INTERNATIONAL JOURNAL of SPINE SURGERY

Comparing 30-Day Outcomes After Emergent Spine Procedures Performed ''During Hours'' vs ''After Hours''

Gabrielle Santangelo, Nathaniel Ellens, Aman Singh, Ricky Hoang, Stephen Susa, Robert Molinari and Thomas Mattingly

Int J Spine Surg 2023, 17 (4) 564-569
doi: https://doi.org/10.14444/8480
https://www.ijssurgery.com/content/17/4/564

The International Journal of Spine Surgery
2397 Waterbury Circle, Suite 1,
Aurora, IL 60504, Phone: +1-630-375-1432

INTERNATIONAL SOCIETY for the ADVANCEMENT of SPINE SURGERY

International Journal of Spine Surgery, Vol. 17, No. 4, 2023, pp. 564–569
https://doi.org/10.14444/8480

Comparing 30-Day Outcomes After Emergent Spine Procedures Performed "During Hours" vs "After Hours"

GABRIELLE SANTANGELO, MD[1]; NATHANIEL ELLENS, MD[1]; AMAN SINGH, BS[1]; RICKY HOANG, MD[2]; STEPHEN SUSA, BS[1]; ROBERT MOLINARI, MD[1]; AND THOMAS MATTINGLY, MD, MSc[1]

[1]*Department of Neurosurgery, University of Rochester Medical Center, Rochester, NY, USA;* [2]*Department of Anesthesiology, University of Rochester Medical Center, Rochester, NY, USA*

ABSTRACT

Background: Spinal injuries, whether mechanical or neurological, frequently require urgent intervention. Superior outcomes are associated with earlier intervention, which often requires operating overnight and on weekends. However, operating after hours has been associated with increased risks of complications in selected studies. The authors sought to determine whether there are differences in outcomes for "after hours" surgery compared with "during hours" surgery for spinal emergencies.

Methods: This is a single-center retrospective cohort study of spine surgery patients who underwent urgent surgery within 6 hours, from January 2015 through December 2019. Surgery was considered during hours if it started between 8 AM and 5 PM Monday through Friday. After hours was defined as from 5 PM through 8 AM on a weekday or Saturday or Sunday. We assessed 30-day outcome measures for differences between operations performed during hours or after hours.

Results: There were 241 spine procedures performed (49 during hours and 192 after hours). There was no significant difference between the length of operation (145.3 vs 129.8 minutes, $P = 0.29$), estimated blood loss (303.9 vs 274.4 mL, $P = 0.61$), improvement in American Spinal Injury Association scale (0.26 vs 0.24 grade, $P = 0.85$), 30-day return to the operating room (OR; 14.3% vs 6.8%, $P = 0.09$), 30-day readmission (2.0% vs 6.3% $P = 0.24$), intensive care unit length of stay (4.6 vs 6.3 days, $P = 0.27$), hospital length of stay (13.5 days vs 14.2 days, $P = 0.72$), or 30-day mortality (4.1% vs 7.3%, $P = 0.42$) for cases performed during hours compared with those after hours, respectively. On multivariate analysis, prior malignancy ($P = 0.008$) and blue immediate status ($P = 0.004$) were predictors of 30-day mortality. However, "after hours" surgery was not a predictor of 30-day return to the OR, readmission, or mortality in either univariate or multivariate analysis.

Conclusions: Spine surgery must often be performed after hours. However, the time of day does not significantly impact the 30-day outcomes for emergent spine surgery.

Level of Evidence: 3.

Other and Special Categories

Keywords: After hours, spine, emergency surgery, mortality, length of stay, readmission

INTRODUCTION

Spinal injuries, whether mechanical or neurological, frequently require urgent or emergent intervention, which often happens on nights or weekends.[1] Due to the time-sensitive nature of many spinal injuries and disease processes, patients with spinal emergencies may have the most to gain from earlier intervention, particularly if it can be performed with a similar safety profile as "during hours" (DH) operations.[2,3] It is postulated that early spine surgery prevents further neurological deterioration and may provide the best chance at a meaningful recovery.[4] Furthermore, delayed surgical intervention has been associated with prolonged length of stay (LOS), increased hospital costs, and more cardiac and respiratory complications after spinal surgery, which all negatively affect health-related quality of life.[5–10] However, "after hours" (AH) operations may be inherently more dangerous within spine surgery because of longer duration and higher acuity cases.

Emergent surgery often requires performing surgery without specialty-specific operating room personnel or anesthesia teams. This may contribute to an increased risk of surgical complications and poorer long-term outcomes. Therefore, the risks associated with AH spine operations must be further elucidated in relation to the well-documented benefits of earlier surgical intervention for emergent spine operations. There have been multiple studies regarding the safety of performing operations in both DH and AH for other surgical specialties demonstrating both increased risks of complications with AH surgeries but also a lack of significant difference in outcomes.[11–16] The only prior study of emergent spine surgery performed AH found worse outcomes on short-term metrics including immediate complications and in-hospital mortality. We wished to examine longer-term 30-day outcomes, including readmission and reoperations between DH and AH surgery in spine patients at a tertiary academic medical center.

METHODS

Patient Population

We performed a retrospective analysis of neurosurgical and orthopedic spine patients who underwent urgent or emergent spine procedures at a tertiary level-1 trauma center within 6 hours of when they were scheduled from January 2015 through December 2019. The study received Institutional Review Board approval. Patient consent was not required because this was a retrospective medical record review, and the study variables were abstracted from the medical record in a deidentified manner. Patients were evaluated by a neurosurgery or orthopedic surgery resident either in the emergency department or as an inpatient prior to being staffed with an attending surgeon. Every patient who was scheduled to undergo surgery within a maximum of 6 hours was included in this study. The decision to book a patient for emergent surgery within the specific time frame was at the discretion of the surgeon and based on the specific clinical scenario. Patients who were booked on a nonurgent or elective basis were not included. Surgery was performed by 1 of 14 neurosurgeons or 5 orthopedic spine surgeons with the assistance of neurosurgery or orthopedic surgery residents. Of note, the hospital system does not have a designated AH operating room staff or spine trauma room for spine surgery.

Definition of DH and AH

Patients were split into 2 cohorts, defined as DH and AH, and categorized based on the time of incision. DH was defined as those cases in which the time of incision was between 8 AM and 5 PM from Monday through Friday. AH was defined as those cases in which the incision occured between 5 PM and 8 AM from Monday through Friday or anytime on Saturday or Sunday.

Statistical Methods

Emergent spine procedures were compared between those that took place DH and those that took place AH. For continuous variables, a 2-sample *t* test without assuming equal variances or a Mann-Whitney *U* test (as appropriate) was used to evaluate differences between the 2 groups. For discrete variables, a χ^2 test (or Fisher's exact test when expected *n* was very small) was used to test for different proportions between the 2 groups. Significance was defined as $P < 0.05$.

Univariate analysis for predictors of the primary 3 outcomes (30-day mortality, 30-day return to the operating room [RTOR], and 30-day readmission) evaluated demographic, medical comorbidities, substance and medication intake, presence of prior incisions or neurological deficit, case classification, American Society of Anesthesiologists (ASA) class, AH status, and operative metrics such as estimated blood loss (EBL) and length of time in the OR. Variables with *P* values < 0.2 were included along with the forced AH variable into a multivariate logistic regression model for each of the 3 primary outcomes. Significance was set at $P < 0.05$. Statistics were performed on Prism 9 (GraphPad, La Jolla, CA).

RESULTS

Demographics

A total of 241 patients underwent emergent spine surgery between January 2015 and December 2019. Demographic data are outlined in Table 1, with no significant differences between the DH and AH group. Eighty-eight of the 241 patients (36.5%) were women, and the average age was 55.3 years. Medical comorbidities were recorded for all patients in each group, with no significant differences noted (Table 1). In terms of relevant antithrombotics, antiplatelet consumption was half as frequent in the AH group ($P = 0.0138$). No significant differences were found in preoperative neurological deficit (either motor or sensory), American Spinal Injury Association (ASIA) impairment scale score, or ASA physical status classification between the DH and AH cohorts ($P = 0.476$, $P = 0.083$, and $P = 0.062$, respectively).

Surgical Characteristics

Of the 241 total patients, 49 patients (20.3%) underwent surgery DH, and 192 (79.7%) underwent surgery AH. The most common indication for surgery across all patients was trauma (101 of 291 patients, 34.7%; Table 2). Approximately half of all patients underwent fusion and instrumentation (127 of 241 patients, 52.7%). The cervical spine was the most common region requiring emergent surgery across all patients (95 of 241 patients, 39.4%), followed by thoracic (85 of 241 patients, 35.3%), and lumbar (61 of 241 patients, 253%). A significant difference was noted in the proportion of patients requiring surgery within 1 hour of booking between the DH and AH cohorts at 22.5%

Table 1. Patient demographics for during hours vs after hours groups.

Demographic	During Hours Group	After Hours Group	*P* Value
Age, y, mean ± SD (range)	55.7 ± 19.8 (16–87)	55.2 ± 20.1 (2–95)	0.89
Sex, men, *n* (%)	34 (69.4%)	119 (62.0%)	0.34
Comorbidity, *n* (%)			
Malignancy	10 (20.4%)	32 (16.7%)	0.54
Congestive heart failure	2 (4.1%)	16 (8.3%)	0.31
Coronary artery disease	8 (16.3%)	23 (12.0%)	0.42
Chronic obstructive pulmonary disease	3 (6.12%)	14 (7.29%)	0.775
Hypertension	22 (44.90%)	91 (47.40%)	0.756
Hyperlipidemia	14 (28.57%)	45 (23.44%)	0.456
Diabetes mellitus	14 (28.57%)	35 (18.23%)	0.108
Liver disease	3 (6.12%)	6 (3.13%)	0.323
Chronic kidney disease	6 (12.24%)	15 (7.81%)	0.326
Alcohol abuse, *n* (%)	3 (6.12%)	23 (11.98%)	0.238
Drug abuse, *n* (%)	2 (4.08%)	18 (9.38%)	0.231
Anticoagulant use, *n* (%)	7 (14.29%)	21 (10.94%)	0.514
Antiplatelet use, *n* (%)	12 (24.49%)	21 (10.94%)	0.014
Prior site surgery, *n* (%)	11 (22.45%)	48 (25.00%)	0.711
Neurological deficit, *n* (%)	24 (50.00%)	84 (44.27%)	0.476
American Spinal Injury Association impairment scale, *n* (%)			0.083
A	4 (8.51%)	20 (11.05%)	
B	3 (6.12%)	26 (14.36%)	
C	8 (17.02%)	28 (15.47%)	
D	24 (51.06%)	56 (30.94%)	
E	8 (17.02%)	51 (28.18%)	
American Society of Anesthesiologists class, *n* (%)			0.062
1 or 2	10 (20.41%)	43 (22.40%)	
3	25 (51.02%)	68 (33.42%)	
4 or 5	14 (28.57%)	81 (42.19%)	

and 40.6% of patients, respectively (*P* = 0.019). Rates of patients requiring surgery within 3 and 6 hours of booking were not statistically different at 46.9% and 18.4% for DH patients and 39.1% and 16.2% for AH patients, respectively (*P* = 0.316 and *P* = 0.709, respectively). No significant differences in spinal level, spinal pathology, or rates of spinal fusion were noted between the 2 cohorts. The mean length of operation was 145.3 and 129.8 minutes (*P* = 0.29) for the DH and AH cohorts, respectively. There was no difference in the use of C-arm or O-arm between groups (*P* = 0.731 and *P* > 0.999, respectively), although the O-arm was used very infrequently. EBL was similar at 303.9 mL DH and 274.4 mL AH (*P* = 0.61).

Outcomes

Improvement in ASIA impairment scale score from admission to discharge was similar at 0.26 and 0.24 grades in the DH and AH cohorts, respectively (*P* = 0.854; Table 3). Intensive care unit and total hospital LOS were not different between groups at 4.6 and 13.5

Table 2. Surgical characteristics of during hours vs after hours groups.

Characteristic	During Hours Group	After Hours Group	*P* Value
Spinal level, *n* (%)			0.5
Cervical	21 (42.9%)	74 (38.5%)	
Thoracic	14 (28.67%)	71 (37.0%)	
Lumbar	14 (28.6%)	47 (24.5%)	
Spinal pathology, *n* (%)			0.2
Degenerative	19 (38.8%)	58 (30.2%)	
Infection	7 (14.3%)	36 (18.8%)	
Oncology	7 (14.3%)	13 (6.8%)	
Trauma	16 (32.7%)	85 (44.3%)	
Urgency of surgery, *n* (%)			
Blue immediate	6 (12.2%)	8 (4.2%)	0.03
Blue within 1 h	11 (22.5%)	78 (40.6%)	0.02
Blue within 3 h	23 (47.0%)	75 (39.1%)	0.32
Blue within 6 h	9 (18.4%)	31 (16.2%)	0.71
Length of surgery, min, mean ± SD	145.3 ± 92.4	129.8 ± 83.9	0.29
Spinal fusion, *n* (%)	28 (57.1%)	99 (51.9%)	0.49
C-arm, *n* (%)	34 (69.4%)	138 (71.9%)	0.73
O-arm, *n* (%)	1 (2.0%)	5 (2.6%)	>0.99
Estimated blood loss, mL, mean ± SD	303.9 ± 379.5	274.4 ± 273.5	0.61

Table 3. Surgical outcomes for during hours vs after hours groups.

Outcomes	During Hours Group	After Hours Group	*P* Value
Improvement in American Spinal Injury Association, mean ± SD	0.3 ± 0.6	0.3 ± 0.8	0.854
Intensive care unit length of stay, d, mean ± SD	4.6 ± 8.7	6.313 ± 12.142	0.272
Hospital length of stay, d, mean ± SD	13.5 ± 11.0	14.2 ± 16.1	0.724
30-day return to operating room, *n* (%)	7 (14.3%)	13 (6.8%)	0.089
30-day readmission, *n* (%)	1 (2.0%)	12 (6.3%)	0.244
30-day mortality, *n* (%)	2 (4.1%)	14 (7.3%)	0.420

days for the DH group and 6.3 and 14.2 days for the AH group, respectively ($P = 0.272$ and $P = 0.724$, respectively). The frequency of RTOR within 30 days was 14.3% for DH and 6.8% for AH cases, respectively ($P = 0.089$). In the DH group, 2.0% of patients were readmitted within 30 days, compared with 6.2% of patients in the AH group ($P = 0.204$). Thirty-day mortality and in-hospital mortality rates were also not statistically different at 4.1% and 4.1% DH and 7.3% and 7.3% AH, respectively ($P = 0.420$ and $P = 0.420$, respectively).

On univariate analysis, ASA class ($P = 0.023$), preoperative diabetes, and hypertension ($P = 0.028$ and $P = 0.048$) were independent predictors of 30-day RTOR rates. AH surgery was not significantly associated with 30-day RTOR ($P = 0.096$) or was fusion status, age, or sex. In the multivariate analysis, ASA class, diabetes, and hypertension remained significant predictors of 30-day RTOR ($P = 0.012$, $P = 0.037$, and $P = 0.001$), and there was no statistical significance found with AH designation. On univariate analysis, preoperative congestive heart failure, chronic obstructive pulmonary disease, and antiplatelet use were significant predictors of 30-day readmission ($P = 0.041$, $P = 0.033$, and $P = 0.013$, respectively). However, on multivariate analysis, these were not found to be independent predictors. Again, AH surgery was not a significant predictor of readmission in either univariate or multivariate regression. On univariate regression of 30-day mortality, prior malignancy, coronary artery disease, anticoagulation use, blue immediate status, and ASA class were independent predictors ($P = 0.007$, $P = 0.031$, $P = 0.017$, $P = 0.003$, and $P = 0.033$, respectively). On multivariate analysis, prior malignancy ($P = 0.008$) and blue immediate status remained predictors of 30-day mortality. AH surgery was not a predictor of 30-day mortality in either univariate or multivariate regression.

DISCUSSION

This is the first study to compare the 30-day outcomes of urgent or emergent spine surgery performed DH with those performed AH. In a retrospective study, Charest-Morin et al investigated AH outcomes in nonelective spine surgery and found an increased risk of perioperative adverse events and in-hospital mortality.[17] However, this study was limited to looking at short-term outcomes, and therefore, little can be extrapolated about long-term outcomes of AH emergent spine surgery, which often are important metrics for quality of care within hospital systems and drivers of increasing healthcare costs.[18] Furthermore, when looking at AH elective spine deformity corrective surgery for patients with adolescent idiopathic scoliosis, Chiu et al found no significant differences in outcomes, as measured through metrics including correction rate and complication rate, between procedures performed DH and AH.[19] There have been numerous studies for other surgical specialties regarding the safety of performing operations DH vs AH that have demonstrated increased risks of complications with AH surgeries but also studies that show no significant difference in outcomes.[11–16] It remains unclear in the literature whether there is a significant difference in outcomes between emergent spine surgeries performed DH and AH.

There were no significant demographic or preoperative differences between cohorts except for an increased rate of antiplatelet medication usage among the DH cohort. Prior studies have demonstrated that antiplatelet medications do not increase perioperative adverse events or poor outcomes in both elective or emergent spine surgery, so this difference should not meaningfully impact 30-day outcomes in emergent spine surgery.[20,21]Across all 241 patients, the most common indication for surgery was the trauma of the cervical spine, and approximately half of all patients underwent fusion and instrumentation with no difference between AH and DH cohorts. A significant increase was observed in the proportion of AH cases requiring surgery within 1 hour of booking as compared with DH cases. This difference was notably not observed in cases booked to start within 3 or 6 hours. Given the lack of data demonstrating the benefit of immediate surgery rather than within 6 hours, we cannot exclude that surgeon motivation may play a role in the designation of case timing. No significant differences were found in the length of surgery, fusion vs non-fusion procedures, or EBL between the 2 groups. Despite the need for emergent intervention in the AH cohort, no significant differences in 30-day outcomes of RTOR, readmission, or mortality were found between the 2 cohorts, suggesting that AH emergent spine surgery is not associated with worse long-term outcomes as compared with surgeries performed DH.

However, on regression analysis, a number of medical comorbidities were found to be significant independent predictors of 30-day outcomes, including congestive heart failure, chronic obstructive pulmonary disease, diabetes, and hypertension, among others. This is consistent with prior literature that previously demonstrated that age, diabetes, ASA class, and prior cardiac history can adversely impact outcomes following spine surgery.[22–24] These data are largely derived from studies on elective spine surgery, and although recent literature is exploring the use of frailty indices that include many of these comorbidities as preoperative screening, this may not be appropriate in emergent cases. Preoperative frailty has been shown to be associated with higher rates of mortality, readmission, and longer hospital LOS as well as increased probability of readmission.[25] Notably, in our series, AH procedures were not significant predictors of any 30-day outcomes.

The explanation for this finding is not straightforward. There are certainly additional challenges associated with AH emergent spine procedures due to the lack of specialty-specific anesthesia teams and operating room personnel, depending on the hospital system’s particular arrangement. However, our findings taken in combination with the study by Charest-Morin suggest that increased risk of perioperative adverse events may not necessarily imply worse long-term outcomes. This is of particular importance for tertiary care hospitals designated level-1 trauma centers, as these centers are defined by their ability to provide 24/7 spine surgery care and, therefore, should minimize any difference in the quality of care that may arise based on the day or time of surgery.

Limitations to this study are its retrospective, single-centered design, which may limit generalizability, makes inferring causality difficult, and has inherent information and selection biases. It is conceivable that there is a statistical power issue. The only other study on the time of day effect on emergent spine care found a negative effect on short-term outcomes but had 6 times as many patients. Even then, in-hospital mortality lost its significance in multivariate analysis. In an effort to control for potential confounding variables, we found demographic and clinical differences between the 2 cohorts were not statistically different. This study has also only examined the differences between DH and AH surgery. This does not take into account the time of injury or symptom onset, which makes the likelihood that the AH group presented closer to the time of surgery whereas the DH cohort may have presented DH or had been delayed from an AH presentation at the discretion of the attending surgeon. This discrepancy, however, does not negate the finding that performing AH surgery is not associated with increased 30-day poorer outcomes.

CONCLUSION

This study suggests that 30-day outcomes, including RTOR, readmission, or mortality, are not significantly impacted by the day or time of emergent spine surgery. The impact of these findings is significant for academic level-1 trauma centers that aim to provide consistent quality spine surgical care 24/7. The broader impact of these findings remains uncertain, and further multi-institutional prospective studies should be performed to validate these findings and explore potential differences at nonteaching hospitals.

REFERENCES

1. Barthélemy EJ, Melis M, Gordon E, Ullman JS, Germano IM. Decompressive craniectomy for severe traumatic brain injury: a systematic review. *World Neurosurg*. 2016;88:411–420. doi:10.1016/j.wneu.2015.12.044

2. Chikuda H, Koyama Y, Matsubayashi Y, et al. Effect of early vs delayed surgical treatment on motor recovery in incomplete cervical spinal cord injury with preexisting cervical stenosis: a randomized clinical trial. *JAMA Netw Open*. 2021;4(11):e2133604. doi:10.1001/jamanetworkopen.2021.33604

3. Yousefifard M, Hashemi B, Forouzanfar MM, Khatamian Oskooi R, Madani Neishaboori A, Jalili Khoshnoud R. Ultra-early spinal decompression surgery can improve neurological outcome of complete cervical spinal cord injury; a systematic review and meta-analysis. *Arch Acad Emerg Med*. 2022;10(1):e11. doi:10.22037/aaem.v10i1.1471

4. Burke JF, Yue JK, Ngwenya LB, et al. In reply: ultra-early (&Amp;Amp;Lt;12 hours) surgery correlates with higher rate of American spinal injury association impairment scale conversion after cervical spinal cord injury. *Neurosurgery*. 2019;85(2):E401–E402. doi:10.1093/neuros/nyz156

5. Kim EJ, Wick JB, Stonko DP, et al. Timing of operative intervention in traumatic spine injuries without neurological deficit. *Neurosurgery*. 2018;83(5):1015–1022. doi:10.1093/neuros/nyx569

6. Ruddell JH, DePasse JM, Tang OY, Daniels AH. Timing of surgery for thoracolumbar spine trauma: patients with neurological injury. *Clin Spine Surg*. 2021;34(4):E229–E236. doi:10.1097/BSD.0000000000001078

7. Croce MA, Bee TK, Pritchard E, Miller PR, Fabian TC. Does optimal timing for spine fracture fixation exist? *Ann Surg*. 2001;233(6):851–858. doi:10.1097/00000658-200106000-00016

8. Schinkel C, Frangen TM, Kmetic A, Andress H-J, Muhr G, German Trauma Registry. Timing of thoracic spine stabilization in trauma patients: impact on clinical course and outcome. *J Trauma*. 2006;61(1):156–160. doi:10.1097/01.ta.0000222669.09582.ec

9. Stahel PF, VanderHeiden T, Flierl MA, et al. The impact of a standardized "spine damage-control" protocol for unstable thoracic and lumbar spine fractures in severely injured patients: a prospective cohort study. *J Trauma Acute Care Surg*. 2013;74(2):590–596. doi:10.1097/TA.0b013e31827d6054

10. Vallier HA, Super DM, Moore TA, Wilber JH. Do patients with multiple system injury benefit from early fixation of unstable axial fractures? The effects of timing of surgery on initial hospital course. *J Orthop Trauma*. 2013;27(7):405–412. doi:10.1097/BOT.0b013e3182820eba

11. Lonze BE, Parsikia A, Feyssa EL, et al. Operative start times and complications after liver transplantation. *Am J Transplant*. 2010;10(8):1842–1849. doi:10.1111/j.1600-6143.2010.03177.x

12. Lairez O, Roncalli J, Carrié D, et al. Relationship between time of day, day of the week and in-hospital mortality in patients undergoing emergency percutaneous coronary intervention. *Arch Cardiovasc Dis*. 2009;102(12):811–820. doi:10.1016/j.acvd.2009.09.010

13. Ricci WM, Gallagher B, Brandt A, Schwappach J, Tucker M, Leighton R. Is after-hours orthopaedic surgery associated with adverse outcomes? A prospective comparative study. *J Bone Joint Surg Am*. 2009;91(9):2067–2072. doi:10.2106/JBJS.H.00661

14. Phatak UR, Chan WM, Lew DF, et al. Is nighttime the right time? Risk of complications after laparoscopic cholecystectomy at night. *J Am Coll Surg*. 2014;219(4):718–724. doi:10.1016/j.jamcollsurg.2014.05.009

15. Lee KT, Mun GH. Is after-hours free-flap surgery associated with adverse outcomes. *J Plast Reconstr Aesthet Surg*. 2013;66(4):460–466. doi:10.1016/j.bjps.2012.12.007

16. Yeung A, Butterworth SA. A comparison of surgical outcomes between in-hours and after-hours tracheoesophageal fistula repairs. *J Pediatr Surg*. 2015;50(5):805–808. doi:10.1016/j.jpedsurg.2015.02.036

17. Charest-Morin R, Flexman AM, Bond M, et al. After-hours' non-elective spine surgery is associated with increased perioperative adverse events in a quaternary center. *Eur Spine J*. 2019;28(4):817–828. doi:10.1007/s00586-018-5848-x

18. McGirt MJ, Speroff T, Dittus RS, Harrell FE, Asher AL. The national neurosurgery quality and outcomes database (N2Qod): general overview and pilot-year project description. *Neurosurg Focus*. 2013;34(1):E6. doi:10.3171/2012.10.FOCUS12297

19. Chiu CK, Chan CYW, Chandren JR, et al. After-hours elective spine deformity corrective surgery for patients with adolescent idiopathic scoliosis: is it safe. *J Orthop Surg (Hong Kong)*. 2019;27(2):2309499019839023. doi:10.1177/2309499019839023

20. Shin WS, Ahn DK, Lee JS, Yoo IS, Lee HY. The influence of antiplatelet drug medication on spine surgery. *Clin Orthop Surg*. 2018;10(3):380–384. doi:10.4055/cios.2018.10.3.380

21. Banat M, Wach J, Salemdawod A, et al. Antithrombotic therapy in spinal surgery does not impact patient safety-a single center cohort study. *Front Surg*. 2021;8:791713. doi:10.3389/fsurg.2021.791713

22. Bays A, Stieger A, Held U, et al. The influence of comorbidities on the treatment outcome in symptomatic lumbar spinal stenosis: a systematic review and meta-analysis. *N Am Spine Soc J*. 2021;6:100072. doi:10.1016/j.xnsj.2021.100072

23. Mannion AF, Fekete TF, Porchet F, Haschtmann D, Jeszenszky D, Kleinstück FS. The influence of comorbidity on the risks and benefits of spine surgery for degenerative lumbar disorders. *Eur Spine J*. 2014;23(Suppl 1):S66–S71. doi:10.1007/s00586-014-3189-y

24. Guyot JP, Cizik A, Bransford R, Bellabarba C, Lee MJ. Risk factors for cardiac complications after spine surgery. *Evid Based Spine Care J*. 2010;1(2):18–25. doi:10.1055/s-0028-1100910

25. Agarwal N, Goldschmidt E, Taylor T, et al. Impact of frailty on outcomes following spine surgery: a prospective cohort analysis of 668 patients. *Neurosurgery*. 2021;88(3):552–557. doi:10.1093/neuros/nyaa468

Funding: The authors received no financial support for the research, authorship, and/or publication of this article.

Declaration of Conflicting Interests: The authors report no conflicts of interest in this work.

Ethics Statement: Institutional Review Board approval was obtained for this study.

Corresponding Author: Gabrielle Santangelo, University of Rochester School of Medicine and Dentistry, 601 Elmwood Ave, Rochester, NY 14642, USA; gabrielle.santangelo@urmc.rochester.edu

Published 21 July 2023