Timing of complications following posterior cervical fusion

J. Mason DePasse^{a,*}, Wesley Durand^b, Adam E.M. Eltorai^b, Mark A. Palumbo^c, Alan H. Daniels^c

^a Department of Orthopaedics, Alpert Medical School of Brown University, 593 Eddy Street, Providence, RI, 02903, United States

^b Alpert Medical School of Brown University, 593 Eddy Street, Providence, RI, 02903, United States

^c Department of Orthopaedics, Division of Spine Surgery, Alpert Medical School of Brown University, 100 Butler Drive, Providence, RI, 02906, United States

ARTICLE INFO

Keywords:

Cervical spine
Cervical fusion
Complications
Pulmonary embolism
Transfusion
Surgical site infection
Timing
Myocardial infarction
Urinary tract infection
Reimbursement

ABSTRACT

Study design: Retrospective cohort study.

Objective: To characterize the timing of complications after posterior cervical fusion.

Summary of background data: Understanding the expected timing of postoperative complications facilitates early diagnosis of potential adverse events and is important for optimizing postoperative care. Though studies have examined the incidence of complications after posterior cervical fusion, no study has characterized the timing of these complications.

Methods: Patient data in the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) dataset with a primary CPT code 22600, corresponding to posterior cervical fusion, was analyzed for demographics, comorbidities, and ten specific complications. Complication timing was assessed, and univariate analysis was performed to investigate the relationship of patient demographic and clinical variables on the development of postoperative complications.

Results: A total of 2517 patients with a mean age of 59.3 ± 12.5 met inclusion criteria. The overall complication rate was 12.4%. The median day of diagnosis and interquartile range for each complication was: blood transfusion (0.0, 0–0), myocardial infarction (3, 2–7), reintubation (3, 1–9), pneumonia (4, 3–10), deep venous thrombosis (7, 5–16), urinary tract infection (11.5, 9–17.5), sepsis (14, 7–20), pulmonary embolism (14, 8–21), surgical site infection (15, 9–21), and wound dehiscence (15.5, 9–25). Less than 50% deep venous thromboses were diagnosed before discharge, and less than 30% of pulmonary emboli were diagnosed before discharge. On univariate analysis, increased age, decreased functional status, fusing more than one level, current smoker status, diabetes, and CHF were associated with increased complications.

Conclusions: This timing data is useful to the practicing spine surgeon as it provides a guide for when to expect and investigate for specific complications after posterior cervical procedures. It may aid in the early diagnosis of complications and may also assist in healthcare reimbursement negotiations.

1. Introduction

Understanding the expected timing of postoperative complications facilitates early diagnosis of potential adverse events and is important for optimizing postoperative care. Information on timing is also important for informed negotiating of payments in the era of bundled care.^{1,2}

Two recent investigations evaluated the timing of complications after spine surgery.^{2,3} De la Garza Ramos et al. studied ten complications after spinal deformity surgery, including myocardial infarction (MI), pulmonary embolism (PE), reintubation, pneumonia, urinary tract infection (UTI), sepsis, deep vein thrombosis (DVT), and deep, superficial, and organ space surgical site infection (SSI).³ Similarly, Bohl et al. examined the timing of eight complications following anterior

cervical decompression and fusion (ACDF) and posterior lumbar fusion (PLF); a division was identified between “early” complications, such as transfusion, MI, and PE, and “late” complications (after postoperative day 7), such as UTI, DVT, and SSI.² Importantly, the timing of complications differed between all three groups of patients (spinal deformity, ACDF and PLF). For example, UTI was diagnosed earlier in PLF patients than ACDF or deformity patients, and SSI was diagnosed earlier in ACDF patients.^{2,3}

Though multiple studies have investigated the incidence and type of complications after posterior cervical fusion (PCF),^{4–8} no study has described the timing of complications after posterior cervical spine surgery. In the current study the timing of ten complications after PCF was characterized in order to define the periods of highest risk for each complication in this patient population.

* Corresponding author at: Department of Orthopaedics, Alpert Medical School of Brown University, 100 Butler Drive, Providence, RI, 02906, United States.
E-mail address: jmdepasse@gmail.com (J.M. DePasse).

2. Methods

2.1. Study design

This study was a retrospective analysis of data from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) dataset for years 2011–2015. The ACS NSQIP is a database containing morbidity and mortality outcomes up to 30-days after major surgical procedures and includes information on the timing of these outcomes. ACS NSQIP data is abstracted by certified staff, and quality assurance is performed with an Inter-Rater Reliability Audit. The NSQIP does not contain data from minor cases, patients < 18 years-old, trauma cases, solid organ transplant cases, and patients with an ASA score of 6.

2.2. Inclusion criteria

The primary inclusion criterion for this study was the presence of a primary listed CPT code corresponding to posterior cervical fusion (22600). Only elective procedures were considered. Patient characteristics and postoperative outcomes were collected from prospectively defined data elements in the NSQIP. The number of levels fused was evaluated using a CPT code for additional fusion levels (22614).

2.3. Data collection

Patient characteristics were analyzed including age, sex, BMI, and functional status. The comorbidities of diabetes, smoking, congestive heart failure, COPD, and dialysis status were also assessed. In total, ten separate complications were examined for timing of occurrence: postoperative blood transfusion, SSI (including deep, organ/space, and superficial), UTI, pneumonia, sepsis (including sepsis and septic shock), unplanned intubation, DVT, wound dehiscence, MI, and PE. Descriptive statistics were generated for patient characteristics and occurrence of any complication; the occurrence of complications was tabulated by number of levels fused.

2.4. Statistical analysis

All statistical analysis was performed using SAS 9.4 (SAS Institute, Cary, NC). Timing of complications was assessed with the reporting of mean, median, minimum, maximum, 25th and 7th percentiles, standard deviation, and cumulative distribution function. The percent of events occurring before discharge was calculated for each complication of interest. A covariance matrix evaluated Pearson Correlation Coefficients between each complication. Differences in rates of complications between patients with different numbers of levels fused were evaluated for significance with Chi-Square tests. Finally, univariate logistic regression was performed to investigate the relationship of patient demographic and clinical variables on the development of postoperative complications. Statistical significance was maintained at $p < .05$.

3. Results

A total of 2517 patients who underwent PCF met inclusion criteria. Mean age was 59.3 ± 12.5 , and 54.6% of the patients were female. Mean BMI was 29.3 ± 6.5 . The most common preoperative comorbidity was smoking status; 710 (28.2%) patients were current smokers. More than one level was fused in 65.0% of patients. Patient demographic and clinical characteristics are shown in Table 1.

The most common complications occurring within 30 days of surgery were anemia requiring blood transfusion (5.3% of patients), SSI (2.8%), and UTI (1.7%) (Table 2). The median day of diagnosis and interquartile range for each complication was: blood transfusion (0.0, 0–0), MI (3, 2–7), reintubation (3, 1–9), pneumonia (4, 3–10), DVT (7,

Table 1

Patient demographic and clinical characteristics.

Characteristic	N	%
Overall	2517	–
Age		
< 65	1646	65.4
65–79	746	29.6
80+	125	5.0
Sex		
Male	1375	54.6
Female	1142	45.4
BMI		
< 18.5	676	26.9
18.5–29.9	836	33.2
≥ 30.0	990	39.3
Missing	15	0.6
Functional Status		
Independent	2382	94.6
Partially Dependent	105	4.2
Totally Dependent	11	0.4
Unknown	19	0.8
Comorbidity		
Current smoker	710	28.2
Diabetic	423	16.8
COPD	145	5.8
Dialysis	15	0.6
CHF	11	0.4
Levels Fused		
1	880	35.0
2+	1637	65.0

Table 2

Complication frequency and timing within 30 days of PCF.

Complication	N	Rate (%)	Mean Day	Median Day (IQR)
Blood Transfusion	133	5.3	0.4 ± 0.9	0 (0–0)
Surgical Site Infection	71	2.8	16.0 ± 7.8	15 (9–21)
Urinary Tract Infection	44	1.7	12.0 ± 8.1	11.5 (5–17.5)
Pneumonia	33	1.3	6.9 ± 6.4	4 (3–10)
Sepsis	30	1.2	14.2 ± 8.0	14 (7–20)
Reintubation	23	0.9	5.0 ± 5.3	3 (1–9)
Deep Vein Thrombosis	21	0.8	9.8 ± 7.0	7 (5–16)
Wound Dehiscence	18	0.7	15.9 ± 8.9	15.5 (9–25)
Myocardial Infarction	13	0.5	4.8 ± 4.2	3 (2–7)
Pulmonary Embolism	11	0.4	15.1 ± 8.3	14 (8–21)

5–16), UTI (11.5, 5–17.5), sepsis (14, 7–20), PE (14, 8–21), SSI (15, 9–21), and wound dehiscence (15.5, 9–25) (Fig. 1). Table 2 provides the complication frequency and timing in all patients within 30 days of PCF.

Early complications including MI, reintubation, and pneumonia were diagnosed before discharge in over 80% of occurrences; later complications such as wound dehiscence and SSI were diagnosed before discharge in less than 10% of cases. Fig. 2 shows the percentage of complications diagnosed before discharge.

A total 313 (12.4%) of patients had complications within 30 days of surgery; 238 (9.5%) had one complication, and 75 (3.0%) had more than one complication. Correlation analysis of the 10 studied complications revealed several significant associations. The strongest associations were between DVT and PE ($r = 0.39$), reintubation and pneumonia ($r = 0.32$), and reintubation and MI ($r = 0.28$) (Table 3). The covariance matrix for complications is shown in Table 3.

Univariate analysis results are shown in Table 4. Increasing age, decreased functional status, and fusion of more than one level were associated with increased complications ($p < .002$). Among comorbidities, current smoker status, diabetes, and CHF were also associated with a higher frequency of complications ($p < .04$). A sub-analysis comparing the frequency of specific complications between patients who had one level fused and patients who had more than one

Fig. 1. Complication Timing within 30 days of PCF.

The light blue boxes represent the second quartile, the dark blue boxes represent the third quartile, and the line separating them represents the median number of days to diagnosis of the complication. The error bars represent the range.

level fused revealed a significantly higher rate of blood transfusion ($p = .007$) in patients who had more than one level fused. There were no differences in the frequencies of any other complication.

4. Discussion

Utilizing the ACS NSQIP dataset, this study characterized the timing of ten complications after posterior cervical fusion. Early complications included blood transfusion, MI, reintubation, and pneumonia. These complications most commonly occurred before postoperative day 5 and over 70% were diagnosed before discharge. In contrast, the late complications of DVT, UTI, sepsis, PE, SSI, and wound dehiscence most often occurred on or after postoperative day 7. Less than 50% of these were diagnosed before discharge highlighting the importance of close patient follow-up. A higher risk of complications was identified in older patients, less functionally independent patients, smokers, diabetics, patients with heart failure, and patients who had more than one level fused.

Both Bohl et al. and De la Garza Ramos et al. also reported on “early” and “late” complications after spine surgery.^{2,3} For both anterior cervical fusions and posterior lumbar fusions, Bohl et al. found that

transfusion, MI, pneumonia, and PE were “early,” while DVT, sepsis, SSI, and UTI were “late.”² Similarly, De la Garza Ramos found that “early” complications (defined as those diagnosed before day 6 after surgery for adult spinal deformity) were MI, reintubation, pneumonia, and PE.³ Late complications in their study included UTI, sepsis, DVT, and superficial/deep/organ space SSI.³ The largest differences in the timing of complications for the patient populations in these two studies were for UTI, which had a median day of diagnosis on day 17 in ACDF patients, day 11 in spinal deformity patients, and day 7 in PLF patients, and for DVT, which had a median day of 12 in spinal deformity patients, 10.5 in ACDF patients, and 8 in PLF patients.^{2,3} These differences were attributed to the differences in patient populations, including urinary tract catheterization practices.^{2,3}

In our study, the median day of diagnosis for UTI was 11.5 which falls in the middle of the other two studies and is most similar to the timing for spinal deformity patients. In contrast, our patient population differs from the other three with regard to timing of DVT and PE. The median day of diagnosis for DVT was 7, which is similar to the PLF patients. The median day of diagnosis for PE was 14 compared to day 5 for the ACDF and PLF patients and day 4 for the adult spinal deformity patients.^{2,3} The 0.4% rate of PE is similar to the other groups: 0.1% for

Fig. 2. Complications Diagnosed before Discharge.

Table 3
Covariance matrix for complications after PCF.

	Blood Transfusion	SSI	UTI	Pneumonia	Sepsis	Reintubation	DVT	Wound Dehiscence	MI	PE
Blood Transfusion	1.000									
SSI	−0.008	0.686								
UTI	0.023	0.014	0.255							
Pneumonia	0.113	−0.020	0.011	0.325						
Sepsis	< .001	< .001	< .001	< .001	0.143					
Reintubation	0.056	0.180	0.209	0.213	0.005	< .001				
DVT	0.089	0.009	0.051	0.319	< .001	< .001	0.151	0.083		
Wound Dehiscence	0.915	0.063	< .001	0.001	< .001	< .001	< .001	< .001	−0.008	
MI	0.043	0.213	0.025	0.032	−0.009	0.041	0.041	0.041	0.060	
PE	0.030	< .001	0.216	0.112	0.640	0.038	0.696	0.696	0.003	
	0.107	−0.012	−0.010	0.138	0.094	0.284	−0.007	0.740	0.060	
	< .001	0.538	0.630	< .001	< .001	< .001	0.391	−0.006	−0.005	1.000
	0.011	−0.011	0.083	0.098	0.104	0.120	0.391	−0.006	−0.005	1.000
	0.572	0.571	< .001	< .001	< .001	< .001	< .001	0.778	0.811	

The top value in each cell is the Pearson correlation coefficient, and the bottom value is the p value. Bold denotes significance.

Table 4
Frequency of complications by patient demographics and clinical characteristics.

Characteristic	N	%	p-value
Overall	313	12.4	
Age			< .001
< 65	151	9.2	
65–79	136	18.2	
80 +	26	20.8	
Sex			0.466
Male	177	12.9	
Female	136	11.9	
BMI			0.890
< 18.5	81	12.0	
18.5–29.9	107	12.8	
≥ 30.0	124	12.5	
Functional Status			< .001
Independent	280	11.8	
Partially Dependent	28	26.7	
Totally Dependent	4	36.4	
Comorbidity			
Current smoker	69	9.7	0.010
Diabetic	68	16.1	0.019
COPD	25	17.2	0.071
Dialysis	4	26.7	0.106
CHF	4	36.4	0.038
Levels Fused			0.002
1	85	9.7	
2 +	228	13.9	

ACDF patients, 0.5% for PLF patients, and 1.2% for spinal deformity patients.^{2,3} It is unclear why PE is diagnosed much later in PCF patients. It is possible that the respiratory effects of the other procedures are more profound and lead to earlier advanced imaging investigation.

The complication rate for posterior cervical surgery has been reported in recent studies. Leckie et al. reported an overall rate of 22.9% for both primary and revision posterior cervical spine surgeries in 262 patients.⁴ Medvedev et al. reported a rate of 35.6%, for all posterior cervical surgeries in 5627 patients.⁵ In the current study the overall complication rate was 12.4%. This difference can be partially attributed to rates of blood transfusion. Medvedev et al. reported a 26.3% rate of blood transfusion,⁵ while only 5.3% of patients in our study required transfusion. This difference is potentially related to our exclusion of trauma cases and fusion incorporating the occiput, C1 and C2 levels.

SSI occurred in 2.82% of patients in our study. This infection rate is similar to the 2.6% of patients in Medvedev et al. and the 2.9% of patients in Sebastian et al., a study of 5441 patients who underwent posterior cervical surgery.^{5,9} Our infection rate is greater than the rate in either the ACDF group (0.4%) or the PLF group (1.8%) in the study by Bohl et al.² but similar to the spinal deformity group (2.8%) in the study by De la Garza Ramos et al.³

In our study, increasing age, increasing levels fused, decreasing functional status, smoking status, diabetes, and CHF were associated with increased complications. This correlates with the findings of Medvedev et al. who identified increasing age, increasing frailty, diabetes, and smoking to be associated with increased complications after PCF.⁵ Of note, both Medvedev et al. and Buerba et al. found no association between BMI and complications after posterior cervical surgery;^{5,8} obesity does not appear to increase the risk of infection at the cervical level.

This study has several potential limitations. The ACS NSQIP database is not specific to spine surgery, and it lacks spine-surgery specific complications such as incidental durotomy and functional outcomes. It also includes only complications that were diagnosed within the first 30 postoperative days. As such, our reported complication rates will be slightly lower than the actual rates, particularly for late-occurring complications. The database, however, is sufficient to characterize the timing of complications in the immediate postoperative period after PCF.

This data is useful to the practicing spine surgeon as it provides a guide for when to expect and investigate for specific complications after posterior cervical procedures. This data is useful in the early diagnosis of complications and may facilitate healthcare reimbursement negotiations by providing information on the rate and timing of complications following posterior cervical fusion.

Funding

No funding was obtained in support of this work.

Conflict of interest

None.

References

1. Sonnenberg EM, Reinke CE, Bartlett EK, et al. Wind, water, wound, walk—do the data

- deliver the dictum? *J Surg Educ.* 2015;72(1):164–169. <http://dx.doi.org/10.1016/j.jsurg.2014.05.019>.
2. Bohl DD, Webb ML, Lukasiewicz AM, et al. Timing of complications after spinal fusion surgery. *Spine.* 2015;40(19):1527–1535. <http://dx.doi.org/10.1097/BRS.0000000000001073>.
3. De la Garza Ramos R, Goodwin CR, Passias PG, et al. Timing of complications occurring within 30 days after adult spinal deformity surgery. *Spine Deform.* 2017;5(2):145–150. <http://dx.doi.org/10.1016/j.jspd.2016.10.009>.
4. Leckie S, Yoon ST, Isaacs R, et al. Perioperative complications of cervical spine surgery: analysis of a prospectively gathered database through the association for collaborative spinal research. *Glob Spine J.* 2016;6(7):640–649. <http://dx.doi.org/10.1055/s-0035-1570089>.
5. Medvedev G, Wang C, Cyriac M, Amdur R, O'Brien J. Complications, readmissions, and reoperations in posterior cervical fusion. *Spine.* 2016;41(19):1477–1483. <http://dx.doi.org/10.1097/BRS.0000000000001564>.
6. Fineberg SJ, Ahmadiania K, Oglesby M, Patel AA, Singh K. Hospital outcomes and complications of anterior and posterior cervical fusion with bone morphogenetic protein. *Spine.* 2013;38(15):1304–1309. <http://dx.doi.org/10.1097/BRS.0b013e31828f494c>.
7. Harel R, Stylianou P, Knoller N. Cervical spine surgery: approach-related complications. *World Neurosurg.* 2016;94:1–5. <http://dx.doi.org/10.1016/j.wneu.2016.06.099>.
8. Buerba RA, Fu MC, Grauer JN. Anterior and posterior cervical fusion in patients with high body mass index are not associated with greater complications. *Spine J Off J North Am Spine Soc.* 2014;14(8):1643–1653. <http://dx.doi.org/10.1016/j.spinee.2013.09.054>.
9. Sebastian A, Huddleston P, Kakar S, Habermann E, Wagie A, Nassr A. Risk factors for surgical site infection after posterior cervical spine surgery: an analysis of 5,441 patients from the ACS NSQIP 2005–2012. *Spine J Off J North Am Spine Soc.* 2016;16(4):504–509. <http://dx.doi.org/10.1016/j.spinee.2015.12.009>.