

Risk Factors and Management Strategies of Cerebrospinal Fluid Leakage Following Lumbar Posterior Surgery

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Research Article

Keywords: lumbar posterior surgery, cerebrospinal fluid leakage(CSFL), risk factor, management strategy, Logistic regression analysis

Posted Date: October 1st, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-871914/v1>

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Version of Record: A version of this preprint was published at BMC Surgery on January 29th, 2022. See the published version at <https://doi.org/10.1186/s12893-021-01442-6>.

Risk factors and management strategies of cerebrospinal fluid leakage following lumbar posterior surgery

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Abstract

Objective: To analyze the risk factors of cerebrospinal fluid leakage (CSFL) following lumbar posterior surgery and summarize the related management strategies.

Methods: A retrospective analysis was performed on 3179 patients with CSFL strategies lumbar posterior surgery in our hospital from January 2019 to December 2020. There were 807 cases of lumbar disc herniation (LDH), 1143 cases of lumbar spinal stenosis (LSS), 1122 cases of lumbar spondylolisthesis (LS), 93 cases of lumbar degenerative scoliosis (LDS), 14 cases of lumbar spinal benign tumor (LST). Data of gender, age, body mass index (BMI), duration of disease, diabetes, smoking history, preoperative epidural hormone injection, number of surgical levels, surgical methods (total laminar decompression, fenestration decompression), revision surgery, extubation time, suture removal time, and complications were recorded.

Results: The incidence of 115 cases with cerebrospinal fluid leakage, was 3.62% (115/3179). One-way ANOVA showed that gender, body mass index (BMI), smoking

history, combined with type 2 diabetes and surgical method had no significant effect on CSFL ($P > 0.05$). Age, type of disease, duration of disease, preoperative epidural hormone injection, number of surgical levels and revision surgery had effects on CSFL ($P < 0.05$). Multivariate Logistic regression analysis showed that type of disease, preoperative epidural hormone injection, number of surgical levels and revision surgery were significantly affected CSFL ($P < 0.05$), and duration of disease and age of the patients were not significantly affected CSFL ($P > 0.05$). The extubation time of CSFL patients ranged from 7 to 11 days, with an average of 7.11 ± 0.48 days, the extubation time of patients without CSFL was 1-3 days, with an average of 2.02 ± 0.13 days, and there was a statistical difference between the two groups ($P < 0.05$). The removal time of CSFL patients was 12-14 days, with an average of 13.11 ± 2.67 days, and the removal time of patients without CSFL was 10-14 days, with an average of 12.87 ± 2.19 days, there was no statistically significant difference between the two groups ($P > 0.05$).

Conclusion: Type of disease, preoperative epidural hormone injection, number of surgical levels and revision surgery were the risk factors for CSFL. Effective prevention were the key to CSFL in lumbar surgery. Once appear, CSFL can also be effectively dealt with without obvious adverse reactions after intraoperative effectively repair dural, head down, adequate drainage after operation, the high position, rehydration treatment, and other treatments.

Keywords: lumbar posterior surgery; cerebrospinal fluid leakage(CSFL); risk factor; management strategy; Logistic regression analysis

1 Introduction

Cerebrospinal fluid leakage (CSFL) caused by dural tears (DT) is a common complication in spinal surgery, especially lumbar surgery ^[1]. According to literature reports, the incidence of CSFL is about 2%-20%^[2-4], which is related to trauma, intraoperative tumor resection, adhesion of dural sac to surrounding tissues, iatrogenic injury and other factors ^[5,6]. CSFL improper handling can lead to pseudo cyst, incision delayed healing of stiff backbone or not healing, infection of incision, infection of the central nervous system complications and even death ^[7, 8]. So CSFL is also gradually has drawn great attention of the spine surgeon. 115 cases of CSFL in 3179 cases of lumbar posterior surgery admitted to our hospital from January 2019 to December 2020 were retrospectively analyzed to explore the incidence, related risk factors and management strategies of CSFL complicated by lumbar posterior surgery. The relevant data were summarized and reported as following.

2 Subjects and methods

2.1 Inclusion Criteria:

(1) Based on the patient's medical history, signs and imaging examination, the patient was diagnosed as lumbar disc herniation(LDH), lumbar spinal stenosis(LSS), lumbar spondylo listhesis(LS), lumbar degenerative scoliosis(LDS), lumbar spinal benign tumor(LST).

- (2) Unsatisfactory results after systematic conservative treatment for more than 3 months.
- (3) No obvious surgical contraindications.
- (4) Posterior lumbar decompression (total lamina decompression or fenestration decompression).
- (5) Patients and their families had good compliance and were willing to cooperate with treatment and follow visitors.

2.2 Exclusion Criteria

- (1) Patients were underwent cervical and thoracic surgery at the same time.
- (2) Lumbar infectious diseases.
- (3) Malignant tumors in the lumbar spinal canal.
- (4) Patients or their families had poor compliance and were unwilling to cooperate with treatment and follow visitors.
- (5) Mental patients.

2.3 Diagnostic criteria for CSFL

- (1) Dural injury or CSFL was confirmed during the operation.
- (2) Postoperative headache, dizziness, and vomiting were related to the position. The incision had reddish blood or clear fluid exudation.
- (3) A large amount of reddish bloody fluid or clear fluid was drained from the drainage tube or incision after surgery.
- (4) Reddish bloody fluid or clear fluid was impaled from subcutaneous after incision.

2.4 General Data

A total of 3840 patients who underwent lumbar posterior surgery in our hospital from January 2019 to December 2020 were selected as the research subjects. 661 patients were excluded by exclusion criteria. A total of 3179 patients met the inclusion criteria, including 1606 males, 1573 females, and 2058 (1435 males, 523 females) who had a history of smoking. Aged from 24 to 80 years (mean 56.3 ± 12.8 years). The Body Mass Index (BMI) was 14.6-35.9kg/m² (mean 21.8 ± 6.2 kg/m²). There were 807 cases of LDH, 1143 cases of LSS, 1122 cases of LS, 93 cases of LDS, and 14 cases of LST. There were 1660 cases of total lamina decompression and 1519 cases of window

decompression. There were 2515 cases of primary surgery and 664 cases of revision surgery. Follow-up time ranged from 6 to 30 months (mean 15.7 ± 6.3 months). See Table 1 for details.

2.5 Surgical Process

All operations were performed under general anesthesia, prone position and posterior median approach. The spinous process, bilateral lamina and facet joints were exposed layer by layer. For revision surgery, the upper, lower, medial and lateral boundaries of the dural sac were exposed from the normal anatomical structure to avoid CSFL caused by separation in the surgical scar. If CSFL was found intraoperatively, when the ruptured site of the dural sac could be repaired by suture, waiting for the cerebrospinal fluid fully flowed out and not affected the surgical field of vision. If the cauda equina nerve was herniated from the rupture, the nerve should be stripped patiently and carefully, and then sutured with a non-injury-free thread until there was no obvious cerebrospinal fluid exudation at the rupture site. When the operation was completed, the leakage was covered with artificial dura or gelatin sponge, and tightly sutured layer by layer without any dead cavity.

2.6 Postoperative Treatment

- (1) After the operation, the head was low and the feet were high, and the bed tail was about 10cm high. According to the symptoms of low cranial pressure, the patient should increase or decrease by 2-3cm appropriately.
- (2) Positive pressure drainage was extended to 7-10 days after the operation. The drainage volume was monitored daily to record the color and properties of the liquid.
- (3) Antibiotics (ceftriaxone sodium, etc.) that could cross the blood-brain barrier were used.
- (4) Fluid supplement was paid attention to daily and monitored regularly electrolyte.
- (5) The dressing was changed regularly to keep the wound dry and avoid infection.
- (6) 6-7 days after the operation, the drainage tube was clamped for 24 hours to observe the wound and lower limbs. If the wound was dry and the lower limbs showed no obvious decrease in muscle strength, the drainage tube was removed 24

hours later, and the mouth of the drainage tube was ligated with silk thread and closed.

2.7 Observation Index

Data of gender, age, body mass index(BMI), duration of disease, diabete, smoking history, type of disease ,preoperative epidural hormone injection, number of surgical levels, surgical methods (total laminar decompression, fenestration decompression), revision surgery, extubation time, suture removal time, and complications were recorded.

2.8 Statistical Analysis

Measurement data were expressed as the mean± standard deviation. All data were analysed using SPSS 23.0 software. Count data were compared using chi-square test. Intergroup difference was compared using independent sample *t* test. Logistic regression analysis was used to analyze the factors with statistical significance in univariate analysis. $P < 0.05$ was considered statistically significant, and $P < 0.01$ was deemed highly significant.

3 Results

3.1 The incidence of CSFL

There were 115 cases of CSFL, with an incidence of 3.62% (115/3179). Intraoperative rupture of dural sac was found in 93 cases(79 cases of suture repair). 22 cases of delayed CSFL, no obvious dural injury or CSFL was found during the operation.

3.2 Univariate Analysis of risk factors for CSFL

One-way ANOVA showed that gender, body mass index(BMI), smoking history, combined with type 2 diabetes and surgical method had no significant effect on CSFL($P > 0.05$). Age, type of disease, duration of disease, preoperative epidural hormone injection, number of surgical levels and revision surgery had effects on CSFL($P < 0.05$). See Table 2 for details.

3.3 Multivariate Analysis of risk factors for CSFL

Multivariate Logistic regression analysis showed that type of disease, preoperative epidural hormone injection, number of surgical levels and revision surgery were significantly affected CSFL ($P < 0.05$), and duration of disease and age of the patients were not significantly affected CSFL ($P > 0.05$). See Table 3 for details.

3.4 Extubation time and removal time of CSFL

The extubation time of CSFL patients ranged from 7 to 11 days, with an average of 7.11 ± 0.48 days, the extubation time of patients without CSFL was 1-3 days, with an average of 2.02 ± 0.13 days, and there was a statistical difference between the two groups ($P < 0.05$). The removal time of CSFL patients was 12-14 days, with an average of 13.11 ± 2.67 days, and the removal time of patients without CSFL was 10-14 days, with an average of 12.87 ± 2.19 days, there was no statistically significant difference between the two groups ($P > 0.05$). See Table 4 for details.

3.5 Postoperative complications of CSFL

There were 29 cases (25.22%) of CSFL patients with low cranial pressure, and the symptoms were gradually relieved after raising the bed and sufficient fluid infusion. There were 6 cases (5.22%) with lower limb pain and numbness after extubation, which were gradually relieved after local physical therapy, dehydration and detumescence, local suction and other treatment, and did not lead to serious nerve injury. No intraspinal infection and intracranial hemorrhage or delayed healing of the incision, death and other complications occurred. There were no long-term complications such as dural pseudocyst at the last follow-up.

Typical case

Patient, SongX X, male, 48 years old, was admitted to the hospital due to "low back pain with left lower limb pain and anesthesia for more than 2 years, aggravating for 3 days". He was performed "L3 / 4, L4 / 5 posterior spinal canal decompression, discectomy, pedicle screw fixation + cage bone graft fusion" under general anesthesia after examination. No obvious CSFL was found intraoperatively, and 40ml dark red bloody fluid was drained on the 1st day after the operation, 120ml reddish bloody fluid was drained on the 2nd day, and 400ml reddish bloody fluid on the 3rd day, which

was considered postoperative delayed CSFL. The patient was treated with symptomatic treatment such as raising the bed tail and strengthening fluid supplementation. 350ml light red bloody fluid on the 4th day, 320ml light red bloody fluid on the 5th day, 270ml clear liquid on the 6th day, and 20ml clear liquid on the 7th day. See Figure 1 for details.

The drainage tube was clamped and observed for 24 hours on the 7th day after the operation. The wound dressing of the patient was dry, and there was no obvious blood or fluid leakage, There was no obvious abnormality in the motor sensation of both lower limbs. The drainage tube was removed, and the drainage tube orifice was sutured and closed with one stitch. MRI was reexamined on the 12th day after the operation (see Figure 2 for details). The wound was sutured and healed on the 13th day after the operation. MRI was re-examined more than 3 months after the operation (see Figure 3 for details).

4 Discussion

4.1 The incidence of CSFL

According to literature reports, the incidence of CSFL was about 2%-20%^[2-4]. The incidence of CSFL in primary lumbar surgery ranged from 5.5%-9.0%, while that in revision surgery ranged from 13.2%-21.0%^[9]. Koji et al.^[3] retrospectively analyzed 2146 patients who underwent lumbar posterior surgery in 8 hospitals, and the incidence of CSFL was about 7.7% (166/2146), among which the incidence of CSFL was 7.48% (123/1644) for LSS, 38.89% (7/18) for OPLL/OYL, 5.45% (23/422) for LDH, and 20.97% (13/62) for LDS. In this study, the incidence of CSFL was 3.62% (115/3179), 0.74% (6/807) for LDH, 2.54% (29/1143) for LSS, 3.29% (37/1122) for LS, 33.33% (31/93) for LDS, and 85.71% (12/14) for LST. The incidence of CSFL in initial surgery was about 1.67% (42/2515), and that in revision surgery was about 10.99% (73/664), which was slightly lower than that reported in domestic and foreign literatures. It might be related to our hospital as a specialized orthopedic hospital, lumbar surgery was now a routine operation in our hospital, and doctors at all levels had mastered various operations and formed our own characteristic procedures.

4.2 Possible reasons for CSFL

Possible reasons for CSFL mainly include the following aspects: (1) Trauma: CSFL caused by lumbar burst fracture tearing dura, and CSFL caused by bone fragments protruding towards the spinal canal puncturing the dura^[10]. (2) Patients' own factors: long course of disease, or severe spinal stenosis, herniated disc tissue, hyperplastic bone block or ligament adhesion to the dural sac^[11]. After multiple operations, the dural sac adhered to the surrounding tissues. The wall of the spinal canal tumor was a part of the dural sac, and partial dural sac should be removed when the tumor was completely removed^[12]. (3) Iatrogenic factors: Iatrogenic injuries are the main cause of most CSFL^[13]. Insufficient preoperative preparation, insufficient estimation of intraoperative difficulties, residual sharp bone edge injury of dura mater, intraoperative injury of dural sac^[14], inexperience of the operator, careless operation, etc. (4) Unexplained CSFL: such as spontaneous CSFL, which may be related to dural dysplasia and degeneration. There was no obvious CSFL in preoperative fracture films or intraoperative dural lesions, but hidden CSFL appeared after the operation.

4.3 Risk factors for CSFL

Multivariate regression analysis showed that the risk factors for CSFL were type of disease, preoperative intraspinal hormone injection, number of surgical levels and revision surgery ($P < 0.05$). Intradural tumor, degenerative scoliosis and severe lumbar spinal stenosis had been previously reported as high risk factors for CSFL^[3,13]. In our study, OR of type of disease was 3.936, with 95% confidence interval of 3.004-5.158, $P < 0.01$, indicating that type of disease had a significant effect on patients with CSFL. The incidence of CSFL was 85.71%, degenerative scoliosis was 33.33%, spondylolisthesis was 3.29%, lumbar spinal stenosis was 2.54%, lumbar disc herniation was 0.74%.

Studies^[15] had shown that patients with a long course of disease and long-term dural pressure lead to reduction of epidural fat, thinning of the dural thickness, the expansion of dural after laminectomy, and dural tear were prone to occur during decompression. However, in our multivariate study, OR of duration of disease was

1.004, 95% confidence interval was 0.739-1.363, $P > 0.05$, indicating that duration of disease was not a risk factor for CSFL.

In our study, OR of preoperative epidural hormone injection was 2.009, with a 95% confidence interval of 1.241-3.252, $P < 0.01$, indicating that preoperative epidural hormone injection was also one of the risk factors for CSFL. We considered that the hormones injected into the spinal canal (triamcinolone acetonide, etc.) were mostly macromolecules, which could not be completely absorbed by the body. They were accumulated around the lesions in the spinal canal and formed adhesion between the dural sac. In the process of decompression, it was easy to form dural rupture, leading to CSFL.

The number of surgical levels was also one of the risk factors for CSFL. In our study, the incidence of CSFL was 1.72% (18 / 1046) in patients with 1 level decompression, 3.81% (42 / 101) in patients with 2-3 levels decompression, and 5.33% (55 / 1032) in patients with more than 4 levels decompression. With the increase of the number of surgical levels, the risk of CSFL also increased, which was basically consistent with the results of foreign Studies^[16]. It was considered that the possible reason may be that with the increase of the number of surgical levels, more extensive treatment was needed. The incidence of CSFL was expected to be higher when the dural sac was exposed for a longer time. Meanwhile, the operative time was longer, the energy consumption of the operator was more, and the operation was not meticulous, which increased the chance of iatrogenic dural injury.

The incidence of CSFL in revision surgery was 10.99%, which was 2.853 times higher than that in primary surgery, suggesting that this factor had a greater impact on the occurrence of CSFL. In revision surgery, the vertebral lamina and other bone structures in the surgical area had been removed, the anatomical structure was different from the normal, the dura mater was widely adhered to the surrounding scar tissue, and the dura mater injury was easy to occur in the process of surgical operation to release the nerve root and dura mater^[16,17].

4.4 Management of CSFL

Combined with our experience and related literature, we summarized the following management methods:

(1) Intraoperative management

① Once CSFL occurred, according to the degree of dural injury, immediately patiently and carefully repair the dural. Early and timely detection of CSFL and tight suture of dura mater were the main methods to prevent postoperative CSFL^[18]. In our study, 93 cases of dural sac rupture were found during operation, of which 79 cases underwent suture repair.

② Artificial spinal patch repair, subcutaneous fascia or deep muscle fascia coverage, and fibrin glue sealing can be considered as the choice of dural rupture repair during operation^[5]. In our study, all patients with CSF were covered with artificial dura mater or deep fascia layer.

③ Close suture of muscle, fascia and skin, especially deep fascia layer, played a good role in preventing postoperative CSFL^[19]. Tight suture of deep fascia was the key to ensure good wound healing in patients with CSFL.

(2) Postoperative management

① Bed rest. Keeping a reasonable position and using head low and feet high (raising the bed tail about 10-15cm), could prevent the symptoms of low intracranial pressure, and reduce the pressure of CSF on the dural break, which was conducive to the healing of dural break.

② Choosing antibiotics that can pass through the blood-brain barrier, to prevent the occurrence of intracranial infection, and appropriately prolong the use time of antibiotics.

③ Frequently changing dressing, keeping the wound dry, strengthening nursing, moistening intestines and defecating, and reducing cough can increase the action of increasing the pressure of CSF caused by abdominal pressure, which were conducive to the healing of dura.

④ Strengthening fluid supplementation, maintaining the balance of water and electrolyte, and properly supplementing protein can promote the healing of dura.

⑤Prolonging the time of drainage tube placement. In our study, the drainage tube time of the CSFL patients was 7-11 days (average 7.11 ± 0.48 days). The drainage tube was clamped for about 7 days to observe the wound and muscle strength of both lower limbs for 24 hours. If the wound was dry, and there was no obvious motor sensory disturbance of both lower limbs, the drainage tube could be removed. If there was exudation on the wound surface and obvious motor sensory disturbance of both lower limbs, the drainage tube should be opened in time to continue drainage for 1-2 days. The time of extubation was judged by the above steps again. In our study, the drainage tube was removed in 3 patients for 11 days. If the drainage tube could not be removed, another operation should be performed to repair the dura. In our study, 1 patient was operated again and found dural break during operation. No CSFL occurred after dural repair.

4.5 Complications of CSFL

CSFL led to the loss of CSF, which would reduce intracranial pressure and lead to postural headache, dizziness, nausea, vomiting and other symptoms of low intracranial pressure^[20]. In our study, 29 patients with low intracranial pressure symptoms were gradually relieved after raising the bed and full fluid supplement. If CSF accumulated in the incision and compressed the related nerves, it would lead to lower limb pain, numbness and even paralysis^[21]. In our study, 6 patients with lower limb pain and numbness symptoms were treated with local physical therapy, dehydration and detumescence, and local suction, and the symptoms were gradually relieved, without causing serious nerve injury. CSFL could lead to the incision directly connected with the outside world, which was easy to cause incision infection. If pathogenic microorganisms retrograded with CSF, it could lead to spinal canal and intracranial infection, endangering the life of patients^[22]. There were no complications such as intraspinal infection, intracranial hemorrhage and delayed healing of incision. At the end of the follow-up period, there were no long-term complications such as dural pseudocyst.

5 Conclusion

CSFL was common in lumbar posterior surgery. Type of disease, preoperative epidural hormone injection, number of surgical levels and revision surgery were the risk factors for CSFL. Although various methods were taken to prevent CSFL, there was no absolute means to prevent CSFL. Effective prevention were the key to CSFL in lumbar surgery. Once appear, CSFL can also be effectively dealt with without obvious adverse reactions after intraoperative effectively repair dural, head down, adequate drainage after operation, the high position, rehydration treatment, and other treatments without obvious adverse reactions. However, due to the limitations of this study, such as only retrospective study, selection bias and so on, the results of this study may be biased, which needs to be further confirmed by multi-center prospective study.

Abbreviations :

BMI :body mass index

CSFL:cerebrospinal fluid leakage

DT :dural tears

LDH :lumbar disc hemiation

LDS :lumbar degenerative scoliosis

LS :lumbar spondylolisthesis

LSS:lumbar spinal stenosi

LST :lumbar spinal benign tumor

Ethical approval

This research was approved by Hubei 672 Orthopaedics Hospital of Integrated Chinese & Western Medicine Ethics Committee(Wuhan, China; permit no. HB6720298) and was in conformity with the guidelines of the National Institute of Health.

Consent for publication

Written informed consents were formally obtained from all participants.

Acknowledgements

Not applicable.

Funding

No funding was received.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

JT,QLL and WX, XWG made substantial contributions to the study conception and design, the acquisition of data and the analysis and interpretation of data. YL, CJW, XGL contributed to drafting the manuscript and critically revising the manuscript for important intellectual content. JT and QLL prepared the manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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Figure 1 Postoperative drainage was shown in Figure 1



Figure 2 MRI was reexamined on the 12th day after the operation.

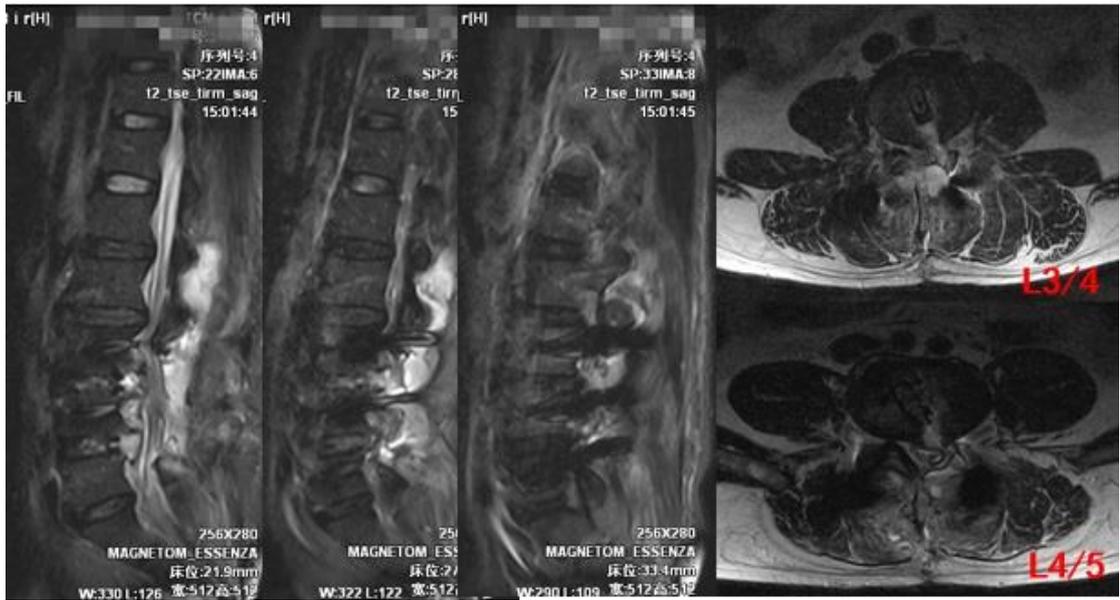


Figure3 MRI was re-examined more than 3 months after the operation.

