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Intensive Care Unit Admission After Spine Surgery: A Narrative Review

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ABSTRACT

Introduction: Intensive care unit (ICU) admissions constitute a substantial financial challenge for health care systems and patients and are linked to various potentially life-altering complications. A wide range of patient-related, surgical, and medical factors are associated with an increased risk of ICU admission following spine surgery.

Discussion: The most notable examples include lung, heart, and kidney disease, as well as estimated blood loss and length of surgery. Various scores that include the most significant patient- and procedure-related factors have been described to assess the risk associated with surgery for individual patients. To date, the fusion risk score and the American Society of Anesthesiologists score have been the most useful in predicting postoperative complications and admission to the ICU. However, other risk factors have also been implicated in ICU admission and length of stay. The current scores must further adapt by using the available evidence to fulfill their intended purpose. Moreover, a handful of measures have shown efficacy in decreasing ICU admission and length of stay, with their benefits still to be demonstrated by future research.

Conclusion: This review underscores the risk factors predictive of ICU admission following spine surgery and will help surgeons and clinicians in patient stratification. However, future studies are needed to validate the role of protective measures in preventing ICU admissions and the significance of certain risk factors.

Complications

Keywords: ICU, spine surgery

INTRODUCTION

Close to 900,000 spine surgeries are performed each year in the United States.[1] Considering that degenerative spine conditions are more common in elderly patients and that the aging US population is rapidly growing, this number is projected to increase.[2] Lumbar discectomy, posterolateral spinal fusion, and anterior cervical discectomy and fusion are the most commonly performed spine surgeries.[3] Frequent spine surgery complications include cerebrospinal fluid leakage, infections, dural tears, wound healing complications, cardiac complications, and electrolyte imbalances.[4]

The admission to an intensive care unit (ICU) in the aftermath of spine surgery can be attributed to numerous variables. Postoperative respiratory complications,[5,6] cardiac complications, neurological complications, and blood loss[6] are the most common causes for the need for intense care after a surgery involving the spine. The reported rates of ICU admission after the occurrence of complications resulting from spine surgery range from 5.1%[6] to 48%.[7] The most typical causes of death were respiratory and cardiac conditions, sepsis, stroke, and blood loss.[8] The highest mortality rates were documented for fracture repair and kyphosis correction procedures. The in-hospital mortality rate following spine surgery was 0.18%.[7]

The aim of the present narrative review was to analyze the significant risk factors in predicting postoperative ICU admission and length of stay (LOS) while listing the evidence regarding variables protecting against ICU admission and LOS after procedures involving the spine.

RISK FACTORS FOR POSTOPERATIVE ICU ADMISSION

Table 1 provides a summary of the studies included in this review and the risk factors they assessed for ICU admission and LOS after spine surgery.

Patient-Related Factors

A multitude of patient-related risk factors were found to be significantly correlated with ICU admission following spine procedures. History of heart disease,[6,9] such as myocardial infarction, coronary artery disease, and congestive heart failure, was strongly linked to

Table 1. Summary of the findings of studies assessing risk factors for ICU admission and LOS after spine surgery.

Study	No. of Patients	Procedure	Outcome
Kay et al, 2016[6]	808	Laminectomy, with or without fusion	Blood loss, operative time, heart disease, age, and female gender were determined to be risk factors for ICU admission following spine surgery. Hypertension, body mass index, and diabetes did not reach significance.
Harris et al, 2001[9]	109	Anterior or posterior cervical spine surgery	Diabetes mellitus ($P < 0.002$), hypertension ($P < 0.02$), lung disease ($P < 0.03$), and heart disease ($P < 0.05$) were linked to an increased risk of ICU admission.
Adogwa et al, 2018[10]	293	Spine decompression and fusion	Chronic kidney disease was associated with an increased rate of ICU admission ($P = 0.04$).
Cloney et al, 2019[11]	6869	Spinal fusion	Bleeding disorders ($P = 0.028$), comorbid disease burden ($P < 0.001$), male gender ($P < 0.001$), and BMI ($P = 0.027$) were patient-related variables correlated to ICU admission following spine surgery. Transfusions ($P < 0.001$), lumbar procedures ($P < 0.001$), corpectomies ($P = 0.007$), fracture repairs ($P < 0.001$), osteotomies ($P = 0.006$), blood loss ($P = 0.009$), and operative time greater than 4 h ($P < 0.001$) were medical and surgical factors predictive of the need for ICU management.
Daubs et al, 2016[12]	65	Pediatric substraction osteotomy	The occurrence of a major complication increased the length of ICU stay.
Raad et al, 2018[13]	425	Adult spinal deformity surgery	Preoperative opioid use was a risk factor for increased ICU LOS ($P = 0.004$).
Line et al, 2022[14]	261	Adult spinal deformity surgery	Opioid users were more likely to experience longer ICU stays than patients who were not opioid users ($P = 0.0065$).
Nahtomi-Shick et al, 2001[15]	103	Spinal decompression without or with fusion and/or instrumentation and other procedures	Age, platelet, and crystalloid administration were predictive of length of ICU stay ($P = 0.000$).
Martini et al, 2021[16]	1124	Posterior cervical discectomy and fusion	Primary posterior cervical discectomy and fusion was associated with an increased rate of ICU admission compared with the revision procedure ($P = 0.0005$).
Myers et al, 2021[17]	465	Spinal fracture surgery	Neurosurgical management of spine fractures was linked to a greater risk of the need for intensive care compared with orthopedic management ($P = 0.04$).
Hartin et al, 2013[18]	364	Lumbar and thoracic fusion surgery	The fusion risk score was an effective indicator of ICU admission, blood loss, and operative time ($P < 0.0001$).
Deogaonkar et al, 2018[19]	242	Lumbar and thoracic fusion surgery	The fusion risk score was an effective indicator of ICU admission ($P < 0.01$), blood loss ($P < 0.001$), and operative time ($P < 0.001$).
Howe et al, 2011[20]	103	Spinal fusion	Estimated blood loss ($P < 0.001$) and staged procedures ($P < 0.001$) were correlated with ICU LOS. Gender, operative time, and procedure invasiveness did not correlate with any outcome.
Lenga et al, 2022[21]	416	Decompression, with or without fusion	Instrumentation increased the risk for a protracted ICU LOS ($P < 0.001$).

Abbreviations: ICU, intensive care unit; LOS, length of stay.

unplanned postoperative ICU admission.[6] Lung conditions were also predictive of ICU admission.[9] Furthermore, an association was established between chronic kidney disease and not only the need for postoperative ICU management but also postoperative delirium and urinary tract infections.[10] Higher comorbid disease burden and history of bleeding disorder were similarly predictive of ICU admission.[11] Moreover, a history of myelopathy was correlated with ICU admission.[9] Nonmodifiable risk factors such as gender as a risk factor for unplanned ICU admission were assessed in multiple studies. While 1 study determined that male spine surgery patients had a higher risk of needing intensive care,[11] another found that female gender was a risk factor for ICU admission after a surgical intervention treating degenerative lumbar spine.[6] Similarly, conflicting results were reported regarding the significance of hypertension, diabetes,[6,9] body mass index,[6,11] and age[6,9] as risk factors for postoperative ICU admission.

Surgical Factors

Numerous surgery-related variables were identified as predictors of ICU admission. These include estimated blood loss[6,11] and operative time.[6] Moreover, fracture management by a neurosurgery team compared with an orthopedic surgery team may be linked to an increased rate of ICU admission. This disparity might result from differing approaches between both specialties, as neurosurgeons tend to prioritize the preservation of neural structures, whereas orthopedic surgeons concentrate on the biomechanical aspect of treatment during their interventions.[17] Furthermore, patients undergoing spinal fusion with laminectomy were more likely to be admitted to the ICU than patients who only had spinal

Table 2. Summary of the findings of studies assessing risk-predicting scores after spine surgery.

Study	No. of Patients	Procedure	Outcome
Hartin et al, 2013[18]	364	Thoracic or lumbar and fusion	The fusion risk score was a reliable indicator of ICU admission ($P < 0.0001$), blood loss ($P < 0.0001$), and operative time ($P < 0.0001$).
Deogaonkar et al, 2018[19]	242	Lumbar and thoracic fusion surgery	The fusion risk score was an effective indicator of ICU admission ($P < 0.01$), blood loss ($P < 0.001$) and operative time ($P < 0.001$).
Nahtomi-Shick et al, 2001[15]	103	Spinal decompression without or with fusion and/or instrumentation and other procedures	The ASA score was correlated with age and predictive of length of stay ($P = 0.000$) and ICU length of stay ($P = 0.012$).
Howe et al, 2011[20]	103	Spinal fusion	The ASA grade was correlated with ICU length of stay ($P = 0.011$). The ASA grade was also associated with complications ($P = 0.030$) and discharge to skilled nursing facilities ($P = 0.008$). The CCI was correlated with complications ($P = 0.028$) and discharge to skilled nursing facilities ($P = 0.039$).
Kay et al, 2016[6]	808	Laminectomy, with or without fusion	The ASA score was a predictive factor of ICU admission ($P = 0.008$).
Ibrahim et al, 2020[22]	101	Multilevel spinal fusion	Lower ASA and CCI scores were consistent with greater patient-perceived improvement in health.
Khechen et al, 2019[23]	298	Single-level minimally invasive transforaminal lumbar interbody fusion	A higher CCI was associated with greater ICU costs ($P = 0.002$) and higher likelihood of complication ($P = 0.005$).

Abbreviations: ASA, American society of Anesthesiologists; CCI, Charlson Comorbidity Index; ICU, intensive care unit.

fusion. This may be explained by the laminectomy group having a higher risk of events potentially linked to ICU admission, such as blood loss, allogenic blood transfusions, and durotomy. Additionally, primary posterior cervical laminectomy with fusion had higher rates of postoperative ICU admission and discharges to places other than home compared with the respective revision intervention.[16] Patients who needed fracture repair, osteotomies, corpectomies, and lumbar surgery were more likely to need to be admitted to the ICU.[11]

Scores

A summary of the included studies' findings relating to risk-predicting scores after spine surgery is provided in Table 2.

The fusion risk score (FRS) is a tool designed to predict the risk of complications resulting from fusion procedures at baseline using patient- and procedure-specific variables. It was revealed that the FRS is a reliable tool indicative of the need for unplanned ICU admission and was correlated with variables linked to ICU admission and LOS, such as blood loss and operative time. The FRS is also proportional to the number of perioperative complications.[18,19]

The American Society of Anesthesiologists (ASA) score was originally described 8 decades ago as a simple assessment of overall patient health. The ASA score is flawed in multiple aspects, most notably the inconsistent classifications given to the same patient by anesthesiologists and surgeons and even among just anesthesiologists.[24] As a matter of fact, the ASA score was found to have an interrater reliability grade ranging from $\kappa = 0.21$ to 0.61, meaning a poor to moderate level of interrater agreement.[25] However, it was established that the ASA score was significantly correlated with patient age,[15] ICU admission,[6] ICU LOS,[15,20] and discharge to a nursing establishment.[20]

The Charlson Comorbidity Index (CCI) is intended to predict the risk of mortality using the number and severity of co-occurring chronic conditions.[26] It was linked to discharge to a nursing establishment and the occurrence of medical complications postoperatively.[20] Lower CCI scores were correlated with an increased perceived improvement in health-related quality of life among patients who had multilevel spine fusion.[22] Higher CCI scores were also linked to higher complication rates following minimally invasive transforaminal lumbar interbody fusion, as well as greater ICU-related costs.[23]

PROTECTIVE FACTORS

A summary of the included studies' findings that evaluated risk-mitigating procedures is provided in Table 3.

Several variables were significantly associated with decreased rates of admission to and protracted stays in an ICU after spine surgery. The use of intraoperative monitoring was revealed to decrease the rate of ICU admission after multilevel spinal fusion, despite also being associated with increased operative time. However, there was no significant difference in rates of complications after surgery between cohorts of patients on whom surgery with and without intraoperative

Table 3. Summary of the findings of studies that evaluated risk-mitigating procedures.

Study	No. of Patients	Procedure	Outcome
Elsamadicy et al, 2017[27]	643	Multilevel (at least 4 levels) spinal fusion	Although patients who benefited from intraoperative monitoring had greater operative times ($P < 0.0001$), they had a smaller likelihood of being admitted to the ICU ($P = 0.015$).
Menapace et al, 2023[28]	53	Posterior spinal fusion for neuromuscular scoliosis	Patients who were operated on by 2 cosurgeons tended to undergo greater corrections ($P = 0.089$), but in shorter operative ($P = 0.0025$) and anesthesia times ($P = 0.0018$) when compared with patients who underwent surgery by a single spine surgeon, with the group, despite only showing a nonsignificant trend toward a lesser rate of ICU admission ($P = 0.36$).
Landi et al, 2017[29]	166	Thoracic and lumbar fracture repair	ICU LOS was decreased and neurological function was improved in patients who had early fracture repair ($P = 0.001$).

Abbreviations: ICU, intensive care unit; LOS, length of stay.

monitoring was performed.[27] Furthermore, having 2 cosurgeons perform the procedure rather than relying on a single spine surgeon is another potential approach to mitigate the risk. While this method was shown to reduce the duration of surgery and anesthesia, it only showed a nonsignificant trend toward decreasing ICU admissions.[28] It was also demonstrated that early surgery in thoracic and lumbar fractures reduced ICU LOS in a study assessing the benefits of surgery timing.[29] Surprisingly, minimally invasive procedures were not associated with decreased rates of ICU admission.

OUTCOMES FOLLOWING ICU ADMISSION

A summary of the included studies' findings that assessed postoperative and post-ICU admission outcomes is provided in Table 4.

Admission to an ICU after spine surgery was shown to be significantly linked to various events and complications. It was associated with the occurrence of more complications and pneumonia when compared with floor admission.[30] It was also linked to more vascular thromboembolic events[31] and the likelihood of 30-day hospital readmission.[32] ICU admission was also shown to be an important risk factor for infections in the aftermath of spine procedures.[33] Furthermore, the ICU LOS increased the risk of fever following the correction of neuromuscular scoliosis.[34] In fact, a stay in the ICU longer than 1 day was shown to be predictive of the occurrence of a major complication.[35]

Moreover, a study that assessed the incidence of vascular thromboembolic events in ICU patients after they had undergone a wide range of spine procedures determined that 10.2% of the included patients had a thromboembolism. More specifically, 8.7% of patients experienced deep vein thrombosis (DVT), with the significant risk factors for DVT during or after postoperative ICU stay being inferior vena cava filter placement, history of DVT, fusion, interbody fusion, foraminotomy, osteotomy, and operative time greater than 4 hours. The remaining 2.8% of patients who experienced a thromboembolic event had a pulmonary embolism (PE). History

Table 4. Summary of the findings of studies that assessed postoperative and post-ICU admission outcomes.

Study	No. of Patients	Procedure	Outcome
Yue et al, 2018[30]	442	C2 fracture repair	ICU admission was more predictive of lung infection ($P = 0.001$) and overall complications ($P = 0.005$) than floor admission.
Cloney et al, 2022[31]	1147	Anterior lumbar fusion	The need for intensive care management was significantly correlated with the occurrence of vascular thromboembolic events ($P = 0.005$).
Cho et al, 2020[32]	3933	Degenerative lumbar disease surgery	ICU admission was found to be a risk factor for hospital readmission within 1 month of discharge ($P < 0.001$) when comparing to the subset of patients who did not experience readmission.
Lim et al, 2006[33]	-	-	ICU admission increased the likelihood of infection in patients following traumatic spine injury surgery.
Yousef et al, 2018[34]	76	Neuromuscular scoliosis correction surgery	ICU length of stay ($P = 0.001$) and operative time ($P = 0.02$) were risk factors for postoperative fever.
Yearly et al, 2022[35]	112	Spine deformity surgery	A stay in the ICU greater than 1 day was a risk factor for the occurrence of a major complication ($P < 0.05$).
Cloney et al, 2019[11]	6869	Spinal fusion	Patients who underwent spine surgery and were admitted to the ICU had a rate of venous thromboembolic events of 10.2 % while all spine surgery patients had a rate of thromboembolic events of 2.5%.
Harris et al, 2001[9]	109	Anterior or posterior cervical spine surgery	Heart disease and lung failure were the leading causes of mortality in the ICU after spine surgery.

Abbreviation: ICU, intensive care unit.

of PE, history of DVT, gender, BMI, scoliosis, fracture, transfusion, chemoprophylactic anticoagulation, and laminectomy being risk factors for PE during or following postoperative ICU stay.[11] Finally, heart disease and pulmonary failure were shown to be the main reasons for death in the ICU following spine surgery.[9]

RECOMMENDATIONS

The FRS and the ASA score stood out as the most reliable and useful tools in predicting postoperative events. However, the adaptation of the FRS to a broader range of spine surgery types is needed. Adopting standardized criteria for the ASA grading system would correct the most significant flaw in this score. The inclusion of factors that have been recently identified as predictive of events after spine surgery may help predict postoperative outcomes with greater precision. Risk-mitigating measures like enhanced recovery after surgery, intraoperative monitoring, adopting the performing of surgery by 2 surgeons and surgery timing can prevent ICU admission. However, their role as protective factors should be assessed in larger-scale studies before recommendation.

CONCLUSION

This review underscores the risk factors predictive of ICU admission following spine surgery. Patient variables such as heart and lung diseases, surgical variables including estimated blood loss and operative time, and specific risk-assessment scores such as the FRS and the ASA classification hold key functions in predicting postoperative outcomes. Furthermore, the implementation of risk-mitigating measures such as intraoperative monitoring, having another surgeon during the operation, and early surgery timing in traumatic cases can help reduce ICU admissions. To improve predictive precision, we suggest refining current scores and considering recent research. Future studies are needed to validate the role of protective measures in preventing ICU admissions and the significance of certain risk factors.

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