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Operating Room Traffic: Is There Any Role of Monitoring It?

Shital N. Parikh, M.D.,

Cincinnati Children's Hospital Medical Center, Division of Pediatric Orthopaedics, 3333 Burnet Avenue ML 2017, Cincinnati, OH 45229

Salih S. Grice, M.D.,

University of Cincinnati, College of Medicine, 231 Albert Sabin Way ML 0212, Cincinnati, OH 45267

Beverly M. Schnell, Ph.D., and

Cincinnati Children's Hospital Medical Center, Division of Biostatistics and Epidemiology, 3333 Burnet Avenue ML 5041, Cincinnati, OH 45229

Shelia R. Salisbury, Ph.D.

Cincinnati Children's Hospital Medical Center, Division of Biostatistics and Epidemiology, 3333 Burnet Avenue ML 5041, Cincinnati, OH 45229

Abstract

Background—Operating room (OR) human traffic has been implicated as a cause of surgical site infection. We first observed the normal human traffic pattern in our Pediatric Orthopaedic ORs, then examined the effect of surveillance on that traffic pattern.

Methods—This study consisted of two phases: phase I sought to observe the OR traffic pattern (number of door swings, maximum and minimum number of OR personnel, number of OR personnel at 30 minute intervals, or changes in nursing, anesthesia or surgeon staff) during surgical cases without OR personnel being notified, and for phase II, the same traffic pattern was monitored with their knowledge.

Results—2442 minutes of surgical time were observed in phase I, and 1908 minutes were observed in phase II. There was no difference ($p=0.06$) in the time between door swings between phase I (1.39 minutes) and phase II (1.70), no difference ($p=1.000$) in the maximum number of people in the OR between phase I (11.5 people, range: 7–15 people) and phase II (11.5 people, range: 8–20 people), no difference ($p=1.000$) in the minimum number of people in the OR between phase I (4.67 people, range: 4–6 people) and phase II (4.71 people, range: 3–6 people). There was a difference in the time between door swings ($p=0.03$) and maximum number of people in the OR ($p=0.005$) based on length of surgery (less or more than 120 minutes). There was no difference in the time between door swings ($p=0.11$), but there was a difference in the maximum number of people in the OR ($p=0.002$) based on type of surgery (spine vs. others).

Corresponding Author: Shital N. Parikh, MD, Assistant Professor of Pediatrics, Cincinnati Children's Hospital Medical Center, Division of Pediatric Orthopaedics, 3333 Burnet Avenue ML 2017, Cincinnati, OH 45229, shital.parikh@cchmc.org, Phone: (513) 636-9219, Fax: (513) 636-3928.

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Ethical Review Committee Statement: This study was reviewed and given an exempt status through the Cincinnati Children's Hospital Medical Center's Institutional Review Board.

Conclusion—There was no role of surveillance of human traffic in the OR. To achieve any change in the OR traffic pattern, monitoring alone may not be sufficient; other novel techniques or incentives may need to be considered.

Introduction

An infection is considered to be a surgical site infection (SSI) when it occurs: (1) at the site of surgery within 30 days of an operation or (2) within 1 year of an operation if a foreign body is implanted during surgery [1]. The Centers for Disease Control and Prevention (CDC) estimates about 27 million surgical procedures are performed each year in the US, with 290,000 SSI and 8000 deaths related to them [2]. The reporting and prevention of SSI has received widespread attention in recent years as it is deemed to be preventable and is associated with substantial morbidity, prolonged hospital stays, and increased economic burden on the health care system [3,4].

The risk factors for development of SSI include patient factors (comorbidities, malnutrition, obesity), surgical factors (antibiotic prophylaxis, surgical duration, hypothermia) and the operating room (OR) environment [5]. Though most SSI originate from the patient's own flora, airborne contaminants can cause or aggravate SSI [6]. These contaminants and microbial level in the OR are directly proportional to the number of people in the OR [7–10]. In addition, frequent opening of the OR door and movement of people in the OR disrupts the positive–pressure OR environment, thus limiting the effectiveness of OR ventilation [11–13]. This has led the CDC to issue guidelines to limit the number of people in the OR and to limit the number of OR door openings to a minimum [14].

We initiated a two-phase observational study at our institution to examine the OR traffic pattern. The first aim of this study was to record the behavior of OR personnel and human traffic patterns in the OR. The second aim of the study was to determine if surveillance (monitoring) had an effect on the OR traffic pattern.

Materials and Methods

This study was a prospective two-phase observational study conducted in three Pediatric Orthopaedic ORs within our institution. Twenty-six consecutive surgical procedures were observed during a one month period. OR personnel were divided into three groups for the purposes of this study: the surgeon group, the anesthetist group and the nursing group. The surgeon group consisted of operating, assisting and training surgeons, the anesthetist group consisted of anesthetists, nurse anesthetists and their assistants, and the nursing group consisted of scrub nurses, circulating nurses and their assistants.

Phase I of the study was performed over the course of two weeks, during which, a medical student observer recorded the OR traffic pattern. All three groups of OR personnel were blinded to the purpose of the observer. The parameters recorded included: the number of door swings during the surgical procedure, the type and total duration of surgery, the maximum and minimum number of OR personnel in the room during the surgical procedure, number of OR personnel at each 30 minute interval, and any personnel changes (breaks or shift changes) from the surgeon group, anesthetist group or nursing group during the surgical procedure. The first door swing was recorded when the patient was brought into the OR, and the last door swing was recorded when the patient left the OR. The numbers of door swings and OR personnel were recorded using a hand-held tally counter placed in the observer's pocket. The observer and the patient were not included in the total OR personnel count.

The second phase of the study was performed over the two weeks directly following phase I. Before the start of the second phase, all OR personnel were notified about the initiation of a quality control study by personal briefing, and signs on the OR doors. During this phase, the OR personnel were specifically informed about the OR traffic pattern and the parameters that were being recorded for this study. The medical student was introduced as a member of the surveillance team. The same parameters were studied in phase II as were studied in phase I.

All data were recorded in Microsoft Excel (Microsoft Corporation, Redmond, Washington). The data were analyzed using SAS v.9.1.3 (SAS, Cary, NC) software. Distributions of continuous variables were evaluated for normality. Statistically significant differences were assessed using general linear models (GLM) for normally distributed data and results are presented as the mean $\pm$ standard deviation. If non-normally distributed, differences were assessed using the Exact Wilcoxon Two-Sample Test for non-parametric data and results are presented as the median and range. Peak traffic periods were defined by plotting the number of OR personnel against the duration of surgical procedure in 30-minute increments. The correlation between the number of personnel changes in each group (surgeon group, anesthetist group and nursing group) as a function of time was calculated using Spearman's correlation. All tests were two-sided and p -values < 0.05 were considered statistically significant.

Results

During a period of 4 weeks, a total of 4350 minutes of surgical time was observed; 14 surgical procedures totaling 2442 minutes were observed in phase I, and 12 surgical procedures totaling 1908 minutes were observed in phase II. (Table 1)

There were a total of 2887 door swings during the 4350 minutes of surgical time observed. There was no statistically significant difference ($p=0.06$) in the time between door swings between phase I (mean $\pm$ sd: 1.39 minutes $\pm$ 0.39) and phase II (mean $\pm$ sd: 1.70 $\pm$ 0.42), though there was a trend toward an increase in the time between door swing in phase II (Table 2). An observation was made during phase II, that the OR personnel would communicate by opening the door without actually entering the OR, though this did not affect the comparison of number of door swings between the two phases.

There was no difference ($p=1.000$) in the maximum number of people in the OR between phase I (median: 11 people, range: 7 – 15 people) and phase II (median: 11 people, range: 8–20 people). (Table 2) There was no difference ($p=1.000$) in the minimum number of people in the OR between phase I (median: 4.5 people, range: 4–6 people) and phase II (median: 5.0 people, range: 3–6 people). Based on observations every 30 minutes, the number of people in the OR was at a maximum around the middle of the surgical procedure (Figure 1).

When both phases were combined, there was a statistically significant difference ($p=0.03$) in the time between door swings between surgical procedures with duration less than 120 minutes (1.34 minutes $\pm$ 0.41) and more than 120 minutes (1.70 minutes $\pm$ 0.37), i.e. the longer the duration of surgery, the more time between door swings. (Table 3) When both phases were combined, there was a statistically significant difference ($p=0.005$) in the maximum number of people in the OR, between surgical procedures with duration less than 120 minutes (median 10, range: 7–12) and more than 120 minutes (median 12, range: 8–20) (Table 4).

When both phases were combined, there was no statistically significant difference ($p=0.11$) in the time between door swings between spine procedures (1.31 minutes $\pm$ 0.34) and other procedures (1.61 minutes $\pm$ 0.43). (Table 5) When both phases were combined, there was a statistically significant difference ($p=0.002$) in the maximum number of people in the OR, between spine procedures (median 14, range; 11–20) and other procedures (median 11, range: 7–15) (Table 6).

Combining both phases, as the total surgery duration increased, the total number of door swings increased ($\rho = 0.95$, $p < 0.0001$), (Figure 2). As the total surgery duration increased, the maximum number of people in the OR increased ($\rho = 0.68$, $p = 0.0001$). (Figure 3) As the maximum number of people in the OR increased, the total number of door swings increased ($\rho = 0.78$, $p < 0.0001$) (Figure 4).

There was no difference ($p=0.76$) in the personnel changes in the nursing group between phase I (median: 0, range 0 – 3) and phase II (median: 0.5, range 0 – 1). There was no difference ($p=0.47$) in the personnel changes in the anesthetist group between phase I (median: 1, range 0–2) and phase II (median: 1, range 0 – 4). For the surgeon group, there was only one case in Phase II where there was a change; hence this group was not analyzed further.

There was a positive correlation ($\rho=0.6983$, $p < .0001$) between number of personnel changes in the nursing group and total surgical time (Figure 5), i.e., as the duration of the surgical procedure increased, the number of personnel changes in the nursing group increased. Similarly there was a positive correlation ($\rho=0.765$, $p < .0001$) between number of personnel changes in the anesthetist group and total surgical time (Figure 6).

Discussion

Though the CDC has issued guidelines to limit the number of OR door openings to a minimum and to limit the number of people in the OR [14], there is no baseline information on normal or essential OR human traffic. This study provides the baseline human traffic information in Pediatric Orthopaedic ORs. Since there was no significant change in the traffic pattern between the two phases of this study, all traffic could be considered essential. This data can be used to compare OR traffic patterns between specialties, institutions or following an intervention.

It has been shown that OR door opening decreases the effectiveness of the ventilation system to clear potential contaminants [6]. Lynch et. al.[15] reported that three common reasons for OR door openings were information issues (ask question, check on case status, or process paperwork), personnel entering or leaving for breaks, and supply issues. Though we didn't study the reasons for OR door openings, it was observed in phase II, that OR personnel would open the door and communicate, without actually entering or leaving the OR. Though this didn't affect the number of door openings in the study, it does represent an opportunity for improvement. OR personnel (nursing group and anesthetist group) entering or leaving the OR for breaks or shift changes is a frequent cause of concern during a surgical case. As expected, there was a positive correlation between the duration of surgery and number of OR personnel shift changes. The shift change is a frequent cause of distraction and interruption for the operating surgeon, and the transfer of care between OR personnel have been reported to increase the likelihood of medical errors [16]. The supply related OR traffic disruption could be reduced by updated surgeon or procedure specific preference cards, especially for routine cases, and better communication with the OR personnel prior to the procedure.

Ritter [10] found an increase in the bacterial count when the OR door was left open. The proximity of the scrub sink and unsterile corridor have been implicated as the cause of OR contamination, especially when the OR door was open [17]. In the current study, the average number of door swings per hour was approximately 40. This is similar to other studies which have found the average number of door swings per hour to range from 37 [15] to 56 [13]. For a longer case (e.g., spine surgery), which can last for more than 5 hours, the average number of door swings during the entire case could approximate 200. The OR personnel in the current study expressed concern when this information was shared with them.

There was a statistically significant increase in the number of OR personnel when the duration of surgery was greater than 120 minutes and during spine procedures. The explanation is that

certain complex or lengthy surgical procedures, and spine procedures may need more resources and OR personnel (imaging personnel, electro physiologic monitoring personnel, implant representative, surgical assistants) and may have more observers and students, compared to a relatively short procedure. Since the number of OR personnel and duration of surgery are positively correlated to the number of door openings, the rate of traffic during such procedures is remarkably high. Pryor and Messmer [18] analyzed 2864 clean surgical procedures and noted that duration of surgery was a statistically significant risk factor for SSI, and there was a rising trend in SSI, as number of OR personnel increased. Ritter [9,10] recommended that the length of time for surgery and number of OR personnel should be reduced to decrease the environmental contamination.

We observed a trend of increased OR personnel during the middle of the surgical case, especially in longer cases. Lynch et. al. [15] noticed an increase in the number of OR personnel in the pre-incision phase while the patient and room preparation were under way and when the staff were arriving in the OR. We didn't initiate monitoring before the patient was in the room, since we considered the room set up and patient preparation as essential. The observed trend of increased OR personnel in the middle of the case can be attributed to the use of fluoroscopic image guidance and/or electro physiologic monitoring, and the presence of observers and vendor representatives during the middle of a surgical case and not during incision and closure.

The Hawthorne effect refers to the change in performance of subjects due to the knowledge that they are being observed or studied. It was first described by Elton Mayo, a Harvard business professor, during studies of worker productivity at the Hawthorne Works plant near Chicago. This concept has been applied to various scientific experiments like hand hygiene [19], pain assessment [20], or emergency room care [21]. Our current study was performed to evaluate the behavior of OR personnel and human traffic patterns in the OR, and then to determine if there was a Hawthorne effect. Contrary to our expectation, there was no significant change in the number of door swings, maximum or minimum number of people in the OR, or changes in OR personnel in the nursing, anesthetist or surgeon group between the two phases, i.e., before and after surveillance. One reason for lack of Hawthorne effect on OR traffic pattern could be that all traffic was considered necessary by the OR personnel. Another reason could be the lack of reward or motivation and reluctance to any change by the OR personnel which could be typical in larger institutions. To achieve meaningful improvement in the OR traffic pattern, instead of just informing the OR personnel and monitoring them, future studies should include OR personnel as a part of a team in the development of the protocols, and goals and incentives should be a part of the study.

Based on this study and review of literature, several recommendations can be made to decrease the human traffic in the OR. Frequently OR personnel would enter the OR to find out the progress of the case, ask questions, or to process paperwork. The evolvement of 'paperless' hospital practice and introduction of computerized case tracking system, an intercom system or real-time OR video monitoring system would help in efficient communication between personnel outside and inside the OR. A measure as simple as a glass window and phone should be used for informational issues, instead of opening the OR door. The frequent change in shifts or breaks for nursing and anesthetist personnel during surgical case does not only increase the OR traffic but frequently causes distraction during a procedure. How common is it that the surgical case may just have started, and there is a change in staff? A surgical coordinator should be responsible for assigning the staff in a way that the need to switch nurses or anesthesia providers, especially during a short case, is minimized. Though all the supplies that a surgeon would need during surgery cannot be anticipated, frequently used supplies like sutures should be stored in the OR console. The surgeon and procedure-specific preference cards should be kept updated, so that the supplies and equipments needed for a particular case are readily available in the OR. Preoperative communication with the surgeon about specific requirements

is imperative. An efficient way of minimizing OR traffic related to supplies would be placement of pass-through windows in the OR, thus allowing access to the supplies from inside and outside the OR with minimal traffic disruption. Visitors, observers and vendors should be educated about the importance of OR traffic. Though medical students and observers should get the opportunity to observe surgical cases, their numbers should be limited during each procedure. For complex cases or high-risk cases like joint replacement, spine surgeries or revision procedures, a sign on the door cautioning the OR personnel against entering the OR, should be encouraged. An option to decrease the number of door swings during the case would be to have an automatic door counter above the door, visible to OR personnel and then set goals on a periodic basis to facilitate improvement in the OR traffic pattern. Surgical quality improvement projects should include the OR traffic pattern as an important parameter.

One limitation of the study is its small sample size and it being limited to Pediatric Orthopaedic ORs at one institution. This study was initiated as a pilot study to achieve baseline information about OR traffic patterns and to study the effect of human surveillance. Future projects should include all surgical specialties and more sophisticated data collection. Another limitation of the study is the lack of correlation of studied parameters to OR contamination, patient factors and outcomes and thus SSI. In future studies, a patient tracking system should be incorporated within the OR traffic data collection, as it might lead to more meaningful conclusions. Also, in future studies, the OR personnel should be included as a part of study or monitoring team.

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Figure 1.
Number of People in the Room at 30 Minute Intervals

Figure 2.
Number of Door Swings vs. Total Time

Figure 3.
Maximum Number of People vs. Total Time

Figure 4.
Maximum Number of People vs. Door Swings

Figure 5.
Correlation between changes in the OR personnel in the nursing group and total surgical time

Figure 6.
Correlation between changes in the OR personnel in the anesthetist group and total surgical time

Table 1

Phase I		Total Time (in minutes)	# of Door Swings	Maximum People	Minimum People	Nursing Change	Anesthetist Change	Surgeon Change
Case	Procedure							
1	Elbow	51	31	7	4	0	0	0
2	Ankle/Foot	73	77	10	5	0	1	0
3	Spine	78	116	11	4	0	1	0
4	Spine	350	216	14	4	2	2	0
5	Forearm	230	121	14	4	1	1	0
6	Hip	93	55	10	5	0	0	0
7	Ankle	67	59	11	6	0	0	0
8	Elbow	70	53	11	6	1	0	0
9	Spine	335	248	14	4	2	1	0
10	Forearm	224	117	12	5	0	2	0
11	Wrist	61	48	9	4	0	1	0
12	Spine	310	188	12	5	2	2	0
13	Forearm	40	48	11	6	0	0	0
14	Hip	460	305	15	4	3	2	0
Total		2442	1682					
Phase II		Total Time (in minutes)	# of Door Swings	Maximum People	Minimum People	Nursing Change	Anesthetist Change	Surgeon Change
Case	Procedure							
15	Spine	332	277	20	6	1	1	0
16	Knee	178	80	11	6	0	1	0
17	Knee	231	126	11	4	1	2	0
18	Forearm	68	44	10	5	0	0	0
19	Tibia	123	62	9	4	1	3	0
20	Ankle	197	81	8	3	1	4	0
21	Tibia	65	36	9	4	0	0	0
22	Hip	131	91	11	4	0	2	0
23	Forearm	55	46	12	5	1	0	0

Phase I												
Case	Procedure	Total Time (in minutes)	# of Door Swings	Maximum People	Minimum People	Nursing Change	Anesthetist Change	Surgeon Change				
24	Foot	47	23	10	5	0	0	0				
25	Spine	358	236	15	5	1	4	2				
26	Spine	123	103	12	5	0	1	0				
Total		1908	1205									

Table 2

Time per door swing and number of people in the OR during the study

	No of cases	Total surgical time (minutes)	No of door swings	Time per door swing in minutes	Minimum no of people (median[range])	Maximum no of people (median[range])
Phase I	14	2442	1682	1.39 (0.39)	4.5 [4,6]	11 [7,15]
Phase II	12	1908	1205	1.70 (0.42)	5 [3,6]	11 [8,20]
Combined	26	4350	2887	1.5	5[3,6]	11 [7,20]

Time per door swing is expressed as mean (standard deviation)

Table 3

Number of minutes per door swing, analyzed by surgical duration

	Less than 120 minutes	More than 120 minutes	P value
Phase I	1.19 (0.11) n = 8	1.66 (0.13) n = 6	0.0173*
Phase II	1.65 (0.22) n = 4	1.73 (0.15) n = 8	0.7699
Combined	1.34 (0.41) n = 12	1.70 (0.37) n = 14	0.0297*

n = number of surgical cases

all values are least square mean (standard deviation)

* statistically significant

Table 4

Maximum number of people in the OR, analyzed by surgical duration

	Less than 120 minutes	More than 120 minutes	P value
Phase I	10.5 (7–11) n = 8	14 (12–15) n = 6	<0.0001 *
Phase II	10 (9–12) n = 4	11 (8–20) n = 8	0.4283
Combined	10 (7–12) n = 12	12 (8–20) n = 14	0.0052 *

n = number of surgical cases
all values are median (range)

* statistically significant

Table 5

Number of minutes per door swing, analyzed by type of surgical procedure

	Spine surgery	Other surgery	P value
Phase I	1.32 (0.20) n = 4	1.42 (0.13) n = 10	0.6981
Phase II	1.30 (0.21) n = 3	1.83 (0.12) n = 9	0.0513
Combined	1.31 (0.34) n = 7	1.61 (0.43) n = 19	0.1108

n = number of surgical cases

all values are least square mean (standard deviation)

Table 6

Maximum number of people in the OR, analyzed by type of surgery

	Spine surgery	Other surgery	P value
Phase I	13 (11–14) n = 4	11 (7–15) n = 10	0.1658
Phase II	15 (12–20) n = 3	10 (8–12) n = 9	0.0136*
Combined	14 (11–20) n = 7	11 (7–15) n = 19	0.0024*

n = number of surgical cases
all values are median (range)

* statistically significant