Published in final edited form as:

Spine (Phila Pa 1976). 2013 February 1; 38(3): 223–228. doi:10.1097/BRS.0b013e318268ffc9.

Risk Factors for Medical Complication after Cervical Spine Surgery: a multivariate analysis of 582 patients

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Abstract

Study Design—Multivariate analysis of prospectively collected registry data

Objective—Using multivariate analysis, to determine significant risk factors for medical complication after cervical spine surgery.

Summary of Background Data—Several studies have examined the occurrence of medical complication after spine surgery. However many of these studies have been done utilizing large national databases. While these allow for analysis of thousands of patients, potentially influential co-variables are not accounted for in these retrospective studies. Furthermore, the accuracy of these retrospective data collection in these databases has been called into question.

Methods—The Spine End Results Registry (2003–2004) is a collection prospectively collected data on all patients who underwent spine surgery at our two institutions. Extensive demographic and medical information were prospectively recorded as described previously by Mirza et al. Complications were defined in detail a priori and were prospectively recorded for at least 2 years after surgery. We analyzed risk factors for medical complication after lumbar spine surgery using univariate and multivariate analysis.

Results—We analyzed data from 582 patients who met out inclusion criteria. The cumulative incidences of complication after cervical spine surgery per organ system are as follows: cardiac – 8.4%, pulmonary – 13%, gastrointestinal – 3.9%, neurological – 7.4%, hematological – 10.8% and urologic complications – 9.2%. The occurrence of cardiac or respiratory complication after cervical spine surgery was significantly associated with death within 2 years (RR 4.32, 6.43 respectively). Relative risk values with 95% confidence intervals and p values are listed individually in Tables 2 and 3.

Conclusion—Risk factors identified in this study can be beneficial to clinicians and patients alike when considering surgical treatment of the cervical spine. Future analyses and models that predict the occurrence of medical complication after cervical spine surgery may be of further benefit for surgical decision making.

Keywords

medical complication; cervical spine; spine surgery; risk factor

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INTRODUCTION

The identification and quantification of risk factors for complication after spine surgery is of paramount importance to the patient and the clinician. In addition to its obvious importance for patient safety, risk factor information becomes critical as health care policy makers implement and enforce 'quality' metrics.

Prior studies have reported complications after spine surgery using different models. These include analysis of Medicare, Workmen's Compensation, National Inpatient Sample[1–3], and retrospective hospital chart review data[4–8]. While there are respective strengths and weaknesses of these studies, the largest weakness is that these reports do not account for the effect of surgical invasiveness. It is intuitive that the occurrence of a medical complication after surgery is a function of the patient's baseline medical status and the extensiveness of surgery. While some studies differentiate arthrodesis from non-arthrodesis surgeries, or instrumented vs. non-instrumented fusions, it is difficult to discern how much additional risk there is based on number of levels decompressed, arthrodesed and instrumented from various approaches.

The Spine End Results Registry 2003–2004 is a prospective cohort of all patients undergoing spinal surgery at the University of Washington Medical Center and Harborview Medical Center. Detailed information regarding patient demographics, medical co-morbidity, surgical invasiveness, and adverse occurrences were obtained prospectively using previous published methods.[10, 11] We utilized a previously validated scoring system for surgical invasiveness score[10] that assigned point values for each level decompressed, arthrodesed, and instrumented from an anterior or posterior approach.

The purpose of the present study is to assess the relative risk of numerous patient specific and surgical factors on peri-operative medical complications (cardiac, pulmonary, gastrointestinal, hematological, renal, neurological, death) using univariate and multivariate log binomial analysis. We hypothesized that age, diabetes, revision surgery, medical co-morbidity, and surgical invasiveness were significant risk factors for peri-operative morbidity after cervical spine surgery.

MATERIALS and METHODS

Data Source

We examined data from a prospective cohort study of patients undergoing spinal surgery between January 1st 2003 and December 31st 2004 at two academic hospitals: a university based medical center, and a county hospital serving as the only Level I trauma center in a large multi-state area. All patients were prospectively followed for the for at least 2 years after their surgery using surveillance methods as previously described by Mirza et al.[10] All patients were followed with institutional review board approval from the University of Washington Medical Center. Detailed information regarding patient demographics, medical co-morbidity, surgical invasiveness, and adverse occurrences were obtained prospectively using previous published methods.[10, 11]

Exclusion Criteria

We excluded all patients who did not undergo cervical spine surgery. We also excluded patients younger than 18 years of age, those with missing surgical invasiveness data and those with a surgical invasiveness index that was either missing or equal to zero as these included patients who did not actually have spinal decompression or fusion (closed casting, placement of halo) (Figure 1).

Medical Complication and Risk Factor Definitions

Medical complications examined fell in to six different categories based on organ system (cardiac, pulmonary, gastrointestinal (GI), neuro, hematological and renal). For each category, detailed definitions of complications are listed in Appendix 1A–1F.

We assessed the relative risk of several risk factors using univariate and multivariate analysis. Risk factors assessed include age, gender, smoking status, alcohol use, drug use, diabetes, body mass index (BMI), medical co-morbidity (myocardial infarction, history of non MI cardiac disease (valve disease, prolapse, abnormal EKG), congestive heart failure, cerebrovascular disease, chronic obstructive pulmonary disease (COPD), asthma, hypertension, rheumatoid arthritis, renal conditions, pre-existing neoplasm, history of syncope or seizure, anemia, bleeding disorder), previous spinal surgery, primary diagnosis (degenerative, trauma, neoplasm, other), surgical approach (anterior, posterior, combined). In addition, we assessed the relative risk of death (within 2 years after the surgery) after the occurrence of medical complication based on organ system.

All patients were actively followed for medical complication. However, some information about their risk factors, such as smoking status and alcohol use, were missing. The data analysis presented in the current manuscript was done with missing data coded as 'no' or 'absent'. However, we did perform the analysis with and without those who had missing data and it did not change the conclusions.

Surgical Invasiveness

The Surgical Invasiveness Index is a previously validated scoring system that assigns a point value for each spine level decompressed, fused, or instrumented, posteriorly and anteriorly. [11] It ranges from 0 to 48, with a higher score indicating greater invasiveness. The index is the sum of 6 weighted surgical components: anterior decompression (ad), anterior fusion (af), anterior instrumentation (ai), posterior decompression (pd), posterior fusion (pf), and posterior instrumentation (pi). The weights for each component represent the number of vertebral levels at which each it is performed [10]. For example, in a C5 – C6 anterior discectomy, with fusion and plating, the score is 5 (ad=1 (one disc) + af = 2 (two vertebrae fused) + ai = 2 (plate at both levels)). For our purpose, we categorized the score into six groups: 1–5, 6–10, 11–15, 16–20, 21–25, greater than 25.

Analysis

For categorical values, Pearson's Chi-square or Fisher's exact tests (where cell counts were low) were used to assess the effect of various risk factors. Relative risk (RR) and 95% confidence intervals (95% CI) were calculated for each of the categorical variables using univariate and multivariate log-binomial analysis. Multivariate log-binomial analysis was used to examine the association between risk factors and medical complication, adjusting for confounding risk factors. In the model we included risk factors that were deemed of clinical importance by the study investigators to contribute to medical complication, were a known confounder, or had a univariate association of $p < 0.10$. We did not include surgical approach and number of levels both in our multivariate because they are both components of the invasiveness index.

Statistical analysis was performed using SAS 9.2 software (SAS Inc., Cary, NC) with hypothesis testing using a 2-tailed test of significance and an alpha level of $p < 0.05$.

RESULTS

Of the original 1745 patients, we did exclude 116 patients who did have missing or zero surgical invasiveness scores. We also excluded 38 patients who were younger than 18 years of age and 1009 non-cervical spine patients. Thus we performed our analysis on the remaining 582 patients (Figure 1).

The cumulative incidences of complication per organ system are as follows: cardiac - 8.4%, pulmonary - 13%, gastrointestinal - 3.9%, neurological - 7.35%, hematological - 10.75% and urologic complications - 9.18%. Details of these complications are listed in Appendix 1A–1F. These differ from the percentage of patients who experienced an organ specific complication as noted in Figure 1, as some patients did experience multiple organ specific complications.

Demographic information is presented in Table 1. The results of our univariate and multivariate analyses are presented in tables 2, 3, and 4. As expected not all significant risk factors identifies in the univariate analysis proved to be significant after multivariate analysis. We did observe that the presence of a cardiac or pulmonary complication did increase the relative risk of death 4.32– 6.43 fold within 2 years of the surgery.

DISCUSSION

In the current literature, there is evidence linking pre-existing general medical conditions with long-term post-operative complications. The currently available literature largely consists of retrospective data from case-reports, case-series, retrospective registry data, with limited prospective reviews. Additionally, most of this research has been focused on the lumbar spine with fewer series on the cervical spine.

Many studies have utilized the Nationwide Inpatient Sample (NIS), data based on a registry and with postoperative complications mapped to an ICD-9-CM diagnosis code. Although these studies have merit, there are limitations to the conclusions that can be made based on these data. As with any registry, data are dependent upon accurate coding of all complications and co-morbidity. Romano et al. found an overall sensitivity of only 35% in reported complications using retrospective administrative data.[12] They reported that the data were “more sensitive for reoperation, sepsis, postoperative infection, and deep vein thrombosis” (60%). Additionally, important data such as pertinent surgical information and other co-morbidities and their respective severities are not available in this database. Capture of complication may also be limited as the NIS data registry follows patients only until discharge from hospital and not necessarily afterwards.

Yadla et al. performed a prospective observational cohort study to determine the incidence of early postoperative complications in patients undergoing cervical spine surgery and their correlation with preoperative spinal diagnosis.[13] In their analysis of 121 patients, they reported a major complication rate of 18.2%. This study collected data on the surgical preoperative diagnosis (degenerative, tumor, infection, or trauma), gender, BMI, fusion surgery, incidence of major and minor complications, and length of stay using stepwise multivariate analysis. However, it does not appear that any pre operative medical co-morbidity or extent of surgical invasiveness was included in the multivariate analysis for early complication. In addition, this study only examined early complications and its analysis only analyzed complications within 30 days from surgery.

The present study is an analysis of prospectively collected data on 582 patients from the Spine End Results Registry UWMC 2003–2004. Hundreds of data elements per patient were prospectively recorded for all patients undergoing surgery at our two institutions. Patients

were followed for at least 2 years after the surgery through multiple surveillance methods. The major strength of this study is the use of this high quality registry. Not only were data recorded prospectively, all data and complications were explicitly defined a priori as noted in Appendices 1A–1F.

In our multivariate analysis we present risk factors and confidence intervals for complication in 6 different organ systems. We determined that age >65 (RR 9.44, CI 3.15–34.66) and a history of prior cardiac event (RR 3.79, CI 1.38–10.41) were significant risk factors for death after cervical spine surgery. We also concluded patients had the highest risk for death after the occurrence of a cardiac or pulmonary complication after surgery.

As with any study, there are weaknesses with ours. Firstly, this was an observational study without any randomization or study control. As one would expect, patients with severe medical co-morbidity were likely not advised to undergo surgery. Thus the true effect of these co-morbidities may have been blunted in our study. Secondly, several data fields were recorded as categorical and not continuous variables. As a result, the severity of various co-morbidities may not have been accounted for in our multivariate analysis. For example, smoking status was recorded as yes or no with no indication of number of cigarettes or packs used per day.

This identification and quantification of risk factors represents a first step towards developing a predictive model for complications after spine surgery. Such a model, which would account for patient demographic background, patient co-morbidity data, and invasiveness of surgery, would provide a percent likelihood for complication, rather than a relative risk value. While Relative Risk values with confidence intervals are of value to a statistician and a clinician scientist, they may be of limited value to a patient. Clinical interpretation of these statistical values may be challenging for the patient and physician. However, if providers were able to inform a patient that that particular patient's chances for a medical complication after a particular kind of surgery was XX% (with a 95% CI range), this would better inform the patient and assist in the patient and provider in clinical decision making. A manuscript presenting a predictive model using these data is in preparation.

As quality metrics are implemented across the board, such a predictive model would concurrently allow for risk adjustment modification. Increasingly, metrics are being applied to providers and medical centers as indicators of quality. These metrics not only grade a medical center negatively, but also are associated with financial penalty. Clearly, complication rates will vary based on the patient's baseline health and the extensiveness of surgery. A 65 year old patient status post organ transplant undergoing a 3 level-cervical laminectomy and fusion is intuitively *expected* to have a higher likelihood for complication than a healthy 25 year old patient undergoing foraminotomy. Yet, 'quality' metrics, without adequate risk modification, may judge these patients and their complications equally. The use of non-risk-adjusted quality metrics has the potential to penalize providers and medical centers for embracing the care of sicker patients who, despite having received quality care, may inherently have a higher likelihood for complication. As a result, the absence of risk modification to quality metrics may potentially have an effect on disparity of patient access to health care.

The present manuscript is an extensive multivariate analysis of medical complications after cervical spine surgery. To our knowledge, this is the largest study utilizing prospective data examining complications after cervical spine surgery. While these data are useful, future studies, specifically predictive models, may further assist physicians and clinicians when considering surgical options for treatment.

Acknowledgments

Supported by grants from the NIH/NIAMS 5K23AR48979 and 5P60-AR48093 and supported in part by the Spine End-Results Research Fund at the University of Washington Medical Center through a gift from Synthes Spine (Paoli, PA)

We would like to acknowledge Dr. Sohail Mirza (Dartmouth Medical Center) for his tremendous contribution to this manuscript.

Appendix

Appendix 1A

Cardiac Complications	N (incidence)
1: air embolism Entrainment of air into the venous circulation and heart detected by any monitoring device including Doppler, TEE, or sudden decrease in end tidal CO ₂ , SpO ₂ , or blood pressure or air in coronary vessels on post-mortem exam	0
2: arrest Cardiac output insufficient to maintain a palpable central pulse, and requiring CPR, electroshock therapy and/or vasoactive drugs to maintain an adequate perfusion pressure.	3 (0.52%)
3: arrhythmia(telemetry+Tx or mc06/death) Any cardiac rhythm which varies from baseline and requires either extra monitoring, drugs, consultations, or electroshock therapy, or results in hypotension or death.	16 (2.8%)
4: CHF(new S3/JVD+rales/CXR+Tx) An abnormality of cardiac function is responsible for the failure of the heart to pump blood at a rate commensurate with the requirements of the metabolizing tissues, manifested by pulmonary edema, a new S3 gallop, jugular venous distension, rales, pleural edema or effusion, and requiring treatment.	1 (0.17%)
5: hypertension Sbp > 180 or Dbp > 100 for > 5minutes	0
6: hypotension(sBP/MAP<50%base, >5min) Mean arterial pressure < 50% of baseline for > 5 minutes.	8 (1.4%)
7: infarction(mc09+enzymes/new Qs) Necrosis of heart tissue as evidenced by elevated ST segments or new Q waves or new wall motion abnormality associated with elevated cardiac enzymes (troponin, CK-MB)	4 (0.69%)
8: inappropriate or inadequate fluid therapy Insufficient replacement of volume with blood products, crystalloid or other colloid to maintain adequate perfusion and oxygenation of all tissues, as evidenced by inadequate urine output, low central filling pressures, elevated lactate, metabolic acidosis with pH < 7.35, and/or hypotension responsive to fluids. Criteria: (1) inadequate urine output (< 0.5 ml/kg/hr); (2) hypotension responsive to fluid challenge ; (3) elevated lactate level; (4) metabolic acidosis (pH < 7.35); and/or (5) low central filling pressures.	0
9: ischemia(sx/1mmST 2 leads, ROMI/Tx) Myocardial ischemia is a deficiency of the blood supply to the heart muscle, leading to symptoms, flat depression of the ST segment of more than 0.1 mV below the baseline (i.e., the PR segment) and lasting longer than 0.08 s, treatment, or rule-out MI monitoring.	0
10: thermoregulation Temperature < 35oC for > 30min.	0
11: other cardiac occurrence Other circulation or cardiac-related occurrence.	3 (0.52%)
Total Cardiac Adverse Occurrences	35 (6%)

Appendix 1B

Pulmonary Complications	n (incidence)
1: ARDS(FiO2>50/vent>48h + mc04/mr05/BxAu) Acute hypoxemic respiratory failure due to pulmonary edema caused by increased permeability of the alveolar capillary barrier. Criteria: (1) FiO2 >50%; (2) Ventilator support for >48h; (3) PaO2/FiO2 <= 300 mm Hg; and (4) bilateral lung infiltrates on CXR.	9 (1.6%)
2: empyema Purulent fluid collection in the pleural space confirmed by imaging studies and aspiration or by surgery.	0
3: hemothorax Blood in the pleural space confirmed by imaging studies and aspiration or surgery.	0
4: pleural effusion Pleural effusion is excess fluid in the pleural space.	4 (0.69%)
4(postop): hypoxia(FiO2>50×48h or suppl O2×7d) Requirement for supplemental oxygen post-operatively, with FiO2 >50% for 48h or supplemental oxygen by nasal cannula for 7 days.	4 (0.69%)
5: pneumonia(>38.0+Cx/CXR and Tx) Infection of the lung parenchyma confirmed by fever, sputum or bronchial cultures, CXR, and requiring treatment.	41 (7%)
6: pneumothorax Accumulation of gas in the pleural space resulting in symptoms (tachycardia, hypotension), requiring extra surveillance (e.g. repeat CXRs or pulse oximetry) or treatment (chest tube placement).	2 (0.34%)
7: pulmonary embolus(CTA/VQ/Angio + Tx) Sudden onset of shortness of breath, tachypnea, cyanosis, tachycardia, hypotension, or chest pain confirmed to be a imaging studies to be a pulmonary thrombus, and requiring treatment; or diagnosis made at autopsy.	4 (0.69%)
8: respiratory arrest Sudden cessation of voluntary breathing, requiring CPR or mechanical ventilation.	5 (0.86%)
9: other respiratory Other respiratory problem.	4 (0.69%)
Total Respiratory Adverse Occurrence Events	73 (12.5%)

Appendix 1C

Gastrointestinal Complications	N (incidence)
1: ascites Effusion and accumulation of serous fluid in the abdominal cavity leading discernable on physical examination or radiologic imaging (free peritoneal fluid >25 ml), leading to symptoms, unplanned evaluation, or requiring treatment.	0
2: colitis Inflammation of the colon manifested as diarrhea or bloody diarrhea, sepsis, abdominal pain, or toxic megacolon. Criteria: 1. Rectal discharge; 2. Perineal ulceration; 3. Colonoscopic and biopsy evidence of inflammation..	1 (0.17%)
3: GI bleeding(heme pos + drop Hct 10% or Tx) Blood loss through the gastrointestinal tract, including hematemesis, melena, hematochezia, occult GI bleeding may be identified in the absence of overt bleeding by special examination of the stool (e.g., guaiac testing), or symptoms of blood loss or anemia such as lightheadedness, syncope, angina, or dyspnea.. Criteria: 1. Bloody vomitus or stool; 2. Bleeding from the rectum; 3. Hct decrease > 10%; 4. Lightheadedness, syncope, angina, or dyspnea.	3 (0.52%)
4: ileus Abdominal distension and no passage of stool or flatus by postoperative day 3.	3 (0.52%)

Gastrointestinal Complications	N (incidence)
5: obstruction Pseudo-obstruction is colonic distension in the absence of mechanical obstruction, with cecal diam > 9 cm and air in all colonic segments on plain radiographs.	0
6: pancreatitis Acute inflammation of the pancreas with sudden onset of: (1) abdominal pain; (2) nausea; (3) vomiting; (4) high levels pancreas enzymes - serum amylase 3X normal.	0
7: perforation Iatrogenic perforation of the stomach, small intestine, or large intestine during the procedure or perforation later caused by implants or instrumentation. Criteria: (1) nausea, vomiting, or ileus; (2) abdominal or groin pain and referred pain; (3) air in the abdomen on plain radiograph or CT or other imaging study; (4) abdominal distension and tenderness; OR surgical finding of perforation.	2 (0.34%)
8: peritonitis Inflammation or infection of the peritoneum with symptoms of: (1) abdominal pain and tenderness; (2) constipation; (3) vomiting; (4) moderate fever.	0
9: other GI occurrence Other GI-related occurrence.	5 (0.86%)
Total Gastrointestinal Adverse Occurrence Events	14 (2.4%)

Appendix 1D

Neurological Complications	N (incidence)
1: CVA/TIA(new focal deficit orCT/MR orBxAu) The abrupt onset of a nonconvulsive and new focal neurologic deficit due to a reduction of blood flow to the brain, or abnormality on imaging studies suggestive of a CNS infarct, or CNS infarction confirmed by biopsy or autopsy.	2 (0.34%)
2: cerebral perfusion(ICP>20orCPP<30for>5min) Reduction in the flow of blood to the brain during the procedure for > 5 minutes, with intracranial pressure >20 or cerebral perfusion pressure < 30 mmHg.	0
3: delerium(confusion>24h +Tx/sitter/restraint) Acute change in level of consciousness characterized by reduced ability to maintain attention to external stimuli, lethargy, or agitation, and disorganized thinking as manifested by rambling, irrelevant, or incoherent speech. Criteria: (1) confusion > 24 hr; and (2) was not related to narcotics; and (3) patient required restraints or continuous supervision.	17 (2.9%)
4: diabetes insipidus Excessive urine production from reduced production or responsiveness to ADH. Diagnosis can be made by relating plasma to urine osmolality, particularly in postoperative neurosurgical patients or after head trauma, where its use can permit quick differentiation of diabetes insipidus from parenteral fluid excess.	0
5: electrolyte change (Na<130/>150, K>5.5,other) The electrolyte balance of the extracellular fluid was sufficiently changed from normal to require extra monitoring, evaluation, or treatment beyond routine post operative care. Specifically: Na < 130 or > 150 or K >5.5	4 (0.69%)
6: meningitis(pos Cx/Bx or CT/MR and Tx) Inflammation of the meninges (the pia-arachnoid) and the cerebrospinal fluid (CSF) of the subarachnoid space associated with symptoms of fever, headache, nausea/diarrhea/abdominal pain, and confirmed by CSF cultures or biopsy, imaging studies, and requiring treatment.	3 (0.52%)
7: SAH/intracerebral hemorrhage Hemorrhage in the space between the arachnoid membrane and pia matter (subarachnoid) causing compression of the brain associated with sudden headache, neurological deficit, and confirmed with imaging studies or blood in the CSF. May also occur in the spinal cord in association with sudden back pain.	0
8: seizure A paroxysmal event due to abnormal, excessive, hypersynchronous discharges from an aggregate of central nervous system (CNS) neurons with manifestations	1 (0.17%)

Neurological Complications	N (incidence)
ranging from convulsive activity to experiential phenomena not discernible by an observer, confirmed by EEG or neurology consultation.	
9: withdrawal, alcohol(history + mn03 + Tx) A patient with history of alcohol abuse exhibits anxiety, confusion and delirium after the cessation of alcohol intake, requiring treatment.	0
10: withdrawal, narcotic The patient exhibits symptoms of nausea and diarrhea, coughing, lacrimation, mydriasis, rhinorrhea, profuse sweating, twitching muscles, and piloerection, or "goose bumps"; mild elevations in body temperature, respiratory rate, and blood pressure after reduction or cessation of narcotic intake, with improvement in symptoms after opioid administration.	1 (0.17%)
11: other neurologic occurrence Other neurologic occurrence.	7 (1.2%)
Total Neurologic Adverse Occurrence Events	35 (6.0%)

Appendix 1E

Hematological Complications	n (incidence)
1: coagulopathy(INR>2 or Plts<50 or Fib<100) Any disorder reducing the ability of the blood to clot. Severity 1: INR>1.5 and < 2.0, or platelets <_100k and >50k Severity 2: INR>2.0 and < 3.0, or platelets <_50k and >20k Severity 3: INR>3.0, or platelets <_20k	2 (0.34%)
2: DVT (confirmed by imaging) The presence of thrombosis of the iliac, femoral, or popliteal or other veins confirmed by imaging studies (duplex scan, CT, or MR) with or without swelling, warmth, erythema, or tenderness..	20 (3.4%)
3: OR hemorrhage >3000cc Blood loss of greater than 3 L during the procedure.	4 (0.69%)
4: transfusion occurrence The patient required an unplanned transfusion during or after the procedure, or adverse reaction to blood product transfusion.	9 (1.6%)
5: other hematologic occurrence Other hematologic adverse occurrence.	1 (0.17%)
Total Hematologic Adverse Occurrence Events	36 (6.2%)

Appendix 1F

Urologic Complications	n (incidence)
1: Foley catheter trauma Injury to the urethra or bladder caused during normal insertion or removal of the Foley catheter, or during inadvertent removal of the catheter.	2 (0.34%)
2: renal insufficiency (Cr >2 over base) <i>Operational definition:</i> Failure of the kidneys characterized by rapid decline in glomerular filtration rate (hours to days), retention of nitrogenous waste products, and perturbation of extracellular fluid volume and electrolyte and acid-base homeostasis. Criteria: serum Cr >2 above baseline.	3 (0.52%)
3: urinary retention Inability to empty bladder under voluntary control.	9 (1.6%)
4: UTI The presence of large amounts of bacteria (>100,000 organisms/mL) in the upper or lower urinary tract associated with symptoms or requiring treatment.	36 (6.2%)
5: other urologic event	1 (0.17%)

Urologic Complications	n (incidence)
Other urologic adverse occurrence.	
Total Urologic Adverse Occurrence Events	51 (8.8%)

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Utilizing the Spine-End-Results-Registry, this study performed an exhaustive univariate and multivariate analysis of risk factors for medical complication after cervical spine surgery. The relative-risk with 95% confidence intervals and p values were determined for numerous potential risk factors. These data can be beneficial when considering surgical treatment of the cervical spine.

Key Points

- 1) This study identifies and quantifies risk factors for medical complication after cervical spine surgery.
- 2) These data represent a step towards the creation of predictive model for medical complication after spine surgery.
- 3) The occurrence of cardiac or pulmonary complication after cervical spine surgery was significantly associated with death within 2 years.

Figure 1.
Inclusion and exclusion criteria

Table 1

Demographic data of the sample population

Risk Factors	N = 582	Risk Factors	N = 582
Age (yr), mean (sd)	49.3 (15.6)	Gender	
18 – 39	148 (25%)	Male	360 (62%)
40 – 64	334 (57%)	Female	222 (38%)
65	100 (17%)		
Smoking		Surgical Approach	
No	335 (62%)	Posterior	265 (45%)
Yes	207 (38%)	Anterior	273 (47%)
Alcohol		Combined	44 (8%)
No	332 (57%)		
Yes	250 (43%)	Revision	
Drug Use		No	518 (89%)
No	512 (88%)	Yes	64 (11%)
Yes	70 (12%)		
Diabetes		Diagnosis Group	
No	516 (89%)	Degenerative	333 (57%)
Yes	66 (11%)	Trauma	180 (31%)
		Neoplasm	36 (6%)
BMI		Infection	19 (3%)
Underweight (< 18.5)	55 (9%)	Other	14 (2%)
Normal (18.5 – < 25)	195 (34%)		
Overweight (25 – < 30)	188 (32%)		
Obese (30 – < 35)	83 (14%)		
35	61 (10%)		
Charlson Co morbidity, mean (sd) *		Invasiveness Index, mean (sd)	
0	268 (49%)	1 – 5	301 (52%)
1	125 (23%)	6 – 10	177 (30%)
2	57 (10%)	11 – 15	69 (12%)
3	44 (8%)	16 – 20	21 (4%)
4	30 (5%)	21 – 25	11 (2%)
5	25 (5%)	> 25	3 (0.52%)

* missing data

Table 2

Risk factors for medical complication after lumbar surgery using univariate analysis.

Significant Risk Factors for Medical Complication after univariate analysis			
Cardiac Cx			
	RR	p	95% CI
Age >65 (ref age 18–39)	8.88	<0.001	2.69 – 29.4
Alcohol use	0.39	<0.02	0.17 – 0.88
Prior Cardiac Event	5.29	<0.001	2.64 – 10.6
Congestive Heart Failure	6.72	<0.001	3.08 – 14.6
Diabetes	2.28	p<0.05	1.02 – 5.59
Hypertension	3.37	p<0.001	1.67 – 6.80
Combined Approach (ref posterior)	3.24	0.007	1.37 – 7.68
Dx Trauma (ref degen)	3.7	0.009	1.28 – 10.7
Pulmonary Cx			
Age <65 (ref 18–39)	2.37	0.003	1.31 – 4.29
Female	0.5	0.02	0.28 – 0.9
Drug use	1.87	0.04	1.04 – 3.34
Congestive Heart Failure	4.19	0.001	2.16 – 8.13
Prior Cardiac Event	2.8	<0.001	1.56 – 5.04
Dx Trauma (ref degen)	6.78	0.001	3.68 – 12.5
Diabetes	2.21	0.006	1.26 – 3.34
Combined Approach (ref posterior)	2.01	0.049	1.01 – 3.98

Table 3

Risk factors for medical complication after lumbar surgery using multivariate analysis.

Significant Risk Factors for Medical Complication after univariate analysis			
Neurological Cx			
Congestive Heart Failure	4.95	0.004	2.12 – 11.5
Combined Approach (ref posterior)	3.01	0.01	1.37 – 6.61
COPD	2.86	0.03	1.25 – 6.53
Hypertension	2.26	0.01	1.17 – 4.38
Renal disease	2.65	0.04	1.12 – 6.71
Liver disease	2.76	0.03	1.20 – 6.35
Combined Approach (ref posterior)	3.01	0.01	1.37 – 6.61
Surgical Invasiveness (ref score 1–5)	3.39	0.02	1.31 – 8.79
Hematological Cx			
Age >65 (ref age 18–39)	3.7	0.01	1.19 – 11.5
Hypertension	2.59	0.005	1.30 – 5.13
Liver disease	3.45	0.01	1.46 – 8.12
Dx Trauma (ref degen)	3.01	0.009	1.27 – 7.12
Dx Infection (ref degen)	11.1	0.001	3.96 – 30.3
Dx Neoplasm (ref degen)	5.78	0.005	2.00 – 16.7
Surgical Invasiveness	3.97	0.002	1.75 – 8.96
Anterior approach (ref posterior)	0.46	0.04	0.21 – 0.998
Urological Cx			
Diabetes	2.01	0.08	1.01 – 3.99
Dx Infection (ref degen)	7.01	0.004	2.42 – 20.3
Dx Trauma (ref degen)	4.81	<0.001	2.37 – 9.75
Anterior approach (ref posterior)	0.54	0.05	0.29 – 1.02

Table 4

Significant Risk Factors for Medical Complication after multivariate log-binomial regression analysis Cardiac Cx.

Significant Risk Factors for Medical Complication after multivariate log-binomial regression analysis			
Cardiac Cx			
	RR	p	95% CI
Prior cardiac event	4.67	<0.0001	2.25 – 9.26
Pulmonary Cx			
Diabetes	2.41	0.0003	1.43 – 3.97
Drug use	1.85	0.02	1.04 – 3.01
Congestive Heart Failure	2.64	<0.0001	1.60 – 4.39
Anemia	2.41	0.0003	1.36 – 3.88
Trauma Dx	9.07	<0.0001	5.25 – 17.52
Neurological Cx			
Congestive Heart Failure	4.27	0.0005	1.60 – 8.76
Liver disease	1.39	0.018	1.02 – 1.78
Hx of Syncope	2.69	0.028	0.96 – 5.92
Surgical invasiveness	2.88	0.0001	1.43 – 5.54
Hematological Cx			
Hypertension	3.19	0.0002	1.65 – 6.14
Dx Trauma	3.82	0.002	1.67 – 9.31
Dx Infection	11.51	<0.0001	3.97 – 26.74
Dx Neoplasm	9.99	<0.0001	3.14 – 28.29
Surgical Invasiveness	3.09	0.0002	1.56 – 5.68
Urological Cx			
Dx Trauma	3.95	<0.0001	2.15 – 7.61
Dx Infection	5.76	0.0007	1.76 – 14.39
Death			
Age >65	9.44	0.0002	3.15 – 34.66
Prior cardiac event	3.79	0.008	1.38 – 10.41
Cardiac Cx	4.32	0.004	1.52 – 11.81
Respiratory Cx	6.43	0.0003	2.31 – 18.04