

Interdisciplinary Work Flow Assessment and Redesign Decreases Operating Room Turnover Time and Allows for Additional Caseload

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Hypothesis: Operating room turnover time (TOT) and daily caseload can be improved by analyzing the routine tasks of the operating team and minimizing inefficiencies.

Design: In this prospective study, the assigned tasks and work flow patterns of the anesthesiologist, circulating nurse, and surgical technologist during operations and operating room turnover were studied and changes were implemented where inefficiencies were observed. A brief pilot followed by a broader-scale study was conducted.

Setting: Tertiary care center.

Participants: Circulating nurses and surgical technicians were routinely assigned to work with one anesthesiologist and one surgeon during the pilot study; 4 surgeons and 32 anesthesiologists participated in the follow-up study.

Interventions: The work flow diagram of each indi-

vidual was redrawn, and changes were implemented. Critical moments were identified, in which brief assistance from other personnel was needed to improve efficiency.

Main Outcome Measures: Operative TOT and number of daily operations were the main outcomes. A 2-tailed *t* test was used to compare the TOTs; χ^2 analysis was used to compare the number of cases completed. Significance was defined as $P < .05$.

Results: A total of 401 operations and 253 turnovers were evaluated. Redesign decreased operating room TOT from 43.7 to 27.7 minutes ($P < .001$). The mean number of cases completed per day increased from 1.78 to 2.34 ($P < .001$).

Conclusion: Interdisciplinary work flow assessment and redesign resulted in decreased operating room TOTs and additional cases being completed each day for 4 different surgeons.

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IMPROVING OPERATING ROOM (OR) efficiency is critical to the economic viability of the institutions and the physicians. It is estimated that for every operative month, the equivalent of 5 working days are wasted through a combination of factors, including inappropriate patient preparation, insufficient staffing (surgeons, anesthesiologists, and nurses), OR reassignment to emergency cases, and congestion in the postanesthesia care unit.¹

The time required preparing the OR for the next case, the turnover time (TOT), has also been the subject of many OR committee discussions and a modest amount of research. Surgeons advocate that reductions in TOT would lead to increased surgical caseloads; however, this argument does not necessarily follow. For example, in a day with two 3-hour-long cases,

even a massive reduction in TOTs from 70 to 40 minutes would only yield an improvement of 30 minutes, and would still not allow for the addition of a third case. In fact, Dexter et al² have delineated the thought process behind that argument eloquently and conclude that reducing the TOT is generally only important when multiple operations of short duration are anticipated.

See Invited Critique at end of article

Rather than compartmentalize the inefficiency into the TOT, we have observed much variable efficiency during and between cases. In particular, there are times during an operation when the circulating nurse is extremely busy, but other times

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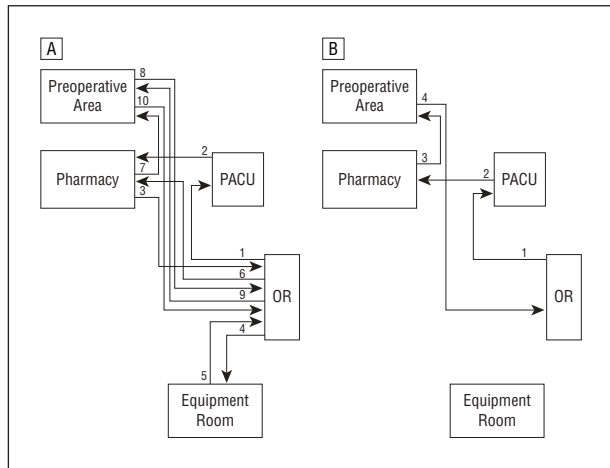


Figure 1. Work flow diagram of the anesthesiology resident before (A) and after (B) initiation of the transition to practice (TTP) program. In A, the anesthesiology resident was observed to move between 5 different locations, for a total of 10 times on any given case, before the restructuring. On initiation of the TTP program, the equipment technicians became involved in assisting with turnover and the resident could concentrate on moving from the operating room (OR) to the preoperative area, which is geographically immediately next to the pharmacy and the postanesthesia care unit (PACU). The pharmacy would accept the return medications and assign the medications for the next operation at the same time, also saving a step.

the nurse is not busy at all. The same can be said of the surgical technician. Our goal was to observe these factors and identify possible interventions that would allow the use of the existing personnel to enhance overall interoperative and intraoperative efficiency.

METHODS

THE ENVIRONMENT

This study takes place in a tertiary care center, a university-based teaching hospital. Our theoretic first case start time is 8 AM. Surgical and anesthesia residents rotate through the services represented in the study, with no specific training level and a wide variety of individual experience.

OBSERVATION PERIOD

The anesthesiologist investigated and observed the assigned tasks and work flow patterns of the anesthesiology resident, circulating nurse, and surgical technologist during OR turnover for the duration of the baseline observation period (November 5 to December 19, 2003). These work flow diagrams were then shared with team leaders for each profession who then redesigned the turnover process by (1) rescheduling nonturnover tasks to non-TOT periods and (2) improving the notification and use of existing support staff.

PILOT STUDY PERIOD

The pilot study was conducted with 1 attending anesthesiologist (M.G.) and 1 surgeon (J.C.C.). The pilot study cases reflected a general surgical practice, and no conscious efforts were made to alter the case type. A variety of ancillary support staff was trained. Individual circulating nurses and scrub technicians were not singled out to participate; rather, we used the ancillary staff that generally worked in these rooms.

For the pilot study, the represented cases reflect only the days that these 2 individuals worked together. New work flow diagrams were then established and implemented for the study participants. A transitional month (January 2004) was allowed to train staff, and the pilot study period was chosen to be February 6 to March 9, 2004. The staff was aware that a study in efficiency was under way. Operating room logs for these periods were reviewed for OR start time (first case start), duration of the surgical component of the case, duration of the anesthesia and preparation component of the case, TOT, and number of cases completed in a given operative day. A 2-tailed *t* test was used to compare all time-based statistics; χ^2 analysis was used to compare the completed number of cases per day before and after initiation of the new scheme. The null hypothesis was that initiation of the new protocol would not produce any improvement in the times being measured or the number of cases; the significance chosen was $P < .05$.

LARGE-SCALE STUDY PERIOD

Once satisfied that the intervention improved TOT, we expanded the program to include 4 ORs, running daily. The intervention was modified to become a particular clinical rotation for the anesthesia residents, which we have termed *transition to practice*. In this model, we chose to use senior-level anesthesia residents, and we charged them with the responsibility to keep the cases moving ahead while using the work flow redesign previously described. The anesthesia residents were scored on their performance, although they did not receive a grade per se. The surgeons involved in the transition to practice rooms were chosen because they tended to have many short-to medium-duration cases (ie, involving several daily turnovers) and, in theory, would benefit most from this type of intervention. More than 50 surgeons have had the opportunity to participate in this environment; however, only 7 surgeons have had more than 25 cases in the new model. We opted to limit the present report to include those surgeons with more than 25 cases in the transition to practice model who also had only 1 OR to work in (ie, we excluded surgeons who tended to “swing” cases into free/available rooms because the TOT was impossible to evaluate). Thus, 4 surgeons’ experiences are reported herein. They include 1 general surgeon (A), 1 surgical breast oncologist (B), and 2 gynecologic oncologists (C and D), whom we included because they function as one (ie, one surgeon always follows the other in the same room); we were interested to see if the TOT efficiency could be maintained when several surgeons used the same room. The number of daily cases and the TOT were recorded for these surgeons for January 5 to March 30, 2004, and compared with the study period of January 4 to March 30, 2005.

WORK FLOW REDESIGN

Initial Observations

Anesthesiologist. During the observation period, the anesthesiologist was responsible for 10 separate functions. These functions required moving between 5 separate physical locations (**Figure 1**). In particular, some functions were purely repetitive (check if OR was ready) and some were responsibilities that could easily be handled by existing technical staff who merely needed to be instructed to perform the functions.

Circulating Nurse. The circulating nurse also had 10 different functions related to each case, and frequently in as many as 7 different locations (**Figure 2**). Several steps in the process were par-

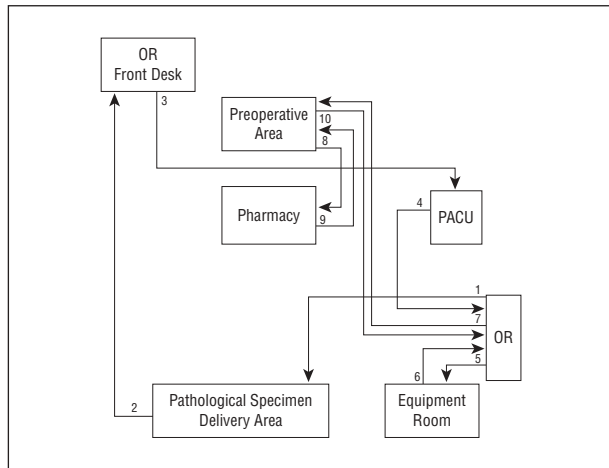


Figure 2. Circulating nurse work flow diagram. The numbered sequential work effort of the circulating nurse is presented. The transition to practice–implemented changes allowed the nurse to do the same tasks during the final 10 to 15 minutes of any operation by having a separate nurse step in for the circulator during the wound closure. In effect, the processes were translated to the intraoperative, instead of the interoperative, time frame. OR indicates operating room; PACU, postanesthesia care unit.

ticularly inefficient: (1) delivery of pathological specimens, (2) picking up medications, and (3) assessing the next patient in the preoperative holding area. There was no specific metric for these observations, merely that there was wide variability from one nurse to the other and that, overall, we believed that with an established protocol some of these steps could be carried out during the ongoing operation, improving turnover.

Scrub Technician. The scrub technician had 4 responsibilities at 3 different sites (**Figure 3**). The movements of this team member were limited, and did not present us with any significant efficiency intervention.

Implementation of the Intervention

Anesthesiologist. Four responsibilities were redirected to existing anesthesia technical staff. These included returning to the OR and going to the equipment room to set up the next case. Equipment and supplies for the next case were arranged during the existing case, before leaving the room with the current patient. This resulted in a further loss of 2 unnecessary trips back to the OR to check if it was ready. Finally, the anesthesiology resident was asked to be diligent about notifying the anesthesia technician of impending room turnover as soon as surgery closure was complete, because anesthesia emergence began to facilitate the room switch. The anesthesia technician then completes the room turnover while the anesthesiologist takes the current patient to the postanesthesia care unit, proceeds to the pharmacy to pick up medications, and returns to the OR with the next patient (**Figure 1**).

Circulating Nurse. The role of the circulating nurse was completely redefined. Assuming the circulating nurse was able to (1) deliver pathological specimens, (2) pick up medications, and (3) assess the next patient in the preoperative holding area during closure of the present case and that there are no pending care issues with the next patient (consent or history and physical), the circulating nurse would remain in the OR during turnover to prepare for the next case. In this setting, the circulating nurse is doing the orchestration for which the anesthesiologist was initially responsible. To achieve these goals, the preoperative holding area

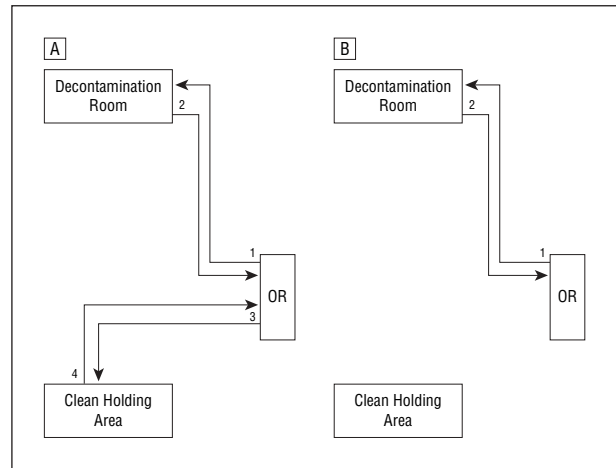


Figure 3. Diagrams depicting the numbered sequential work flow of the scrub technician before (A) and after (B) restructuring. The scrub technician was spared from having to go to the clean holding area by implementing a system whereby the equipment needed for the upcoming case is prepared the evening before and positioned next to the operative suite. OR indicates operating room.

nurse was asked to call the circulating nurse in the OR immediately on arrival of the next patient to the preoperative holding area. The circulating nurse would then arrange momentary coverage with the charge nurse during surgery closure to be able to deliver specimens to pathology, obtain medications from the pharmacy for the next patient, and check in the next patient in the preoperative holding area. The circulating nurse would not be responsible for delivering the printed operative record to the postanesthesia care unit. Retrieval and delivery of the operative record was eliminated as a work task by using electronic signature and document transmission. Again, coordination with the turnover assistants, in this case, the patient service technician, of impending room turnover as soon as surgery closure was imminent would be needed.

Scrub Technician. The scrub technician was infrequently the observed cause for delay and there was only 1 observed possible efficiency-related change implemented. By having the patient service technician bring the OR patient's cart (clean instruments and supplies) to the OR, we allow the scrub technician to take the dirty instruments to decontamination and then return to the OR directly (**Figure 3**).

RESULTS

PILOT STUDY

The observation period was 2 months long. During this time, 14 surgical dates were reviewed, with 30 cases completed. The range of cases was from 1 to 3 on any given date, with a mean \pm SD of 2.14 ± 0.66 cases per day. The study period was also 2 months long. During this time, 12 surgical dates were reviewed, with 38 cases completed. Following the intervention, the cases completed ranged from 2 to 4 per day (mean \pm SD, 3.17 ± 0.63 ; $P = .009$).

The OR turnover was a mean \pm SD of 52 ± 27 minutes, and improved to 16 ± 10 minutes following implementation of the new protocols ($P < .001$). Because the number of cases per day increased, the data reflect 16 room

Table. Data for 4 Surgeons Before and After TTP*

Surgeon†	Before TTP	After TTP	P Value
A (n = 105)			
TOT, min	40.0 ± 17.5	24.2 ± 13.3	<.001
Caseload per day	1.68 ± 0.70	2.48 ± 1.10	<.001
B (n = 60)			
TOT, min	45.6 ± 31.6	31.8 ± 15.1	.04
Caseload per day	2.27 ± 0.90	3.25 ± 0.70	<.001
C (n = 48)			
TOT, min	44.7 ± 18.6	31.2 ± 17.8	.01
Caseload per day	2.11 ± 1.10	1.80 ± 0.90	.44
D (n = 38)			
TOT, min	42.2 ± 16.2	32.4 ± 11.7	.05
Caseload per day	1.33 ± 0.50	1.71 ± 0.60	.09
C and D‡			
Caseload per day	1.50 ± 0.65	1.88 ± 0.80	.05

Abbreviations: TOT, turnover time; TTP, transition to practice.

*Unless otherwise indicated, data are given as mean ± SD.

†Data in parentheses indicate the number of cases.

‡These 2 surgeons generally follow one another in the same room, have similar caseloads, and effectively function as one individual.

turnovers from the evaluation and 26 room turnovers from the study period.

LARGE-SCALE STUDY

A total of 401 operations and 253 TOTs were included in the large-scale study. Taken together, the 4 surgeons generally completed a mean ± SD of 1.78 ± 0.81 cases per day before initiation of the transition to practice model; this daily caseload improved to 2.34 ± 1.03 ($P < .001$) once the model was implemented. Improvement in daily caseload was observed for surgeons A, B, and D; no change was noted for surgeon C. Improvement in caseload was noted for 3 of the 4 surgeons when considered individually; in addition, if surgeons C and D were considered as one (as they follow each other in the same room) the improvement persisted (**Table**).

The TOT was also improved for all study surgeons, from a mean ± SD of 43.7 ± 23.3 minutes before the new protocols to 27.7 ± 14.6 minutes after initiation of the protocols ($P < .001$) (Table).

COMMENT

Improving the efficiency of the OR makes sense for the hospital, the anesthesiologist, and the surgeon.³ These goals are shared by academic health centers and private-sector hospitals. In the academic environment, the need to achieve academic goals while fulfilling departmental fiscal objectives and the real decrease in assistance from resident staff have compounded the problem. One further observation is that the care team involves the physicians and the nurses, but the nurses are employed, generally, by a different entity. Thus, the pressure to provide rapid turnover is not the same for the physicians as it is for the nurses, and we were not hopeful that we would be able to affect much change in this setting. In fact, the observational and interventional phase

of this study relied heavily on our principal circulating nurses and team leaders from each profession, who were asked to redesign their own work flow to minimize redundancy and improve efficiency. Traditionally in health care, there is a tendency for OR management to redesign work flow processes directly or to use external or even internal consultants to assess and reengineer the OR work flow. In our study, we simply shared with the nursing and technician leaders our goal of reducing TOT in an attempt to complete an additional surgical case each day. They, in turn, provided various improvement suggestions, which, when implemented, were the changes primarily responsible for the significant reduction in OR TOT.

Several observations arose from this study. Of particular interest is that once the anesthesiologist and the surgeon observed that turnover was in fact much improved, the surgeon began to schedule more cases for any given day, increasing essentially by 1 additional case of 1 hour 30 minutes' mean duration in the pilot part of the study and maintained throughout the study at approximately a half extra case per day for all surgeons. Like Dexter et al,² we found that brief operations can be added to the day as TOT efficiency improves. We believe this reflects some of the psychology of the underlying problem (ie, an environment of poor turnover affects the desire to schedule more cases because surgeons see themselves as the only persons of the care triad left after 5 PM). Three of the surgeons incorporated in this study have an open practice, which is reflected in a large variety of cases; one of the surgeons (surgeon B) is a surgical breast oncologist and has in essence a "boutique" practice. All benefited from improvements in turnover and larger caseloads. We believe that the OR throughput problem is a multifactorial one, and all involved must be harnessed to yield improvements. Mathematical models reveal that the anesthesiologist alone cannot cure the problem,⁴ and we agree with that finding.

Although there is no real metric for this observation, we believe that the most critical changes were as follows. (1) Communication between the anesthesia resident and the anesthesia technician was improved; when appropriately timed, the resident can leave the technician in the room to set up for the next case while the resident proceeds to the postanesthesia care unit-pharmacy area. (2) The circulating nurse was liberated during the final 10 to 15 minutes (during closure) by the secondary charge nurse; this allows for many critical steps to occur during, rather than between, cases. (3) The anticipation that the next case was upcoming also affected the surgical team, who would then not wander to their offices or make rounds between cases, allowing the next case to start right away. We also observed that existing resources, human and computer based, could be used to implement these changes. Existing staff was interested in giving insight to improve efficiency and then to implement the new protocols.

There were several important weaknesses in this study. Costs and revenues were not specifically addressed. There were some increased OR costs associated with the reengineered work flow. Specifically, a

second OR nurse was needed in the study OR for approximately 15 minutes during the closure of each case so that the primary circulating nurse could leave to deliver pathological specimens, check in the next patient, and pick up medications needed for the next patient. This relief task was assigned to the secondary OR charge nurse. Although not specifically measured, the OR nursing leadership believed the investment of 30 to 45 minutes during the day per room involved in the study of nursing staff costs was small compared with the hospital revenue generated by completing additional surgical cases.

During the pilot study, many of the participants became distressed by what was described as too brief a TOT (16 minutes); however, the staff informally agreed that our eventual 20- to 25-minute TOT was indeed sustainable. A further weakness in the design is that the study was not blinded and the staff involved knew that the TOT was being scrutinized; although we believe that this was the principal bias in the pilot study, the broader study included 4 surgeons and 32 anesthesia attending staff, spanned several hundred operations, and represented various cases, which we believe corresponds to a less biased data set. The mean duration of operations (incision to dressing time) in the study period varied from 1 hour 23 minutes to 1 hour 46 minutes by surgeon. We did not include surgeons whose principal practice is that of lengthy operations, because we believe that the benefit to this model is for ORs assigned to multiple procedures or multiple surgeons in rapid sequence; simplistically, if you spare 15 to 20 minutes 3 or 4 times a day, you can perform 1 more operation. Surgeons whose practice in-

volves lengthy preoperative luminal access, epidurals, and the like warrant evaluation for different efficiency improvements.

In conclusion, we found that analyzing the interactions between the anesthesiologist, the scrub technician, and the circulator yielded opportunities in which, with little or no expense, turnover was improved and the surgeon felt comfortable that scheduling more cases would not translate to running over the time that the OR was maximally staffed.

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