INTERNATIONAL JOURNAL of SPINE SURGERY

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Int J Spine Surg 2023, 17 (2) 198-204
doi: https://doi.org/10.14444/8430
http://ijssurgery.com/content/17/2/198

The International Journal of Spine Surgery
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Aurora, IL 60504, Phone: +1-630-375-1432

International Journal of Spine Surgery, Vol. 17, No. 2, 2023, pp. 198–204
https://doi.org/10.14444/8430

Laminectomy vs Fusion for Intradural Extramedullary Tumors

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ABSTRACT

Background: Laminectomy (LA) and LA with fusion (LAF) have been demonstrated as surgical techniques that treat intradural extramedullary tumors (IDEMTs). The purpose of the present study was to compare the rate of 30-day complications following LA vs LAF for IDEMTs.

Methods: Patients undergoing LA for IDEMTs from 2012 to 2018 were identified in the National Surgical Quality Improvement Program database. Patients undergoing LA for IDEMTs were substratified into 2 cohorts: those who received LAF and those who did not. In this analysis, preoperative patient characteristics and demographic variables were assessed. 30-day wound, sepsis, cardiac, pulmonary, renal, and thromboembolic complications, as well as mortality, postoperative transfusions, extended length of stay, and reoperation, were assessed. Bivariate analyses, including χ^2 and *t* tests, and multivariable logistical regression were performed.

Results: Of 2027 total patients undergoing LA for IDEMTs, 181 (9%) also had fusion. There were 72/373 (19%) LAF in the cervical region, 67/801 (8%) LAF in the thoracic region, and 42/776 (5%) LAF in the lumbar region. Following adjustment, patients who received LAF were more likely to have increased length of stay (OR 2.73, $P < 0.001$) and increased rate of postoperative transfusion (OR 3.15, $P < 0.001$). Patients undergoing LA in the cervical spine for IDEMTs tended to receive additional fusion ($P < 0.001$).

Conclusions: Increased length of stay and rate of postoperative transfusion were associated with LAF for IDEMTs. LA in the cervical spine for IDEMTs was associated with additional fusion.

Level of Evidence: 3

Tumor

Keywords: cancer, spine surgery, intradural extramedullary, laminectomy, fusion

INTRODUCTION

Intradural extramedullary tumors (IDEMTs) are rare, with a reported incidence of 3 to 5 per 1,000,000 people annually.[1–3] The majority of IDEMTs are benign and include schwannomas, neurofibromas, meningiomas, and ependymomas.[4,5] IDEMTs can lead to spinal cord compression with subsequent back pain, radicular pain, and motor and sensory deficits.[6] Decompression surgery and total tumor resection are considered the gold standard for treating IDEMTs and have been shown to improve general health, quality of life, pain, disability, and survival.[7,8] However, the postoperative morbidity associated with excision of IDEMTs is significant despite advances in intraoperative monitoring, minimally invasive approaches, and neuroimaging.[9,10]

The goals of IDEMT resection are to obtain sufficient exposure of the tumor, remove the lesion without damage to the nervous system, and preserve the stability of the spinal column.[11] The conventional approach for resection of IDEMTs is total laminectomy (LA), which affords surgeons a wide view of the surgical field. Despite this benefit, clinical and biomechanical studies have demonstrated that iatrogenic destruction of posterior elements of the spinal column during removal of IDEMTs can cause spinal instability, deformity, and long-term postoperative pain.[12] LA accompanied by spinal fusion is an alternative technique that has been shown to reduce instability associated with LA.[13–15] While both are effective methods for treating IDEMTs, it is not clear which method is superior.[13,15–17] Studies comparing these procedures in the treatment of other spinal disorders have shown increased blood loss, increased operative time and costs, longer hospital stay, and increased instrument-related complications in LA with fusion vs decompression alone.[13,15,16] Factors influencing the decision whether to perform fusion are patient age, number of levels involved, and preoperative pain; however, the major predictor appears to be physician preference.[18] The decision whether to perform LA vs LA with fusion (LAF) is not always clear cut, and the selection of the appropriate surgical procedure remains difficult and controversial. Therefore, a thorough understanding of the limitations of LA vs LAF in the treatment of IDEMTs is necessary to achieve adequate resection and optimize outcomes.

Due to the rarity of IDEMTs, there are relatively small numbers of clinical series describing the surgical outcomes of IDEMTs. Although there have been studies comparing these procedures in the treatment of degenerative spinal disorders, solid tumor destabilization of posterior spinal structures likely presents complications that are unique compared with typical degenerative processes. To the best of our knowledge, no studies have investigated the clinical outcomes of LA vs LAF for patients undergoing IDEMT resection surgery. The aim of this study was to determine whether a clinically significant difference exists between postoperative outcomes following LA vs LAF of IDEMT.

METHODS

Data Source and Cohort Selection

Data from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) during 2012 to 2018 were used to conduct this retrospective cohort study. ACS-NSQIP is an extensive risk-adjusted national database containing 30-day postoperative morbidity and mortality outcomes. It includes data contributions from clinical abstractors from approximately 700 hospitals varying in size, socioeconomic location, and academic affiliation. Collected data encompass more than 150 demographic, preoperative, intraoperative, and 30-day postoperative variables. A number of quality improvement programs based on ACS-NSQIP have been validated and deemed successful. Current procedural terminology codes used were 63280, 63281, and 63282 for LA of cervical, thoracic, and lumbar IDEMTs, respectively. Procedure codes for concurrent fusion were 22612, 22600, 22610, 22802, 22558, 22595, 22590, 22800, 22630, 22532, 22534, 22614, and 22804.

Variable Definitions

Preoperative variables included were age (>65 years), gender, obesity (body mass index ≥35 kg/m^2), smoking status (within 1 year of surgery), diabetes (diabetes mellitus with oral agents or insulin), functional status (unknown, independent, or partially/totally dependent ≤30 days before surgery), pulmonary comorbidity (history of chronic obstructive pulmonary disease), dyspnea (at rest or moderate exertion), cardiac comorbidity (history of congestive heart failure or hypertension requiring medication ≤30 days before surgery), renal insufficiency (history of renal failure or currently on dialysis), weight loss (>10% loss of body weight in past 6 months), steroid use for chronic condition, and preoperative physical health status (American Society of Anesthesiologists [ASA] classification 1–4).

Operative variables included tumor location (cervical, thoracic, or lumbar) and use of general anesthesia as the principal anesthesia technique.

Postoperative variables included mortality, prolonged length of stay (>5 days), wound complication (superficial or deep surgical site infection), sepsis complication (including septic shock), cardiac complication (cardiac arrest requiring cardiopulmonary resuscitation or myocardial infarction), venous thromboembolism (deep vein thrombosis or pulmonary embolism), neurological complications (cerebrovascular accident or stroke), progressive renal insufficiency, intraoperative or postoperative red blood cell transfusion, and unplanned reoperation (related to the initial procedure).

Statistical Analysis

All statistical analyses were performed using Stata version 17. Univariate statistics were performed on preoperative patient characteristics and demographics, risk factors, and major postoperative outcomes. χ^2 tests were used to evaluate the association between various risk factors and outcomes as appropriate. Multivariable logistic regression was performed to control for patient factors and outcomes. Odds ratios were calculated with 95% confidence intervals. For all analyses, a *P* value <0.05 was considered statistically significant.

RESULTS

Study Population

A total of 2027 patients met the inclusion criteria for this study; of whom 1846 (91%) underwent LA alone, while 181 (9%) underwent LA and spinal fusion. In the cervical region, 19% of patients received LAF, while 8% of patients received LAF in the thoracic region and 5% of patients received LAF in the lumbar region (Table 1).

Patient characteristics were different in those who received LAF as opposed to LA alone (Table 2). Patients undergoing LA for IDEMTs in the cervical spine were more likely to receive additional fusion

Table 1. Fusion with laminectomy by location of intradural extramedullary tumor.

Total	Laminectomy Without Fusion, *n*	Laminectomy With Fusion, *n*	Total, *n*	Rate of Undergoing Fusion Procedures
Cervical	311	72	383	19%
Thoracic	801	67	868	8%
Lumbar	734	42	776	5%
Total	1846	181	2027	9%

(16% vs 40%; $P < 0.001$). Furthermore, patients who received LAF for IDEMT treatment were more likely to be classified as a higher anesthesia class (4% vs 2%; $P = 0.046$), have hypertension (39% vs 47%; $P = 0.035$), be on dialysis ($P = 0.004$), and have previous steroid use (6% vs 10%; $P = 0.03$).

Unadjusted Analysis

There were statistically significant differences in unadjusted 30-day postoperative complications between the 2 cohorts (Table 3). Patients who received LA with additional fusion were more likely to have a myocardial infarction (0.05% vs 0.55%; $P = 0.042$), require blood transfusion (3.74% vs 10.50%; $P < 0.001$), and require a hospital stay longer than 5 days (35.64% vs 58.56%; $P < 0.01$) than patients who were treated with LA alone.

Multivariate Analysis

Results of the multivariate analysis are presented in Table 4. Following adjustment, patients who received LAF were still more likely to require blood transfusion (OR 3.15, 95% CI 1.78–5.57, $P <$ 0.001) and a hospital stay longer than 5 days (OR 2.73, 95% CI 1.95–3.820, $P < 0.001$) as compared with patients who received LA alone. The effect of LAF resulting in a greater number of postoperative myocardial infarctions did not persist after statistical correction.

DISCUSSION

LA is the conventional approach for resection of IDEMTs. However, LA can lead to instability, and the addition of fusion has been shown to reduce loss

Table 2. Patient characteristics and demographic variables.

	Laminectomy Without Fusion		Laminectomy With Fusion		
Variable	***n***	**%**	***n***	**%**	***P* Value**
Total	1846		181		
Cervical	301	16%	72	40%	<0.001
Thoracic	801	43%	67	37%	
Lumbar	734	40%	42	23%	
Age, y, mean	54.8		56.8		0.1118
Body mass index, mean	29.27		29.73		0.4186
Male	833	45%	91	50%	0.184
Female	1013	55%	90	50%	
American Society of Anesthesiologists classification					
1	73	4%	4	2%	0.046
2	749	41%	66	36%	
3	936	51%	94	52%	
4	85	5%	16	9%	
Smoking	265	14%	31	17%	0.314
Functional status					
Independent	1722	93%	171	94%	0.617
Dependent	99	5%	9	5%	
Totally dependent	17	1%	0	0%	
Unknown	8	0%	1	1%	
Diabetes	239	13%	20	11%	0.466
Chronic obstructive pulmonary disease	49	3%	7	4%	0.342
Congestive heart failure	3	0%	0	0%	0.587
Hypertension	719	39%	85	47%	0.035
Renal failure	0	0%	0	0%	
Dialysis	2	0%	2	1%	0.004
Weight loss	19	1%	1	1%	0.536
Steroid use	116	6%	19	10%	0.03
Bleeding disorder	32	2%	3	2%	0.94
Dyspnea at rest	3	0%	1	1%	0.048
Dyspnea at moderate exertion	56	3%	11	6%	

Note: Data presented as *n* and % unless otherwise indicated.

Table 3. Postoperative outcomes.

Outcome	Laminectomy Without Fusion *n*	Laminectomy Without Fusion %	Laminectomy With Fusion *n*	Laminectomy With Fusion %	*P* Value
Total	1985		42		
Cardiac arrest	5	0.25%	0	0.00%	0.745
Myocardial infarction	2	0.10%	0	0.00%	0.837
Renal insufficiency	1	0.05%	1	2.38%	<0.001
Deep vein thrombosis	28	1.41%	1	2.38%	0.6
Pulmonary embolism	19	0.96%	0	0.00%	0.524
Cerebral vascular accident or stroke	4	0.20%	0	0.00%	0.771
Mortality	20	1.01%	0	0.00%	0.513
Transfusion	87	4.38%	1	2.38%	0.529
Length of stay >5 d	739	37.23%	25	59.52%	0.001
Return to operating room	67	3.38%	23	54.76%	<0.001

of stability. The aim of our study was to determine whether there were significant differences in postoperative outcomes between LA and LAF for IDEMTs. This information may be used to assist surgeons in their decision regarding whether to perform LA or LAF. Our study found that LAF was associated with higher odds of blood transfusion and longer hospital stays when compared with LA alone. Patients who received surgery in the cervical spine also had an increased tendency to receive additional fusion.

Blood Transfusion

Our findings of increased transfusion for patients undergoing LAF vs LA may be explained in part due to increased operating time. LA requires exposing muscle and bone, which bleed unless coagulated. Increased operating room time during fusion causes these tissues to be exposed longer,[19] leading to greater risk of blood loss. LAF for spinal stenosis has been shown to have an operating time that is on average 2.3 times longer, with blood loss noted as 2 to 6 times higher than LA alone.[15,16] This is consistent with our findings that patients treated with fusion had a rate of postoperative transfusion that was 3.15 times higher than those without fusion. Blood transfusions are not without risk and may expose patients to transfusion reactions, disease, transfusion-related immunosuppression, and infection.[20]

Hospital Stay

Prolonged hospital stays may have adverse effects on patient health and economic burden and are often a consequence of multiple compounding factors. These include increased blood loss during or after surgery, older age, ASA physical status, and number of vertebrae fused.[21] Our study found that 58.6% of patients who had LAF spent greater than 5 days in the hospital, while only 35.6% of those who received LA stayed longer than 5 days. Previous studies have shown similar results. For example, Forsth et al found that in the treatment of spinal stenosis, fusion had an average hospital stay of 4.2 to 7.4 days, while decompression alone averaged 2.6 to 4.1 days.[15,16] Prolonged hospital stays may raise the risk of hospital-acquired infections, pressure ulcers, venous thromboembolism, and delirium, as well as increase the financial burden on the patient.[22–24]

Table 4. Risk factor analysis.

Risk Factor	OR	Lower CI Bound	Upper CI Bound	*P* Value
Body mass index	1.05	1.01	1.09	0.01
Diabetes	1.14	0.49	2.65	0.769
Hypertension	1.88	0.88	4.05	0.105
Weight loss	12.23	3.27	45.75	<0.001

Laminectomy vs Laminectomy With Fusion

There have been conflicting findings from studies comparing the risks and benefits associated with LA vs LAF in treating various spinal diseases, although none has compared these procedures in the treatment of IDEMTs.[13,15,16,25,26] A meta-analysis comparing LA vs LAF in patients with spinal stenosis and with and without spondylolisthesis showed better postoperative outcomes and better Oswestry Disability Index and visual analog scale ratings in those who underwent fusion. However, this same study found that fusion did not improve clinical outcomes over a 2-year follow-up period.[27] It should also be noted that spondylolisthesis is usually associated with preoperative instability but IDEMTs are not; therefore, the benefits of treating spondylolisthesis with fusion may be more significant when compared with treatment of IDEMTs. Other studies have shown a higher likelihood of postoperative complications and increased surgical costs ($6800–$14,659 and higher) in fusion groups in the treatment of spinal stenosis.[13,15,16,25]

The demographic outcomes of individuals diagnosed with IDEMTs are often also those at higher risk of adverse surgical events and may benefit from additional precautionary protocols. The incidence of IDEMTs is higher in women and increases with age, with the peak incidence between the ages of 70 and 79 years.[28,29] There is an increased risk of bleeding and longer hospital stays in patients with thin periosteum, osteoporosis, higher ASA classification, hypertension, degenerative scoliosis, or an increased number of fusions needed.[5,16,30,31] Discontinuation of nonsteroidal anti-inflammatory drugs a week prior to surgery has been shown to decrease operative bleeding, while autodonating blood prior to surgery reduces the likelihood that a patient will be exposed to allogeneic blood.[19] LAF may not be appropriate in elderly patients or those with coexisting conditions due to increased blood loss and operation times. Thorough assessment of these individuals and a comprehensive preoperative plan are warranted in these situations.

Studies have reported spinal stability outcomes of either LA or LAF in the treatment of spinal tumors; however, none has compared these techniques.[32–37] In the treatment of intradural tumors, Sciubba et al found that 33% of patients with 3 or more vertebral levels removed experience instability compared with 5% with 2 or less. They also noted that each level of resection had a 3.1-fold increase in the likelihood of vertebral instability.[34] Mehlman et al found similar results in pediatric patients, indicating spinal instability was associated with the removal of 3 or more laminae.[35] Yasuoka et al suggested that LA in children has an increased likelihood of instability.[38,39] This study noted that deformity developed after LA in 46% of patients younger than 15 years and 6% of patients between the ages of 16 and 24 years. This study also found that 100% of LAs performed in the cervical spine developed spinal deformity.[39] Tumors in the cervical region have been shown to be significant factors in the development of deformity following LA.[36,37,39] Other studies have indicated an increased likelihood of instability with increasing vertebral levels.[33–35] This correlates with our finding of a higher rate of fusion in the cervical spine. Although fusion may be indicated in these situations, the rate of spinal fusion in practice is low, with only 9% of our study population undergoing fusion. The risks of spinal fusion may outweigh the benefit of reducing the risk of spinal instability. The goal of a surgical approach should be to minimize complications while maximizing benefits, such as a quick recovery, and improving the patient's quality of life. Understanding when fusion is indicated in patients with IDEMTs is a significant factor when considering treatment options.

LAF should only be considered in patients who would otherwise experience instability due to the increased risk in fusion surgery. LA has been shown to have an increased likelihood of instability in children, removal of 3 or more vertebrae, and tumors located in the cervical spine.[33–39] Further research is necessary to determine when fusion is warranted in patients being treated for IDEMTs as well as long-term outcomes of LA with and without fusion in these patients.

Limitations

This retrospective medical record review utilized ACS-NSQIP. While allowing for a larger sample size, the records were gathered for clinical purposes rather than following a strict research protocol. The types of tumors as well as their stages are not indicated in the database. Also not included are tumor margin after resection, preoperative signs of instability, vertebral body compromise, number of vertebrae involved, and reasoning for choice of fusion vs LA alone. Current procedural terminology codes may not be recorded consistently, there may be additional compounding variables not measured, and ACS-NSQIP database is biased toward predominantly academic centers, which may not be representative. This study also assessed only 30-day outcomes as a limitation of ACS-NSQIP; thus, the presented results may not be applicable for long-term follow-up. Despite these limitations, this study is useful in demonstrating the postoperative risk factors for patients undergoing LA with or without fusion in treatment for IDEMTs, and these risks should be taken into consideration when planning patient care.

CONCLUSION

Increased length of stay and rate of postoperative transfusion were associated with LAF for IDEMTs. Patients undergoing LA in the cervical spine for IDEMTs tended to receive additional fusion. LAF was also associated with increased anesthesia class, hypertension, dialysis, and steroid use.

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Funding: The authors received no financial support for the research, authorship, and/or publication of this article.

Declaration of Conflicting Interests: The authors report no conflicts of interest in this work.

Ethics Approval: The study was not subject to institutional review board approval. Data are available for review. No portions of this work were previously published.

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Published 28 March 2023