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# Incidence and management of cerebrospinal fluid fistulas in 336 multilevel laminectomies with noninstrumented fusions

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## Abstract

**Background:** The incidence (e.g., 3–27%) and the types of cerebrospinal fluid (CSF) fistulas occurring during multilevel lumbar laminectomy with noninstrumented spinal fusions varies.

**Methods:** From 2000 to 2015, we retrospectively evaluated the incidence/etiologies of CSF fistulas occurring for 336 patients undergoing average 4.7 laminectomies with average 1.4 level noninstrumented fusions over a 15 year period. The varied etiologies of CSF leaks included; ossification of the yellow ligament (OYL) extending through the dura, postoperative surgical scar, iatrogenic traumatic leak, epidural steroid injections (ESI), resection of synovial cysts, and the removal of intradural tumors. Techniques for primary repairs included combinations of; 7-0 Gore-Tex (Newark, Delaware, USA) sutures, micro-dural staples, muscle patch/other (e.g., bovine pericardial) grafts, fibrin sealants/glues (e.g., Tisseel; Baxter International Inc., Westlake Village, CA, USA), and Duragen (Integra LifeSciences, Hawthorne, NY, USA) including both the thin and suturable types.

**Results:** The etiologies of CSF fistulas in descending order included: Epidural spinal injections (ESI) (7 patients), synovial cysts (6 patients), OYL (5 patients), and equally for postoperative scar and intradural tumors (3 patients). CSF fistulas occurred in 24 (7.14%) of 336 patients; this frequency was reduced to 4.2% when ESI and intradural tumors were excluded.

**Conclusion:** CSF fistulas occurred in 7.14% of 336 patients undergoing average 4.7 multilevel laminectomies with average 1.4 level noninstrumented fusions attributed to a lumbar stenosis with mild/moderate instability. The dural repair addressed seven prior ESI, six synovial cysts, five OYL, and operative scarring and intradural tumors (three apiece). Knowing the pathologies contributing to CSF fistulas should help the surgeon to better anticipate and treat these fistulas.

**Key Words:** Cerebrospinal fluid fistulas, epidural steroid injections, lumbar stenosis, multilevel laminectomy, noninstrumented fusion, ossified yellow ligament, postoperative scar, synovial cysts

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## INTRODUCTION

The incidence/type of cerebrospinal fluid (CSF) fistulas for patients undergoing multilevel laminectomies with noninstrumented fusions varies from 3% to 27% in the literature.[5-8,10,11] In our series of 336 patients undergoing multilevel laminectomies with noninstrumented posterolateral fusions, the frequency and etiology of such fistulas were evaluated over a 15-year period. Anticipated



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factors likely to contribute to CSF leaks included: ossification of the yellow ligament (OYL), prior operative scar, synovial cysts, epidural steroid injections (ESI), and the resection of intradural tumors.

## MATERIALS AND METHODS

### Clinical background

The 336 patients averaged 66.5 years of age, included 211 females and 47 males, and were followed for an average of 7.1 years [Table 1]. Based upon dynamic X-rays and both magnetic resonance imaging (MR) and computed tomography (CT) studies, patients required average 4.7 level laminectomies addressing stenosis/OYL (336 patients), synovial cysts (66 patients), prior operative scar (38 patients), and intradural tumors (3 patients). Instability was attributed to Grade I spondylolisthesis at one (195 patients), two (67 patients), or three levels (3 patients), or for an additional 71 patients without preoperative olisthy, to anticipated extensive facet resections likely to result in instability. Average 1.4 level noninstrumented fusions utilized lamina autograft, bone marrow aspirate, and one of three bone graft supplements. The latter included inductive conductive matrix (ICM (first 72 patients), Medtronic, Memphis, TN, USA), vitoss (next 213 patients: Stryker, Malvern, PA, USA), and nanOss bioactive (final 51 patients: RTI Surgical, Alachua, FL, USA).

### Incidence of cerebrospinal fluid fistulas

The frequency of CSF fistulas was retrospectively assessed for all 336 patients. Direct primary repair required combinations of: 7-0 Gore-Tex (Newark, Delaware, USA) sutures, micro-dural staples, muscle patch grafts, or other grafts (e.g., bovine pericardium), a fibrin sealant (we used Tisseel: Baxter International Inc., Westlake Village, CA, USA), and Duragen (Integra LifeSciences, Hawthorne, NY, USA) utilizing thin and/or sutureable variants.

## RESULTS

Clinical parameters for the total of 24 patients who developed dural tears (DTs) revealed: they were slightly older, had more synovial cysts, included a comparable number with prior surgery, showed slighlty more average laminectomy levels, but included identical average levels of noninstrumented fusions [Tables 1 and 2]. The various etiologies of the CSF fistulas occurring in all 24 patients was 7.14%; if one subtracts out those with ESI and intradural tumors, it would be reduced to 4.2% [Tables 1-3].

### Seven epidural steroid injections: the leading etiology of intraoperative cerebrospinal fluid fistulas

Although we did not have accurate data regarding the total number of ESI performed for all 336 patients, we did encounter 7 patients with intraoperative punctate

**Table 1: 336 patients undergoing multilevel laminectomies/noninstrumented fusions**

| Variable | All 336 patients laminectomy/fusion | 24 patients with CSF^ leaks |
|---|---|---|
| Age | | |
| Average | 66.5 | 69.3 |
| SD*/median/mode | 10.31/69/73 | 10.3/70/78 |
| Range | 41-82 | 49-83 |
| Sex | | |
| Females/males | 211/47 | 20/4 |
| Average follow-up | 7.1 | 6.8 years |
| SD/range | 3.64/0.5-15 | 4.0/0.5-13 |
| Bone graft supplements | | |
| ICM** | 72 | 5 |
| Vitoss | 213 | 15 |
| Nanoss | 51 | 4 |
| Disc herniations | 93 | 4 |
| Single routine disc | 75 | 4 |
| Two routine discs | 9 | 0 |
| Far lateral disc | 61 | 0 |
| Single/double | 57/2 | 0 |
| Synovial cysts | 66 | 6 |
| Unilateral | 46 unilateral | 5 |
| Bilateral | 20 bilateral | 1 |
| Multiple | 9 | |
| L34/L45 | 6 | |
| T9/10 and T10/11 | 1 | |
| L23/L45 | 1 | |
| L45/L5S1 | 1 | |
| Average laminectomies | 4.7 | 5.1 |
| SD**/median/mode | 1.6/5/5 | 0.97/5/5 |
| Range | 2-10 | 3-7 |
| Laminectomy levels | | |
| 2 levels | 1 | 0 |
| 3 levels | 68 | 1 |
| 4 levels | 72 | 6 |
| 5 levels | 100 | 8 |
| 6 levels | 90 | 8 |
| 7-10 levels | 5 | 1 |
| Grade I spondylolisthesis | | |
| 0 slip | 71 | 7 |
| 1 slip | 195 | 13 |
| 2 slips | 67 | 4 |
| 3 slips | 3 | 0 |
| Levels fused: Average | 1.4 | 1.4 |
| 1 level fusions | 214 | 16 |
| 2 level fusions | 111 | 7 |
| 3 level fusions | 11 | 1 |
| Reoperations | 38 | 3 |
| Two operations | 35 | |
| Three operations | 1 | |
| Four operations | 2 | |

**ICM: Inductive conductive matrix, *SD: Standard deviation, CSF^: Cerebrospinal fluid

**Table 2: Clinical variables for 24 patients with CSF^ leaks**

| Variable | 24 patients with CSF^ leaks |
|---|---|
| CSF^ leaks total | 24 |
| Epidural steroid injections (ESI***) | 7 |
| Synovial cysts | 6 |
| OYL^^ | 5 |
| Tumor removal | 3 |
| Prior surgery scar/reoperations | 3 |
| Comorbidities | |
| Hypertension | 17 |
| Diabetes | 4 |
| Elevated cholesterol | 5 |
| Coronary artery disease | 5 |
| Smokers | 7 |
| Obesity | 8 |
| Osteoporosis | 11 |
| Average BMI** for 24 patients | 27.5 |
| SD* | 5.2 |
| Median/mode | 28.4/24.4 |
| Range | 14-41 |
| Average duration of surgery (h) | 4.25 |
| SD* | 0.64 |
| Range | 3.5-5.5 |
| Average estimated blood loss (cc) | 181.8 |
| SD* | 75.08 |
| Range | 100-350 |
| Average time to fusion (months) | 5.4 |
| SD* | 1.9 |
| Range | 2.5-10 |
| Synovial cysts | 6 |
| Unilateral | 5 |
| Bilateral | 1 |
| Discs herniations | 4 |
| Postop scar/routine disc | 1 |
| OYL/routine disc | 1 |
| ESI/routine disc | 2 |
| Fusion levels | |
| L123 | 1 |
| L23 | 2 |
| L2345 | 1 |
| L34 | 1 |
| L345 | 6 |
| L45 | 12 |
| L45S1 | 1 |
| Laminectomy levels | |
| L1-S1 | 8 |
| L2-S1 | 8 |
| L3-S1 | 3 |
| L1-L3 | 2 |
| L1-L4 | 2 |
| L3-L5 | 1 |

*SD: Standard deviation, OYL^^: Ossification of the yellow ligament, BMI**: Body mass index, CSF^: Cerebrospinal fluid, ESI***: Epidural steroid injection

CSF fistulas secondary to ESI requiring direct dural repair; these were predominantly recognized in patients undergoing the most recent surgery. All 7 had undergone at least one ESI within 5 weeks of surgery; 5 patients had undergone 3 ESI, 1 patient had over 6 ESI performed over the prior 2 years, and another patient had over 12 injections over the last 4 years.

## Six synovial cysts leading to cerebrospinal fluid fistulas

Sixty-six of 336 patients in the series had synovial cysts; 46 were unilateral while 20 were bilateral [Table 1]. In addition, 9 of the latter 20 patients exhibited multilevel synovial cysts: 6 at L3–L4 and L4-L5, and one each at T9/T10 and T10/11, L23 and L45, and L45 and L5S1. CSF leaks occurred in 6 (9.1%) of 66 patients; these occurred with single synovial in 5 cases, while one patients with synovial cysts [Table 2].

## Five cerebrospinal fluid fistulas with ossification of the yellow ligament extending to/through the dura

All 336 patients in this series had OYL in conjunction with lumbar spinal stenosis; 5 (1.5%) of these patients developed CSF fistulas due to OYL extending to/through the dura [Tables 1 and 2].

## Three cases of cerebrospinal fluid fistulas following prior surgery

There were 38 patients in this series who had prior lumbar surgery; 35 patients had two, one had three, and two had a total of four prior operations [Tables 1 and 2]. Three (7.9%) of 38 patients with prior surgery developed CSF fistulas; all 3 had just one prior operation (2 total lumbar procedures).

## Three cerebrospinal fluid fistulas due to intradural tumor removal (neurofibromas)

Three (7.9%) patients required removal of intradural extramedullary neurofibromas in conjunction with decompression of stenosis [Table 2].

## Subset of disc herniations with dural tears attributed to postoperative scar, ossification of the yellow ligament, and epidural steroid injections

Four of the 24 patients with intraoperative DT also exhibited routine disc herniations in conjunction with the previously noted: prior operative scar (1 patients), OYL (1 patient), and ESI (1 patient) [Tables 1 and 2].

## Incidence of postoperative recurrence of cerebrospinal fluid fistulas

Utilizing combinations of complex intraoperative repair techniques under an operating microscope, including 7-0 Gore-Tex sutures, micro-dural staples, muscle patch grafts, Duragen (soft/suturable-2 types), and Tisseel, no patients developed recurrent postoperative CSF fistulas.

**Table 3: Frequency of DTs in spine surgery (majority: Lumbar procedures)**

| Author year | Intraoperative DTs^^ (%) | Postoperative dural leaks (%) | Numbers and types of operations |
|---|---|---|---|
| Epstein 2015 (present study) | 7.14<br>4.2 | 0 | 336<br>Multilevel lumbar laminectomies<br>Noninstrumented fusions<br>Without ESIs^ or tumors |
| Epstein 2007[8] | 9.1 | 0 | 110<br>Multilevel lumbar laminectomies<br>Noninstrumented fusions |
| Bydon *et al.* 2015[1] | 10.0 | 1.6 | 500<br>Lumber laminectomies |
| Khazim *et al.* 2015[10] | | 0.83 | 2052<br>Lumbar surgery |
| Tsahtsarlis and Wood 2012[16] | 0 | 0 | 34<br>MI** TLIF* |
| Ross 2014[14] | <br>2.7 overall<br><br>3.4 lumbar only | | 1231<br>MI** tubular microdiskectomy: Cervical, thoracic, lumbar (overall)<br>Lumbar only |
| Park *et al.* 2015[13] | 0.8 | | 124<br>MI** TLIF* |
| Cammisa *et al.* 2000[2] | 3.1 | 0.28 | 2144<br>Lumbar/thoracolumbar |
| Du *et al.* 2014[4] | 3.8 | | 4822<br>Lumbar or thoracolumbar |
| Kogias *et al.* 2015[11] | 19.5<br>17 | | 135<br>Revision lumbar microdiskectomy<br>Open<br>MI** |
| Hughes *et al.* 2006[9] | 8.7 | | 184<br>Instrumented lumbar fusions |

*TLIF: Transforaminal lumbar interbody fusion, ^ESI: Epidural steroid injections, **MI: Minimally invasive, DTs^^: Dural tears

## DISCUSSION

### Anticipated incidence of durotomy

Many quote an overall 3–27% incidence of intraoperative DT occurring during lumbar spinal surgery, while others cite additional smaller frequencies for postoperative dural fistulas [Table 3].[5-8,10,11,16] In 2007, Epstein found that 10 (9.1%) of 110 predominantly geriatric patients experienced DT during multilevel laminectomies/noninstrumented fusions that were attributed to; OYL through the dura (3 patients), synovial cysts (5 of 10 patients with DT had synovial cysts vs. 8 of 100 without DT), and prior surgical scar (2 of 10 patients with DT had prior surgery vs. 10% without DT).[8] Bydon *et al.* study in 2015, evaluated the clinical and surgical outcomes following 500 laminectomies for patients who were followed an average of 46.79 months; the intraoperative durotomy rate was 10.00%, with an additional 1.60% experiencing a postoperative CSF leak.[1] Khazim *et al.* in 2015 further observed that 17 (0.83%) of 2052 consecutive patients developed the late presentation of DT (LPDT-postoperatively); 15 initially required surgery (2 patients required second operations, and 2 required lumbar drains); one initially received a lumbar drain, and one patient's DT resolved with conservative measures.[10]

### Under-reported cerebrospinal fluid leaks for minimally invasive lumbar surgery

Although the studies quoted below cite extremely low frequencies of DT with minimally invasive (MIS or MI) lumbar surgery, the medicolegal system indicates a much higher incidence of DT in the hands of others' not publishing their untoward experiences including major paralyses [Table 3]. Tsahtsarlis and Wood, in 2012, found no CSF fistulas following 34 consecutive MI transforaminal lumbar interbody fusions (MI-TLIF).[16] In 2014, Ross utilizing MIS tubular access surgery to the cervical, thoracic, and lumbar spine; found only 33 DT (2.7% overall or 3.4% of lumbar cases) out of 1231 cases; DT's were not more common for MIS versus open procedures, and typically did not warrant secondary surgical repairs.[14] In 2015, Park *et al.* evaluated the perioperative complications associated with their institution's first 124 MI-TLIF; 11 complications included 1 DT, 3 postoperative neuralgias, 2 deep wound infections, 2 pedicle screw misplacements, 2 cage migrations, and 1 graft extrusion.[13] Notably, 8 occurred in the first third of the series cases.

## Rate of cerebrospinal fluid leaks for lumbar reoperations

Spine surgeons know that intraoperative DT's are more frequent with reoperations [Table 3]. In 2000, Cammisa *et al*. documented that DT occurred in 74 of 2144 patients undergoing spinal procedures; 66 occurred intraoperatively and were most frequently encountered in those with prior surgery, while 0.28% were solely noted postoperatively.[2] Notably, 60 of 66 were primarily repaired and required no further surgery, while the remaining 6 (5 with pseudomeningoceles) all required secondary operative repairs. In Epstein's 2007 study, 2 of 10 DT occurring in 110 patients undergoing multilevel laminectomies/noninstrumented fusions; these were attributed to prior surgical scar, while a lesser 10% of the remaining 100 patients without DT had prior surgery.[8] In 2014, Du *et al*. encountered DT in 182 (3.8%) of 4822 patients undergoing lumbar or thoracolumbar surgery: factors contributing to DT included (in descending order); revision spine surgery, laminectomy, and older age.[4] In 2015, Kogias *et al*. retrospectively compared the frequency of DT for open (19.5% =16/82 patients) versus MIS (17% =9/53 patients) revision microdiskectomy (135 patients); the majority were successfully repaired with an absorbable fibrin sealant patch alone.[11]

## Risks of cerebrospinal fluid fistulas with synovial cysts

In 2012, Epstein discussed the "pros" of open surgical management of synovial cysts (success rates of up to 92.5%) versus the high incidence of DT and other complications with MIS or percutaneous techniques.[5] Synovial cysts were emptied, and capsules were excised where feasible, only leaving behind the portion of capsule densely adherent to the dura. Alternatively, percutaneous measures largely left the majority of these lesions behind (e.g., thick fibrinous capsules with crank-case intracyst (nonaspirable) fluid). In 2015, Scholz *et al*. reviewed the records of 148 patients undergoing microsurgical lumbar synovial cyst excision; although only 8 cysts (5.4%) were incompletely resected due to dural adhesions, none required secondary surgery for recurrent synovial cysts.[15]

## Epidural steroid injections contribute to intraoperative cerebrospinal fluid fistulas

In 2014, Epstein noted that despite no documented long-term efficacy for ESI in spinal stenosis, ESI are typically administered in multiples of 3 to older patients, and increasingly result in intraoperative punctate DT.[7] Looking at a recent subset of 33 of 39 patients undergoing average 4.3 level laminectomies and 1.3 level noninstrumented fusions utilizing lamina autograft and nanoss bioactive, 6 (18.2%) patients had operatively confirmed, punctate CSF fistulas due to ESI. What they had in common that most likely contributed to these leaks was a recent ESI injection that had been performed between 2 and 5 weeks prior to lumbar surgery (average 3.9 weeks).

## Treatment strategies for repairing cerebrospinal fluid fistulas

In 2015, Clajus *et al*. found that of 109 neurosurgical departments in Germany treating CSF fistulas, 65.1% utilized combinations of techniques; 28 (25.7%) used suture alone, 7 (6.4%) used fibrin-coated fleeces alone, 2 used (1.8%) muscle patch alone, and 1 (0.9%) used fibrin glue alone.[3] Furthermore, 72.5% used bed rest for 1–3 days, while 25.7% allowed patients out of bed immediately.

### *Fibrin glues to strengthen dural repair*

In 2013, Epstein reviewed the various techniques for direct primary repair of operatively recognized CSF fistulas.[6] Direct surgical repair techniques included utilizing interrupted 7-0 Gore-Tex (W.L. Gore and Associates Inc., Elkton, MD, USA) sutures, muscle or other (e.g., bovine pericardium) patch grafts, fibrin glues or dural sealants (e.g., Tisseel: Baxter Healthcare Corporation, Deerfield, IL, USA), and soft or saturable microfibrillar collagen (Duragen: Integra Life Sciences Holdings Corporation, Plainsboro, NJ). Notably, lumbar drains (which may produce larger more cephalad CSF fistulas) and wound-peritoneal and/or lumboperitoneal shunts are used only very rarely.

## Computed tomography-guided epidural patching of postoperative cerebrospinal fluid fistulas

In 2014, Mihlon *et al*. evaluated the efficacy of repairing postoperative CSF fistulas utilizing MI, percutaneous CT-guided epidural patching.[12] The study retrospectively identified 9 such cases utilizing CT myelography; those effectively treated percutaneously had dural defects of 4 mm or less without pseudomeningoceles, while those with larger defects and pseudomeningocele could not be managed with this percutaneous strategy.

## Prolonged Jackson-Pratt drainage for cerebrospinal fluid leaks following instrumented fusions

As an example of what not to do, I would offer the study by Hughes *et al*. in which they utilized prolonged Jackson-Pratt (JP) drainage to treat lumbar CSF leaks.[9] In their retrospective study of 184 instrumented fusions, they identified 16 (8.7%) patients for whom DT were repaired and treated with subfascial JP drains. However, 8 of the 16 patients were treated with prolonged JP drainage. In fact, they were discharged home on oral antibiotics and had the drains removed as outpatients 10–17 days later. Although no patients developed postoperative complications attributed to this management technique, it still placed patients at increased risk for infection and other complications attributed to over-drainage of CSF (e.g., including cranial or spinal subdural hematomas).

## CONCLUSION

Although DT may occur during any lumbar surgery, their frequency is greater with: recently preoperatively performed ESI (e.g., within the last 5 weeks), synovial cysts, severe OYL, prior surgery, and of course, electively opening the dura (e.g. a direct requisite for resection of intradural tumors). For all of these patients, the routine use of the operating microscope should help limit the frequency of DT, along with greater anticipation and vigilance at the levels of the most severe pathology. The recent over-use/abuse of ESI should also be taken into account, as patients with recent ESI should be counseled that resulting DT newly documented intraoperatively may require repair.

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### Conflicts of interest
There are no conflicts of interest.

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