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Major Article

Operating room traffic in total joint arthroplasty: Identifying patterns and training the team to keep the door shut

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Background: Surgical site infections after joint arthroplasty are devastating complications and are influenced by patient, surgical, and operating room environmental factors.

Methods: In an effort to reduce the incidence of door openings (DOs) during total joint arthroplasty cases, this prospective observational study consisted of 3 phases. Phase 1 determined the baseline incidence of DOs, followed by installation of a mechanical door counter (phase 2). Finally, an educational seminar was presented to all personnel (phase 3) regarding the implications frequent DOs have on patient and surgical outcomes.

Results: The average openings per case (OPC) for each of the 3 phases were 33.5, 34.2, and 27.7, respectively. There was a 17% reduction in OPC between phases 1 and 3 ($P = .02$). There were no significant differences between knee and hip arthroplasty cases during the 3 phases ($P = .21$, $P = .46$, and $P = .81$, respectively). There was a strong correlation between length of surgery and OPC, with a Pearson coefficient of $r = 0.87$ during phase 3. To account for differences in average operative time between phases, data were normalized for the length of surgery with the ratio of door openings per minute determined (0.36, 0.34, and 0.32 for each phase, respectively).

Conclusions: We were able to show that simply monitoring door openings during joint arthroplasty was not effective in reducing the occurrences. However, after a novel educational seminar given to all personnel, we were able to significantly reduce the incidence of operating room door openings, reducing a potential risk factor for surgical site infections.

BACKGROUND

Surgical site infections after orthopedic surgeries are a devastating complication and can range from small suture abscesses to deep tissue infections, such as periprosthetic joint infections and fulminant sepsis. Infection after total joint arthroplasty is a destructive problem that rapidly expends patient, surgeon, and institutional resources.[1] It has been projected that >3.5 million primary total joint arthroplasties will be performed annually by 2030.[2] With an incidence of infection between 1% and 7%, arthroplasty surgeons can expect a cumulative rate of increase between 2012 and 2030 of 306% for revision total knee arthroplasty alone.[2-8] Amidst the national debate of health care costs, measures to prevent infection are of utmost importance to help reduce these burdens because the annual cost of infected revisions is projected to reach $1.6 billion by 2020.[9]

The development of surgical site infections is multifactorial. Strategies to minimize these complications are focused on 3 key areas: the patient, the surgical techniques, and the operating room (OR) environment.[10] Laminar airflow (LAF), exhaust suits, ultraviolet light, and OR traffic control are several factors within the OR environment that have been studied to reduce airborne bacterial contamination.[11-15] Frequent OR door opening disrupts the LAF, changing the dynamics of the airflow pattern, and ultimately resulting in the quicker spread of airborne organisms.[9,16]

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The focus of this study was to determine whether an educational intervention could effectively decrease the number of door openings during a total joint procedure. We initiated a 3-phase observational study to examine the OR traffic pattern. The first phase was primarily to determine the baseline incidence of OR door openings, followed by a second phase where door counters were installed on the OR doors to count the number of door openings and raise awareness. The final phase was conducted after an educational seminar given to all OR personnel, informing them of the potential implications door openings have on patient and surgical outcomes and strategies to reduce door openings. There have been several studies in the literature reporting the incidence of door openings during total joint arthroplasty; however, to our knowledge, this is the first study to use an intervention to actively reduce door openings and compare the effect of the intervention on the number of door openings per case (OPC).[9,10,16-20]

MATERIALS AND METHODS

This study was prospectively designed as a 3-phase study to examine the patterns of door openings in 2 hip and knee replacement ORs. These 2 ORs are specifically designed for total joint arthroplasty and are used by 4 different surgeons 4-5 d/wk. The doors to the OR open to a sterile core area, not to a public space. Only primary and revision total hip and knee surgeries were included in this study. Other cases, such as arthroscopy, fracture fixation, manipulation, or irrigation and debridement, were excluded. Our institutional review board approved the study and protocol.

Prior to initiating the study, one of the study personnel observed a pilot series of cases in person to gauge the number of OPC. Sample size was calculated based on the pilot data that demonstrated a mean of 23.5 OPC, with an SD of 7.9. Using these data, a power analysis was performed to determine the number of study cases required to measure a significant difference if the average number of door openings was reduced by 4. For a power of 95% and an α of 0.05, a sample size of at least 50 cases per phase was required to show a significant change.

Preexisting video cameras that could visualize the doors and most of the room were used to videotape the door openings for all cases. The video cameras were controlled remotely, and files were saved to an external hard drive. Personnel were not aware of the counting, and no additional door openings were created by using the cameras. In phase 1, the cameras were used to record a baseline number of OPC as a control group. All consecutive primary and revision total joint arthroplasties (n = 85) over the course of 19 days were recorded. In phase 2, door counters were installed on each of the 2 doors that personnel use to enter and exit the OR. A second consecutive set of cases was then recorded (n = 92 over 21 days). The purpose of the door counters was to passively raise awareness that openings were being monitored; however, data from the video cameras were still used to count the number of OPC. To begin phase 3, an educational forum was held to teach staff about reducing OR traffic and door openings. The principal surgeon investigator and the director of infection control for the hospital attended the monthly OR staff meeting. A handout was distributed and a verbal presentation was given emphasizing the rationale and the need to reduce door openings during cases. Reasons behind limiting door openings in the OR were discussed, including the interruption of intended airflow resulting in turbulence and risk of surgical field contamination. In addition, relevant literature was presented that documented the risk of increased airborne microbial counts and infection because of increased door openings. Common reasons for frequent door openings were also discussed, such as vendor supplies, personnel breaks, and social/nonessential door openings with emphasis on reducing the latter. After the educational intervention, a third set of consecutive cases was then recorded (n = 87 over 22 days).

After recording all cases, one individual watched the videos and counted the number of door openings for each case, from the time of skin incision to closure. Each door opening was attributed to a surgeon, physician assistant, anesthesia provider, nurse, or industry representative.

RESULTS

In phase 1, the baseline measure of OR traffic, there were an average of 33.5 OPC (range, 10-88). In phase 2, in which door counters were mounted, there was no significant change in door openings ($P = .075$) with an average OPC of 34.2 (range, 7-141). Phase 3, which measured door openings after educating staff and vendors, had an average of 27.7 OPC (range, 7-93). Table 1 shows a comparison of the 3 phases for the whole study group and subgroups by joint, revision status, case order, and length of surgery. The average number of door openings was reduced by 17% between phase 1 and phase 3 ($P = .02$), and the SD decreased from 17.7 to 14.7.

There were no significant differences in the number of door openings regarding procedure type (total hip vs knee arthroplasty) in phase 1 ($P = .21$), phase 2 ($P = .46$), or phase 3 ($P = .81$). The largest improvement was noticed between phases 1 and 3 in hip arthroplasty cases, which improved from 34.8 OPC to 27.4 OPC ($P = .03$).

As shown in Table 1, revision cases resulted in approximately twice as many door openings as primary cases, which was significant in all 3 phases of the study ($P < .0001$). In a similar manner, cases performed earlier in the day, predominantly primary cases, tended to have fewer OPC than cases performed at the end of the day, which often included revision cases (Table 1).

The effect of the length of surgery on the number of door openings during a case is demonstrated in Table 2. Using the Pearson test for correlation, we found a very strong positive correlation between the operative time and the number of door openings. In phase 1, the Pearson coefficient was 0.79, and in phase 3, it was even stronger with a correlation coefficient of $r = 0.87$ (Fig 1). To account for changes in average operative time between phases, the data were normalized for the length of surgery. The frequency of door openings was reduced from an average of one door opening every 2.8 minutes in phase 1 to every 3.1 minutes in phase 3. Conversely, in phase 1, there were an average of 0.36 door openings per minute

Table 1
Average door openings per case for each phase and for subgroups

Subgroups	Phase 1 (n = 85)	Phase 2 (n = 92)	Phase 3 (n = 87)
Average door openings ± SD	33.5 ± 17.7	34.2 ± 24.9	27.7 ± 14.7
Total hip arthroplasty	34.8	35.7	27.4
Total knee arthroplasty	29.2	31.4	28.2
Primaries	28.2	28.3	24.9
Revisions	59.3	66.5	47
Case order (% revisions)			
First case of the day	26.5 (0)	32.3 (7)	25.3 (0)
Second case of the day	30.2 (3)	27 (3)	24.3 (6)
Third case of the day	46.4 (48)	46 (43)	35.7 (35)
Fourth case of the day	45 (100)	0 (0)	37 (100)

Table 2
Time is a driving factor in door opening

Parameters	Phase 1	Phase 2	Phase 3
Average skin-to-skin time	1:34	1:41	1:27
Correlation *r*	0.79	0.84	0.87
Ratio of minutes per door opening	2.8	2.9	3.14
Door openings per minute	0.36	0.34	0.32