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Where Are the Costs in Perioperative Care?

Analysis of Hospital Costs and Charges for Inpatient Surgical Care

Alex Macario, M.D., M.B.A., Terry S. Vitez, M.D.,† Brian Dunn, B.A.,‡ Tom McDonald, M.D.§*

Background: **Many health-care institutions are emphasizing cost reduction programs as a primary tool for managing profitability. The goal of this study was to elucidate the proportion of anesthesia costs relative to perioperative costs as determined by charges and actual costs.**

Methods: **Costs and charges for 715 inpatients undergoing either discectomy (n = 234), prostatectomy (n = 152), appendectomy (n = 122) or laparoscopic cholecystectomy (n = 207) were retrospectively analyzed at Stanford University Medical Center from September 1993 to September 1994. Total hospital costs were separated into 11 hospital departments. Cost-to-charge ratios were calculated for each surgical procedure and hospital department. Hospitalization costs were also divided into variable and fixed costs (costs that do and do not change with patient volume). Costs were further partitioned into direct and indirect costs (costs that can and cannot be linked directly to a patient).**

Results: **Forty-nine (49%) percent of total hospital costs were variable costs. Fifty-seven (57%) percent were direct costs. The largest hospital cost category was the operating room (33%) followed by the patient ward (31%). Intraoperative anesthesia costs were 5.6% of the total hospital cost. The overall cost-to-charge ratio (0.42) was constant between operations. Cost-to-charge ratios varied threefold among hospital departments. Patient charges overestimated resource consumption in some hospital departments (anesthesia) and underestimated resource consumption in others (ward).**

Conclusions: **Anesthesia comprises 5.6% of perioperative costs. The influence of anesthesia practice patterns on "downstream" events that influence costs of hospitalization requires further study. (Key words: Anesthesia costs. Economics. Hospital costs. Patient charges. Surgery costs.)**

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MANY health-care institutions are emphasizing cost reduction programs as a primary tool for managing profitability. Services related to surgery can represent more than 40% of hospital costs and revenues.‖ Knowing the actual costs of providing care to surgical patients will assist hospital managers in developing targets for reduction and improving usage of health-care resources.[1] Although reducing anesthesia costs may lead to savings,[2–8] the relative contribution of anesthesia costs to total perioperative costs is uncertain.[9]

Analysts often use patient charges to approximate costs.[10–16] The rationale behind this strategy involves: (1) hospital charges are more accessible than true costs; and (2) charges are believed to be related to costs by a constant correction factor—the cost-to-charge ratio. However, basing an economic analysis on charges alone is known to lead to misleading results.[17–19] The goal of this study was to elucidate the proportion of anesthesia costs relative to the major hospital departments involved in surgical care and to explore the cost-to-charge relationship in perioperative care.

Methods and Materials

Surgical Procedures

This retrospective study was approved by the institution's Human Subjects Committee. We selected four in-

* Research Fellow, Department of Anesthesia.

† Associate Professor, Department of Anesthesia.

‡ Analyst, Department of Utilization Management.

§ Associate Chief of Staff, Department of Utilization Management.

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Address reprint requests to Dr. Macario: Department of Anesthesia, Stanford University School of Medicine, Stanford, California 94305-5115. Address electronic mail to: macario a@hosp.stanford.edu.

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patient surgical procedures: (1) intervertebral disc excision (discectomy); (2) retropubic or radical prostatectomy (prostatectomy); (3) appendectomy; and (4) laparoscopic cholecystectomy. These procedures were chosen because they represent common, nontertiary operations that may require a range of hospital resources.

We used International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) procedure numbers 80.51 (discectomy, n = 234 patients), 60.4–60.5 (prostatectomy, n = 152 patients), 47.0 (appendectomy, n = 122 patients), and 51.23 (laparoscopic cholecystectomy, n = 207 patients) to retrieve hospital cost data for all 715 patients undergoing one of the four procedures between September 1993 and September 1994. Patients with other ICD-9-CM codes as principal procedures were excluded. Data were analyzed for each patient, by surgical procedure, and then in the aggregate for all patients. All patients underwent surgery at Stanford University Medical Center.

Cost Data Source

Cost data were obtained from Stanford's integrated hospital cost management and decision system software (Transition Systems Inc., Boston, MA; TSI). The TSI software was developed at the New England Medical Center in the 1980s and has been implemented in more than 100 hospitals in the United States and in Europe. The TSI system acquires data from the hospital's existing data management systems, including clinical and financial transactions systems.

The TSI system divides costs into various categories based on the information available in the hospital's information systems. Clinical and financial data are combined to determine actual supply costs, compensation rates, and labor effort as measured by hospital department managers. TSI cost standards are continuously tested for accuracy and calibrated to actual expenses and revenues. All labor costs (*e.g.*, nursing, technician, house staff) are included except for physician professional fees.

Total Costs

The total hospital cost for each patient and for each operation was separated into 11 hospital departments: operating room, ward, surgery admission unit, postanesthesia care unit, anesthesia, laboratory, pharmacy, intensive care unit, blood blank (blood), radiology, and miscellaneous. Operating room costs include all equipment, labor, and supplies used once the patient entered the operating room. Ward costs reflect nursing density and the room and board function of the patient ward. The miscellaneous category included costs of occupational and physical therapy, emergency room, ambulatory treatment unit, endoscopy, and dietary services. Using patient-specific data, detailed resource consumption profiles were established for each of the 11 hospital departments.

Anesthesia Costs

Anesthetics were delivered by staff anesthesiologists and anesthesia house staff. All medications and supplies used to anesthetize each patient were recorded and included in the "anesthesia" hospital department. Examples of these costs were all airway supplies (*e.g.*, endotracheal tube), intravenous and blood administration supplies (*e.g.*, blood pump intravenous tubing), invasive pressure monitoring (*e.g.*, transducers), regional anesthesia supplies (*e.g.*, epidural kit), and salaries of anesthesia technicians. The professional fees of anesthesiologists (and all other attending staff) were excluded. Fixed costs such as the depreciation of the anesthesia machine were also used to calculate total costs.

Classification of Costs

Variable and Fixed Costs. Total costs for each of the 11 hospital departments were separated into variable and fixed components. Variable costs change in direct proportion to volume; fixed costs remain unchanged despite changes in volume.[20]

Direct and Indirect Costs. Costs were also partitioned into direct and indirect components. Direct costs could be identified specifically with a patient care service. Indirect costs, conversely, are not directly related to individual patients but are incurred to support the clinical service.

Using the categories described earlier, costs were arranged into four subcategories: variable direct, variable indirect, fixed direct, and fixed indirect.

Variable Direct Costs

Variable direct costs were defined as labor and supplies directly involved in producing a specific patient service. Examples include operating room personnel and supply costs required to deliver an anesthetic or nursing labor and medical supply expenses used to produce a patient day with 6 h of nursing care. Variable direct costs may reflect costs controlled by physicians' clinical decision-making because neither fixed costs nor overhead costs are included in the variable direct

cost category. The total variable direct cost attributed to a specific hospital unit (*e.g.*, postanesthesia care unit) for a given patient was the sum of all the variable direct costs required to provide that service to the patient.

Variable Indirect Costs. Variable indirect costs were support costs driven by the level of service provided. Salaries for workers in Dietary or filing personnel in Medical Records are examples of variable indirect costs.

Fixed Direct and Indirect Costs. Fixed costs were allocated to the production of a patient service. Unit clerks and telephone expenses on nursing units are examples of fixed direct costs. Conversely, if a cost could not be linked with a particular patient, it was considered a fixed indirect cost (*e.g.*, administration). As another example, a department's allocated depreciation expense was calculated from the square footage it occupied.

Cost-to-charge Ratios

We also collected hospital bill charges for each patient. For each surgical procedure, an overall cost-to-charge ratio was calculated by dividing total hospitalization costs for all patients by the corresponding charges. Cost-to-charge ratios were also obtained for each of the 11 hospital departments.

Statistics and Data Management

Data management and calculations were performed on Excel 4.0. (Microsoft Corporation, Redmond, WA) The proportion of hospital costs accounted for by each department were calculated by dividing the sum of department (*e.g.*, anesthesia) costs for all patients by the sum of each patient's total costs. Ninety-five percent confidence intervals (95% CI) for these proportions (ratio of mean values of two random variables) were obtained with Fieller's Theorem.[21] Analysis of variance with the Bonferroni method was used to describe statistical significance for cost-to-charge ratios among hospital departments and for percentages of total departmental costs due to variable direct costs.[22] Follow-up comparisons were performed with *t* tests. Cost and charge data for patients were compared using the Wilcoxon signed-rank test. Cost-to-charge ratios and variable direct cost to total cost percentages are presented as mean ± one standard deviation.

Results

Total Costs

Variable direct costs accounted for 44% of the total cost of hospitalization. Fixed indirect cost were 38% of total costs and fixed direct costs accounted for 13% of total costs. The remaining 5% of costs were variable indirect costs.

Distribution of Total Costs by Hospital Department

When using actual *cost* data, intraoperative anesthesia costs as a percentage of the total hospital cost equaled

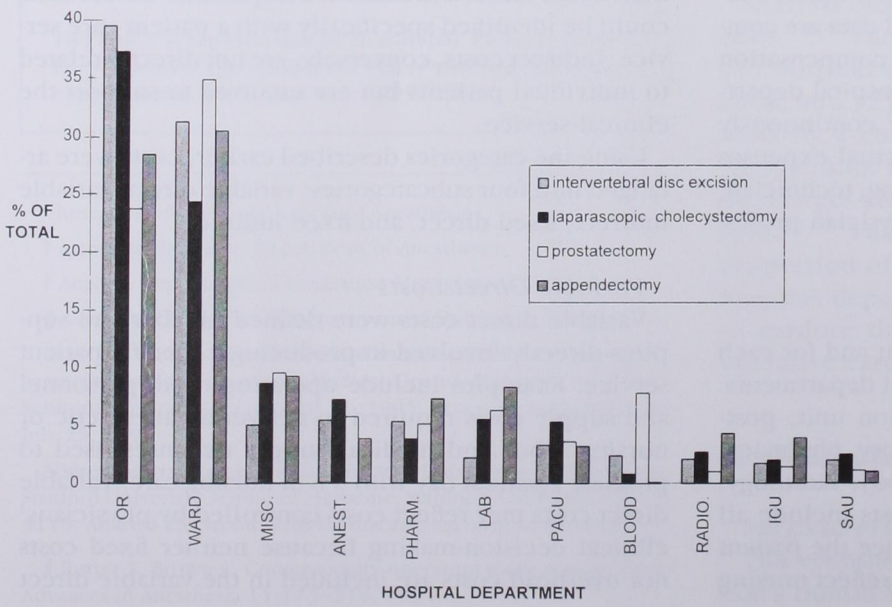

Fig. 1. Distribution of hospital costs for surgical inpatients. Resource consumption by surgical inpatients varied across the 11 hospital departments. The operating room and the patient ward (nursing and room and board functions) have the majority of costs.

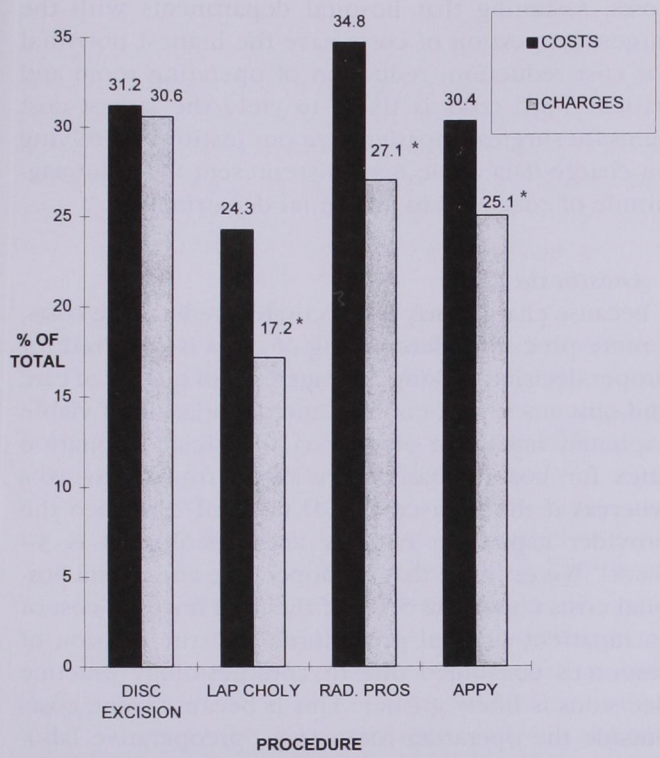

Fig. 2. Charges underestimate proportion of hospital costs attributed to the ward. The numerator used to calculate the percentages is total ward costs (or charges) and the denominator is total hospital costs (or charges). Using charge data only would have underestimated the cost proportion of the patient ward (*$P < 0.001$). For example, laparscopic cholecystectomy charges attributed to anesthesia were 29% (7.1%/24.3%) smaller than actual costs.

5.6% (±0.7%, 95% CI ± 1.4%). The largest hospital cost category was the operating room (33% ± 0.2%, 95% CI ± 0.4%). Costs attributed to the patient ward equaled 31% (±0.1%, 95% CI ± 0.2%). Postanesthesia care unit costs were 3.7% (±0.96%, 95% CI ± 2.0%) of the total perioperative cost. The relative contribution of each hospital department to total cost varied among procedures (fig. 1).

Costs Versus *Charges*

The ranking of the relative contribution of the hospital departments using charge data was similar to that for cost data. However, the actual percentages attributed to the hospital departments were different than when calculated with cost data. There was no consistent pattern to the differences.

Patient charges resulted in a 23% relative underestimate of the percentage of hospital resources utilized in delivering postoperative ward care ($P < 0.001$; fig. 2). In contrast, patient charges resulted in a 48% relative overestimate of actual anesthesia costs ($P < 0.001$; fig. 3). In absolute terms, charge analysis overestimated operating room costs as a fraction of total hospital costs for laparoscopic cholecystectomy (41.7% of total charges *vs.* 37.2% of total costs; $P < 0.001$). Charge analysis underestimated operating room costs for discectomy (33.6% of total charges *vs.* 39.2% of total costs; $P < 0.001$). For appendectomy and prostatectomy, charge data analysis resulted in negligible differences with actual cost analysis when estimating operating room costs as a fraction of total hospital costs.

Overall Cost-to-charge Ratio

Dividing all hospital costs by all patient charges produced an overall cost-to-charge ratio of 0.42 (±0.01). Overall cost-to-charge ratios were constant among operations.

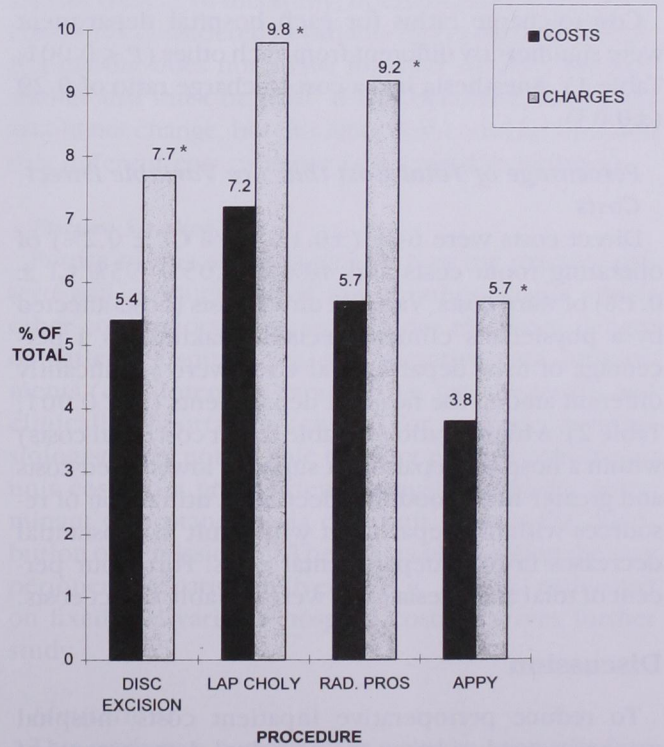

Fig. 3. Charges overestimate proportion of hospital costs attributed to anesthesia. The numerator used to calculate the percentages is total anesthesia costs (or charges) and the denominator is total hospital costs (or charges). Charge and cost data analyses produce different proportions of anesthesia resource use (*$P < 0.001$). For example, disc excision charges attributed to anesthesia were 43% (2.3%/5.4%) greater than costs.

Table 1. Cost-to-Charge Ratio Differs Significantly* by Hospital Department

Hospital Department	Cost-to-Charge Ratio (mean ± SD) (all patients)
Surgery admission unit	0.92 ± 1.04
Radiology	0.63 ± 0.10
Post anesthesia care unit	0.54 ± 0.56
Blood bank	0.53 ± 0.16
Patient ward	0.52 ± 0.15
Laboratory	0.50 ± 0.20
Miscellaneous	0.48 ± 0.03
Operating room	0.44 ± 0.02
Pharmacy	0.41 ± 0.61
Intensive care unit	0.37 ± 0.03
Anesthesia	0.29 ± 0.03

Cost-to-charge ratio = total departmental costs/total departmental charges.

* Significant at $P < 0.001$ with ANOVA and follow-up *t* test for each comparison.

Cost-to-charge Ratios Vary Among Hospital Departments

Cost-to-charge ratios for each hospital department were significantly different from each other ($P < 0.001$; Table 1). Anesthesia had a cost-to-charge ratio of 0.29 (±0.03).

Percentage of Total Cost that Are Variable Direct Costs

Direct costs were 64% (±0.1%, 95% CI ± 0.2%) of operating room costs and 48% (±0.05%, 95% CI ± 0.1%) of ward costs. Variable direct costs (costs affected by a physician's clinical decision-making) as a percentage of total departmental costs were significantly different among the hospital departments ($P < 0.001$; Table 2). A higher ratio (variable direct cost/total costs) within a hospital department suggests lower fixed costs and greater likelihood that decreased utilization of resources within a department will result in substantial decreases in total departmental costs. Forty-four percent of total anesthesia costs were variable direct costs.

Discussion

To reduce perioperative inpatient costs, hospital managers need to know the principal determinants of costs. Assuming that hospital departments with the largest proportion of costs have the highest potential for cost reduction, reduction of operating room and patient ward costs is likely to yield the largest cost gains for surgical inpatients. At our institution, relying on charge data alone may misrepresent the true magnitude of costs within a hospital department.

Anesthesia Costs

Because charges may not accurately reflect true costs, a more precise understanding of costs is required for proper decision-making, management of quality of care and outcomes, cost control, and negotiation of viable capitated rates. For anesthesia, physician capitation rates for hospital-based care range from 8 to 10% whereas if the plan covers all medical care then the provider capitation rate for anesthesiologists is 3–5%.#** We estimate that intraoperative anesthesia hospital costs constitute 5.6% of the total hospital cost of an inpatient surgical procedure. The true fraction of resources consumed due to anesthesiology practice decisions is likely greater. This is because some costs outside the operating room (*e.g.*, preoperative laboratory testing) were not allocated to "anesthesia" but may have been due to decisions related to anesthesia care.[23]

We found that half of the intraoperative anesthesia costs are variable direct costs. The greatest cost savings occur if interventions address variable costs (*e.g.*, intravenous supplies).[24] Choosing less costly alternatives

Table 2. Percentage* of Hospital Departmental Costs Due to Variable Direct Costs

Hospital Department	Percentage (mean ± SD) (all patients)
Blood bank	73.0 ± 6.5
Pharmacy	69.8 ± 12.0
Miscellaneous	50.4 ± 21.1
Intensive care unit	47.7 ± 0.2
Operating room	44.4 ± 7.7
Anesthesia	44.3 ± 0.2
Patient ward	37.9 ± 4.4
Laboratory	37.5 ± 17.3
Post anesthesia care unit	32.7 ± 0.1
Radiology	32.0 ± 0.2
Surgery admission unit	29.7 ± 0.1

Percentage = variable direct cost within a department/total cost within a hospital department.

* Significant at $P < 0.001$ with ANOVA and follow-up *t* test for each comparison.

Personal communication, R. Miller, M.D., 3/11/95.

** Arens J: Negotiating with managed care contract holders. American Society of Anesthesiologists 1994 Annual Refresher Course Lectures. 236A:1–4, 1994

can reduce such costs as long as the quality of care is not decreased.[25] Thus, the lower bound of costs (*e.g.*, anesthesia drugs, intubation supplies) under immediate control of anesthesia providers is approximately 3% of inpatient surgical costs. Although the cost per case of anesthesia resources is small, given the volume of anesthetics administered, small savings per case have represented substantial savings when aggregated.[3–6]

Hospital Cost Structure

Our results suggest that approximately one third of total operating room costs and one half of patient ward costs are indirect costs used to maintain clinical support services (*e.g.*, Medical Records). In other words, costs associated with Medical Records, for instance, are shifted to billable clinical services such as the operating room. Varying cost-to-charge ratios (from 0.29 to 0.91 at our institution) for different hospital cost centers may reflect attempts to achieve reasonable profit margins and to use collections from a revenue-producing department to support non-revenue-producing hospital functions. Hospital operations improvement efforts that optimize efficiencies of hospital support functions will reduce perioperative costs by reducing indirect costs. In fact, attaining the targeted level of savings from operating room restructuring, for instance, may be compromised by the large (one third) indirect component of the total cost of running an operating room.

Costs Versus *Charges*

Charge data should be used cautiously in economic analyses because there is no fixed relationship between true economic costs and charges.[17–19] The reason for this may be that charges have historically relied on comparisons with competing hospitals' charges and on imprecise internal costs. Prior to implementation of Medicare's prospective payment system in 1983, the Medicare Cost Report was the main approximation of cost accounting in most hospitals. An example of where charge data might be appropriate is in outpatient care in which the patient pays "out of pocket."

The calculated overall cost-to-charge ratio (0.42) was consistent across operations. Therefore, relative total charges may be a reasonable proxy for relative total costs. In other words, if two patients underwent the same procedure and the first patient had twice the total charges of the second patient, then on average the first patient had twice the total costs of the second patient. However, as hospital payment methods have changed, more accurate and precise cost management requires hospital cost accounting systems to specifically measure all inputs necessary for patient care.[26] For our institution, had we only inspected patient charges as a proxy for hospital resources, we would have obtained misleading results about the proportions of costs, particularly, for the patient ward and for anesthesia.

Using cost data we found that 31% of hospital costs for radical prostatectomy was for operating room and anesthesia and 5% was for pharmacy. This is in contrast to a study of patients undergoing radical prostatectomy, which reported that 53% of the hospital charges was for the operating room and anesthesia while 16% was attributed to pharmacy.[15] Differences in local medical practice patterns may also affect the distribution of costs and charges for a particular procedure.

Differences in charge and costing methods (*e.g.*, how resources are assigned to a hospital department) can influence the economic evaluation of a procedure. Depending on how variable and fixed costs are defined, cost differences between surgical procedures can vary significantly.[19] In this study, operating room personnel costs were considered as variable direct costs. However, if a patient does not arrive for their surgery, the personnel still must be paid. If this occurred, total costs would not change, but this labor cost could be allocated to a different cost category (*e.g.*, variable indirect).

Future Studies

Future studies should focus on how the practice pattern and productivity of the anesthesiologist affects other cost factors—operating room efficiency, length of patient hospital stay, postoperative care requirements (*e.g.*, intensive care unit *vs.* patient ward), and clinically important outcomes. For example, anesthesiologists may not be able to affect postanesthesia care unit costs to a great extent because the major determinant of postanesthesia care unit costs is the distribution of admissions.[27] The effects of changing the way perioperative care is delivered (*e.g.*, clinical pathways) on fixed and variable hospital costs deserves further study.

Limitations

This study was performed in a single university hospital using a well-known cost accounting application (TSI). The results are not necessarily transferable to other institutions with other cost taxonomies. Nevertheless, the proportions of hospital departmental costs are likely to be generalizable to other hospitals. We did not evaluate ambulatory procedures, which are

an important segment of surgical volume in the United States.

Anesthesia costs are a small portion of the overall costs associated with a surgical patient's hospital encounter. Our design could not evaluate the influence of physician practice patterns on "downstream" events in the hospitalization, some of which may have substantial economic impact (*e.g.*, enhanced pain control in high-risk patients who experience fewer postoperative adverse events). Greater cost savings may come with improving operating room efficiency as well as those processes of care that reduce length of hospital stay (while maintaining similar or improved quality of care). This would seem more important than restriction of anesthesia agents, supplies, and equipment. More studies are needed on how anesthesiologists can promote more-cost efficient perioperative care by balancing economic pressures and the ability to deliver high quality medical care.

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