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Clinical Studies

Postoperative complication rates and hazards-model survival analysis of revision surgery following occipitocervical and atlanto-axial fusion

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ABSTRACT

Background: Complication rates following occipitocervical and atlanto-axial fusion are high. While methods to fuse the upper cervical spine levels have evolved, complication rates and surgical survivorship of occipitocervical fusion versus atlanto-axial fusion are incompletely understood.

Methods: The PearlDiver Research Program (www.pearldiverinc.com) was used to identify patients undergoing primary occipitocervical or atlanto-axial fusion between 2007 and 2017. Incidence of each fusion procedure was studied across time. Multivariable logistic regression was used to compare 30-day readmission, 30-day medical complications, and post-operative opioid utilization at 1, 3, 6, and 12 months between cohorts, controlling for age, gender, Charlson Comorbidity Index (CCI), and indication for surgery. Risk of revision was compared through Cox-proportional hazards modeling, Kaplan-Meier survival, and log-rank test.

Results: Cohorts of 483 occipitocervical fusions and 737 atlanto-axial fusions were examined. From 2008 to 2016, incidence of occipitocervical fusion rose 55.9%, whereas atlanto-axial fusion rose 21.6%. A greater percentage of atlanto-axial fusions were due to trauma (69.9% vs. 50.5%), whereas a greater percentage of occipitocervical fusions were due to degenerative disease (41.6% vs. 29.4%) ($p = 0.0161$). Total 30-day complications were seen in 40.9% of occipitocervical fusion patients compared to 26.3% of atlanto-axial fusion patients (aOR=2.06, $p < 0.0001$). Risk of surgical site infection was increased (aOR=2.59, $p = 0.0075$). Kaplan Meier survival analysis and Cox-proportional hazards demonstrated greater risk of revision following surgery for occipitocervical fusion (log rank: $p < 0.0001$, aHR=2.66, 95%CI 1.73–4.10, $p < 0.0001$).

Conclusions: Rates of occipitocervical and atlanto-axial fusion are rising, while complication and revision surgery rates remain high, with occipiticervical fusion leading to higher rates even after controlling for patient characteristics and surgical indication. Spine surgeons should be cautious when considering fusion of the occipitocervical levels if atlanto-axial fusion could be performed safely and provide adequate stabilization to treat the same pathology.

Introduction

Complication rates following occipitocervical and atlanto-axial fusion are high [1,2]. Surgeon decision making on which levels to include in their fusion is likely based on several factors, as it is possible that some surgeons feel more comfortable fusing the occiput instead of C1. Indeed, C1 screws can be harder to place, and the anatomy in some patients may preclude placement of C1 screws [1]. For example, if there is severe basilar invagination, erosion of the C1 lateral mass, or aberrant vascular anatomy, a surgeon may be forced to fuse to the occiput instead of C1. The internal carotid artery lies anterior to the C1 arch which can be injured in the setting aberrant position [3]. One study showed a 6% revision rate for misplaced C1 lateral mass screws [4].

Despite the perceived difficulties of atlanto-axial fusion difficulties, several retrospective reviews have suggested increased complications such as non-union, neuralgia, sepsis, and return to OR following occipitocervical compared to altanto-axial fusion with no difference in functional outcomes as measured by Neck Disability Index [5–7]. However, occipitocervical fusion has yet to be compared to atlanto-axial fusion in a matched analysis [8–10]. The goal of this investigation was to compare complications, revision rate, and prolonged opioid use between occipitocervical fusion and atlanto-axial fusion patients. We hypothesized that patients undergoing occipitocervical fusion would endure greater number of complications, reoperation, and prolonged opioid use compared to patients undergoing atlanto-axial fusion after controlling for diagnosis, age, and comorbidities.

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Materials and methods

Data

The PearlDiver Patient Records Database (http://www.pearldiverinc.com) was utilized for this study. PearlDiver is a publicly available and Health Insurance Portability and Accountability Act-compliant database holding records from Humana individual health plans and Medicare medical records capturing around 25 million records.

Characteristics of patient cohort

Patients who underwent occipitocervical or atlanto-axial fusion between 2007 and the first quarter of 2017 were identified with first instance Current Procedure Terminology (CPT) codes (Appendix A). Incidence of each fusion procedure was calculated as number of fusions each year divided by the total number of patients in the database during that year, and the time trends of each procedure was studied across the years captured in the study. A breakdown of the patients by age and gender was performed. Indications for fusion were categorized as congenital, trauma, degenerative, or cancer-related as identified by ICD-9-CM and ICD-10-CM codes (Appendix A).

Outcome measures

ICD-9-CM and ICD-10-CM codes were used to identify postoperative complications within 30 days of surgery, including surgical site, implant-related, durotomy, deep vein thrombosis (DVT), neurologic, respiratory, cardiac, myocardial, cardiac arrest, coagulation, sepsis, pneumonia, spinal cord, plexus, visual, iatrogenic, reintubation, and hyperthermia-related complications, as well as an aggregate total of all complications and 30-day readmission, comparing between occipitocervical and atlanto-axial fusion (Appendix A).

Revision fusion was specified by CPT code (Appendix A). Rate of revision was compared between occipitocervical and atlanto-axial at 6 months, 1 year, and 2 year time points. Median time until revision was also recorded for each procedure.

Statistical analysis

Descriptive statistics were generated for each patient cohort. Incidence of each fusion procedure was plotted annually with time trend assessed through linear regression. Odds of each complications were computed directly as the number of events occurring within 30 days of fusion. Odds of 6mo, 1y, 2y revisions, 30-day readmission, and 30-day complications were compared between occipitocervical and atlanto-axial fusion through multivariable logistic regression. A Cox-proportional hazards model was developed to compare risk of revision between fusion procedures. All regression controlled for age, sex, Charlson Comorbidity Index (CCI), and indication for fusion. Kaplan-Meier survival analysis was performed with endpoint set to revision surgery for occipitocervical and atlanto-axial fusion. Log-rank test was used to compare survival curves. Statistical analysis was performed using the PearlDiver software, built on R, Version 1.1.442 (RStudio Inc., Boston MA). An α value of 0.05 was set as the level of significance.

Results

Cohorts of 483 occipitocervical fusions and 737 atlanto-axial fusions were examined (Table 1). From 2008 to 2016, incidence of occipitocervical fusion rose linearly by 55.9% ($p = 0.0099$), whereas atlanto-axial fusion rose linearly by 21.6% ($p = 0.0232$) (Fig. 1). For occipitocervical fusions, 66.05% of patients were ages 65–84. For atlanto-axial fusions, 67.98% of patients were ages 65–84 (Table 1). Of atlanto-axial fusions, 53.1% were female. Comparing indications for fusion between the two procedures, a greater percentage of atlanto-axial fusions were due to trauma (69.9% vs. 50.5%), whereas a greater percentage of occipitocervical fusions were due to degenerative disease (41.6% vs. 29.4%) ($p = 0.0161$).

Table 1
Demographics of occipitocervical and atlanto-axial fusion patients.

	Occipitocervical		Atlanto-axial	
	n	%	n	%
All Patients	483		737	
Age Group				
<45	*	*	*	*
45 to 49	13	2.69	*	*
50 to 54	15	3.11	14	1.90
55 to 59	25	5.18	38	5.16
60 to 64	32	6.63	52	7.06
65 to 69	83	17.18	102	13.84
70 to 74	76	15.73	147	19.95
75 to 79	86	17.81	131	17.77
80 to 84	74	15.32	121	16.42
85 to 89	20	4.14	51	6.92
90 and over	36	7.45	44	5.97
Gender				
Female	245	50.7	391	53.1
Male	238	49.3	346	46.9
Indications*				
Congenital	139	28.8	119	16.1
Trauma	244	50.5	515	69.9
Degenerative	201	41.6	217	29.4
Cancer	21	4.3	11	1.5
p-value	0.0161			

* Indicates <11 patients to protect patient privacy. Percentages do not add to 100% as patients may have more than 1 diagnosis.

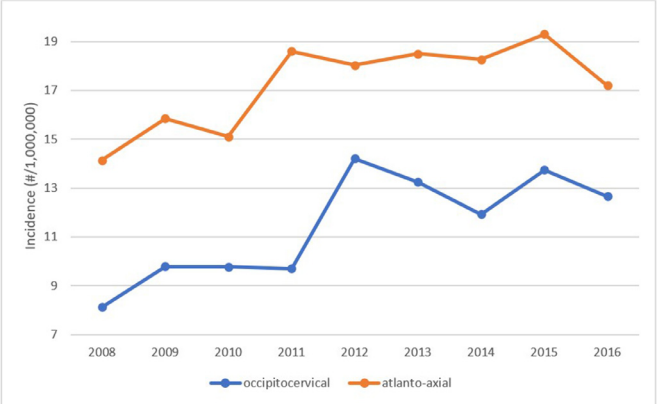

Fig. 1. Incidence of atlanto-axial fusion vs. occipitocervical fusion from 2008 to 2016.

Readmission and complications in occipitocervical fusion

After adjusting for age, gender, CCI, and indication for surgery, the independent risk of 30-day readmission was greater in occipitocervical fusion compared to atlanto-axial fusion (aOR=1.45, 95%CI 1.07–1.96, $p = 0.0150$) (Table 2). Risk of total 30-day complications was also increased (aOR=2.27, 95%CI 1.73–2.99, $p < 0.0001$) with 40.9% of occipitocervical fusions leading to 30-day complication vs. 26.3% in atlanto-axial fusion. Specifically, occipitocervical fusion patients had higher risk of respiratory (aOR=2.06, 95%CI 1.50–2.83, $p < 0.0001$), surgical site (aOR=2.59, 95%CI 1.30–5.28, $p = 0.0075$), implant-related complications (aOR=2.47, 95%CI 1.20–5.25, $p = 0.0155$), and sepsis (aOR=2.53, 95%CI 1.24–5.32, $p = 0.0119$).

Table 2
Complications following Occipitocervical Fusion vs. Atlanto-axial Fusion.

	C1-C2 Fusion		Occiput-C2 Fusion		aOR		95%CI	p-value
	n	%	n	%				
30-day Readmission Complications	139	19.0	120	25.1	1.45	1.07	1.96	0.0150
30-day complications	192	26.3	196	40.9	2.27	1.73	2.99	<0.0001
Respiratory	114	15.6	117	24.4	2.06	1.50	2.83	<0.0001
Pneumonia	32	4.4	24	5.0	1.23	0.68	2.20	0.4841
DVT	39	5.3	31	6.5	1.50	0.87	2.56	0.1411
Surgical Site	16	2.2	23	4.8	2.59	1.30	5.28	0.0075
Implant	18	2.5	22	4.6	2.47	1.20	5.25	0.0155
Sepsis	15	2.1	23	4.8	2.53	1.24	5.32	0.0119
Spinal Cord	20	2.7	22	4.6	1.85	0.93	3.70	*0.0796*
Myocardial	*	*	11	2.3	1.98	0.67	6.06	0.2178

* Multivariable regression adjusted for age, gender, CCI, and indication for surgery. Models for opioid utilization also included preoperative opioid as a covariate.Bold represents $p < 0.05$ considered statistically significant.

Table 3
Revisions following atlanto-axial fusion vs. occipitocervical fusion.

	Atlas-Axis Fusion		Occipitocervical Fusion		aOR	95%CI		p-value
	n	%	n	%				
6-mo Revisions	29	4.0	36	7.5	1.94	1.12	3.41	0.0194
1-yr Revisions	34	4.7	46	9.6	2.29	1.38	3.83	0.0015
2-yr Revisions	38	5.2	54	11.3	2.47	1.53	4.04	0.0025

Median days to revision: 31 days for atlanto-axial fusion and 35 days for occipitocervical fusion.

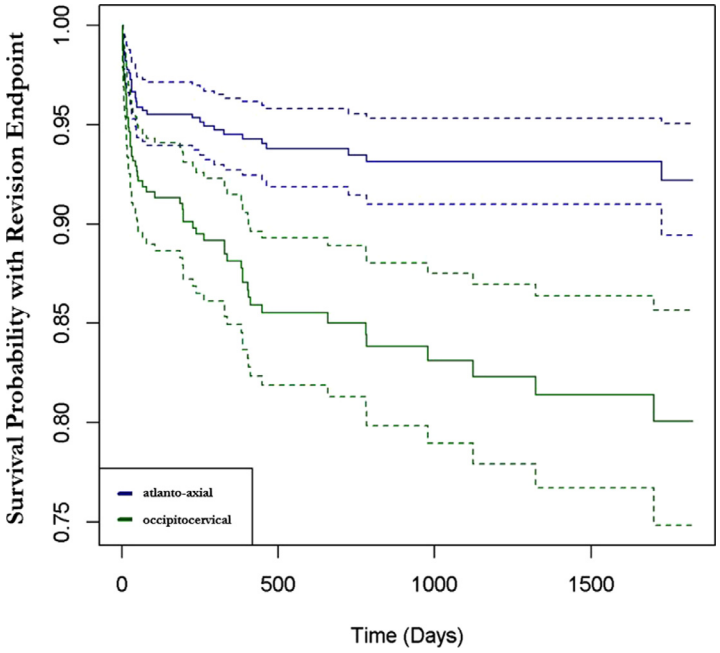

Fig. 2. Kaplan–Meier survival of atlas-axis fusion vs. occipitocervical fusion with endpoint of revision.

Rate of revision following occipitocervical fusion

Median days to revision following atlanto-axial fusion was 31 days and following occipitocervical was 35 days (Table 3). Risk of revision following fusion was increased in occipitocervical fusion at 6 months (aOR=1.94, 95%CI=1.12–3.41, $p = 0.0194$), 1 year (aOR=2.29, 95%CI=1.38–3.83, $p = 0.0015$), and 2 years (aOR=2.47, 95%CI=1.53–4.04, $p = 0.0025$). By 2 years, 11.3% of occipitocervical fusions required revision, whereas 5.2% of atlas-axis fusions required revision. Kaplan Meier survival analysis and Cox-proportional hazards also demonstrated greater risk of revision following surgery for occipitocervical fusion (log rank: $p < 0.0001$, aHR=2.66, 95%CI 1.73–4.10, $p < 0.0001$) (Fig. 2).

Discussion

Patients who undergo occipitocervical fusion have higher complication rates andrevision surgery rates compared to those undergoing atlanto-axial fusion, even after controlling for age, gender, medical comorbidities, and reason for surgery. Their 30-day readmission rate is also higher, driven by higher rates of 30-day complications, specifically respiratory issues, surgical site and implant complications, and sepsis.

The goal of our study was to examine patients with the same pathology and risk factors who undergo occipitocervical versus atlanto-axial fusion. The present investigation adds to a developing body of evidence highlighting important post-operative differences between occip-

itocervical fusion and atlanto-axial fusion. Importantly, occipitocervical demanded higher rates of revision than atlanto-axial as demonstrated through Kaplan-Meier analysis and Cox proportional hazards modeling. To our knowledge, this study is the first to study rates of occipitocervical and atlanto-axial fusion over time and found that annual rates of occipitocervical fusion are increasing more than that of atlanto-axial fusion. However, for any category of surgical indication, occipitocervical fusion results in poorer outcomes in terms of revision and complication rate. Further research to describe surgical indications demanding occipitocervical fusion over atlanto-axial is needed; it may be valuable to characterize baseline characteristics of typical patients undergoing occipitocervical fusion vs. atlanto-axial fusion.

There is a paucity of literature comparing the outcomes of occipitocervical fusions and atlanto-axial fusions. One published study by Hu et al. was a retrospective review of 68 patients with unstable Jefferson fractures, with 48 treated atlantoaxial fusion and 20 with occipitocervical fusion according to surgeon preference [7]. Patients with atlantoaxial fusion had fewer complications. For example, more than 25% of occipitocervical fusion patients also reported headeache, numbness, or postoperative occipital neuralgia, and those receiving occipitocervical fusion had a single instance of nonunion at 24 months, and [7]. The authors concluded that although the traditional view is to perform occipitocervical fusion in patients with unstable Jefferson fractures with associated atlanto-axial instability, they recommend performing atlantoaxial fusion combined with halo vest for 3 months in young patients and observing the status of bony fusion [7]. A more recent study by Wenning and Hoffmann retrospectively evaluated 96 patients with upper cervical spine trauma, 44 of which were treated with occipitocervical fusion and 52 of which were treated with atlantoaxial fusion based on surgeon preference [6]. However, average age was high, at 79 years old, and there were no significant differences in clinical outcome including Neck Disability Index [6,7]. This highlights that younger patients have higher postoperative expectation of neck function.

A study of the American College of Surgeons National Surgical Quality Improvement Program database (NSQIP) by Bhimani et al., compared occipitocervical fusion and atlanto-axial fusion for specifically Type II odontoid fractures of C2 [2]. Similar to the present study, the study of 44 occipitocervical fusions and 121 atlanto-axial fusions revealed a higher rate of return to the OR following occipitocervical fusion. The rate of return to the OR after occipitocervical fusion was 9.1%, which can increase up to 14.9% in patients over 65 years old [11]. Interestingly, Bhimani et al. also found a higher rate of 30-day sepsis (4.6%) after occipitocervical fusion with approaching significance ($p = 0.0699$) [2]. Similarly, in the present study 4.8% of occipitocervical fusion patients developed sepsis. We found an increased rate of instrument failure in occipitocervical fusion patients (4.6% vs. 2.5%). These findings in addition to higher rates of surgical site infection (OR=2.49) following occipitocervical fusion may highlight the impact of longer incisions extending into the hair line, more instrumentation, and longer operative time on outcomes [12–14]. Bhimani et al. found that occipitocervical fusions were on average a half an hour longer with patient length of stay one day more than atlanto-axial fusions [2]. A study of 49 patients undergoing occipitocervical fusion highlighted deep and superficial infection, implant loosing, and hardware prominence as among the most common complications [12].

To our knowledge the present study is the largest thus far to examine occipitocervical fusion. We also compare outcomes to that of atlanto-axial fusion, controlling for age, gender, CCI, and categories of indications. Injuries to the upper cervical spine are debilitating and potentially fatal; however optimal outcomes can still be achieved with a comprehensive plan and appropriate surgical intervention [15]. Even for C2 fractures requiring surgical stabilization, optimal strategy remains unknown, whether atlanto-axial or occipitocervical fusion [2]. The upper cervical spine is responsible for a significant portion of neck mobility. The occiput-C1 articulation provides 23–24° of flexion/extension while the atlanto-axial joint adds an additional 10–22° [16]. The atlanto-axial articulation also typically provides 25–30° of rotation, with some studies suggesting up to 38° [16,17]. Hence, it is important to consider the magnitude of movement affected when surgically fusing these joints and the large impact on patients' lives.

This study has several potential limitations. First, though PearlDiver is commonly employed for orthopedic and neurosurgical research, for any retrospective database study the data accuracy is contingent on accuracies within the system by administrators and physicians [18,19]. We were not able to characterize baseline pre-operative characteristics and intraoperative characteristics as well as relevant covariates such as operative time, which would enhance the analysis. Regarding possible correlation between severity of the underlying indication for surgery and poorer outcomes, we controlled the analysis for categories of each indication, as the more granularity is not available through the database. Further, coding in the dataset does not capture the symptomology or severity of complications. Lastly, the external validity of the findings may not apply to non-Humana patients or patients on public insurance. However, despite these limitations, the data shows that patients requiring fusion of the occiput have worse outcomes and higher risk of revision compared to those only receiving atlanto-axial fusion. With rising rates of both occipitocervical and atlanto-axial fusion, physicians when possible consider atlanto-axial fusion, and the data from this study may help physicians counsel patients about expected postoperative risks.

Conclusions

Compared to atlanto-axial fusion, occipitocervical fusion patients may be associated with higher risk of readmission, medical complications and increased revision rates. Further research is needed to investigate specific indications demanding each surgery. Spine surgeons should be cautious when considering fusion of the occipitocervical levels if atlanto-axial fusion could be performed safely to treat the same pathology.

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Declarations of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Codes Used to Identify Procedures, Indications, and Complications

Procedure	Codes
Occipitocervical Fusion	CPT-22590
Atlanto-axial Fusion	CPT-22595
Occipitocervical Revision	CPT-22590, CPT-22830, CPT-22849, CPT-22850, CPT-22852, CPT-22010
Atlanto-axial Revision	CPT-22595, CPT-22830, CPT-22849, CPT-22850, CPT-22852, CPT-22010
Indications	**Codes**
Congenital	ICD-9-D-71888, ICD-10-D-Q7649, ICD-10-D-M4322, ICD-9-D-75615, ICD-9-D-83901, ICD-10-D-S13111A, ICD-10-D-S13100A, ICD-10-D-S13100D, ICD-10-D-S13100S, ICD-10-D-S13101, ICD-10-D-S13101A, ICD-10-D-S13101D, ICD-10-D-S13101S, ICD-10-D-S13110A, ICD-10-D-S13110D, ICD-10-D-S13110S, ICD-10-D-S13111D, ICD-10-D-S13111S, ICD-10-D-S1312, ICD-10-D-S13120, ICD-10-D-S13120A, ICD-10-D-S13120D, ICD-10-D-S13120S, ICD-10-D-S13121A, ICD-10-D-S13121D, ICD-10-D-S13121S, ICD-10-D-Q759, ICD-9-D-756, ICD-9-D-7560, ICD-9-D-7561, ICD-9-D-75610, ICD-9-D-75611, ICD-9-D-75612, ICD-9-D-75613, ICD-9-D-75614, ICD-9-D-75616, ICD-9-D-75617, ICD-9-D-75619, ICD-9-D-7562, ICD-9-D-7563, ICD-9-D-7564, ICD-9-D-7565, ICD-9-D-75650, ICD-9-D-75651, ICD-9-D-75652, ICD-9-D-75653, ICD-9-D-75654, ICD-9-D-75655, ICD-9-D-75656, ICD-9-D-75659, ICD-9-D-7566, ICD-9-D-7567, ICD-9-D-75670, ICD-9-D-75671, ICD-9-D-75672, ICD-9-D-75673, ICD-9-D-75679, ICD-9-D-7568, ICD-9-D-75681, ICD-9-D-75682, ICD-9-D-75683, ICD-9-D-75689, ICD-9-D-7569, ICD-9-D-3484, ICD-10-D-Q0700, ICD-10-D-Q774, ICD-10-D-Q780
Trauma	ICD-9-D-83901, ICD-10-D-S13111A, ICD-9-D-83911, ICD-9-D-80502, ICD-10-D-S12100A, ICD-10-D-S12100B, ICD-10-D-S12100D, ICD-10-D-S12100G, ICD-10-D-S12100K, ICD-10-D-S12100S, ICD-10-D-S12101A, ICD-10-D-S12101B, ICD-10-D-S12101D, ICD-10-D-S12101G, ICD-10-D-S12101K, ICD-10-D-S12101S, ICD-10-D-S1211, ICD-10-D-S12110A, ICD-10-D-S12110B, ICD-10-D-S12110D, ICD-10-D-S12110G, ICD-10-D-S12110K, ICD-10-D-S12110S, ICD-10-D-S12111A, ICD-10-D-S12111D, ICD-10-D-S12111G, ICD-10-D-S12111K, ICD-10-D-S12111S, ICD-10-D-S12112A, ICD-10-D-S12112B, ICD-10-D-S12112D, ICD-10-D-S12112G, ICD-10-D-S12112K, ICD-10-D-S12112S, ICD-10-D-S12120A, ICD-10-D-S12120D, ICD-10-D-S12120G, ICD-10-D-S12120K, ICD-10-D-S12120S, ICD-10-D-S12121A, ICD-10-D-S12121D, ICD-10-D-S12121K, ICD-10-D-S12121S, ICD-10-D-S12130A, ICD-10-D-S12130D, ICD-10-D-S12130K, ICD-10-D-S12131A, ICD-10-D-S12131D, ICD-10-D-S12131G, ICD-10-D-S12131K, ICD-10-D-S1214XA, ICD-10-D-S1214XD, ICD-10-D-S1214XS, ICD-10-D-S12150A, ICD-10-D-S12150D, ICD-10-D-S12150K, ICD-10-D-S12151A, ICD-10-D-S12151D, ICD-10-D-S12190A, ICD-10-D-S12190D, ICD-10-D-S12190G, ICD-10-D-S12190K, ICD-10-D-S12190S, ICD-10-D-S12191, ICD-10-D-S12191A, ICD-10-D-S12191B, ICD-10-D-S12191D, ICD-10-D-S12191G, ICD-10-D-S12191K, ICD-10-D-S12191S, ICD-9-D-805, ICD-9-D-8050, ICD-9-D-80500, ICD-9-D-80501, ICD-9-D-80503, ICD-9-D-80504, ICD-9-D-80505, ICD-9-D-80506, ICD-9-D-80507, ICD-9-D-80508, ICD-9-D-8051, ICD-9-D-80510, ICD-9-D-80511, ICD-9-D-80512, ICD-9-D-80513, ICD-9-D-80514, ICD-9-D-80515, ICD-9-D-80516, ICD-9-D-80517, ICD-9-D-80518, ICD-9-D-8052, ICD-9-D-8053, ICD-9-D-8054, ICD-9-D-8055, ICD-9-D-8057, ICD-9-D-8058, ICD-9-D-8059, ICD-10-D-S12000, ICD-10-D-S12000A, ICD-10-D-S12000B, ICD-10-D-S12000D, ICD-10-D-S12000G, ICD-10-D-S12000K, ICD-10-D-S12000S, ICD-10-D-S12001, ICD-10-D-S12001A, ICD-10-D-S12001D, ICD-10-D-S12001G, ICD-10-D-S12001K, ICD-10-D-S12001S, ICD-10-D-S1201XA, ICD-10-D-S1201XB, ICD-10-D-S1201XD, ICD-10-D-S1201XS, ICD-10-D-S1202XA, ICD-10-D-S1202XD, ICD-10-D-S1202XG, ICD-10-D-S1202XS, ICD-10-D-S12030A, ICD-10-D-S12030D, ICD-10-D-S12030G, ICD-10-D-S12030K, ICD-10-D-S12030S, ICD-10-D-S12031A, ICD-10-D-S12031D, ICD-10-D-S12031G, ICD-10-D-S12031K, ICD-10-D-S12031S, ICD-10-D-S12040A, ICD-10-D-S12040B, ICD-10-D-S12040D, ICD-10-D-S12040K, ICD-10-D-S12040S, ICD-10-D-S12041A, ICD-10-D-S12041B, ICD-10-D-S12041D, ICD-10-D-S12041K, ICD-10-D-S12041S, ICD-10-D-S12090A, ICD-10-D-S12090D, ICD-10-D-S12090G, ICD-10-D-S12090K, ICD-10-D-S12090S, ICD-10-D-S12091A, ICD-10-D-S12091B, ICD-10-D-S12091D, ICD-10-D-S12091G, ICD-10-D-S12091K, ICD-10-D-S12091S
Degenerative	ICD-10-D-M5030, ICD-10-D-M5080, ICD-10-D-M5090, ICD-9-D-72291, ICD-9-D-71888, ICD-10-D-M532 × 1, ICD-9-D-7230, ICD-9-D-7232, ICD-9-D-7233
Cancer	ICD-9-D-1985, ICD-10-D-C7951, ICD-10-D-D166, ICD-9-D-2139, ICD-9-D-2132, ICD-9-D-20300, ICD-9-D-20301, ICD-9-D-20302, ICD-9-D-2031, ICD-9-D-20310, ICD-9-D-20311, ICD-9-D-20312, ICD-9-D-2036, ICD-9-D-2038, ICD-9-D-20380, ICD-9-D-20381, ICD-9-D-20382, ICD-9-D-20280, ICD-9-D-20281, ICD-9-D-20282, ICD-9-D-20283, ICD-9-D-20284, ICD-9-D-20285, ICD-9-D-20286, ICD-9-D-20287, ICD-9-D-20288
Complications	**Codes**
Surgical Site Complication	ICD-9-D-99832, ICD-9-D-99851, ICD-9-D-99859, ICD-9-D-9986, ICD-9-D-99883, ICD-10-D-T8131XA, ICD-10-D-T814XXA, ICD-10-D-K6811, ICD-10-D-T8183XA, ICD-10-D-T8189XA
Implant-related Complications	ICD-9-D-9962, ICD-10-D-T8509XA, ICD-10-D-T85190A, ICD-10-D-T85192A, ICD-10-D-T85199A, ICD-9-D-99640, ICD-10-D-T84498A, ICD-9-D-99642, ICD-10-D-T84029A, ICD-9-D-99647, ICD-10-D-T84099A, ICD-9-D-99649, ICD-10-D-T84119A, ICD-10-D-T84129A, ICD-10-D-T84199A, ICD-10-D-T84498A, ICD-9-D-99663, ICD-10-D-T8579XA, ICD-9-D-99667, ICD-10-D-T8460XA, ICD-10-D-T847XXA, ICD-9-D-99675, ICD-10-D-T8581XA, ICD-10-D-T8582XA, ICD-10-D-T8583XA, ICD-10-D-T8584XA, ICD-10-D-T8585XA, ICD-10-D-T8586XA, ICD-10-D-T8589XA, ICD-9-D-99677, ICD-10-D-T8481XA, ICD-10-D-T8482XA, ICD-10-D-T8483XA, ICD-10-D-T8484XA, ICD-10-D-T8485XA, ICD-10-D-T8486XA, ICD-10-D-T8489XA, ICD-10-D-T849XXA, ICD-9-D-99678, ICD-10-D-T8481XA, ICD-10-D-T8482XA, ICD-10-D-T8483XA, ICD-10-D-T8484XA, ICD-10-D-T8485XA, ICD-10-D-T8486XA, ICD-10-D-T8489XA, ICD-10-D-T849XXA, ICD-9-D-99679, ICD-10-D-T8581XA, ICD-10-D-T8582XA, ICD-10-D-T8583XA, ICD-10-D-T8584XA, ICD-10-D-T8585XA, ICD-10-D-T8586XA, ICD-10-D-T8589XA, ICD-9-D-9982, ICD-10-D-D7811, ICD-10-D-D7812, ICD-10-D-E3611, ICD-10-D-E3612, ICD-10-D-G9748, ICD-10-D-G9749, ICD-10-D-H59219, ICD-10-D-H9531, ICD-10-D-H9532, ICD-10-D-I9751, ICD-10-D-I9752, ICD-10-D-J9571, ICD-10-D-J9572, ICD-10-D-K9171, ICD-10-D-K9172, ICD-10-D-L7611, ICD-10-D-L7612, ICD-10-D-M96820, ICD-10-D-M96821, ICD-10-D-N9971, ICD-10-D-N9972, ICD-10-D-T888XXA

(*continued on next page*)

Durotomy	ICD-9-D-34931, ICD-10-D-G9741, ICD-9-D-34939, ICD-10-D-G9611
DVT	ICD-9-D45340, ICD-10-D-I82409, ICD-9-D45341, ICD-10-D-I82419, ICD-10-D-I82429, ICD-10-D-I82439, ICD-10-D-I824Y9, ICD-9-D45341, ICD-10-D-I82419, ICD-10-D-I82429, ICD-10-D-I82439, ICD-10-D-I824Y9, ICD-9-D45381, ICD-10-D-I82619, ICD-9-D-45382, ICD-10-D-I82629, ICD-9-D-45383, ICD-10-D-I82609, ICD-9-D-45384, ICD-10-D-I82A19, ICD-9-D-45385, ICD-10-D-I82B19, ICD-9-D45386, ICD-10-D-I82C19, ICD-9-D45387, ICD-10-D-I82290, ICD-9-D45389, ICD-10-I82890, ICD-9-D4539, ICD-10-D-I8291, ICD-9-D-41512, ICD-10-D-I2690, ICD-9-D41513, ICD-10-D-I2692, ICD-9-D41519, ICD-10-D-I2699
Neurologic Complication	ICD-9-D-99700:ICD-9-D-99709, ICD-10-D-G9781, ICD-10-D-G9782
Respiratory Complication	ICD-9-D-51851, ICD-10-D-J95821, ICD-10-D-J9600, ICD-9-D-51852, ICD-10-D-J951, ICD-10-J952, ICD-10-D-J953, ICD-9-D-51853, ICD-10-D-J95822, ICD-I0-D-J9620, ICD-9-D-51881, ICD-10-D-J9600, ICD-10-D-J9690, ICD-9-D-51884, ICD-10-D-J9620, ICD-9-D-99731, ICD-10-D-J95851, ICD-9-D-99732, ICD-10-D-J9589, ICD-9-D-99739, ICD-10-D-J95859, ICD-10-D-J9588, ICD-10-D-J9589
Cardiac Complication	ICD-9-D-9971, ICD-10-D-I97710, ICD-10-D-I97790, ICD-10-D-I9788, ICD-10-D-I9789
Death	DSTATUS-20, DSTATUS-B, DSTATUS-40, DSTATUS-41, DSTATUS-42
Myocardial	ICD-9-D-41000:ICD-9-D-41091,ICD-10-D-I210:ICD-10-D-I238
Cardiac Arrest	ICD-9-D-4275, ICD-10-D-I469
Coagulation	ICD-9-D-2866, ICD-10-D-D65
Sepsis	ICD-9-D-99591, ICD-10-D-A419
Pneumonia	ICD-9-D-48200:ICD-9-D-4838, ICD-9-D-481, ICD-10-D-J13, ICD-10-D-J181,ICD-10-D-J150:ICD-10-D-J18
Spinal Cord	ICD-9-D-95200, ICD-10-D-S14101A, ICD-10-D-S14102A, ICD-10-D-S14103A, ICD-10-D-S14104A, ICD-9-D-95201, ICD-10-D-S14111A, ICD-10-D-S14112A, ICD-10-D-S14113A, ICD-10-D-S14114A, ICD-9-D-95202, ICD-10-D-S14131A, ICD-10-D-S14132A, ICD-10-D-S14134A, ICD-9-D-95203, ICD-10-D-S14121A, ICD-10-D-S14122A, ICD-10-D-S14123A, ICD-10-D-S14124A, ICD-9-D-95204, ICD-10-D-S14151A, ICD-10-D-S14152A, ICD-10-D-S14153A, ICD-10-D-S14154A, ICD-9-D-95205, ICD-10-D-S14105A, ICD-10-D-S14106A, ICD-10-D-S14107A, ICD-9-D-95206, ICD-10-D-S14115A, ICD-10-D-S14116A, ICD-10-D-S14117A, ICD-10-D-S14118A, ICD-9-D-95207, ICD-10-D-S14135A, ICD-10-D-S14136A, ICD-10-D-S14137A, ICD-9-D-95208, ICD-10-D-S14125A, ICD-10-D-S14126A, ICD-10-D-S14127A, ICD-9-D-95209, ICD-10-D-S14155A, ICD-10-D-S14156A, ICD-10-D-S14157A, ICD-10-D-S14158A
Plexus	ICD-9-D-9530, ICD-10-D-S142XXA, ICD-9-D-9531, ICD-10-D-S242XXA, ICD-9-D-9532, ICD-10-D-S3421XA, ICD-9-D-9533, ICD-10-D-S3422XA, ICD-9-D-9534, ICD-10-D-S143XXA, ICD-9-D-9535, ICD-10-D-S344XXA, ICD-9-D-9538, ICD-10-D-S142XXA, ICD-10-D-S242XXA, ICD-10-D-S3421XA, ICD-10-D-S3422XA, ICD-10-D-S344XXA, ICD-9-D-9539, ICD-10-D-S142XXA, ICD-10-D-S242XXA, ICD-10-D-S3421XA, ICD-10-D-S3422XA, ICD-10-D-S344XXA
Visual	ICD-9-D-36811, ICD-10-D-H53139, ICD-9-D-37741, ICD-10-D-H47019, ICD-9-D-37775, ICD-10-D-H47619, ICD-9-D-36230, ICD-10-D-H349, ICD-9-D-36231, ICD-10-D-H3413, ICD-9-D-36235, ICD-10-D-H34819
Iatrogenic	ICD-9-D-99702, ICD-10-D-I97811, ICD-10-D-I97821
Reintubation	ICD-9-P-9604, ICD-10-P-0BH17EZ, ICD-10-P-0BH18EZ
Hyperthermia	ICD-9-D-99586,ICD-10-D-T883XXA

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