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Optimizing your operating room: Or, why large, traditional hospitals don't work

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ABSTRACT

Introduction: Caring for patients in traditionally designed, large teaching hospitals is often frustrating. Attempts at decreasing internal costs and inpatient length of stay are universally undertaken in order to address dwindling reimbursement, and patient care becomes more specialized and fractionated. These attempts have proven to be myopic, at best, and injurious to patient care and professional job satisfaction, at worst. This manuscript attempts to characterize the operational processes of our university operating room facility as well as make suggestions for operational improvements that can be applied to all hospitals.
Methods: Through a step-by-step approach, we analyze the patient's journey from the surgeon's office through the day of surgery to discharge. Using this approach, a series of studies designed to identify operational shortcomings and inefficiencies are undertaken, and the results of these shortcomings are elucidated.
Results: In our operating room, the peri-operative services are composed of multiple departments, each accountable to their own administrative silo. We found this to result in fragmented goals and objectives confounded by individualized and conflicting incentives. Consequently, we conclude with a recommendation that veers from process modification to a disruptive innovation of the hierarchical organization.
Conclusion: Nowhere in the hospital is this drive for cost containment and increased patient volume more evident than in the operating theatre. Long-term improvements must embrace radical reduction of OR costs and increased operative patient through-put, (i.e. per 8 h day; per fiscal year) by re-engineering the processes of operative patient care. In the end, the ultimate goal of safe and high-quality patient care must not be compromised.

1. Introduction

For those of us that work in large teaching hospitals of traditional design, providing efficient, high-quality patient care can be frustrating. New DRG and capitated/bundled reimbursement systems are exerting enormous financial pressures on us, and our hospitals. The initial response to succeed in this economic climate has been to offset the demands of decreasing reimbursement by curbing internal costs and decreasing inpatient length of stay; thus, pushing more patients through the hospital on a shoestring budget to maintain our operating margin. We hire physician extenders and nurse assistants; case managers and discharge planners; bed coordinators and insurance coders – more and more professionals to care for a smaller, specific piece of each patient's hospitalization. This approach has proven to be myopic, at best, and injurious to patient care and professional job satisfaction, at worst.[1–4]

Nowhere in the hospital is this drive for cost containment and increased patient volume more evident than in the operating theatre. Here, costs are measured in minutes and revenue gained on a per case basis. Long-term improvements must embrace radical reduction of OR costs and increased operative patient through-put, (i.e. per 8 h day; per fiscal year) by re-engineering the processes of operative patient care.[5] During the re-engineering processes, teaching hospitals must also preserve the mission of resident education. In the end, the ultimate goal of safe and high-quality patient care must not be compromised.

This manuscript attempts to characterize the operational processes of our university operating room facility. This is a large hospital system servicing the tertiary care needs of the New York Upstate. The process for a patient begins in the surgeon's office and continues through the day of surgery to discharge. We hope to offer specific plans to 1. Maximize revenue production by increasing patient through-put without increasing costs. 2. Maintain bench mark levels of patient safety. 3. Increase patient and employee satisfaction. We recognize that these objectives are inter-related

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and may even be in conflict. What's good for the hospital's bottom line might not always be good for the patient! The lessons learned from our specific process study are applicable to every large tertiary care hospital.

In our operating room, the peri-operative services are composed of multiple departments, each accountable to their own administrative silo: Surgery, Anesthesiology, Nursing, Materials Processing/sterilization, Transport/Housekeeping, clerical support, Information technology. This traditional teaching hospital structure leads to fragmented goals and objectives confounded by individualized and conflicting incentives. What's good for the surgeon might not be good for the nurse; what's good for the nurse might cost the materials processing division extra.[6,7] Consequently, we conclude with a recommendation that veers from process modification to a disruptive innovation of the hierarchical organization.

From our focused examination, we offer broad institutional suggestions that are applicable in any hospital setting, in any country, and across any hospital service. Operational considerations are inherently linked to the pattern of accountability. We have taken an in depth look at our hospital's work flow and are confident our findings and suggestions can spur process improvements in operating rooms everywhere. This will lead to an understanding of why the big, traditional hospital doesn't work.

2. Methods

2.1. "Does the operative day start on time?" (Study 1)

To answer this simple question in our OR, a cohort of 115 "first start" patients was examined. "First start" patients were those scheduled to start the day as the "first" patient in a given operating room. This group was chosen to eliminate the downstream effects that develop as the operative day progresses and delays/variabilities accumulate.[6] Variations of start time from scheduled start time were recorded. In theory, the patients scheduled for a "first start" should represent the best-case scenario for the operating room flow process.

2.2. "What does this delay cost us?" (Study 2)

A dollar value for operating room "down time" was assigned. This standard value was derived from the URMC – Office of the Director and reflects an activity-based (ABC) accounting of operating room costs.

2.3. "How many additional cases can be performed during lost time?"(Study 3)

300 consecutive cases performed in the Division of Pediatric Surgery were chosen and operating incision time to the time dressings were applied was used to calculate total time of the surgical case. From this data, we are able to extrapolate the number of cases that can be performed during "down time".

2.4. "Do we end the operating day on time?" (Study 4)

We examined the end of a typical operating room day by examining a full operating day. A "full day" of prime OR schedule is to end at 5 pm. All support staff is scheduled as such and the hospital budgets for a dedicated amount of overtime pay. We enlisted hospital financial records to determine the actual amount of overtime pay spent relative to the budgeted amount ($500,000).

2.5. "Are pre-operative documents completed on time?" (Study 5)

To grossly assess the end product of patient processing preoperatively, 35 random charts were selected to represent the end products of pre-operative document management. These charts were examined to determine the presence of all necessary preoperative documentation.

2.6. Analysis of area 1 (Study 6)

The entire surgical experience from decision to operate through surgery is evaluated in a step-by-step fashion. Three operational AREAS were evaluated in this process; Area 1 involves pre-operative planning, scheduling, insurance approval, and testing. Historical data was acquired in all areas that were studied utilizing existing hospital tracking technology.

2.7. Analysis of area 2 (Study 7)

Area 2 involves the mechanics on the day of surgery which process the patient from hospital arrival to the operating room. Data (times) were collected over a three-month period and were further refined to patients $\leq$ 18 years of age to focus analysis on pediatric providers.

2.8. Analysis of area 3 (Study 8)

Area three involves the actions and events in the operating room itself. The operative time consisted of the interval when a patient enters the operating room, undergoes his/her procedure, and exits the room to recovery. Start time is currently defined in the data collection system as the time when the patient enters the room. Within the operating time, there are three specific steps that are performed by unique individuals. Step one of area 3 is the time from patient entering the room until he/she is ready for the surgical team to begin. Step 1 is attributable to the anesthesiologist and includes activities such as IV placement, patient transfer to the table, and anesthetic induction. Step 2 of area 3 is the time attributable to the surgical team and includes activities such as patient positioning, prep, and the surgical procedure itself. Step 2 is completed when the "dressing" is applied to the patient. Step 3 is again attributable to the anesthesia team and involves reversal of anesthesia, emergence and transfer of the patient out of the room.

Data for intra-operative processes are collected electronically: the time the patient physically enters the OR, time to anesthesia induction, time devoted to surgical preparation/patient positioning, operative duration from incision to closure, and time of anesthesia reversal.

2.9. Assessment of ASA status (Study 9)

We investigated the variability of the above 100 patient's ASA scores and their correlation with times dedicated to induction and reversal. Statistical analyses for all studies were carried out using SAS version 9.1 (SAS Institute, Inc., Cary, N.C.).

2.10. What account for delays and is the process stable? (Study 10)

In order to link time intervals to varying surgeon, anesthesiologist, nursing team, and ASA classification, a regression analysis was performed where complete data (times) were available. The primary analysis looked at the association of each independent variable on the time interval while controlling for the other variables (listed above) not being assessed. This was done in a univariate fashion. No adjustments for multiple comparisons were made.

We then attempted to ascertain whether or not this process is stable – if variation is minimal and expected – through X-bar and X-mR analysis.

2.11. Reliability of documented times (Study 11)

Direct observation was performed by independent nurses of randomly selected operating rooms and procedures to record reliability of; documented ASA class, patient arrival time, time of induction, induction complete, positioning time, incision time, skin closure/dressing, and patient out of room. An additional data sheet allowed the observer to record the common causes of delay.

3. Results

3.1. Study 1

Of the 115 "first start" cases, only 19 (16%) entered the operating room within 5 min of their scheduled 7:30 AM start. It is important to note that this "time in the room" does not equate with surgical start of the case. The actual operation itself does not begin until a later time. 28 cases entered the room between 6 and 15 min of the 7:30 AM start time representing 24% of the total. 64 cases (56%) entered the room between 16 and 20 min, and the remaining cases entered the room more than 20 min late. Breaking these cases down into delay categories in proportion to the 115 sample cases, 24% would be expected to be delayed approximately 10 min, 56% delayed 18 min and 3% delayed for some time longer than 20 min.

3.2. Study 2

The URMC Office of Director quotes a cost of $3600 per hour of unused operative time per operating room. This value excludes physician time lost and was estimated in the fall of 2007. Given this estimate, these delays represent a cost of $90,720 on a first case basis alone over a two-week observation period.

On a light day, our operating suite runs 30 rooms. Assuming 5 days a week for 50 weeks of the year (conservative estimates), this represents 7500 "first start" cases annually. Total delay time for "first start" cases would approximate 98,100 min annually and cost nearly $5.9 million. Separate data from the administrator of peri-operative services in the fall of 2007 increased this time/value estimate to $100/minute or $6000/hour. Using these figures, the lost opportunity cost nearly doubles to $9.6 million for only first case delays.

3.3. Study 3

Using pediatric surgical divisional data, we find that the average pediatric operation requires 60 min and, even if we double that time to account for non-surgical activities, there are over 800 operations that could be additionally performed annually in those minutes lost at the start of the day. From our surgical chief's report, the average contribution margin per surgical case (including inpatient and out patient cases) approaches $6000 – that translates into potential profit of $4.8 million.

3.4. Study 4

For fiscal year 06–07 the operating room exceeded the overtime budget by $960,000. Total overtime pay for the nursing staff alone approached $1.4 million – a near 200% variance from budget.

3.5. Study 5

From the random sampling of pre-operative charts, we found that *no charts* were complete. Each chart was missing formal documentation that would require updating or completion on the day of surgery.

3.6. Study 6

A process map of area 1 (Exhibit 1) was created to diagram the flow of patients and their accompanying chart materials from the "decision for surgery" in the surgeon's office to "patient arrival" on the day of scheduled surgery.

The process starts immediately after a surgeon makes a decision to proceed with surgery and a patient consents. Two forms are generated in our hospital: the Assessment/History & Physical form (H&P), and the Consent for Medical or Surgical Procedure form (Consent Form). These forms are then provided to the surgeon's secretary. The secretary is the main resource of the document management process. The surgeon's secretary initiates the formal request for surgery with an electronic Form 973 (includes patient information, patient insurance, scheduling details, patient medical physician information, ICU, anesthesia requirements, pre-operative testing, special needs, and discharge needs, if any). The secretary also enters a CPT code (billing code provided by the physician), an ICD-9 code (diagnosis code), and LOS information (Length of Stay). The electronic form is then submitted to multiple departments: document management, scheduling, utilization review, financial counseling, and referral intake.

3.7. Study 7

Approximately 1300 patients were identified in our study age group. Data was surprisingly sporadic and incomplete with errors such as surgical start time entered before patient ready time. Less than 50% of these charts were suitable for examination. From this set, 100 clean cases were selected.

Patients check-in and register on the day of surgery and then wait, on average, 19 min before physically moving into the surgical center. The standard deviation of this wait time, however, is 28 min – exceeding the average time. Once in the surgical center, the patient changes clothes and waits over 1 h (67 min Average; SD 53 min). The next step is transport to the Pre-anesthesia unit where a typical wait averages 48 min (SD 28 min).

3.8. Study 8

As with the electronically recorded time data, standard deviations were high. The time credited to anesthesia induction was 13 min (SD 9). Surgical preparation and positioning was the same, averaging 13 min (SD 9). Average operative time is variable and was not isolated by CPT or ICD-9 for this analysis (Average 66 min; SD 67 min). Anesthesia reversal then consumes an additional 11 min and has a standard deviation of 15 min.

3.9. Study 9

Of the clean charts available, 84% of all patients were low risk with ASA classifications of 1 or 2. On average, the ASA status of the patient is not a predictor of the wide variation in the data presented above (Exhibit 4). In fact, the lower ASA patients required more time for anesthesia induction.

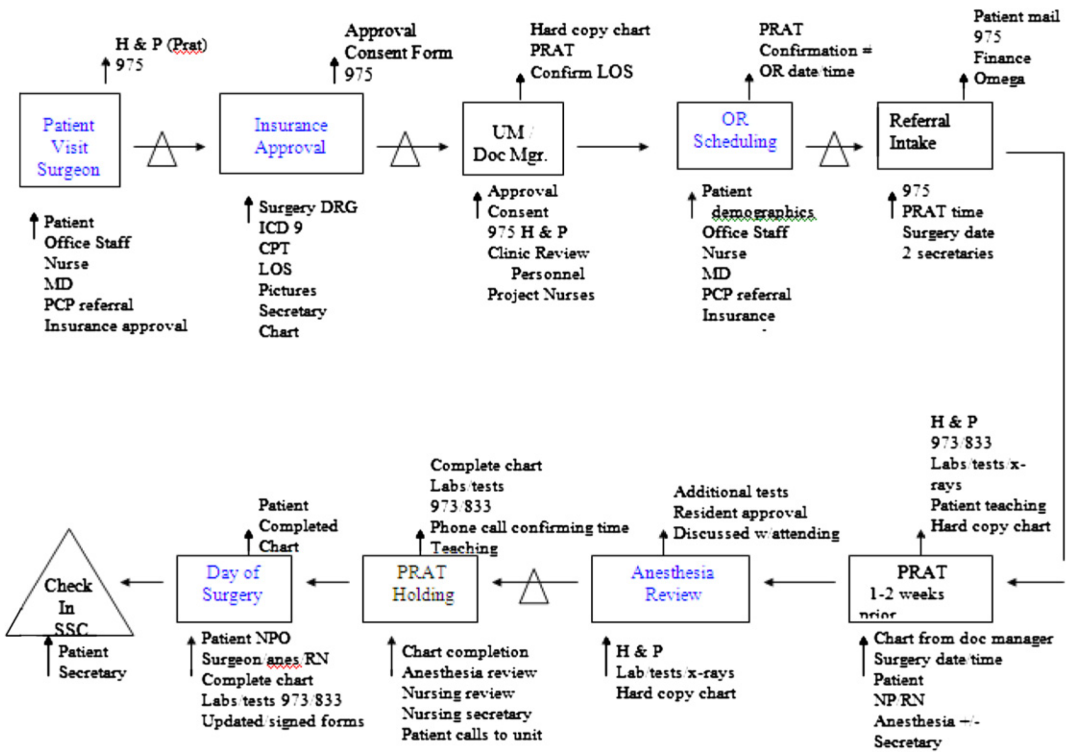


Exhibit 1. Pre-operative Planning: The activities performed during each step and the people/machines/materials utilized are included. The flow diagram documents the process of care for patients including the site of service, resources per service and those "value-added" (blue) steps as perceived from the patient's perspective. The activities performed during each step were identified and enumerated through interviews conducted with the individuals involved in each of the steps (surgeons, anesthesiologists, office managers, secretaries, and nurses).

3.10. Study 10

On average, turnover times consume 26 min with a standard deviation of 11 min. Time for anesthesia induction was found to be independent of anesthesiologist (Exhibit 5) but dependent on surgeon ($r = 0.65$, $p < 0.0001$). Time of induction was found to vary inversely with ASA classification. Given the limited data sets available, X-bar and X-mR analysis reveal an unstable system (Exhibits 6 and 7). Upper and lower control limits were set three standard deviations away from the mean or calculated from the observed moving range. Exhibits 6 and 7 demonstrate frequent process deviation above the limits.

3.11. Study 11

Generally, the times recorded in the electronic system matched our experimental results with respect to anesthesia induction and patient positioning – steps 1 and 2. However, the electronically

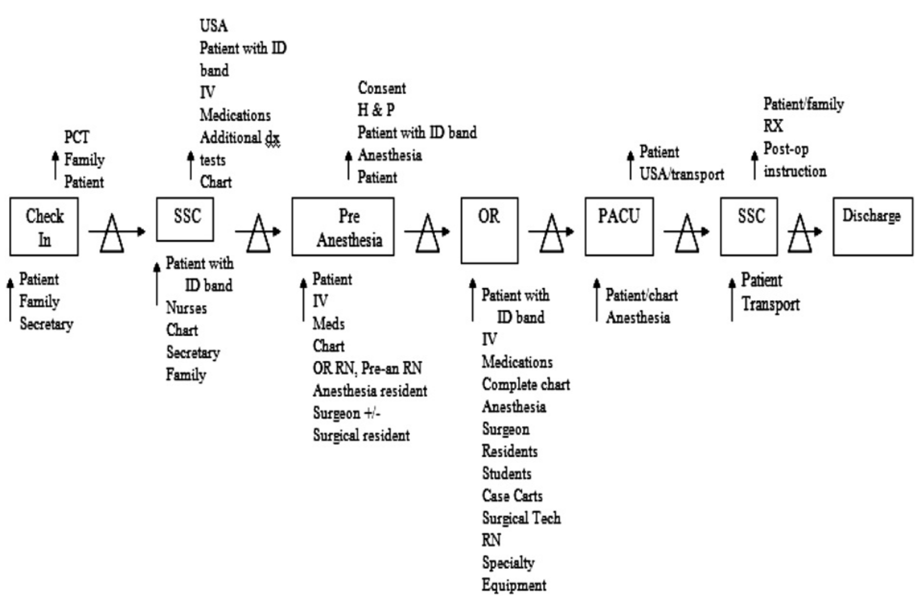


Exhibit 2. Day of Surgery: The patient's operative day is outlined here from arrival to discharge from the hospital.

ASA Classification

Class 1	Healthy patient, no medical problems
Class 2	Mild systemic disease
Class 3	Severe systemic disease, but not incapacitating
Class 4	Severe systemic disease that is a constant threat to life
Class 5	Moribund, not expected to live 24 hours irrespective of operation
An **e** is added to the status number to designate an emergency operation. An organ donor is usually designated as Class 6	

Exhibit 3. ASA Classification.

recorded times significantly *underestimate* the time required for patient emergence from anesthesia to patient leaving the room (Step 3). Our experiment documented a total non-operative in room time on average 51 min versus 34 min documented in ESI.

4. Discussion

We first asked a simple question "Does the operative day start on time?" (Study 1) Akin to any production schedule, first start activities have a downstream impact. Initial delays are amplified and culminate in overtime shifts, patient and employee dissatisfaction, and negatively impact financial measures – an ideal operating room should not waste resources.[6,8] When we asked what these delays cost, the results were significant (Study 2). Because lost minutes are only good if they can translate into additional cases or operations (Study 3), we feel that our estimation of additional cases has utility.[9–12] We recognize, again, that capturing delay time in 5 min intervals is difficult to translate into additional case contribution margin, but it must be acknowledged that recapturing even a percentage of this cumulative time delay would lead to additional case revenue.[11] This additional revenue, again, is not small.

It is possible that our assumption regarding "start time" was not relevant (Study 1) in that the operating room day was able to absorb the lax start times and still produce an adequate product.[6,12] We therefore examined the end of the typical OR day (Study 4). A "full day" of prime OR schedule is to end at 5 pm. Nursing shifts and support technicians are scheduled accordingly. Variability in room turnover, patient induction, and surgery times results in a high demand for nursing "overtime pay differential".[6] Some of this is unavoidable as an emergency trauma case or transplant occurs; consequently nearly $500,000 a year is budgeted by our hospital for nursing overtime demand. Actual overtime pay far exceeded this budgeted amount.

Surgical delay is a significant issue and improvement in this area could confer a large financial benefit. We submit that a goal of improved adherence to a schedule is one way to achieve improved patient through-put with the corollary benefits of decreasing overtime costs and increasing employee/patient satisfaction. In addition, a stable schedule, like a stable production line, is then in a position for process analysis and optimization.[7] The problem is clear: in large teaching hospitals we don't start on time and we don't finish on time. These delays in the morning cost us revenue opportunities and lead to delays at the end of the day. It isn't too much of a stretch to see how this impacts staff and patient satisfaction.

It is important to explore the role of incentives in this system.[8] In this electronic system, the web database is accessible by all those involved in the process, resulting in a system of relative checks and balances. It tries to foster a pattern of accountability for completion of the documentation process quickly and accurately. However, there is no single individual in charge of this process and, therefore, no evaluation metric for this pre-operative phase – no reward, or punishment for incomplete/inaccurate patient records. There are no incentives. An economist would argue that people behave according to their incentives, or people behave to maximize the good and minimize the bad. This mechanism is completely lacking in the big university scheduling system.

In Study 6 we see that the electronic system has placed the surgeon's secretary in a central role for the pre-hospital phase

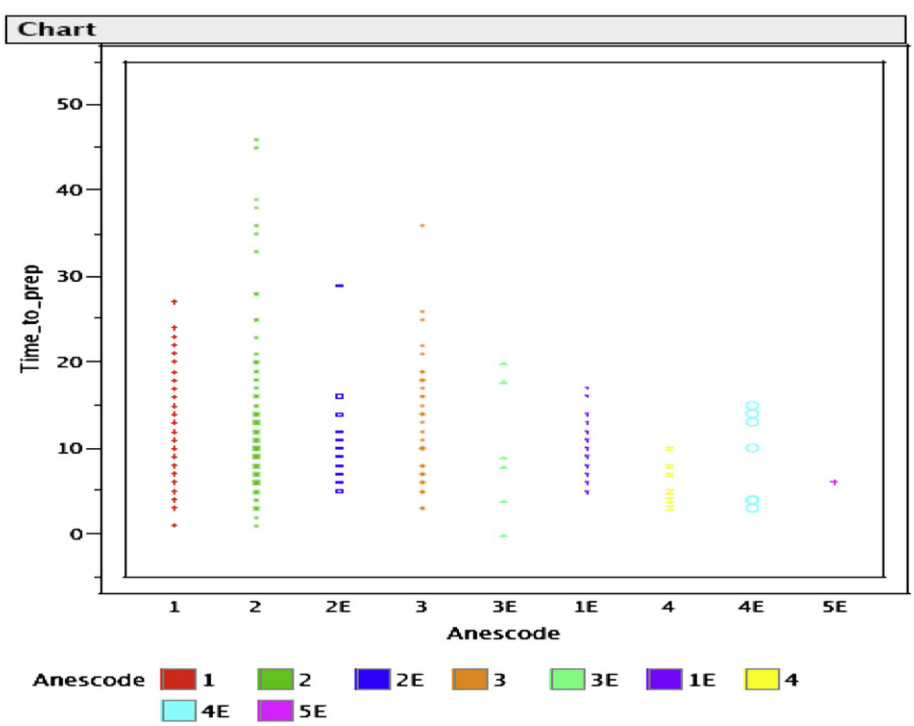


Exhibit 4. The variability of ASA status is correlated here with duration to surgical preparation. The "sicker" patients are induced faster than the more healthy patients.

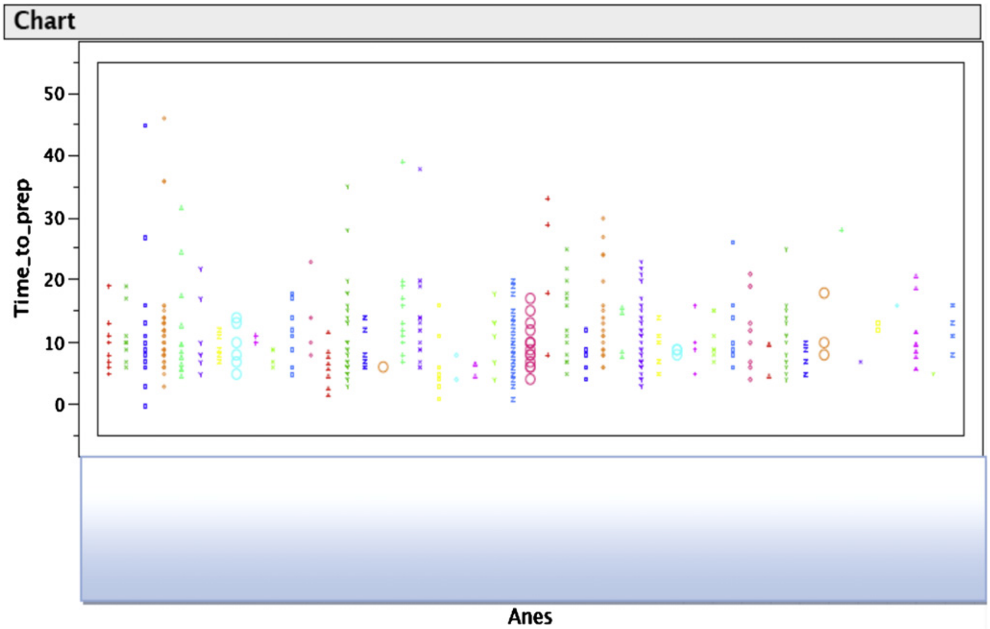


Exhibit 5. Individual Anesthesia providers are shown here with their individual times from entrance of room to surgical preparation. Regression analysis revealed that time to induction was independent of Anesthesia provider and dependent on surgeon.

(Area 1), providing them with decision rights over the documentation management process. These individuals have decentralized specific knowledge about individual procedure requirements, surgeon availability and preferences, and patient variables (age, geography, insurance, and co-morbidities). When we discuss evaluations and incentives, we find that secretaries are employed by the hospital. Their pay scale is rigidly defined. They are evaluated by the rules established by HR across the entire University. The surgical secretary is paid and evaluated in the same fashion as the secretary working in the pathology department (or, the English Literature division). The effective implementation of incentive systems may require a restructuring of the current administrative silos. It may be that the secretarial pool is reassigned under the managerial governance of the operating room where their decision rights have a direct and measurable impact.

When the charts of “Same Day” admit patients delivered to the surgical center the day prior to surgery (Study 5) were assessed as the end product of this Area, it was found that no charts were complete. According to the flow diagram, these charts should be complete and ready for processing the morning of surgery. Each chart was missing formal documentation that would require updating or completion on the day of surgery. No feedback loop exists to inform those that generate or pass on incomplete or flawed data. This also results in a potential compromise of the quality of care, as patients were not uniformly treated with Venothromboembolic (VTE), Antibiotic, and peri-operative Myocardial Infarction prophylaxis. To maintain safety, surgical delay is incurred as these measures are manually corrected on the day of surgery.

Performance data from our institution based on procedures scheduled per-week found that 62% of ICU beds needed on the day

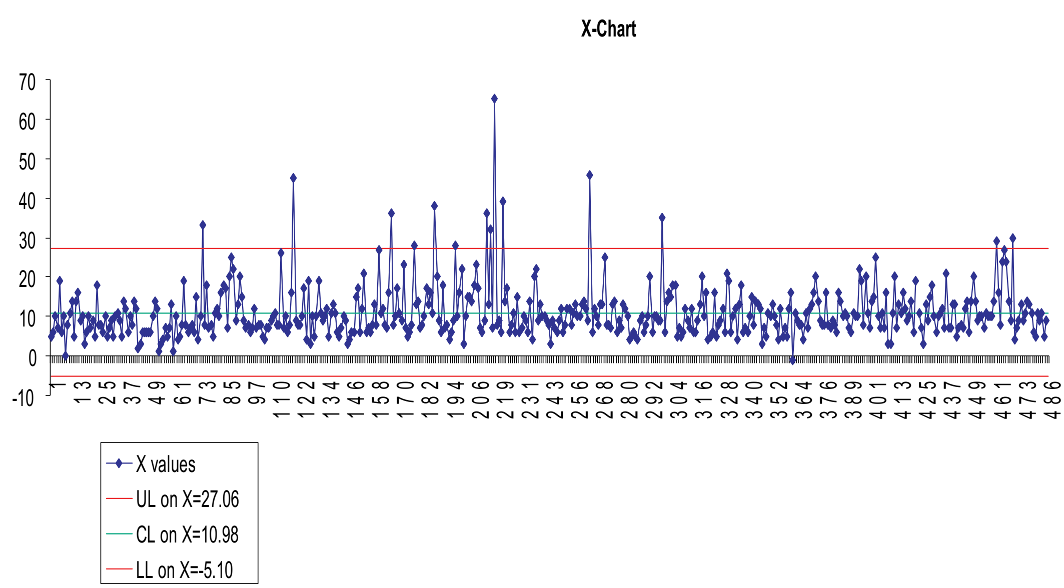


Exhibit 6. X-bar and X-mR analysis of control charts reveals variation (stability) of the system is not minimal.

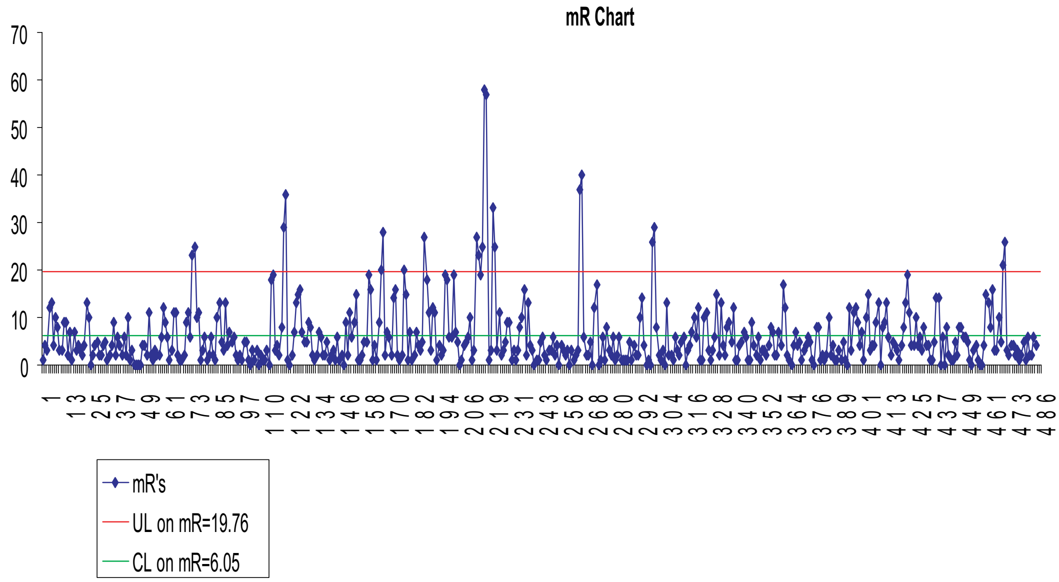


Exhibit 7. Upper and lower control limits are set 3 standard deviations from the mean or calculated from the observed moving range.

of surgery were not scheduled and nearly 10% of scheduled cases were booked with the incorrect level of care (Outpatient, 23-h stay, same day admit). Fully 83% of patients arriving for surgery had incomplete chart documentation. Thirty-one percent had no chart documentation whatsoever on the day of surgery. These data are supported by previous reports that suggest operational errors may impact patient flow time on the day of surgery and compromise quality of care.[7,8]

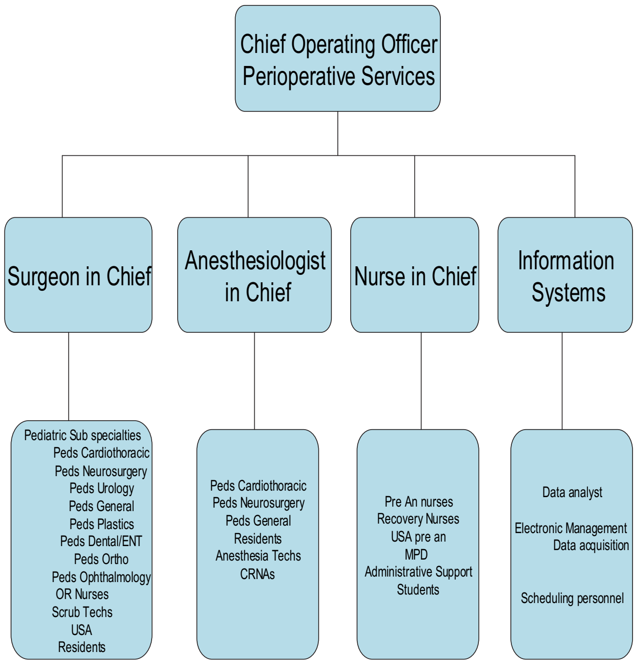
When patients arrive for surgery (Exhibits 2 and 3), their process though the operating suite is closely followed (Study 7). In recent years, a computerized system includes the electronic processing of patient documents in the pre-operative period. Data collection begins in this computer program when the patient arrives at the operative suite on the day of surgery. The system tracks the patient through the operating room and to the PACU for recovery and discharge via bar code scans. The cases that were selected in Study 7 represented cases where all time data were available from check-in through discharge. Again, it is important to note that there is no feedback loop to correct data entry or any incentive for providers or transporters to accurately enter this data. Consequently, the holes in the electronic flow chart are not surprising.

In total, Area 2 consumes 134 min in waiting and processing and has virtually no "value-added" merit. We expect that this has a negative impact on patient satisfaction.[7–9] One cannot separate waiting time from actual raw activity/service time. The wide variation in the time is also significant. Because this is clearly not a stable it cannot be optimized. Furthermore, the 134 min consumed in non-operative activity is offset by patients asked to arrive 90 min before their scheduled operative time – again, a potential negative impact on patient satisfaction.

As configured, the electronic system is effective in documenting patient location and time in the hospital, but it does not offer any extractable mechanism to identify causes for delays. In addition, the current pattern of accountability in peri-operative services does not evaluate what data there is for system improvements. Because of the separate managerial silos existing in peri-operative services, any delay leads to a finger pointing mentality rather than unified problem solving. One must proceed nearly to the director's office before the independent silos intersect with a common leadership. The agency costs associated with this system clearly are a detriment to efficient operations, quality patient care, and revenue generation. Individual "utility maximizing behavior" is rampant and does not equate with "hospital or patient maximizing behavior." This system processes patients; it is not patient centered. This is another argument in favor of hierarchical restructuring.

It is important to understand that each operation is scheduled based on the surgeon's estimate of his/her raw activity time to perform the posted procedure. The operating room schedule only takes this predicted time into consideration – exclusive of times/activities incurred by the anesthesia team. Under this system, delays are inevitable. Each operative room must have a turnover time to prepare and set up for the next case. This period involves cleaning the room, opening new and case-specific instruments, and setting up a new anesthesia circuit. It is a process that requires the teamwork of nursing staff, anesthesia staff, and the materials/processing group – all who belong to different managerial silos with different incentive structures. As such, there is no documentation of the reasons for delay occurring at this step. There is no data tracked for the time expended, or by whom, on these activities. Similarly, there is no extractable data that documents reasons for delay in this turnover process. Conceivably, by tracking the personnel involved in the turnover process, (i.e.: surgeon, USA staff, RN, Tech, Anesthesia) the times required for each activity, and reasons for delay, we could standardize the process and decrease the turnover times. In addition, we would recommend metrics to institute a reward structure for those who perform above benchmarks. Decreasing turnover times by 10 min each over a standard operative day could lead to one additional operative procedure performed in that room/day. If we apply the financial measures above, that leads to $30,000 additional contribution margin for the hospital weekly, or $1.5 million over a year. Or, even if that case doesn't happen, the ability to end on time will significantly decrease the overtime burden! The non-financial costs of overtime and an unpredictable schedule such as demoralization of the staff, dissatisfied patients, and future lost clients are difficult to quantify but should be acknowledged.[10]

Anesthesiologists were found to share similar times of induction regardless of patient specific variables or nursing team (Study 10). However, they performed significantly faster for different operative surgeons, suggesting a bias for providers to perform more efficiently when working with surgeons who offer incentives for good performance, however tangible or intangible these incentives may be. Incentives for good performance range from interpersonal praise to



Tree Diagram 1. Proposed restructured hierarchy with elimination of traditional department structures (silos) in the surgical suite.

offering rewards for timely service, and anything in between. That is to say anesthesiologists took more time – for non-productive activities – on healthy patients and moved more rapidly when the patients were more complicated. It is not surprising that emergent patients, where intubation and access was accomplished in the emergency room or ICU, took less induction time. While it is possible that specific patients required more detailed anesthesia preparations with their patient population, this was outside of the scope of this examination and not likely to have impacted our results significantly due to the fact that only the pediatric surgical service was studied.

Taken together, operative delays are a very significant source of operating room cost. A "full" operative day for a surgeon is to end at 5:00. However, because of these hidden times, the full day frequently runs into the evening shift. Differential pay for nursing is substantially greater than the standard rate and occurs daily. Smoothing the scheduling in this fashion leads to more predictable allocation of resources. Scheduling must account for the additional times that are not predicted by the posting surgeon – these should include an estimate of the anesthesia and nursing related activity times. At the very least, a goal of improved adherence to a schedule may be one way to achieve improved patient through-put with the corollary benefits of decreasing overtime costs and increasing employee/patient satisfaction. In addition, a stable schedule, like a stable production line, is then in a position for process analysis.

As we discussed with room turnover times, surgery involves the coordinated action of many different team members – surgeons, nurses, materials/processing, anesthesiologists. Each of these individuals are said to be on the "operative team," but they report to very different hospital divisions. These divisions have various incentive structures and expectations. We may be a team when we are facing a patient, but we are frequently in competition within the hospital for time, resource allocation, or even parking spaces.

5. Conclusions: why large, traditional hospitals don't work

The analysis of our operating room identified many duplicated processes. It also identified many areas where improvements could be directly linked to increased revenue, patient safety benchmarks, and potentially, staff satisfaction. This study identified the following:

1. Pre-operative charts are incomplete.
2. Operating room scheduling is inaccurate.
   a. Operating room doesn't start on time.
   b. Operating room doesn't end on time.
3. Anesthesia activity times are not incorporated in scheduling.
4. Patients experience long queue times.
5. Patient through-put on the operative day is an unstable system.
6. Data collection is inadequate and inaccurate.
7. There is no feedback mechanism or pattern of accountability to correct errors.
8. There are no incentives or consequences for improved patient care, through-put, cost containment, chart readiness, or adherence to schedule. In fact, the fragmented "silo" structure of the operating room leadership leads to conflicting incentives.

There are many suggestions that we could make to identify process changes aimed at fixing the areas that our study found to be flawed. For example, we suggest that the operating room could stagger the room start times so that attending anesthesiologists need not be in two rooms at once and the first case delay is minimized; or that all surgeons use a standard procedure to submit operative consent forms.

However, the current leadership structure in most large teaching hospitals is one of traditional "silo" organizations comprised of nursing services, anesthesia, materials processing, administrative support, and surgery. It focuses on the *components* of patient care and not on the patient. Consequently, each faction is prone to maximizing individual utility and excellence rather than patient centered, team care. Our findings illustrate these inadequacies. Ultimately we want to improve the experience and outcomes for our patients who require surgical care and simultaneously enhance the work environment in a cost effective fashion. The operating room needs to become a single service area where multiple professionals provide coordinated care, identify strategic priorities, and share the risks/rewards.

Based on our findings, we propose that elimination of the traditional department structures in the surgical suite will lead to a restructuring that is more patient focused and outcome driven. We are currently pursuing this restructuring at our institution. (Tree Diagram 1). The first step is to establish a managerial team with primary leadership recruited from outside the hospital. This chief operating officer cannot be perceived as "belonging to" one of the traditional silos or departments of nursing, anesthesia, or surgery. His/her direct reports will include representation from these groups and also an information technology officer. This last member is essential as operations become "on line" but also because evaluation of outcomes/data will guide strategy decisions. We cannot over state the importance of this objective position. As we discussed above, the electronic system in the operating room only marks the location of the patient during the day of surgery, but not any extractable data about providers or reason of delay and the document managing systems that follow the patient's chart, insurance, and paperwork similarly can't provide information about how the chart is prepared or who is doing a good job.

This leadership structure needs to become patient focused and not department focused. Evaluation metrics will be jointly agreed upon by the leadership team and gathered by the Information Systems division. By eliminating the traditional silos, evaluation metrics can be uniformly applied to all OR personnel. For example, if a surgeon is routinely late for his/her case, then they might loose the privilege of a first start. This will be applied and enforced from the operating room COO even if the surgeon is the "chief" of a surgical division. Similarly, Anesthesia personnel that do not perform up to their peers (locally or nationally) could be reassigned or penalized financially – even if the anesthesiologist is "chief" of a division. This objective evaluation of the IT data and adjustment of behavior works best when everyone functions under a single patient centered team. Currently, each team member reports to a different silo, so when a dispute emerges between a cleaning worker and a nurse; a doctor and a nurse, there is no central authority to mitigate the conflict. Similarly, each team member currently has different reward metrics administered by their respective silo chairperson and individual utility maximizing behavior does not lead to hospital/operating room/patient utility maximization. This can change by restructuring the pattern of accountability.

Process analysis and performance evaluation is an on going activity – not an end point. We must balance the benefits of incentives/performance metrics with the cost of acquiring and evaluating that data. We recognize that incentives cannot be too small or too infrequent that people loose interest in performing well; however, acquiring and analyzing performance data on a daily basis is expensive and time consuming, and fails to consider outliers. There is a role of incentives in motivating performance.

Your large tertiary hospital doesn't work because every employee is focused on his/her individual division and not on the patient. The prevalent accountability metric favors performance within each department – within each silo – not in a patient centered culture. A patient centered service center restructuring would be beneficial to all hospitals. This is the only way to align everyone's incentives and ultimately break down departmental silos and conflicting interests. This investigation will be repeated once this restructuring has taken place at our institution.

Conflict of interest

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this article.

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Ethical approval

This study was approved by our institutional research subjects review board.

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