



Turnover Time Between Elective Operative Cases: Does the Witching Hour Exist for the Operating Room?

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Abstract

Background Efficient resource management in the operating room (OR) contributes significantly to healthcare expenditure and revenue generation for health systems. We aim to assess the influence that surgeon, anesthesiology, and nursing team assignments and time of day have on turnover time (TOT) in the OR.

Methods We performed a retrospective review of elective cases at a single academic hospital that were completed between Monday and Friday between the hours of 0700 and 2359 from July 1, 2017, through March 31, 2018. Emergent cases and unplanned, add-on cases were excluded. Data regarding patient characteristics, OR teams, TOT, and procedure start and end times were collected and analyzed.

Results A total of 2174 total cases across 13 different specialties were included in our study. A multivariate regression of relevant variables affecting TOT was performed. Consecutive specialty ($p < 0.0001$), consecutive surgeon ($p < 0.0001$), anesthesiologist ($p < 0.0001$), and prior case ending before 1400 ($p < 0.0001$) were independent predictors of lower TOT. A receiver operating characteristic analysis demonstrated an area under the curve of 0.848 and a cutoff of 1400 having the highest sensitivity and specificity for TOT difference.

Conclusions TOT can be significantly affected by the time of the day the procedure is performed. Staffing availability during late procedures and the differences in how OR team staff are scheduled may affect OR efficiency. Additional studies may be needed to determine the long-term implications of changes implemented to decrease organizational operational costs related to the OR.

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Introduction

As the Centers for Medicare and Medicaid Services has adjusted their reimbursement models to incentivize high-quality, low-cost healthcare [1], there has been an increased focus on efficient resource utilization. It is estimated that 70% of hospital revenue is generated in the operating room (OR) [2]. Thus, the effective and efficient management of OR resources are vital to organizational fiscal stability and quality healthcare.

Factors that influence effective OR management include staff utilization, OR allocation, case scheduling, accuracy of procedural timing, and pre-operative testing protocols [3]. Over time, healthcare systems have found that

effective and efficient management of OR resources can be reflected by efficient OR start times and turnover time (TOT). The influence of OR staffing on TOT has previously been examined by assessing the impact of efficiency trainings, as well as the benefits of a nursing team during TOT [4]. Recent publications have reported that maintaining the same team for consecutive cases with the same surgeon independently predicted lower TOT [5–7].

Many studies have explored different tools and incentive programs to improve efficiencies in the OR [8]. Dexter et al. reported an incremental increase in TOT after the 8-h shift period with peak hour at 13:00 and progressive increase after each hour [3]. However, studies have been specialty specific or focused on ancillary staff. Additionally, the association between OR staffing changes and timing of day that further exacerbates inefficiencies in the OR has not been studied. This is particularly important today as the world continues to deal with the Coronavirus Disease 2019 (COVID-19) pandemic as it has negatively affected the utilization of OR resources, efficiency and presented a huge economic burden in many healthcare systems [9].

In this study, we assess elective OR procedures by different subspecialties and explore how staffing and specifically time of day potentially influence TOT in the OR. In addition, this report analyzes the TOT data to identify the etiology of staffing induced delays and introduce potential methods to optimize OR staffing to meet patient needs while ensuring optimal OR resource utilization. We hypothesize that there is a time of day at which point, OR TOT increases and this may correspond with staff shift hours.

Methods

Study population

A retrospective review of OR procedures from July 2017 through March 2018 done in the ORs of a tertiary, academic teaching hospital was completed. Analyzed cases were confined to adult elective, scheduled surgical procedures that were completed on weekdays between hours of 0700 and 2359. The reason is that in our ORs, elective cases typically run past normal operating hours. Additionally, we wanted to capture more hours of the day to study whether specific hours later in the day have differing TOT. Exclusion criteria included: pediatric patients, non-elective or emergent cases, unplanned or add-on cases, and cases starting after 00:00 or before 06:59.

Data collection

Case data were tracked prospectively within the institution's electronic medical record system. This was done by

OR nurses, anesthesia team, and the surgical team. Baseline characteristics included American Society of Anesthesiologists (ASA) status, inpatient status (inpatient versus outpatient), OR room, specialty, type of procedure, surgeon, anesthesiologist. OR variables analyzed included wheel-in time, procedure start time, procedure end time, and wheel-out time. TOT was defined as the time from when the preceding procedure ended to when the subsequent case's patient was wheeled into the OR. This definition was chosen because there are times when a patient is ready to be wheeled out of the OR; however, they are placed on hold due to staffing or unavailable space in the post-anesthesia care unit. Therefore, by including the time between procedure end and wheel-out within the TOT, we were able to capture any delays related to getting the patient out of the OR. Additionally, in most instances, the turnover process begins while the prior patient is waiting to leave the OR.

Statistical analysis

Baseline and outcome variables were classified as either categorical or continuous variables. A univariate analysis was performed using the following statistical tests: Wilcoxon and Kruskal–Wallis. Statistical analyses were performed using R (version 3.6.3) [10]. For all statistical analyses, specific R packages were used: `generalhoslem`, `MASS`, `RColorBrewer`, `tidyverse`, `writexl` R packages [11]. A significance was assigned by a p value < 0.05 . Multivariate analysis was completed with receiver operating characteristic (ROC) curve.

Results

A total of 2174 cases from 13 different subspecialties were included in the analysis. Cases were analyzed by time of prior procedure end time over the course of the day and demonstrated that there was a significant difference in median TOT depending on time of day (Table 1, Fig. 1). Cases were then compared against each other by time of day using procedure end time of the prior case, with prior cases ending between 14:00 and 19:00 having a significantly longer TOT in comparison to cases that had a procedure end time that occurred before 14:00 (Tables 2, 3).

Upon completing a multivariate regression of relevant variables affecting TOT, consecutive specialty (Odds Ratio [OdR] 0.61; $p < 0.0001$), consecutive surgeon (OdR 0.10; $p < 0.0001$), consecutive anesthesiologist (OdR 0.28; $p < 0.0001$), and prior procedure end time before 14:00 (OdR 0.59; $p < 0.0001$) were independent predictors of lower TOT (Table 4). An ROC analysis was conducted to review the performance of our multivariate regression

Table 1 Median turnover time (TOT) based on time of day

Case prior end time (hr)	N	TOT (min ± SD)	p-value
0800	80	69.5 ± 60	< 0.0001
0900	341	64 ± 51	
1000	482	70 ± 45	
1100	450	81.5 ± 54	
1200	430	84 ± 55	
1300	332	78 ± 54	
1400	274	89.5 ± 59	
1500	188	86.5 ± 81	
1600	77	95 ± 65	
1700	37	129 ± 76	
1800	9	218 ± 67	
1900	10	152.5 ± 20	
2000	2	122 ± 27	
2100	2	39 ± 37	

model against prior procedure end time (before vs. after 14:00), which demonstrated an area under the curve of 0.848 (Fig. 2). Calculated performance for this model yielded a specificity of 78.7% and sensitivity of 79.6% when using 14:00 as the threshold for increased OR TOT.

Discussion

There are several staff team members who are involved in the OR case and OR turnover process: nurses, surgical technologists, anesthesia teams, and environmental services. The OR turnover process requires the efficient and timely coordination between multiple staff members throughout the day. Our study demonstrates there was a significant difference in TOT when comparing procedures that followed procedures that ended before 14:00 and after 14:00 (mean 78 vs. 96 min, $p < 0.0001$, Table 3) with relatively high sensitivity and specificity (79.6 and 78.7%; Fig. 2). 14:00 was specifically chosen for cutoff of the case prior end time since this correlated with the 15:00 h when the 8-h shift ends for many of the OR staff including surgical technologists, nurses, nurse anesthetists, and anesthesiologists. During this time, support staff end their shift and transfer their responsibilities to either a replacement or stay on for overtime in the event of staff shortage. Given this context, it is not surprising that our study found an increase in TOT for procedures that follow a procedure that ends after 14:00.

Our results also demonstrate that consecutive specialty, surgeon, and anesthesiologist have significant influence on TOT. Specifically, our results showed that TOT between

cases with the same surgeon were shorter than that of cases with different surgeons (66 vs. 110 min, $p < 0.0001$). These variables were included in our multivariate regression analysis to demonstrate that time of day is a significant contributor of TOT, when accounting for other variables. These factors go along with the idea that there is no interruption in staffing within the OR and there is continuity of the care team during and between cases. These variables have been previously discussed and analyzed [5]. Patient ASA status also included. Although not a marker of case difficulty, it may be used as a gross marker of patients' medical complexity. It was not a significant factor related to TOT in our multivariate regression; however, in Sarpong et al., it was a significant variable when comparing ASA level 2, 3, and 4 patients [5]. This is likely related to difficult or longer intubation and/or extubation times. Since the collection of the data for the present study, our ORs have implemented staggered shifts for staff as to provide overlap between incoming and outgoing staff members and assigned dedicated subspecialty ORs since consecutive specialty cases have lower TOT.

The significance of such findings requires further investigation. Findings can be associated with inadequate staffing during the shift-change or due of the differences in incentivization structures between shift-based staff versus case-based employees. This is particularly important especially during the nationwide shortage of nurses and support staff—a growing shortage that has also been exacerbated by the ongoing COVID-19 pandemic due to the high demand and low supply [12, 13]. Perhaps, this is also deeply rooted in the fact that after a long day of work in the OR, staff members tend to be “physically” or “mentally” fatigued as their end of shift gets closer—a complex phenomenon that has been described in the literature as “Shift Work Disorder” [14, 15].

To understand if the increase in TOT at or after 14:00, one must delineate the differences in incentivization structure. Both nursing and anesthesia typically operate on a shift-based schedule that can range from 8- to 12-h shifts, while surgical teams are often operating on a case-based schedule. Studies have shown inefficiencies in OR scheduling stem from insufficient allotment of OR time beginning with the first case of the day [16]. For example, it would be inefficient to send 8-h shift staff to ORs where cases are run on a continuum and consistently run for more than 12 h due to the length of cases or case load. The differing scheduling structures create diverging incentives for each group. Case-based scheduling incentivizes surgeons to reduce delays in TOT and complete their assigned cases as efficiently as possible. Dexter et al. estimated that reductions in average TOT of 3–9 min would lead to a 0.8–1.8% reduction in costs, while reductions in

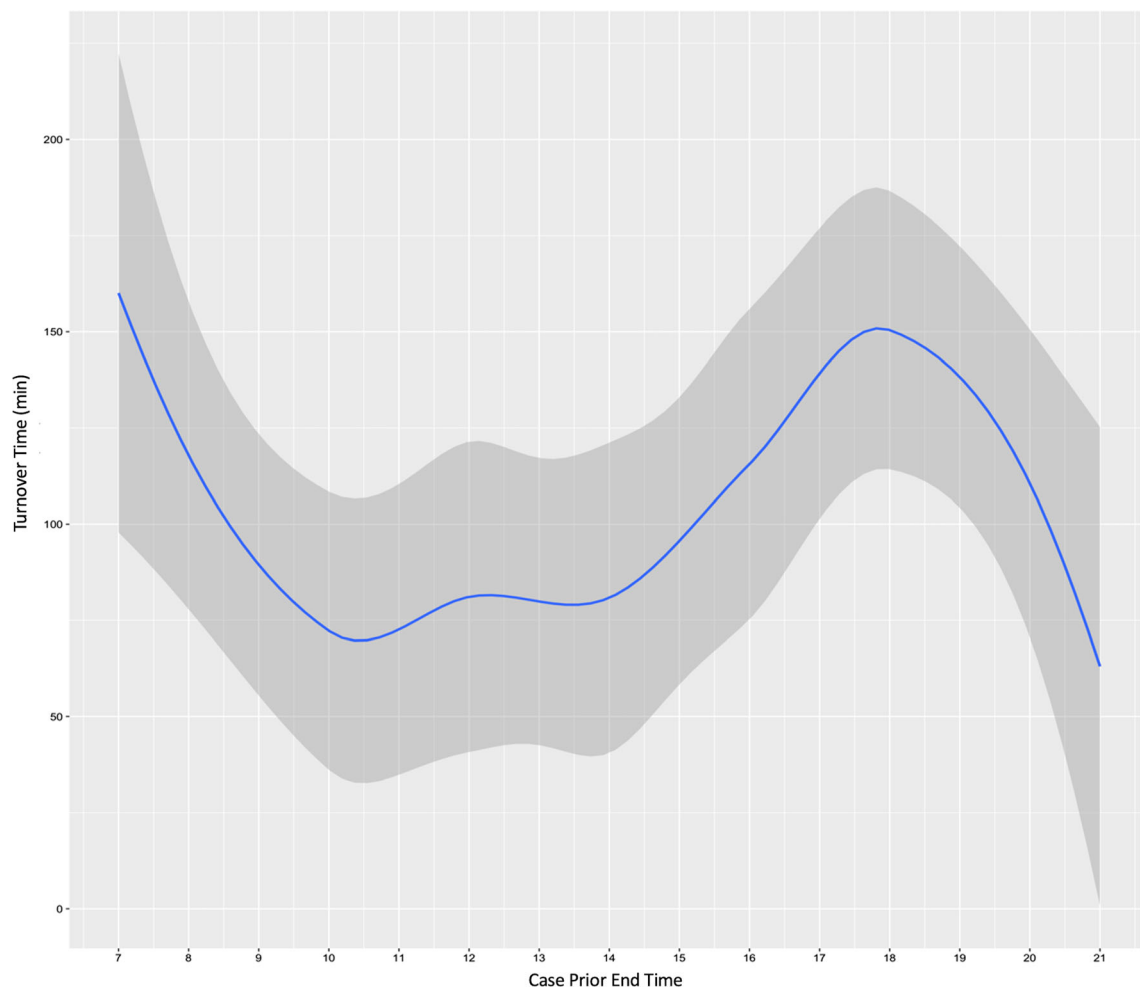


Fig. 1 Turnover time (TOT) by time of case prior end time

10–19 min would result in 2.5–4.0% reductions in costs [17].

In identifying time of day and staff scheduling as factors that influence OR TOT, organizations must be creative in finding ways to streamline processes. A trend within healthcare has been the adoption of Lean Management (LM) principles. LM is anchored in the belief that positive improvement is created through eliminating waste and streamlining processes. One of the LM methods, value-stream mapping, applies the principles of LM and allows organizations to create a visual guide of all the components required to deliver an end-product. A study by Cerfolio et al. applied value-stream mapping to review the steps that go into OR turnover—finding that by eliminating non-valued processes and performing processes simultaneously rather than sequentially, improved median TOT from 37 to 14 min [18]. One study applied LM-5S methodologies to a neurosurgery OR at a large urban, academic, tertiary acute care hospital over an 8-week period, and found that there

was a 68% reduction in costs associated with inventory and the ability to increase OR space capacity [19]. Additionally, by creating efficient checklists and structured communication, there is the potential for decreased work-related stress and greater workplace satisfaction.

Another factor often less emphasized the effects of scheduled breaks, and its impact of staff shift changes and TOT time. Scheduled break time is an important component impacting patient safety, staff satisfaction and TOT. Studies have shown that scheduled short breaks improve productivity in the workplace and reduces fatigue [20, 21]. Norman and Bidanda demonstrated that teamwork and staffing inefficiencies may contribute to the TOT because team members with fewer tasks simply took unscheduled breaks when their tasks were completed instead of assisting the rest of the team [22]. This is an area where cross-training staff and redefining roles can boost teamwork efforts and reduce TOT. Taking scheduled breaks requires planning and anticipation on the part of staff. For example,

Table 2 Paired Wilcox Test based on time of day

		Case Prior End Time												
		800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
Case Prior End Time	800													
	900	0.25												
	1000	0.68	0.00											
	1100	0.01	0.00	0.00										
	1200	0.00	0.00	0.00	0.28									
	1300	0.05	0.00	0.00	0.51	0.13								
	1400	0.00	0.00	0.00	0.00	0.04	0.00							
	1500	0.00	0.00	0.00	0.07	0.26	0.03	0.68						
	1600	0.00	0.00	0.00	0.05	0.15	0.03	0.66	0.58					
	1700	0.01	0.00	0.00	0.05	0.12	0.06	0.28	0.28	0.56				
	1800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.12			
	1900	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.12	0.60	0.12		
	2000	0.26	0.17	0.22	0.28	0.30	0.36	0.60	0.53	0.68	0.93	0.28	0.65	
	2100	0.26	0.21	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.20	0.27	0.23	0.69

Bold p-values denote statistical significance

an environmental service staff on break at the time of turnover will significantly delay TOT thereby affecting OR utilization [23].

Strengths and limitations

The strength of this study is that it presents the largest single-institution study evaluating OR TOT in an academic setting. It provides specific perspective on time of day in a situation where parties involved are designated shift time. Thus, we are able to answer the question of whether time of day does play a role in TOT efficiency in the OR.

The retrospective design and inclusion of a single institution in our study are a limitation. The data used were based on documentation available from operative and anesthesia records. The data are from pre-COVID-19 era which may not be directly applicable today. Other institutions may not have shift scheduling for OR staff limiting the generalizability of our findings. Our definition of TOT incorporates the time period between procedure end and when patient is wheeled out of the OR which may be variable due to prolonged extubation time, or post-anesthesia care hold times. The representation of different subspecialties within the study is also a limitation given

that specialties may not have been represented equally. Only elective cases were included. Urgent or emergent cases may delay elective cases if there is not another available OR to accommodate these cases. Case difficulty is a variable not captured in our data collection that may influence TOT. However, subspecialty-specific data have been analyzed in a previous study and demonstrate that specialties such as transplant and urology have significantly higher TOTs compared specialties such as orthopedics and otolaryngology that have lower TOT [5]. Finally, TOT is influenced by multiple factors and there are other factors that may be at play which are not as easily captured in a retrospective study, including delays related to medical clearance, patient transport, and technical or equipment issues that may be encountered within or in between OR cases.

Conclusion

Our study shows that OR TOT can be significantly affected by the time of the day the procedure is performed. Moreover, it can be influenced by the OR team including the surgeon and anesthesia team. Staffing availability during

Table 3 Median turnover time (TOT) comparison between cases following a case ending before or after 1400

Procedure end time of prior case	N	TOT (mins)	SD	p value
Before 1400	2390	78	51.3	< 0.001
After 1400	324	95.5	75.5	

Table 4 Multivariate linear regression analysis of variables affecting operating room turnover time

Variable	Estimate	OR	95% CI	p value
Case prior end time before 1400	−0.403	0.59	0.52–0.86	< 0.001*
ASA status	−0.027	0.97	0.79–1.20	0.798
Consecutive specialty	−0.491	0.61	0.47–0.80	< 0.001*
Consecutive surgeon	−2.229	0.10	0.08–0.15	< 0.001*
Consecutive anesthesiologist	−1.179	0.28	0.25–0.38	< 0.001*
Running multiple operating rooms	−0.019	0.98	0.75–1.28	0.887

ASA American Society of Anesthesiologists; OR odds ratio; CI confidence interval

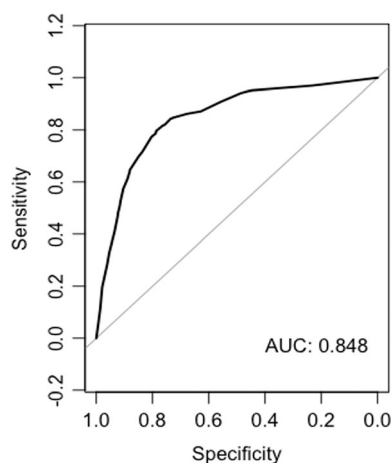


Fig. 2 Multivariate linear regression Receiver Operating Characteristic curve of turnover time and case prior end time with an area under the curve of 0.848, $p < 0.0001$. A threshold cutoff at 14:00 yielded the highest sensitivity and specificity for increased turnover time (sensitivity: 79.6%; specificity: 78.7%)

late procedures and the differences in how OR staff are incentivized need to be systematically studied to better understand ways to improve how today's ORs can run effectively and efficiently. Further, prospective, larger studies may be needed to determine the long-term implications of changes implemented to decrease organizational operational costs related to the OR.

Authors contribution SK and KS contributed to data analysis and writing and editing of the first draft of the manuscript in methods and results. JM and AA contributed to writing and editing of the first draft

of the manuscript and data collection. ED and MNN contributed to critically revising the manuscript and study supervision. MNN contributed to conception and design. All authors read and approved the final manuscript.

Data availability statement All relevant data are published in the study. Further data used in this study are available upon reasonable request from the corresponding author.

Declarations

Conflict of interest The authors have no conflicts of interest to disclose in relation to this article.

Ethics and other permissions This study uses data from electronic medical records with Institutional Research Board approval from the corresponding institution.

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