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Core competencies

Efficiency of the operating room suite

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Abstract

Background: The need to control high costs of running operating rooms while providing for timely patient care led us to assess the time wasted in the operating room (OR).

Methods: OR use by two general surgery and two orthopedic departments in a metropolitan public hospital were analyzed, and the time elapsed when a scheduled OR remained unused or the patient was still awaiting surgery was measured.

Results: OR "time-waste" defined as the time in which the scheduled OR was not busy with the scheduled patient amounted to 79 hours over the 30-day study period (15% of total time). It was wasted owing to inappropriately prepared patients (12%), unavailability of surgeons (7%), insufficient nursing staff, anesthesiologists, or OR assignment to emergency surgery (59%), congestion of the postanesthesia care unit (10%), and delay in transport to the OR (2%) Another issue delineated was the frequent occurrence of surgical cases running longer than their scheduled time (termed "spill-over"), outrunning the staffing expectations after 3:00 PM and delaying admission of add-on and emergency procedures, adding 33% to the time wasted. A quality-assurance committee review resulted in implementation of new guidelines, and within 3 months several underlying causes were rectified, and time-waste and spill over time was reduced by 35%. Surgical time predictions were also improved. Shortage of nurses and anesthesiologists, and OR emergency reassignment remained the major causes of OR waste time.

Conclusions: Continuous surveillance on OR suite—patients' prompt care, repeated evaluation, and wise staff deployment—could maximize OR efficiency.

Keywords: Operating room; Costs; Time management

Several studies have proposed strategies for cost saving in the surgical unit [1,2] and in the department of anesthesiology. The departments have historically been expensive to run because of their costly equipment and medication and their specialized nursing and medical staff [3]. While anesthesiology departments, which manage the surgical units in many institutions, can economize by reducing acquisition of new brands of medication, decreasing stocks, and selecting less expensive medications [4], these savings can only partially reduce costs in the operating room (OR).

Accurate scheduling of operations [1], matching needs with availability of room and staff, and efficient utilization of the surgical unit [2,5] can provide appropriate and accessible service to patients even with limited resources. These are the responsibilities of the director of the OR, who decides on the activity in the ORs and on the OR's allocation to urgent needs, and assigns the medical staff. The nurse in charge of the OR is usually autonomous in the management of activities pertaining to nursing within the unit, but the anesthesiologist in charge makes the final medical decisions. The ORs are staffed in advance or ad hoc according to the available manpower and the special skills required for any given procedure.

Recent studies have evaluated OR efficiency, mainly by analyzing the causes of first case delays [6] or the survival of trauma patients [2]. However, these and other data were criticized because it became clear that the most significant barrier to real cost reduction in the OR is waste of surgical operating time [7].

Our objective was to evaluate the possible existence of periods of OR inactivity, ie, to measure the time wasted when an operating room was not employed despite its use

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being scheduled for a given patient by one of the surgical departments, and to analyze what causes this waste and its impact on OR-related performance and cost.

Methods

The study was performed prospectively in a surgical suite consisting of 10 ORs in a metropolitan teaching public medical center, and focused on two general surgery and two orthopedic departments that account for more than 70% of the surgical volume. It was conducted over 30 days that were randomly selected from 90 working days, excluding weekends and holidays. The study period also included on call days, in which the relevant departments were receiving all new emergency room admissions, thus obviating the influence of specific departmental tasks, number of people on call or their professional levels.

The possible impact of time delays secondary to patient transport, reception in the OR holding area, congestion of the postanesthesia care unit (PACU), and the availability of nurses, anesthesiologists, and surgeons on the OR's nonutilization was assessed as follows. Underuse of the OR, defined as the condition in which an OR was not employed while a patient awaited surgery, was evaluated ("underuse"). In addition, the amount of time a surgical department exceeded their allotted time in the OR because of unexpected prolongation of surgery or any other reason ("spill-over time") was measured. This was also considered inefficient use of OR time because staffing was not available to start other afternoon scheduled or emergent cases. The subefficiency of the surgical unit was calculated by adding spill-over time to the underuse time.

Data were collected in real time by a research assistant who attended the OR unannounced. The OR office provided data on the schedule of operations as requested by the departments for elective and emergency surgery as well as times of admission to the holding area, the OR, and the PACU. The observer followed every case from the scheduled start time until the patient was transferred to the ward or intensive care unit (ICU).

At the end of the 30-day study, a quality assurance (QA) team consisting of an anesthesiologist, a surgeon, a nurse, and a production engineer analyzed the causes of wasted time and propose remedies. These were summarized and distributed among departmental chairs, and subsequently guidelines were disseminated. Three months later, data were collected again, over a period of 10 individual days, arbitrarily chosen within a 1 month period, under the same conditions used in the first phase of the study.

The patient's itinerary from the time the decision was made to operate until discharge from the PACU is illustrated in Fig. 1.

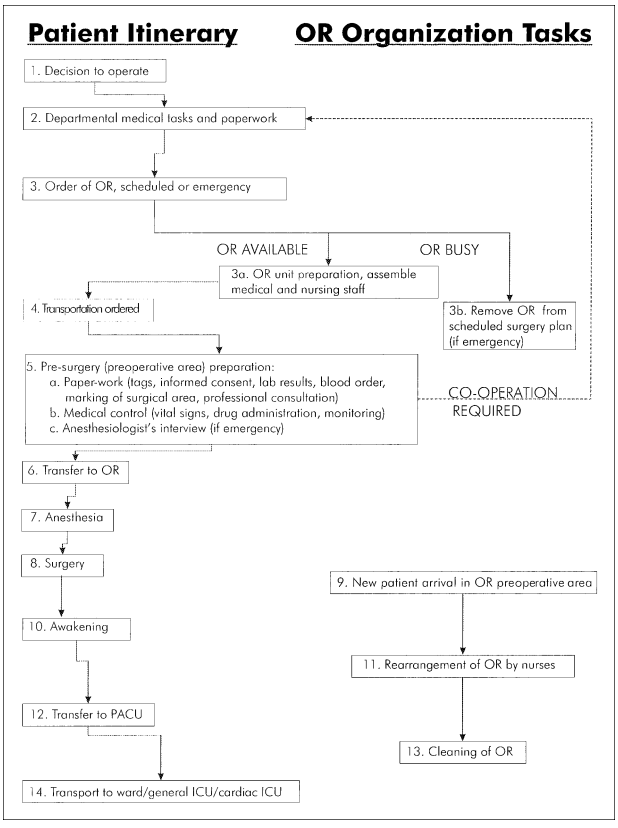

Fig. 1. Sequences of patient itinerary and surgical tasks. (OR = operating room; PACU = postanesthesia care unit; ICU = intensive care unit.)

Statistics

Statistical analysis of data was done using the Mann-Whitney *U* test. *P* values <0.05 were considered statistically significant. Values are expressed as a mean $\pm$ standard error of the mean, or as a median (range), when not normally distributed.

Results

Phase 1, before intervention

A total of 814 operations were performed in the relevant period, on patients aged 63 $\pm$ 4 years, 42% of whom were male, and 72% of them took place in daytime shifts (7 AM to 11 PM). The relative load on the two general surgery and two orthopedic departments was similar. Of these, 102 operations met the inclusion criteria that the surgery was scheduled but was not performed.

Overall, almost 79 hours were wasted, ie, almost three quarters of an OR's working day each week, and they accounted for 15% of the daily time scheduled surgery time, as habitually the OR is not active between 12:30 AM and 7:00 AM, except for life-saving procedures. The analysis of the reasons for time-waste is summarized in Fig. 2 depicting

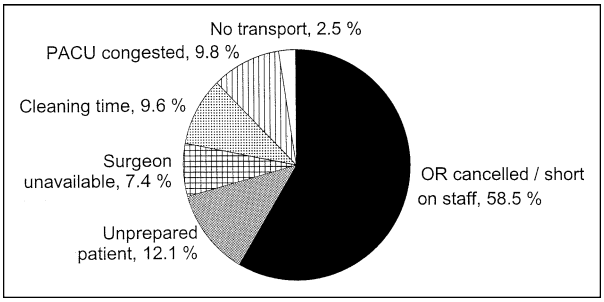

Fig. 2. Causes of time wasted in the operating room (OR) and their proportion. (PACU = postanesthesia care unit.)

the accumulated times and their proportion by cause. The total time wasted in the various departments was statistically similar (Table 1), and is detailed in Table 2.

Surgeon unavailability

An "unavailable surgeon" could result from the following scenarios: late arrival to the OR (15 instances), a junior surgeon waiting for a senior surgeon (17 times), intraoperative problems necessitating the intervention of a senior surgeon who was delayed or not located (12 occasions), or a surgeon operating elsewhere (7 times). The total time lost from surgeon unavailability amounted to 5.9 hours. Surgeons of Orthopedics 2 and Surgery 2 were, however, unavailable during significantly longer periods of time and more frequently than their counterparts in Orthopedics 1 and Surgery 1 (Table 2).

Inappropriate patient preparation

Inadequate preoperative patient preparation was the cause of 24 occasions of OR time waste and totaled 9.6 hours, half of which occurred between 7:00 AM and 3:00 PM. They included inadequate paperwork (n = 7), unsigned or improperly signed forms (n = 4), missing laboratory results (n = 3), unmarked operative site (n = 3), specific problems that occurred prior to surgery requiring special tests or consultations (n = 5), or when blood was not ordered from the blood bank or was ordered late (n = 2). Two-thirds of these delays involved patients arriving directly from the wards. Lacking patient preparation (administrative and medical deficiencies) was similar among the departments (Table 2).

Table 1
Total time wasted in the operating room

Department	Total (h)
Phase 1	
Orthopedics 1	16.1
Orthopedics 2	18.9
Surgery 1	17.6
Surgery 2	16.8
Total	69.4
Phase 2	
Orthopedics 1	11.1*
Orthopedics 2	10.6*
Surgery 1	14.1*
Surgery 2	9.8*
Total	45.6*

* Significantly lower ($P < 0.05$) than the corresponding phase 1 value.

Unavailable room or staff

The use of the OR was canceled by administrators due to insufficient nursing or medical staff four times for each reason (Table 2), and eight more times because the OR was occupied by emergency operations. These causes were similar for all departments (Table 2). The total time lost due to these causes was 46.2 hours, and accounted for 59% of the total wasted time, and was attributable to unavailability of OR 32%, of nurses 20%, and of anesthesiologist 7%.

Cleaning time

Cleaning is an integral part of all surgical activity and therefore was recorded. About 10% of time wasted was due to OR preparation (Fig. 2). Approximately 8 minutes were required to clean the OR, irrespective of the department.

PACU space and transport

When the PACU was full, patients were held in the OR for 7.75 hours, which constituted approximately 10% of the time defined as wasted (Fig. 2), and this was similarly distributed among the departments.

The total time of unavailable transport amounted to 1.95 hours. Shortage of transport personnel during morning and afternoon hours occurred 15 times: twice during the morning shift (5 and 7 minutes delay of patients arriving for surgery) and 13 times (9 ± 1.6 min/case) during afternoons and evenings.

The reasons for increased transport delays in this period could be traced to transport of patients for scheduled afternoon surgery (21% of time), pediatric transport to and from emergency operations (morning service uses vehicular transport), and transport of overweight patients to and from gastroplasty operations requiring two transporters per patient. In four instances bearers were unavailable to discharge patients from the PACU, and this eventually affected the schedule of the OR. Thus, the total time of unavailable transports plus that of congested PACU resulted in 9.7 wasted OR hours. This wasted time was similarly distributed among the groups except for Surgery 2 where time was significantly longer (Table 2).

Spill-over time

The 8-hour morning shift of elective operations frequently exceeded the allotted time, and this could prevent starting emergent or added on surgical procedures, as staff is busy in the ongoing surgical procedures and the total OR capacity is reduced after 3:00 PM. The time all departments ran past 3:00 PM, ie, "spill-over time" amounted to 26.2

Table 2
Time of inactivity of the surgical unit by cause (min)

Cause	Orthopedics 1		Orthopedics 2		Surgery 1		Surgery 2	
	N	Median (range)	N	Median (range)	N	Median (range)	N	Median (range)
Phase 1								
Physician unavailable	7	5 (1–8)	18	5 (1–18)*	10	7.5 (2–15)	16*	7 (2–14)
Patient unprepared	4	12.5 (9–36)	7	20 (14–75)	6	17.5 (10–35)	7	20 (14–60)
Operating room canceled/lack of staff	4	210 (120–240)	4	180 (120–240)	4	180 (90–240)	4	135* (72–240)*
Postanesthesia care unit jammed/ no transport	2	40 (9–72)	3	36 (12–48)	4	36 (12–84)	2	60* (48–72)*
Phase 2								
Physician unavailable	2†	5 (3–7)	2†	2.5 (2–3)†	2†	5 (3–8)	2†	7.5 (7–8)
Patient unprepared	2†	6† (5–7)†	1†	9†	2†	7† (3–11)†	2†	6.5† (6–7)†
Operating room canceled/lack of staff	3	216 (165–252)	3	198* (174–252)*	3	276† (168–372)	2	279*† (246–312)*†
Postanesthesia care unit jammed/ no transport	1†	12†	0†	0*†	1†	9†	0†	0†

* $P < 0.05$ versus corresponding department(s).
† $P < 0.05$ versus corresponding phase 1.

hours, and occurred on 20 occasions during the 30 days of the study. Surgery 2 and Orthopedics 2 had many more overextended operations than their counterparts (Table 3), but no direct relationship was found between availability of doctors in the various departments and spill-over time (data not presented).

The combination of wasted time and spill-over time defines "subefficiency," that is, the total monthly working hours during which, inadvertently, a scheduled OR would have been idle, and totaled 105.2 hours, about 20% of 1-month working time of one OR.

Phase 2, QA intervention and subsequently improved efficiency

Analysis of the data in phase 1 of the study resulted in agreed guidelines that were disseminated among the users of the OR. They consisted of (1) a revised presurgery checklist that included all paper and medical duties that must be accomplished before the patient is transported to the OR, and it must be signed by both the ward physician and nurse; (2) if a specialist failed to consult within 2 hours of being requested, the ward nurse must inform the ward physician; (3) consultation by specialists of emergency admitted patients who need urgent surgery should be performed in the emergency room before admission to the ward or to the OR suite takes place; (4) heads of departments should receive a detailed account of time lost despite these new guidelines periodically, and should study the causes in order to prevent future recurrence; (5) no patient should be brought to the OR without a qualified surgeon ready to operate present in the OR; (6) the addition of one patient transporter during the 3:00 PM to 9:00 PM shift; (7) head of departments were asked to present surgical schedules that accurately reflect surgical time for the type of operation; they were also requested to review past cases of spill-over and predict their surgery length realistically; (8) enlargement of the PACU space; (9) recruitment of 35% additional anesthesiologists and nurses; and (10) monthly staff meetings of surgeons, anesthesiologists and nurses to further clarify difficulties.

Table 3
Spill-over time

Department	N	Median hours (range)	Total (hours)
Phase 1			
Orthopedics 1	3	1.2 (0.85–1.5)	3.6
Orthopedics 2	7	1.2 (0.4–2.4)	7.5
Surgery 1	2	1.65 (0.8–2.5)	3.3
Surgery 2	8	1.4 (0.6–2.5)	11.8*
Total			26.2
Phase 2			
Orthopedics 1	4	1.7 (1.1–2.1)	4.9†
Orthopedics 2	6	1.3 (0.5–2.5)	4.6†
Surgery 1	4	0.9† (0.8–1.0)	1.8†
Surgery 2	9*	2.4*† (1.1–2.5)*†	6.0*†
Total			17.3†

* $P < 0.05$ versus other departments.
† $P < 0.05$ versus corresponding phase 1 data.

Three months later new data were analyzed and it was observed that an overall of 35% of the time wasted earlier was now saved (Table 1). Specifically, the total time wasted, ie., subefficiency, amounted to 84.3 hours, or 16% of the OR time, equivalent to 5.3 working days, a 17% decrease from phase 1. The parameters that did not improve included OR cleaning time and availability of room and staff.

Surgeon unavailability

The quality assurance evaluation confirmed an equivalent roster of surgeons in the two orthopedic and two sur-

gical departments, and thus removed the possibility that shortage in personnel is the cause of surgeon unavailability. The departments' chairs also directed surgeons to respond immediately when called to the OR. A total of 38 minutes was lost due to this cause in the second phase, compared with almost 6 hours earlier, a reduction of 89% (Table 2).

Inappropriate patient preparation

After the evaluation of phase 1, four meetings with the nurses of the departments were held. They were introduced to the findings and were encouraged to offer suggestions. During the third meeting the nurses were presented with illustrative cases of patients who required medical or administrative attention and waited too long to receive it. The last meeting was dedicated to the instruction of a structured sequence of actions for preparing a patient for surgery in 2 hours. If this sequence could not be accomplished in time, the surgeon had to be informed and was required to intervene.

After these conferences, a 92% reduction (from 9.6 hours to 0.8 hours) in the time lost owing to improperly prepared patients was achieved (Table 2).

Unavailable room or staff

The assessment committee recommended to increase the personnel (anesthesiologist and nurses) and to enlarge the OR. This was rejected ad hoc due to lack of funds, but was added to the triennial investment plan. The number of instances when surgery was postponed because of insufficient nursing or medical staff or because an emergency operation occupied the room is detailed in Table 2. Indeed, in phase 2, the overall time wasted from this cause remained similar to that of phase 1 in the orthopedic departments but it increased in the surgical ones. It now constituted a larger proportion of time wasted because of reduction in other causes.

PACU space and transport

Enlargement of PACU was accomplished within 10 weeks, and the QA team arranged the transfer of three intensive care nurses to the PACU, and one patient transporter was added to the afternoon shift. Both measures resulted in recovery of 96% of the time wasted (Table 2).

Spill-over time

The assessment team could not agree on whether the prime shift overrun was due to inappropriate prediction of the duration of surgery or was a chance occurrence. The team rejected arguments that teaching residents prolonged the procedure, claiming that this is inherent to a teaching hospital, and that departmental chairs had to plan surgery realistically. However, after the intervention, the time of spill-over decreased by one third (Table 3), reaching an absolute value of 17.3 hours.

Comments

The frequent changes in resources, objectives, and methods of health provision in contemporary medical systems necessitate repeated assessment of all its aspects[1,2]. The dictate to economize and the reality of reduced investment oblige hospitals, regardless of their economic autonomy, to provide the best possible and competitive health care services with increased efficiency.

The present study compared OR time nonutilization by two general surgery and two orthopedic departments that carry more than 70% of the case volume of the OR suite. As surgery by other specialized departments is essentially different, particularly in the grade of emergency, we could not include them in our study. Other factors that might have influenced operating time, such as the expertise of the surgeons and anesthesiologists [6,7], were also not considered, to avoid biased evaluation [6]. However, our investigation was conducted in a public institution where the number of personnel is limited and fixed, PACU capacity is usually inflexible, staff is limited, and inefficiencies are the norm. Therefore, improving efficiency is crucial for improving cost effectiveness of the operating suite, but is hard to accomplish.

The most important findings of this pre-post study are that the OR was not used for the given patient for a period equivalent to 5 working days every month, and this amount of time could be reduced. We also found that most lost time was due to the unavailability of a room or staff, but this could not be easily remedied, and that inaccurate surgical time predictions potentially increased subefficiency by another quarter.

It is difficult to calculate the economic value of saving OR time in absolute terms, especially in a public hospital, but income from ORs accounts in our institution for 30% of total revenue of the hospital. It is estimated that the cost of one OR to the health consumer or insurance carrier is approximately $10 to $20 per minute [8] or in local currency equaling $600 per hour and the PACU hourly cost is rated at $110 to $200 [9,10]. Therefore, the nominal monthly loss calculated from our findings would amount to $41,600 to 83,200 as a result of time waste, or to $57,000 to $114,000 due to subefficiency. Monetary loss from patients who could not have had surgery and the added cost of extra services, beds, medication, and nursing and medical staff should be added to the above sums. Besides, patients may also turn to competing hospitals and generate invaluable loss of reputation.

We tried to identify reasons of OR underuse that might be rectified, but the literature had no clear criteria on what constitutes efficient OR utilization. For example, how much time is required to accomplish standard activities such as cleaning [5,11], the type and extent of transporting services required for a given number of ORs, the time spent in the PACU stratified by age, medical history, or type of surgery, the absolute size of PACU for a given number of ORs, or

the turnover of patients per shift in an OR. Underutilization and to what extent OR loss of activity is financially innocuous [11] are also not defined.

PACU overflow is usually related to shortage of PACU nursing staff, limited space secondary to a shortage of intensive care beds for critically ill patients who then remain in the PACU, and bed demand for afternoon scheduled and emergency operations. Indeed, in our institution, much sicker patients have surgery now than before (ASA 3.7 ± 0.1 in 1997 to 2000 versus ASA 2.8 ± 0.1 during 1994 to 1996; $P < 0.05$). Consequently, intensive care type of recovery in the PACU was needed for 2.3 ± 0.2 and 0.4 ± 0.1 patients per night in the respective periods ($P < 0.05$). We found that resolving problems with this topic and patient transport directly and strongly relieved PACU congestion.

Improperly prepared patients, both administratively and medically, or their delayed arrival to the OR could be more justified when patients are transferred directly from the emergency department. This usually happens in the evening and night when only limited staff is available, and the attending surgeon may need last-minute consultations before making the final decision to operate. However, in our study, most emergency patients had been admitted to the ward at least several hours prior to surgery, and were still not properly prepared. Besides, from the second phase data it is clear that preoperative specialist consultation could be performed in real time even for emergency patients. The quality assurance intervention succeeded in improving patient preparation, as reported elsewhere [6], and adopting these recommendations could benefit other medical centers.

A published review of the literature explained only partly why surgeons are delayed [6], blaming their tardiness on lack of proper communication between the OR and the departments, carelessness, disobedience, or preoccupation elsewhere. In our study, the total number of physicians and operations performed by the different departments during the period of study was similar, so that understaffing or overcrowding were not likely causes. The number of doctors allocated to each operation and their experience might have played a role, but this was beyond the objectives of the study. We, however, believe that there was a connection between unavailability of surgeons and spill-over of procedures beyond 3:00 PM. The almost total ablation of surgeon's delay in the second phase after the intervention of the departmental chairs could indicate that disregard of both medical and nursing staff is the primary reason. Fortunately, this can be easily controlled and corrected.

Spill-over of operations deserves particular attention, not only because it influences the financial bottom line, but also because overrun may elicit dissatisfaction from patients whose procedures were consequently postponed. Furthermore, overworked staff are kept longer hours with the same load of procedures, and this is reflected in their performance on the following day [1]. The minimal improvement obtained after the QA team intervention indicates that prime-shift overrun is probably unavoidable with the type of patients undergoing surgery in our center, and that additional OR nurses and anesthesiologists are needed to be in place when surgery runs past expected time.

In Israel, nurse staffing is standardized according to a complex hospital bed indexing, and ad hoc employment of temporary personnel is not possible. The quota of anesthesiologists is also rigid and fails to account for needs, such as the requirements of safe anesthesia, the development of acute pain service, or the growing need for anesthesia in outpatient suites. Moreover, because it is common to have several dispersed ORs on campus, the diverse anesthesia services are semiautonomous, with a separate physician, nursing, and technical management hierarchy that requires additional administrative resources. Therefore, prompt investment in space and human resources was not possible in our hospital, as it is in other public health institutions, thus limiting the available remedies.

Controversy exists about the preferred utilization rate of ORs: 90% or 100%, with 97% considered optimal [13]. The system we examined had a utilization rate of 81% during the first phase and 83% in the second phase. It is therefore important to mobilize the entire system in a sustained process to improve efficiency [14]. This can be achieved by using the above-mentioned strategies [5] with deployment of institution-specific cross-functional teams that survey continuously the efficiency of work, save costs, and consequently raise profits [15,16].

In conclusion, the magnitude of subefficiency in the OR and its impact on the cost of a public health center were studied. Continuous surveillance, repeated cost evaluations at all levels, and wise staff deployment could minimize OR time loss.

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