Patient and Procedural Factors That Influence Anesthetized, Nonoperative Time in Spine Surgery

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Global Spine J 2016;6:447–451.

Abstract

Study Design Retrospective study.
Objective Efficient use of operating room time is important, as delays during induction or recovery increase time not spent operating while in the operating room. We identified factors that increase anesthetized, nonoperative time by utilizing a database of over 5,000 consecutive neurosurgical spine cases.
Methods Surgical records were searched to identify all spine surgeries performed between January 2010 and July 2012. Anesthetized, nonoperative time was calculated from the anesthesia record and compared with both patient and procedure characteristics to determine any significant relationships
Results There were 5,515 surgical cases with a mean age of 60.5 and mean body mass index (BMI) of 29.7; 3,226 (58%) were male subjects. There were 1,176 (21%) fusion cases, and level of pathology was predominantly lumbar (4,010 cases, 73%). Fusion cases had a significantly longer total anesthetized, nonoperative time (fusion: 98 minutes, nonfusion: 76 minutes, mean difference: 22 minutes, $p < 0.0001$). Significant factors affecting anesthetized, nonoperative time in nonfusion cases include age greater than 65 years (mean difference 5 minutes, $p < 0.0001$), American Society of Anesthesiologists (ASA) grade, and BMI (BMI < 25: 72 ± 1.2 minutes, BMI 25 to 29: 74 ± 0.6 minutes, BMI 30 to 39: 79 ± 0.6 minutes, BMI $40+$: 87 ± 1.8 minutes, $p < 0.0001$). Similarly, for fusion operations, age > 65 years significantly increased nonoperative time (mean difference 6 minutes, $p < 0.01$), as did increasing ASA (mean difference 9 minutes, $p < 0.0001$) and increasing BMI.
Conclusion Patient and surgical factors, including ASA grade, BMI, level of pathology, and surgical approach, have noticeable effects on anesthetized, nonoperative times in spine surgery.

Keywords
- anesthesia
- spine
- surgery
- time
- patient
- factors

Introduction

Efficient use of operating room (OR) time is increasingly important in modern medicine, as delays in patient arrival, induction of anesthesia, surgical positioning, and recovery in the OR all increase time in the OR not spent operating. Computer simulations have determined that OR utilization efficiency of 85 to 90% provides the best cost–benefit ratio with the lowest patient delays or staff overtime.[1] This efficiency is calculated by adding the anesthesia induction

received July 10, 2015
accepted after revision August 24, 2015
published online September 29, 2015

DOI http://dx.doi.org/10.1055/s-0035-1564808.
ISSN 2192-5682.

and recovery time and the surgical time and the interpatient change over time, and dividing this result by the overall allocated OR time. Several suggestions have been made in attempts to improve efficiency, including structural changes to the OR environment for improved patient flow (rooms for anesthetic induction/recovery separate from the OR) to scheduled induction or incision times.[2,3]

Further studies have been concerned with increased anesthesia induction time based on the complexity of anesthetic induction and/or the presence of anesthesia residents.[3–5] Studies suggest that the presence of learners has a very small but significant effect on anesthetic induction time (3 to 5 minutes).[4,6] Patient-specific factors, including age, American Society of Anesthesiologists (ASA) grade, and body mass index (BMI) have been studied in various surgical disciplines, and age and BMI have been found to increase anesthetic induction times.[5,7,8]

Patients undergoing spine surgery vary in the complexity of their anesthetic induction. Some procedures may not require arterial cannulation (such as some single-level diskectomies), but some may require central access, arterial access, and spinal cord monitoring setup and baselines, and patients may have to undergo positioning procedures such as 180-degree flip of the OR table while in traction. These factors have significant effects on anesthetized, nonoperative time (total time between intubation and extubation, minus the time between incision and closure). Patient-specific factors (age, BMI, ASA grade) may also have noticeable effects on these times. In this study, we sought to determine what factors increase this time by utilizing a database of over 5,000 consecutive neurosurgical spine cases at our institution.

Methods

Institutional Review Board approval was obtained for this study. The surgical records were searched in a retrospective fashion to identify all spine surgeries performed between January 2010 and July 2012. Patient demographic and procedural information (►**Table 1**) was obtained from the medical record, and anesthetized, nonoperative time was obtained from the anesthesia record by subtracting the incision to closure time from the intubation to extubation time. The anesthesia record is a detailed database of patient information, including vital signs, medications administered, and procedural events recorded at specific times during the operation. When an event such as intubation/extubation or incision/closure is performed, the anesthesiologist records the specific time of the event in the record, allowing for accurate determination of operative events to the minute. This record is kept during all anesthetized cases in the same fashion by all involved anesthesiologists. Multiple factors were analyzed, including age, BMI, ASA grade (►**Table 2**), level of pathology, and surgical approach.

Recognizing that fusion operations are often longer and require more anesthesia preparation compared with nonfusion operations, these two procedure types were analyzed separately. The demographic and surgical factors were compared with anesthetized, nonoperative time using Student *t* tests, ANOVA, and multivariate linear regression, with a *p* value of 0.05 deemed significant.

Table 1 Patient demographics

Demographics	Combined
Mean BMI	29.7
Age (y)	60.5
ASA grade	
I	256
II	3,237
III	2,004
IV	18
Sex	
Male	3,226
Female	2,289
Level of pathology	
Cervical	1,385
Thoracic	120
Lumbar	4,010
Approach	
Anterior	354
Posterior	5,130
Combined	31

Abbreviations: ASA, American Society of Anesthesiologists, BMI, body mass index.

Results

During the interval stated, we identified 5,515 surgical cases. The demographic information is provided in ►**Table 1**. The mean patient age was 60.5 years (±0.2, range 14 to 97) and 3,226 (58%) were male. The mean BMI of the cohort was 29.7 (±0.08). A fusion procedure was performed in 1,176 (21%) cases, and 11 different surgeons performed these procedures. The level of pathology was predominantly lumbar (4,010 cases, 73%), and the majority of cases were performed via a posterior approach (5,130 cases, 93%).

Fusion cases had a significantly longer total anesthetized, nonoperative time when compared with nonfusion cases (mean ± standard error of the mean, fusion: 98 ± 1 minutes,

Table 2 ASA classification system

ASA grade	Description
I	Normal healthy patients
II	Patients with mild systemic disease
III	Patients with severe systemic disease that is limiting but not incapacitating
IV	Patients with severe systemic disease that is a constant threat to life
V	Moribund patients not expected to live more than 24 hours
VI	Patients declared brain-dead undergoing donation procedures

Abbreviation: ASA, American Society of Anesthesiologists.

nonfusion: 76 ± 0.5 minutes, mean difference: 22 minutes, $p < 0.0001$).

Factors affecting anesthetized, nonoperative time in nonfusion cases are listed in ►**Table 3**. Age greater than 65 years was significantly associated with an increased anesthetized, nonoperative time (>65 years: 79 ± 0.6 minutes, <65 years: 74 ± 0.6 minutes, mean difference: 5 minutes, $p < 0.0001$). ASA grade was significantly associated with increased anesthetized, nonoperative time (ASA I: 68 ± 1.8 minutes, ASA II: 74 ± 0.6 minutes, ASA III: 81 ± 0.6 minutes, ASA IV: 114 ± 9 minutes, $p < 0.0001$). Increasing BMI was also significantly associated with increased nonoperative time (BMI < 25: 72 ± 1.2 minutes, BMI 25 to 29: 74 ± 0.6 minutes, BMI 30 to 39: 79 ± 0.6 minutes, BMI 40 + : 87 ± 1.8 minutes, $p < 0.0001$). Age, ASA grade, and BMI all maintained significance on multivariate analysis. The level of pathology was significantly associated with different anesthetized, nonoperative times (cervical: 92 ± 1.2 minutes, thoracic: 100 ± 3 minutes, lumbar: 72 ± 1.2 minutes, $p < 0.0001$). The vast majority of nonfusion cases were performed through a posterior-alone approach (4,328 cases, 99%), but there was a significant difference in nonoperative times between approaches (anterior: 113 ± 10 minutes, posterior: 76 ± 0.6 minutes, combined: 218 ± 31 minutes, $p < 0.0001$).

Factors affecting anesthetized, nonoperative time in fusion cases are listed in ►**Table 4**. Age > 65 years was significantly associated with increased nonoperative time (age > 65 years: 102 ± 1.2 minutes, age < 65 years: 96 ± 1.2 minutes, mean difference: 6 minutes, $p < 0.01$). There were very few ASA grade I or IV cases in the fusion cohort; the few ASA grade I cases were included with ASA II cases, and the ASA grade IV cases were included with the ASA grade III cases so the comparison was made between ASA grade I to II and ASA grade III to IV. There was a significant increase in nonoperative time between ASA I to II cases and ASA grade III to IV cases (ASA I to II: 95 ± 12 minutes, ASA III to IV: 104 ± 1.8 minutes, mean difference 9 minutes, $p < 0.0001$). Increasing BMI was significantly associated with increased nonoperative time as well (BMI < 25: 96 ± 1.8 minutes, BMI 25 to 29: 98 ± 1.8 minutes, BMI 30 to 39: 99 ± 1.8 minutes, BMI 40 + : 113 ± 4.2 minutes, $p < 0.01$). Age, ASA grade, and BMI all maintained significance on multivariate analysis. Both level of pathology and approach were significantly associated with differences in nonoperative time (cervical: 100 ± 1.2 minutes, thoracic: 124 ± 7.2 minutes, lumbar: 95 ± 1.2 minutes, $p < 0.0001$) and (anterior: 92 ± 1.8 minutes, posterior: 101 ± 1.2 minutes, combined: 123 ± 6 minutes, $p < 0.0001$).

Discussion

We sought to identify the patient- and procedure-specific factors that have significant effects on anesthetized, nonoperative times in spine surgery. Multiple studies have looked at nonoperative OR time, attempting to identify factors within the patient flow or anesthesia team that contribute to

Table 3 Factors affecting anesthetized, nonoperative time in nonfusion spine cases

	Nonoperative time (min)	*p* Value
BMI		<0.0001
<25 25–29.9 30–39.9 40+	72 ± 1.2 74 ± 0.6 79 ± 0.6 87 ± 1.8	
Age (y)		<0.0001
<65 ≥65	74 ± 0.6 79 ± 0.6	
ASA grade		<0.0001
I II III IV	68 ± 1.8 74 ± 0.6 81 ± 0.6 114 ± 9	
Level of pathology		<0.0001
Cervical Thoracic Lumbar	92 ± 1.2 100 ± 3 72 ± 1.2	
Approach		<0.0001
Anterior Posterior Combined	113 ± 10 76 ± 0.6 218 ± 31	

Abbreviations: ASA, American Society of Anesthesiologists, BMI, body mass index.

Table 4 Factors affecting anesthetized, nonoperative time in spine fusion cases

	Nonoperative time (min)	*p* Value
BMI		<0.01
<25 25–29.9 30–39.9 40+	96 ± 1.8 98 ± 1.8 99 ± 1.8 113 ± 4.2	
Age (y)		<0.01
<65 ≥65	96 ± 1.2 102 ± 1.2	
ASA grade		<0.0001
I–II III–IV	95 ± 12 104 ± 1.8	
Level of pathology		<0.0001
Cervical Thoracic Lumbar	100 ± 1.2 124 ± 7.2 95 ± 1.2	
Approach		<0.0001
Anterior Posterior Combined	92 ± 1.8 101 ± 1.2 123 ± 6	

Abbreviations: ASA, American Society of Anesthesiologists, BMI, body mass index.

increased times,[1,4–6] but few studies have focused on patient- or procedure-specific factors that influence this nonoperative time. Some studies have looked into patient-specific factors, identifying age and BMI as important factors in predicting increased anesthetized, nonoperative times,[5,7,8] but to our knowledge, this analysis has not been performed in a high-volume, tertiary care spine practice at a major teaching institution.

This study has several interesting findings: first, there is an average increase in anesthetized, nonoperative time of 22 minutes when comparing fusion procedures to decompression-only cases. This finding likely represents the extra time required for the complex positioning on specialized surgical tables, the need for more invasive access by the anesthesia team, and the presence of neuromonitoring in some of these cases. There are small but significant increases in nonoperative times as patient age, BMI, and ASA grade increase for both fusion and decompression operations, and these findings remained significant on multivariate analysis in both operations. Even though the increase seems minimal (minutes), the effect is likely additive, and the time increase becomes very apparent for a 65-year-old obese patient with multiple comorbidities set to undergo a cervical fusion requiring monitoring and a Jackson table flip. The level of pathology and approach also influence the nonoperative time for both fusion and decompression operations, with cervical and thoracic levels increasing nonoperative times compared with lumbar pathology for both cohorts. This result may be due to the more complex positioning and the need for monitoring in some of these cases. There is a similar effect noted when an anterior approach is selected over a posterior approach for both cohorts, which may represent the added time required for fluoroscopic imaging prior to skin incision as well as complex positioning required in many of these cases.

These nonoperative times are from a large, tertiary care teaching institution, and there is likely significant variation around the world in the anesthetized, nonoperative time surrounding spine surgery. Nonetheless, this data does identify patient- and procedure-specific factors that may increase the nonoperative time and represents areas for potential improvement. The early recognition of patients and procedure types that lead to increased nonoperative times could allow the surgeon or anesthesiologist to proactively address this problem. Certain basic access lines could be obtained by anesthesia in the preoperative area, and specific patients could be labeled “high-efficiency,” leading to extra nurse-anesthetist or resident assistance during induction and positioning in the OR.

This study has several limitations, including the retrospective nature of the analysis and the fact that these cases took place at a large, tertiary care teaching hospital where learners at all stages are present and involved in patient care. The effects of learners on operative and anesthetic times have been studied; for anesthesia residents, the increase in time is minimal (3 to 5 minutes per induction), and the effect on operative times for surgical residents is conflicting and dependent on procedure type and specialty, with no overall consensus met.[4,6,9–13] Each group, both fusion and nonfusion, includes a wide variety of cases, involving differing numbers of involved levels and very likely significant differences in patients' baseline health characteristics, which may increase nonoperative times significantly more than just age or BMI. We attempted to account for this variety with ASA grade; however, this grade is not the best comorbidity index as the ASA system is designed mainly for risk of undergoing anesthesia. Although surgeon variability was analyzed in this study and did not cause a significant change in the nonoperative times, anesthesiologist variability, presence of a nurse-anesthetist or resident, and type of invasive monitoring required were not independently analyzed and could have effects on the nonoperative times.

OR efficiency has been studied and attempts have been made to best utilize work-flow changes to increase the efficiency of the OR environment. There appear to be patient- and procedure-specific factors that lead to tangible increases in preincisional time in the OR, and these factors should be accounted for when OR efficiency is being calculated in spine surgery. Identification of these variations in operative and anesthetized time in the future should be compared with surgical outcomes to determine if any associations are present. If discovered, changes within the system aimed to decrease nonoperative time could be made in attempt to lessen the risk of complications.

Conclusion

Patient and surgical factors, such as age, ASA grade, BMI, level of pathology, and surgical approach, have noticeable effects on anesthetized, nonoperative times in spine surgery.

Disclosures
Ross C. Puffer, none
Grant W. Mallory, none
Anthony M. Burrows, none
Timothy B. Curry, none
Michelle J. Clarke, none

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