

Delays in the operating room: signs of an imperfect system

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Accepted for publication
Aug. 25, 2009

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Background: Delays in the operating room have a negative effect on its efficiency and the working environment. In this prospective study, we analyzed data on perioperative system delays.

Methods: One neurosurgeon prospectively recorded all errors, including perioperative delays, for consecutive patients undergoing elective procedures from May 2000 to February 2009. We analyzed the prevalence, causes and impact of perioperative system delays that occurred in one neurosurgeon's practice.

Results: A total of 1531 elective surgical cases were performed during the study period. Delays were the most common type of error (33.6%), and more than half (51.4%) of all cases had at least 1 delay. The most common cause of delay was equipment failure. The first cases of the day and cranial cases had more delays than subsequent cases and spinal cases, respectively. A delay in starting the first case was associated with subsequent delays.

Conclusion: Delays frequently occur in the operating room and have a major effect on patient flow and resource utilization. Thorough documentation of perioperative delays provides a basis for the development of solutions for improving operating room efficiency and illustrates the principles underlying the causes of operating room delays across surgical disciplines.

Contexte : Les retards dans les blocs opératoires exercent un effet négatif sur l'efficacité de ces services et sur le milieu de travail en général. Dans cette étude prospective, nous avons analysé les données sur les retards affectant le système périopératoire.

Méthodes : Un neurochirurgien a noté de façon prospective toutes les erreurs, y compris les retards périopératoires, pour les patients consécutifs devant subir des interventions non urgentes entre mai 2000 et février 2009. Nous avons analysé la prévalence, les causes et l'impact des retards affectant le système périopératoire survenus dans la pratique d'un neurochirurgien.

Résultats : En tout, 1531 chirurgies non urgentes ont été effectuées durant la période de l'étude. Les retards étaient le type d'erreur le plus courant (33,6 %) et plus de la moitié (51,4 %) de tous les cas ont subi au moins un retard. La cause la plus fréquente des retards était une défaillance matérielle. Les premiers cas de la journée et les cas de chirurgie crânienne présentaient plus de retard que les cas subséquents et que les cas de chirurgie rachidienne, respectivement. Les retards affectant le début des premiers cas se répercutaient sur les suivants.

Conclusion : Les retards sont fréquents au bloc opératoire et exercent un effet majeur sur le roulement des chirurgies et sur l'utilisation des ressources. La consignation minutieuse des retards périopératoires constitue une base pour l'élaboration de solutions en vue d'améliorer l'efficacité des blocs opératoires et illustre les principes qui sous-tendent les causes des retards au bloc opératoire, dans toutes les disciplines chirurgicales.

Delays can be attributed to human errors and system deficiencies,¹ and the surgical operating room is rife with both. Whereas preoperative treatment delays have been associated with adverse consequences,²⁻⁷ very few studies have addressed the prevalence, causes or impact of perioperative delays. Unlike preoperative delays, which include prolonged wait times or postponements, perioperative delays occur on the day of the scheduled operation and include delays getting to the operating room and delays during the

operation. Perioperative delays are perceived to be inefficient and undesirable because they act as barriers to optimal patient flow and are a source of frustration, but their causes and impact on patient care and resource utilization are not well defined. However, solutions for inefficiencies in the operating room cannot be devised unless the delays that occur on the day of surgery are better understood.

Currently, there is no consensus about how best to monitor delays or classify their causes. A study on operating room efficiency compared the prevalence and causes of perioperative delays before and after educational interventions.⁸ Sophisticated quantitative models have also been used to identify optimization strategies for operating room efficiency.⁹⁻¹² Other studies have attempted to quantify operating room delays, focusing on delays resulting from turnover between surgeries,¹³ admission into the postanesthetic care unit¹⁴ and nonoperative time.¹⁵ Hospital records may provide information about the prevalence of delays getting into the operating room, but they do not document the myriad delays that occur during surgery, nor do they record the causes of the delays. Hence, despite the fact that perioperative delays are experienced daily by both surgeons and patients, these delays and their causes have yet to be regularly and thoroughly documented.

In this study, we report how perioperative delays can be identified, classified and analyzed using a prospective database accrued by the senior author over a period of almost 9 years.¹⁶ By having one surgeon record perioperative delays, as well as their perceived causes, for all elective surgeries performed during a 9-year period, we present a method for regularly documenting perioperative delays in detail. We focus on perioperative system delays, which are delays in the operating room due to system inefficiencies; that is, failures of either the process or equipment. System delays need to be differentiated from delays that are due to human factors, such as experience or skill of the surgeon. We analyzed the prevalence, causes and impact of perioperative system delays that occurred in one neurosurgeon's practice. We highlight some principles underlying the causes of perioperative delays across surgical subspecialties and emphasize the importance of recording perioperative delays.

METHODS

Study design

All patients undergoing elective surgery with the senior author (M.B.) between May 2000 and February 2009 were entered prospectively into an observational study that identified and recorded all errors.¹⁶ We excluded emergency and after-hours cases. The senior author entered all errors into the database immediately after each case. All data gathered during this study were kept confidential. The study was approved by the Research Ethics Board of the University Health Network.

Error classification

The senior author developed a simple system to classify errors. The types of errors in this system were technical (errors in the performance of a task by the surgeon or assistant), contamination (instrument required resterilization), delays (long wait because of system inefficiency), equipment (missing or malfunctioning equipment), communication (failure in communication between members of the operating team [e.g., no prophylactic antibiotics given because the anesthetist did not hear the surgeon's request]), management/judgment (insufficient preoperative preparation [e.g., abnormal blood result was not corrected]), nursing (error on the part of the nurse), anesthesia (error on the part of the anesthetist), and other.¹⁶

For the purposes of this study, we included only data pertaining to delays. All equipment failures were considered to be delays.

We further classified the delays on the basis of cause. The types of delays were delays getting the patient into the operating room (later than 8:10 am for the first case of the day and more than 1 hour after the preceding case for subsequent cases), equipment failure (missing or malfunctioning equipment), quick section delay (quick section results received from the pathologist more than 30 min after submission of the specimen), intraoperative radiography delay, and other.

Statistical analyses

We determined the number and cause of the delays in all cases. We performed subgroup analyses for the following categories: first case of the day versus second and third (i.e., subsequent) cases, cranial versus spinal cases, awake brain tumour surgery versus under general anesthesia, and inpatient versus outpatient surgery. Except for in the first

Table 1. Overview of all surgeries performed between March 2000 and February 2009

Category	No. (%) of neurosurgeries
Total	1531
Procedure	
Cranial surgery	1232 (80.5)
Spinal surgery	299 (19.5)
Order	
First case of the day	745 (48.7)
Second or third case the of day	786 (51.3)
Anesthesia	
Awake	528 (34.5)
General anesthesia	1003 (65.5)
Admission status	
Inpatient	1092 (71.3)
Outpatient	439 (28.7)

subgroup analysis, we included only first cases of the day to limit the number of variables. Furthermore, we included only first-case brain tumours in the analysis based on the type of anesthesia and patient's admission status (i.e., scheduled for admission v. outpatient). We also performed a cost analysis based on hourly rates of pay at the Toronto Western Hospital (TWH).

We performed Student *t* tests for normally distributed variables and Wilcoxon rank-sum tests for variables that were not normally distributed. We set the significance threshold at $p < 0.05$. We analyzed the data using Microsoft Excel and SAS version 9.1.3 (SAS Institute Inc.).

RESULTS

A total of 1531 elective neurosurgical cases were included. An overview of the cases is provided in Table 1, and the types of errors identified are listed in Table 2. System delays, which included equipment failures, made up the

majority of errors (33.6%). In total, 51.4% of all cases had at least 1 delay and 88.5% had at least 1 error.

First cases had significantly more delays than second and third cases (Table 3), and cranial cases had more delays than spinal cases. The type of anesthesia used and the patient's admission status did not have a significant effect on the frequency of delays.

We also determined whether an initial delay was associated with subsequent delays. After counting the mean number of delays, we subtracted 1 from this value to account for the initial delay. We found that there were significantly more delays in second and third surgeries if there had been a delay in the first surgery of the day (Table 3).

Table 4 compares the causes of delay in cranial and spinal procedures. Equipment failure was the most common source of delay in both groups, but cranial cases had more initial delays (i.e., patient arriving late in the operating room), whereas spinal cases had more delays because of waiting for an intraoperative localizing radiograph.

Table 2. Types of errors that occurred during the study period

Type of error	No. (%) of errors
Delay	1180 (33.6)
Technical	923 (26.3)
Contamination	859 (24.4)
Nursing	186 (5.3)
Anesthesia	160 (4.6)
Management/judgment	91 (2.6)
Communication	47 (1.3)
Other	66 (1.9)
Total	3512 (100.0)

Table 3. Mean number of delays during the study period

Category	No. of delays, mean (SD)	<i>p</i> value
All cases	0.77 (0.92)	
Order		< 0.001
First case of the day	0.92 (0.97)	
Second and third cases of the day	0.63 (0.85)	
Procedure*		< 0.001
Cranial	1.00 (1.01)	
Spinal	0.70 (0.82)	
Anesthesia†		0.58
Awake	1.08 (1.05)	
General anesthesia	1.03 (1.00)	
Admission status‡		0.18
Inpatient	1.11 (1.03)	
Outpatient	0.98 (1.00)	
Presence of initial delay		0.033
Yes	0.69‡ (0.80)	
No	0.57 (0.82)	

SD = standard deviation.

*First cases only.

†First-case brain tumours only.

‡We subtracted 1 from this value to eliminate the value of the initial delay.

Cost analysis

About 10 000 surgical cases are performed at TWH each year. Of these, about 3000 are the first case of the day. We estimated that, if each delay lasts 10 minutes, the cost of nursing and operating room attendants (i.e., porters) for each 10 minute delay is \$18 based on the current hourly pay rate for both. During the study period, there were about 135 delays per year (1180 delays over 8.75 years), which translates to \$2430 per year. If we extrapolate this cost to the entire department of surgery at TWH (which includes neurosurgeons, orthopedic surgeons, general surgeons, plastic surgeons and urologists), and if we assume that other operating rooms have a similar prevalence of delays, the total additional cost because of delays per year is about \$138 857. This is likely a gross underestimate of the real financial costs. We did not account for

Table 4. Causes of delays in cranial and spinal procedures

Procedure; cause of delay	% of delays
Cranial	
Equipment failure	57.9
Getting into the OR	35.8
Quick section	2.4
Other	3.9
Total	100.0
Spinal	
Equipment failure	55.2
Intraoperative radiograph	22.1
Getting into the OR	17.2
Other	5.5
Total	100.0

OR = operating room.

the occasional cases cancelled at the end of the day because of delays throughout the day, the cost of paying nurses overtime for cases that extend after regular hours because of previous delays during the day and the psychological costs to patients and their loved ones, surgeons and anesthetists.

DISCUSSION

Delays in the operating room negatively affect both patients and health care workers. Although not all delays directly affect patient health, they often increase anxiety for patients and their families and are a source of frustration for surgeons and other staff.¹⁵ However, Dexter and colleagues¹⁷ argue that saving time in the operating room does not necessarily increase efficiency because the amount of time saved by working faster is not enough to allow an extra case to be completed. This is especially true in the neurosurgical operating room, where the average operating time is usually longer than in general surgery or orthopedic operating rooms. However, even if no extra cases are accommodated, the time saved is still time that can be used for other purposes by surgeons and anesthetists, such as extraoperative patient care, teaching and research. For operating room staff, the additional free time can be used to help with other aspects of overall operating room function. Finally, for patients, performing operations on time would improve satisfaction with their experience at the hospital.¹⁵

In this study, we focused exclusively on perioperative system delays. These are defined as delays due to system deficiencies in the operating room, which were classified in the error database as failures of process (“delay”) and equipment (“equipment failure”). We arbitrarily categorized any missing or malfunctioning equipment as a form of delay because fixing the instrument or procuring a new item invariably wastes time. In fact, Khan and colleagues¹⁸ calculated that a fallen instrument causes an average delay of 7.6 minutes. Other types of errors, such as technical or communication errors, may also lead to delays but these are more dependent on human and interpersonal factors rather than on system failures.

We calculated that more than half (51.4%) of all cases have at least 1 delay and that each case has an average of 0.77 delays. This value is slightly higher than the number reported by Overdyk and colleagues,⁸ which was 0.63 delays per case before intervention and 0.49 delays per case after intervention. In our study, the most common cause of delay was equipment failure (55.2%–57.9%). Harders and colleagues¹⁵ found that the second most commonly recorded reason for delay in the operating room, after patient clinical condition, was the availability of instruments. However, the most common reason cited by Overdyk and colleagues⁸ for perioperative delays was unavailability of the surgeon; this was not the cause of any

delays in our study. Differences between authors in the identification of the most common causes for delays reflect the variability between patient populations and systems at various hospitals, as well as the changing causes of perioperative delays over time with the advancement of technology.

Our subgroup analyses revealed that the first case of the day was associated with significantly more delays than the subsequent cases; the potential reasons for this are outlined in Box 1. Because an operating room may have several first cases starting at the same time among all surgical subspecialties, the same factors that delay first cases in neurosurgery probably also affect other subspecialties at our institution. First cases probably have a higher incidence of delays than subsequent cases because several operating rooms are preparing to start simultaneously, causing an increased demand on the services of the clerks at registration, the imaging department, the nurses in the patient holding area and the hospital porters. The number of these support staff remains constant throughout the day, whereas the first-case patients all arrive at about the same time, giving rise to a “bottleneck” situation early in the morning. Because first cases do not all end at the same time, the subsequent cases start in a staggered fashion, with enough support staff to attend to their needs.

The rest of our subgroup analyses were performed using first cases only. Isolation of first cases allows for clearer identification of delays that are due to system deficiencies and limits the variables that may affect punctuality. Compared with subsequent cases, first cases are more homogeneous and have fewer confounding variables, which tend to appear later in the day. For example, the second case may be affected by the length and conduct of the first case, whereas no such conditions exist for the first case.

Cranial surgeries are more frequently delayed than are spinal surgeries. This situation may not be universally

Box 1. Possible reasons for a late start of first cases of the day in the operating room

- Patient arrives late from home
- Suboptimal prioritization of multiple surgical navigation MRI scans
- Delayed transfer of patients from imaging, admissions or wards
- Slow registration of patients in the admissions departments
- Anesthetist arrives late to check the patient in the holding area
- Surgeon arrives late to check the patient in the holding area
- Late patients are not tracked aggressively enough by nurses in the holding area
- Delayed surgical set-up of the OR by nurses
- Random events (e.g., patients having to go to the washroom just before being taken into the OR)
- Delays because of waiting for a radiograph technician or insufficient technicians available if multiple spinal ORs are to be run simultaneously
- Equipment failure (e.g., e-film monitors in the OR)
- Inadequate number of nursed beds available
- Inadequate number of nursing and anesthesia staff and OR facilities for an unplanned emergency surgery

MRI = magnetic resonance imaging; OR = operating room.

applicable because in our institution all cranial surgery patients undergo imaging, usually magnetic resonance imaging (MRI), around 6 am on the morning of the surgery; this MRI is used for neuronavigation purposes. Spinal surgery patients do not require similar preoperative imaging. The amount of time needed to perform the imaging adds to the delay, especially because there may be up to 4 surgical cranial cases scheduled to start at 8 am (as well as 2 or 3 stereotactic radiosurgery cases that also require MRI early in the morning). The hypothesis that preoperative imaging contributes to delays was supported by our finding that a higher proportion of cranial cases (35.8%) are delayed getting into the operating compared with spinal cases (17.2%). In contrast, spinal cases require intraoperative radiographs to confirm the correct level; intraoperative imaging was the second most common cause of delay in spinal cases, after equipment failure. Our results demonstrate that surgeries with extra steps such as imaging tend to have higher incidences of delays.

Because brain tumours make up the majority of the senior author's practice, our analysis of cases by type of anesthesia and patient's admission status was limited to this patient group, which is a fairly uniform population with limited confounding variables. Our analysis showed that there was no difference in the mean number of delays between patients who had awake surgery and those who had general anesthesia. Likewise, there was no difference in the mean number of delays between patients scheduled for admission and those whose surgery was on an outpatient basis. The category of admission status was meant to examine the patient registration process, which is the same registration process used in other surgical subspecialties in our institution; inpatients come in through the same day admission unit, whereas outpatients are registered at the day surgery unit. Our results indicate that the performance of both units was comparable in terms of delays, which might be expected because the same physical unit and nursing staff are used for both groups of patients.

Finally, we used our database to evaluate the impact of perioperative delays. We asked whether an initial delay is associated with more subsequent delays. Our analysis shows that this is indeed the case, because initially delayed cases have a higher average number of subsequent delays compared with cases that are not delayed, even after subtracting 1 delay for the initial delay from the calculation. Initial delays may be associated with further delays because there is already deviation from the schedule from the start, setting off a "domino" effect. Moreover, the anxiety and frustration felt by the operating room team over the delay may affect their subsequent performance and contribute to more delays. Repercussions from delays in the operating room are shared experiences across surgical subspecialties.

The findings of our study illustrate the principles underlying the causes of perioperative delays in surgery in general. Our finding that equipment failure is a major

cause of perioperative delay is probably a universal phenomenon, given the heavy dependence of many surgical specialties on equipment in recent years. Analysis of cranial versus spinal cases shows how additional procedures, such as imaging, that are dependent on technology and coordination of operating room staff significantly increase the incidence of delays. Our analysis of awake versus general anesthesia procedures suggests that neither of these 2 types of anesthesia significantly affects efficiency. Because neurosurgery shares limited operating room space and time with other subspecialties, it is likely that the same system failures increase the incidence of delays in first cases across subspecialties. Similarly, our analysis of patient admission status is relevant to all subspecialties at our institution because all surgical patients undergo similar admission processes. Finally, given that the reasons we suggest for delays getting into the operating room are common in the surgical operating room, the association between an initial delay and additional subsequent delays may be applicable to other surgical subspecialties.

Suggested solutions

Box 1 lists the possible reasons for delays getting into the operating room. Most of these reasons pertain to all surgical specialties; however, suboptimal prioritization of MRIs is more specific to imaging-dependent surgical procedures such as cranial neurosurgery.

There are potentially easy remedies for many of these delays. To address late patient arrivals, a reminder phone call could be made to each patient the day before his or her surgery to decrease the chance of the patient arriving late on the day of surgery. Prioritizing the order of MRIs the day before by a surgeon or operating room nurse might help to optimize MRI scheduling; for example, the MRI for an outpatient whose surgery is scheduled to start at 8 am should be performed before that of a patient who is scheduled to have surgery at noon. Alternately, the registration of the surgical navigation device could use a recently obtained MRI, thus eliminating the need for imaging on the day of surgery. To address delays in transfer by porters, each operating room should have an adequate number of dedicated porters, and they should be strategically deployed.

Having staggered start times for different operating rooms might decrease delays because the finite pool of human and other resources would not be overtaxed before the universal 8 am start for all operating rooms. To address delays because of waiting for radiograph technicians, extra radiation technologists should be assigned by a manager overseeing the operating list on days when there are multiple spinal cases starting at 8 am. Implementing a reliable process to regularly screen equipment for malfunctions by nurses or engineers would decrease the incidence of unanticipated equipment failures during surgery.

Other causes of delays might entail more long-term, complex solutions. Resolving causes such as patients not being registered quickly enough, late patients not being located quickly enough, delays in setting up the operating room and late arrivals of anesthetists or surgeons would require a change in the culture of the operating room, and all members of the operating room team would need to be more conscientious of scheduling and efficiency. The first step in this process would be to develop a transparent system to monitor efficiency.⁸ Some random events, such as patients having to go to the washroom just before being taken into the operating room, could possibly be mitigated by enhancing communication between patients and operating room staff. Major investment of additional resources by the hospital and funding governmental bodies will be required to solve the issue of inadequate beds and nursing and anesthesia staff.

Limitations

This study has several limitations. First, all delays were recorded by the senior author based on his personal criteria. Although having only one observer eliminates inter-observer variability, it can give rise to bias in how the delays are identified and classified. However, this kind of study is often generated by one committed individual, especially if others are not keen to participate. This was the case in our study; thus, having only one recorder was the only option. Furthermore, recording delays is not as subjective as recording other errors, because the former involves a quantitative measurable variable (time).

Another important limitation is the way in which errors were classified. Some errors may have multiple causes and be eligible for inclusion in more than 1 category. However, errors were classified as only 1 type based on the discretion of the senior author. For example, some delay or equipment failure errors may have been caused by a combination of human factors and system deficiencies, but these errors were only placed in 1 category. This ambiguity could be resolved by creating a more detailed classification system that eliminates as many overlapping factors as possible.

The third limitation is the limited scope of the study population. This database was limited to the patients of a single neurosurgeon whose practice consists mainly of patients with brain tumours operated on in a large teaching hospital. This enhances the reliability but weakens the generalizability of the results. Furthermore, we included only elective cases.

The fourth limitation deals with the classification of the system delays. There is no established classification in the literature; thus, we developed our own system, which has not been validated. Furthermore, this classification is not very specific, and it does not identify the exact reason for the delay, especially for cases that were delayed getting into the operating room. Such a delay could have stemmed from any step in the multiple processes that a patient has to

go through before he or she enters the operating room. To pinpoint the exact cause of the delay, a neutral observer who is not part of the surgical team would have to shadow a patient from the time of arrival in the hospital until the end of the operation and meticulously record all causes of system delays as they occur.

Our financial analysis was crude and does not accurately reflect the actual lost costs because of delays. Furthermore, we did not quantitatively or qualitatively assess the human costs of delays on patients and surgeons.

There is as yet no implementation plan to institute measures to prevent delays and errors on a system-wide basis in our institution. Certainly, the awareness of these flaws has resulted in a conscious effort on the part of the surgical team and the rest of the staff to avoid them, but they still happen with alarming frequency. We hope that the data from this study can be used to show that delays do happen frequently and to elevate awareness about them so that appropriate steps can be taken to prevent them. One could start by addressing the causes of delays described in Box 1 and attempting to put other systems in place to mitigate these causes of delay. This could improve quality assurance in the operating room, patient satisfaction and flow, and decrease frustration and anxiety on the part of the surgical team.

CONCLUSION

This study demonstrates that perioperative system delays are a common type of error in the neurosurgical operating room and that lessons from analyses of perioperative delays in neurosurgery are applicable to other surgical disciplines. Furthermore, an initial delay is associated with additional subsequent delays, propagating a vicious cycle. The most common types of delays were equipment failures and delays in getting the patient into the operating room; measures devised to combat inefficiency in the operating room will have to primarily target these areas. Such system improvements will require a dedicated collaborative effort at multiple levels, including imaging departments, porter systems, patient registration processes and others. Thorough documentation of perioperative delays and their causes in different surgical subspecialties may be a useful way to start designing solutions to improve operating room efficiency.

Competing interests: None declared.

Contributors: Ms. Wong and Dr. Bernstein designed the study and acquired and analyzed the data, which Drs. Khu and Kaderali also analyzed. Ms. Wong wrote the first draft of the article. All authors reviewed the article and approved its publication.

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