ Primary Repair (%)</th>
<th>Intraop Adjuncts Used</th>
<th>Success Rate (%)</th>
<th>Incidence of Postop CSF Fistula or Pseudomeningocele (%)</th>
<th>Postop CSF Leak Management</th>
<th>No. of Patients Requiring Revision Op (%)</th>
<th>Revision Repair</th>
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<tr>
<td>Abe et al., 1981</td>
<td>12</td>
<td>3 (25)</td>
<td>3/3 (100)</td>
<td>Gelfoam</td>
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<td>NM</td>
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<td>Belanger et al., 2005</td>
<td>65</td>
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<td>1/8 (13)</td>
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<td>3/8 (38)</td>
<td>5/8 (62)</td>
<td>bed rest, lumbar drain</td>
<td>3/8 (38)</td>
<td>reop</td>
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<tr>
<td>Chen et al., 2009</td>
<td>138</td>
<td>18 (13)</td>
<td>0</td>
<td>none</td>
<td>NA</td>
<td>18/18 (100)</td>
<td>continuous pressure to wound for 3–5 days</td>
<td>3/18 (17)</td>
<td>multiple percutaneous aspirations over 2–3 mos</td>
</tr>
<tr>
<td>Choi et al., 2005</td>
<td>47</td>
<td>2 (4)</td>
<td>2/2 (100)</td>
<td>fibrin glue, fat or fascia graft, lumbar drain</td>
<td>2/2 (100)</td>
<td>0/2 (0)</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Epstein, 2001</td>
<td>65</td>
<td>3 (5)</td>
<td>3/3 (100)</td>
<td>bovine pericardial graft, fibrin glue, WP shunt, LP shunt</td>
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<td>WP shunt, LP shunt</td>
<td>0</td>
<td></td>
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<tr>
<td>Epstein, 2009</td>
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<td>5 (6)</td>
<td>5/5 (100)</td>
<td>bovine pericardial graft, fibrin glue, collagen matrix, WP shunt, LP shunt</td>
<td>5/5 (100)</td>
<td>0/5 (0)</td>
<td>WP shunt, LP shunt</td>
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<td>Harsh et al., 1987</td>
<td>19</td>
<td>3 (16)</td>
<td>3/3 (100)</td>
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<tr>
<td>Joseph et al., 2009</td>
<td>144</td>
<td>9 (6)</td>
<td>9/9 (100)</td>
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<td>Min et al., 2008</td>
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<td>NM</td>
<td>lumbar drain</td>
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<td>lumbar drain</td>
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<td>NM</td>
<td>lumbar drain for 7 days</td>
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<td>Smith et al., 1992</td>
<td>22</td>
<td>7 (32)</td>
<td>7/7 (100)</td>
<td>Gelfoam, fascia graft, lumbar drain in 1 patient</td>
<td>2/7 (29)</td>
<td>5/7 (71)</td>
<td>lumbar drain for 4–7 days</td>
<td>3/7 (43)</td>
<td>reop</td>
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</table>

* NA = not available; NM = not mentioned.
Management of CSF leaks in surgery for OPLL

Wound Drains. The use of subfascial drains for management of intraoperative CSF leaks is controversial. Such drains are placed to evacuate any accumulation of serous fluid, blood, or CSF and to obliterate the dead space in the immediate postoperative period. When patients are mobilized after surgery, a hydrostatic pressure gradient develops that facilitates transient CSF effusion into the subfascial space. When porous grafts, such as collagen matrix, are used, the risk of CSF egress may increase, especially in the first few postoperative days before the chemical seal forms and the graft becomes established. Although some authors have argued against the use of drains, most studies have found no associated increase in the rate of durocutaneous fistulas with their use.

Postoperative Strategies

Lumbar Drains. The use of CSF diversion for the treatment of CSF leaks is well documented. Reported success rates have ranged from 83% to 100%. Tables 2 and 3 compare studies of patients undergoing repair of CSF leaks after anterior decompression for OPLL with and without intraoperative placement of a lumbar drain or shunt. None of the patients who received a lumbar drain or shunt developed a CSF fistula or pseudomeningocele or required reoperation. Treatment of a dural tear by CSF diversion may be explained by the decreased fluid pressure through the leak with preferential egress through the catheter or by decreased distension of the dural sac with approximation of the dural edges to facilitate healing.

Kitchel et al. retrospectively reviewed 19 cases involving patients treated with postoperative lumbar drainage after a CSF leak and found that 14 of the 17 patients treated with CSF diversion for a full 4 days had resolution of the leak. Smith et al. reported on a series of 22 patients who underwent anterior decompression of the spinal canal for OPLL and cervical myelopathy, 7 of whom had absent dura adjacent to the ossified part of the ligament. Two patients had transient CSF leak at the time of the decompression that ceased during the operation; in 1 of these 2 cases, the patient underwent immediate placement of an LP shunt. Five of the 7 developed a postoperative CSF fistula, and 3 of these 5 underwent a second operation to repair the defect in the dura. The CSF fistula was identified on the first postoperative day in 3 patients who had large amounts of obvious CSF drainage from the wound; the other 2 had smaller amounts of drainage but unexpected swelling of the neck that was noted later on postoperative Day 2 in 1 case and Day 16 in the other.

Because of the delayed diagnosis of a CSF leak in these patients, the authors recommended patching the dural defect with a graft of muscle and fascia, prophylactic placement of a lumbar drain, limited mechanical pulmonary ventilation as safely feasible, and administering antimicrobial and antitussive medications in the postoperative period to minimize extreme positive thecal pressure and thereby protect the autogenous fascial graft.

In a series involving 36 patients undergoing 2- to 4-level anterior corpectomy and fusion operations, 9 of whom had OPLL, 3 patients developed postoperative CSF leaks that were successfully treated by lumbar drainage. Choi et al. reported on a series of 47 patients who underwent corpectomy for OPLL, 2 of whom developed a CSF leak intraoperatively; both of these patients underwent primary repair with either a fat or a fascial graft augmented with fibrin sealant followed by immediate placement of a lumbar drain in the recovery room. Similarly, Min et al. reported successful resolution using lumbar drainage and bed rest of 6 intraoperative CSF leaks among 19 patients who underwent ventral surgery for OPLL, and Joseph et al. described successful resolution of 9 intraoperative CSF leaks in 144 patients. All 9 in the latter series were treated with a fascia graft, Gelfoam, and immediate placement of a lumbar drain that remained in place for 5 days.

In one of the largest series evaluating CSF leak after elective anterior cervical spine surgery, Hannallah et al. reported the overall incidence of a CSF leak to be 1%, but in patients with OPLL, the incidence was 12.5%. Of the 20 patients who developed CSF leaks, 15 had dural tears that were not accessible to direct repair, 4 of which were treated successfully by placement of a lumbar CSF shunt either at the time of the index procedure (in 3 cases) or on postoperative Day 7 (in 1 case).

For CSF leaks diagnosed in the postoperative setting only (for example, in patients with CSF in the drainage container or cutaneous CSF fistulas), bed rest alone does not lead to a favorable outcome in most patients. Although direct surgical repair with suture is an accepted treatment, it requires a second operative procedure. Many authors have advocated the use of lumbar drains without reoperation for primary closure of the dural tear. Other measures, shown to be less effective, include application of continuous direct pressure. Although effective in treating CSF leaks, the use of lumbar drains is not without complications, being associated with an approximately 5% reported infection rate. In addition, lumbar drains are gravity-dependent systems in which a pressure gradient is necessary for CSF drainage; any change in the position of the drain channel...
ber with respect to the patient can result in rapid egress of CSF. Pneumocephalus with brainstem compression after overdrainage has been reported. Other side effects associated with overdrainage include headaches, nausea, and vomiting. Moreover, the standard practice of keeping patients with lumbar drains on bed rest to prevent rapid CSF drainage due to positional change may increase the risk of postoperative morbidity due to the development of deep venous thrombosis and pulmonary embolism due to prolonged immobilization. The use of flow-regulated CSF draining systems using a volumetric pump set to withdraw CSF at a controlled rate, a low-pressure control valve, or a combined volume- and pressure-controlled system (LiquıGuard; Möller Medical) may overcome most of these potential problems associated with lumbar drains.

**Shunts.** More complex intraoperative CSF leaks may require the addition of closed-system WP or LP shunts. Such complex dural tears include those that are not accessible without performing additional bone resection to gain access for a direct repair. Epstein described performing a complex primary dural repair combined with placement of both WP and LP shunts in patients undergoing multi-level anterior cervical corpectomies and fusion to ressect OPLL. Dural repair consisted of bovine pericardial grafts sewn in place with sutures and microdural staples in 1 patient and used as onlay grafts in 4 patients, in addition to 2 layers each of microfibrillar collagen and fibrin sealant. The WP catheter was placed with the proximal catheter positioned superficial to the bone graft and to the left of the cervical plate. Finally, an LP shunt was placed in case of WP shunt failure or obstruction.

Although shunting CSF into the abdominal cavity may provide short-term advantages such as decreased risk of infection and postoperative subdural hematomas with immediate postoperative mobilization compared with multiple percutaneous aspirations or temporary lumbar external drainage, major drawbacks must be considered. It is an invasive therapy that may expose the patient to many additional problems such as over- or underdrainage, migration or obstruction of the proximal or peritoneal tip, infection, or shunt breakdown, which may require revision surgeries over time. Therefore, placement of a permanent shunt represents a last resort after failure of all other measures.

**Prevention of CSF Leakage**

**Anterior Floating Technique.** Various surgical techniques have been proposed to minimize the chance of intraoperative dural tears during anterior decompression in patients with OPLL. The “anterior floating method” and variations thereof have been well described. In general, these techniques leave behind the thinned down medial posterior wall of the vertebral body and the ossified PLL but decompress laterally around it, so that the ossified PLL becomes a “free-floating” mass on the dura. Epstein described that during the drilling process, the ossified PLL mass should be left attached to the margins of the corpectomy defect to keep it stabilized until the midportion of the PLL has been thinned sufficiently. After the PLL mass is freed from the bony margins, further thinning of the ossified PLL must be done with great care. A few isolated islands of ossified PLL tightly adherent to the dura can be left in place, thereby reducing the chance of CSF leak. One group reported that incidence of postoperative CSF fistulas with the anterior floating method for OPLL was 5.1% compared with a reported 16–25% incidence associated with the standard anterior extirpation method.

**Discussion**

Because anterior decompressive surgery for OPLL of the cervical spine involves up to a 32% risk of dural tear, the surgeon must have a strategy to manage CSF leaks both during and after surgery. Given the many problems that stem from an unresolved CSF leak, such as delayed wound healing with cutaneous CSF fistula, risk of meningitis, or pseudomeningocele, repair should involve appropriate measures to promote healing of the dural tear. If a violation of the dura is recognized during the surgery, a primary closure with microsurgical suture may be attempted, although it is frequently technically not feasible. In most cases of OPLL, lack of dural elasticity or gaps due to resection of adherent or ossified dura or even absence of dura preclude a watertight closure with sutures. Therefore, it appears to be more important to use intraoperative adjuncts in combination with postoperative measures to decrease the pressure gradient across the dural tear. Onlay adjuncts such as collagen matrix (Duragen; Integra LifeSciences Corporation) or autogenous fascia have been successfully used in patients with dural tears. Alternatives may include equine or bovine pericardium or Gelfoam (Pharmacia & Upjohn). Collagen matrix can

### Table 3: Studies reporting outcomes of repair of CSF leak after anterior decompression for OPLL with intraoperative placement of lumbar drain or shunt

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
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be used as onlay graft without the necessity of a primary watertight closure, which is particularly helpful for large dural tears after resection of an ossified PLL. It can also be combined with fibrin glue. In vitro, fibrin glue increased the strength of the repair of the sutured dura 7-fold and was also found to be effective as a stand-alone sealant. Experimental data on fibrin glue is corroborated by clinical experience. Moreover, a combination of adjuncts may enhance the overall sealing effect.

The simplest device to decrease intrathecal CSF pressure is the lumbar drain, which is left in situ for the first 4–5 days after surgery, with drainage at a rate of 5–15 ml/hour. This time frame is based on histological evidence for dura sealing, which takes approximately 4 days to complete. The collection system attached (automatic pressure/volume-regulated pump versus gravity-assisted collection bag) guides whether a patient must be managed in the intermediate care unit with close observation or on the general floor and how much mobilization is possible. Mobilization is generally restricted because of concerns about overdrainage and the risk of tonsillar herniation and a rise of the gradient across the dural tear. With pressure/volume-regulated CSF drainage devices, mobilization may be possible without the risk of overdrainage or substantial increases of the intrathecal pressure because the dural tear is in the cervical spine. Stool softeners are prescribed to

**Fig. 2.** Treatment algorithm for avoidance and management of CSF leaks in anterior approaches for OPLL. The left side of the diagram shows the strategy for high-risk situations, and the right side shows intra- and postoperative management of unanticipated CSF leaks.
avoid intrathecal pressure peaks during Valsalva maneuvers.

Patients with multilevel or broad-based OPLL are at the greatest risk of intraoperative CSF leaks. In these cases, the surgeon may choose to place a lumbar drain as part of the anesthesia setup and have it opened if CSF leakage is noticed during surgery. This will immediately diminish the egress of CSF and help the adjuncts to adhere to the dura. A lumbar drain is also a therapeutic choice for a CSF leak that is suspected postoperatively on the basis of CSF in the wound drain or the development of a cutaneous CSF fistula.

The use of wound drains with CSF fistulas is controversial. At our institution, we tend not to use deep wound drains in the case of a CSF leak. Placement of an LP or WP shunt is considered a last-resort therapy, to be undertaken after failure of all previously mentioned modalities. The potential complication rate for infection, obstruction, disconnection, dislocation, or over- or underdrainage is substantial; therefore, we choose to perform a second revision surgery with the mentioned adjuncts and a lumbar drain before considering placement of a permanent shunt.

Figure 2 demonstrates the treatment algorithm that we use in most cases at our institution. The presence of multilevel and broad-based OPLL increases the likelihood that there is dural ossification, which increases the risk for a dural tear. In these situations, we insert a lumbar drain preoperatively and use the anterior floating technique unless the ossified PLL can be separated from the underlying dura. When a dural tear arises, we attempt a primary repair using a combination of adjuncts such as a nonautologous onlay graft augmented by fibrin glue. Primary suture is reserved for cases in which the dural defect is minimal and exposure of the site is sufficient. If the CSF leak cannot be controlled using intraoperative adjuncts, we insert a lumbar drain at the end of the operation. The patient is kept on bedrest, and CSF is drained at a rate of 10–15 ml/hour for 4–5 days, which is the time needed for adequate dural sealing. Postoperative drainage of CSF may cause nausea and emesis, which are treated with antiemetics or slight reduction of the drainage rate. This treatment, together with the use of stool softeners, aims to prevent sudden peaks of intrathecal pressure.

Anterior decompression to resect an ossified PLL is associated with an increased risk of CSF leak, which may not be amenable to direct repair. Studies have shown that postoperative lumbar drainage decreases the likelihood of the patient developing a persistent CSF fistula or pseudomeningocele and minimizes the likelihood of re-operation. Therefore, we favor the placement of a lumbar drain as a first-line intervention when an intraoperative CSF leak is difficult to control. We also recommend the use of a lumbar drain as an adjunct to surgical exploration if a CSF fistula is diagnosed in the postoperative setting.

Conclusions

Currently, the management of CSF leakage after resection of an ossified PLL has been described primarily in case series and technical notes. No large-scale studies have been reported. Most dural tears associated with surgery for OPLL can successfully be managed by a combination of intraoperative adjuncts (sealants, grafts) and postoperative lumbar CSF drainage for 4–5 days.

Disclosure

The authors do not report any conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following: Conception and design: Bisson, Schmidt. Acquisition of data: Mazur. Analysis and interpretation of data: Mazur, Jost. Drafting the article: Mazur, Jost. Critically revising the article: Bisson, Schmidt. Reviewed final version of the manuscript and approved it for submission: Bisson, Schmidt. Study supervision: Bisson, Schmidt.

Acknowledgment

The authors thank Kristin Kraus, M.Sc., for kind review and editing of the paper.

References

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47. Nakano N, Nakano T, Nakano K: Comparison of the results of laminectomy and open-door laminoplasty for cervical spondylosis and spinal cord compression with neuroimaging modalities in ability to identify the disease. J Neurosurg Spine 2:245–249, 2005


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