Resident Teaching Versus the Operating Room Schedule: An Independent Observer-Based Study of 1558 Cases

Elizabeth A. Davis, RDCS*

Alejandro Escobar, MD*

Jan Ehrenwerth, MD*

Gail A. Watrous, RN*

Gene S. Fisch, PhD†

Zeev N. Kain, MD, MBA*

Paul G. Barash, MD*

Efforts to improve operating room efficiency may threaten clinician training. Therefore, we designed a prospective, observational study to determine the actual time spent teaching anesthesiology residents during the interval from patient-on-table to skin incision and to determine whether anesthesia teaching in the peri-induction period increases the time to surgical incision. This study was conducted in an inpatient operating room suite of a tertiary academic medical center. Of 1558 cases examined, 75% had an element of teaching (mean percent teaching per case = 46.4). A 33% decrease in teaching occurs when the attending anesthesiologist concurrently directed care in 2 rooms ($P < 0.001$). The percent teaching significantly increased as a function of ASA physical status classification and time of day of surgical case ($P = 0.001$). Teaching accounted for a mean increase of time to incision of 4.5 ± 3.2 min, but represented only 3% of the mean surgical case length (207 ± 132 min). We conclude that teaching occurs in the majority of cases in the operating room and although it contributes to increased time to incision, this increase is insignificant compared with the time required to complete the surgical procedure.

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Education, a core mission of academic medical centers, increases costs of providing patient care (1–3). Indeed, the difference in operating costs between teaching and nonteaching hospitals has been recognized by the Medicare program, which compensates teaching hospitals with special Medicare Indirect Medical Education Payments. The Medicare legislation states that "the adjustment for indirect medical education costs is only a proxy to account for a number of factors which may legitimately increase costs in teaching hospitals" (4–6). Boex et al. (7) have evaluated the "indirect cost" of education in teaching versus nonteaching ambulatory care centers and concluded that education increased operating costs by 24% to 36%. Similarly, Bridges and Diamond (8) found that the added cost of training a single surgical resident is $47,970 as a result of increased operative times. Only recently have the costs of perioperative teaching been explored in the discipline of anesthesiology (9–10). Using data collected by caregivers, Eappen et al. (10) reported that teaching is associated with a statistically significant increase in the times required for induction and emergence from anesthesia. The authors concluded, however, that these differences were not clinically or economically meaningful.

As one of the most expensive areas in the health care delivery system, the operating room (OR) is currently a focus of intense programs to improve efficiency (11). One concern is that these external pressures to improve OR efficiency and increase the profit margin will result in less than adequate training for future clinicians (12). This was highlighted in a study in which Blumenthal et al. (13) reported on the preparedness of graduating anesthesia residents to perform as an anesthesia attending. In the areas of preoperative assessment and postoperative management, 95% and 100% of respondents, respectively, self-reported as being very prepared. In contrast, scores for intraoperative care, such as performance of regional blocks (45%), provision of cardiac anesthesia (60%), and anesthesia for complex illness (87%), were less robust. The fragile state of resident education was highlighted by the results of a recent survey (14) of leaders in academic medicine. Although teaching is a core mission of academic medical centers, these leaders ranked education of residents and fellows 15th on a list of priorities of academic medical centers (34% of mentions). The reimbursement policy of commercial insurers was ranked as the first concern of these academic leaders (100% of mentions).

From the *Department of Anesthesiology, †General Clinical Research Center, Yale University School of Medicine and Yale-New Haven Hospital, New Haven, Connecticut.

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Address correspondence and reprint requests to Paul G. Barash, MD, Department of Anesthesiology, Yale University School of Medicine, 333 Cedar Street, PO Box 208051, New Haven, CT 06520-8051. Address e-mail to paul.barash@yale.edu.

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The time devoted to clinical teaching of anesthesiology residents and the relationship between teaching time and surgical case length has never been examined using direct, observational, prospective techniques. Therefore, we undertook an independent observer-based prospective study to determine: 1) the actual time spent teaching anesthesiology residents during the interval from patient on the operating room table until skin incision and 2) whether anesthesia teaching in the peri-induction period increased the time to surgical incision.

METHODS

After review by the Human Investigation Committee, an exemption of informed consent was granted. All guidelines for confidentiality were followed. This observer-based prospective study was performed in the South Pavilion ORs at Yale New Haven Hospital from September 24, 2001 to July 22, 2002. This facility includes 19 ORs and 2 cystoscopy suites. Although a few outpatient procedures are performed in this location, it is predominantly an adult inpatient OR. Inclusion criteria for this study included all patients ASA physical status (ASA PS) I through IV scheduled to undergo elective surgical procedures. Exclusion criteria included: emergency procedures, ASA PS V, and patients with an endotracheal tube or other artificial airway on arrival in the OR. Data regarding the anesthesiologists who were part of this study were not collected. For this study, the composition of the anesthesia care team was one of the following configurations: faculty concurrently supervising two locations with a combination of residents and/or certified registered nurse anesthetists (CRNAs); faculty supervising one location (resident or CRNA); or faculty as caregiver.

All data were recorded on a standardized form by trained observers who were not involved in patient care. These observers were instructed by two of the authors (AE, ED) using a formal syllabus and a 2-wk training period in the OR. After the 2-wk period, the observers completed several practice data collection sessions. These practice data were compared with those simultaneously collected by one of the authors (AE or ED). After this, two observers were assigned to the same OR case and interobserver agreement was examined. The observers were allowed to collect data independently only when their results, during the training period, were within 1 min of the Anesthesia Release Time (ART) and the Surgical Preparation Time (SPT) as compared to the trainers and to each other (2.5% interobserver error) In addition, interobserver study variability for the teaching component (5-min units) was 4%. To prevent bias, all observers were rotated through each of the 21 ORs with assignment sequence based on the use of a random number generator. This ensured that all observers sampled all ORs and were randomly exposed to all combinations of cases and anesthesia and surgical teams. The observers were in place for each study before the patient entering the OR and left the OR after skin incision. They stationed themselves in the OR so as not to be obtrusive and yet close enough to be able to observe and hear all the OR events. A pilot study was used (n = 125) to determine if any logistical or data recording methods required revision. No pilot data were used in the compilation and analysis of the study data.

Definitions of clinical practice in this study were based on the standardized definitions of the Association of Anesthesia Clinical Directors (15). The study period is defined as the period when the patient was placed on the OR table until the skin incision was made or a procedure was started by the surgeon. This time period is subdivided into two phases: ART and SPT. ART is defined as the time at which a sufficient level of anesthesia is established so that surgical preparation can begin and at which remaining anesthesia tasks do not preclude positioning and surgical preparation. Where possible, objective end-points of ART were used as a marker of completion of this phase (e.g., endotracheal intubation, placement of the pulmonary artery catheter). SPT is defined as the time from the end ART to skin incision or at which a painful stimulus occurred, such as introduction of a cystoscope. ART and incision time were measured by use of a stopwatch and are reported in minutes, with start time (on table time) being defined as time zero. Specific time-related details of the study period, such as induction and tracheal intubation time, times for placement of regional anesthetics and invasive hemodynamic monitors, and teaching were recorded on the data sheet in units (1 U = 5-min time interval). As part of the study, after induction of anesthesia was completed, the attending anesthesiologists were asked to rate the difficulty of the induction for the case on a scale of 1–5 scale (1 = not difficult, 3 = average difficulty, 5 = very difficult).

Teaching for this study was defined as any conversation or guided demonstration between members of the anesthesia care team that transfers or imparts knowledge. Teaching intervals were obtained for the entire study period. Each unit (5-min time period) was scored "1" when 50% or more of the total unit was spent teaching and "0" if <50% or no teaching occurred.

The sample size met standards for simple random sampling as recommended by the Joint Commission on Accreditation of Healthcare Organizations (16). Data were read by an optical scanner and stored in Microsoft Access 2000. Two investigators reviewed all data sequentially and inquiries regarding errors or outliers were resolved on a weekly basis. Data were analyzed using SAS statistical software (version 8.12; Cary, NC). Except where noted, data are expressed as mean ± SD. Descriptive statistics including Pearson correlation coefficients were initially used to examine data. Multivariate and linear regression analyses were

Table 1. Summary of Demographics of Teaching Cases*

	Number of cases	Total units	Total teaching units	Teaching units/case	*P* value
Anesthetic technique					
General anesthesia	991	11,004	5222	5.3 ± 4.0	0.22
Regional anesthesia	98	1027	474	4.8 ± 3.1	
ASA physical status					
ASA PS I	98	779	334	3.4 ± 2.3	0.001
ASA PS IV	294	4535	2340	8.0 ± 4.7	
Time of day					
First case of day	437	6006	3021	6.9 ± 4.6	0.006
All other cases	652	6011	2671	4.1 ± 2.9	
Attending coverage					
Coverage ratio is 1:1	756	8870	4388	5.8 ± 4.2	0.001
Coverage ratio higher than 1:1	333	3147	1304	3.9 ± 2.7	

ASA PS = American Society of Anesthesiologists physical status classification (1 unit = 5 min).

* Monitored Anesthesia Care (MAC) excluded.

performed based on correlation coefficients obtained. For linear analysis, the teaching units (5-min intervals) were converted to percent teaching (%teaching = number teaching units to incision/total case units). Analysis of variance for difference between teaching and nonteaching cases was performed. Analysis of variance (Tukey's HSD test) evaluated differences within groups. A level of $P < 0.05$ was considered significant.

RESULTS

A total of 1559 patients were enrolled in the study. One patient having a difficult intubation and an ART (206 min) more than 12 SD above the mean was considered an extreme outlier and was thus excluded from data analysis. Thus, data from 1558 surgical cases were observed and encompassed a total of 15,506 total time units (unit = 5 min) or 1292 h of observation. The mean age of patients was 57.4 ± 17.2 yr (range, 16–92 yr). The overall distribution of ASA PS was as follows: I (9%), II (36%), III (31%), and IV (24%). The distribution of ASA PS IV cases by year of training was CA1 = 14%, CA2 = 37%, and CA3 = 42% ($P < 0.001$).

Seventy-five percent of all cases had an element of teaching, with a mean percentage of teaching per case of 46.4% (range, 5%–96%). The percentage of teaching significantly increased as a function of ASA PS classification and time of day of surgical case ($P = 0.001$) (Table 1). We also found a 33% decrease of time spent in teaching occurred when the attending anesthesiologist concurrently directed anesthetic care in 2 ORs (1:2 staffing). That is, anesthesia attending/resident staffing of 1:1 was associated with 5.8 ± 4.2 U teaching, whereas anesthesia attending/resident staffing of 1:2 was associated with 3.9 ± 2.7 U teaching ($P < 0.006$). The attending anesthesiologist was present 76% ± 19% of the study period when covering 1:1 ratio and 62% ± 24% when covering 2 rooms ($P < 0.001$).

During the study period, 53% of teaching occurred before the anesthesiologist turned the patient over to the surgical team (mean, 3.0 U), as compared with that conducted during SPT (2.7 U). Of interest, resident year of training was not associated with a significant difference in percentage of teaching ($P = 0.23$).

Effects of teaching on variables such as time to endotracheal intubation and time to surgical incision were evaluated by comparison of teaching cases ($n = 1167/1558$) to nonteaching cases ($n = 391/1558$). To make such a comparison valid, we wanted to ensure that the population of surgical cases in each of these groups was similar. Indeed, variables such as age, gender, and ASA PS and case lengths were similar between the teaching and nonteaching groups. To further assure the teaching to nonteaching group equality, Diagnosis-Related Group weights were cross-matched to hospital records ($n = 1249$ data available). No significant differences in variance were found in Diagnosis-Related Group weight between the teaching and nonteaching groups (2.7 versus 2.4; $P = 0.78$). Therefore we documented a similar diversity and complexity of cases in each group. After assuring comparability between groups, we found that the time to surgical incision was 32% longer in the teaching compared with the nonteaching group (45.4 ± 22.7 min versus 32.1 ± 18.7 min; $P < 0.001$). For cases in which a general anesthetic was administered and an endotracheal tube placed, the time units to incision were significantly higher in the teaching group as compared with the nonteaching cases (10.7 ± 3.6 versus 7.7 ± 4.8, $P = 0.001$) (Table 2). Concomitantly, time units required from induction to endotracheal intubation differed significantly ($P = <0.001$). Time units required for placement of invasive monitors (arterial catheter, central venous pressure, and pulmonary artery catheters) showed no significant difference between the teaching and nonteaching groups ($P = 0.5$).

Linear regression of percentage of teaching on the time to incision [DF(1,1556)]F = 81.14, adjusted $R^2 = 0.05$ showed that teaching had only a small effect on overall time to incision. However, a significant positive linear relationship ($P < 0.001$) was demonstrated with a parameter estimate of 0.18. That is, each increase in percentage of teaching contributed an increase in time to

Table 2. Time Required for Teaching Versus Nonteaching Cases

	Teaching group		Nonteaching group		
	N	Mean units	N	Mean units	*P* value
General anesthesia*	688	10.7 ± 3.6	186	7.7 ± 4.8	<0.001
Endotracheal intubation†	688	2.6 ± 1.4	186	2.1 ± 0.8	<0.001
Insertion arterial	434	2.6 ± 1.7	63	2.5 ± 1.3	0.7
Insertion CVP/PAC	336	3.8 ± 1.7	31	3.6 ± 1.2	0.5

1 unit = 5 min.

* Units to incision; † time to endotracheal intubation (units).

CVP = central venous pressure catheter; PAC = pulmonary artery catheter.

Table 3. Comparison of Case Difficulty and Mean Teaching Units/Case

Case difficulty	N	Teaching units/case
1	54	3.74 ± 3.19
2	489	4.34 ± 3.35
3	378	5.52 ± 3.79
4	177	6.07 ± 4.70
5	44	6.27 ± 4.65

Values are mean ± SD. 1 unit = 5 min. Scale: 1 = not difficult, 3 = average difficulty, 5 = very difficult.

Overall significance $P < 0.001$.

incision in minutes based on the calculation: added time to incision[min] = %teaching*[(ART + SPT)*0.18], when calculated anesthesiology resident teaching accounted for a mean increase of 4.5 ± 3.2 min (range, 1–20 min) in time to surgical incision.

Finally, after induction of anesthesia was completed, the attending anesthesiologists rated the difficulty of each induction. Analysis of variance revealed that resident teaching was increased in cases in which the anesthesiology attending rated the case as more difficult ($P < 0.001$) (Table 3).

DISCUSSION

This large-scale study found that anesthesia resident teaching was present in 75% of all surgical cases observed. Increased anesthesia teaching was primarily associated with increased case complexity and favorable attending staffing patterns (1:1). In fact, there was a decrease of 28% in anesthesia teaching when the attending anesthesiologist was assigned to cover more than one OR. There was no significant difference in the percentage of teaching by resident year. One factor in the data that accounts for this is the significant difference in ASA PS cases performed by resident year. The frequency of ASA PS IV cases for the CA1 year was 14% whereas for the CA3 group it was 42%. Although early residency is marked by intensive teaching, as the residency progresses increased case complexity provides a greater teaching opportunity and accounts for the lack of significant difference in teaching requirements by years of experience.

Anesthesia teaching increased the time to surgical incision by an average of 4.5 minutes. This finding, similar to previous reports in educational settings such as surgery and ambulatory care, also demonstrates that intraoperative anesthesia teaching does increase the time required for a physician encounter. One should note, however, that this increase in time to surgical incision represents only 3% of the total mean surgical case duration of 206.7 minutes. Although beyond the scope of the present investigation, others have shown a significant increase in the time required to complete an operation when surgical resident teaching occurs concomitantly. For example, Babineau et al. (17) reported a 21%–52% (8–60 minutes) increase in operative time in a surgical training program. A similar increase (59%) in surgical time was found in a training program based in Europe (18).

Over the past decade the financial environment in teaching hospitals and medical schools has changed significantly (19–20). Although costs for new technology, drugs, and personnel increased significantly, the passing of the federal Balanced Budget Act in 1997 resulted in the removal of millions of dollars in financial support for resident training (21). As a result of this changing environment, individual departments are now expected to demonstrate better financial performance, resulting in the current increased emphasis on clinical productivity (22). Similarly, in academic anesthesiology departments, the measurement of both individual and departmental productivity is currently a major issue that results in pressure to decrease overall faculty staffing (23–25). As a result, there is currently an increased demand for anesthesiology faculty to supervise more than one OR at any given time point. Data from our study suggest that this trend leads to a significant decrease in resident teaching. However, we only evaluated preincision teaching. Teaching occurs in a continuum during the perioperative period. Thus, a significant amount of teaching may have already occurred before the patient entered the OR and was placed on the OR table. In addition, a faculty–resident educational interaction may have also occurred at other points in the case (e.g., during maintenance and/or emergence from anesthesia). Further, as performance-based compensation is now encouraged in medical schools to improve faculty productivity, anesthesiologists are under pressure to develop individual incentive plans (23–25). That is, anesthesiology faculty may have a strong incentive to supervise two ORs at the same time to produce more clinical revenue. Conversely, if part of the incentive plan is based on resident evaluation of faculty teaching, attending anesthesiologists who supervise two residents simultaneously may receive lower teaching scores on the basis of a decreased teaching opportunity that may result in reduced compensation.

The finding that the average increase of 4.5 minutes in time to surgical incision attributable to teaching represents <3% of total case duration is not surprising. Previous research has demonstrated that anesthesia controlled time represents only 8%–10% of the entire duration of the surgical case (11). Thus, the impact of anesthesia resident teaching of 4.5 minutes should not be considered as clinically or logistically significant. Certainly, based on previous work done by Dexter et al. (26), the financial impact of anesthesia controlled time secondary to teaching is minimal. Estimation of perioperative costs is a complex process and beyond the extent of this current study (8,17,18,27). One should consider, however, various options and strategies to enhance anesthesiology resident teaching out of the OR. One such example is the rapidly evolving simulation technology. That is, teaching residents skills such as endotracheal intubation and arterial catheter placement may be more effective and less time consuming using simulation technology than using the OR environment (28). A combination of simulation technology such as video technology coupled with teaching in the OR may be ideal (29–31).

Several procedural issues related to the method of observation may have affected data collection. This is the first large-scale study using objective independent observed-based methodology. At the onset of the study, four techniques of observation were considered: self-reporting by the OR personnel, data from an OR information system, video recordings in each OR, and use of trained independent observers. Numerous studies have reported the biases and disadvantages of both self-reporting mechanisms and the use of information systems (11,32,33). Videotaping might be deemed too intrusive in an OR environment and may be less accurate when compared with an independent observer-based system (34). Our stringent use of a standard curriculum, practice observation sessions and interobserver comparisons helped to assure excellent validity of the data collected (35). The use of a random number generator for assignment of observers to a given OR ensured equal rotation of all observers through all ORs and prevented any bias in case selection by investigators or observers.

A limitation of the current study is the potential for a Hawthorne effect on the OR personnel. Though plausible, the length of this study (10 months) as well as the internal consistency of the collected data on attending presence does not support this notion. Also, one could criticize the definition of the term "teaching" as used in this study. Indeed, the use of a more specific definition of teaching may have resulted in a decrease of the percent teaching observed. However, given the observation technique used, the definition of teaching as used resulted in the collection of highly reproducible data. Finally, because this study evaluated only teaching that occurs in the preincision period in a single institution, no conclusions may be drawn regarding the role of the attending anesthesiologist in clinical care and teaching during other points in the perioperative period.

In conclusion, we examined teaching practices in an inpatient OR suite at an academic medical center. We found that anesthesia resident teaching was present in 75% of all the cases observed and that increased teaching was primarily associated with increased case complexity and favorable attending converge. Also, we found that anesthesia teaching increased the mean time to surgical incision by only 4.5 minutes per case. Although our results indicate that teaching occurred in the majority of cases, the issue of decreased teaching when attending anesthesiologists were directing care in more than one OR is very worrisome, as this coverage ratio will become more prevalent in the future. In an environment of cost-containment and need for increasing efficiency in ORs, data from this investigation suggest the need for innovative teaching techniques coupled with computer simulation to supplement anesthesia resident teaching in the future.

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