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Original Contribution

Time of day is not associated with increased rates of mortality in emergency surgery: An analysis of 49,196 surgical procedures☆,☆☆,☆☆☆,☆☆☆☆

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ABSTRACT

Study objective: There is a lack of large, multi-institutional studies analyzing the association of timing of emergency surgery with death occurring either intraoperatively or in the recovery room setting. The primary objective of this study was to determine if time of day for emergency surgeries was associated with mortality.
Design: Retrospective analysis.
Setting: U.S. healthcare facilities.
Patients: Adult patients undergoing emergency surgery and general anesthesia.
Interventions: No intervention.
Measurements: Utilizing the National Anesthesia Clinical Outcomes Registry database, all emergency non-cardiac, non-obstetric surgeries undergoing general anesthesia occurring between 2010 and 2015 in the United States were identified. We performed mixed effects logistic regression to determine the effect of time of day with mortality occurring during the intraoperative and immediate postoperative period.
Main results: There were 46,196 cases that were eligible for this analysis, in which 24,247 and 21,949 occurred during day and after-hours shifts, respectively. The overall morality rate was 0.28%. Mortality rates were 0.17% and 0.41% in the day and after-hour shifts, respectively. There was no statistically significant association of time of day with mortality (odds ratio 1.31, 95% CI 0.90–1.92, p = 0.16). American Society of Anesthesiologists physical status classification, age, and operative body part were all associated with mortality.
Conclusions: Although, theoretically, health care providers working after-hour shifts may be impacted by sleep deprivation and/or limited resources, we found that time of day was not associated with increased risk of mortality during the intraoperative and immediate postoperative period in emergency surgery.

1. Introduction

The estimated overall mortality within surgical populations is about 0.4% to 5.6% [1,2]. The range depends on the time range capturing mortality (intraoperative, in-hospital, 30-day survival, etc.), surgical population in question, type of surgeries, urgency, and risk profile [3–8]. Several studies have demonstrated that work hour patterns and fatigue are associated with reduced physician performance [9–14]. The effect that this may have on surgical and anesthesia performance, and consequently patient morbidity and mortality, is unclear. One theory is that physician fatigue and limited resources during after-hour shifts may be associated with worse outcomes in the operating room setting. Consequently, it would make sense that non-urgent surgery should be undertaken during daytime hours whenever possible. Many studies report mixed results regarding surgical outcomes as it relates to work hours or time of day [5,6,15–17]. A large, prospective multi-

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institutional study based in Europe found no association between time of day and in-hospital mortality after adjusting for multiple independent predictors [18].

To our knowledge, there has been no large, multi-institutional studies analyzing the association of timing of surgery with death occurring either intraoperatively or in the recovery room setting specifically for emergency surgeries in the United States. The question of outcomes during emergency surgery performed after-hours can be investigated using case data from the National Anesthesia Clinical Outcomes Registry (NACOR) - the largest anesthesia outcomes database in the United States. NACOR was created by the Anesthesia Quality Institute (AQI) and consists of perioperative data, including surgery and anesthesia type, patient demographics and select outcomes. It is the largest anesthesia database in the country and stores over 20% of all anesthetics performed annually [19,20]. The hypothesis of our study is that time of day for emergency non-cardiac, non-obstetric surgery involving general anesthesia is associated with mortality (defined here as occurring intraoperatively or in the recovery room). We performed a retrospective study using mixed effects logistic regression.

2. Materials and methods

2.1. Data source

NACOR is a voluntary submission registry with institutions that participate in the sharing of anesthesia-related data and outcomes in order to evaluate the quality of care both nationally and locally [21]. NACOR accepts case-level administrative, clinical and quality capture data from voluntary participating anesthesia practices and healthcare facilities in the United States. Electronic data are obtained from these institutions, typically on a monthly basis, and data elements are mapped to fields in the NACOR schema in accordance with a publicly available data dictionary. Incoming data are loaded into NACOR by AQI technologists, and are subject to both manual and automated review to identify systematically missing elements, mis-coding and inadvertent corruption. Our data were collected by AQI from 2010 to 2015. The AQI database contains de-identified patient information and various data regarding patient demographics, billing, procedural, diagnostic, provider information, as well as rates of adverse events. Institutional Review Board approval was obtained from the Brigham and Women's Hospital. Because the database is de-identified, it meets the criteria of the Health Insurance Portability and Accountability Act to protect personal information and was exempt from the consent requirement by our institutional review board.

2.2. Study sample

All non-cardiac, non-obstetric emergency surgery cases in patients receiving general anesthesia and who were greater than or equal to 18 years of age occurring from 2010 to 2015 were identified in the database. Of note, patients that received regional anesthesia in addition to general anesthesia were also included in the study. All cases with American Society of Anesthesiologists physical status (ASA PS) class of 6 were removed from the study. Furthermore, all cases with missing data for ASA PS class, age, sex, and case duration were excluded. Only cases that underwent general anesthesia as their primary anesthesia type were included. Finally, all cases that were performed at a facility that reported < 3 patients for each covariate were removed (to avoid separability). Fig. 1 illustrates the exclusion methodology. We utilized STROBE guidelines for reporting in the observational study.

The primary objective of this study was to evaluate the association of time of day of emergency surgery to perioperative mortality. In NACOR, the definition of emergency surgery is surgery that needs to be performed "immediately, without delay, as soon as surgeon is available". Time of day was defined as either day shift (time of anesthesia start between 7:00 to 17:00) or after-hours shift (time of anesthesia start between 17:01 and 06:59 or occurring on the weekend or holiday). Within NACOR, mortality is defined as having occurred intraoperatively or during the immediate postoperative period until discharge from the postanesthesia care unit (PACU). In the case of a direct admission to a non-PACU destination (i.e. ICU), the eligible period would end at admission to that unit. Data related to ASA PS classification, age, sex, case duration, facility type, comorbidities, procedure location (operating room versus non-operating room site), Current Procedural Terminology (CPT) anesthesia time units, and surgical specialty (based on operative body part) were collected for each case. Health care system-related characteristics include facility type: university hospitals (reference group), community hospitals (which consolidated large community hospitals (consisting of > 500 beds), medium community hospitals (consisting of 100–500 beds) and small-sized community hospitals (< 100 beds)), and "other" facility type - such specialty hospitals, freestanding surgery centers, attached surgery centers, pain clinics, and surgeon's office. NACOR further categorizes cases by operative body part. We used this categorization to stratify cases into surgeries involving the head, intrathoracic space, lower abdomen, upper abdomen, and 'other' (which includes operations involving any of the extremities, spine, chest wall, shoulder, pelvis, radiological). Presence of comorbidities were based on existence of specified ICD9 codes – codes of interest were diabetes mellitus type II, chronic kidney disease, congestive heart failure, coronary artery disease, liver cirrhosis, and hypertension. To report most common procedures resulting in mortality during each shift, cases were identified by their Clinical Classifications Software (CCS) for ICD-9-CM code, which is a diagnosis and procedure categorization scheme developed as part of the Healthcare Cost and Utilization Project.

2.3. Statistical analysis

R, a software environment for statistical computing (R version 3.3.3), was used to perform all statistical analyses. To compare categorical variables between both cohorts, Pearson's chi-squared test was performed with a $p < 0.05$ considered statistically significant. A mixed effects multivariable logistic regression analysis was modeled to determine if time of day was associated with mortality in emergency, non-cardiac, non-obstetric surgeries in adult patients. To accomplish this, data for age, case duration, and CPT anesthesia base units were dichotomized. Age was categorized based on geriatric status (< 65 years old versus ≥65 years old). Case duration was categorized based on the 75% quartile of case duration of the entire final sample. CPT base units were categorized based on physiological complexity of the procedure (< 8 units versus ≥8 units). ASA PS was converted into a binary variable (ASA 1-2 versus 3-5). Furthermore, sex, procedure location (operating room versus non-operating room), comorbidity (i.e. diabetes mellitus, chronic kidney disease, etc.) were treated as binary variables. Finally, surgical specialty (by body part) and facility type were categorical variables.

A 1:1 (day shift:after-hours shift) propensity score matching method (using nearest neighbor matching without replacement) was utilized to create matched cohorts. Propensity score for time of day was determined using logistic regression based on all covariates included in this analysis. To determine balance between matched groups, an absolute standardized difference that is < 0.2 for each variable was considered adequate. Using the matched cohorts, the first step in the analysis was to perform multiple univariable logistic regression models for the primary predictor of interest as well as all the predictors. All covariates with a p-value of < 0.2 were included in the stepwise multivariable logistic regression model building. A mixed effects multivariable logistic regression model was subsequently performed. The facility at which each procedure was performed (identified as "facilityID" in NACOR database) was included into the model as the random intercept, and the listed covariates were incorporated as fixed effects. Stepwise regression was performed via backward elimination by