Surgical Factors Associated with Prolonged Hospitalization after Reconstruction for Oncological Spine Surgery

Hannah M. Carl, BS
Devin Coon, MD, MSE
Nicholas A. Calotta, BA
Rachel Pedreira, BA
Justin M. Sacks, MD, MBA

Background: Posterior trunk reconstruction is increasingly possible as a result of advances in spinal instrumentation, reconstructive approaches, and perioperative critical care. Extensive cases often require a muscle flap or complex closure to obliterate dead space. Postsurgical wound complications and subsequent reoperations can lead to neural injury, higher hospital costs, and longer hospitalizations. We aim to identify risk factors that are associated with increased length of stay (LOS) for patients receiving flaps to close a spine defect.

Methods: A single institution, retrospective cohort study was performed on all patients from 2002 to 2014 who received a muscle flap to close a spine defect. Medical and perioperative variables that were significantly associated with LOS ($P < 0.05$) in univariate analysis were included in a stepwise regression model.

Results: A total of 288 cases were identified. Presence of instrumentation, preoperative chemotherapy, wound dehiscence, cerebrospinal fluid leak, partial/total flap loss, and medical morbidity occurrence were all independently associated with increased LOS in a combined multivariate model ($P < 0.02$ for each of the 6 variables). Importantly, Kaplan–Meier analysis demonstrated that postoperative wound dehiscence increased LOS by 12 days.

Conclusions: Spinal tumor resections often create large cavitary defects that necessitate the use of muscle flaps for closure. Patients who have received adjuvant chemotherapy require instrumentation, or those who develop specific wound-related or medical complications are at increased risk for prolonged hospitalization after spinal reconstruction. Thus, implementing measures to mitigate the occurrence of these adverse events will reduce costs and decrease the length of hospitalization.

(Plast Reconstr Surg Glob Open 2017;5:e1271; doi: 10.1097/GOX.0000000000001271; Published online 7 April 2017.)

Disclosure: The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.
Despite recent advances in complex muscle closures and perioperative critical care, these patients often still experience long postoperative hospital admissions.

Length of stay (LOS) has been extensively studied as a risk factor for many conditions. High-quality studies have shown that increasing LOS is associated with pneumonia, deep venous thrombosis (DVT), pulmonary embolism (PE), and “never events” such as pressure ulcers and catheter-based urinary tract infections (UTIs). Patients undergoing posterior trunk reconstruction after oncological surgery are at risk for similar complications from increased LOS, which may be magnified because of high rates of comorbidities and lack of mobility after large en bloc resections. Moreover, risk factors for increased LOS such as age, smoking, diabetes, malnutrition, obesity, preoperative hemoglobin level, and anesthesia duration are known to affect surgical patients in general. Crucially though, there is very little known about predictors of increased LOS germane to this population. Whether there are preoperative medical characteristics, intraoperative conditions, or specific postoperative insults that uniquely affect these patients is unknown. Understanding specific risk factors will enable more accurate risk stratification and will help improve outcomes in the highest risk patients.

In an era of health-care reform with increased emphasis on quality of health care and minimization of postoperative complications, having a better understanding of the factors associated with worse outcomes and longer hospitalization after spine surgery is essential. In this study, we aimed to identify perioperative risk factors and postoperative complications that are associated with increased LOS for patients undergoing posterior trunk reconstruction. We hypothesized that patient comorbidities, the timing of reconstruction, and postoperative wound complications would be significantly associated with longer LOS. The specific aims of this study included analyzing how preexisting conditions, surgical variables, and largely preventable postoperative complications contribute to prolonged hospitalization in this patient population.

METHODS

Study Design and Subjects

This study was a retrospective review of subjects derived from a prospectively collected database and was approved by the Johns Hopkins Institutional Review Board. Included patients were seen at our institution and treated within the Department of Neurosurgery and the Department of Plastic and Reconstructive Surgery over a 12-year period (2002–2014). Enrolled patients satisfied the following inclusion criteria: (1) age 18 to 100 years at the time of surgery; (2) minimum of 6 months of follow-up after their initial operation; (3) complete electronic medical record; and (4) initial operation performed by a neurosurgeon, with soft-tissue reconstruction performed by a plastic surgeon.

Study Variables

The primary outcome variable in this study was the length of hospitalization. Collected predictor variables included demographic variables (age, sex), medical variables (body mass index, diabetes, cardiovascular morbidities [hypertension, coronary artery disease, congestive heart failure, prior myocardial infarction, percutaneous coronary intervention, coronary artery bypass grafting], smoking status, chronic steroid/immunosuppression use], surgical variables (previous spine irradiation, previous spine surgery, flap type, location along the spine, and spinal hardware], and postoperative medical (DVT, PE, pneumonia, UTI, bacteremia, meningitis, small bowel obstruction] and wound-related [seroma, hematoma, infection, wound dehiscence, cerebrospinal fluid (CSF) leak] complications.

Data Collection, Management, and Analyses

Subjects were input into the database in a consecutive manner. Descriptive statistics were computed for the patient population. A P value of 0.05 was established as the threshold for statistical significance. Statistical computations were carried out using Stata/MP version 14.0 (StataCorp Inc.; College Station, Tex.).

LOS is well described in the literature to follow a highly nonnormal distribution with a long right-tail skew. Nonparametric methods (Mann–Whitney rank-sum/Kruskal–Wallis/Spearman correlation) were used to evaluate univariate predictors of LOS. Kaplan–Meier survival analysis (Cox proportional hazards model) was also used to measure variables correlated with a longer LOS. Goodness-of-fit tests were used to validate the overall models.

For regression and multivariate analysis, various distributions were evaluated. Zero-truncated negative binomial regression was found to produce the best model fit and is congruent with theoretical expectations for LOS (i.e., an over-dispersed nonzero Poisson count distribution). Stepwise regression evaluation was performed to develop the model with exclusion of collinear variables and maximization of model fit (as measured by AIC/BIC information criteria).

RESULTS

Demographics

A total of 288 cases in 258 patients were included in the study. The average age for the overall cohort was 52.6 ± 16.8 years, and 130 (50.4%) of the subjects were men. General demographic information is presented in Table 1. Surgical and postoperative course variables are presented in Table 2.

Medical and Surgical Variables: Univariate Analysis

Presence of spinal instrumentation during the neurosurgical and subsequent reconstructive surgeries was significantly associated with increased LOS (P = 0.004). The average LOS in patients without instrumentation was 13.68 (SD: 12.64) days, whereas the average LOS in patients with instrumentation was 19.85 (SD: 19.37) days. In cases involving tumor resection, the average tumor volume was 310.8 cm³. After log correction for nonnormality, tumor volume was still significantly associated with longer
hospitalization \( (P = 0.008) \). Preoperative chemotherapy was also associated with longer LOS \( (P = 0.002) \).

Postoperative Complications: Univariate Analysis

The LOS was significantly longer for patients who experienced a wound complication postoperatively \( (P < 0.001) \). Specifically, major wound complications that required reoperation \( (P < 0.001) \), wound dehiscence \( (P = 0.002) \), infection \( (P < 0.001) \), CSF leak \( (P = 0.003) \), and partial/total flap loss \( (P = 0.025) \) increased LOS, whereas the development of a hematoma and seroma did not significantly increase LOS. Postoperative medical morbidities also significantly increased LOS \( (P < 0.001) \); specifically, development of a DVT was associated with a longer LOS \( (P = 0.005) \). Significant variables with a \( P \) value <0.05 in univariate analysis are ranked according to their influence on LOS in Table 3. Kaplan–Meier analysis showed that wound dehiscence postoperatively increased LOS by 12 days [median LOS, 11 [95% confidence interval (CI): 9–14] vs 23 (95% CI: 14–28)] (Fig. 1).

LOS and Complications: Multivariate Analysis

The multivariate model for preoperative factor prediction of increased LOS included presence of instrumentation \( (P = 0.004) \), previous chemotherapy \( (P = 0.001) \), and log-transformed tumor size \( (P = 0.001) \). The model for postoperative incident prediction of LOS consisted of medical morbidity occurrence \( (P < 0.001) \), wound dehiscence \( (P = 0.02) \), CSF leak \( (P = 0.003) \), and partial/total flap loss \( (P = 0.02) \). The final combined multivariate LOS model successfully included all of these factors except for tumor volume \( (P < 0.02 \) for each of the 6 variables).

**DISCUSSION**

The aim of this study was to identify factors associated with increased LOS for patients undergoing posterior trunk soft-tissue reconstruction. It was previously unknown which medical or surgical factors are most predictive of increased LOS in this vulnerable patient population. We aimed to describe independent predictors of LOS to better understand and mitigate risks after posterior trunk reconstruction.

The results of this study demonstrate that risk factors including presence of instrumentation, previous chemotherapy, and specific postoperative complications are associated with increased LOS. The only factor dropping out of the multivariate model was tumor volume. Thus,
although tumor volume is still a possible factor potenti-
atating prolonged hospitalization that requires future in-
vestigation, in our study, only presence of hardware and
previous chemotherapy independently accounted for in-
creased LOS in the preoperative model. Most importantly,
postoperative wound breakdown was associated with a 12-
day longer hospitalization. It has previously been shown
that the use of prophylactic flaps helps minimize wound
complications by increasing vascularity and obliterating
the dead space after spine surgery.5 For example, the over-
all rate of CSF leak in patients undergoing spine surgery
ranges from 5.5% to 21%, and in our series, the incidence
with the use of flaps falls on the lower end of this range
at 6.6%.13 Although future prospective studies would be
needed to determine specific indications for prophylac-
tic flaps, given that wound dehiscence and CSF leak sig-
nificantly increase LOS, muscle flaps should be utilized
whenever possible in high-risk patients undergoing poste-
rrior trunk surgery. Flaps are especially important in cases
of multilevel en bloc tumor resections where there is an
increased risk of complications due to the creation of a
large defect. Although flap loss is also associated with in-
creased LOS, this complication is uncommon. Total flap
loss only occurred in 6 cases (2.1%) and partial flap loss
occurred in 18 cases (6.3%) within 5 years of surgery. We
therefore believe that the potential benefit that flaps pro-
vide in preventing wound complications and decreasing
LOS outweighs the small risk of flap failure.

As more complex spine surgeries are made possible
because of advances in instrumentation and reconstruc-
tive approaches, flaps will continue to play a larger role
in covering large spinal defects to lessen the likelihood of
complications.14 In patients undergoing extensive spinal
tumor resection, wound complications can be particularly
devastating because of the risk of exposed hardware or
neural structures. Subsequent reoperations and washouts
potentiate the risk for hardware removal, which can cause
long-term deformity and neural injury. Previous studies
have reported the benefits of using muscle flaps in pos-
terior trunk reconstructions. Cohen et al.5 reported a
wound complication rate of 6.8% in patients who received
a muscle flap to close a posterior trunk defect. Likewise, a
study by Garvey et al.4 reported a major complication rate
of 12% in a series of 52 patients who received an immedi-
ate flap after spinal tumor resection. These complications
rates are substantially lower than rates ranging anywhere
from 19% to 78% that are seen in patients undergoing
complex spinal surgery without the use of flaps.15–17 Chang
et al.2 have examined the importance of spinal instru-
mentation and reported a lower rate of wound complica-
tions among patients with instrumentation when flaps
were used prophylactically. Given that our study shows
an association between presence of instrumentation and
increased LOS and previous work has shown that flaps
can decrease wound complications in these patients, lo-
cal muscle flaps may be particularly beneficial for patients
with instrumentation. Mericli et al.10 have previously iden-
tified smoking, malnutrition, obesity, thoracic defect loca-
tion, and neoplasm as significant factors associated with
LOS after paraspinous muscle flap reconstruction in a
series of 92 patients. We add to this growing body of lit-
erature by reporting the association between medical and
surgical variables and also postoperative complications
and increased LOS.

Some of the factors that were implicated in increasing
LOS in our multivariate model can be easily addressed in
the postoperative period. Chief among these are medi-
cal complications, particularly DVT (39% of the medical
complications in this study). Previous data have shown
that chemoprophylaxis against DVT is safe and effective

Fig. 1. Wound dehiscence and LOS. Wound dehiscence added 12 days, on average, to the
postoperative LOS.
for patients undergoing spine surgery. Commonly used agents include low–molecular-weight heparin, subcutaneous heparin, and intravenous heparin, among others. Despite the large body of evidence demonstrating the safety and effectiveness of these methods, a recent survey indicates that some spine surgeons do not employ DVT prophylaxis at all, even in cases of complex oncological resections. Beyond this, for surgeons who choose to order DVT prophylaxis medications, the timing of the first dose varies considerably, from immediately postoperatively to 96 hours later. Heterogeneity is further demonstrated in the length of prescription of these medications, particularly in the setting of malignancy. This inconsistency in DVT prophylaxis very likely reflects the lack of high level of evidence studies to guide these decisions; however, the literature is very clear that pharmacological approaches to preventing DVT are safe, effective, and necessary. Our data are a call to action that for these patients, who are at very high risk for DVT formation due to nonmodifiable risk factors, DVT prophylaxis is essentially mandatory. This simple intervention can improve patient safety and significantly reduce LOS.

Similarly, we determined that wound dehiscence increases LOS by an average of 12 days. Typical postoperative interventions such as meticulous wound care by trained nursing staff, timely administration of antibiotics, routine skin assessment or monitoring devices for pressure sores, and negative pressure wound therapy can all be implemented to reduce the risk of dehiscence in patients undergoing spinal surgery. Even marginal decreases in local wound complications could have a major impact on the 12-day increase in LOS that our data demonstrate. Although the nonnormality of the data prohibited similar estimations of LOS increase for other specific complications, these data strongly encourage the participation of plastic surgeons early on in the care of these patients.

Our study has several limitations that warrant discussion. Because our study is retrospective, our ability to make causal conclusions regarding factors increasing LOS is limited. However, this is the largest study to date examining factors associated with LOS after posterior trunk reconstruction. Also, we did not assess readmission rates. Future studies are needed to examine whether similar factors are associated with reduced readmissions and whether efforts to lower LOS influence rates of readmissions. Finally, the nature of the LOS variable restricted our ability to produce quantitative estimates for the impact of certain complications on LOS. The data were amenable to this calculation for wound dehiscence, but we felt that we could not accurately produce similar estimates for the other complications identified. Despite this, actionable steps can still be taken to decrease the frequency of these complications and, thus, LOS. Moreover, future studies should continue our efforts and collect data adequate for these calculations.

CONCLUSIONS

Spine tumor resections often create large defects that necessitate the use of muscle flaps for closure. Specifically, patients who have received chemotherapy, require instrumentation, or experience wound dehiscence or a medical complication postoperatively are at increased risk for prolonged hospitalization after spinal reconstruction. Straightforward interventions can be implemented to reduce the risk of these costly complications.

Justin M. Sacks, MD, MBA, FACS
Department of Plastic and Reconstructive Surgery
The Johns Hopkins Hospital
601 North Caroline Street, Suite 2114C
Baltimore, MD 21287
E-mail: jmsacks@jhmi.edu

REFERENCES

1. Moore B, Levit K, Elixhauser A. Costs for Hospital Stays in the United States, 2012. Statistical Brief #181. Healthcare Cost and Utilization Project (HCUP) Statistical Briefs. Agency for Healthcare Research and Quality: Rockville, MD; 2014.
2. Chang DW, Friell MT, Youssaf AA. Reconstructive strategies in soft tissue reconstruction after resection of spinal neoplasms. Spine (Phila Pa 1976) 2007;32:1101–1106.
3. Eshima I, Mathes SJ, Paty P. Comparison of the intracellular bacterial killing activity of leukocytes in muscleucutaneous and random-pattern flaps. Plast Reconstr Surg. 1990;86:541–547.
4. Garvey PB, Rhines LD, Dong W, et al. Immediate soft-tissue reconstruction for complex defects of the spine following surgery for spinal neoplasms. Plast Reconstr Surg. 2010;125:1460–1466.
5. Cohen LE, Fullerton N, Mundy LR, et al. Optimizing successful outcomes in complex spine reconstruction using local muscle flaps. Plast Reconstr Surg. 2016;137:295–301.
6. Khalafallah AA, Kirkby BE, Wong S, et al. Venous thromboembolism in medical patients during hospitalisation and 3 months after hospitalisation: a prospective observational study. BMJ Open 2016;6:e012546.
7. Lynch JP III. Hospital-acquired pneumonia: risk factors, microbiology, and treatment. Chest 2001;119(2 Suppl):373S–384S.
8. Shah NK, Farber A, Kalish JA, et al. Occurrence of “never events” after major open vascular surgery procedures. J Vasc Surg 2016;63:738–745.e28.
9. Luzzati AD, Shah SP, Gagliano FS, et al. Four- and five-level en bloc spondylectomy for malignant spinal tumors. Spine (Phila Pa 1976) 2014;39:E129–E139.
10. Meridci AF, Tarola NA, Moore JH Jr, et al. Paraspinal muscle flap reconstruction of complex midline back wounds: risk factors and postreconstruction complications. Ann Plast Surg 2010;65:219–224.
11. Patel RS, McCluskey SA, Goldstein DP, et al. Clinicopathologic and therapeutic risk factors for perioperative complications and prolonged hospital stay in free flap reconstruction of the head and neck. Head Neck 2010;32:1345–1353.
12. Matas AJ, Gillingham KJ, Elick BA, et al. Risk factors for prolonged hospitalization after kidney transplants. Clin Transplant. 1997;11:259–264.
13. Menon SK, Onyia CU. A short review on a complication of lumbar spine surgery: CSF leak. Clin Neurol Neurosurg. 2013;139:248–251.
14. Chieng LO, Hubbard Z, Salgado CJ, et al. Reconstruction of open wounds as a complication of spinal surgery with flaps: a systematic review. Neurosurg Focus 2015;39:E17.
15. Wise JJ, Fischgrund JS, Herrkowitz HN, et al. Complication, survival rates, and risk factors of surgery for metastatic disease of the spine. Spine (Phila Pa 1976) 1999;24:1943–1951.
16. Weigel B, Maghsudi M, Neumann C, et al. Surgical management of symptomatic spinal metastases. Postoperative outcome and quality of life. Spine (Phila Pa 1976) 1999;24:2240–2246.
17. Amendola L, Cappuccio M, De Iure F, et al. En bloc resections for primary spinal tumors in 20 years of experience: effectiveness and safety. Spine J. 2014;14:2608–2617.

18. Cox JB, Weaver KJ, Neal DW, et al. Decreased incidence of venous thromboembolism after spine surgery with early multimodal prophylaxis: Clinical article. J Neurosurg Spine 2014;21:677–684.

19. Glotzbecker MP, Bono CM, Harris MB, et al. Surgeon practices regarding postoperative thromboembolic prophylaxis after high-risk spinal surgery. Spine (Phila Pa 1976) 2008;33:2915–2921.

20. Strom RG, Frempong-Boadu AK. Low-molecular-weight heparin prophylaxis 24 to 36 hours after degenerative spine surgery: risk of hemorrhage and venous thromboembolism. Spine (Phila Pa 1976) 2013;38:E1498–E1502.

21. Khorana AA, Streiff MB, Farge D, et al. Venous thromboembolism prophylaxis and treatment in cancer: a consensus statement of major guidelines panels and call to action. J Clin Oncol. 2009;27:4919–4926.

22. Adogwa O, Fatemi P, Perez E, et al. Negative pressure wound therapy reduces incidence of postoperative wound infection and dehiscence after long-segment thoracolumbar spinal fusion: a single institutional experience. Spine J. 2014;14:2911–2917.