PAPER

The "Cost" of Operative Training for Surgical Residents

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Hypothesis: There is an increase in the amount of time required to perform an operation when the procedure involves training a surgical resident. This increased time does not translate into a financial burden for the hospital.

Design: Retrospective review of prospectively collected data. During the study period, surgeons and residents were blinded to the study's intent. We compared the operative times of academic surgeons performing 4 common surgical procedures before and after the introduction of a postgraduate year 3 resident into a community teaching hospital. Between January 1, 2001, and June 30, 2002, 4 academic surgeons performed operations without a resident in a community hospital that was recently integrated into a tertiary medical center system. During that period, surgeons operated alone (hernia surgery) or assisted one another (laparoscopic cholecystectomy, colectomy, and carotid endarterectomy). From July 1, 2002, through March 31, 2003, these same 4 surgeons were assisted by a postgraduate year 3 resident on similar procedures.

Setting: Community hospital recently integrated into a tertiary medical center system.

Participants: Four experienced academic surgeons operating in the community setting and patients undergoing 1 of 4 surgical procedures (inguinal hernia repair, laparoscopic cholecystectomy, partial colectomy, or carotid endarterectomy) from January 1, 2001, through March 31, 2003.

Intervention: The introduction of a postgraduate year 3 surgical resident rotation into a community hospital in which the same academic surgeons had been performing operations without a resident for 18 months.

Main Outcome Measures: Mean operating time with and without a postgraduate year 3 resident participating in 4 common surgical procedures.

Result: For the 4 procedures studied, there was a significant increase in the operative time required to complete such procedures.

Conclusions: There is an increased time cost associated with the operative training of surgical residents. This "cost" primarily impacts the attending surgeon.

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IT IS A WIDELY HELD BELIEF AMONG most experienced academic surgeons that training residents in the operating room (OR) increases the time required to perform most surgical procedures. In surgical gathering places nationwide, anecdotal stories of the difference in "skin-to-skin" time when procedures are performed with and without a resident are often told by senior surgeons. This increased time is an inherent inefficiency of the training process and a necessity that ensures adequate training and quality outcomes. There are few data and reports in the literature, however, that have attempted to define the precise amount of time associated with training a particular level resident on a particular procedure. The few reports that do exist examine residents at different postgraduate levels performing various procedures with numerous different surgeons. Therefore, it is difficult to quantify the amount of extra time a surgeon can reasonably expect to spend training a particular resident on a particular procedure.[1-4]

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We identified a unique opportunity to examine the difference in operative times required to perform 1 of 4 common surgical procedures with and without a postgraduate year (PGY) 3 resident. To minimize surgeon and resident variability, we examined data only for the

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Operating Room Time With and Without a Resident

Procedure	Time in the Operating Room, min* Without a Resident	With a Resident	Change in Time, min	*P* Value
Hernia repair	38.0 ± 1.7 (n = 18)	46.0 ± 3.1 (n = 14)	8	.03
Laparoscopic cholecystectomy	63.0 ± 3.5 (n = 32)	86.0 ± 5.8 (n = 26)	23	.002
Carotid endarterectomy	124.0 ± 2.1 (n = 42)	168.0 ± 7.9 (n = 17)	44	<.001
Partial colectomy	115.0 ± 7.9 (n = 25)	175.0 ± 28.6 (n = 9)	60	.08

*Data are given as mean ± SE.

surgeon that was deemed to be most expert in that particular procedure and limited our study to only PGY 3 level residents. We sought to quantify as accurately as possible the average amount of extra time required to train a PGY 3 resident on 4 common surgical procedures.

METHODS

This study is a retrospective analysis of prospectively collected data on patients undergoing 1 of 4 common operations in a community teaching hospital.

On November 1, 1999, a community hospital (Quincy Medical Center) became a new teaching affiliate of Boston Medical Center and the Boston University School of Medicine. Before then, the institution was a municipal hospital with no active residency training programs in place. Subsequent to the affiliation (January 1, 2001, through June 30, 2002), 4 full-time academic surgeons (T.J.B., S.S., D.H., and G.G.) operated in the community hospital either alone (hernia surgery) or assisting one another (laparoscopic cholecystectomy, partial colectomy, and carotid endarterectomy). From July 1, 2002, through March 31, 2003, these same 4 surgeons were assisted by a PGY 3 surgical resident on similar procedures.

For each type of procedure, only one surgeon's data were studied to decrease the variability of operative times among surgeons. For example, the data for hernia surgery were collected only for the surgeon with a particular interest/expertise in hernia surgery (T.J.B.); and for laparoscopic cholecystectomy, a surgeon with advanced minimally invasive surgery training was studied (D.H.). Similarly, for colectomy, a board-certified colorectal surgeon was selected (S.S.); and for carotid endarterectomy, a senior board-certified vascular surgeon was examined (G.G.). In a further attempt to minimize the variability between procedures, all urgent and emergency procedures were excluded from analysis. In addition, the following were also excluded: recurrent and bilateral hernia surgical procedures, laparoscopic cholecystectomies that were converted to open procedures, total colectomies, surgery involving the rectum, and reoperative carotid endarterectomies.

Only PGY 3 residents rotate through this community hospital—a fact that also minimized any variability in the data due to participation by residents of different levels. For all procedures in which the PGY 3 resident participated, the resident performed the role of operating surgeon in accordance with the Residency Review Committee/Accreditation Council for Graduate Medical Education guidelines. Postgraduate year 3 surgeons in our program enter their third year of training with an average of 375 procedures performed during the prior 2 years. All PGY 3 residents have substantial prior experience with hernia surgery (35-100 procedures), moderate experience with laparoscopic cholecystectomies (10-35 procedures), and limited experience with colectomies and carotid surgery (<10 procedures each).

Operative times were prospectively collected from an OR information system (Meditech) present in the OR and completed at the operation. Operative times were defined as the time from skin incision to the time of wound closure. All results are expressed as mean±SE. Statistical analysis was performed using SAS statistical software (SAS Institute Inc, Cary, NC). *P* values were determined using the *t* test for unpaired data, and were considered significant at $P<.05$.

Cost analyses were performed using various methods. A fixed cost analysis was considered but deemed inappropriate for reasons outlined in the "Comment" section. Instead, an opportunity cost analysis was used to best quantify and understand the implications of increased operative times. Opportunity cost is defined as the "cost" used to quantify the value difference between investing in one product or activity vs another.

RESULTS

For all 4 procedures studied, there was an increase in the operative time when a PGY 3 resident was involved with the procedure (**Table**). For hernia surgery, the increase was 8 minutes; for laparoscopic cholecystectomy, the increase was 23 minutes; for carotid endarterectomy, the increase was 44 minutes; and for partial colectomies, the increase was 60 minutes.

Of the 4 procedures studied, 3 revealed statistically significant increases in operative times (hernia surgery [$P=.001$], laparoscopic cholecystectomy [$P=.002$], and carotid endarterectomy [$P=.03$]). The difference in operative times tended to increase with the greater complexity of the procedures: carotid endarterectomy took longer than laparoscopic cholecystectomy, which took longer than hernia surgery. The increase in operative time was the greatest for colectomies, although not statistically significant ($P=.08$). This was likely due to fewer procedures with residents (n=9) and the larger standard error (28.6 minutes) for mean times for those procedures.

COMMENT

We identified a unique opportunity to study the hypothesis that introducing a PGY 3 surgical resident into a community hospital would increase the operative times for common surgical procedures. Because we did not propose this study until April 1, 2003, none of the surgeons or residents involved during the study period (January 1, 2001, through March 31, 2003) had any knowledge that this study would be conducted. Thus, it is unlikely that any increased operative time could have been deliberately manipulated. It was only subsequent to developing this hypothesis that we reviewed the prospectively collected data on operative times. For all 4 procedures studied, there was an increase in the operat-

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ing time when a PGY 3 resident was assisting during the procedure (Table).

Having documented the increased operative time, the natural question to ask is, "What did this increased time cost?" Although the term cost is used daily, it is often misused and misinterpreted. Strictly defined, cost is the irreversible use of a resource. Cost is not the same as charges, and should not be used interchangeably with that term. It is essential to understand these concepts to ensure a rational discussion.

When examining cost implications, other studies have correlated this increased time with an increased financial burden to the hospital. Often, this correlation is based on the logic that OR time is estimated to cost between $5 and $20 per minute (depending on the type of cost analysis used—usually total fixed plus variable costs divided by total OR minutes) and, therefore, any increase in time would directly translate into real increased expenses to the hospital. Such arguments are potentially erroneous, however, given that most OR costs are fixed and are (relatively) use independent. In other words, fixed costs are just that—fixed! Although there are OR costs that are defined as semifixed (fixed costs that increase in a stepwise fashion with increased volume), their precise impact is beyond the scope of this article. Although such costs may play a role in total OR costs and can change with differences in case mix, volume, and procedure, purely fixed costs represent the largest contribution to true OR costs and expense budgets. (Fixed costs are those costs that are roughly independent of the quantity of units produced or the volume of services provided [eg, staffing, utilities, the cost of nondisposable equipment, and rent]. Variable costs, by definition, vary with the volume of product produced or service provided [eg, raw materials and disposable items such as sutures and trocars]. Direct costs are those costs that are unambiguously associated with a specific cost center [eg, OR instruments and anesthesia machines]. Conversely, indirect costs are those costs that apply to more than one cost center and, thus, must be distributed among all the cost centers that use them—frequently, these costs are referred to as overhead [eg, laundry and dietary costs].)

While we recognize that inefficient OR schedules and excessive overtime costs (defined as a semivariable cost) represent potential financial burdens for hospitals, these extra costs are usually a small percentage of total OR costs. An example of a "typical" OR system and cost analysis is as follows: a typical academic OR has 24 rooms in which 15 000 procedures are performed per year, the total OR costs are approximately $54 million per year (80% are direct and 20% are indirect costs), the OR staff costs $19 million per year (35% of the total), overtime costs $1 million per year (a semivariable cost), an OR staff reduction (a semifixed cost) resulting from improved OR efficiency is extremely unlikely, and eliminating overtime entirely would only save approximately 1.7% of the total OR costs. Moreover, if surgical residencies were to vanish from academic hospitals tomorrow, it is unlikely such hospitals would realize a significant financial gain from OR expense reductions. The only 2 possible exceptions to this statement would be if the hospital could drastically reduce OR staff or dramatically increase surgical volume as a result.

Rather than focusing on accounting idiosyncrasies, we believe the more pertinent question (particularly to surgeons) may be the following: Does the increased operative time represent a cost for the attending surgeon? We believe the answer is yes, and is best understood in terms of opportunity costs. Opportunity cost is defined as the cost used to quantify the value difference between investing in one product or activity vs another. For example, if a company has only $1 million to invest and does so in a company that returns $1.5 million but passed on an opportunity to invest in a company that returned $2.0 million, the opportunity cost would be $500 000. Similarly, any increased time that a surgeon spends in the OR represents an opportunity cost in time that the surgeon is not investing in other activities (research, writing, didactic teaching, and seeing patients). While we would never suggest that taking extra time in the OR to train residents is wasted time (in fact, it is the raison d'être for most academic surgeons—including ourselves), it does represent an opportunity cost for the attending surgeon. In fact, if an average academic general surgeon performs 100 hernia operations and 100 laparoscopic cholecystectomies per year (a conservative estimate in some practices), there would be an average opportunity cost of nearly 50 hours per year! Such a cost, however, must be balanced against the time savings that residents generate by unloading many of the preoperative and postoperative patient care tasks that would otherwise fall to the attending staff. This point has been brought into sharp focus by the recent implementation of the 80-hour workweek rule.

In the present study, 2 attending surgeons were often involved in the same operative procedure. Freeing up one surgeon through the use of a resident obviously mitigates some of the opportunity costs of resident training. However, it is difficult to precisely quantify the value of substituting a resident for an attending surgeon because the assisting attending surgeon was usually only present for critical parts of the procedure. In addition, many institutions use nonsurgeons, such as a physician assistant, a certified registered nurse first assistant, or scrub technicians, to perform the role of assistant, and although nominal, surgeon first assistants are often paid an assistant fee. That said, however, we recognize that using 2 attending surgeons to perform common surgical procedures is not a good allocation of resources and must be considered when evaluating the true opportunity costs of resident training.

While the addition of a PGY 3 surgical resident into a community hospital certainly adds value to patient care and residency training, the resulting increase in operative times has a significant impact on attending surgeons. The impact is likely even greater in academic centers in which resident involvement is standard. This impact, although present in residency training for decades, has taken on new significance in an era of declining reimbursement and increased pressure to do more with less. If we are to ensure adequate training for the next generation of surgeons, the opportunity cost for the attending surgeon—accurately quantified in this study—

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must be recognized as a tangible cost of surgical education. That cost primarily impacts the attending surgeon and does not represent a significant financial burden to the hospital.

To our knowledge, this is the first study demonstrating and quantifying the increased operative time required to train surgical residents of a particular level on specific procedures and the associated opportunity costs for surgeons. Although we reviewed only 4 types of procedures performed on a relatively small number of patients, to our knowledge, this is the first study to minimize the inherent variability of studying different types of procedures performed by numerous surgeons with residents of differing levels. We recognize, however, that each academic surgeon teaches at his or her own pace, individual residents learn at their own pace, and, therefore, our specific time differences may not be applicable to other academic settings.

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DISCUSSION

Richard J. Barth, Jr, MD, Lebanon, NH: I was wondering how many total residents were working with the 4 attendings during that 9-month study period. As you know, there is some variability between the operative times of residents. I'm sure that when you and I were trained, we didn't slow anyone down, although Drs Cady and Stone might beg to differ. So, I was wondering how many residents were in your study? The second question is, did you look at complication rates for these surgeries? Was there any increase or decrease in the complication rates with the resident involvement?

Dr Babineau: Those are 3 excellent questions. One of the confounding variables of the other published data is that there are multiple-level residents assisting multiple different attendings during multiple different procedures, so we tried to keep it as simple as possible and focus on one PGY 3 resident. Now granted, a PGY 3 resident in July is different than a PGY 3 resident in March. Our PGY 3 residents enter their third year having done 375 cases on average. They have extensive experience in hernia surgery, which is perhaps why the time difference was less. They have moderate experience with laparoscopic cholecystectomy and very minimal experience with carotid surgery and colectomy surgery. That is perhaps why we see the greater time differences. It would be hard to control for the time period of the year.

Regarding the second question, we did not look at complications per se. I chair the department at Quincy and run the monthly M & M [morbidity and mortality] meetings. Anecdotally, there was not any difference. Dr Gibbons, one of the authors on the paper, is looking at that precise question in terms of the carotid data.

Clement Hiebert, MD, Portland, Me: You've looked only at one gross cost to the surgeon, that is, the operating time. What about the time saved from other duties that the surgeon performs by service provided by that resident, such as taking care of patients in the hospital? Would it be a fair analysis to look at the overall net cost of taking care of that surgical patient?

Dr Babineau: Those are excellent questions. We realize that surgical resident training is more than just time in the operating room and that residents obviously play a vital role in the care of our patients and do free us up by attending to our patients while we are engaged in different activities. For the purposes of this study, however, we focused very strictly on the time spent in the operating room. There are other data, however, that suggest when seeing patients in the office or conducting rounds with residents, there is a time cost associated with having residents involved in that activity.

Peter J. Deckers, MD, Hartford, Conn: As someone who has more than a little interest in how an academic health center is managed and what is done with the IME [indirect medical expense] dollars, I can't resist giving you the opportunity to expand on what you would do with that money.

Dr Babineau: I don't know what it's like at your academic medical center but I have always found it very hard to exactly trace the path which the IME money travels through the system until it winds up in either the surgeon's pocket or the department. The formulae are extremely complex and institution specific. One thing we might think about is rather than having the IME money flow to the academic medical center, have it flow directly to the surgeon. In other words, have the surgeon bill the federal government for the additional time. Why not be able to bill a first assistant's fee for the time that you took training that resident and have the IME money come directly to the surgeon as opposed to filtering through the academic medical center and having it pared down along the way? That's one idea. A long shot, I realize, and not likely to happen in my lifetime.

Paul S. Russell, MD, Boston, Mass: Comments on 2 issues. Your use of opportunity cost as really being the fundamental basis for your financial analysis is an interesting one, but you need to consider the issue of opportunity cost for the hospital as well. That would be whether or not—and this is something you could look at—there was a change in the distribution of cases from your scheduled cases vs add-ons; in other words, if the additional surgical case time resulted in fewer cases being able to be booked electively, and perhaps also having an impact on waiting times for elective cases to be scheduled for surgery. That would be something to look at.

Second, your concept, and I guess I am echoing Dr Deckers' earlier statement, of redirecting the IME to surgeons is an interesting one, but one not likely to go very far in your institution. The IME formula for institutional reimbursement of graduate medical education costs by Medicare really doesn't have much relationship to the volume of surgical activity. The allocation of graduate medical education costs and the development of the method are by which institutional GME [graduate medical education] costs were put into the DME [direct medical expense] category vs the IME goes back to the 1980s, and so most institutions see IME as being a surrogate measure and

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recognition of the increased complexity of patients in a teaching hospital. Probably most importantly, I suspect you would have very great difficulty in getting the institutional IME reimbursement so segmented that those dollars would go to you as a teaching surgeon, but it is an interesting concept.

Dr Babineau: Thank you for those comments. They are well taken, and clearly my suggestion is an overly simplistic one but I think there does need to be some better correlation between the time that surgeons spend training residents and how they are compensated for that time.

Walter B. Goldfarb, MD, Portland: You didn't mention anesthesia costs, and I think that they are time related and so money saved on one side may be money paid on the other side.

Dr Babineau: Yes, I will admit that I am not an expert on anesthesia billing but I know that part of the formula is time driven. In addition, it is also based on the complexity and the DRG [diagnosis related group] of the case. Clearly there may be a marginal cost there; you are correct.

Robert Udelsman, MD, New Haven, Conn: Cost analysis is complicated, and you discussed the important issue of opportunity cost. At the onset of your study, 2 attending surgeons were working together, one assisting the other. In the latter part of your investigation, at least in some cases, the second attending was freed up and could, therefore, perform another case in another room. This must be considered in your calculation of opportunity cost.

Dr Babineau: That's an excellent point. When the surgeon assisted the other surgeon, they usually came in only for the "critical" middle hour, if you will. In addition, they were able to bill a first assistant's fee, which, on average, was about $380. If a surgeon's time is worth approximately $380 an hour, then it's probably a wash. Clearly having 2 academic surgeons doing a laparoscopic cholecystectomy is not a good use of resources. I wouldn't argue with that, but there is some compensation when you're first assisting your colleague and able to collect a first assistant's fee.

Surgical Anatomy

The hypoglossal nerve runs forwards between the submandibular gland and the hypoglossus well below the lingual nerve. As it crosses the hypoglossus, fibers radiate to supply the extrinsic muscles of the tongue; at the anterior border of the hypoglossus, it plunges into the tongue to supply the intrinsic muscles.

Source: Boileau Grant JC. *A Method of Anatomy: Descriptive and Deductive.* 5th ed. Baltimore, Md: Williams & Wilkins Co; 1952:754.

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