Chapter

46 OPERATING ROOM MANAGEMENT

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Healing is an art, medicine is a science, and health care is a business.

Author unknown

Anesthesiologists are in a unique position as physicians. In providing care, anesthesiologists bridge medical and surgical specialties working directly with many specialists, including surgeons, obstetricians and gynecologists, emergency physicians, and other proceduralists including, but not limited to, interventional radiology, gastrointestinal specialists, cardiologists, and hematologists-oncologists. Further, in evaluating patients, anesthesiologists work with primary care physicians and medical specialists to understand underlying comorbid conditions and how to optimize care for these conditions. Because of these many varied relationships with other physicians, anesthesiologists are often identified to help with administrative tasks within a hospital or medical school. Although these positions can be at all levels of administration, the most common administrative role for an anesthesiologist is that of medical director of the operating room (OR), which can include the postanesthesia care unit (PACU) (also see Chapter 39) and day surgery unit (also see Chapter 37). Traditionally, this role has not included administrative roles over OR purchasing and materials management or nursing staff.

On the other hand, the role involves day-to-day case flow management as well as overall governance of block scheduling and staffing. The role also overlaps with anesthesiology group management with decisions of the OR management impacting staffing, billing, income, and, ultimately, the success of the anesthesiology group. The goal of this chapter is to provide a basic discussion of OR management issues that impact the anesthesiology group and that an OR medical director faces daily: (1) staffing, (2) efficiency and utilization, and (3) turnover and OR throughput. At the end of this chapter, additional resources and references are supplied that allow for more in-depth exploration of these issues and other topics.

PERIOPERATIVE LEADERSHIP

Anesthesiologists can also fill the role of the perioperative physician because of their daily interactions with surgeons and proceduralists, hospitalists and internal medicine physicians, nursing staff, and hospital administrators. Because of the involvement of these different health care clinicians and administrators, the effective anesthesiologist leader needs to be able to work well in teams, to be able to communicate the vision of what the overall goals of the facility are, and to assure that high-quality care remains the first priority.

The physician leader often works directly with a nursing director of perioperative services and an OR governing committee. In this setting, the physician leader uses his or her clinical skills to provide context to policy decisions. In addition, an anesthesiologist may be the only physician who is practiced in all the varied locations (e.g., in the OR, intensive care unit, preoperative evaluation clinic) and, therefore, frequently has the best ability to know how all the different aspects of perioperative care are interconnected. This wide perspective is important when leading work flow improvements, including OR throughput, and developing clinical and hospital policies.

Anesthesiologists who have the interest to be in a leadership and administrative role for their medical group or facility often seek additional education in business and leadership. Although there are physician executive education programs, anesthesiologists in the United States are fortunate to have numerous options targeted specifically to anesthesiologists and perioperative care. These include offerings from the American Society of Anesthesiologists conferences, professional seminars, and certificates in business as well as other conferences and courses offered by business schools.

ANESTHESIOLOGY STAFFING

In today's health care economy, the cost of anesthesia personnel staffing an OR often exceeds the revenue generated from anesthesia care, creating the need for medical facilities to provide funds for staffing.[1,2] A number of personnel configurations can be used to provide intraoperative anesthesia, including physician anesthesiologists, nurse anesthetists, residents, fellows, and several other types of providers. This variability requires an examination of staffing needs and how such needs are determined and met. The medical center facility, which may be paying for part of the anesthesia staffing, wants to minimize the number of staff members needed, and the anesthesiology group that provides the services wants to ensure that the staff numbers are adequate. Also, legal requirements in various places may vary (i.e., states, countries, regions). This variance leads to a desire from everyone to have an objective manner to determine the actual staff needs.

The various staffing approaches for intraoperative patient care are beginning to be considered by general medical journals. For example, a recent editorial in the *Journal of the American Medical Association*[3] outlines the risks of "concurrent surgeries." Although this editorial was directed to surgeons, the same questions could be addressed to anesthesiologists. One of the important conclusions was that patients should be provided the same type of information regarding their anesthesia. The potential implications for anesthesiologists are clear.

The most logical process is to determine the workload and the average workload per full-time equivalent (FTE). Then simple division will lead to the number of FTEs needed on any given day. (See later discussion about converting FTEs to actual number of providers.)

This logic is often applied to anesthesia-provider staffing. The workload is often used to determine the staffing needs. The problem with this approach becomes evident when simply answering the following question: "For your OR tomorrow, how many people do you need to provide anesthesia at the start of the day?"[4] Unfortunately, the answer rarely includes the number of cases to be performed. Instead, the primary determinants of staffing requirements are the number of clinical sites to be staffed and the staffing ratio (i.e., concurrency). Other determinants include whether or not a second shift is needed in the evening and the number of staff members who are on-call or post-call. In other words, if an anesthesiology group needs to provide care for 20 ORs at 7:30 AM, the number of anesthesia providers required is no different whether all the ORs finish at noon or 3 PM. Therefore, instead of determining staffing needs, workload should be used to determine the appropriate number of ORs needed—assuming this decision is based solely on workload.

A staffing grid, utilizing a spreadsheet, can be used to determine staffing needs[4] (see Additional Resource 1 and online spreadsheet). The spreadsheet has in the first column the types of clinical sites/duties and in the second column the number of anesthesia providers; for care-team model groups, the third and fourth columns are used for the number of anesthesia providers (resident, certified registered nurse anesthetist [CRNA], anesthesiologist assistant [AA]) that are supervised or medically directed by the anesthesiologists (Table 46.1). Several factors will impact the staffing ratio. First, for residents in training, the accrediting rules limit staffing ratio to a maximum of two; that is, one anesthesiologist can cover only two rooms. For Medicare billing of medical direction, the limit is four rooms. Second, the type of surgery may determine the safety of staffing a second room. For example, a neonatal surgery case may not allow the anesthesiologist to cover another room. Third, location of clinical site may not allow for a second room to be covered. Finally, other duties must be considered; for example, the schedule runner (anesthesiologist in charge of the schedule) may be able to cover only one room. All these factors on staffing ratio will need

Table 46.1 Example Staffing Grid for an Academic Anesthesiology Department Covering 22 ORs Model: Single Day Shift With Single In-House Call Shift

	ORs Covered	Faculty	Resident	CRNA/AA
Clinical FTEs Needed				
Medical direction main OR (includes remotes)	18.0	9.0	13.0	5.0
One-on-one rooms	1.0	1.0	1.0	
Faculty rooms in main OR	2.0	2.0		
Schedule runner main OR	1.0	1.0		1.0
Total OR sites covered	**22.0**			
Preoperative clinic		1.0	1.0	
Labor and delivery		1.0	3.0	
Pain management clinic and consults		1.0	2.0	
Critical care services		1.0	3.0	
Post call		2.0	6.0	
Daily clinical FTEs needed		**19.0**	**29.0**	**6.0**
Nonclinical FTEs				
Average clinical FTE % of FTE		0.75	0.89	0.80
Number of providers that are nonclinical		**6.50**	**4.00**	**1.50**
Away FTEs				
Meeting		1.15	0.21	0.19
Vacation		2.31	1.38	0.77
Sick		1.00	1.00	0.50
Total away FTEs		**4.46**	**2.59**	**1.46**
Total FTEs needed in dept.		29.96	35.59	8.96
Total on Staff				
Current		30	36	10
Departures		5	12	1
Hires		6	12	0
Total available FTEs		**31**	**36**	**9**
Excess (or deficit) expected		**1.04**	**0.41**	**0.04**

See text for details of the department. Results based on calculations found in the Excel worksheet available as Additional Resource 1 and online. Initial estimates utilized no faculty rooms, but results showed a deficit in residents and nurse anesthetists/AAs. Final estimates include two faculty rooms.
AA, Anesthesiologist assistant; *FTE*, full-time equivalent; *OR*, operating room.

to be examined before a final number is determined. For instance, the anesthesiology group might argue that the schedule runner, the anesthesiologist covering radiology, and two other anesthesiologists must be planned for covering only one room with a resident or CRNA, resulting in four clinical sites covered one-on-one. The hospital might argue that only the schedule runner and the radiology anesthesiologist need one-on-one coverage.

The next part of the grid includes the non-OR locations, such as labor and delivery, pain management clinic and procedures, preoperative clinic and consults, and intensive care unit, and for academic departments, resident away rotations. In addition, the number of call providers coming in later in the day and the number who are not available because of post-call status are also listed. The final numbers need to be agreed upon by the anesthesiology group and the hospital.

The staffing grid determines the number of FTEs needed each day. But this number of FTEs cannot be simply converted to determine the number of staff required. For example, 1 FTE anesthesiologist does not work 52 weeks of the year or even all 50 weeks of weekdays remaining after the typical 10 weekday holidays or 2 weeks vacation during a year. Therefore, if 1 FTE is needed, then more than 1 anesthesiologist will be needed on staff. An estimate can be made by determining the number of weeks a full-time anesthesia provider works in the year, or in other words, determining how many weeks off the typical anesthesiologist has in that group. To illustrate with a hypothetical example, suppose each anesthesiologist takes off 2 weeks for hospital holidays, 4 weeks for vacation, 1 week for continuing medical education activity, and 1 week for sick leave, for a total of 8 weeks. Therefore, the typical anesthesia provider in this group works

44 of 52 weeks (or 86%). One way to look at this number is to say that each anesthesiologist represents 0.86 FTE. So, if 6 FTEs are needed, then 7 anesthesiologists will be needed. In addition, for academic departments, the issue of nonclinical rotations also needs to be factored into the calculations. (In Table 46.1, these calculations are at the end of the staffing grid. For more details, see Additional Resource 1 and spreadsheet online). The preceding processes describe only the first steps in determining staffing needs. With daily hour limits, types of shifts people work, the usual inability to hire a fraction of an FTE, and special considerations of the facility, the staffing grid can become complex. But the final message is the same as the initial point: staffing needs are determined by the clinical sites to be covered, not by the workload!

OPERATING ROOM EFFICIENCY

Because the staffing needs and costs are determined by number of sites to be covered and not by the actual work being done in those sites, then a goal of any OR management is to use the staff efficiently. In other words, if one is going to pay for a person to be there, then the goal is to have that person working rather than simply being available. This is true for the anesthesiology group as well as for the hospital staff (OR nurses and surgical technicians).

The idea that anesthesia staff members should be working (e.g., administering anesthesia) every minute of their shift can actually lead to unintended consequences. The concept of underutilized and overutilized hours is important to understand. An underutilized hour occurs when the staff (and the OR) is not working during the scheduled shift. That is, if the staff is supposed to work until 5 PM, but finishes the last case at 4 PM, then there is 1 underutilized hour. On the other hand, if the last case finishes at 6 PM, there is 1 overutilized hour. In this latter case, one may at first think this is good because the staff worked all of the shift and then some. Unfortunately, that overutilized hour can be costly. For scientific studies, a factor of 1.75 to 2.0 is used to multiply the cost of a regular shift to determine the cost of the overutilized hour. This increased cost may be in direct costs (in compensation) or in indirect costs (for recruitment of new staff to replace former staff members who left because of having to stay late frequently). Therefore, 1 underutilized hour costs less than 1 overutilized hour. A measurement of efficiency would be the sum of underutilized hours and overutilized hours (multiplying by the factor). An efficient OR would be one in which this sum is minimized.[5] Consequently, one of the goals of an efficient staffing system is to match staffing shifts to the actual demand. The work shifts should be aligned among anesthesiologists, the OR staff, and the schedule. For example, if the OR allows for surgeons to schedule cases to finish at 5 PM, then inefficient staffing practice would be to staff the OR until 3 PM and then make staff stay late. On the other hand, an efficient staffing approach would be to increase staffing by either increasing individual shift hours or planning for a second shift to start later in the day.

Alternatively, efficiency of an OR can be evaluated by how well the OR is running. Macario recommended seven performance measurements in scoring OR efficiencies (Table 46.2).[6] In addition to staffing costs, the measurements also include OR function costs and scheduling costs. Factors such as first-start tardiness, prolonged turnover times, delays, and PACU holds all contribute to an inefficient OR. An infrequent case cancellation and a good prediction of case length are signs of an efficient OR. Finally, measurement of contribution margin (revenue minus costs, including staffing costs) is the best measurement of efficiency for the hospital.

Operating Room Utilization

Unlike efficiency, utilization is easier to measure and better reported and followed. The simplest definition of utilization is the percentage of time the OR is used for patient care by dividing the time the patient is in the OR by the time that is available for patient care. A more accurate numerator would include setup and cleanup as well as the time the patient is in room time. In addition, determining the denominator correctly—the available time for patient care—is very important. Unfortunately, this definition is not always the same among the OR nursing staff, the hospital administration, the anesthesiology group, and surgeons. From an operational perspective, the utilization of regularly scheduled time is the important number. So inclusion of after-hour shifts can confuse the final calculations. The exercise of determining what the regularly scheduled hours are may in fact point out that staffing shifts do not match the available hours of patient care. For example, surgeons may feel that every OR is staffed and available for surgery till 5 PM each weekday. But in reality, surgical nursing staffs only 40% of the ORs after 3 PM. That is, nursing does not plan or have staff for 60% of ORs from 3 PM to 5 PM. Further, the anesthesia staff may turn over cases to the call team at 4:30 PM with the plan of only staffing a few rooms after this time. Without a consensus of the hours of operation, confusion, dissatisfaction, and frustration will occur. Coming to an agreement of the definition is essential to any OR management team.

But what is a good utilization percentage? Again, this depends on who is answering the question. For example, hospital administrators may feel that 100% utilization should be the goal, whereas nursing and the anesthesiology group would like 75%. Also, the surgeons can benefit from a poor utilization. When a surgeon has an add-on case, the surgeon would like to do it when he or she wants, in the OR he or she wants, and with the staff he or she wants; therefore, poor utilization means the OR is more likely to be open for add-ons). As discussed

Table 46.2 A Scoring System for Operating Room (OR) Efficiency[a]

	Points Scored		
Metric	**0**	**1**	**2**
Excess staffing costs	>10 %	5-10%	<5%
Start-time tardiness—mean tardiness of start times for elective cases per OR per day	>60 min	45-60 min	<45 min
Cancellation rate	>10%	5-10%	<5%
PACU admission delays—% of workdays with at least one delay in PACU admission	>20 %	10-20%	<10%
Contribution margin (mean) per OR per hour	<$1000/h	$1000-$2000/h	>$2000/h
Turnover times—mean setup and cleanup turnover time for all cases	>40 min	25-40 min	<25 min
Prediction bias—bias in case duration estimates per 8 hours of OR time	>15 min	5-15 min	<5 min
Prolonged turnovers—% of turnovers that take longer than 60 minutes	>25 %	10-25%	<10%

[a]Efficiency scoring system for an OR that takes into account staffing costs, scheduling costs, and functioning costs. For full details of how to use this system, see table source.
PACU, Postanesthesia care unit.
From Macario A. Are your hospital operating rooms "efficient"? A scoring system with eight performance indicators. *Anesthesiology*. 2006;105:237-240.

previously, 100% of regular hours means that no underutilized time exists, but because not all the rooms will finish at the end of regular hours, overutilized hours must exist. This will lead to costly direct staff compensation or indirect costs of having to recruit new staff to replace those who leave in frustration of always working overtime. On the other hand, a utilization of 70% to 80% reflects some underutilized hours that actually might mean a better managed OR. Also, it allows for some leeway for emergency cases.

The most common method of analyzing utilization is by determining block time; that is, the amount of time a surgeon has available to schedule cases. Unfortunately, simply relying on utilization for determination of block time can result in poor OR management decisions. For example, if Surgeon A has utilization of 120% and Surgeon B has utilization of 75%, then the OR management decision based on utilization alone is to give more time to Surgeon A and take time away from Surgeon B. But what if Surgeon A and B are doing the same exact surgical procedures and the same number of patients each day? Surgeon B obviously has shorter surgical durations. If one assumes both surgeons have the same payer mix, then revenue is the same for each, but the costs of Surgeon A would be higher because of more OR time and overtime of OR staff. So the contribution margin (i.e., net profit = revenue minus costs) is better for Surgeon B. An additional benefit of Surgeon B is that there is regular time available for an add-on case. A more detailed tutorial on the impact of block scheduling, service-specific staffing, and OR productivity will allow further exploration of these issues.[7]

Another use of utilization is to determine if hospital funding is needed to cover costs of anesthesia staffing. This is often seen in negotiated agreements between a hospital and an anesthesiology group when expanding into new clinical sites. The average revenue per hour of care (average revenue per ASA unit and ASA units billed per hour care) can be used to estimate the number of hours of patient care that is needed to cover the staffing costs for one OR. By dividing the number of hours needed by the agreed-upon scheduled staffing hours, a break-even utilization can be estimated. The hospital agreement can state that if utilization is less than this point, the facility will need to help fund the staffing costs. On the other hand, if utilization is above the break-even mark, no facility funding will be necessary.

Operating Room Throughput and Turnover Time

Once the hospital or facility and the anesthesiology group have agreed to staff a clinical site or an OR, then the goal is to maximize the output for that OR (efficiency) without increasing costs further (e.g., with overtime). Therefore, a common focus of OR management is how to perform more cases per OR, or in other words, how to maximize OR throughput.

A complete examination of OR throughput starts at the beginning of the process, which begins at the time of referral to the surgeon's office. Then, scheduling (including block scheduling), properly predicting surgical duration, and preoperative evaluation and testing (the preoperative clinic) all occur prior to the day of surgery. On the day of surgery, the day surgery unit must prepare the patient and have the patient transported to the OR in a timely fashion. The surgery is completed and then the patient is admitted to the PACU and then either discharged from day surgery or admitted to the hospital. The whole process ends back in the surgeon's office during the postoperative outpatient visit. As one can see, the OR throughput process involves many other departments and personnel than simply the OR staff and anesthesia providers on the day of surgery.[7]

Prolonged turnover time is often stated as the reason more cases cannot be performed. As the previous description of OR throughput demonstrates, this criticism about turnover time is an oversimplification. But why is this criticism so prevalent? The answer is that turnover time is easy to measure and understand. Many of the other parts of OR throughput are complex or involve many different parties, but turnover time is focused on one OR and its small number of staff members, including the anesthesia provider in that one OR. Therefore, OR managers must understand the issues of turnover time, especially as it relates to OR throughput.

Turnover Time

A commonly stated theme is, "if turnover time were shorter, we could do more cases." Intuitively, it is clear that this is usually not true, and research has established the fact that further reducing reasonable turnover times usually does not increase the number of cases that can be performed in a workday.[8,9] The exception would be if the anesthesia providers and surgeons are unavailable for some reasons. In these instances an excessively long turnaround could result. For example, if the surgical and anesthesia personnel are different than in the first case, they may not be readily available. Turnover time is defined as the time beginning when the preceding patient leaves the OR and the next one enters the OR. For instance, for an OR in a nonambulatory surgical center hospital, a reasonable maximum turnover time between procedures might be 35 minutes. Reducing this number by 20% would only result in a 7-minute time saving between cases. If three cases were done per OR per day, this would mean a 14-minute time saving per day, which is only a fraction of the duration of one case. Therefore, even a good effort of reducing turnover time by 20% will not allow for one more surgical case to be done. Obviously, in an OR where more cases are being performed in a day (e.g., 7 to 10 cataract or pediatric otolaryngology surgeries), reducing turnover time by 7 minutes per case may be significant. But in these specific ORs, the turnover time is already much shorter than in the rest of the ORs (e.g., 15 minutes) and further reduction may not be possible.

Despite the foregoing discussion, evaluation of turnover times has merit. Instead of working on all turnovers, which will result in few benefits, emphasis should be on reducing delays. A delay is a prolonged turnover time that is longer than the reasonable maximum turnover time. Focusing on delays and not all turnovers allows for more potential improvement in the process. For instance, suppose it is decided that the maximum allowed turnover is 35 minutes. Then when a turnover is longer than 35 minutes (a delay), the reasons for the delay must be reported. Avoidable delays are analyzed and often identify system issues that occur not just in this one case but multiple times during the week and even each day. Examples of system issues include (but are not limited to) the preoperative preparation process (anesthesia evaluation), proper surgical paperwork (history and physical examination, informed consent) not completed or available, delayed process of preparing the patient on the day of surgery (from arrival to the hospital to being ready for transport to the holding room), transportation issues, equipment issues (including proper procedure posting), and processes in the OR. By focusing on the delays, more than a handful of minutes per case can be saved that add up over a multitude of cases, in contrast to when all turnovers are examined.

Throughput on the Day of Surgery

Traditional Approach

Traditionally, OR throughput initiatives have focused on how to improve the work processes of the current staff.[10,11] Successful initiatives have involved an interdisciplinary team that includes all personnel involved from physicians (surgeons and anesthesia providers) and nursing staff to transportation staff and environmental service personnel. Surgeons who are technically efficient intraoperatively facilitate throughput of surgical cases. The improvement process looks at work flow assessment and redesign of work. This process works, at least over the short run. Unfortunately, to maintain any gains, the improvement process must include continuous and repeated educational efforts and monitoring. Further, potential gains are limited by the existing staffing levels.

Parallel Processing

Additional approaches can improve OR throughput even more, but additional staff and a paradigm shift in the work flow will be needed. Most OR work flow is performed in series. Specifically, one task is completed before the next task is started. For instance, setup for the next case is not performed until the preceding patient is in the PACU and the OR is cleaned. Further, induction of anesthesia in the next patient cannot be performed before the OR surgical equipment is completely set up. In parallel processing, tasks done during the nonoperative time are not

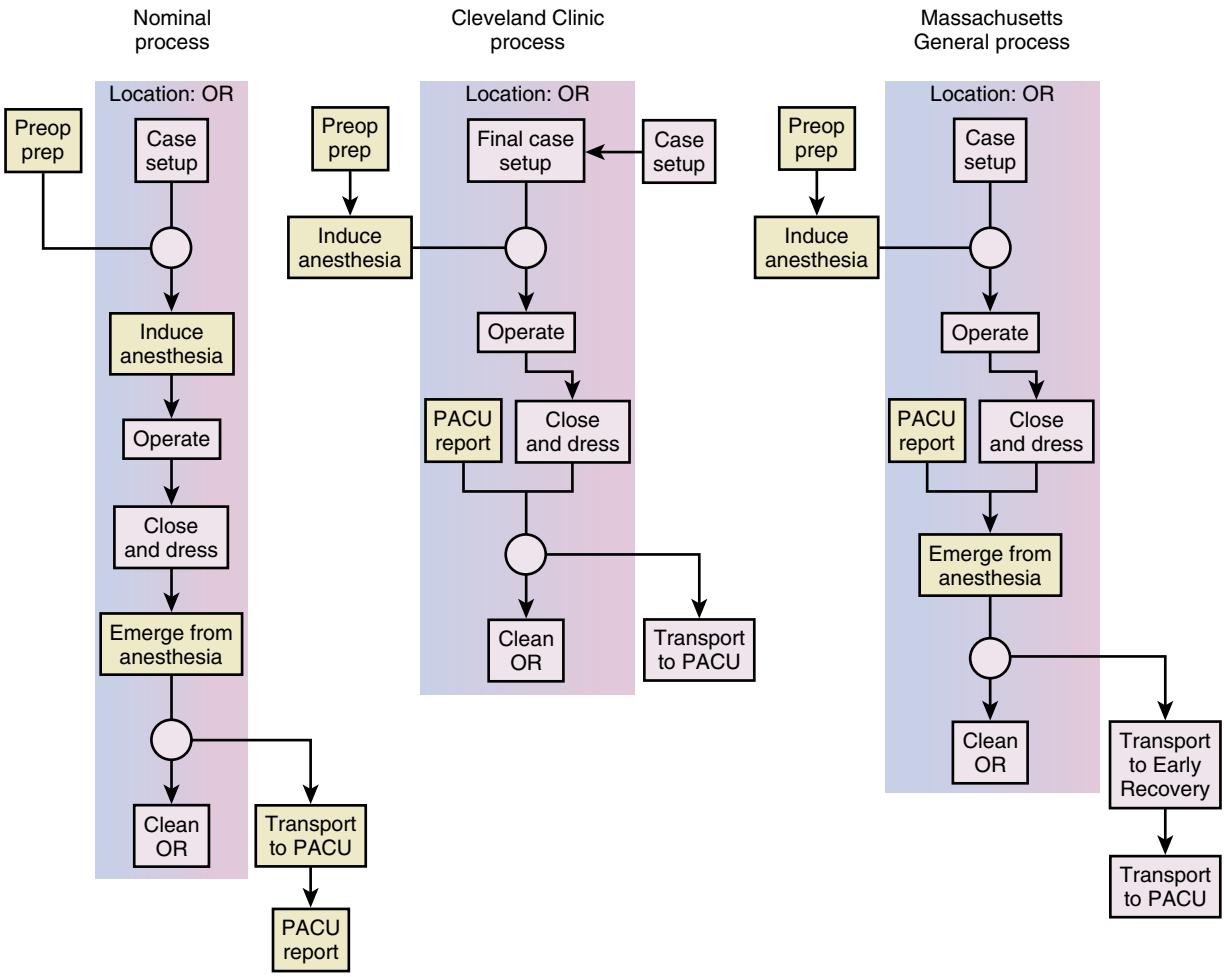

Fig. 46.1 Flow diagrams of parallel processing for operating room (OR) throughput. Three processes are illustrated. Nominal is the traditional series process in which all activity is done sequentially. The Cleveland Clinic Process (see reference 15) and the Massachusetts General Process (see reference 12) are examples of parallel processes. In both of these processes, nonoperative tasks are not done in series but can be done at the same time (i.e., in parallel) but may require additional staff and space. *PACU,* Postanesthesia care unit. (Redrawn from Sandberg WS. Engineering parallel processing perioperative systems for improved throughput. ASA Monitor. 2010;74(1):26-30. http://monitor.pubs.asahq.org/article.aspx?articleid=2446748&resultClick=3; last accessed February 16, 2017.)

done faster or reduced but are done at the same time. By doing them at the same time, the total nonoperative time is reduced (Fig. 46.1). Parallel processing can be successful in allowing an additional case to be performed.[12-17] In practice, all parallel process solutions will require additional staffing, with the type of staffing dependent on the solution. Parallel processing is used on an increasing frequency in busy tertiary care hospitals.

One example of parallel processing is the practice of providing a surgeon with two ORs. This is such an important concept that this approach was examined in a 2016 issue of JAMA.[3] In these situations, the surgeon's operative time should be the same or less than the nonoperative time (emergence, clean up/setup, and induction) and the surgeon's caseload is sufficient to justify two ORs. In other words, while the surgeon is working in OR A on patient 1, the next patient (patient 2) is induced in OR B. While patient 1 is emerging in OR A and then OR A is cleaned and set up and patient 3 is induced in OR A, the surgeon is completing the procedure on patient 2 in OR B. The surgeon then moves to OR A and begins surgery on patient 3 while patient 2 is emerging in OR B.

Another example of parallel processing is the use of a regional block room. In this situation, the surgeon is working in the OR, but the induction of anesthesia with regional blocks is done in the block room. While the

surgeon is finishing the surgery in the preceding patient, regional anesthesia is performed on the next patient. When the OR is cleaned and ready, then the next patient is taken into the OR and the preparation begins immediately. Further, the emergence time period is minimal and time is saved there as well.

Another example is to utilize not another OR but an alternative space to complete tasks. This space may allow for induction of general anesthesia and invasive monitoring to be placed. Alternatively (or in addition), a sterile space is provided to allow for the surgical equipment to be set up on a movable table. Both of these solutions will allow for tasks to be performed while the preceding patient is still in the OR or while the OR is being cleaned.

Several limitations to parallel processing exist. First, all the solutions require additional resources—sometimes physical space, but always additional staff. Economically, these solutions may make sense if the additional revenue is larger than the incremental staffing costs. On the other hand, if overutilized time exists, staffing cost savings may occur even if additional staff members are hired. For instance, hiring an assistant to help the surgical technician set up the surgical equipment may be less costly than having the whole OR staff (including a registered nurse) work overtime. The second limitation is that to do an additional case, the surgical duration must not be long. For example, it makes no sense to implement parallel processing for surgical duration cases of 12 hours, but it may make sense in cases of less than 1 hour. In addition, the surgeon should have the additional patients to fill freed-up OR time. For example, a surgeon may request two rooms. The operative time needs to be short. Providing a second room seems reasonable. But if the patient volume is too small, then the surgeon will go from one OR with a full schedule to two ORs with a partial schedule in each OR. Finally, the last limitation may occur if the "time-out briefing" is changed. Currently, the process is done immediately before incision. But if the process requires the surgeon to be present prior to induction of anesthesia or regional block, then some of the solutions noted here may not be possible. The technical and clinical skills of all providers, including surgeons, anesthesia providers, nurses, and other OR personnel, are essential components of efficiently managed ORs.

QUESTIONS OF THE DAY

1. How does the staffing ratio in an anesthesia care team model affect the total number of anesthesia providers needed to administer care in an operating room (OR) suite with 10 ORs?
2. What measurements can be used to assess OR efficiency?
3. Under what circumstances can reduced OR turnover time lead to an increase in number of cases completed in a 10-hour OR day?
4. What is "parallel processing" in the context of OR throughput? Under what circumstances will throughput be improved? What are the limitations to the effectiveness of parallel processing?

REFERENCES

1. Sandberg WS. Barbarians at the gate. *Anesth Analg*. 2009;109:695–699.
2. Kheterpal S, Tremper KK, Shanks A, et al. Six-year follow-up on work force and finances of the United States anesthesiology training programs: 2000 to 2006. *Anesth Analg*. 2009;109:263–272.
3. Mellow MM, Livingston EH. Managing the risks of concurrent surgeries. *JAMA*. 2016;315:1563–1564.
4. Abouleish AE, Zornow MH. Estimating staffing requirements: how many anesthesia providers does our group need? *ASA Newsletter*. 2001;65:14–16. The 2013 update to this reference can be found at http://monitor.pubs.asahq.org/article.aspx?articleid=2431404&resultClick=3#103544379/; Last Accessed December 15, 2016.
5. Strum DP, Vargas LG, May JH. Surgical subspecialty block utilization and capacity planning. A minimal cost analysis model. *Anesthesiology*. 1999;90:1176–1185.
6. Macario A. Are your hospital operating rooms "efficient"? A scoring system with eight performance indicators. *Anesthesiology*. 2006;105:237–240.
7. McIntosh C, Dexter F, Epstein RH. Impact of service-specific staffing, case scheduling, turnovers, and first-case starts on anesthesia group and operating room productivity: a tutorial using data from an Australian hospital. *Anesth Analg*. 2006;103:1499–1516.
8. Dexter F, Abouleish AE, Epstein RH, et al. Use of operating room information system data to predict the impact of reducing turnover times on staffing. *Anesth Analg*. 2003;97:1119–1126.
9. Dexter F, Macario A. Decrease in case duration required to complete an additional case during regularly scheduled hours in an operating room suite: a computer simulation study. *Anesth Analg*. 1999;88:72–76.
10. Overdyk FJ, Harvey SC, Fishman RL, et al. Successful strategies for improving operating room efficiency at academic institutions. *Anesth Analg*. 1998;86:896–906.
11. Cendan JC, Good M. Interdisciplinary work flow assessment and redesign decreases operating room turnover time and allows for additional caseload. *Arch Surg*. 2006;141:65–69.
12. Sandberg WS, Daily B, Egan M, et al. Deliberate perioperative systems design improves operating room throughput. *Anesthesiology*. 2005;103:406–418.
13. Hanss R, Buttgereit B, Tonner PH, et al. Overlapping induction of anesthesia: an analysis of costs and benefits. *Anesthesiology*. 2003;103:391–400.
14. Torkki PM, Marjamaa RA, Torkki MI, et al. Use of anesthesia induction rooms can increase the number of urgent orthopedic cases completed within 7 hours. *Anesthesiology*. 2005;103:401–405.

15. Smith MP, Sandberg WS, Foss J, et al. High-throughput operating room system for joint arthroplasties durably outperform routine processes. *Anesthesiology*. 2008;109:25–35.
16. Abouleish AE. Increasing operating room throughput: just buzzwords for this decade? *Anesthesiology*. 2008;109:3–4.
17. Sandberg WS. Engineering parallel processing perioperative systems for improved throughput. *ASA Monitor*. 2010;74(1):26–30. http://monitor.pubs.asahq.org/article.aspx?articleid=24467&resultClick=3; last accessed February 16, 2017.

ADDITIONAL RESOURCES

1. Amr Abouleish, Anesthesia Staffing Worksheet. This interactive Excel worksheet allows detailed calculation of staffing requirements of an OR with variable numbers of anesthesiologists, CRNAs, and residents. Worksheets allow entry of faculty nonclinical time and resident away rotations to determine the number of FTEs needed in a department.
2. Sperry RJ. Principles of economic analysis. Basic economic principles written with an anesthesiologist's perspective. *Anesthesiology*. 1997;86:1197–1205.
3. Franklin Dexter. A bibliography of OR management articles can be found at http://www.franklindexter.net/bibliography_TOC.htm; Last Accessed December 15, 2016.
4. ASA Resident Practice Management Tools. Resident Practice Management Education Webpage with podcasts, lectures, and a primer on practice management. Available for ASA members at https://www.asahq.org/about-asa/component-societies/asa-resident-component/resident-resources/resident-practice-management-tools; Last Accessed December 15, 2016.

E-ONLY MATERIAL

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