When to Release Allocated Operating Room Time to Increase Operating Room Efficiency

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We studied when allocated, but unfilled, operating room (OR) time of surgical services should be released to maximize OR efficiency. OR time was allocated for two surgical suites based on OR efficiency. Then, we analyzed real OR schedules. We added new hypothetical cases lasting 1, 2, or 3 h into OR time of the service that had the largest difference between allocated and scheduled cases (i.e., the most unfilled OR time) 5 days before the day of surgery. The process was repeated using the updated OR schedule available the day before surgery. The pair-wise difference in resulting overutilized OR time was calculated for $n = 754$ days of data from each of the two surgical suites. We found that

postponing the decision of which service gets the new case until early the day before surgery reduces overutilized OR time by <15 min per OR per day as compared to releasing the allocated OR time 5 days before surgery. These results show that when OR time is released has a negligible effect on OR efficiency. This is especially true for ambulatory surgery centers with brief cases or large surgical suites with specialty-specific OR teams. What matters much more is having the correct OR allocations and, if OR time needs to be released, making that decision based on the scheduled workload.

(Anesth Analg 2004;98:758–62)

Suppose that a group of two gynecologists has been allocated 8 h of operating room (OR) time on Friday June 6th. By the morning of Monday June 2nd, Gynecologist 1 has filled the 8 h of time with cases. Gynecologist 2 now wants to schedule a case for June 6th. Since the gynecologists have no remaining open OR time, some other service's OR time must be released.

We studied when the allocated but unfilled OR time of other services should be released so that Gynecologist 2 can schedule her case. The basis for the decision is the maximization of OR efficiency, as defined below. The case will be performed on the Friday, June 6th. The question is at what time the case will be scheduled to start, and when that decision will be made. Would waiting to release the allocated OR time until Thursday, the day before surgery, result in an increase in OR efficiency, and if so would the increase in OR efficiency be large enough to be operationally important? We would expect that the closer to the day of surgery that the OR time is released, the higher

would be the OR efficiency, because data on subsequently scheduled cases would be available. The best open OR time in which to schedule the case would be more obvious by waiting. The extent to which this matters quantitatively is unknown, and is the focus of this article.

Methods

Releasing Allocated OR Time Based on Maximizing OR Efficiency

OR efficiency is defined functionally in terms of underutilized and overutilized hours of OR time (1–3). For example, if allocated OR hours are 7 AM to 3 PM, and the last case of the day ends at 1 PM, then there are 2 underutilized OR hours. In contrast, if the last case of the day ends at 5:30 PM, then there are 2.5 overutilized OR hours. The inefficiency of use of OR time is measured by taking the sum of two products: "the hours of underutilized OR time × the cost per hour of underutilized OR time" and "the hours of overutilized OR time × the cost per hour of overutilized OR time." OR efficiency is maximized by minimizing the inefficiency of use of OR time.

By the day of surgery, the relationship is simplified because the cost per hour of underutilized OR time is a sunk cost. Consequently, by the day of surgery,

ANESTH ANALG
2004;98:758–62

ECONOMICS, EDUCATION, AND HEALTH SYSTEMS RESEARCH   DEXTER AND MACARIO   **759**
WHEN SHOULD OPERATING ROOM BLOCK TIME BE RELEASED?

maximizing OR efficiency is achieved simply by minimizing overutilized OR time (3).

OR time can be allocated, cases can be scheduled, and OR time can be released to maximize OR efficiency (1–4). Previous work has shown that:

a. The most important step to maximizing OR efficiency is to allocate OR time appropriately (1,4). Then, only rarely should services encounter the situation wherein their allocated OR time is full and, yet, they have another case to schedule (1,4).

b. If a service's OR time is released, that service should still be able to schedule cases, provided they can be performed safely in the available ORs. From point (a), this should occur infrequently. When cases are performed on any future workday, and OR time is allocated based on maximizing OR efficiency, OR allocations should not limit OR workload (1–4).

c. There is no advantage in terms of OR efficiency to releasing a service's allocated OR time until there is a case to be scheduled into that OR time (3).

d. Whether a service's OR time is released should not affect the service's future OR allocations, since allocations to maximize OR efficiency are based on the service's expected future OR workload, not their utilization or release of allocated OR time (1–2,4). When OR time is allocated based on OR utilization, only the hours of underutilized OR time are considered. However, when cases are performed on any future workday, provided the case can be done safely, the cost per hour of overutilized OR time is more than the cost per hour of underutilized OR time. Thus, it is in fact the overutilized OR hours that are more important than the underutilized hours. This is why allocations based on maximizing OR efficiency are often markedly different than those based on OR utilization (2,5).

e. When a service has filled its allocated OR time, but has another case to be scheduled, OR efficiency is higher by performing that case in OR time that has been allocated to another service but is likely to be underutilized, instead of into overutilized OR time (3).

f. OR time should not be released other than in point (e) (3,4).

g. Services fill their allocated OR time at different rates. Thus, theoretically, the service that should have its OR time released for a new case should be the service that is predicted, when the new case is scheduled, to be the service that will have the most underutilized OR time in the future on the day of surgery (3). In practice, provided that OR time is allocated and cases are scheduled based on maximizing OR efficiency, this is not different from scheduling the case into the OR time of the service with the largest current difference between allocated and scheduled OR time (4).

h. Releasing the OR time of the service with the second most, instead of the service with the most, allocated but unscheduled OR time can have a large negative effect on OR efficiency (4). This is because usually a particular case can only be scheduled into a few services' OR time, and the differences among the few services in their amount of expected open OR time is often large.

Referring to the scenario in the Introduction, Gynecologist 2 requests that a case be scheduled on Monday to be done the next Friday. From point (e), that case should not be scheduled to follow Gynecologist 1, but rather some service should have its OR time released. Provided Gynecologist 2 is assured by the scheduler that the case will be done, it is not known whether the decision to assign the case a start time should be made right away or postponed. That is the issue studied in this paper.

Postponing the decision of releasing allocated OR time for a few days would likely reduce Gynecologist 2's and her patient's satisfaction with surgical suite management. Yet, postponing the decision would likely increase the professional satisfaction of the service that would have its OR time released. This would be particularly important for a service that routinely schedules its cases a few days before the day of surgery (e.g., cardiac surgery at some hospitals), since such a service would often be the service that has its OR time released.

Anesthesiologists may choose to stay out of this decision, leaving it to heads of surgery services to battle over in committee meetings. However, this decision could affect anesthesia groups. Postponing the decision of which service's OR time is released may permit a better decision to be made, because the closer the decision is made to the day of surgery, the more is known about what cases other services will schedule. Thus, whereas the scheduling surgeon may want to know immediately at what time his or her case will start, postponing that decision may increase OR efficiency.

Raw Data Used in the Analysis

The raw data used in the analysis were as in our previous study of how to release allocated OR time to maximize OR efficiency (4). Summarizing, we used all the elective cases performed at two surgical suites between July 1, 1998, and June 30, 2001. There were 754 regularly scheduled OR days during this 3-year period. There were 16,114 elective cases at the ambulatory surgery center and 30,775 elective cases at the hospital surgical suite.

A service's daily OR workload was defined as the service's total hours of elective cases including turnover times for that day. Each service's OR workload was calculated for each workday of the three-year period. The best OR allocation to maximize OR efficiency for each combination of the day of the week and service was obtained from these OR workload values (1–4). This was done by trying an allocation of 0 h (0 ORs), of 8 h (1 OR), of 16 h (2 ORs), and so forth. For each possible choice of 0 h, 8 h, and so forth, the inefficiency of use of OR time was calculated (equation above) (2). The optimal OR allocation was the number of 8 h ORs yielding the least inefficiency of use of OR time. In these calculations, the relative cost of overutilized to underutilized OR time was considered to equal 1.75. The calculations were performed using CalculatOR (MDA Ltd., Jenkintown, PA).

The ambulatory surgery center studied had seven services with allocations ranging from one to eight 8-h allocated OR each week (Table 1 in Reference (4)).

The larger hospital surgical suite studied had nine services with allocations ranging from two to twenty-five 8-h allocated OR each week.

From points (e) and (f) above, OR time is released when a service has filled its appropriately allocated OR time and has another case to schedule (3–4). At the surgical suites studied, the number of days before the day of surgery when each service filled its allocated OR time was (median ± quartile deviation) 3 ± 3 ($n = 928$) for the ambulatory surgery center and 1 ± 2 ($n = 2,337$) for the large hospital surgical suite (4). Therefore, we studied new cases scheduled on the day of surgery, morning of the day before surgery (shortest possible), 3 days before the day of surgery, and 5 days before the day of surgery. Five days ahead of time was the longest reasonable time that we could study using our data. At other surgical suites, this could just as well be 2 or 3 weeks.

Statistical Analysis

When to release allocated OR time was studied for new 1, 2, or 3 h hypothetical cases booked into the actual schedules above. A hypothetical case was scheduled into OR time of the service with the largest difference between allocated and scheduled cases early in the morning 5 days before the day of surgery. The process was repeated for the day before surgery. The difference in resulting overutilized OR time was calculated. Thus, a pair-wise difference in overutilized OR time was calculated for $n = 754$ days of data and 2 surgical suites.

For example, a new, hypothetical case is considered to have been submitted on a Friday, five days before a studied Wednesday. The planned, real OR schedule for the next Wednesday is reviewed. The new, hypothetical, case is scheduled into the OR time of the service that actually had the most allocated but unscheduled OR time on the studied Friday for surgery on the following Wednesday.

Continuing the example, then, additional (real) cases were scheduled between Friday and Tuesday. Actual case durations were used to calculate the resulting overutilized OR time on the Wednesday including the new case. The process was repeated while the hypothetical case was scheduled on Tuesday, the day before surgery. The resulting overutilized OR time was calculated.

For the example, the end-point for the studied Wednesday was the difference in the overutilized OR time between scheduling the case on the preceding Friday (five days before the day of surgery) versus on the preceding Tuesday (one day before the day of surgery).

The analysis was repeated comparing the release of allocated OR time 3 days before the day of surgery versus on the morning of the day before surgery.

Confidence intervals for the pair-wise differences were calculated by Student's *t*-test.

Results

Postponing the decision, of which service has its OR time released for the new case, until early the day before surgery reduces overutilized OR time by <15 min per OR per day versus releasing the allocated OR time 3 to 5 days before surgery. An exception was the larger surgical suite for long cases that were submitted 5 days before surgery (Table 1).

Discussion

Recommendations

When OR time is released is often of marked concern to surgeons. We found that OR managers and anesthesiologists can leave this decision to whatever best matches local organizational politics, as long as OR time has been allocated optimally from the beginning. Optimal allocations based on OR efficiency usually require a computer analysis of historical OR usage to find the best balance between underutilized time and overutilized time (1–3,5).

Our results are sensitive to the size of the surgical suite and the duration of the new case to be scheduled. We recommend waiting until early the day before surgery to decide which service has its OR time released to provide OR time for a new case if (a) there are likely to be several ORs into which a case could be scheduled, or (b) a case is of a relatively long duration as compared to the allocated hours (e.g., 3-hour case into 8 hours of allocated OR time).

ANESTH ANALG
2004;98:758–62

ECONOMICS, EDUCATION, AND HEALTH SYSTEMS RESEARCH   DEXTER AND MACARIO   **761**
WHEN SHOULD OPERATING ROOM BLOCK TIME BE RELEASED?

Table 1. Reduction in Overutilized Operating Room (OR) Time from Waiting to Assign the Case to an OR Until Early the Day Before Surgery, Instead of Assigning the New Case Right Away into the OR with the Most Allocated but Unscheduled OR Time

Surgical suite	Duration of new case (h)	Case submitted this number of days before surgery	Excess minutes of overutilized[a] OR time versus scheduling with the information available early the day before surgery (95% confidence interval, $n = 754$ for each)
Medium-sized ambulatory surgery center	1	3	1 (0 to 1)
	1	5	1 (0 to 2)
	2	3	1 (0 to 3)
	2	5	2 (1 to 4)
	3	3	2 (1 to 4)
	3	5	4 (2 to 6)
Large hospital surgical suite	1	3	3 (2 to 5)
	1	5	6 (5 to 8)
	2	3	7 (4 to 10)
	2	5	14 (10 to 17)
	3	3	11 (7 to 15)
	3	5	21 (16 to 26)

[a] A few days before the day of surgery and on the day of surgery, the direct incremental cost per hour of underutilized OR time is zero (3). Thus, maximizing the efficiency of use of OR time is the same as minimizing the hours of overutilized OR time.

At an ambulatory surgery center with brief cases, when OR time is released has virtually no effect on OR efficiency (Table 1). The reason is that there is typically only one good choice for the service to have its OR time released (4), and so there is no reason to wait in making the decision.

Likewise, suppose that at a large surgical suite cases are scheduled as if there are many smaller suites. For example, at a 25 OR surgical suite, one nursing and anesthesia team may cover the 5 ORs used for otolaryngology and general surgery. Then, from the perspective of releasing OR time for a new otolaryngology or general surgery case, there are only five ORs. Consequently, when OR time is released will have a negligible effect on OR efficiency (Table 1). In both circumstances, we recommend that the timing of the release of allocated OR time be based on the individual preferences of the relevant surgeons and their patients. We reiterate point (h) that the choice of the service whose time is released is exceedingly important in this circumstance (4).

Moving a case on the day of surgery from one OR to another can reduce overutilized OR time (i.e., increase OR efficiency) (6–7). For example, a case may be scheduled into released OR time, but that OR has specialized equipment that is now needed by that OR's original service for a newly scheduled (e.g., urgent) case. Moving the case is often an option, because a case that is scheduled into released OR time is usually scheduled to be performed late in the day. This is because such a case is scheduled only a few days before the day of surgery, by which time the first case of the day starts have already been filled.

Study Design and Limitations

Our study is limited to surgical suites that have already taken the important step of allocating OR time based on OR efficiency. Our study realistically considered releasing allocated OR time for one additional new case at a time. If overutilized OR time is twice as expensive as underutilized OR time, then 1/3 of ORs should have overutilized OR time. The likelihood of a service filling its allocated OR time and having another case to schedule is less (e.g., 1/5 ORs). Large surgical suites with more than five or so services are generally not interchangeable ORs because of nursing and anesthesiologists' skill sets. Still, once OR time has been released for one new case, the decision is simply repeated for subsequent cases.

We used OR allocations in 8-hour increments, to make interpretation of the results easier. The mathematics of OR allocation and case scheduling based on OR efficiency are identical when ORs have different durations, such as a mixture of 8-hour, 10-hour and/or 13-hour ORs (1–3).

Preeminent Importance of OR Allocation

The criteria used to release allocated OR time is of small consequence to enhancing OR efficiency versus

762   ECONOMICS, EDUCATION, AND HEALTH SYSTEMS RESEARCH   DEXTER AND MACARIO
WHEN SHOULD OPERATING ROOM BLOCK TIME BE RELEASED?

ANESTH ANALG
2004;98:758–62

the large importance of allocating OR time and scheduling cases based on OR efficiency (1–5). They should be the focus of the OR manager and anesthesia group.

Our study is limited to surgical suites at which releasing allocated OR time affects at what time a case is started, not on what day it is performed. This is not limiting in the United States. Contribution margins per OR hour are consistently at least several hundred dollars, and usually several thousand dollars (8–9). Even if OR teams were paid several hundred dollars per hour, it would make financial sense to perform a case, provided the case can be performed safely (i.e., appropriate intensive care unit, postanesthesia care unit, hospital ward, and OR staff and beds are available). Although cases may often be called "add-on," or some other category to get onto an OR schedule, they usually get done.

There are facilities where almost all allocated OR time is full most every day, and there are additional add-on cases. If the add-on cases invariably get done, and the issue is at what time of day they get done, then the cases are being performed on the workday chosen by the surgeon and patient (5). Such a facility has poor OR allocations (1–2,5). Releasing allocated OR time will not solve this problem (4). Facilities not allocating OR time based on OR efficiency should not rely on the results of this paper.

A facility may have almost all allocated OR time full most every day, additional add-on cases, and many add-on cases not being completed. This was not the problem studied in this paper. At such a facility, the hours of OR time are effectively fixed, because otherwise there would not be cases not being performed. The relevant operational objective is to minimize underutilized hours. How and when to schedule add-on

cases to maximize OR utilization is well understood scientifically (10).

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