Calculating a Potential Increase in Hospital Margin for Elective Surgery by Changing Operating Room Time Allocations or Increasing Nursing Staffing to Permit Completion of More Cases: A Case Study

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Administrators routinely seek to increase contribution margin (revenue minus variable costs) to better cover fixed costs, provide indigent care, and meet other community service responsibilities. Hospitals with high operating room (OR) utilizations can allocate OR time for elective surgery to surgeons based partly on their contribution margins per hour of OR time. This applies particularly when OR caseload is limited by nursing recruitment. From a hospital's annual accounting data for elective cases, we calculated the following for each surgeon's patients: variable costs for the entire hospitalization or outpatient visit, revenues, hours of OR time, hours of regular ward time, and hours of intensive care unit (ICU) time. The contribution margin per hour of OR time varied more than 1000% among surgeons. Linear programming showed that reallocating OR time among surgeons could increase the overall hospital contribution margin for elective surgery by 7.1%. This was not achieved simply by taking OR time from surgeons with the smallest contribution margins per OR hour and giving it to the surgeons with the largest contribution margins per OR hour because different surgeons used differing amounts of hospital ward and ICU time. We conclude that to achieve substantive improvement in a hospital's perioperative financial performance despite restrictions on available OR, hospital ward, or ICU time, contribution margin per OR hour should be considered (perhaps along with OR utilization) when OR time is allocated.

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Margin is an accounting term (margin = [revenue − costs]/revenue). Many hospitals operate with small margins. In the United States, hospitals' average margins were 2.7% in 1999 (1). Forty-three percent of not-for-profit hospitals had negative margins (2). Hospitals improve their margins by increasing their contribution margins (contribution margin = [revenue − variable costs]). Variable costs are those that increase with each successive patient receiving care (e.g., disposable anesthesia circuits). The remainder of hospital costs are fixed costs (e.g., surgical lights).

Many hospitals are also challenged by a growing shortage of skilled hospital nurses available at average national wage rates. This case study describes a hospital at which surgeons reported that many patients needing elective surgery were waiting months for surgery because of difficulties in recruiting additional nursing staff. In this paper, we address the dilemma of allocating surgical services in an environment where demand exceeds available capacity and the hospital is constrained by relatively small margins.

In hospitals operating with small margins, increasing elective surgical capacity may not be a feasible alternative because the costs of employing nurses on

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overtime and/or engaging agency ("traveling" or "contract") nurses may be prohibitive. More precisely, the marginal increase in revenue created by the expanded capacity may be insufficient to offset the increased costs of the additional nursing staffing.

Hospitals can aim to increase the contribution margin to better cover their fixed costs by allocating operating room (OR) time for elective surgery to surgeons based in part on their contribution margins per hour of OR time rather than OR utilization (3). However, implementing a change in OR allocations can be a difficult organizational challenge for hospital executives and OR managers. Before implementing such a change, administrators should estimate its impact on the hospital contribution margin so that they can decide whether the financial benefit will likely outweigh the time and risk required to make the change. In this study, we use a hospital's surgeons' contribution margins per hour of OR time and apply the mathematical method of linear programming to calculate how the hospital's contribution margin for elective surgery can be increased by adjusting the hours of OR time allocated to each surgeon.

Methods

Hospital accounting data were obtained for all patients who underwent outpatient or same-day admission surgery during the 2000 fiscal year at a large, academic, multiple specialty hospital in the southeastern United States of America (US). The data were extracted from the hospital's activity-based costing system (Transition 1™; Eclipsys Corp., Delray Beach, FL) and calculated using year 2000 US dollars.

Patients who were admitted preoperatively, including emergency and urgent cases, were excluded from this study because it was assumed that access to OR time for these patients would not be changed. Specifically, we assumed a commitment to provide appropriate care to a patient once he or she had been admitted to the hospital.

Overall variable costs, revenues, hours of OR time, hours of regular ward time, and hours of intensive care unit (ICU) time were calculated for each physician. We limited the analysis to the 98 physicians who performed at least 15 cases during the study year, to obtain meaningful measures of each physician's averages for each of these values (4) and to limit consideration to surgeons. There were 9184 cases, 28,290 h of OR time, and $44 million of variable costs.

We used the Solver linear programming (5) routine in Microsoft Excel (Microsoft, Redmond, WA) to determine the mix of surgeons' OR time allocations to maximize contribution margin. We included the following constraints on the availability of resources. First, we assumed that each surgeon could expand his or her use of OR time by as much as one-quarter of the number of OR hours that he or she used during the past fiscal year. Second, we assumed that the OR time for a surgeon could be reduced by as much as one-quarter. The surgeons at the hospital under study only have privileges at the one hospital; therefore a maximum reduction of 25% was the lowest practical limit. Third, we added constraints specifying that neither OR, nor nursing ward, nor ICU usage could exceed that of the previous year. Finally, we repeated the analysis by permitting an increase in ICU hours, but at a cost that was twice the hospital's current average variable rate for ICU nursing care.

Results

The contribution margins per hour of OR time varied more than 1000% among surgeons (Fig. 1). The surgeons with contribution margins per OR hour less than $250 performed oral surgery, outpatient pediatric otolaryngology, and hand surgery, respectively. The nine surgeons with contribution margins per OR hour more than $2500 performed cardiothoracic surgery.

Increasing or decreasing OR time for each surgeon by as much as 25% can increase the hospital contribution margin for elective surgery by 7.1% (Fig. 2) or more than $2.5 million. For 95 of the 98 surgeons, the absolute percentage change in the surgeon's OR time equaled the maximum of 25%.

Although Figure 1 showed a wide range in contribution margin per OR hour among surgeons, the linear programming did not achieve an increase in contribution margin simply by taking more OR hours from the surgeons with the smallest contribution margins per OR hour and giving it to the surgeons with the largest contribution margins per OR hour. The reason was that the different surgeons used differing amounts of hospital ward and ICU time. When the analysis allocated OR time, it maximized the contribution margin subject to constraints on the availability of these resources. Thus, some surgeons with smaller contribution margins per OR hour received increases in OR time because they consumed relatively little hospital ward and ICU time. For example, the OR time for the surgeon with the second-smallest contribution margin per OR hour was increased to the maximum. This surgeon performed outpatient pediatric otolaryngology cases and as such consumed few nursing ward or ICU resources. Likewise, the surgeon with the third-largest contribution margin per OR hour was allocated less OR time than he or she previously used; this cardiac surgeon had more ward and ICU hours per OR hour than his or her colleagues.

We assessed the percentage "allowable change" (5), whether a decrease or increase, in each surgeon's contribution margin per OR hour that was sufficiently

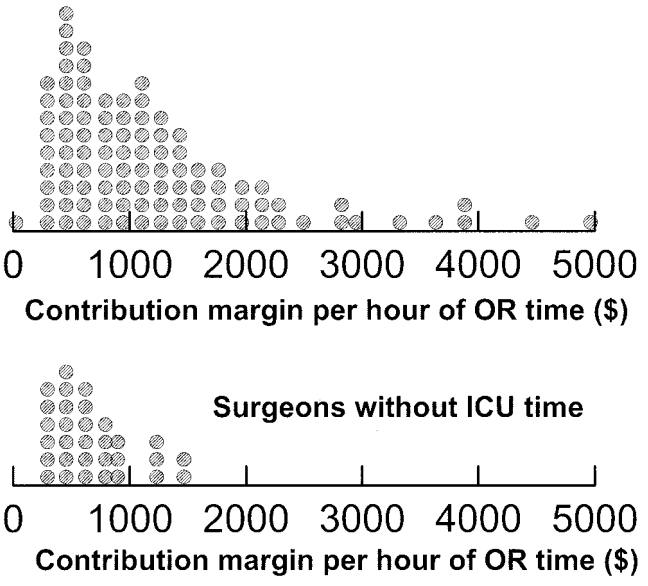

Figure 1. Hospital contribution margins per hour of operating room (OR) time for elective surgical cases grouped by surgeon. Each circle represents one surgeon. Contribution margin equals revenue minus variable costs. The surgeons in the bottom pane used an average of less than one intensive care unit (ICU) day each 3-mo period.

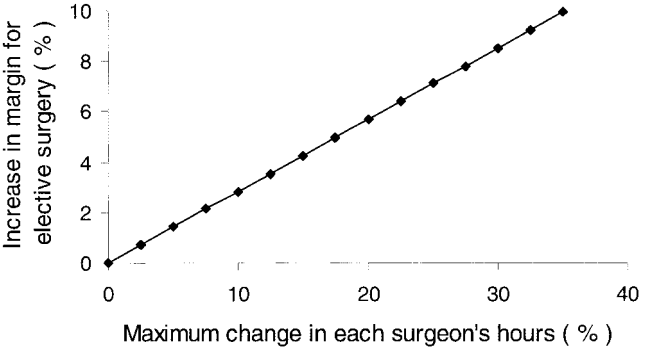

Figure 2. Impact on hospital overall contribution margin (%) of relaxing the constraint on the maximum change in each surgeon's operating room time, as a specified percentage of his or her historical usage. Each 3.5% relaxation of this constraint provided for a 1% increase in hospital contribution margins for elective surgery. This response was expected because hospital contribution margin for elective surgery was modeled as a linear function of the amount of operating room time used by each surgeon.

small that the surgeon's resulting OR allocation would not change. The mean ± SEM percentage allowable change was 40% ± 4%. Using each surgeon's allocated OR time as a weight, the weighted mean allowable change was 30% ± 3%.

Most surgeons with large contribution margins per OR hour used scarce ICU time (Fig. 1 lower panel). Consequently, increasing ICU hours by using expensive overtime or agency ("traveling" or "contract") nurses could increase the hospital margin. The maximum contribution margin was achieved with a 13% increase in ICU time using the higher priced labor. This arrangement of resources could increase hospital contribution margin for elective surgery by 9.1% and hospital margin by 3.6%.

Discussion

We reported previously, using data from a different hospital (Stanford University Medical Center), that contribution margins per OR hour can vary moderately among surgeons (3). Figure 1 shows that the range can be even larger, more than 1000%. Thus, allocating OR time strictly on the basis of OR utilization may be inadvisable financially. Raw utilization is a very poor surrogate for contribution margin. The achievable increase in hospital margin, from allocating OR time based on contribution margin per OR hour instead of utilization, exceeds the US national average (1).

We do not think that contribution margin per OR hour should be the sole basis for allocating OR time for elective cases. However, our and other (3) results show that the routine, small, and politically charged quarterly changes in OR allocations among surgeons to maintain "high" OR utilization can have little impact on margin. To affect substantive improvement in a hospital's perioperative financial performance through redistribution of resources, the contribution margin per OR hour should be considered (along with OR utilization) as part of the allocation process.

Contribution margin measurement allows hospital administrators to make rational decisions regarding service levels and profits. "Profit" for a not-for-profit hospital is the "surplus" of revenues over expenses (variable costs, fixed costs, and depreciation) (6). These "profits" are the equity capital available for the not-for-profit hospital to finance asset acquisitions (e.g., the deployment of computerized patient record systems or construction of a new surgical suite) and uncompensated community benefits (e.g., research and indigent care) (6).

Allocation of resources, such as OR time, on the basis of contribution margin does not necessarily imply an ethical problem. Hospitals and their managers generally have a range of goals that they wish to reach, most of which are not related to profitability. Contribution margin may not be the goal in itself, but it is a tool that hospital administrators can use to cover fixed costs and still have sufficient funds remaining for society's ultimate good. If a hospital plans to expand its services to the poor, fund-increasing research, and so forth, then it must also identify and maintain an appropriate mix of larger-margin services.

A rationale for allocating OR time based on contribution margin instead of OR utilization is not only to increase hospital margin but also to align incentives between surgeons and the hospital. For example, the contribution margin at the hospital studied was limited by its ICU capacity. Because the cost per day in an

ICU is higher than a ward, allocating OR time based on contribution margin per OR hour may, in concept, encourage surgeons to move patients promptly from the ICU to regular ward beds. This increases their contribution margins and could therefore contribute toward their being provided more OR time. Undesirable incentives to transfer patients inappropriately may be discouraged because a patient suffering a complication would decrease the contribution margin. Thus, although the linear programming assumes implicitly that for small changes in OR allocation surgeons do not change their behaviors and corresponding model parameters, an incentive may be created to do just that and in a desired direction of change. However, we found that the average surgeon would need to change his or her contribution margin per OR hour by 40% before that would result in a change in OR allocation. This large change suggests that the principal determinant of a surgeon's OR allocation may not be how efficiently he or she provides care, but what type of work he or she does (e.g., outpatient pediatric otolaryngology versus cardiac surgery). This may reduce the effectiveness of this method of OR allocation as a means to align incentives between the hospital and surgeons.

We described a rational process of deciding how to expand services to accommodate additional elective surgery. Hiring "traveling" or "contracting" nurses or using overtime to expand OR, regular ward, or ICU capacity is expensive. The linear programming approach permits the hospital to balance increases in revenue by expanding capacity against the higher variable costs incurred to increase that capacity.

Currently, hospitals that have financial data often consider the contribution margin of the surgical service or surgeon *in toto*, rather than the more appropriate analysis of contribution margin for outpatient and same-day admission elective cases. Except for the rare situation of hospitals transferring patients, once a patient is admitted he or she receives full care. Consequently, the effects of expanding OR, hospital ward, or ICU capacity or adjusting the allocation of that capacity among surgical services or surgeons affects only new elective surgical admissions, not unscheduled ones such as emergencies.

As part of building new facilities, surgeons leaving, and practices decreasing in volume resulting in less OR utilization, large hospitals often have small amounts of open OR time available. Contribution margin per OR hour seems to be as reasonable a choice as any other criteria currently used to decide who gets it (versus, for example, who yells the loudest). The importance of our paper is thus twofold. First, the issue is not which surgeon "brings in the most money," but whose contribution margin per resource use, in this case OR and ICU time (Fig. 1), is the largest. Second, as evidenced by the limitation in ICU time at the hospital described in this case study, using contribution margin per OR hour alone can produce markedly suboptimal results. Other hospital resources that the surgeon uses (e.g., hours of ICU time per OR hour) may need to be included when allocating OR time. The linear programming approach considers all surgeons and resource requirements simultaneously.

To maximize the hospital contribution margin, OR time should, theoretically, be allocated based on contribution margins per allocated OR hour rather than per actual OR hour (3). However, for the hospital studied, using the contribution margin per OR hour achieved the same result for two reasons. First, surgeons' revenue was limited by access to hospital resources, specifically OR time, ICU time, and ward beds. The adjusted OR utilization at the site was 92%. Consequently, the surgeons had an incentive to fully use their allocated OR time. Second, the contribution margins were positive for all surgeons, unlike at the hospital we studied previously (3). Surgeons with negative contribution margins have a perverse incentive to consume extra OR time to dilute their losses among more OR hours and reduce the negative contribution margins per OR hour.

We limited the change in OR allocations for each surgeon to ±25% of his or her current OR workload. Linear programming can use a range of more sophisticated constraints. For example, a minimum volume may be required for an educational program. Alternatively, for example, providing more OR time for one or more surgeons may not be useful if a limiting factor in those surgeons' workload is limited clinic hours of a referring medical service. The surgeons at the hospital under study only have privileges at the one hospital, so a maximum reduction of 25% was the smallest practical limit.

Our work is limited primarily by its applicability to surgical suites with a limited number of hours of OR time available for elective cases. The analysis would not be suitable for surgical suites at which the surgeons and patients can schedule their elective cases on whatever future workday they choose (7–9) or at surgical suites that care for all elective cases within a "reasonable" (not decided by the surgeon) number of days (10–11).

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