Eur Spine J (2014) 23:389–394
DOI 10.1007/s00586-013-3091-z

ORIGINAL ARTICLE

Incidental dural tear in spine surgery: analysis of a nationwide database

Hiroyuki Yoshihara · Daisuke Yoneoka

Received: 13 June 2013 / Revised: 30 October 2013 / Accepted: 30 October 2013 / Published online: 9 November 2013

Abstract
Purpose The purpose of this study was to report the incidence of dural tear (DT) in spine surgery, risk factors, and patient outcomes on a national level.
Methods Clinical data were obtained from the Nationwide Inpatient Sample for 2009. Patients who underwent spine surgery were identified and, among them, patients who had DT were identified, according to the International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) codes. Patient and hospital demographic data were retrieved. The incidence of DT and in-hospital patient outcomes were analyzed. Multivariate logistic regression analysis was performed to identify the risk factors for DT.
Results The incidence of DT was 2.7 % (17,932/665,818). Multivariate analysis revealed that older age, female gender, increased Elixhauser comorbidity score, and high hospital caseload were the significant risk factors for DT. Comparison between patients with and without DT showed that those with DT had significantly higher overall in-hospital complications (18.8 vs. 10.2 %), higher in-hospital mortality rate (0.4 vs. 0.3 %), longer hospital stays (5.1 vs. 3.7 days), lower proportion discharged home routinely (61.0 vs. 76.8 %), and increased total hospital charges ($85,138 vs. $71,808), respectively.
Conclusions The reported incidence of DT in spine surgery was 2.7 % in the US. Risk factors included older age, female gender, increased comorbidities, and high hospital caseload. DT increased the rate of in-hospital complications and mortality and health care burdens.

Keywords Dural tear · Spine surgery · Incidence · Risk factor · Patient outcome · Nationwide Inpatient Sample

H. Yoshihara (✉)
Department of Orthopaedic Surgery, NYU Hospital for Joint Diseases, 301 East 17th St., New York, NY 10003, USA
e-mail: hiroyoshihara55@yahoo.co.jp

H. Yoshihara
Department of Orthopaedic Surgery, SUNY Downstate Medical Center, Brooklyn, United States

D. Yoneoka
Department of Statistical Science, School of Advanced Sciences, The Graduate University for Advanced Studies, Tachikawa, Japan

Introduction

Incidental dural tear (DT) is a frequent intraoperative complication of spine surgery. The reported incidence of DT for all spine surgeries is 1.6–10 % [1–6]. Previous studies have examined various risk factors for DT, which include age, patient gender, and experience level of the surgeon [1, 2, 7–12]. DTs that cannot be closed, those that are not adequately closed, or those that are unrecognized may result in relevant cerebrospinal fluid leakage, which may cause postural headaches, vertigo, posterior neck pain, neck and/or stiffness, nausea, diplopia, photophobia, tinnitus, and blurred vision [13–15]. To prevent continuous cerebrospinal fluid leakage as well as these symptoms, postoperative managements of DT include subarachnoid lumbar drain and postoperative bed rest [4, 16–19]. However, these management methods can lead to higher complication rates, extended hospital stays, and higher hospital charges, and the data on those patient outcomes associated with DT were sparse in the previous studies.

In this study, we determined the reported incidence of DT in spine surgery, statistically significant risk factors, and in-hospital patient outcomes by analyzing population-based national hospital discharge data in the US collected for the Nationwide Inpatient Sample (NIS) for 2009.

Methods

Data source

The NIS is the largest all-payer inpatient care database in the US and contains data from approximately 8 million hospital stays from 1,000 hospitals each year. These data comprise a 20 % stratified sample of all United States community hospitals [20]. Every entry in the database represents a single hospitalization record. Records in the NIS database include discharge and hospital information which were used to generate national estimates in this analysis.

Patient selection

A retrospective analysis using hospital discharge data from the NIS for the year 2009 was performed. The International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) codes were used to identify discharges. The Clinical Classification Software (CCS) devised by the Federal Agency for Healthcare Research and Quality (AHRQ), which combines relevant ICD-9-CM procedure codes into clinical meaningful groups, was used in the study for identifying discharges for spine surgery (CCS code: 3; laminectomy, excision intervertebral disc, CCS code: 158; spinal fusion). The patients were then divided into those with DT (DT group) (ICD-9-CM code: 349.31) and those without DT (nonDT group).

Patient and hospital characteristics and patient outcomes

Patient age, gender, comorbidities, hospital caseload, complications, mortality, duration of stay, disposition of patients, and total charges were extracted from the NIS. Age was categorized into the following five groups: birth–17 years, 18–44 years, 45–64 years, 65–84 years, and older than 84 years. Comorbidity was assessed using the Elixhauser method, a well-established technique for identifying comorbidities from administrative databases [21]. Total comorbidity score was determined for each case by adding 1 point per comorbidity. Annual hospital caseload was defined according to the number of procedures performed at each participating institution during each study calendar year and divided into tertiles. In-hospital complications associated with the procedures were obtained using the following ICD-9-CM codes: neurologic complications (997.00–997.09); respiratory complications (518.4, 518.5 518.81–518.84, 997.3); cardiac complications (410, 997.1); gastrointestinal complications (535.0, 570, 575.0, 577.0, 997.4); urinary and renal complications (584, 997.5); pulmonary embolism (415.1); and wound-related complications including infection, dehiscence, seroma, and hematoma (998.1, 998.3, 998.5, 998.83, 999.3) (4-digit and 5-digit codes are included under the respective 3-digit and 4-digit codes). Disposition of patients was categorized into "discharge home routinely" and "discharge others".

Data analysis

To calculate national estimates using the NIS, discharge weights supplied by the AHRQ were applied. Categorical patient data were retrieved. Chi-square test was used to assess equality of proportions, and Fisher's exact test was used to assess differences of proportions between the DT and nonDT groups. Student's *t* test was used to analyze the mean value of continuous variables between the two groups. Logistic regression models were used to elucidate whether DT was associated with independently increased odds while controlling for age, gender, comorbidities, and hospital caseload. The statistical software, R, version 2.15.1 (Free Software Foundation's GNU General Public License) was used to perform statistical analyses. A *p* value of 0.05 was used to define a significant change.

Results

Incidence

There were 665,818 hospitalizations in 2009 associated with laminectomy, excision of intervertebral disc, and spinal fusion (Table 1). Among them, 17,932 patients had DT. The incidence of DT was 2.7 % (17,932/665,818).

Patient and hospital characteristics

Table 2 contains detailed information on patient and hospital demographics for the DT and nonDT groups. The DT group included 17,932 patients, and the nonDT group included 647,886 patients. The average age was 61.7 years for the DT group and 55.0 years for the nonDT group.

Table 1 Incidence of incidental dural tear in spine surgery in the US in 2009

Total number of cases	665,818
Cases with dural tear	17,932
The incidence of dural tear	2.7 %

Table 2 Patient and hospital demographics

	Patients who underwent spine surgery				p value
Total number of cases:	665,818				
	DT group		nonDT group		
Total number of cases	17,932		647,886		
Mean age (years) (SD)	61.7 (14.6)		55.0 (16.0)		<0.001
	WF	%	WF	%	
Age					<0.001
≤17	131	0.7	14,092	2.2	
18–44	2,148	12.0	142,595	22.0	
45–64	7,133	39.8	294,170	45.4	
65–84	8,073	45.0	186,745	28.8	
≥85	443	2.5	9,536	1.5	
Gender					<0.001
Male	8,308	46.3	317,082	48.9	
Female	9,619	53.6	328,564	50.7	
Elixhauser comorbidity score					<0.001
0	3,577	19.9	187,134	28.9	
1	5,265	29.4	182,990	28.2	
2	4,291	23.9	137,450	21.2	
3	2,622	14.6	77,680	12.0	
4 or more	2,177	12.1	62,631	9.7	
Hospital caseload					<0.001
Low ≤ 229	215	1.2	12,900	2.0	
Middle (230–1,371)	2,547	14.2	116,679	18.0	
High ≥ 1,371	15,170	84.6	518,306	80.0	

DT group patients with dural tear, *nonDT group* patients without dural tear, *WF* weighted frequency

Significant differences for all variables were noted between the two groups ($p < 0.001$).

Risk factors for DT

Multivariate logistic regression analysis was performed to identify independent risk factors for DT. Table 3 shows the odds ratio (OR) and 95 % confidence interval (CI) for the incidence of DT. The analysis revealed that DT was significantly associated with older age compared with 18–44 years [(age 45–64: OR 1.52, 95 % CI 1.35–1.72, $p < 0.001$), (age 65–84: OR 2.63, 95 % CI 2.29–3.02, $p < 0.001$), (age ≥85: OR 2.8, 95 % CI 2.14–3.66, $p < 0.001$)]. Female patients had a significantly increased risk of DT compared to male patients (OR 1.08, 95 % CI 1.01–1.16, $p = 0.02$). As Elixhauser comorbidity score increased, patients were more likely to have DT (score 1, OR 1.23, 95 % CI 1.12–1.35, $p < 0.001$; score 2, OR 1.23, 95 % CI 1.1–1.38, $p < 0.001$; score 3, OR 1.27, 95 % CI 1.12–1.44, $p < 0.001$; score ≥4, OR 1.25, 95 % CI 1.08–1.45, $p < 0.001$). Patients treated at high hospital caseload institutions were more likely to have DT compared with those treated at low hospital caseload institutions (high: OR 1.45, 95 % CI 1.01–2.09, $p = 0.044$).

Patient outcomes

Patient outcomes are presented in Table 4. The overall in-hospital complication rate was significantly higher in the DT group than in the nonDT group (18.8 vs. 10.2 %, $p < 0.001$). The rates of all in-hospital complications were significantly higher in the DT group than in the nonDT group (neurologic 3.4 vs. 0.9 %, respiratory 4.2 vs. 3.0 %, cardiac 1.6 vs. 0.8 %, gastrointestinal 2.2 vs. 1.1 %, urinary and renal 3.2 vs. 2.0 %, pulmonary embolism 0.7 vs. 0.3 %, and wound-related complications 3.5 % vs. 2.0 %, respectively; $p < 0.001$). The in-hospital mortality rate was significantly higher in the DT group than in the nonDT group (0.4 vs. 0.3 %, $p = 0.044$). The mean length of hospital stay was significantly longer in the DT group than in the nonDT group (5.1 vs. 3.7 days, $p < 0.001$). The proportion of patients who were discharged home was significantly lower in the DT group than in the nonDT group (61.0 vs. 76.8 %, $p < 0.001$). The mean total charge was significantly higher in the DT group than in the nonDT group ($85,138 vs. $71,808, $p < 0.001$).

Table 3 Multivariate logistic regression analysis for dural tear

	Odds ratio	95 % CI	*p* value
Age			
0–17	0.64	0.41, 1.01	0.055
18–44	Ref.	–	–
45–64	1.52	1.35, 1.72	<0.001
65–84	2.63	2.29, 3.02	<0.001
≥85	2.8	2.14, 3.66	<0.001
Gender			
Male	Ref.	–	–
Female	1.08	1.01, 1.16	0.02
Elixhauser comorbidity score			
0	Ref.	–	–
1	1.23	1.12, 1.35	<0.001
2	1.23	1.1, 1.38	<0.001
3	1.27	1.12, 1.44	<0.001
4 or more	1.25	1.08, 1.45	<0.001
Hospital caseload			
Low ≤229	Ref.	–	–
Middle (230–1,371)	1.1	0.75, 1.61	0.621
High ≥1,371	1.45	1.01, 2.09	0.044

Ref. reference

Discussion

The incidence of DT in spine surgery associated with laminectomy, excision of intervertebral disc, and spinal fusion was 2.7 % (17,932/665,818) on a national database. This rate is comparable with the reported incidence of DT. As a retrospective study, Cammisa et al. [4] reported 3.1 % (74/2,144) and Guerin et al. [5] reported 3.84 % (51/1,326) overall incidence of DT for all spine surgeries, and Ruban and O'Toole [6] reported 9.4 % (53/563) for minimally invasive spine surgery. Recently, as a prospective study, Williams et al. [1] reported 1.6 % (1,745/108,478), Baker et al. [2] reported 10 % (161/1,591), and McMahon et al. [3] reported 3.5 % (104/3,000) overall incidence of DT for all spine surgeries. Williams et al. [1] reported the rate among experienced spine surgeons. In contrast, the NIS includes the data of all experience levels of spine surgeons. In addition, combination of CCS codes 3 and 158 includes all types of spine surgeries such as discectomy, decompression, fusion, and total disc replacement. Therefore, this data can be used as a general information on DT in all spine surgery.

Our multivariate analysis revealed that older age, female gender, increased Elixhauser comorbidity score, and high hospital caseload were the significant risk factors for DT. The risk increased with the age, and patients older than 84 years were 2.8 times more likely to have DT than those aged between 18 and 44 years. Age has been previously suggested to be a risk factor for DT [1, 7, 9]. Possible reasons for age as a risk factor include normal signs of

Table 4 Patient outcomes following spine surgery

	DT group		nonDT group		*p* value
Mean length of stay (SD)	5.1 (4.5)		3.7 (5.5)		<0.001
Mean total charges (SD)	85,138 (86,678)		71,808 (78,010)		<0.001
	WF	%	WF	%	
In-hospital complications					
Overall complications	3,374	18.8	66,054	10.2	<0.001
Neurologic	608	3.4	6,057	0.9	<0.001
Respiratory	756	4.2	19,708	3.0	<0.001
Cardiac	279	1.6	5,148	0.8	<0.001
Gastrointestinal	388	2.2	7,438	1.1	<0.001
Urinary and renal	582	3.2	12,837	2.0	<0.001
Pulmonary embolism	129	0.7	1,741	0.3	<0.001
Wound-related complications	632	3.5	13,125	2.0	<0.001
Disposition status					
In-hospital mortality	66	0.4	1,839	0.3	0.044
Discharge home routinely	10,933	61.0	497,274	76.8	<0.001
Discharge others	6,928	38.6	148,516	22.9	<0.001

DT group the patients with dural tear, *nonDT group* the patients without dural tear, *WF* weighted frequency aging such as narrowing the spinal canal, thicker ligamentum flavum, and osteophyte formation [22]. Shortening of the spine by degeneration may also cause redundant dura, which is more easily trapped between the jaws of a Kerrison rongeur [19]. In addition, in elderly patients, the dura tends to have a more friable appearance, which may predispose it to DT [2]. Experience level of surgeon also has been reported as a risk factor for DT [1, 11, 12]. High hospital caseload institutions are usually the teaching hospitals. At a teaching hospital, spine surgeries are assisted by residents and fellows, and the incidence can be higher from the experience standpoint. Further, difficult cases such as revision cases are often referred to the hospitals that perform the most procedures. However, we do not have a clear explanation for the increased risk of DT in female patients and patients with increased Elixhauser comorbidity score.

This study demonstrated significantly increased rates of all in-hospital complications in patients with DT than in those without DT; particularly, the rates of neurologic and pulmonary embolism complications were more than twofold higher. Ahn et al. [23] reported that unrecognized dural tear with nerve root herniation may cause permanent neurological sequelae. In addition, the in-hospital mortality rate was significantly higher in patients with DT than in those without DT, although it was a small difference. Possible reasons include postoperative bed rest and insufficient closure of DT. Postoperative management of a patient with DT in lumbar spine often necessitates postoperative bed rest in a flat position. Patients in supine bed rest may be at increased risk of aspiration, thromboembolic disease, wound infection, ileus, and decubiti [24]. Urinary catheterization is usually necessary for the patients, which can increase the possibility of urinary tract infection. Clearly, the risk of pulmonary embolism increases because the patients tend to develop deep venous thrombosis due to bed rest. If DT is unable to be closed, not properly closed or unrecognized, cerebrospinal fluid continues to leak and the wound does not dry, which can also lead to meningitis.

The mean hospital stay was 1.4 days longer in patients with DT than in those without DT. Postoperative management of a patient with DT often involves placement of a subarachnoid drain and postoperative bed rest, which can extend hospital stay. Closed subarachnoid drainage is a nonsurgical option for management of DT, either primarily or as an adjunct for a less-than-optimal closure. Kitchel et al. [19] described an 82 % success rate for those in whom the subarachnoid catheter was left in for the recommended 4 days. To minimize fluid pressure at the DT site, patients with DT in the lumbar spine are usually maintained in a flat position. The duration of bed rest is not standardized. Wang et al. [16] systematically used bed rest for a short period (2.9 days). Cammisa et al. [4] used bed rest ranging from 3 to 5 days in all patients. Guerin et al. [5] used an average duration of 2.68 days bed rest.

Despite the longer hospital stay, a lower proportion of patients with DT were routinely discharged home. This indicates that patients with DT need more care after discharge. In accordance with longer hospital stay, the mean total charges were significantly higher in patients with DT than those without DT. Considering the higher proportion of other discharge in patients with DT, the economic burden is even higher in patients with DT than in those without DT.

Our study was limited by several factors inherent to retrospective analysis of large administrative databases. Data entry may subjected to an element of coding or reporting bias and the true incidence of DT may have been underestimated, although reporting should not vary substantially within the database. Our data were limited to in-hospital events; consequently, the true incidences of complications and mortality may have been underestimated. It would be interesting to note the rate of deep venous thrombosis as a complication. However, ICD-9-CM code to specify venous embolism/thrombosis as either acute or chronic was added in October 2009 and, therefore, it was impossible to exclude patients with an admission diagnosis of deep venous thrombosis before that period. In addition, we were unable to assess the incidence based on primary diagnosis, spinal location, and primary or revision surgery due to coding. Despite these limitations, we believe that these data give a reasonable picture of the incidence and in-hospital patient outcomes associated with DT in spine surgery.

In conclusion, the reported incidence of DT in spine surgery was 2.7 % in the US. Risk factors included older age, female gender, increased comorbidities, and high hospital caseload. DT increased the rate of in-hospital complications and mortality and health care burdens.

Conflict of interest None.

References

1. Williams BJ, Sansur CA, Smith JS et al (2011) Incidence of unintended durotomy in spine surgery based on 108,478 cases. Neurosurgery 68:117–123
2. Baker GA, Cizik AM, Bransford RJ, Bellabarba C, Konodi MA, Chapman JR, Lee MJ (2012) Risk factors for unintended durotomy during spine surgery: a multivariate analysis. Spine J 12:121–126
3. McMahon P, Dididze M, Levi AD (2012) Incidental durotomy after spinal surgery: a prospective study in an academic institution. J Neurosurg Spine 17:30–36
4. Cammisa FP Jr, Girardi FP, Sangani PK, Parvataneni HK, Cadag S, Sandhu HS (2000) Incidental durotomy in spine surgery. Spine 25:2663–2667

5. Guerin P, El Fegoun AB, Obeid I, Gille O, Lelong L, Luc S, Bourghli A, Cursolle JC, Pointillart V, Vital JM (2012) Incidental durotomy during spine surgery: incidence, management and complications. A retrospective review. Injury 43:397–401
6. Ruban D, O'Toole JE (2011) Management of incidental durotomy in minimally invasive spine surgery. Neurosurg Focus 31:E15
7. Sin AH, Caldito G, Smith D, Rashidi M, Willis B, Nanda A (2006) Predictive factors for dural tear and cerebrospinal fluid leakage in patients undergoing lumbar surgery. J Neurosurg Spine 5:224–227
8. Strömqvist F, Jönsson B, Strömqvist B, Swedish Society of Spinal Surgeons (2012) Dural lesions in decompression for lumbar spinal stenosis: incidence, risk factors and effect on outcome. Eur Spine J 21:825–828
9. Takahashi Y, Sato T, Hyodo H, Kawamata T, Takahashi E, Miyatake N, Tokunaga M (2013) Incidental durotomy during lumbar spine surgery: risk factors and anatomic locations: clinical article. J Neurosurg Spine 18:165–169
10. Hannallah D, Lee J, Khan M, Donaldson WF, Kang JD (2008) Cerebrospinal fluid leaks following cervical spine surgery. J Bone Joint Surg Am 90:1101–1105
11. Wiese M, Krämer J, Bernsmann K, Ernst Willburger R (2004) The related outcome and complication rate in primary lumbar microscopic disc surgery depending on the surgeon's experience: comparative studies. Spine J 4:550–556
12. Pechlivanis I, Kuebler M, Harders A, Schmieder K (2009) Perioperative complication rate of lumbar disc microsurgery depending on the surgeon's level of training. Cen Eur Neurosurg 70:137–142
13. Bosacco SJ, Gardner MJ, Guille JT (2001) Evaluation and treatment of dural tears in lumbar spine surgery. Clin Orthop 389:238–247
14. Mayfield FH, Kurokawa K (1975) Watertight closure of spinal dura mater: technical note. J Neurosurg 43:639–640
15. Mokri B (1999) Spontaneous cerebrospinal fluid leaks: from intracranial hypotension to cerebrospinal fluid hypovolemia—evolution of a concept. Mayo Clin Proc 74:1113–1123
16. Wang JC, Bohlman HH, Riew DK (1998) Dural tears secondary to operations on the lumbar spine: management and results after a two-year-minimum follow-up of eighty-eight patients. J Bone Joint Surg Am 80:1728–1732
17. Eismont FJ, Wiesel SW, Rothman RH (1981) Treatment of dural tears associated with spinal surgery. J Bone Joint Surg Am 63:1132–1136
18. Jones AAM, Stambough JL, Balderston RA, Rothman RH, Booth RE Jr (1989) Long-term results of lumbar spine surgery complicated by unintended incidental durotomy. Spine 14:443–446
19. Kitchel SH, Eismont FJ, Green BA (1989) Closed subarachnoid drainage for management of cerebrospinal fluid leakage after an operation on the spine. J Bone Joint Surg Am 71:984–987
20. Healthcare Cost and Utilization Project (HCUP) (2004) Agency for Health-care Research and Quality. Available at: http://www.hcup-us.ahrq.gov/nisoverview.jsp. Last Accessed 1 Mar 2013
21. Elixhauser A, Steiner C, Harris DR, Coffey RM (1998) Comorbidity measures for use with administrative data. Med Care 36(1):8–27
22. Espiritu MT, Rhyne A, Darden BV 2nd (2010) Dural tears in spine surgery. J Am Acad Orthop Surg 18:537–545
23. Ahn Y, Lee HY, Lee SH, Lee JH (2011) Dural tears in percutaneous endoscopic lumbar discectomy. Eur Spine J 20(1):58–64
24. Radcliff KE, Sidhu GD, Kepler CK, Gruskay J, Anderson DG, Hilibrand A, Albert TJ, Vaccaro AR (2012) Complications of Flat Bedrest Following Incidental Dural Repair. J Spinal Disord Tech (epub ahead of print)