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12 by 12: Obtaining True OR Efficiency with Radical Time Transparency and Operational Excellence

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In the modern era of healthcare, true surgical efficiency and value are more important than ever. Applying the same general principles used in other disrupted industries will help us in our quest to improve the value we contribute to our healthcare industry.

INTRODUCTION: WHY EFFICIENCY IS NEEDED

How efficient is your operating room? Ask any orthopedic surgeon and the response you will likely be met with a smirk, indicating some combination of disgust, disappointment and disillusionment. Left to wait in surgeon lounges and complain about wasted time, we often spend more of our operative day waiting—and complaining—than operating. Most joint surgeons are restricted to an average of 3-4 cases per day (n.d.) and wonder why they can't do more. Our decision to become surgeons was based on our love of operating, thus our job satisfaction is directly related to our ability to operate as much as we can (Holzer et al. 2019). Unfortunately, there are few surgeons that are satisfied with their level of efficiency and the number of cases they perform. Thus, it is imperative that during this time of increased healthcare costs that are driving the US GDP, we develop new technologies, ideas, and techniques that will disrupt our healthcare industry. This disruption must provide care that offers improved outcomes at a lower cost in a more convenient form. While most other industries have undergone this type of disruption, healthcare continues to lag. One of the greatest opportunities to reset and enhance healthcare will occur in the operating room.

Disrupting the current level of operating room productivity and efficiency will be a major step toward true progress in the healthcare industry. The authors have utilized a simple formula of radical time transparency coupled with operational excellence to fundamentally change the productivity and efficiency of our hospital and ambulatory surgery center (ASC). Presently, we are routinely doing 12 primary total joint cases by 12:00pm in two operating rooms. This production and efficiency have brought true value to our healthcare system, and we believe there is no reason why this simple, reproducible process could not disrupt every OR and bring concrete, measurable value to all parties.

INSIGHTS FROM OTHER INDUSTRIES

Disruption has occurred in most industries, including media, food and beverage, travel, automotive, travel, commerce, and manufacturing. In general, this disruption involves new technology and ideas that deliver goods or services faster, cheaper, and better than the status quo. The last two major industry holdouts to disruption have been education and healthcare. Gaining precise insights as to how other industries have made such radical shifts can help us understand how we might improve the overall value we bring to the operating room and healthcare in general.

Walmart and Amazon have been the most recent disruptors of the commerce industry, driving down prices and delivering products in an incredibly simple manner. One of Amazon's four core principles since its inception has been operational excellence. Company founder Jeff Bezos described this principle as, "Delivering continuous improvement in customer experience and driving productivity, margin, efficiency, and asset velocity across all our businesses" (n.d.). No truer words have been used to describe every orthopedic surgeon's desire for operational excellence in the OR.

Of course, the concept of operational excellence has been around long before Amazon and indeed was the cornerstone of the industrial revolution. Henry Ford was the biggest disruptor of the automobile industry and brought reliability and reproducibility to a new industry that was competing

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Visit the Open Payments Data Page for Dr. DeCook

Conflicts of Interest Statement for Dr. DeCook

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with the horse and carriage. One of Ford's most famous quotes was, "You can have any color as long as its black" (Ford and Crowther 1922). It has been suggested that Ford knew that black paint dried much faster than the other colors because he knew down to the second how long each step of the process took. From frame assembly times to paint drying times, Ford's stopwatch helped him track not only how long the entire process would take but how each individual component contributed to the overall time. The genius of his moving assembly line was that one step in the process would automatically lead to the next step, thus avoiding the long wait times between different steps of the manufacturing process. Years later, the Japanese manufacturer Toyota described this type of time waste as Mura, meaning lack of uniformity (*Kenkyusha's New Japanese-English Dictionary* 2003; Emiliani et al. 2007).

From Ford to Toyota, time transparency allows manufacturers to determine where waste is occurring, thus allowing them to make process improvements. This advance not only saves time but enhances the overall product quality. Time transparency and operational excellence are critical components of every manufacturing process and to date have not been incorporated into operating rooms in order to enact change, disruption, and true improvements to operational efficiency. We have found that having a healthy obsession with time, cost, and efficiency in the operating room brings about true disruption as well as an improved quality of care.

The "goods and services" of healthcare are actual human beings, making our job ever so critical. The improvement of patient outcomes, as well as the reduction of complications and readmissions, will continue to be the primary driving forces with our precious "products". But as costs rise and overall healthcare spending increases, we must consider new ways to effectuate better outcomes. The great lesson learned from other industries is that time is a critical metric to obtaining increases in quality and cost. Although it would seem ridiculous to any other industry to not measure time, our industry has essentially turned a blind eye to this vital metric. We have sought to distinguish ourselves from assembly lines of vehicles and have been mortified to treat our patients like cars on a conveyor belt. The great irony is that the quicker we realize our industry is no different than any other, the faster our patients will benefit from improved outcomes.

Time is a critical success metric that can no longer be ignored in our industry. Having radical time transparency allows for more efficiency, less cost, and a better end product. As total joint surgeons, much of our surgeries are similar and repeatable, offering us a unique opportunity to apply these principles to achieve true efficiency.

PART I: THE PROBLEM

THE OR INEFFICIENCY "CULTURE"

The causes of operating room inefficiency are always multifactorial, with each institution having its own unique set of challenges and deficiencies that lead to time delays, lost revenue, and less than satisfactory outcomes. While blame is often placed on turnover, anesthesia, inexperienced staff, miscommunication, instrument/implant readiness, and patient readiness to name a few, each individual problem never strikes at the fundamental causes. What caused the OR delay today is often a different cause tomorrow. Almost universally, it becomes difficult to assign fault to one individual or one process. When a particular individual or process is identified as mediocre and partially contributing to operating room inefficiency, there is often insufficient data to enact process changes. Most surgeons and OR administrators are left to simply summarize their institution as having a "culture" problem because they can't identify the root causes of their inefficiency. The OR "culture" proves insurmountable, and the status quo remains unaffected.

CORE PROBLEM: TIME TRANSPARENCY

Every operating room in the country measures time. Surgeons schedule cases at a particular time. Nurses are required to document several time stamps during a surgery including surgery start and end times, incision times, time-out times, etc. Yet, with all of this data, no one really knows where the time goes. Despite measurements being performed, these metrics are not easily accessible—nor are they actionable. These institutions lack time transparency.

For those rare institutions that make time measurements available to their teams and staff, it is often accessed days or weeks later instead of in real time when intervention is still possible. Time is locked away in an EMR or tracking system, never to be seen or used again. Ask the manager of your surgery department what your average turnover time was last month. Ask your partner what their average time to close a total hip or how long it takes to expose and prepare the acetabulum. Ask yourself what is the actual time it takes you to do a total hip? Almost no one has access to their own time metrics. Why is that? Lack of time transparency—the core problem of any inefficient institution is a lack of time transparency.

Every step of the patient journey must not only be measured, but readily displayed so that it can be utilized to effect change. When time transparency becomes ingrained in the culture of an operating room and when those time metrics lead to fundamental changes in procedure, we call this "Radical Time Transparency".

As Mother Theresa said, "Honesty and transparency make you vulnerable. Be honest and transparent anyway." If your institutional administrators want to improve patient care, cut down on waste and become more efficient, they must invest in radical time transparency. It will reveal the faults/blind spots of any organization and can lead to concrete operational changes.

WHY SURGICAL TIME MATTERS

SURGICAL TIMES

The average surgical time for a total hip arthroplasty (THA) is 95 minutes from incision to closed (Cantrell et al. 2019). Despite advances in implants and technology, dramatic reductions in length of stay, improved recovery times, and reduction in complications, operative times have not changed over the last two decades (Cantrell et al. 2019). The average

operative times for a total knee arthroplasty (TKA), which have been stable over the years, are quite similar at 96 minutes (Shah et al. 2019). Hospital volume has had an inverse effect on surgical time, with higher volume centers actually having longer surgical times (Anis et al. 2020). In European countries where there is a large distinction between public and private hospitals, there is no significant difference in operative time (Cowley, Frampton, and Young 2019).

Outcomes have been clearly associated with length of time required to complete the surgical procedure. Readmissions, reoperations, surgical site infections, and wound complications all rise with longer operative times (George et al. 2018). Looking at TKA, Stearns et al determined that operative times less than 80 minutes resulted in significantly fewer complications (George et al. 2018). Della Valle et al found similar results with prolonged operative times over 15 minutes resulting in higher rates of: transfusion, wound dehiscence, renal insufficiency, sepsis, surgical site infection (SSI), urinary tract infection (UTI), readmissions, and length of stay (LOS) (Bohl et al. 2018). Similar findings also occur in partial knee replacements that average 85 minutes per case. Gerlinger et al found that re-operation, SSI, transfusion and prolonged LOS all related to longer operative times (Cregar et al. 2021).

It is widely known that infection is a complication of prolonged operative times in both hip and knee arthroplasty populations. In 2019, Parvizi et al reviewed nearly 20,000 joint arthroplasties and found that for every 20 minutes of operative time the risk of 1yr PJI increased 25% (Wang et al. 2019). They further demonstrated that operative times over 90 minutes resulted in a two-fold increase in SSI as compared to those whose operations took 60 minutes (Wang et al. 2019). Iorio et al also proved that the only modifiable risk factors that could decrease infection risk included lower body mass index (BMI), diabetes mellitus (DM), and lower operative times (Maoz et al. 2015). With the average hip arthroplasty case taking over 90 minutes there is clear incentive to significantly decrease operative times. Stearns et al suggested that operative times less than 80 minutes could significantly reduce complications, including infection (George et al. 2018).

PART III: RADICAL TIME TRANSPARENCY

TRUE TIME TRANSPARENCY

- Measured
- Live
- Visible
- Valued
- Personal
- Radical

MEASURE TIME

The first step toward true OR efficiency is measuring time. While some time metrics are measured in operating rooms today, there are many time metrics that go unnoticed. Having a complete and complimentary set of time measurements is key to understanding the true efficiency problems in your operating room. Many institutions measure room turnover but do not measure the individual components of that turnover. Simply stating that the room turnover is 45 minutes will not help unless you know what your In Room to Prepped and Draped time is. If your turnover continues to be high, it may be that your Closed to Out of Room time is excessive. Do you know what your Closed to Out of Room time is? Have you ever known? What is your scrub tech's opening time for a total hip? What is your instrument time out of room? Having detailed time metrics is key to better understanding broad metrics like turnover time.

See Table 1 for Basic Time Metrics.

Table 1. Important time metrics

- First case start time
- In room to Prepped/draped
- In room to Cut time
- Cut to Closing time
- Cut to Closed time
- Closing time
- Closed to Out time
- Breakdown time
- Cleaning time
- Opening time
- Room ready to in room time
- Non-surgical Patient OR time

LIVE TIME

Looking at time in retrospect can be helpful. Reviewing past time metrics can provide a benchmark for future improvement. Live time metrics carry the advantage of allowing on-demand staff changes to continue the OR flow. Live metrics demonstrate where bottlenecks and delays are occurring in real time. Your live time is actionable and can help reduce time that would have otherwise been excessively long.

VISIBLE TIME

Time must be visible. "What was incision time? In room time? How many times have you heard team members attempt to find out what time an event occurred? Having time visible brings more value to the metric and it helps everyone stay focused on the common goal. With so many potential pitfalls, bottlenecks, and delays, it is impossible to determine the fundamental sources of inefficiency in your institution without having this time transparency. By placing time more prominently in the OR, staff are more aware of their current progress. Imagine if each OR room has its Turnover Time prominently displayed for all to see. Each team member that contributes to turnover has a personal vested interest in the time displayed. Imagine if you could see how ahead or behind you are in your OR room.

VALUED TIME

Time must be valued. It is obvious which teams have embraced time metrics as one measure of team effectiveness. Those are the teams that recognize when they are running behind and know how to get help. Those who value time make efforts to improves processes that enhance efficiency. Teams that don't value time are unaware of time around them and don't recognize when delays are occurring. Ultimately, teams that don't value time lack meaningful ways to improve their processes.

TIME = VALUE

We have always considered healthcare as different from any other industry. Quality patient care can't be rushed, or mass produced. Some even take a moral stand against measuring time in an OR, saying, "If a surgeon is thinking about time, or how many cases they need to do in a day, then they can't have excellent patient outcomes." Although operating from a place of good intentions, healthcare has been slow to transition from thinking solely about patient outcomes to thinking of overall value.

$$Value = \frac{Outcomes + Patient\ Satisfaction}{Cost}$$

As we become more accepting of value in healthcare (Porter 2010), we must also embrace that time plays a major role in delivering value. If surgeon A performs three total hips with the same outcomes as surgeon B who performs seven in the same amount of time, it is no doubt that surgeon B's performance provides more value to the system. Interestingly, regardless of time, the higher the volume the better the outcome (Lau et al. 2012; Kreder et al. 1997). This phenomenon has been seen across total joints, and across specialties (Birkmeyer et al. 2003). What has also been proven, just as in other industries, is that as efficiency improves, so do patient outcomes. Delphin et al found that OR efficiency had no negative impact on patient safety and quality of care (Chernov et al. 2020).

PERSONAL TIME

Time must be personal. Hospitals typically do not capture time based on individuals, teams, or OR rooms. Instead, they report overall, generalized time measurements about turnover or start times. If the data is not personalized, the change cannot be personalized. Just because a nurse noted when a patient entered a room does not necessarily help your team improve. For some teams the problem may be start times, for others it may be slow turnover, and for yet others it may be that there is not enough staff to open trays. When used properly, personalized time serves as one of our most effective tools to track our improvement and compare ourselves to our peers. This means that the surgeon is not telling the anesthesiologist he is slow; rather the anesthesiologist recognizes it and makes a change in his or her process. Personalized data draws out the native competitiveness in most people and gives them a goal to work towards (Gabriel et al. 2014).

See Table 2 Individual Team Metrics.

Table 2. Team member metrics

Circulator Efficiency

- What is your average true turnover time (closed prior case to incision this case – how long does it take from the time the surgeon stops to when the surgeon starts again)?
- What is your closed to wheels-out time?
- How do your metrics compare to other circulators in the hospital/ASC and how do they compare across the country?

Scrub Tech Efficiency

- What is your average case opening time (time from when the room is clean to all trays are open)?
- What is your average turnover time?
- How do your metrics compare to other techs in the hospital/ASC and how do they compare across the country?

Anesthesia Efficiency

- What is the time from request to spinal complete?
- What is the in-room time to anesthesia?
- What is your closed to patient out time?
- How do your metrics compare to other anesthesia in the hospital/ASC and how do they compare across the country?

Assistant Efficiency

- What is your average surgical time?
- What is your closing time for each procedure (time from when the surgeon has finished to full closure)?
- How do your metrics compare to other assistants in the hospital/ASC and how do they compare across the country?

RADICAL TIME

Time must be radical. To become radical, time must be used to improve the operation of the OR. Those transparent times need to be embraced and used by all parties of your organization from the sterile processing department (SPD) to the administrator. Every staff member uses their metrics to change their processes. Whether that is turnover of trays or the duration of spinals, radical time transparency means that the process of how we improve is fundamentally altered. Radical time transparency is the fuel for the second key ingredient to operating room efficiency: operational excellence.

PART IV OPERATIONAL EXCELLENCE: PRACTICAL SOLUTIONS

OPERATIONAL EXCELLENCE

Time, by itself, is not enough. You must connect those time metrics to a system of process improvement in order to achieve operational excellence. Time transparency is the fuel needed to run an efficient engine, but operational excellence is the real engine of efficiency. Remember the goal is never to be faster, but to be more efficient. In fact, the goal is never about time at all. The real goal is to improve the process. Time and efficiency are delightful and natural byproducts of the process of measuring time and operational excellence.

Commitment by management and staff to improve operational control of the OR has shown concrete time savings in multiple studies. Ertl et al looked at the application of the Six Sigma program in the OR and noted that on-time starts improved from 32% to 73%, room utilization improved from 56% to 68%, and overall revenue increased 10% (Bender et al. 2015). Similar interventions at a children's hospital that led to a reduction of turnover time from 41 to 32 minutes (Tagge et al. 2017). Fundamentally "redesigning" OR operations with interventions like parallel processes, minimizing non-operative tasks, and reducing disruptions can have profound effects on OR efficiency (Harders et al. 2006). Implementing operational changes can be particularly effective in the ASC, as Richter el al described a 13 minute reduction in turnover time resulting from these changes (Kubala et al. 2021).

Certainly, the goal of efficiency and operational excellence is to increase the volume of cases being done by a single surgeon and/or the institution. If efficiency improves enough to increase OR production, then more cases can be performed, and more value brought to the process. Bolognesi demonstrated that by changing operations at an academic facility the number of total joint cases improved ("increased" instead of "improved"?) by 29% (Attarian et al. 2013).

A. WAITING ROOM

Patients should be brought to pre-op based on OR and pre-op availability. Priority is based on the OR bottleneck which is the operating room itself. Do not bring Surgeon A's patient to pre-op if it is going to be another four hours before the OR is ready. Instead, bring back Surgeon B's patient who is going to be ready in 30 minutes. Without transparency, a patient will be waiting in a pre-op room for an extended period of time, which wastes time and resources(I might add that it affects patient satisfaction as well). The waiting room opens the funnel of patients and if there are problems getting patients from their home to the waiting room or from the waiting room to the pre-op area, delays will occur.

B. PRE-OP

Pre-op staff. must know their average time from in the room to ready for surgery. They must also know the length of each pre-op nurse's average time to ready. Dealing with a late patient is a common occurrence. Recognizing when a patient arrives late, recognizing the readiness of the OR and surgeon are critical in order to determine flexible additional staffing needs to ready that patient in time. Monitoring how many patients were not prepared when the OR was ready is a key metric to pre-op efficiency. The pre-op nurse has to be aware of the OR status and the OR needs to be aware of the pre-op status. Staffing must be sufficiently flexible to meet the immediate needs of the OR. If pre-op administrators or charge nurses are unaware how long the process takes, then there will be times when patients are not be ready for the OR. Ensuring an open line of communication between the waiting room and pre-op is critical to ensure patients are brought back in a timely manner. The communication also extends to the surgical suite where OR readiness takes precedence over other factors.

See Table 3: Pre-op Efficiency Questions.

Table 3. Pre-op Efficiency Questions

- What is the average time required to prepare the patient for surgery?
- Who are your fastest and slowest pre-op nurses?
- What type of patient takes the longest to get ready?
- How much faster is it if a tech or assistant helps the pre-op nurse?
- When do you tell patients what their arrival time will be?
- Who is responsible for alerting patients to arrive earlier or later? What cues are in place to call patients to change their arrival time?
- Are you flexible enough to change patient arrival times the day before surgery?
- How long are patients waiting from arrival to being brought back to pre-op?
- How long after a patient is ready for surgery do they wait to be brought back?
- How many pre-op rooms are being utilized at the beginning of the day versus the busiest time of day?

C. ANESTHESIA

Anesthesia staff play a large part in the pre-op area, often performing regional blocks and spinals in that area. We have found spinals/blocks administered in the pre-op area to be a critical aspect of OR efficiency. The OR should be left for operating and not for time-consuming anesthesia procedures. The communication between the OR and anesthesia is absolutely critical. Anesthesia always needs to be alerted as to the appropriate time to start the block and/or spinal or the appropriate time to go back to the OR. This often

is complicated if a surgeon utilizes two rooms as the exact time to perform these tasks require a keen awareness of surgical time. Too often, surgeons are unaware how long it will take them to finish a case and they wait until the very end of the procedure to initiate the next room. This often translates into lost time, i.e., waiting on the next patient to be prepped and draped. Surgeons need to know their surgical times and communicate clearly with anesthesia as to when to administer spinals and or general anesthesia. If general anesthesia is utilized, the anesthesia team needs to know how much time is left in the case so that the patient can be awakened at the same time the case is over. Research has indicated that prolonged extubations result in an average of 12.5 minutes of time of OR patients (Dexter and Epstein 2013). In addition to other advantages, spinals can lead to improved efficiency as there is no wake-up time and no time spent putting the patient to sleep in the OR (Caggiano, Avery, and Matullo 2015).

Overlapping of cases refers to the process of beginning the anesthesia on the next case prior to the completion of the previous case. While this generally occurs with surgeons who have two or more operative rooms, it can also occur with surgeons who have a "flip" room or even one room. This is a critical component of any successful efficient OR and represents significant time savings. Szucs et al randomized two groups—overlapping vs. sequential anesthesia and found significant reductions in turnover time (13 minutes) as well as an additional OR occupancy time of one hour per day (Sokolovic et al. 2002). Often, this also refers to initiating blocks and spinals in the pre-op area as opposed to the operating room. Significant reductions in turnover times can result from the use of induction rooms instead of OR rooms (Friedman et al. 2006). This concept of alternative sites for anesthesia was demonstrated in a Canadian study by Schwarz et al who found a significant reduction of average turnover time: from 54 minutes to 15 minutes (Head et al. 2011). This concept of parallel processing with anesthesia was validated by a recent meta-analysis that demonstrated improvement in all OR time metrics (El-Boghdadly et al. 2020).

D. OPERATING ROOM

DRUM-BUFFER-ROPE THEORY

Drum-Buffer-Rope theory is a manufacturing concept that identifies and handles constraints in a process in order to improve efficiency (Goldratt 2004). The theory is that the slowest aspect of the process (constraint) is identified and then buffers are placed in order to keep the process moving at a steady pace in order to prevent bottlenecks. The operating room is the bottleneck of the OR assembly line. The Drum-Buffer-Rope theory tells us that there should be cues (rope) in place to continue to feed patients (the buffer) into the OR. Creating a system in which patients are ready to go back to the OR at the perfect time is where true efficiency lies.

A truly efficient OR consistently works to improve this metric that we have named, "True Turnover Time". A thorough understanding of the drum-buffer-rope theory is needed to accomplish this. Pre-op's role is to continue to feed the buffer (the patient) to the operating room. Patients need to be ready and waiting to enter the operating room. If the OR is empty, then the system has failed. As successful operating room exists when the surgeon is operating. If a patient is in the OR and no operating is happenning, it is not producing. To keep the buffer ready, there must be cues and communication between the OR and pre-op so that patients are ready for surgery. In a perfect setting the wound is closed, and the next patient is incised immediately with no time lag.

E. PARALLEL VS. SEQUENTIAL TASKS

The typical approach to room turnover is to perform each necessary task in a particular sequence. A typical example of sequential tasks in the OR is as follows. The wound is closed. Nursing removes the drapes. Anesthesia extubates patients and transfer help is summoned. The patient is transferred to the stretcher and along with the circulator and anesthesia staff member, moves the patient to PACU. The trays from surgery are broken down by the scrub tech and are then moved out of the room. Cleaning help is requested and the room is then mopped, wiped, and cleaned. The OR staff is then alerted that the OR is clean. The scrub tech brings in the next cart of instruments. The circulator is then called to help open trays and the circulating nurse then moves to pre-op to get the next patient. Sequential tasks are often assigned to particular team members; this process often relies on the next person in the sequence to be alerted that their task is ready to be performed.

An alternative approach is to perform the same tasks simultaneously or in parallel. Instead of waiting for each necessary task to finish before proceeding with the next, multiple steps occur in parallel. Often these duties can be performed by multiple members of the team. Patient and instrument turnover are prime examples of parallel tasks. Anesthesia, scrub techs, orderlies, circulators, and surgeons can all be working in parallel to reduce total turnover time. An efficient scrub tech will know when the surgeon is done with a specific instrument and thus begins to clean it and pack it for removal. In a highly efficient room, the instruments can be removed before the patient leaves. Team members responsible for cleaning can also help remove trays and assist with patient transfer.

Opening trays and preparing instruments for the next case is the longest aspect of turnover. This task, which can be quite onerous in total joint cases, averages 19 minutes at our facility. While traditionally this process is done by one scrub tech and one circulator, improving time metrics means evaluating different ways to improve times. Having additional staff to open, a reduced number of trays, and even disposable instruments has been shown to be effective at reducing opening times (Marchand et al. 2020). Reducing instrument variability from surgeon to surgeon has also been effective in reducing opening times. Running parallel tasks means having the right number of staff available at the right time. Effective communication and flexible staffing allow these parallel processes to occur.

F. DEDICATED STAFF

Surgeons understand the importance of working with the

same staff on a consistent basis. The general public would be aghast if they knew that often surgeons and staff who have never worked together before start doing cases together for the first time. Dedicated teams have clearly demonstrated reductions in surgical times. Dedicated staff can also affect turnover times as well. A study by Matullo et al looked at turnover times comparing cases that were done with orthopedic staff vs. non-orthopedic staff. Dedicated and familiar orthopedic staff on average had turnover times of 20 minutes compared to 31 minutes for non-orthopedic staff (Avery and Matullo 2014). Heiji et al found similar results when using "fixed" staff that worked with the same surgeon every day and found lower turnover times (How many minutes?) as well as lower operative times by over 10 minutes (Stepaniak et al. 2010).

G. FIRST CASE START TIMES

Despite the critical nature of starting the surgical day on time, most surgeons experience delays in start times. A study by Onyebum et al found that 99% of first cases started late (Okeke et al. 2020). Defining what an on-time start time actually means is also important. We have chosen to define "start time" as "incision time." The rationale is that there is a large amount of variability between in-room and incision time. Mazzei reviewed their in-room to incision time and found between 21 and 49 minutes prior to incision (Mazzei 1994). Tardiness has a tendency to build over the course of the day and starting late for the first case of the day only exacerbates the situation (Wachtel and Dexter 2009).

H. TWO ROOM MODELS

Clearly two room models can improve overall efficiency. A study by Namdari et al found significantly more efficiency among high volume total shoulder surgeons (Padegimas et al. 2017). In fact, one room resulted in 3 total shoulder cases in a 10-hour period, vs. 4 total shoulder cases in two rooms over a 9-hour period (Padegimas et al. 2017).

PART V: SURGEONS

Throughout our careers we operate in a relative vacuum as it is rare for other surgeons to observe or critique our own performance. As such, we can experience stagnation in our technique and overall efficiency. Too many of us do the same things over and over because this is how we learned to do them in training. Attempts to learn new techniques or even new instruments can be onerous. The application of any new technique means a learning curve and a period of uncertainty and prolonged OR times. Change is difficult and it is a normal human response to resist it.

In order to improve efficiency, we must be willing to see the world, or at least how we perform surgery, in a different light. Constantly analyze your surgical flow. "Operative efficiency is a critical ingredient to surgical success" (Booth, n.d.). Our surgical skills and behaviors are formed early in our careers but are "rarely consciously analyzed or critically evaluated thereafter" (Booth, n.d.). Far too often we perform steps that are not necessary—simply because that is the way we have always done it. We must be willing to question each step and make beneficial changes.

Perform the surgery the same way every time. Consistency from the surgeon encourages everyone around you to also be consistent. And, critically, if you are constantly changing how you do a particular step or the order in which you do the steps, there is no way for your assistant and scrub tech to anticipate your next move.

Limit the surgical tools that are required for every case. Instead of having everything possible for each case, be critical about what you need and create a tray that meets your needs in 95% of your cases. Plan for the norm not the exception. Any extra tools can be placed in peel packages that can be opened in unique circumstances.

Lead out. Surgeons that lead the process of efficiency and process improvement see improved results. A study by Hendahewa et al found a 58% reduction in turnover times with teams led by the surgeon themselves (Mizumoto, Cristaudo, and Hendahewa 2016). Often, surgeons go to the lounge and wait for the next case. The most productive surgeons are part of the team—they pick up the mop, assist with opening cases, and are generally an active participant in the process. Hitchin et al determined that turnover time improved significantly when the surgeon was present in the room (Ricketts et al. 1994).

Lastly, adopt technology that makes you more efficient. Like every other industry, new technology for anterior hip arthroplasty is constantly being developed and introduced. Carefully evaluate these technologies and then do not hesitate to introduce any that will make it easier for you to perform the surgery. Do not adopt all technologies. Some devices or techniques complicate the surgery and adds steps that prolong the process.

See Table 4: Surgeon Efficiency Metrics.

PART VI: DOES LOCATION AFFECT EFFICIENCY? HOSPITAL VS. ASC

Total joint arthroplasty is currently in a transition state from hospitals to ambulatory surgery centers. We have traditionally only performed total joints in the hospital setting due to concerns about pain control, the patient's ability to ambulate and the desire to monitor and treat complications.

THE HOSPITAL EFFICIENCY DILEMMA

Hospital organizational and incentive structure can be a major challenge to efficiency. Due to the multiple layers of nursing leadership, change can be slow and sometimes nonexistent. ASCs are often physician-run and have few, if any, bureaucratic layers that allow change to occur quickly. In hospital settings, the stakeholder structure is often at odds where the profits go solely to the hospital. ASCs have the benefit of multiple owners that incentivize efficiency and cost reduction.

Operating room staffing in hospitals vs. ASCs can be quite different. Typically, hospitals rotate nurses and scrub techs through many different types of surgery and as a result the experience level can be quite different. Staff often rotates and it can be difficult to predict who will be helping

Table 4. Surgeon Efficiency Metrics

- OR Room Metrics
  - 1st Case Cut Time
    - What is your average first case cut time time last month?
    - What is the latest you have started and the earliest you have started this year?
  - Time to Incision - How many minutes does it take for you to cut after the patient enters the room?
  - Time to Out - When the wound is closed, how long does it take for your patient to leave the room?
  - True turnover – Time from closure prior case to incision next case.
    - Which teams have the fastest turnover?
- Surgery Times
  - Skin to skin, what is your average time for a total hip this year?
  - What is the longest step in a total hip replacement for you?
  - What was your fastest and slowest total hip case this year?
  - How was your surgical time changed over the last three years? Are you getting faster, slower, or are you stagnant?
  - How long does it take for you to expose a total hip?
  - When you have two rooms, at what point in a total joint do you send the patient back to the other room?
  - How often are your waiting on the second room?
  - How do these times compare to your peers at the hospital and around the country?
- Closure Times
  - How long does it actually take for your first assist to close a total knee?
  - What percent of the total surgical time is spent closing?
  - Which of your assistants close the fastest?
  - How much time do you save by assisting with closing?
  - How do these times compare with your peers?

on any given day. Because of the sheer volume of cases and variety of procedures, hospitals have on average much lower experienced staff compared to ASCs. ASCs also attract high-performing surgeons as a result of the draw of smaller facilities, less variability, and less call responsibility.

Anesthesia and staff also suffer from similar demands in the hospital setting that are not present in an ASC. The sheer volume and call associated with hospitals often means that there is great variability in numbers and talent of its team members in the hospital. ASCs have the luxury of a significantly reduced number of anesthesia staff, which can lead to less variability in care. The sheer reduction in space also is beneficial for the anesthesiologist who is a step away from pre-op, OR, and Post Anesthesia Care Unit (PACU).

Turnover time, a surrogate for overall efficiency, is on average remarkably different between an ASC and hospital. A study by Phelan et al found a significant difference in mean turnover time, ancillary time, procedural time, exit time, and non-operative time in the ASC setting vs. the hospital (Imran et al. 2019). Sippel et al also found significant reductions in turnover time by over 18 minutes in the ASC setting (Clark et al. 2013).

ASC EFFICIENCY ADVANTAGE

Over the last 5-10 years we have seen a shift of total joint cases moving from the hospital to the ASC. There are multiple reasons for this, including patient outcomes, experience, and surgeon preference. Improved efficiency is also one of the major drivers of this change.

An ASC footprint is smaller, which leads to more efficiency at multiple levels, including patient transport and anesthesia movement throughout the day. At an ASC, surgeons move from OR to pre-op, PACU, and family consultation rooms multiple times throughout the day.

ASC organizational structure lends well to adaption.

ASC staffing has several advantages, one of which is that they can incentivize staff in different and unique ways in order to keep them motivated. The ASC staff should feel like part of a team that is accomplishing something worthwhile, thus providing them with a sense of a fulfillment in their work.

ASC stakeholder incentive structure is geared toward cost reduction and overall production. Surgeons often have ownership in ASCs and as such are motivated to bring true value to the facility. From implant costs to staff hours, surgeons have visibility into the true cost of joint replacement and are financially motivated to limit those costs.

Not only does the ASC provide an easier environment to make the changes needed to become more efficient, but the these facilities also thrive on improved efficiency. When staff members see that it is possible to finish 12 cases by 12pm, they develop a sense of pride that reverberates throughout their days. Patient experience improves with improved efficiency as well. When patients leave a facility mere hours after undergoing total hip replacement and can ambulate with adequate pain control, they tell everyone they know.

Physician burnout is an increasingly recognized problem, especially among orthopedic surgeons.46 Burnout among physicians has been found to be twice that of the average occupation and leads to twice the normal number of medical errors, a decrease in quality of care, and a decrease in patient satisfaction.47 When operating in an ASC with improved efficiency, surgeons thrive on the sense of knowing that they will have a good day. They arrive at the ASC confident that they will have everything they need. Each staff member will know their job and will get it done. Delays and obstacles are rare.

PART VIII : SUMMARY

Modern-day hip and knee design, implant materials and techniques have undergone tremendous evolution over the last seventy years. Ironically, what has not improved significantly in arthroplasty surgery is efficiency. The average operative times over the last two decades have been quite stagnant with the average operative being 95 minutes; it is assumed that the surgical times have changed little since John Charnley placed the first successful low friction arthroplasty. Some have made a compelling case that operative time has increased with the advent of new approaches and technologies that have done little to improve patient outcomes.

In the modern era of healthcare, true surgical efficiency and value are more important than ever. With the rising cost of healthcare, and the fact that it represents an ever-higher percentages of the GDP, hip and knee arthroplasty are poised to be the primary beneficiaries of the improvement brought on by surgical efficiency. To achieve true surgical efficiency, application of radical time transparency and operational excellence must be performed at both the institutional and operating room levels. Applying the same general principles used in other disrupted industries will help us in our quest to improve the value we contribute to our healthcare industry.

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