Healthcare Economics

Costs of postoperative cerebrospinal fluid leakage: 1-year, retrospective analysis of 412 consecutive nontrauma cases

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Abstract

Background: Cerebrospinal fluid (CSF) leaks are widely recognized as commonly occurring postoperative complications of neurosurgical procedures. We will focus on the direct costs associated with CSF leaks in a single center across multiple neurosurgical procedures, based on a retrospective analysis. We will also compare the costs of using a synthetic agent to prevent such leaks with these costs from a more recent study.

Methods: The single-center retrospective study was carried out at the Neurosurgical Center Nijmegen (University Medical Center St Radboud and Canisius Wilhelmina Hospital, Nijmegen, Netherlands) from January 01, 1999, until December 31, 1999. Four hundred twelve consecutive, nontrauma, elective procedures were examined.

Results: By applying strict criteria for CSF leakage (including those self-limiting subcutaneous minor CSF collection), we found an overall leak rate of 10.7% with a lower number for supratentorial and transsphenoidal procedures and much higher numbers for infratentorial procedures and extensive skull base procedures (6 [12.8%] of 47 and 18 [34.6%] of 52, respectively). The CSF leak in these 44 patients was associated with high additional costs which accounted for 21.7% of the total costs of all 412 procedures or on average €1508 per patient and procedure. If DuraSeal (Confluent Surgical, Inc, Waltham, MA) were to be used prophylactically for every procedure, and assuming a 4% leak rate postprocedure (which was achieved in a more recent study of 46 patients using DuraSeal), there would be a saving of €550 for every procedure (reduction in additional costs of CSF leak minus the cost of the sealant), or a total saving of €226 600 in the series of 412 patients.

Conclusion: Our analysis establishes that CSF leaks occur with high frequency and incur significant costs across all types of surgical procedures. A direct correlation of this complication (and ensuring costs) is observed with more extensive procedures, and reduction of these significant costs can be achieved by using augmentation of the dural closure with DuraSeal.

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Keywords: Cerebrospinal; CSF; Leakage; Costs; Dural repair; DuraSeal; Neurosurgery; Postoperative complication; Retrospective

1. Introduction

Cerebrospinal fluid leaks are widely recognized as commonly occurring postoperative complications of neurosurgical procedures. However, little is known about the specific costs involved with CSF leaks, and it is imperative for the neurosurgical community to appreciate these costs in their entirety. Studies [1,3] have been performed to compare success rates of different methods of CSF leak closure and the cost benefits of not using prophylactic antibiotics. Success with fibrin sealants has been variable across different teams [6,8,9]. Fibrin glue applications come with complications of their own, both acute as well as chronic. Acute reactions include immune responses to protein content and, rarely, anaphylaxis. Very often, procedures using fibrin glue still require surgeons to use lumbar and ventricular drainage as a prophylactic measure, which can act as a source for infection.
Table 1
412 Elective craniotomies and transsphenoidal procedures
• 269 Supratentorial craniotomies (Table 2)
• 47 Infratentorial craniotomies (Table 3)
• 44 Endoscopic transsphenoidal procedures (Table 4)
• 52 Extensive skull base procedures (Table 5)

Table 2
Supratentorial craniotomies
• 39 Glioma
• 54 Aneurysm
• 39 Metastases
• 30 Meningioma
• 10 Arteriovenous malformation
• 9 Pituitary tumor
• 8 Craniopharyngioma
• 8 Intracerebral hematoma
• 7 Cavernoma
• 6 Pineal tumor
• 4 Ependymal cyst
• 3 Brain abscess
• 2 Epidermoid tumor procedures

Table 3
Infratentorial craniotomies
• 11 Microvascular decompression
• 10 Metastasis
• 6 Cysts
• 4 Arnold-Chiari decompression
• 5 Astrocytoma
• 4 Medulloblastoma
• 2 Ependymoma
• 1 Aneurysm
• 1 Arteriovenous malformation
• 1 Hemangioblastoma
• 1 Epidermoid tumor
• 1 Abscess procedure

Table 4
Endoscopic transsphenoidal procedures
• 37 Pituitary adenomas
• 4 Recurrent pituitary adenomas
• 2 Rathke Cleft Cyst
• 1 Olfactory groove meningioma

Table 5
Extensive skull base procedures
Anterior fossa procedures:
• 7 Cavernous minus meningioma
• 6 Sphenoid/orbital meningioma
• 3 Midfacial degloving for chordoma
• 1 Esthesioneuroblastoma
• 1 Frontobasal resection for sarcoma
Middle fossa procedures:
• 1 Petrous apex granuloma
• 1 meningioma “en plaque”
Posterior fossa procedures:
• 16 Retromastoid vestibular schwannoma
• 9 Petroclival meningioma
• 7 Translabyrinth vestibular schwannoma

Table 6
Typical direct medical costs (€)
<table>
<thead>
<tr>
<th>Procedure type</th>
<th>No. of procedures</th>
<th>No. of CSF leaks</th>
<th>% Leaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital stay (regular)</td>
<td>499</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital stay (ICU)</td>
<td>1089</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgeon’s fee (glioma)</td>
<td>220</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgeon’s fee (aneurysm)</td>
<td>309</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgeon’s fee (MVD)</td>
<td>261</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT diagnostics</td>
<td>193</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRI diagnostics</td>
<td>354</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory (preoperative) exams</td>
<td>113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-d Intravenous antibiotics</td>
<td>1021</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ICU indicates intensive care unit; MVD, microvascular decompression; MRI, magnetic resonance imaging.

Table 7
Summary of procedures and leaks

<table>
<thead>
<tr>
<th>Procedure type</th>
<th>No. of procedures</th>
<th>No. of CSF leaks</th>
<th>% Leaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supratentorial</td>
<td>269</td>
<td>17</td>
<td>6.3</td>
</tr>
<tr>
<td>Infratentorial</td>
<td>47</td>
<td>6</td>
<td>12.8</td>
</tr>
<tr>
<td>Transsphenoidal</td>
<td>44</td>
<td>3</td>
<td>6.8</td>
</tr>
<tr>
<td>Skull base</td>
<td>52</td>
<td>18</td>
<td>34.6</td>
</tr>
<tr>
<td>Totals</td>
<td>412</td>
<td>44</td>
<td>10.7</td>
</tr>
</tbody>
</table>

Table 8
Comparison of all procedures

<table>
<thead>
<tr>
<th>Group</th>
<th>For each procedure, €</th>
<th>For the group (totals), €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without CSF leak</td>
<td>12386</td>
<td>4723719</td>
</tr>
<tr>
<td>With CSF leak</td>
<td>29798</td>
<td>1311130 (21.7% of total costs)</td>
</tr>
<tr>
<td>Average cost</td>
<td>14648</td>
<td>6034850</td>
</tr>
<tr>
<td>Average extra cost</td>
<td>1508</td>
<td>621198 (10.3% of total costs)</td>
</tr>
</tbody>
</table>

Table 9
Supratentorial procedures

<table>
<thead>
<tr>
<th>Group</th>
<th>Cost per procedure, €</th>
<th>No. of procedures</th>
<th>Total costs, €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without CSF leak</td>
<td>12012</td>
<td>252</td>
<td>3027133</td>
</tr>
<tr>
<td>With CSF leak</td>
<td>23591</td>
<td>17</td>
<td>378360</td>
</tr>
<tr>
<td>All procedures</td>
<td>12744</td>
<td>269</td>
<td>3428182</td>
</tr>
<tr>
<td>Extra leak costs</td>
<td>11579</td>
<td>17</td>
<td>196837 (5.7% of total costs)</td>
</tr>
</tbody>
</table>

Table 10
Infratentorial procedures

<table>
<thead>
<tr>
<th>Group</th>
<th>Cost per procedure, €</th>
<th>No. of procedures</th>
<th>Total costs, €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without CSF leak</td>
<td>14433</td>
<td>41</td>
<td>591750</td>
</tr>
<tr>
<td>With CSF leak</td>
<td>27111</td>
<td>6</td>
<td>162664</td>
</tr>
<tr>
<td>All procedures</td>
<td>16051</td>
<td>47</td>
<td>754414</td>
</tr>
<tr>
<td>Extra leak costs</td>
<td>12678</td>
<td>6</td>
<td>76066 (10.0% of total costs)</td>
</tr>
</tbody>
</table>
Chronic complications include adhesions and a new nidus for infection. In this paper, we will focus on the direct costs associated with CSF leaks in a single center across multiple neurosurgical procedures, based on a retrospective analysis. We will also compare the costs of using a synthetic agent to prevent such leaks with these costs from a more recent study.

2. Patients and methods

The single-center retrospective study was carried out at the Neurosurgical Center Nijmegen (University Medical Center St Radboud and Canisius Wilhelmina Hospital, Nijmegen, Netherlands) from January 01, 1999, until December 31, 1999. Four hundred twelve consecutive, nontrauma, elective procedures were examined (Tables 1-5 for breakdown of patient types). All events associated with postoperative CSF leak have been recorded, including minor subcutaneous CSF collection resolving without any treatment, puncture of subcutaneous collections, asymptomatic CSF collections of postoperative imaging, pseudomeningocele, and overt leakage from the surgical site or through nose or ear.

The factors used to calculate the direct medical costs were days of hospital and intensive care unit stay, surgeon’s fee including costs of extra CSF drainage (lumbar/ventricular) and/or surgical reexploration, costs of diagnostic procedures (computed tomography/magnetic resonance imaging/laboratory), and costs of antibiotic therapy (Table 6).

3. Observations

There are significant differences in the incidence and cost impact of CSF leaks across procedures (Tables 9-12).

Extensive skull base and infratentorial procedures are especially prone to CSF leaks and incur significant additional costs (Table 4). However, all categories of procedures in our study incurred a significant amount of CSF leaks.

Procedures involving CSF leaks cost, on average, 141% more than procedures that do not result in a postoperative CSF leak (Table 8).

Procedures involving CSF leaks accounted for 10.7% of all procedures and also for 21.7% of the total costs for all procedures (Tables 7 and 8). The total extra cost attributed to CSF leaks for all 412 patients was €621198 which is an average of €1508 per patient (Table 8).

We compared these costs to the costs of using a synthetic tissue sealant in a more recent study, which we presented in 2003 [2]. In this more recent patient group (Table 13), we observed a similar mix of patients across a variety of neurosurgical procedures.

In our sample of 46 patients, we used on average 1 kit of sealant per patient and achieved 96% success, that is, no CSF leaks. The incremental average price per procedure was €400 (based on current selling prices in the European union).

If one would assume a reduction of the leak rate to 0% when using this sealant in every single procedure, the saving per patient and procedure would be €1508 minus the cost of the sealant which is on average €400. However, an overall reduction leak rate of 0% does not seem realistic. At present, we had a reduction from 10.7% overall CSF leak to 4% which is a reduction of 63% in leak rate.

Therefore, the total saving in those 412 patients would not have been €621198 but 63% of it, €391355, or on average €950 per patient.

Because this would have been achieved by using the sealant in all cases, the final saving would have been €550 per patient or a total of €226600 during that 1-year period with 412 procedures, and that is certainly a substantial amount of money.
4. Discussion

To the best of our knowledge, this is the only, albeit retrospective, cost study that evaluates costs across the entire spectrum of neurosurgical procedures. Previous studies have focused on specific neurosurgical areas, such as [5] percutaneous procedures to treat lumbar sacral leaks. The incidence of CSF leaks in our patients was similar to levels reported by other authors [4,7]. Our analysis establishes that CSF leaks occur with high frequency and incur significant costs across all types of surgical procedures. A direct correlation of this complication (and ensuring costs) is observed with more extensive procedures.

We anticipate 3 other similarly significant cost categories that have occurred as a result of CSF leaks that were not analyzed as part of this study, namely indirect medical costs and direct and indirect nonmedical costs.

When we compare only the additional average direct medical costs due to postoperative CSF leak per patient (€ 1508) with those of using a synthetic sealant (€ 400) from the data that we presented in 2003, a simple mathematical model would indicate that if DuraSeal were to be used prophylactically for every procedure (as it was done in the study of 2003), and assuming a 4% leak rate postprocedure (as achieved in the study of 2003), there would be a saving of € 550 for every single neurosurgical procedure. Although certain procedures are associated with very low risk of postoperative CSF leak, one could argue that it would be sufficient to use the sealant only in those procedures that are prone to CSF leak, such as infratentorial and skull base procedures. However, according to this study (and applying strict criteria for CSF leak), even supratentorial procedures are associated with a leak rate of 6%.

There are limitations to this comparison, since our costs were calculated in 1999, and the costs of the sealant were assessed in 2002 to 2003. Furthermore, our study is limited due to its location at a single-center retrospective nature and case heterogeneity. However, even with these limitations, these data are indicative of the fact that:

a. Postoperative CSF leak is associated with high additional direct medical costs.

b. Reduction of the leak rate will result in significant economic savings.

c. Augmentation of the usual dural closure with a sealant that has been proven to lead to a significant reduction of CSF leak rate, although costly, is more than justified in view of the significant reduction in overall medical costs of neurosurgical procedures.

The current lack of data creates the need for larger more comprehensive studies. We propose to collaborate with other centers interested in similar research to conduct future studies of the economics involved in CSF leaks and price-worthy technologies to decrease their occurrence.

References


Commentary

This paper has a nidus of useful information, which is the comparison in direct medical costs between cases with and cases without postoperative cerebrospinal fluid leak, and a somewhat rough estimate of the overall cost, or cost savings, in using a dural sealant prophylactically.

It is, however, a weak comparison and is more a suggestion that routine DuraSeal use might be useful for cranial surgery than a scientific proof of the thesis. I would have preferred to see the use of this rough data as suggestive of a proposition, proven or disproven with a randomized study with concurrent controls. In that case, the confounding factors could be eliminated, and a valid conclusion drawn about the advisability of routine use of dural sealants.

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Doctor Grotenhuis is to be congratulated for his careful analysis of the total and differential costs which are attributable to the management of CSF leaks in a variety of cranial neurosurgical procedures. CSF leaks in infratentorial and, particularly, skull base cases are well known to be a significant clinical and economic problem, but the quantification of the extent of the cost is eye opening.