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Clinical Study

Comparative analysis of perioperative complications between a multicenter prospective cervical deformity database and the Nationwide Inpatient Sample database

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Abstract

BACKGROUND CONTEXT: Complication rates for adult cervical deformity are poorly characterized given the complexity and heterogeneity of cases.

PURPOSE: To compare perioperative complication rates following adult cervical deformity corrective surgery between a prospective multicenter database for patients with cervical deformity (PCD) and the Nationwide Inpatient Sample (NIS).

STUDY DESIGN/SETTING: Retrospective review of prospective databases.

PATIENT SAMPLE: A total of 11,501 adult patients with cervical deformity (11,379 patients from the NIS and 122 patients from the PCD database).

OUTCOME MEASURES: Perioperative medical and surgical complications.

METHODS: The NIS was queried (2001–2013) for cervical deformity discharges for patients ≥18 years undergoing cervical fusions using *International Classification of Disease, Ninth Revision* (ICD-9) coding. Patients ≥18 years from the PCD database (2013–2015) were selected. Equivalent complications were identified and rates were compared. Bonferroni correction (p<.004) was used for Pearson chi-square. Binary logistic regression was used to evaluate differences in complication rates between databases.

RESULTS: A total of 11,379 patients from the NIS database and 122 patiens from the PCD database were identified. Patients from the PCD database were older (62.49 vs. 55.15, p<.001) but displayed similar gender distribution. Intraoperative complication rate was higher in the PCD (39.3%) group than in the NIS (9.2%, p<.001) database. The PCD database had an increased risk of reporting overall complications than the NIS (odds ratio: 2.81, confidence interval: 1.81–4.38). Only device-related complications were greater in the NIS (7.1% vs. 1.1%, p=.007). Patients from the PCD database displayed higher rates of the following complications: peripheral vascular (0.8% vs. 0.1%, p=.001), gastrointestinal (GI) (2.5% vs. 0.2%, p<.001), infection (8.2% vs. 0.5%, p<.001), dural tear (4.1% vs. 0.6%, p<.001), and dysphagia (9.8% vs. 1.9%, p<.001). Genitourinary, wound, and deep

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veinthrombosis (DVT) complications were similar between databases (p>.004). Based on surgicalapproach, the PCD reported higher GI and neurologic complication rates for combined anterior-posterior procedures (p<.001). For posterior-only procedures, the NIS had more device-related complications (12.4% vs. 0.1%, p=.003), whereas PCD had more infections (9.3% vs. 0.7%, p<.001). **CONCLUSIONS:** Analysis of the surgeon-maintained cervical database revealed higher overall and individual complication rates and higher data granularity. The nationwide database may underestimate complications of patients with adult cervical deformity (ACD) particularly in regard to perioperative surgical details owing to coding and deformity generalizations. The surgeon-maintained database captures the surgical details, but may underestimate some medical complications. © 2017 Elsevier Inc. All rights reserved.

Keywords: Adult cervical deformity; Complication rates; Nationwide inpatient sample; Spinal malalignment; Surgeon-maintained database; Surgical approach

Introduction

Adult cervical deformity (ACD) is a complex group of disorders with a wide range of etiologies, including inflammatory arthropathy, trauma, and spondylosis [1]. Adult cervical deformity is uncommon but can have debilitating consequences related to pain and severe disability in the form of progressive neurologic symptoms. In contrast to thoracolumbar deformities, less progress has been made for ACD with regard to optimal treatment approaches and complication rate assessments [1–3]. Adult cervical deformity is a highly heterogeneous group of disorders, and it is not surprising to find a lack of uniformity in the surgical treatment [4]. Corrective ACD procedures involve the use of either an anterior-only, posterior-only, or combined approaches, resulting in varied postoperative complication rates [5]. This variance

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EVIDENCE & METHODS

Context
A solid understanding of complication rates following surgery is vital for truly informed consent. Additionally, these rates might be used to compare outcomes between surgeons.

Contribution
The authors compared complication rates using NIS and PCD databases and found considerable differences.

Implications
To get the "right" answers, the "right" questions need to be asked. Clearly, as it pertains to surgical outcomes, surgical pathology, surgical technique, and outcomes (positive and negative) need to be clearly defined and collected as accurately as possible. Given the implications of the potential uses (informed consent, quality comparisons, etc.) of this information, the greater the detail the better. It is important to remember that while review articles discussing results of large, crude databases are popular and easy to perform, they are, at best, low Level 4 evidence. Large numbers cannot overcome insufficient data and thus many are best conceived as filters for catastrophic failures outliers which might be scattered across a population (such as was seen with metal-on-metal hip prostheses) as opposed to true measures of outcomes.

underscores the importance of evidence-based literature regarding complications associated with surgical correction of ACD, as most of the surgeons have to rely on the few previously published retrospective case series and anecdotal experiences.

Evolution of evidence-based practice has resulted in tremendous improvement in assessment and treatment of spinal pathologies. Given restrictions related to ethical concerns, and the size and scope of randomized controlled trials available in the orthopedic literature, health-care providers have frequently relied on national administrative databases to scrutinize surgical outcomes. Bekkers et al. queried the National Hospital Discharge Survey and the Nationwide Inpatient Sample (NIS), and found more than half of the factors in demographics, comorbidities, and adverse effects after total hip arthroplasty differed between the two databases by more than 10%, and that certain factors were accounted for in one database but not in the other [6]. Comparing the NIS and the National Surgical Quality Improvement Program databases results in varied outcomes for hip fracture complication rates and length of stay, as well as for lumbar spine fusion procedures [7,8]. Although national databases are highly impactful for certain orthopedic disorders, they vary in data collection methods and may be subject to a number of pitfalls, including clerical inadequacies, lack of clinically relevant variables, and temporal changes in billing codes [8,9]. Importantly, in national database studies, ACD is defined only using *International Classification of Disease, Ninth Revision* (ICD-9) or CPT coding, whereas for prospective surgeon-maintained databases, specific radiographic criteria are often used, which might influence the patient group being studied.

Recently, one study reported an early complication rate following cervical deformity correction of 79% for combined approach procedures, with 44% of patients developing at least one complication, drawing from a prospective multicenter database [10]. Similarly, Theologis et al. reported a perioperative complication rate of 60% in patients with cervicothoracic deformities undergoing three-column osteotomies [11]. Several reports have evaluated perioperative outcomes following cervical fusion procedures through the National Surgical Quality Improvement Program database, although studies that look specifically at ACD pathology using a national database are lacking [12,13]. The increased recent attention and intervention for ACD calls for precise complications assessment workup using database analysis. The pitfalls of national databases create a gap in the understanding of specific pathologies, including ACD, whereas surgeon-maintained databases may be able to fill in many of the specifics [9]. Concurrent usage of national and surgeon-maintained database may facilitate accurate complication rates reporting. Therefore, the purpose of this study was to compare early-onset complication rates in patients with ACD undergoing surgical correction between a surgeon-maintained database (PCD) and a national database (NIS). Agreement between databases is important for measuring reliability of clinical interpretations from these databases that influences future patient care. Our hypothesis is that the complication rates will differ between the PCD and the NIS databases owing to variations in patient identification and data collection of complications.

Methods

Study design and database description

This is a retrospective, comparative review of patients with ACD undergoing corrective surgery derived from two databases: a prospective multicenter database for patients with cervical deformity (PCD) and the NIS.

The PCD database is a surgeon-maintained database of patients consecutively enrolled from 13 sites around the United States from 2013 to 2015. Internal review board approval was obtained at each participating site before study initiation. Inclusion criteria for the database were patients aged ≥18 years, radiographic evidence of cervical deformity at baseline assessment, and plan for surgical deformity correction. Adult cervical deformity was defined in the PCD as the presence of at least one of the following: cervical kyphosis (C2–C7 Cobb angle >10°), cervical scoliosis (C2–C7 coronal Cobb angle <10°), C2–C7 sagittal vertical axis >4 cm, or chin-brow vertical angle >25° (Figure). Patients with active tumors or infections were excluded from the study. The operative

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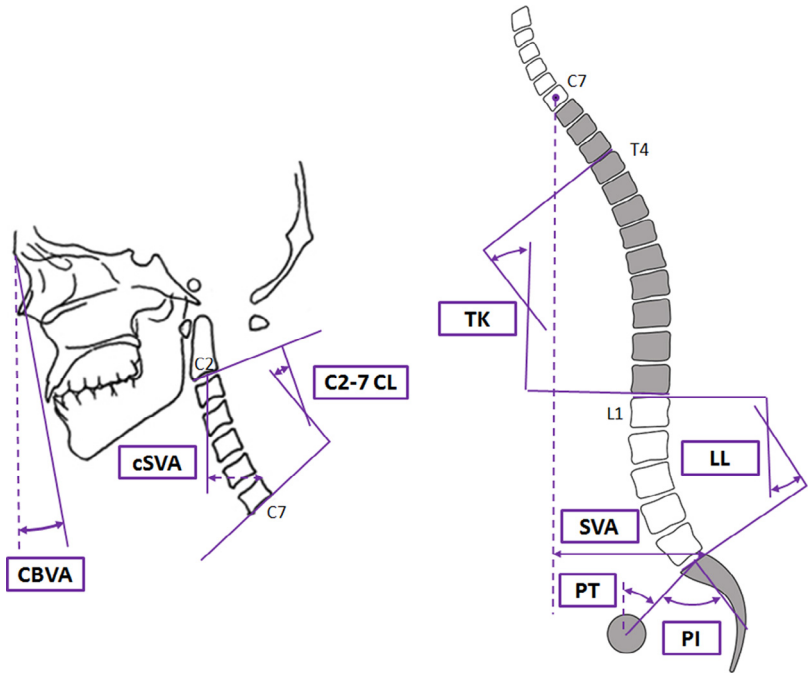

Figure. Sagittal alignment parameters for cervical (left) and global spinopelvic (right) regions. CBVA, chin-brow vertical angle; cSVA, cervical sagittal vertical axis; CL, cervical lordosis; TK, thoracic kyphosis; LL, lumbar lordosis; PT, pelvic tilt; PI, pelvic incidence.

approach, procedural choice, and instrumentation selection are at the discretion of the operating surgeon.

The NIS is the largest in-patient nationwide database for all-payer categories, and employs a stratified random sampling design to capture approximately 20% of all inpatient discharges from nonfederal US hospitals. Each annual file of the NIS contains approximately 8 million discharges from about 1,000 hospitals in 45 states, and presents 100 clinical and nonclinical data elements with diagnoses and procedures in ICD-9, Clinical Modification (ICD-9-CM) format. National estimates from each annual file are produced using discharge weight files. A detailed design overview of the NIS is available at http://www.hcupus.ahrq.gov/db/nation/nis/NIS_Introduction_2010.jsp [14]. The NIS was queried from 2001 to 2013 for discharges of patients >18 years meeting the diagnostic and procedural ICD-9 codes for ACD (see Appendix S1 for selected diagnoses). Subsequently, these patients undergoing the following cervical procedures were further isolated: anterior cervical discectomy and fusion or revision fusion at C2 or below (81.02 or 81.32), posterior-only fusion or refusion at C2 or below (81.03 or 81.33), or combined anterior and posterior fusion-refusion at C2 or below (81.02 and 81.03 or 81.32 and 81.33).

Data collection

Demographic data collected in both the PCD and the NIS included age, gender, and Charlson comorbidity index (CCI). Mean operative variables were assessed for each database: surgical approach, levels fused, revision status, corpectomy, and osteotomy use. All ICD-9-CM codes used to collect data from NIS can be found in Appendix S1.

Complications reporting

In the PCD database, patients were assessed for intra- and perioperative complications (<6 weeks of hospital discharge). Collected complications were assigned to the following categories, based on prior publications: cardiopulmonary, dysphagia, dysphonia, electrolyte, gastrointestinal (GI), infection, instrumentation, musculoskeletal, neurologic, operative, organ failure, other, radiographic, renal, vascular, and wound [10,15,16].

For the NIS database, procedure-related complications were determined using ICD-9-CM codes specifying complications of surgical and medical care occurring within the hospital visit. Nationwide Inpatient Sample complications were fit to PCD complication categories. Individual complications assessed included dysphagia, device-related, neurologic, peripheral vascular, respiratory, GI, genitourinary, wound, postoperative infection, deep vein thrombosis (DVT), pulmonary embolism, and dural tear.

Statistical analysis

Demographic (age, sex, comorbidities) and procedural differences between patients with ACD in the PCD database and those in the NIS database were assessed using univariate independent *t* tests for continuous variables and chi-square analyses for categorical variables. Complication rates between databases were compared using chi-square tests with a Bonferroni correction ($p<.004$). A complications subanalysis stratified patients by surgical approach (anterior, posterior, or combined) using the same methods as the main analysis. Binary logistic regression was used to generate odds ratios

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(95% confidence interval) for each complication rate compared between the PCD and the NIS. Relative risk was assessed between patients in the PCD and those in the NIS. All statistical analyses were performed using SPSS Statistics 23.0 (IBM Corp, Armonk, NY, USA). Statistical significance was defined as p<.05.

Results

Patient populations

The ACD study population included 122 enrolled patients from the PCD database and 11,379 identified NIS discharges. Comparison between the two patient groups revealed that patients from the PCD database with cervical deformity were older (PCD: 62.5±10.9 years vs. NIS: 55.2±13.8 years, p<.001) (Table 1). The NIS had significantly more patients under the age of 50 than the PCD (31.5% vs. 12.3%, p<.001). There were more patients with PCD in the age ranges of 50–65 and ≥65 years (45.1% vs. 42.1% and 42.6% vs. 23.8%, respectively, both p<.001). The gender distribution of the patients was not significantly different between the two databases (PCD: 59.5% female, NIS: 58.5% female, p=.456). The patients in both databases had similar mean CCI scores (PCD: 0.72±1.12, NIS: 0.77±1.34, p=.701).

By surgical approach, the PCD reported more posterior-only (50.4% vs. 21.9%) and combined approach (35.3% vs. 15.7%) surgeries than the NIS (both p<.001) (Table 1). The NIS showed a higher percentage of anterior-only approach than the PCD (62.4% vs. 14.3%, p<.001). Analysis of mean levels fused revealed that PCD had a higher proportion of four to eight (45.1% vs. 42.8%) and nine or more (35.2% vs. 3.5%) levels fused, whereas NIS had a higher rate of two to three levels fused (53.8% vs. 19.7%) (all p<.001). Osteotomy use was significantly higher in the PCD database than in the NIS database (19.7% vs. 1.4%, p<.001). The PCD database had a significantly higher rate of revisions than the NIS (35.2% vs. 8.5%, p<.001). Corpectomy rates were not significantly different between the PCD and the NIS (10.2% vs. 12.2%, p=.214).

Medical and surgical complication rates

Overall intraoperative complication rate was higher in the PCD (n=48, 39.9%) than in the NIS (n=1,050, 9.2%) (p<.001). The PCD database had an increased risk of reporting a complication than the NIS overall (odds ratio: 2.81, confidence interval: 1.81–4.38), when controlling for age, race, gender, CCI, approach, levels fused, revision status, and osteotomy use. The relative risk of any complication in PCD was 3.34 (2.61–4.28) compared with NIS.

Patients from the PCD database displayed higher rates of the following complications overall: neurologic (13.9% vs. 0.7%, p<.001), peripheral vascular (0.8% vs. 0.1%, p=.001), respiratory (8.2% vs. 0.9%, p<.001), GI (2.5% vs. 0.2%, p<.001), infection (8.2% vs. 0.5%, p<.001), dural tear (4.1% vs. 0.6%, p<.001), pulmonary embolism (1.6% vs. 0.3%, p=.01), and dysphagia (9.8% vs. 1.9%, p<.001) (Table 2). Genitourinary, wound, and DVT complications were similar between databases (p>.004). Only device-related complications were higher in the NIS (7.1% vs. 1.1%, p=.007) than in the PCD. When controlling for age, race, CCI, surgical approach, levels fused, revision status, and osteotomy use, PCD had higher odds of reporting every complication except for device-related complications (Table 2).

Table 1
Demographic and surgical details for patients in the surgeon-maintained database (PCD) and the national database (NIS)

		PCD (% or mean [SD])	NIS (% or mean [SD])	*P*
Age	<50	12.3%	34.1%	**<.001**
	50–65	45.1%	42.1%	
	≥65	42.6%	23.8%	
Sex	% Female	59.5%	58.5%	.456
CCI		0.72 [1.12]	0.77 [1.34]	.701
Approach	Anterior	14.3%	62.4%	**<.001**
	Posterior	50.4%	21.9%	
	Combined	35.3%	15.7%	
Levels fused	2–3	19.7%	53.8%	**<.001**
	4–8	45.1%	42.8%	
	9+	35.2%	3.5%	
Osteotomy use		19.7%	1.4%	**<.001**
Corpectomy		10.2%	12.2%	.214
Revisions		35.2%	8.5%	**<.001**

PCD, surgeon-maintained cervical deformity database; NIS, Nationwide Inpatient Sample.

Values in bold represent statistical significance to p<.05 between the two databases.

Table 2
Complication rates compared between the PCD and the NIS databases

	PCD	NIS	p-Value	OR [95%CI]
Dysphagia	9.8%	1.9%	**<.001**	7.89 [3.92–15.86]
Device related	0.8%	7.1%	**.007**	.019 [.003–0.14]
Neurological	13.9%	0.7%	**<.001**	12.77 [6.25–26.07]
Peripheral vascular	0.8%	0.1%	**.001**	20.25 [1.46–280.65]
Respiratory	8.2%	0.9%	**<.001**	7.06 [3.21–15.51]
Gastrointestinal (GI)	2.5%	0.2%	**<.001**	10.10 [1.70–60.11]
Genitourinary (GU)	.0%	0.5%	.446	
Wound	.0%	0.2%	.612	
Infection	8.2%	0.5%	**<.001**	8.74 [3.19–23.95]
Deep vein thrombosis (DVT)	.0%	0.4%	.491	
Pulmonary embolism (PE)	1.6%	0.3%	**.010**	3.50 [0.51–24.14]
Dural tear	4.1%	0.6%	**<.001**	3.88 [1.38–10.88]

PCD, surgeon-maintained cervical deformity database; NIS, Nationwide Inpatient Sample.

Values in bold represent statistical significance to p<.05 between the two databases. Multivariate analysis was performed on any complication with a significantly different complication rate between the two databases (reported as odds ratio [95% confidence interval]).

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Table 3
Complication rates by surgical approach compared between PCD and NIS databases

	PCD	NIS	p-Value
Anterior only			
Dysphagia	23.5%	1.9%	**<.001**
Device related	0.0%	3.7%	.0532
Neurological	5.9%	0.3%	**<.001**
Peripheral vascular	0.0%	0.0%	.932
Respiratory	5.9%	0.7%	**.012**
Gastrointestinal (GI)	5.9%	0.1%	**<.001**
Genitourinary (GU)	0.0%	0.3%	.825
Wound	0.0%	0.0%	.944
Infection	0.0%	0.2%	.843
Deep vein thrombosis (DVT)	0.0%	0.3%	.834
Pulmonary embolism (PE)	0.0%	0.1%	.876
Dural tear	0.0%	0.2%	.839
Posterior only			
Dysphagia	1.7%	0.7%	.409
Device related	0.0%	12.4%	**<.001**
Neurological	16.7%	1.2%	**<.001**
Peripheral vascular	0.0%	0.0%	.876
Respiratory	8.3%	1.0%	**<.001**
Gastrointestinal (GI)	3.3%	0.4%	**.002**
Genitourinary (GU)	0.0%	0.9%	.472
Wound	0.0%	0.7%	.506
Infection	10%	1.0%	**<.001**
Deep vein thrombosis (DVT)	0.0%	0.7%	.531
Pulmonary embolism (PE)	1.7%	0.5%	.209
Dural tear	3.3%	0.9%	.055
Combined			
Dysphagia	16.7%	3.2%	**<.001**
Device related	2.4%	13.3%	**.02**
Neurological	14.3%	1.1%	**<.001**
Peripheral vascular	2.4%	0.1%	**<.001**
Respiratory	9.5%	1.4%	**<.001**
Gastrointestinal (GI)	0.0%	0.3%	.705
Genitourinary (GU)	0.0%	0.7%	.576
Wound	0.0%	0.1%	.827
Infection	9.5%	0.7%	**<.001**
Deep vein thrombosis (DVT)	0.0%	0.5%	.642
Pulmonary embolism (PE)	2.4%	0.7%	.199
Dural tear	7.1%	1.4%	**.002**

PCD, surgeon-maintained cervical deformity database; NIS, Nationwide Inpatient Sample.

Values in bold represent statistical significance to p<.05 between the two databases.

Complication rates by surgical approach

For the anterior-only approach surgeries, PCD had significantly higher complication rates for dysphagia (23.5% vs. 1.9%), neurologic (5.9% vs. 0.3%), respiratory (5.9% vs. 0.3%), and GI (5.9% vs. 0.3%) complications (all p<.001) (Table 3). All other complication rates did not significantly differ between the PCD and the NIS for anterior-only surgery.

In the posterior-only approach category, device-related complications were significantly higher in the NIS than in the PCD (12.4% vs. 0.0%, p<.001), whereas infection (10.0% vs. 1.0%, p<.001), respiratory (8.3% vs. 1.0%, p<.001), and GI (3.3% vs. 0.4%, p=.002) complications were significantly higher in the PCD than in the NIS (Table 3). All other complication rates were not significantly different between the two databases for the posterior-only approach.

Combined approach surgeries in the PCD reported significantly more dysphagia (16.7% vs. 3.2%), infection (9.5% vs. 0.7%), neurologic (14.3% vs. 1.1%), respiratory (9.5% vs. 1.4%), and peripheral vascular (2.4% vs. 0.1%) complications than in the NIS (all p<.001) (Table 3). Dural tear complications were also higher in the PCD (7.1% vs. 1.4%, p=.002). Device-related complications were the only complication significantly higher in the NIS than in the PCD (13.3% vs. 2.4%, p=.02). All other complications were not significantly different between the databases for the combined approach.

Discussion

Complication rates in ACD surgeries are poorly reported, given the complexity and heterogeneity of cases as well as the variability of surgical treatments [1–4]. This retrospective database comparison between a prospectively collected surgeon-maintained database for patiens with cervical deformity (PCD) and the national database NIS reveals differences in complication rates for cervical deformity surgeries. Patients from the PCD database were older but had similar gender distribution and CCI to the NIS. The PCD database displayed higher intraoperative complication rates overall (39.9% vs. 9.2%, p<.001). The NIS had significantly higher device-related complications than the PCD, but all other complication categories had higher rates in the PCD. The complication rates were significantly higher in the PCD for all complications except device-related complications, which had higher rates in NIS both overall and for posterior-only and combined approach surgeries. Comparing perioperative complication rates following ACD surgery between the PCD and the NIS databases revealed higher granularity for the surgeon-maintained database and higher complication rates than the national database.

This study demonstrates that two cohorts with a similar diagnosis and procedure being performed will have different complication rates reported between the NIS and a surgeon-maintained database (PCD). One explanation for the differences in complications is likely attributable to different data query and recording methods on the respective databases. The NIS reports diagnosis and procedure information via ICD-9 coding, which is recorded by hospital coders. The surgeon-maintained database is maintained and validated by enrolling surgeons. Variations in complication rates between the two databases may be owing to variable ICD-9 code reporting—either because of missing reports or the study's inability to query every single derivative ICD-9 code for a specific diagnosis. *International Classification of Disease, Ninth Revision* coding cannot create a dedicated cohort of patients with ACD, a diagnosis mostly hinging on radiographic analysis, and thus we must rely on invasiveness comparison to look at differences in complication rates between the two patient populations because the two cohorts cannot be

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compared radiographically. The complexity of the deformities (number of levels fused, osteotomy use, revision status) and the older age of patients in the PCD also might contribute to higher complication rates for PCD versus the NIS. Caution is needed in comparing patients with ACD in the existing literature because study populations between a national database and a surgeon-maintained database are different, thus making generalizations difficult.

The low incidence of DVT (PCD: 0.0%, NIS: 0.4%) and pulmonary embolism (PCD: 1.6%, NIS 0.3%) in our study for both databases is supported by past studies looking at these complications in spine surgery patients. Schulte et al. [17] reported 0.7% incidence of DVT and 0.4% pulmonary embolism complications in a retrospective review of 1,485 patient charts undergoing spine surgery. Additionally, Al-Dujaili et al. [18] reported a DVT incidence of 0.6% out of 158 spine surgery patients. Smith et al. [10] reported early complication rates for ACD surgery, with the most common complications being dysphagia (11.5%), new C5 motor deficit (6.4%), deep wound infection (6.4%), and respiratory failure (5.1%). Overall, we found that dysphagia occurred in 9.8% of patients from the PCD and in 1.9% of patients from the NIS, which are both lower incidences than reported in the Smith et al. study. The difference in dysphagia complications in this study might be a result of different thresholds used to define dysphagia between the PCD and the NIS. Yoshihara and Yoneoka [19] reported a 0.45% incidence of dural tears using the NIS 2009 data with ICD-9 coding for dural tear, and their multivariate analysis revealed posterior approach and combined approach to be risk factors for dural tear during surgery. This could explain the higher incidence of dural tears in the posterior-only and combined categories in our analysis. In addition, one study reported old age as a risk factor for dural tear during spine surgery [20], which might explain why we observed more patients with dural tears in the PCD than in the NIS, as significantly more patients in the PCD than in the NIS were in the >65 year old age group.

Differences in overall rates between the two databases can be attributed to differences in reporting of complications between the two databases, as complications are recorded using ICD-9 coding by hospital coders for billing purposes in the NIS, whereas in PCD, complications are reported by the surgeons. Other factors affecting the overall rates include the size of the patient population being studied—the NIS database includes 11,379 patients in this study, whereas the PCD database contains only 122 patients. Differences in patient demographics and surgical details (age, approach, levels fused, osteotomy use, revisions) also contribute to the observed differences in complication rates. PCD does not have a direct measure of revision rates because of the way the database was created; thus, previous cervical surgery must be used to determine revision status, which might increase the reported rate of revisions for PCD. A surgeon-maintained database (PCD) contains more surgical detail complications than a national database created for billing purposes, as PCD is constructed by the surgeons performing the ACD procedures.

The PCD captured highest complication rates for dysphagia, neurologic, respiratory, and infection. The higher rates of these complications could be attributed to more precise reporting and greater complexity of surgeries in the surgeon-run database as well as reflect coding and recording errors in the national database. The NIS had significantly higher device-related complication rates than the PCD, which might be attributed to the fact that the population of patients in the NIS being analyzed in this study have higher incidence of lower complexity procedures being performed (less levels fused, mostly anterior approaches, fewer revisions necessary). All other complication rates were higher in the PCD than in the NIS, suggesting higher granularity and more precise reporting in the PCD for ACD surgery complications. The NIS misses surgical complications, whereas PCD misses some medical complications as well as rarer medical complications, because it deals with smaller numbers of patients. Surgical complications are missed in the NIS possibly because of the recording methods used for the national database and the fact that the surgical information is recorded by hospital recorders for billing purposes. The NIS lacks information such as length of stay, estimated blood loss, and follow-up data once the patient leaves the hospital. The small number of patients in the PCD database means that some medical complications occur at too low of frequencies to be caught in the database.

In summary, there are several factors that might contribute to the differences in complication rates between the NIS and the surgeon-maintained cervical deformity database. The methods of querying the data and recording information vary greatly between the two databases, likely contributing to the seen differences. The NIS data are recorded by hospital coders and uses only ICD-9 coding for diagnoses, procedures, and complications, whereas the prospective cervical deformity database is surgeon-maintained and validated by the enrolling surgeons. *International Classification of Disease, Ninth Revision* codes are not necessarily specific enough to define a dedicated adult cervical deformity cohort, particularly given that ACD diagnoses and severity assessments are traditionally based on radiographic analysis and are not made available in national databases. In addition, because the prospectively collected database has stringent enrollment criteria for the complexity of the deformities of these patients and the subsequent surgeries these patients undergo, these disparities in cervical deformity-related disease severity may also contribute to the higher rates of complications seen for these patients in the cervical deformity database than in the NIS.

Limitations

Surgeon-maintained databases offer granularity and potential specificity to a particular condition being studied. However, they suffer from limited patient selection and low numbers of patients. National databases benefit from identifying medical complications with specific ICD coding and large patient populations, but lack the granularity about details

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of a surgery, and are limited by the specificity regarding surgical morbidity. They can also succumb to clerical errors, recording bias, and other issues mentioned previously. Surgeon-maintained databases have the potential for conflict of interest, especially relating to funding, and they mostly rely on self-reported complications, which could potentially be skewed by surgeon's recall bias or a desire to minimize poor reported outcomes. These surgeon-maintained databases also have limited external validity as they are from a small, select group of surgeons, although these databases benefit from their selectivity and small size when looking at a particular surgery type or condition.

Conclusions

Analysis of the surgeon-maintained cervical database revealed higher overall and individual complication rates, and concomitantly higher granularity and more precise reporting. The two databases compare different patient populations, as the surgeon-maintained database includes more specific ACD surgical information that the national database misses, whereas the national database can capture medical complications. Caution should be used when extrapolating complication rates from national databases for specific cervical deformity operations.

Supplementary material

Supplementary material related to this article can be found at http://dx.doi.org/10.1016/j.spinee.2017.05.018.

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