*Original Article*

# Causes and Effects of Inefficient Operating Room Flow during Working Hours in a University Hospital

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***Background***: Operating rooms (ORs) are major source of both hospitals' revenue and expenses; hence, OR efficiency is not only essential, but challenging for providing high-quality care, whilst utilizing limited resources.

***Materials and Methods***: A prospective, observational study was conducted in a tertiary care university hospital to identify both causes and effects of inefficient OR flow, including the rate of first case tardiness, time delays while patients are in room, turnover time, cancellation rate, and OR-overutilization. Patients scheduled for elective surgery between September 2014 and February 2015 were recruited.

***Results***: Three thousand nine hundred sixty-five elective surgical cases were recruited. The rate of first case tardiness was 48%. The average delay time of the first case was 25±16.6 minutes, with the main cause being late arrivals of surgical teams (97.4%). The rate of time delay while the patients were in room, was 73.2%. This is being associated with both the surgical and the anesthesia teams (83%), as well as positioning and procedures-related to the general anesthesia. The delay in turnover time was 12.9% with an average of 32.3±23.3 minutes, with most common causes being swapping of cases between ORs (22.7%) and delays in transferring patients from the ward (21.7%). The cancellation rate was 11.8%, with General surgery having the highest rate (15.5%) due to insufficient OR time (26.2%). Sixty-four-point-eight percent of the operations continued after working hours, with an average of 121.7±106.1 minutes (range 4 to 670 minutes).

***Conclusion***: The present study identified five process points of OR inefficiency in a university hospital, demonstrating that there are substantial opportunities for enhancement of OR efficiency.

***Keywords***: Efficiency, Operating room, First case, Tardiness, Cancellation, Turnover time, Utilization

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Operating rooms (ORs) are one of the costliest units in the hospital, thus, managing an OR efficiently is essential, but also challenging for the delivery of high-quality care, under limited resources. OR efficiency depends on several factors such as scheduling, preoperative preparation, first case on-time or tardiness, predictability of to-follow cases, turnover time, add-on cases and cancellations, and OR utilization.

Starting the first cases on-time is complex and challenging. If a case is delayed, it might affect the next patient, which in turn might result in cases running late, overutilization of OR, or cancellations of next patients.

Cancellation rates of elective scheduled operations varies from 4.6% to 18%[1]. The reasons for cancellation differ from one hospital to another and can be either due to being patient-related, or non-medical problems[2].

Turnover time is the duration from the time one patient exits the OR, until the succeeding patient enters (the AACD glossary)[1]. Multiple factors can affect turnover time such as preoperative preparation, patient transport services, anesthesia drug management, and OR turnover teams in cleaning and preparing the OR for the next case. Inefficiency of the OR along with

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turnover and time delays are a source of frustration to the patients, the surgeons, and the anesthesiologists. There is no standard for acceptable turnover time. In most facilities, the turnover represents only 10% to 20% of the total case time[1].

Most ORs seek a target of utilization between 70% to 80% to maximize benefits, while reducing stress on the system. There are costs whether ORs experience either overutilization or underutilization. Underutilization results in a lower revenue generation to offset fixed costs. Overutilization may require overtime pay for all personnel working late and increases costs per-minute.

Improvement in the OR scheduling process, proper preoperative preparation, starting the first case on-time, surgical case performance benchmarks, and ORs turnover are all critical elements that make the OR run efficiently. Therefore, in the present study, the authors aimed to evaluate OR efficiency in five elements, 1) first case tardiness, 2) cancellation rates, 3) time delay while patient is in room, 4) turnover time, and 5) OR overutilization.

## Materials and Methods

The present study was approved by the Human Research Ethics Committee, Faculty of Medicine, Prince of Songhkla University, Thailand (REC 57-0128-081-1).

The authors collected data prospectively, between September 1, 2014 and February 28, 2015 from eighteen ORs within Songklanagarind Hospital, a 1,000-bed tertiary, public university hospital in the south of Thailand. The data included general surgery, urology, vascular, plastic, pediatrics, cardiovascular and thoracic (CVT), trauma, otolaryngology (ENT), obstetrics or gynecology (OB-GYN), orthopedic, neurosurgery, and two remote areas, which were cardiac catheterization center and radiological intervention. Working hours were from: 8.30 am to 4.30 pm, Monday to Friday, except weekends and public holidays. The scheduled starting time of each case was limited by patient arrival, but cases could start earlier than scheduled if the patients, anesthesiologists, surgeons, and OR teams were available before the scheduled start time.

The authors included all elective cases set on the schedule, prior to 4.30 pm on the day before surgery, and add-on cases that were set on the schedule in the OR before, or on the day of the surgery. The authors excluded all elective and emergency cases that were set in the emergency ORs or the ophthalmological OR.

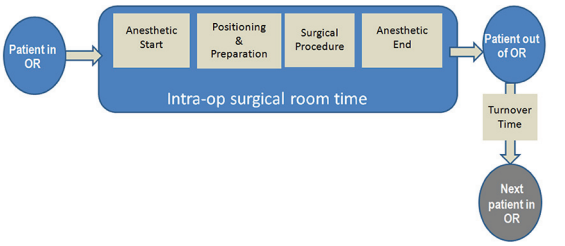


**Figure 1.** Show timeline when once patient in OR until next patient in OR.

The primary outcomes consisted of five process points, 1) rate of first-case tardiness, 2) cancellation rate, 3) time delay while patient was in room, 4) turnover time, and 5) OR overutilization.

The secondary outcome was to identify the causes of primary outcome, except OR overutilization.

The authors used the following definitions for the analyses[2-4].

First-case-tardiness was defined as when the patient entered the OR 10 minutes behind schedule. The reasons for tardiness were classified as patient, anesthesia, surgical, and OR team.

Operating cancellations were defined as cases that were booked in the operative schedule but did not have the planned surgery on the intended date. Patients, who died before the time of their scheduled surgery were excluded. Cancellation rate measurements were calculated as percentage of surgical procedures cancelled (i.e., rescheduled to another day, or cancelled altogether) on the previous day, after schedules were released, after 4 pm or on the day of surgery including add-on cases that were set on the schedule, prior to or on the day of the surgery. The reasons for cancellation were classified as patient-related, administrative-related, and medical-related.

Time delay while patient was in room was the delay from the time the patient entered the OR until the patient left (Figure 1). It included patient in room, start of anesthesia, surgical preparation and positioning, surgical start, surgical finish, end of anesthesia, and patient exiting room. The authors defined delay as any period of more than 10 minutes, exception being duration of surgery[5,6].

Turnover time was the duration from when one patient exited until the next patient entered (Figure 1). It included clean up times, set up times, and delay between cases. The authors defined delay when the turnover time was more than 10 minutes[5,6].

OR overutilization was the number of operations performed after 4.30 pm. The rate of overutilization was calculated by the number of operations performed

**Table 1.** Reasons of cancellation categorized by clinical conditions and non-clinical condition

| Clinical conditions (n) | | Non-clinical conditions (n) |
|---|---|---|
| • Cardiovascular system; | • Genitourinary system; | • Insufficient OR time (150) |
| - atrial flutter/fibrillation (2) | - have a period (2) | • Patient failed to attend (90) |
| - abnormal ECG (2) | - UTI (2) | • Change plan of treatment (61) |
| - suspected myocardial infarction (2) | • Hemotological system; | • Operation is already done before scheduling (42) |
| - heart failure (1) | - thrombocytopenia (4) | • Postpone operation (30) |
| - new heart murmur (1) | - taking antiplatelet (4) | • No bed or ICU available (13) |
| - severe HT (1) | - coagulopathy (1) | • Patients refuse surgery (10) |
| • Respiratory system; | • Endocrine; | • Error in surgical case scheduling (9) |
| - upper respiratory tract infection (17) | - severe hypothyroidism (1) | • Not fasting (6) |
| - suspected TB (3) | - hyperthyroidism (1) | • Surgeons unavailable (6) |
| - aspiration pneumonia (1) | • Others; | • Unplanned emergency surgery cases (5) |
| - asthma (1) | - fever (13) | • Equipment failure (laser, CT, MRI) (5) |
| - fat embolism (1) | - V/S unstable (12) | • Need further investigations (4) |
| - pleural effusion (1) | - sepsis (3) | • Incomplete document (3) |
| - pulmonary embolism (1) | - infection (2) | • Unavailability of surgical equipments (3) |
| - COPD with acute exacerbation (1) | - post-cardiac arrest (1) | • No information (11) |
| - sinusitis (1) | - dead (1) | |
| • Gastrointestinal system; | | |
| - ascites (1) | | |
| - diarrhea (1) | | |

COPD=chronic obstructive pulmonary disease; CT=computer tomography; ECG=electrocardiography; HT=hypertension; ICU=intensive care unit; MRI=magnetic resonance imaging; OR=operating room; TB=tuberculosis; URI=upper respiratory tract infection; UTI=urinary tract infection; V/S=vital sign

after 4.30 pm, divided by the total of the last scheduled cases.

Statistical analysis was performed by R software, version 3.1. Categorical data were expressed as percentages, and quantitative data were presented as mean ± standard deviation (SD), or median (interquartile range, or range) where appropriated. Secondary outcomes were reported as descriptive data.

## Results

Four thousand five hundred seventy-nine cases were included (4,340 elective, 191 add-on, and 48 emergency cases that took priority over elective OR). The authors excluded 72 cases due to incomplete data.

The rate of first-case tardiness was 47.9% (641 out of 1,339 cases). The topmost type of operation was orthopedic surgery (23.2%), with the lowest being the cardiac catheterization center (0.6%). The average (SD) time of tardiness was 25±16.6 minutes. Five cases started over 100 minutes late and included three cases due to an emergency case taking priority, one case due to incomplete laboratory results, and one case being unscheduled.

The most common causes of first-case tardiness were caused by the late arrival of the surgical, anesthesia, and OR team, which accounted for 97.4%, 42.9%, or 33.8%, respectively, and due to patients in 50% of the cases.

The reasons of first case tardiness, caused by the patient, was a late arrival of outpatient 50%, clinical conditions 18.8%, such as fever, upper respiratory tract infection, poor control hypertension, or heart murmur requiring further investigation, others 18.9%, and no show 9.4%,

The rate of cancellation was 11.8% (542 of 4,579 cases). The highest cancellation rate was in general surgical services (15.5%), with the least occurring from (0.5%) trauma surgical services. The reasons of cancellation, caused by clinical and non-clinical condition, was 16.6% and 83.4%, respectively (Table 1). The most common causes of cancellation was insufficient OR time, (26.2%), clinical conditions of patient, and patients failed to attend (each 16.6%).

Time delay, while the patient was in the room occurred in 2,903 cases from 3,965 cases (73.2%). The mean time ± SD of each period while patient was in room is shown in Figure 2.

Each case could have more than one period of time delay. The most common cause of time delay while patient was in OR was due to surgical, anesthesia, OR teams, and patients (50.7%, 42.5%,

**Table 2.** Reasons of time delay while patient is in OR categorized by procedure-related and non-procedure-related

| Procedure-related (n) | Non procedure-related (n) |
|---|---|
| • Patient; none | • Patient; |
| • Anesthesia; | - clinical conditions* (34) |
| - GA (280) | - go to toilet (5) |
| - GA+A-line (108) | - refuse surgery (2) |
| - GA+C-line (12) | • Anesthesia; |
| - GA+A-line & C-line (167) | - wait anesthetic staff (280) |
| - GA with difficult intubation (31) | - cases of medical students (42) |
| - GA with awake intubation (9) | - cases of anesthetic nurse trainee (24) |
| - GA with fiberoptic intubation (6) | • Surgical; |
| - RA (162) | - wait senior resident/surgical staff (297) |
| - RA+A-line (2) | - late arrival to timeout (50) |
| - combine GARA (18) | - surgeon have lunch (6) |
| - inadequate regional block (25) | • OR team; |
| - RA then GA (13) | - prepare surgical equipment (23) |
| - extubation (596) | - close surgical wound (16) |
| | - change bed (15) |
| • Surgical; | • Others; |
| - positioning (1,488) | - delay transfer to ward (100) |
| - scrub and surgical draping (365) | - wait crib staff (44) |
| - use navigator (15) | - no ICU bed available (8) |
| - blue dye/ contrast injection (15) | - no ventilator available at ward (3) |
| - use USG localized lesion (14) | - death on table (3) |
| • OR team; none | - outside team not available (3) |
| • Others; none | |

A-line=arterial line; C-line=central venous line; GA=general anesthesia; HT=hypertension; ICU=intensive care unit; OR=operating room; RA=regional anesthesia; USG=ultrasonography; V/S=vital sign

* Such as heart disease, arrhythmias, atrial flutter, desaturation, wheezing, morbid obesity, thrombocytopenia, poor controlled HT, V/S unstable, etc.

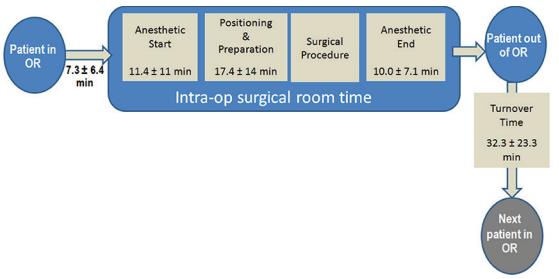


**Figure 2.** Show time delay while patient is in room.

1.5%, and 1.2%, respectively). Breaking down the causes of surgical teams, the most common causes were positioning (71.1%), scrub and surgical draping (17.4%), waiting on surgical staff (14.2%), and late arrival of surgeon to timeout (2.4%). The second cause of time delay while patient was in OR, was due to anesthesia. The most common causes were general anesthesia and procedure-related such as invasive monitoring (arterial line, central venous line insertion) (35%), extubation (34%), anesthetic staff unavailable (16%), and other causes (15%) including regional anesthesia (spinal block, epidural block, combine spinal-epidural block, and peripheral nerve block), and combined general anesthesia and regional anesthesia, cases of medical students or anesthetic nurse trainee, etc. The reasons of the time delay while the patient was in the OR were categorized as procedure-related and non-procedure-related as shown in Table 2.

The turnover time of longer than 10 minutes was 12.9% (511 of 3,965 cases). The average delay in turnover time was 32.3±23.3 minutes, with the causes being transferred case from another OR (22.7%), delayed arrival of patient from the floor (21.7%), cleaning and preparing room (11.9%), OR damping (8.2%), no information (7.6%), patients were blocked in the induction room (7.6%), and other causes (20.3%), which included a change in schedule, surgeons having lunch, emergency cases taking priority, cancelled cases, changing of beds,

**Table 3.** Reasons of each categories that causes of delay in turnover time

| Causes of delay in turnover time (n) |
|---|
| • Patient; |
| - patient go to other intervention (needle localization, hemodialysis) (3) |
| - go to toilet (4) |
| - not fasting (1) |
| - failed to attend (1) |
| • Anesthesia; |
| - patient was blocked on induction room (41) |
| - anesthetic machine failure (2) |
| • Surgical; |
| - change scheduling (18) |
| - surgeon have lunch (17) |
| - emergency case taking priority (14) |
| - standby ORs (9) |
| - wait surgeon (4) |
| • OR team; |
| - delay arrival patient from the floor (111) |
| - cleaning and prepare equipment (61) |
| - OR damping (42) |
| - change bed (7) |
| - change lamp (1) |
| - receive wrong patient (1) |
| • Others; |
| - alternate cases between ORs (116) |
| - no information (39) |
| - cancelled case due to clinical conditions or need further investigation (8) |
| - princess visit (5) |
| - no ICU bed available (2) |

ICU=intensive care unit; OR=operating room

and so forth (Table 3).

The OR overutilization made up 870 cases out of 1,343 last cases (64.8%). The average duration of OR overutilization was 121.7±106.1 minutes, ranging from 4 to 670 minutes).

## Discussion

In the past decade, OR efficiency has become an important role for the improvement of scheduling management. A decrease in cancellation rates of the elective cases as well as maximization provides long-term benefits for the patients having surgery, the OR staffs, and the hospital. In addition, the aim for this optimization should deliver the best safety and patient outcome. Even though there are several existing studies on OR management, a valid and reliable instrument for assessment of these circumstances is still limited. In the present study, the authors assessed five tools to evaluate OR efficiency including first case of the day tardiness, cancellation rates, time delays while patient is in the OR, turnover time, and OR overutilization.

The authors found that the rate of the first case of the day tardiness was 48%, with an average delay of 25±16.6 minutes. In comparing to Ontario's surgical efficiency target program in Canada, which is 85% of first case being either on time or early while the ORs opens at 7 am[7], it has also become apparent that our ORs need to make improvements in the scheduling of start time of the first case to decrease OR inefficiency. Several factors can be managed to improve the OR efficiency, including the late arrival of surgeons (97.4%). The cause of the first case of the day tardiness was the same as reported in American and Australian publications[8-10].

Macario, assessed the cancellation rates and found that well-functioning OR suites should have cancellation rates of less than 5%[11]. The present study found that the cancellation rate was 11.8%. Many of the reasons recorded for cancellation were due to surgeries. The most common cause of the present study was insufficient OR time (26.2%), which may be due to overbooking in the schedules. The second most common cause was the clinical conditions of patients along with patients failing to attend (each being 16.6%). The present study results revealed that the management might be able to reduce the rate of cancellations via the use of a more efficient booking process. In other studies, the lack of OR time was dominant due to surgeons underestimating the time needed for an operation[12].

In the present study, the most cancellations were in the general surgery (15%), followed by orthopedic surgery (13%), OB-GYN (12%), X-ray intervention (9.5%), CVT (9.3%), urology surgery and ENT (8%), neurosurgery (7%), plastic surgery (6.5%), and vascular surgery (5%). The highest cancellation rate occurred in the general surgical services (15.5%) while the least (0.5%) occurred in trauma surgical services. The lesser cancellation rates in trauma service might be due to only a few ORs being used per week, with no data being recorded on some days.

For the time delay while the patient is in the OR room, 73.2% of the patients had at least one period, and some cases had more than one period or cause of said delay. The most common cause was the surgical team (50.7%). Breaking down the causes of surgical team, the most common cause was positioning (71.1%). Other causes were anesthesia, other, OR team, and patient (42.5%, 4.1%, 1.5%, and 1.2%,

respectively). In the case of the anesthetic team, the most common causes were general anesthesia and procedural-related such as invasive monitoring (arterial line, central venous line insertion) (35%) and extubation (34%). The analysis of the different causes for delay at each time interval revealed that delays were related to several causes. The more cohesively each member of the team works as a group is likely to lead to improved efficiency and fewer delays.

For the turnover time, there is no national standard. The most turnover time is about 10% to 20% of the total case time. It is reasonable to expect a turnover time of 10 minutes, or less between simple procedures. However, when changing between open heart surgery, or complex surgical cases such as orthopedic surgery, turnover time may require 45 minutes or even longer. A review at four academic institutions indicated that turnover times ranged from 34 to 66 minutes[1]. Dexter et al, collected data from 31 U.S. hospitals. The average turnover times were less than 25 minutes[13]. In the present study, the authors set a target of 10 minutes or less of turnover time per case. The rate of turnover time was longer than this predicted target by 12.9%. The average turnover time was 32.3±23.3 minutes. The most common cause of delay were alternate cases between ORs (22.7%), late arrival of patient from the floor (21.7%), cleaning and preparing equipment (11.9%), OR damping (8.2%), waiting on patient blocked in the induction room (7.6%), and other causes of 20.3% such as a change in schedule, surgeons having lunch, emergency cases taking priority, cancelled cases, or changing of bed. The overall causes of delay in turnover time can be improved to minimizing OR turnover time.

There is no defined target for OR utilization. The optimal utilization varies among entities involved in the OR. The target of utilization for most ORs is about 70% to 85% to maximize benefits and reduce stress on the system[1]. In the present study, the volume of surgeries performed after 4.30 pm were 870 cases from 1,343 last cases (64.8%), and the mean time of operations extending after 4.30 pm was 121.7±106.1 minutes (range 4 to 670 minutes). The present study result showed more than 65% of ORs were overutilized, however, the authors did not record causes of overutilization. Hence, the study requires to conduct further investigations on causes of overutilization to improve the OR efficiency in this aspect. In addition, overutilization requires overtime pay for nurse anesthetists, anesthesiologists, scrub nurses, and surgeons, which in turn results in higher costs per minute of OR usage.

## Limitation

The present study did have some limitations. First, there was a 2% loss of data in studied cases. Secondly, the authors did not differentiate between simple cases and complex cases in regards to time delay while patient is in the room, and in turnover time. Complex cases may require more time than simple case in each step. Thirdly, some surgical services such as trauma surgery and the cardiac catheterization laboratory had less data available, compared with other services. This may be because only a few ORs operated each week and no data was recorded on some days. Additionally, the authors did not contact patients who did not attend; therefore, could not establish the reason for non-attendance. Finally, in the present study, the authors had informed every department involved. Therefore, there may have been concern about the Hawthorne effect thus, some personnel may have altered their behavior as they were aware that their performance were being actively evaluated.

## Conclusion

Management of OR inefficiency can affect patient flow and resource utilization. The present study reported many causes of delay throughout every step and demonstrated what should be managed to improve OR efficiency. The existence of perioperative system facilitates for the planning and management of elective surgery, with maximum efficiency, whilst minimizing OR time inefficiency.

## What is already known on this topic?

Several factors associated with OR efficiency have been identified but may be different according to the context of each individual hospital.

## What this study adds?

This study identified the factors that will improve efficiency of the OR in the context of a Thai medical school.

## Conflicts of interest

The authors declare no conflict of interest.

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