

Cerebrospinal Fluid Leakage after Thoracic Decompression

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Abstract

Objective: The objective of this study is to review cerebrospinal fluid leakage (CSFL) after thoracic decompression and describe its regular and special features.

Data Sources: Literature cited in this review was retrieved from PubMed and Medline and was primarily published during the last 10 years. “Cerebrospinal fluid”, “leakage”, “dural tears”, and “thoracic decompression” were the indexed terms. Relevant citations in the retrieved articles were also screened to include more data.

Study Selection: All retrieved literature was scrutinized, and four categories were recorded: incidence and risk factors, complications, treatment modalities, and prognosis.

Results: CSFL is much more frequent after thoracic decompression than after cervical and lumbar spinal surgeries. Its occurrence is related to many clinical factors, especially the presence of ossified ligaments and the adhesion of the dural sac. While its impact on the late neurological recovery is currently controversial, CSFL increases the risk of other perioperative complications, such as low intracranial pressure symptoms, infection, and vascular events. The combined use of primary repairs during the operation and conservative treatment postoperatively is generally effective for most CSFL cases, whereas lumbar drains and reoperations should be implemented as rescue options for refractory cases only.

Conclusions: CSFL after thoracic decompression has not been specifically investigated, so the present study provides a systematic and comprehensive review of the issue. CSFL is a multi-factor-related complication, and pathological factors play a decisive role. The importance of CSFL is in its impact on the increased risk of other complications during the postoperative period. Methods to prevent these complications are in need. In addition, though the required treatment resources are not special for CSFL after thoracic decompression, most CSFL cases are conservatively curable, and surgeons should be aware of it.

Key words: Cerebrospinal Fluid Leakage; Incidence; Systemic Review; Thoracic Decompression; Treatment

INTRODUCTION

Cerebrospinal fluid leakage (CSFL) frequently occurs after spinal surgeries. This complication is always associated with low intracranial pressure symptoms, high risk of perioperative infection, prolonged hospital stay, and increased medical cost. In some cases, it can lead to more severe events, such as meningitis and intracranial hemorrhage, when not promptly and appropriately treated.^[1-18] Huge variance has been reported regarding CSFL incidence following surgeries at different spinal segments. Hannallah *et al.*^[16] reported only 1% of cervical spinal surgeries developed CSFL, whereas Wang *et al.*^[17] found that the proportion following lumbar surgeries rose to 14%. However, data on CSFL after thoracic decompression are currently limited and, consequently,

few references can be located regarding the incidence, predisposing clinical factors, and prognosis of this complication. Hence, this study was designed to provide a comprehensive analysis of CSFL following thoracic decompression, identifying its peculiarities in the context of thoracic spinal surgeries and eventually establishing some useful references for future studies and clinical practice.

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INCIDENCE AND RISK FACTORS

Previous publications reported variable values about the incidence of CSFL following thoracic decompression and most of them fell in the range of 20–30% [Table 1].^[1,5,7-9,18-24] Yamazaki *et al.*^[24] recruited 24 patients with thoracic myelopathy due to ossification of the posterior longitudinal ligament (OPLL), all of whom underwent posterior decompression (PD), and found the incidence of CSFL was 4.2%. This proportion is much lower than the 50% reported by another study of twenty cases of thoracic OPLL in patients who underwent anterior decompression (AD).^[23] Although such difference could be attributed to the small sample sizes of these studies, the fact that different surgical approaches were performed should not be overlooked. Compared with PD, surgical approaches including manipulations anterior to the spinal cord, such as circumferential decompression (CD) and AD, have a higher risk of dural tears (DT) and CSFL, due to the challenges of smaller operating spaces and partial or even total loss of visual access during the procedure. This speculation has been validated by another single-center study.^[20]

Surgeons' experience and techniques may also be responsible for the difference in the incidences of CSFL across different surgical approaches.^[2,25,26] Dural tear seems inevitable given the existence of strong and/or ossified adhesions between the ossified ligaments and the dural sac. Previous studies have demonstrated that strong or even ossified adhesion frequently presents in patients with thoracic myelopathy.^[7,8,21,23,27] Fengbin *et al.*^[28] compared results between patients with and without the ossified adhesion, and found that the former group had a much higher ratio of DT than the latter (63.6% vs. 3.5%), suggesting that adhesion is a significant risk factor for DT. Hence, the finding that PD among patients with thoracic OPLL has a lower likelihood of CSFL than AD and CD seems justifiable,^[24] since no dissection of the adhesion is involved in PD. For the same reason, the incidence of CSFL increases to more than 20% in PD patients when the diagnosis includes ossification of ligamentum flavum (OLF),^[1,5,22,27] considering the occurrence of adhesion between OLF and the dural sac behind the spinal cord.

Previous studies on cervical and lumbar spinal surgeries revealed that old age, being female, having comorbidities, revision surgery, and long operation length were risk factors for CSFL.^[4,6,7,12,16-19,25,29] Sun *et al.*^[7] reported that three or more levels of thoracic decompression showed a higher risk of CSFL (odds ratio = 2.4, $P < 0.01$). Currently, there is no convincing explanation for the links between CSFL and being female, or CSFL and having comorbidities such as diabetes mellitus. A previous study found that OPLL is the most significant risk factor for CSFL.^[16] This conclusion, combined with the finding of gender disparity in the prevalence of OPLL,^[30-32] may explain the link between being female and CSFL. In addition, a recent large-scale survey also confirmed that diabetes mellitus is a predisposing factor for OPLL,^[30] which is compatible with the aforementioned association between having diabetes mellitus and CSFL. Therefore, CSFL is a multiple factor-related complication, whereas technical and pathological factors remain as the main determinants.

COMPLICATIONS RELATED TO CEREBROSPINAL FLUID LEAKAGE

Although previous studies have found that CSFL has only a trivial impact on the mid- and long-term neurological recovery,^[3,4,15,17,28,29,33-36] researchers have collected increasing evidence for its association with a higher risk of transient neurological deterioration and new emerging paresthesia, such as numbness and stinging sensation along the chest wall.^[1-4] In addition, there were some reports of late neurological deterioration due to the compression from a persistent pseudomeningocele.^[2,5,6] Some common complications of CSFL are listed as follows:

1. Headache, dizziness, nausea, and other low intracranial pressure symptoms: these symptoms usually present when the drain output surpasses 500 ml/24 h.^[17] All of these symptoms are conservatively curable, and the treatment algorithm includes bed rest, reducing the output of cerebrospinal fluid (CSF), administration of hypertonic solutions and analgesics if necessary
2. Common infection, including infection at the wound site, or in lung and urinary tract: the collection and

Table 1: Previous studies regarding cerebrospinal fluid leakage after thoracic decompression

Studies	Patients, <i>n</i>	Disease	Surgical approaches	CSFL, <i>n</i> (%)	Complications*
Sun <i>et al.</i> ^[7]	266	OLF	PD	85 (32.0%)	Pseudomeningocele, infection, wound poor healing
Takahara <i>et al.</i> ^[8]	30	OPLL	CD	12 (40.0%)	Infection, pseudomeningocele, meningitis, transient neurological deterioration
Hu <i>et al.</i> ^[15]	26	OPLL	CD	10 (38.5%)	Pseudomeningocele, infectino, wound poor healing, transient neurological deterioration
Matsumoto <i>et al.</i> ^[19]	154	OPLL	PD, AD, and CD	34 (22.1%)	Epidural hematoma, meningitis
Kawashara <i>et al.</i> ^[21]	15	OPLL	PD and CD	3 (20.0%)	NM
Min <i>et al.</i> ^[23]	120	OPLL	AD	10 (50.0%)	NM
Yamazaki <i>et al.</i> ^[24]	24	OPLL	PD	1 (4.2%)	NM
Aizawa <i>et al.</i> ^[27]	72	OLF	PD	9 (12.5%)	Epidural hematoma

*Only those documented in original articles are listed. CSFL: Cerebrospinal fluid leakage; OPLL: Ossification of posterior longitudinal ligament; OLF: Ossification of ligamentum flavum; PD: Posterior decompression; CD: Circumferential decompression; AD: Anterior decompression; NM: Not mentioned

persistence of subcutaneous fluid increase the risk of wound infection and poor healing [Figure 1]. At the same time, a long period of bed rest and lack of exercise can also lead to the development of infection in the urinary and respiratory tracts^[1,7-9]

3. Infection of the central nervous system, with a reported incidence of up to 5–10%.^[2,11,17,37] The opening of the dural sac provides a potential pathway for exterior pathogenic organisms to invade the central nervous system, which might cause meningitis, arachnitis, or abscess formation
4. Formation of pseudomeningocele and fistula: with no effective treatment, CSFL persists and evolves into some more aggressive complications. Pseudomeningocele may cause many devastating events, including but not limited to neurological compression, herniation of the spinal cord, hemorrhage, and syncope.^[7,8,10-12] Fistulas may form in the pleural cavity, peritoneal cavity, skin, or subcutaneous, which may lead to many complications at these sites^[11,38]
5. Thromboembolism and other vascular events: the established treatment algorithm for CSFL requires long bed rest, which increases the risk of pulmonary thromboembolism, heart attack, stroke, and other vascular events^[15]
6. Intracranial hemorrhage: the rapid and massive loss of CSF results in a sudden decrease of intracranial pressure, possibly causing of rupture of small vessels and subsequent bleeding^[1,11,13,14]
7. Herniation of cerebral or cerebellar components: this fatal emergency has been randomly reported and may be due to intracranial hemorrhage, sudden decrease of intracranial pressure, and swelling of intracranial contents.^[10,14]

INTRAOPERATIVE TREATMENT STRATEGIES

The treatment algorithm for CSFL includes intra- and post-operative stages. Once the openings of the DT are

identified during the operation, primary repair is indicated. Many repair methods and materials have been described by previous publications, reporting comparable efficacy. In general, CSFL resolves within 4–5 days after an operation.^[10,28] This phenomenon is corroborated by an *in vitro* histological study, which found that dural healing takes 4 days.^[39] Therefore, one fundamental principle of variable intraoperative repairs is to provide a reliable watertight closure for at least 4–5 days that can withstand the pressure exerted by CSF and prevent a lasting flow through dural openings. The common repair methods and materials are listed as follows:

Covering

This method is suitable for small dural breaches (0.5 cm or less), irregular dural defects, sites beyond the reach of suturing, or cases without recognizable dural opening. Previous studies demonstrated this mechanism has a fair efficacy.^[2,12,28,35,40] The covering materials include gelfoam, tissue patches, and artificial dura. Patches of hetero- or homo-geneous tissues, such as fat, muscle, blood and fascia, are always used. Of those tissues, fascia is regarded as optimal but difficult to harvest.^[35,40] Although the use of tissue patches is simple and fairly effective, it provides poor watertight closure and potentially forms contractive scars, which might compress neurological components.

Suturing

The use of sutures is suitable for DT, especially long regular tears behind the spinal cord. The success rate is up to 70% in cervical and lumbar spinal surgeries but only 30% in thoracic decompression,^[4,7,8,16,17] since the dura at the thoracic spine is vulnerable and the openings are usually irregular.^[7,8] Approximately, 4-0 to 7-0 continuous or interlocking silk sutures are always used without tension, to avoid pinhole tears. Suturing is always used in combination with fibrin glue, gelfoam, and tissue patches, providing a higher success rate.^[4,7,8,16,17]

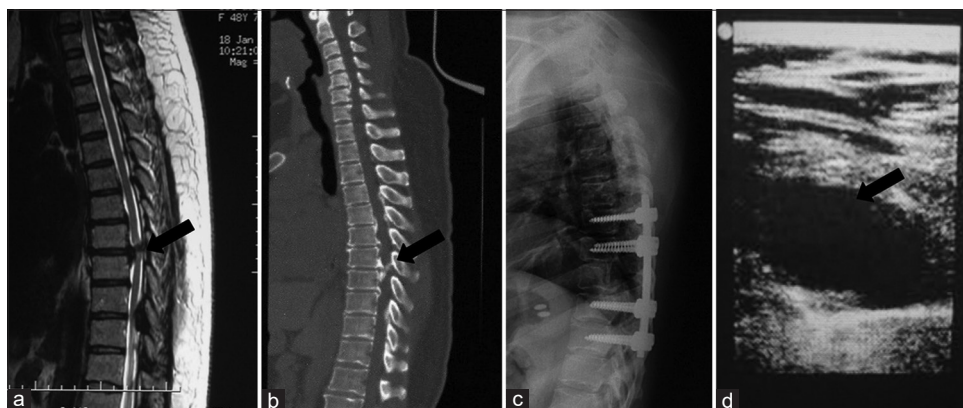


Figure 1: Presentation of a 48-year-old female, who presented with weakness and numbness in lower extremities and walking difficulty for 3 months. Preoperative imaging work-up showed ossification of ligamentum flavum at the vertebra T5–T9 and ossification of posterior longitudinal ligament at the vertebra T78 (arrows, a and b). She underwent posterior decompression with instrumented fixation (c). During the procedure, a small dural tear was observed, but without apparent leak of cerebrospinal fluid. After the operation, ultrasonography revealed the massive collection of subcutaneous fluid (arrow, d). A total of 85 ml clear fluid was released by ultrasound-guided aspiration, which was confirmed of cerebrospinal fluid by laboratory test.

Chemical sealants and dural substitutes

Currently, a variety of products is commercially available, including fibrin glue, collagen matrix, and polyglycolic acid.^[41-43] These materials are being widely used as supports to provide a more reliably watertight closure. Fibrin glue can be used separately or more often as a supplementary sealant in combination with suturing and dural grafting, which helps reinforce a watertight closure and withstand higher pressure across the dural openings.^[10,36,39,43] Fibrin glue disintegrates *in vivo* within 5–7 days after the operation, suggesting that other repair methods are needed to secure the water-resistant capacity.^[10] Polyglycolic acid, as a dural substitute, can withstand higher CSF pressure but may lead to spinal arachnoid adhesion. However, its properties can be complemented by fibrin glue, and the combination of the two provides a satisfying solution.^[44] Collagen matrix is a chemical attractant for the gathering of fibroblasts and provides a scaffold for the secretion and deposit of collagen fibers to form new dura. A sutureless repair with collagen matrix was therefore utilized and displayed an appreciable healing rate of 95% in a clinical research study of 110 patients.^[43]

POSTOPERATIVE TREATMENT STRATEGIES

In total, primary repairs have a modest efficacy, leaving 10–70% CSFL cases unresolved, according to different publications.^[4,7,16,17,34,35,42] Sun *et al.*^[7] reported that only 20 out of 85 cases of DT did not develop CSFL postoperatively after different intraoperative repair processes, yielding a poor success rate of 23.5%. Therefore, the researchers emphasized rational and effective treatments after the operation. In general, the drain of clear fluid and/or subcutaneous collection of clear fluid reminds of CSFL. Besides, the drain output is another determining criterion. As the bleeding in thoracic decompression is more extensive than that in cervical and lumbar surgeries, it is logical that the suggested criterion for drain output is 150 ml or more per 24 h within the first 3 days.^[37]

Both conservative and operative modalities are utilized to treat CSFL during the postoperative period. However, the treatment strategies in current literature regarding thoracic decompression tend to be conservative, and the overall success rate is reported up to 95.5%.^[7]

Paraspinal drain

Although controversial regarding the timing of removal, 48–72 h of a paraspinal drain helps eliminate empty space by evacuating blood and CSF, which facilitates dural healing, especially when intraoperative repair fails to provide a reliable watertight closure.^[16,17,43] A normal pressure drain is recommended to avoid a consistent flow of CSF via the dural opening. Conventionally, the drain tube should be removed once the drain output turns clear. This, however, is not a unique solution. For example, a delayed placement of a Jackson-Pratt tube until 10–17 days after the surgery also provided a satisfying result.^[37]

Compression dressing and bed rest

Compression dressing can exert a mild force on the wounds and subcutaneous tissues to preclude both egression and accumulation of CSF, which improves the seal of dural openings. This modality is presumably more suitable for the thoracic spine, which possesses a kyphotic sagittal profile. Sun *et al.*^[7] reported that conservative treatments, namely compression dressing and bed rest, had a remarkable effect for the CSFL following thoracic decompression. However, it is very difficult and painful for patients to lie prone for 5–7 days, which is required by conservative treatment. In addition, lengthy bed rest is also a predisposing factor to devastating vascular events, especially for older patients. Another potential consequence is local ischemia due to inappropriate application of compressive dressing, which leads to wound infection and poor healing.

Lumbar drain and other shunt maneuvers

By reducing local CSF volume and flow across dural openings, this modality allows time for healing of the dural sac. Lower CSF volume means less local stress, which can accelerate the process of blood reperfusion and tissue repair. Lumbar arachnoid drain or lumbar drain is one of several CSF shunt maneuvers, but more feasible and common in clinical practice. Lumbar drain can be employed as a rescue option after the failure of conservative treatment. Since massive loss of CSF increases the risk of severe low intracranial pressure symptoms and may induce intracranial bleeding, the volume of the lumbar drain should be controlled within 120–360 ml/24 h.^[2,11] After 4–5 days of drainage, CSFL resolves in about 83–100% of cases.^[10,16,35,45] Other shunt maneuvers include the wound-peritoneal shunt and the lumbar-peritoneal shunt, but they are more invasive and only used for refractory CSF fistula and pseudomeningocele.^[10] However, as an invasive modality, CSF shunts increase the risk of infection in the central nervous system.

Other nonoperative treatment modalities

Ultrasound-guided aspiration has been shown effective for subcutaneous CSF collection, in combination with compression dressing and bed rest.^[7] Cho *et al.*^[11] proposed a volume-controlled pseudomeningocele method to treat CSF fistula for patients after AD, which demonstrated a comparable effectiveness to lumbar drains. The underlying mechanism is to balance the pressures across dural openings by regulating CSF volume inside pseudomeningocele and thus facilitate the seal of dural openings. Besides, percutaneous, ultrasound-, or computed tomography-guided placement of blood and fat patches with or without fibrin glue have been shown effective for some CSFL cases.^[40,46,47]

Reoperation

When the above-listed treatment strategies fail, reoperation is indicated to directly repair dural openings. The repairing methods have been introduced above.

DISCUSSION

CSFL is much more common after thoracic decompression than after cervical and lumbar surgeries. This phenomenon

is primarily related to many clinical factors. Patients with ossified ligaments, including OPLL and OLF, have a higher likelihood of DT and CSFL.^[7,15,16,18,23] The underlying issue is the frequent appearance of strong adhesions or even ossified dura in these patients.^[7,8,21,23,27] OPLL has been reported as the most significant risk factor for CSFL.^[16] Therefore, surgical procedures involving the extirpation of OPLL should be performed with profound caution. Although the thinning and floating of OPLL lesions in the case of ossified adhesion has been suggested by some authors, there is a potential pitfall of residual compression.^[19] Therefore, the complete removal of compressive OPLL is preferred, and the clinical follow-up study demonstrated a favorable result for the extirpation technique.^[48]

Given the higher risk of other perioperative complications in CSFL cases, repair during the operation is clearly indicated when DT appears. Although there are a variety of repair methods available, their primary goal is to provide a reliably watertight closure for dura healing. Silk sutures seem the most direct and reasonable closing method,^[4,10,16,17] but are not always technically feasible, as we mentioned above. Thus, the usage of gelfoam in combination with other materials, such as muscle, fascia and artificial dura, remains a routine strategy. The main concern of this strategy is the lack of reliable closure,^[10] which can be reinforced by the combined use of sealants. Fibrin glue has shown effective to reinforce the sealing effect.^[10,36,39,43]

Although previous publications reported a wide range of healing rates after intraoperative repair,^[4,7,16,17,34,35,42] a large-scale study among patients with thoracic decompression demonstrated a more negative result.^[7] Therefore, the subsequent treatment during the postoperative stage is very important. According to the current literature on thoracic decompression, conservative treatment, such as bed rest and compression dressing, shows a satisfying effectiveness.^[7,8,15] Conservative treatment remains the first-line therapy during postoperative hospitalization, while lumbar drain and other invasive therapies are indicated if those conservative treatments fail. Although the timing of drain tube removal remains controversial, we prefer to remove it once the draining fluid turns clear. The use of prophylactic antibiotics is necessary, and debridement should be performed with no hesitation to avoid the spread of infection into the central nervous system. Neurological deterioration from persistent pseudomeningocele has been reported^[7,8,10-12] and, in those cases, reoperation is then indicated. The timing of reoperation is approximately 3–6 months after the indexed surgery. However, for those who develop pseudomeningocele but present with apparent neurological improvement, more credence should be given to regular follow-ups and careful examination.

CONCLUSIONS

CSFL is a common complication following thoracic decompression. Its occurrence is multi-factorial, especially in the pathology of thoracic myelopathy. Although its

impact on late neurological recovery is controversial, CSFL increases the risk of other perioperative complications, such as low intracranial pressure symptoms, infection, and vascular events. The combined use of primary repairs during surgery and conservative treatment postoperatively is presumably effective for the most CSFL cases, whereas lumbar drain and reoperation should be implemented as rescue options for refractory cases. In addition, there are many novel methods and products to treat CSFL, but they still require careful examination before their wider application in clinical practice.

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Conflicts of interest

There are no conflicts of interest.

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