Increased In-hospital Complications After Primary Posterior versus Primary Anterior Cervical Fusion

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Abstract

Background Although anterior (ACDF) and posterior cervical fusion (PCDF) are relatively common procedures and both are associated with certain complications, the relative frequency and severity of these complications is unclear. Since for some patients either approach might be reasonable it is important to know the relative perioperative risks for decision-making.

Questions/purposes The purposes of this study were to: (1) characterize the patient population undergoing ACDF and PCDF; (2) compare perioperative complication rates; (3) determine independent risk factors for adverse perioperative events; and (4) aid in surgical decision-making in cases in which clinical equipoise exists between anterior and posterior cervical fusion procedures.

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Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research. This work was performed at the Hospital for Special Surgery, Weill Medical College of Cornell University, New York, NY, USA.

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Methods The National Inpatient Sample was used and entries for ACDF and PCDF between 1998 and 2006 were analyzed. Demographics and complication rates were determined and regression analysis was performed to identify independent risk factors for mortality after ACDF and PCDF.

Results ACDF had a shorter length of stay and their procedures were more frequently performed at nonteaching institutions. The incidence of complications and mortality was 4.14% and 0.26% among patients undergoing ACDF and 15.35% and 1.44% for patients undergoing PCDF, respectively. When controlling for overall comorbidity burden and other demographic variables, PCDF was associated with a twofold increased risk of a fatal outcome compared with ACDF. Pulmonary, circulatory, and renal disease were associated with the highest odds for in-hospital mortality.

Conclusions PCDF procedures were associated with higher perioperative rates of complications and mortality compared with ACDF surgeries. Despite limitations, these data should be considered in cases in which clinical equipoise exists between both approaches.

Level of Evidence Level II, prognostic study. See Guidelines for Authors for a complete description of levels of evidence.

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Introduction

Over the last three decades, the total number of cervical spine surgical operations has grown dramatically in the United States. Between 1980 and 1990, the total number of cervical cases increased by 45%, whereas the same case volume grew by approximately 110% between 1990 and 2000 [12, 20, 25]. As our understanding of the pathoanatomy and as our diagnostic capabilities and technologies have improved, the proportion of cervical fusion procedures has seen a sharp increase, whereas nonfusion cervical procedures have sharply declined. Between 1990 and 2000, the number of anterior cervical fusions rose 800%. Concurrently, the number of posterior cervical fusions rose 300% [25]. Patients undergoing cervical fusion procedures have benefited from this evolution as complication rates continue to decline (mortality rates declining from 0.21% at the beginning of the decade to 0.15% at the end of the decade) and hospital stays continued to decrease (from an average of 5.5 days of postoperative stay in 1990 to 2.2 days in 2000 for all degenerative cervical spine patients undergoing surgery) despite increasing comorbidity burden and age among this population [12, 20, 25]. From 1990 to 2000, the mean age of hospitalized patients undergoing surgery for degenerative cervical spinal disease increased from 47.5 to 49.2 [2]. During that same decade, the fraction of patients without major comorbidity declined from 91.3% to 86.5% of the hospitalized cervical spine degenerative disease surgery population [25].

Key considerations affecting the choice of an anterior versus posterior approach include location and type of stenosis, number of affected levels, and sagittal alignment. Several protocols have been described and analyzed in an attempt to standardize the decision-making in regard to matching a patient's presentation with the best possible surgical approach [2, 8]. Having an understanding of outcomes reflective of current technologies and of perioperative risk is essential to decision-making as well as managing patient and surgeon expectations. More importantly, in a subset of cases in which clinical equipoise exists, this information is vital to maximizing outcomes and minimizing patient mortality and morbidity.

Imaging modalities, surgical technique, instrumentation technologies, healthcare delivery, and patient expectations are highly dynamic. Numerous epidemiologic studies have been performed using data from the 1980s and 1990s [1, 8, 17, 25, 31]. These data inform physicians and their patients of short-term risks associated with these specific procedures, provide nationally representative (not affected by single or specialized institution bias) data to researchers and administrators to aid them in the appropriate allocation of hospital resources, and help generate hypotheses for future studies. For example, among the highest procedure-

related complications after anterior cervical fusion (ACDF) in the early 1990s were those affecting the central nervous system [20]. This knowledge allowed for the generation of hypotheses regarding the etiology of such complications and led to the development of improved routine perioperative testing modalities and interventions (ie, carotid Doppler for the detection of carotid stenosis and continued use of perioperative aspirin in high-risk patients) that may have contributed to a dramatic reduction in these events from approximately 0.7% to 0.1% [20].

Although valuable, available studies currently are limited by their lack of inclusion of more recent data, direct comparison of procedures using nationally representative data, and their limited analysis of risk factors for adverse short-term mortality.

The purposes of our study were therefore to (1) characterize the patient population undergoing ACDF and posterior cervical fusion (PCDF); (2) compare perioperative complication rates; (3) determine independent risk factors for adverse perioperative events; and (4) aid in surgical decision-making in cases in which clinical equipoise exists between anterior and posterior cervical fusion procedures. This information may be of special value for surgical decision-making in cases in which either anterior or posterior cervical fusion procedures appear reasonable.

Materials and Methods

National Inpatient Sample (NIS) annual data files for data collected between 1998 and 2006 were commercially obtained from the Hospital Cost and Utilization Project (HCUP). The NIS represents the largest all-payer inpatient database in the United States, and as such, part of the HCUP is sponsored by the Agency for Healthcare Research and Quality (AHRQ). In brief, the NIS contains information on inpatient discharges from approximately eight million hospital admissions per year. We identified a total of 228,113 admissions during which a primary cervical spine fusion procedure was performed. This represented a weighted national estimate of 1,108,005 surgical hospitalizations. Of those, 91.7% were ACDF procedures, whereas 8.3% were PCDF procedures.

Having grown since its inception in 1988 when it included data from eight US states, the most recent data files represent a 20% stratified sample of approximately 1000 hospitals in 38 states. The NIS provides weights that allow for nationally representative estimates. It includes over 100 clinical and nonclinical data elements such as diagnoses, procedures, admission and discharge status, patient demographics (eg, gender, age, race, payment source, length of stay), and hospital characteristics (eg, size, location, teaching status). By offering such a diverse

sampling, the database overcomes some of the inherent biases associated with literature emanating from major academic institutions. Detailed information on the NIS design can be found at <http://www.hcup-us.ahrq.gov/nisoverview.jsp> [14] and http://www.hcup-us.ahrq.gov/db/nation/nis/2006NIS_INTRODUCTION.pdf [16]. The NIS database has been used previously in a large number of studies addressing various questions across the spectrum of medical specialties (<http://www.ahrq.gov/data/hcup/hcupref.htm>) [26], including cervical spine surgery [8, 19, 20, 25]. Because data used in this study are sufficiently deidentified, this study was exempt from review by the Institutional Review Board.

Data collected for each year between 1998 and 2006 were read into a statistical software program (SAS Version 9.1.3; SAS Institute, Cary, NC) and analyzed. To improve the representativeness of the NIS, the sampling and weighting strategy was modified beginning with the 1998 data. To avoid any bias introduced by this change, we included only data collected after 1998 in our study. At the time of analysis, the 2006 data set was the latest complete year available. Discharges with a procedure code (International Classification of Diseases, 9th Revision, Clinical Modification [ICD-9-CM]) for primary anterior (81.02) or primary posterior (81.03) spine fusion were identified and included in the sample. The prevalence of procedure subtypes and respective demographics (age, gender, race, disposition status, primary source of payment, distribution of procedures by hospital size, teaching status and location, and length of care) were evaluated. Frequencies of procedure-related complications were analyzed by determining cases that listed ICD-9-CM diagnosis codes specifying complications of surgical and medical care (ICD-9-CM 996.X to 999.X). In addition, we studied the prevalence of selected adverse diagnoses, including pulmonary embolism, venous thrombosis, respiratory insufficiency after trauma or surgery/adult respiratory distress syndrome (ARDS), acute posthemorrhagic anemia, and the use of blood product transfusion, using the ICD-9-CM diagnosis code system. Comorbidity profiles were analyzed by determining the prevalence of a number of disease states as defined in the Comorbidity Software and provided by the AHRQ [13]. To determine overall comorbid burden, comorbidity indices were calculated as described by Charlson et al. [6] and adjusted for use with administrative data by Deyo et al. [10]. In brief, the Deyo comorbidity index predicts mortality and postoperative complications for a patient with a range of comorbid conditions with each condition assigned a score depending on the risk of dying. The scores are summed up and given a total score that predicts mortality. This methodology was validated in the Medicare spine surgical population [10]. However, like any predictive statistical construct, its use is limited by the

number of components entered and the population for which it was devised.

We determined differences in patient- and healthcare system-related characteristics between ACDF and PCDF procedures by using a t-test for continuous variables (average age, length of hospital stay, average comorbidity index) and chi square test for categorical variables (gender, race, age group, payer, discharge disposition, hospital size, teaching status and location, individual comorbidities). Differences in the rates of complications and mortality among procedure groups were assessed using the chi square test. Continuous variables are presented as mean and 95% confidence intervals. Categorical variables are computed as percentages. Subsequently, multivariate regression analysis was performed and odds ratios and 95% confidence intervals were calculated to determine independent predictors for in-hospital mortality. For multivariate logistic regression analysis, control variables included in the model were procedure type, age, gender, race, hospital size, hospital location, hospital teaching status, primary source of patient payment, admission status, and comorbidity index. Individual comorbidities were substituted for comorbidity index to determine the impact of specific comorbidities on mortality. For each individual predictor, odds ratio, 95% confidence intervals, and p values were computed. Confidence intervals and p values are presented to allow for evaluation of the level of significance. All statistical analyses were performed using SAS Version 9.1.3 (SAS Institute). SAS procedures (eg, SURVEYFREQ and SURVEYLOGISTIC) were used to account for weighting, clustering, and stratification in the NIS' complex survey design.

Results

Patient and healthcare system-related demographics varied substantially between ACDF and PCDF procedures (Table 1). Proportionally, PCDF procedures were more frequently performed among racial minority groups and after emergent admission. Hospitals performing PCDF procedures tended to be more frequently urban, of large size, and teaching institutions. Higher overall comorbidity burden was reflected in a higher ($p < 0.001$) average comorbidity index in the latter group (0.49 [confidence interval 0.48–0.50] versus 0.34 [confidence interval 0.33–0.34]).

The average length of hospital stay was approximately three times ($p < 0.001$) that of ACDF recipients as for patients undergoing PCDF (2.4 [confidence interval 2.39–2.43] days versus 7.8 [confidence interval 7.59–7.94] days). The incidence of procedure-related complications was lower ($p < 0.001$) among patients undergoing ACDF (4.14%) compared with patients undergoing PCDF

Table 1. Demographics of anterior and posterior cervical spine fusion surgery discharges

Spine surgery type	Anterior			Posterior			p value
	F	WF	Percent	F	WF	Percent	
Frequency/weighted frequency/percent	209,136	1,014,778	91.68	18,977	93,227	8.32	
Age groups (years)							
0–44	74,244	361,346	35.71	5195	25,618	28.00	< 0.0001
45–64	109,137	528,541	52.24	7896	38,685	42.29	
65–74	18,588	89,982	8.89	3334	16,342	17.86	
75+	6563	31,949	3.16	2199	10,833	11.84	
Gender							
Male	103,051	500,973	49.40	11,161	54,820	58.73	< 0.0001
Female	105,969	513,231	50.60	7840	38,522	41.27	
Race							
White	124,969	604,899	84.03	11,224	55,154	78.06	< 0.0001
Black	12,617	60,789	8.44	1697	8287	11.73	
Hispanic	6369	30,305	4.21	880	4251	6.02	
Other	4951	23,890	3.32	602	2967	4.20	
Insurance							
Medicare	34,702	168,000	16.60	6416	31,479	33.78	< 0.0001
Medicaid	10,316	50,495	4.99	1501	7395	7.93	
Private/HMO	131,200	636,735	62.92	8779	43,249	46.40	
Other	32,341	156,731	15.49	2276	11,077	11.89	
Discharge status							
Routine	192,569	933,813	92.02	11,632	56,992	61.13	< 0.0001
Short-term hospital	502	2444	0.24	251	1248	1.34	
Other transfers	8958	44,121	4.35	5072	25,078	26.90	
Home health care	6451	31,170	3.07	1731	8467	9.08	
Against medical advice	113	549	0.05	14	69	0.07	
Died in hospital	533	2632	0.26	272	1,347	1.45	
Alive, destination unknown	10	50	0.00	5	25	0.03	
Hospital size							
Small	20,472	93,708	9.23	1479	6860	7.34	< 0.0001
Medium	52,135	248,759	24.51	3777	18,295	19.58	
Large	136,529	672,333	66.25	13,766	68,289	73.08	
Hospital location							
Rural	10,242	50,632	4.99	610	3047	3.26	< 0.0001
Urban	198,894	964,169	95.01	18,412	90,398	96.74	
Teaching status							
Nonteaching	98,550	467,095	46.03	5623	26,834	28.72	< 0.0001
Teaching	110,586	547,706	53.97	13,399	66,611	71.28	
Admission type							
Emergency	11,799	58,188	6.32	3875	19,208	22.83	< 0.0001
Urgent	14,770	71,013	7.71	1749	8590	10.21	
Elective	162,539	789,486	85.75	11,346	55,633	66.14	

F = frequency; WF = weighted frequency.

(15.35%) (Table 2). The incidence of pulmonary embolism was also lower ($p < 0.0001$) among patients undergoing ACDF (0.07%) compared with PCDF recipients (0.54%). Venous thrombosis occurred at a rate of 0.21% and 1.12%,

respectively. Posthemorrhagic anemia requiring transfusion was coded less frequently ($p < 0.001$) for patients undergoing ACDF (0.54%) compared with those undergoing PCDF (3.73%), whereas blood transfusions were

Table 2. Procedure-related complications after spine fusion

Frequency/weighted frequency/percent	Anterior			Posterior			p value
	F	WF	Percent	F	WF	Percent	
Device-related complications							
Device-related complications	2410	11671	1.15	2410	11671	6.92	< 0.001
Organ-specific complications							
Central nervous system	494	2415	0.24	151	754	0.81	< 0.001
Cardiac	629	3080	0.3	193	962	1.03	< 0.001
Peripheral vascular	46	233	0.02	19	96	0.1	< 0.001
Respiratory	1079	5271	0.52	290	1455	1.56	< 0.001
Gastrointestinal	708	3455	0.34	118	578	0.62	< 0.001
Genitourinary	855	4214	0.42	214	1065	1.14	< 0.001
Other complications of procedure							
Shock	16	77	0.01	7	34	0.04	< 0.001
Hematoma/seroma	1087	5262	0.52	251	1225	1.31	< 0.001
Puncture vessel/nerve	674	3274	0.32	155	759	0.81	< 0.001
Wound dehiscence	44	214	0.02	71	350	0.37	< 0.001
Infection	209	1026	0.1	166	814	0.87	< 0.001
Other	802	3913	0.39	295	1434	1.53	< 0.001
Medical complication	77	367	0.04	41	204	0.22	< 0.001

F = frequency; WF = weighted frequency.

Table 3. Risk factors for perioperative mortality after cervical spine fusion: demographics

Risk factor category	Risk factors	Odds ratio	Lower 95% CI	Upper 95% CI	p value
Procedure type (referent: ACDF)	PCDF	2.02	1.64	2.49	< 0.001
Age group (referent: 45–64 years)	0–44	0.60	0.45	0.79	< 0.001
	65–74	3.15	2.44	4.08	< 0.001
	> 75	7.09	5.51	9.13	< 0.001
Gender (referent: female)	Male	2.06	1.68	2.54	< 0.001
Race (referent: Hispanic)	White	0.82	0.53	1.25	0.345
	Black	1.41	0.89	2.24	0.145
	Other	1.17	0.65	2.12	0.596
Hospital location (referent: urban)	Rural	1.33	0.82	2.17	0.253
Hospital teaching status (referent: nonteaching)	Teaching	0.78	0.63	0.97	0.023
Admission status (referent: emergent)	Urgent	0.39	0.29	0.50	< 0.001
	Elective	0.08	0.06	0.10	< 0.001
	Other	1.67	0.84	3.33	0.147

CI = confidence interval; ACDF = anterior cervical spine fusion; PCDF = posterior cervical spine fusion.

necessary at a lower rate ($p < 0.001$) among ACDF compared with PCDF patients (0.84% versus 6.33%, respectively). The incidence of ARDS was also less frequent ($p < 0.001$) among patients undergoing ACDF versus patients undergoing PCDF (0.80% versus 3.88%, respectively). In-hospital mortality rates were higher ($p < 0.001$) in the PCDF group compared with the ACDF population (1.44% versus 0.26%, respectively). Patients after ACDF were more frequently ($p < 0.001$) discharged to their home than PCDF admissions (92% versus 61.1%,

respectively) (Table 1). During the hospitalized postoperative period, there was a higher rate of identified wound complications in the PCDF compared with ACDF groups (Table 2).

When controlling for comorbidity index and other demographic variables, PCDF was associated with a two-fold increased risk of a fatal outcome compared with ACDF (Table 3). Additional risk factors included male gender, advanced age, surgery performed in a nonteaching hospital, and emergently performed procedures (Table 3).

Table 4. Risk factors for perioperative mortality after cervical decompression and fusion: comorbidities

Comorbidity	Odds ratio	Lower 95% CI	Upper 95% CI	p value
Alcohol abuse	1.15	0.75	1.79	0.5216
Chronic lung disease	1.37	1.03	1.81	0.03
Congestive heart failure	3.16	2.25	4.44	< .0001
Uncomplicated diabetes mellitus	0.75	0.56	1.02	0.065
Complicated diabetes mellitus	0.95	0.47	1.94	0.8952
Liver dysfunction	0.89	0.39	2.01	0.778
Coagulopathy	3.38	2.16	5.30	< .0001
Neurologic disorders	2.31	1.55	3.45	< .0001
Obesity	0.76	0.37	1.56	0.4481
Peripheral vascular disease	0.60	0.30	1.23	0.1662
Renal disease	5.55	3.59	8.55	< .0001
Pulmonary circulatory disease	9.52	5.44	16.68	< .0001
Cardiac valvular disorders	0.98	0.59	1.62	0.9286
Electrolyte/fluid abnormalities	3.97	3.05	5.17	< .0001
Metastatic cancer	4.21	2.53	7.00	< .0001
Cancer	2.53	1.29	4.97	0.007

CI = confidence interval.

Increased comorbidity burden was also associated with increased odds of perioperative death. Every point increase in the Deyo Index increased the odds of a fatal outcome by 25% (odds ratio 1.25; confidence interval 1.15–1.37). When examining individual comorbidities, pulmonary, circulatory, and renal disease were associated with the highest odds for in-hospital mortality (Table 4).

Discussion

Despite increases in use, information on comparative perioperative complication rates after ACDF and PCDF procedures remains rare. Because there is a subset of patients in whom either of the two approaches would appear reasonable, data assessing perioperative risk are essential to decision-making. The purposes of this study were to (1) characterize the patient population undergoing ACDF and PCDF; (2) compare perioperative complication rates; (3) determine independent risk factors for adverse perioperative events; and (4) aid in surgical decision-making in cases in which clinical equipoise exists between anterior and posterior cervical fusion procedures.

There are several limitations to our study. First and most importantly, the NIS database, designed primarily for administrative purposes, does not include complete information on pathoanatomic features of spondylosis or trauma, number of affected levels and patterns of disease,

Table 5. Studies comparing outcomes after ACDF and PCDF over time

Author	ACDF				PCDF				Study outcomes time period		
	Age (years)		Volume		Mortality		Percent of all cervical fusion cases		Volume		Mortality
	< 65	> 64	Estimated average cases/years over study period	Percent of all cervical fusion cases	< 65	> 64	Estimated average cases/years over study period	Percent of all cervical fusion cases	Estimated average cases/years over study period	Percent of all cervical fusion cases	
Shamji et al. [29]	N/A	N/A	51,156	94.5%	N/A	N/A	3327	5.5%	3327	5.5%	1.00% 1988–2003
Wang et al. [31]	90.2%	9.8%	68,036	96.6%	71.2%	28.8%	2424	3.4%	2424	3.4%	0.44% 1992–2001
Memtsoudis et al. [21]	88.0%	12.0%	112,753	91.7%	70.3%	29.7%	10,359	8.3%	10,359	8.3%	1.44% 1998–2006

ACDF = anterior cervical spine fusion; PCDF = posterior cervical spine fusion; N/A = not available.

number of levels fused, the sagittal cervical spine alignment, or detailed clinical information (ie, length of surgery, blood loss, etc). Second, the indication for surgery using ICD-9 codes within this data set is speculative at best, because no defined variable for surgical indication exists in the NIS. As a result, although our multivariate regression analysis controlled for comorbidity index and demographic features, we could not distinguish patient populations based on these relevant surgical factors. Therefore, there is likely still bias injected into the analysis because current practice trends and surgical decision-making still favor using posterior fusion for constructs of three or more segments, making the PCDF group likely to have more extensive disease. Furthermore, our analysis includes a heterogeneous group of cervical spondylosis, trauma, and other diagnoses resulting in the need for fusion. Third, because the data are compiled only for inpatients, actual complication and mortality rates may be higher and our data should be interpreted in this context. The literature suggests PCDF wound complications (as a result of late presentation at initial followup) may be slightly higher than that captured here [9, 15, 30]. Further, the database does not allow for reliable distinction of major from minor complications. Finally, parameters such as fusion rates, late reoperation, sagittal alignment, adjacent level disease, and late clinical outcomes are not included here. ACDF surgeries are associated with decreasing fusion rates as the number of segments or instrumented levels increases. Recent advances in anterior plating techniques, however, have led to a 96% fusion rate in three-level ACDF with an anterior plate [24]. Others have reported an average fusion rate of 93% for four-level ACDF with an anterior plate [5]. Posterior cervical instrumented fusion rates have ranged from 95% to 100% in the literature [7]. However, concerns persist about loss of cervical lordosis in the posterior cervical spine surgical patients [4]. Additional considerations include a 2.9%/year incidence of clinically important adjacent segment disease among ACDF patients versus a 1%/year incidence in posterior cervical fusion patients [28]. Although considered important, other limitations not listed here are those inherent to secondary analysis of large administrative databases, including but not limited to its retrospective nature and potential coding bias.

Demographics associated with ACDF and PCDF differed. The PCDF group was older and consequently had more medical comorbidities, it tended to be performed more frequently among male patients, and it occurred more often in a trauma setting and in large urban, teaching centers rather than small rural nonteaching hospitals. One obvious explanation for the age discrepancies is the increased reliance on posterior fusion procedures in the setting of multilevel cervical spondylosis—an entity more commonly seen in an elderly patient population. By the

same token, increased prevalence of trauma patients among the posterior fusion group is reflective of biomechanical requirements and practice preferences in the trauma setting. Often, traumatic injuries of the cervical spine represent three-column injuries. This can be initially stabilized by an all posterior construct. Furthermore, rapid decompression and the establishment of long, stable constructs is the primary objective in acute trauma—thereby favoring posterior fusions in this group [23]. Overall patient age and comorbidity burden has increased among all patients undergoing cervical fusion over time in both anterior and posterior groups [8, 12, 20, 25].

We found PCDF procedures were associated with increased rates of in-hospital complications and mortality compared with ACDF procedures. The in-hospital mortality rate for ACDF procedures seems to have decreased from the period of 1988 to 2003 when compared with that encompassing the years 1998 to 2006 (0.57% to 0.26%) (Table 5). At the same time, postoperative mortality rate for the PCDF increased from 1.03% to 1.45% between the two data sets, perhaps reflective of the shift in age and comorbidities [29]. Furthermore, the PCDF group had a higher incidence of immediate postoperative wound complications, recognized implant or hardware failure, and longer hospital stay. This is an important finding because postoperative complications, the need for revision surgery, and the length of hospital stay have been identified as major factors determining overall hospital cost [15, 17, 19]. Although an important issue, cost analysis was beyond the scope of this particular study.

When controlling for patient comorbidity burden and demographic factors, we found PCDF was an independent risk factor for postoperative mortality (odds ratio 2.01; confidence interval 1.64–2.49). Additional risk factors were male gender and advanced age. Comorbidities increasing the risk for perioperative death included pulmonary circulatory disease, renal disease, cancer, coagulopathy, congestive heart disease, or myelopathy. Although PCDF has not been identified as a risk factor previously, the other factors are associated with such risk in other orthopaedic surgical setting in the past [21]. Patients with pulmonary circulatory disease may represent an especially vulnerable group because perioperative insults such as mechanical ventilation and embolization of bone marrow and debris during the instrumentation process may aggravate right heart dysfunction and its sequelae. Intensive perioperative care and other advanced services should be available to optimize perioperative safety in these challenging patients. Interestingly, a number of comorbidities, including liver dysfunction and diabetes, did not alter perioperative mortality despite being associated with an overall increased perioperative morbidity [3, 22, 27].

We identified PCDF to be associated with increased rates of perioperative morbidity and mortality and as an independent risk factor for in-hospital death when compared with ACDF procedures. Despite the limitations, this data set offers clinicians an important insight into the impact of either anterior or posterior fusion procedures on their patients. Rather than dictating surgical decision-making, this information is important for managing surgeon and patient expectations on risk, hospital course, and immediate postoperative complications. In terms of surgical decision-making, there remains a subset of patients with cervical disease in whom clinical equipoise exists as to whether they should be treated with an anterior versus posterior cervical fusion after considering such factors as diagnosis, diseased levels, stenosis type, and sagittal alignment [12, 29]. Traditional dogma has suggested elderly patients do not tolerate multilevel anterior surgery [2] and has cautioned against multilevel ACDF exceeding three segments. However, implant improvements (especially improved anterior plating systems) have given reason to rethink some of these paradigms [5, 18, 24]. As a result, there is still a need in the literature for prospective diagnosis and age-matched cohort analysis to determine relative risks for postoperative complications such as mortality, wound complications, and prolonged hospital stay between anterior versus posterior fusion. These “pure” matched cohorts would then enable us to make the best possible decision for these patients who fall “in between” the clear established criteria for anterior versus posterior approach to cervical pathology.

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