Acta Neurochirurgica (2022) 164:1883–1888
https://doi.org/10.1007/s00701-022-05259-x

ORIGINAL ARTICLE - SPINE DEGENERATIVE

Incidence and risk factors for incidental durotomy in spine surgery for lumbar stenosis and herniated disc

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Received: 29 January 2022 / Accepted: 2 May 2022 / Published online: 31 May 2022

Abstract
Purpose Incidental durotomy (ID) is one of the most common complications in degenerative surgery. Due to the negative consequences of ID, knowledge about incidence and risk factors is warranted.
Methods A total of 1,139 surgical procedures for lumbar spinal stenosis (LS) and lumbar herniated disc (LDH) were included from the spine surgery database: DaneSpine. Uni- and multivariate analyses were performed for the assessment of possible risk factors.
Results ID occurred in 10.4% of the surgical procedures. A multivariate regression analysis revealed an increased relative risk of ID by 2% per year of age, 58% by revision surgery, and 55% by decompression on multiple levels.
Conclusion In our single-centre cohort study, one in ten patients experiences an ID. Increasing age, revision surgery and decompression of multiple levels are risk factors of ID in degenerative surgery of the lumbar spine.

Keywords Incidental durotomy · Herniated disc disease · Spinal stenosis · Complication · Surgery

Introduction

Incidental durotomy (ID), also known as dural tear or dural lesion, is one of the most common complications in degenerative surgery of the lumbar spine [17, 19, 20]. It is defined as an unintended tear of the dura mater and arachnoid mater causing cerebrospinal fluid leakage [7, 17]. ID may cause complications including postural headache, vertigo and nausea and more severe complications such as pseudomeningocele, nerve root entrapment, arachnoiditis, intracranial haemorrhage, durocutaneous fistula formation and meningitis [1–4, 6–8, 12, 15, 19–21]. Further, ID increases the duration of surgery due to the time needed for repair and does also increase length of hospital stay [5–7].

The reported incidence of ID in degenerative spine surgery varies among study populations between 1.9 and 16.46% [3, 4, 6, 7, 9, 10, 12, 13, 16–18, 20, 21] reported higher in surgery for lumbar spinal stenosis (LS) compared to surgery for lumbar disc herniation (LDH) [21].

Risk factors for ID have previously been investigated in both larger [17] and smaller cohorts [20], applying different approaches with regard to uni- and multivariate models [4]. For instance, one study [21] found that female gender reduced the risk of ID, whereas two other studies [1, 18] found in their univariate analyses that female gender had an increased risk of ID. However, none of the studies had a clear explanation for the association with the risk of ID. In general, the studies apply different approaches in terms of statistics, and there is a discrepancy in the identified risk factors, which could be attributable to potential confounding. Especially, there is a lack of adjusting for diagnosis when procedures are identified as risk factors and vice versa. Here we present a systematic prospective multivariate analysis on risk factors for ID in a Danish single-centre cohort. We hypothesize that the surgical factors such as diagnosis, procedure, number of surgically involved levels and timing along with the basic demographic attributes such as age, gender, smoking and alcohol consumption are associated with the risk for ID.

This article is part of the Topical Collection on *Spine degenerative*

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Methods

Data source and extraction

The data was extracted from the Danish national database for spine surgery: DaneSpine. DaneSpine comprises prospectively collected patient-reported data and surgical-reported data including ID (yes/no) which is registered by the surgeon postoperatively [11, 14]. Patient-reported outcome data (PRO) is obtained preoperatively by a questionnaire. The analyses include patients meeting the inclusion criteria stated above that have answered the questionnaire. Not all questionnaires were complete, and consequently, the number of observations varies for each variable. For the multivariate analysis, patients with incomplete data were omitted.

The inclusion criteria were surgery for LS and LDH from February 1, 2015, to February 1, 2020, at our neurosurgical department. Included diagnosis (ICD-10) codes were M47.2 (other spondylosis with radiculopathy), M48.0 (spinal stenosis), M51.1 (thoracic, thoracolumbar and lumbosacral intervertebral disc disorder with radiculopathy) and M51.3 (other thoracic, thoracolumbar and lumbosacral intervertebral disc degeneration). Thoracic disc disorders were excluded. Included procedure codes were KABC16 (hemilaminectomy including microdiscectomy), KABC26 (hemilaminectomy including open discectomy), KABC36 (hemilaminectomy with decompression of the lumbar nerve root), KABC56 (laminectomy), KNAG64 (spinal fusion (spondylodesis) without fixation in columna) and KNAG74 (spinal fusion (spondylodesis) with fixation in columna).

Statistical analyses

The statistical analyses were performed using Stata 16.1 (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC). For the univariate analyses of binary data, chi-square was used to assess the hypothesis of no difference of risk in acquiring an ID during surgery using relative risk as measure. Welch *t*-test was used to assess the hypothesis of no difference in mean for continuous data. Chi-square and Welch *t*-test were used to determine if the distribution of the shared variables is similar in the two different datasets used. Checks for normal distribution were done by histograms and QQ plots. The level of statistical significance was 5%.

The multivariate binary regression model was used to identify risk factors.

Included variables

To avoid overfitting, the number of included variables, for the model, was determined by the number of IDs, divided by 15 and rounded off to the nearest higher integer. The variables were included based on a predefined prioritized list; please see supplementary.

Age was included as a continuous variable. The diagnoses were divided between LDH containing the diagnosis codes DM51.1 and DM51.3 and LS containing DM47.2 and DM48.0. Throughout the paper mentioning LS, it includes central and foraminal stenosis. KABC16, KABC26, and KABC36 were combined and called hemilaminectomy. Hemilaminectomy were divided into two variables, uni- and bilateral hemilaminectomy. The spondylodesis, KNAG64 and KNAG74, were divided between hemi- and laminectomies based on the surgeries' secondary procedure code. KABC56, the laminectomy, was included as its own variable. Surgeries performed on two, three, four, and five levels were collapsed to one variable called surgery performed on two levels or more. Due to lack of data alcohol consumption, it was omitted from the multivariate analysis. BMI and timing were omitted from the analysis due to variable restriction.

Results

Incidence

A total of 1,139 surgical procedures were included. The overall incidence of ID was 10.4%. 385 surgical procedures were due to LS and 754 for LDH with the incidence of ID being 14.8% and 8.2%, respectively. The incidences of ID for the individual variables are shown in Table 1.

Of the 1139 surgeries, 952 surgeries were primary surgeries with incidence of ID of 9.3%. The 187 revision operations had an ID incidence of 16.0%.

Within the same period, three revision surgeries were made for durotomies, which corresponds to a revision rate of 2.5%.

Risk factors

Univariate analyses

The results of the univariate analyses are presented in Table 2.

There was a significant difference in age and BMI, with patients not sustaining an ID being younger and having a lower BMI. LS compared to LDH had a significantly increased risk of sustaining an ID. The risk of sustaining ID was decreased by unilateral hemilaminectomy. The risk

Table 1 Incidences of incidental durotomy in spine surgery for lumbar herniated disc and lumbar stenosis

	Total (*n*)	Incidental durotomy (*n*)	Percentage of incidental durotomy (%)
Total surgeries	1139	119	10.4
Male	562	54	9.6
Female	577	65	11.3
Smoking	299	30	10.0
Alcohol on daily basis	227	30	13.2
Primary surgeries	952	89	9.3
Revision surgeries	187	30	16.0
Lumbar herniated disc	754	62	8.2
Lumbar stenosis	385	57	14.8
Hemilaminectomy	818	65	7.9
KABC16	115	6	5.2
KABC26	538	45	8.4
KABC36	165	14	8.5
Unilateral decompression	711	55	9.3
Bilateral decompression	107	10	16.8
Laminectomy(KABC56)	321	54	16.8
1 level	929	78	8.4
2 levels	156	32	20.5
3 levels	42	9	21.4
4 levels	8	0	0.0
5 levels	4	0	0.0
Elective	964	97	10.1
Acute	175	22	12.6

Table 2 Univariate analyses of surgical data. *Chi-square test, +Welch *t*-test. *SD* Standard deviation, *Diff* difference, *CI* confidence interval

Variables	Incidental durotomy ($n=119$)	Percentage (%)	No incidental durotomy ($n=1020$)	Percentage (%)	Risk Ratio	95% CI		*P* value
Male	54	45.38	508	49.80				
Female	65	54.62	512	51.08	1.17	0.83	1.65	0.36*
Age, mean (SD)	60.48 (15.1)		53.13 (16.4)		Diff (−7.35)	−10.26	−4.43	**< 0.00+**
BMI, mean (SD)	28.51 (5.7)		27.34 (5.1)		Diff (−1.17)	−2.25	−0.09	**0.03+**
Smoker	30	25.21	269	26.37				
Nonsmoker	82	68.91	718	70.39	0.98	0.66	1.46	0.92*
Alcohol consumption on daily basis	30	25.21	197	19.31				
No alcohol consumption on daily basis	26	21.85	307	30.10	1.69	1.03	2.78	**0.04***
Lumbar herniated disc	62	52.10	692	67.84				
Lumbar stenosis	57	47.90	328	32.16	1.80	1.28	2.52	**< 0.00***
Unilateral hemilaminectomy	55	46.22	656	64.31	0.52	0.37	0.73	**< 0.00***
Bilateral hemilaminectomy	10	8.40	97	9.51	0.88	0.48	1.64	0.70*
Laminectomy	54	45.38	267	26.18	2.12	1.51	2.97	**< 0.00***
Revision surgery	30	25.21	157	15.39	1.72	1.17	2.52	**0.01***
Elective surgery	97	81.51	867	85.00				
Acute surgery	22	18.49	153	15.00	1.25	0.81	1.93	0.32*
Decompression of 1 level	78	65.55	851	83.43				
Decompression of 2 levels or more	41	34.45	169	16.57	2.33	1.64	3.29	**< 0.00***

was increased by daily alcohol consumption, laminectomy, revision surgery and surgery on two or more levels. Bilateral hemilaminectomy, acute surgery and smoking did not show a statistically significant association with ID (Table 2).

Multivariate analyses

The results of the binary regression analysis are shown in Table 3.

Three risk factors reached were found significantly associated to ID: age increases the relative risk of ID in lumbar degenerative surgery by 2% per increasing year. Revision surgery increases risk by 58%, and undergoing surgery on two levels or more increases the risk of ID by 55%.

Stenosis, hemi- and laminectomy, smoking and gender are in the multivariate analysis not found to be associated with the risk of ID.

Discussion

In our cohort, one in ten had an ID. This includes all primary and revision surgeries, lumbar central and foraminal stenosis and herniated disc, and hemi- and laminectomies performed by all surgeons at our department of neurosurgery. The revision rate of durotomies was 2.5%.

In another single-centre study [18], ID incidence was 4%. They only included primary surgeries performed by surgeons with more than 15 years of experience and included juxtafacet cysts and spondylolisthesis in addition to LDH and LS, which might explain some of the difference. Several multicentre studies have reported from 6.3 to 10.1% for LS and 1.7 to 2.7% for LDH [7, 15, 16, 21]. In comparison, our study found an incidence of 14.8% for LS and 8.2% for LDH. Our department has surgical teaching obligations and, in addition, receives the acute and most extensive cases of degenerative diseases of the spine. Thereby, the incidence of complications may be expected to be higher.

Risk factors for ID have previously been investigated, and the following were found significant in predicting incidental durotomy: age, female gender, BMI, smoking, previous spine surgery, laminectomy, minimal/less invasive surgery, degenerative spondylolisthesis, juxtafacet cysts, bilateral decompression via an unilateral approach and surgery on more than three segments surgery on a teaching hospital (vs. non-teaching hospital), congestive heart failure, renal disease, diabetes and hypertension [3, 4, 6, 7, 10, 13, 15–18, 20, 21].

Even though the univariate analysis suggested lumbar spinal stenosis to be a risk factor, the multivariate analysis did not find it to be a significant risk factor, which opposes previous findings [21]. This implies the diagnosis of lumbar stenosis as a risk factor is confounded by age, which was found to be a significant risk factor.

Laminectomy has been mentioned as a risk factor for ID [7]. The univariate analysis in this study showed that laminectomy increases the risk of ID by 112%, but this was not found to be significant in the multivariate analysis; again, implying laminectomy as a risk factor is confounded by age, since this procedure is the most used for central LS.

Revision surgery was found as a risk factor for sustaining an ID, which aligns with previous work [1, 4, 6, 7, 13, 15–17]. Scar tissue and adhesions complicate surgery making ID more likely to occur [1, 4, 6, 7, 13, 20]. Two studies [12, 20] containing six and 76 revision surgeries, respectively, did not identify it as a risk factor. Surgery on multiple levels was found be a significant risk factor. The finding supports previous work [6, 10, 16]. Age was found to significantly increase the relative risk by 2% per year. Age decreases dural tissue strength and elasticity [4, 13, 16, 17]. The result corresponds to previous works [1, 3, 4, 7, 12, 13, 16–18, 20, 21].

Smoking reduces the strength and elasticity of the dural sac [16], and it has previously been found to be a risk factor for ID [3, 16]. Smoking was not found associated with the risk of ID in this study. One study found smoking as a risk factor [3] but only included 11 patients who were both smoking and had an ID. In a larger study, smoking was only marginally significant (OR: 0.696, 95% CI: 0.485; 0.999) [16].

Table 3 Binary regression analysis of risk factors for incidental durotomies including patient reported outcome ($n = 1{,}099$)

Incidental durotomy	Risk ratio	Standard error	z	*P* value	95% confidence interval	
Age	1.02	0.01	3.22	**0.00**	1.01	1.04
Revision surgery	1.58	0.32	2.20	**0.03**	1.05	2.37
Stenosis	0.74	0.20	− 1.10	0.27	0.44	1.26
Bilateral hemilaminectomy	0.98	0.35	− 0.05	0.96	0.49	1.96
Laminectomy	1.54	0.42	1.59	0.11	0.90	2.61
Decompression of two levels or more	1.55	0.34	2.02	**0.04**	1.01	2.37
Smoking	1.09	0.22	0.43	0.67	0.73	1.62
Gender	1.22	0.22	1.12	0.26	0.86	1.73

Contrary to other studies [1, 18, 21], gender was not found associated with the risk of ID. One study [21] found that female gender reduced the risk of ID, and two others found the opposite [1, 18]. One study found that increasing BMI is associated with increased risk of ID and supposed it could be due to greater volume of soft tissue and depth of incision making the surgical exposure more difficult [7]. In this study, mean BMI was 1.2 points higher for patients acquiring an ID.

However, BMI, alcohol consumption and surgical timing were not assessed due to the exclusion of these variables in the multivariate analysis.

Conflicting results are reported concerning surgical experience and durotomies [6, 12, 13]. Although experience may reduce the overall risk, more experienced surgeons tend to perform more difficult cases, among them revision surgeries [13]. Although relevant to investigate, it was not possible to subtract data from DaneSpine regarding surgical experience.

Our analysis is based on database data from a single-centre cohort. Data might be biased by entry failure or lack of follow-up. The latter situation would require the surgeon to fail to notice the durotomy. The rate of revision surgeries may be underestimated if the primary surgery has not been included in DaneSpine.

Conclusion

The incidence of incidental durotomy in surgery for LS and LDH performed at our neurosurgical department was 10.4%. ID was significantly associated with increasing age, revision surgery, and decompression at multiple levels.

Declarations

Ethics approval The study protocol was approved according to the local legislation.

Informed consent Patients included in DaneSpine consent individually to data storage and usage.

Conflict of interest The authors declare no competing interests. The material has not been published or submitted for publication elsewhere.

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