The anesthetic record: accuracy and completeness

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Purpose: To evaluate if anesthesia training and experience influenced chart completion and accuracy.

Methods: One hundred and twenty-four subjects, including medical students, anesthesia residents and community and university based clinical anesthesiologists, were given a standardized patient in a simulator environment and asked to conduct induction and maintenance of anaesthesia. Three critical events were introduced resulting in changes in BP, HR, $P_{ET}CO_2$ and SpO_2. Subjects were instructed to manage the patient and the anesthetic chart, as was their customary practice. Discrepancy, calculated as the difference between the actual and charted values divided by the actual physiological value was compared by level of training with a two-way repeated measures analysis of variance (ANOVA) for all four physiological variables. The completeness of charting, defined as at least one data point recorded for each of the four physiological variables of the three critical events, was compared across level of training, age of participants and number of years in practice.

Results: The overall completeness of charting remained low (<37%) with no relationship based on the anesthesiologist's age, level of training or number of years in practice. There was discrepancy in charting for all physiological variables (HR, BP, $P_{ET}CO_2$ and SpO_2, $P < 0.0001$), with a marked difference in the degree of discrepancy within each level of training. Training resulted in no differences in charting discrepancy.

Conclusion: Charting of data to the anesthetic record remained incomplete and inaccurate in all groups based on level of training, age and number of years in practice.

Objectif : Évaluer si la formation en anesthésie et l'expérience influencent la tenue de dossier et son exactitude.

Méthode : Cent vingt-quatre sujets, y compris des étudiants en médecine, des résidents en anesthésie et des anesthésiologistes de pratique privée ou universitaire ont reçu le modèle d'un patient dans un environnement simulé et on leur a demandé de procéder à l'induction et à l'entretien de l'anesthésie. On a introduit trois incidents critiques impliquant des changements de TA, FC, $P_{ET}CO_2$ et SpO_2. On a demandé aux sujets de procéder à l'anesthésie et de remplir le dossier comme ils avaient l'habitude de le faire. La discordance, calculée à partir de la différence entre les valeurs réelles et celles du dossier divisée par la valeur physiologique véritable, était comparée sur la base du niveau de formation selon une analyse de variance (ANOVA pour valeurs répétées) pour les quatre variables physiologiques. Le dossier complet, défini par l'enregistrement d'au moins une donnée pour chacune des variables physiologiques des trois incidents critiques, était comparé selon le niveau de formation, l'âge des participants et le nombre d'années d'expérience.

Résultats : L'achèvement global du dossier a été faible (<37 %) et ne présentait pas de différences basées sur l'âge, la formation ou le nombre d'années de pratique. Il y avait des divergences d'inscription au dossier pour toutes les variables physiologiques (HR, BP, $P_{ET}CO_2$ et SpO_2, $P < 0,0001$), avec une nette différence dans le degré de divergence pour chaque niveau de formation. La formation n'a pas eu d'influence sur la discordance dans le dossier.

Conclusion : L'entrée des données au dossier anesthésique était incomplète et inexacte dans tous les groupes basés sur le niveau de formation, l'âge et le nombre d'années d'expérience.

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DURING an operation, the anesthesiologist simultaneously acts as a controller, decision maker, and data gatherer in addition to performing a number of technical procedures.[1,2] Through a combination of handwritten records, technical or electronic instrumentation and patient observation the anesthesiologist collects, analyses, and interprets the appropriate information required for managing the patient's intra-operative course. Time-motion studies have shown that anesthesiologists direct 12% of intra-operative time to the recording of cardiovascular and respiratory physiological variables, as well as all accompanying dynamic events on the anesthetic record.[3] Time spent on charting is time that is not spent on direct patient care. It is unclear whether improved capabilities of modern physiological monitors to store physiological patient data electronically has reduced the time spent on charting or improved accuracy of data collection and recording.

Although the anesthesiologist spends a considerable part of the intra-operative time reporting physiological variables and major events, upon review, the anesthetic record continues to show signs of omission, skewing and overall poor quality.[4–6] Common problems of poor record keeping include: (i) the omission of abnormal values; (ii) the smoothing or rounding of abnormal values to within the expected upper or lower physiologic limits; and (iii) the averaging of a number of measurements around an abnormal value, thereby reducing the precision of a single abnormal value.[5,6] Advances in anesthetic procedures and the use of more complicated automated devices will continue to place a greater demand on the anesthesiologist's time in the operating room. These time-consuming tasks may necessitate a decrease in the time available for charting, and an increase in the time between the actual event and its recording.

Anesthesia patient simulators recreate a variety of clinical and physiological conditions in a standardized and consistent manner.[7] When a simulator is placed in a mock environment, realistic operating room conditions can be imitated and physiological measurements can be recorded. The anesthesia simulator environment would thus appear to be an ideal tool for studying the anesthetic record as standardized and repeatable conditions can be presented to each subject. The purpose of the study was to use the patient simulator to evaluate the recording and charting of anesthesia-related intra-operative events and to determine whether anesthesia training and experience were associated with improved charting accuracy.

Methods

After institutional research ethics board approval, written, informed consent was obtained from all participants. Subjects for this study consisted of medical students, anesthesia residents and clinical anesthesiologists from community and university based practice. Medical students were in their final year and participated in the study during the second week of a two-week anesthesia clerkship. Residents were in their final six months of training and eligible to sit the national specialty examination. University and community anesthesiologists were drawn from local institutions.

All subjects were asked to participate in a study that evaluated the simulator as a testing tool. Subjects were aware that simulated problems would be presented to them, as part of the testing procedure, but the nature of the problem was not known in advance. Participants were given a standardized patient in the simulator environment and asked to conduct the induction and maintenance phases of an anesthetic in which standardized problems were presented. All were given a blank anesthetic record (Figure 1) and were instructed to manage the patient and deal with the chart, as was their customary practice. The physiological monitor had a trend function that the participants could use if they wished. Subjects were blinded with respect to the charting component of the study.

Our Simulation Centre consists of a mock operating room containing an anesthesia gas machine, patient physiological monitors, anesthesia drug cart, operating table, instrument table, and electrocautery machine. Drapes, intravenous infusions, and surgical instruments were used to enhance the realism of the simulation. The patient mannequin (Eagle Simulation Inc.) was positioned on the operating table, and the role of the members of the operating room team, such as the surgeon and circulating nurse, were scripted and acted by the investigators. The actors playing the role of the surgeon and circulating nurse were instructed to provide the appropriate responses during the case simulation by means of a radio frequency communications system in order to maintain standardization of the scenarios. The details of our simulation centre have been described elsewhere.[7] During each simulation, all physiological variables were continuously monitored with wave-form and digital displays on the physiological monitor (Datex). These included ECG, BP by arterial catheter, $P_{ET}CO_2$ and SpO_2. The video output of the physiological monitor was processed with a digital to analogue converter. The video signal of the physiological monitor was recorded to video tape simultaneously with the anesthesia work space camera for later review and study as required.

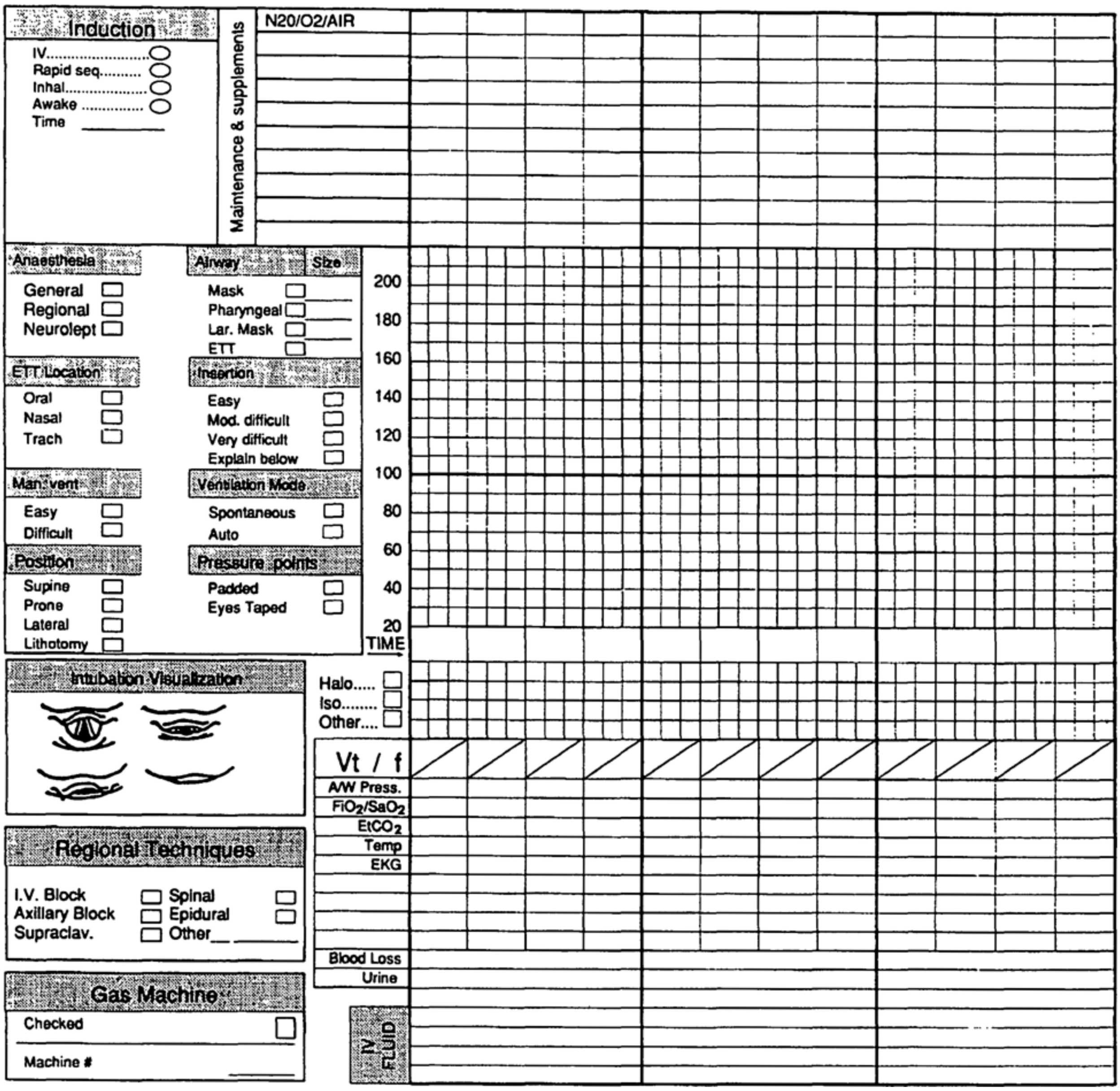

FIGURE 1 A blank sample anesthesia record with charting grid given to all subjects.

During the simulated anesthetic, three critical events took place. Each event was five minutes in duration, and all events were spaced a minimum of ten minutes apart, thus allowing for both the stabilization of the computer models and time for charting. The three critical events included hypercapnia from rebreathing due to a gas machine fault, moderate hypotension with a compensatory tachycardia due to mesenteric traction, and severe oxygen desaturation brought on by a pneumothorax. Four physiological values (HR, BP, $P_{ET}CO_2$, SpO_2) corresponding to the time of their respective critical events were evaluated for this study.

At the end of the simulated scenario, the anesthesia chart was collected from each participant. For the comparisons we used the value on the physiological monitor and compared this value with what the participants had charted. The most abnormal value displayed on the simulation centre physiological monitor for each of the

TABLE I Distribution of participants based on level of training

Group	*Number*	*Mean Age (± SD)*	*Years in Practice (± SD)*
University A	31	39.4 ± 7.0	7.7 ± 6.6
Community A	38	46.2 ± 10.0	15.5 ± 10.8
Resident	22	31.2 ± 3.9	N/A
Clerk	33	26.6 ± 3.2	N/A

P=NS

TABLE II Completeness of charting and use of trend function by level of training

Group	*Completeness of Charting (%)*	*Use of trend Function (%)*
University A	36.4	61.3
Community A	18.2	39.5
Resident	18.2	59.1
Clerk	24.2	42.4

P=NS

TABLE III Percent completeness and discrepancy of charting for trend function *vs* non-trend function user

Trend Function	*% Complete*	*% Discrepancy : BPs*	*HR*	*$P_{ET}CO_2$*	*SpO_2*
User	16.0	23.7	16.2	40.0	19.6
Non-User	15.9	26.9	17.6	39.5	25.1

P=NS

four variables during each of the three events was designated the "actual value". The participant's charted value was designated as the value that the participant had recorded during the critical event. Values for BP and HR were determined from the participants' charted symbols and rounded to the nearest five units, or from any charted notes concerning the specific event if detailed physiological information was recorded. The $P_{ET}CO_2$ and SpO_2 values were determined from the chart corresponding to the time of the event.

Analysis

We defined complete charting as at least one data point recorded for each of the four physiological variables of the three critical events. If a data point was not charted for any one of the four physiological values corresponding to their respective simulated critical event, then overall charting was considered incomplete.

Actual values from the physiological monitors were then compared with charted values for all four physiological variables and the discrepancy (accuracy) was calculated as the difference between the actual and charted value divided by the actual physiologic value.

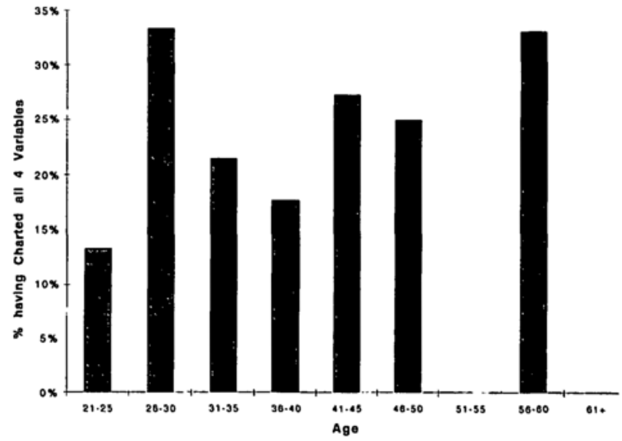

FIGURE 2 Completeness of Charting Based on Age (n=124). Frequency of complete charting by age. A chart was complete if the anesthesiologist had recorded each of the four physiological parameters corresponding to its respective scenario in the simulation.

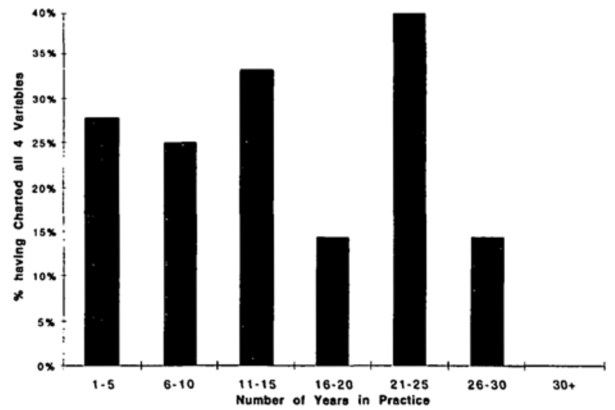

FIGURE 3 Completeness of Charting Based on Number of Years in Practice (n=69). Frequency of complete charting by number of years in practice. A chart was complete if the anesthesiologist had recorded each of the four physiological parameters corresponding to its respective scenario in the simulation.

Familiarity with the physiological monitor might be a factor in charting in that stored data would be available to those who knew how to access it. We compared the completeness of charting and the discrepancy between those subjects who accessed the electronic data storage (trend function) in the physiological monitor and those who did not to determine if accessing stored data resulted in less discrepancy or a more complete chart.

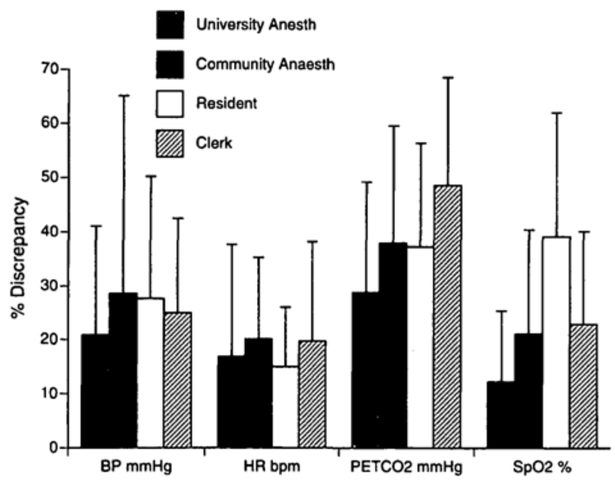

FIGURE 4 Percent Discrepancy by Level of Training. Mean per cent discrepancy with standard deviation for each of the four parameters by level of anesthetic training and practice where University Anesth, Community Anesth, Resident and Clerk represent university based anesthesiologists, community anesthesiologists, anesthesia residents and medical students respectively.

Level of training was divided into four groups: final year medical students (Clerk), final year residents (Resident), and clinical anesthesiologists from university (University A) and community (Community A) based practice. Age was sub-divided into eight groups based on five year increments, ranging from 21-60 yr of age plus an additional group for >61 yr. Number of years in practice was sub-divided into six five-year groups, ranging between 1-30 yr in practice. Two additional groups were also included for 0 and >30 yr in practice.

The completeness of charting was compared across level of training, age of the participant and number of years in practice with a one-way analysis of variance (ANOVA). The discrepancy of actual physiological values compared with charted values was compared by level of training with a two-way repeated measures ANOVA.

We examined the completeness of charting and discrepancies on the four physiological variables with the use of the trend function using a t test and the effect of using the trend function was compared across level of training with a one-way ANOVA. Since there were many statistical tests applied to the data, and we used conservative principles of multiple testing, $P < 0.01$ was considered to be statistically significant.

Results

One hundred and twenty-four subjects participated in the study. As expected, community anesthesiologists were older and had been in practice longer than university anesthesiologists; residents were about four years older than medical students (table I). All 124 participants' charts were readable so that no data were lost due to illegibility of charting.

Overall and according to the level of training, the completeness of charting was low (Table II). While university-based anesthesiologists and medical students showed the highest proportion of complete charting, there was no relationship in charting completeness based on level of training (P=NS). The proportion of participants using the monitor trend function varied across the four groups but the differences seen were not statistically significant.

When examined by age of participants, no relationship was found between age and proportion of complete charting (Figure 2). Figure 3 represents the frequency of chart completion as a function of years in practice for community and university based anesthesiologists. Again there was no relationship between chart completion and years in practice (P=NS).

The size of discrepancy between the monitor and charted values for each of the four physiological variables is reported by level of training (Figure 4). There was a discrepancy in charting for all physiological variables (HR, BP, $P_{ET}CO_2$ and SpO_2, $P < 0.0001$). For example, for $P_{ET}CO_2$, the values ranged from 30% for university anesthetists to 50% for clinical clerks. As well, there was a marked difference in the degree of discrepancy across the four physiological parameters within each level of training. For example, the mean discrepancy percentages for university anesthesiologists were 20%, 15%, 30% and 10% for BP, HR, $P_{ET}CO_2$ and SpO_2 respectively. Training resulted in no differences in charting discrepancy.

Sixty-one of the 124 participants (49%) used the trend function on the physiological monitor. No difference in level of discrepancy was found between those who used the trend function and those that did not for the four physiological variables (Table III). Similarly, there was no difference between trend function users and non-users in the proportion of participants whose charts were complete.

Discussion

In our study, completion and charting accuracy of the anesthetic record were low, regardless of the anesthesiologist's age, level of training or number of years in practice. All groups of anesthesiologists from medical students to university faculty failed to chart significantly abnormal hemodynamic parameters. Familiarity with the monitoring equipment did not seem to affect either accuracy or completeness of the charting.

Previously published studies on record keeping have focused on discrepancies in and level of completeness of anesthetic records during actual operating conditions, thus introducing variations due to type of operation.[5,8] In this study, using the Simulation Centre, and a mock operating room, the physiological variables and intra-operative course of the patient were controlled and standardized. Yet, even under these ideal conditions, the quality of charting was poor leading us to speculate that the quality of charting in usual clinical practice may be less than adequate.

Other studies confirm that there is room for improvement in anesthesiologists' practices of record keeping in the operating room. Edsall's review found a lack of quality and a skewing of physiological variables when handwritten anesthesia records were compared with automated anesthesia records.[4] Lerou *et al.* reported error fractions (based on missing and erroneous (>20% variance) handwritten *vs* automated data) of 0.19, 0.20 and 0.31 for systolic BP, HR and SpO_2 respectively.[9] Similarly, Cook *et al.* showed that in 46 handwritten *vs* electro- mechanical generated BP records, 9.4% of all automatic systolic BP readings were greater than the highest handwritten systolic BP record.[5]

The range of discrepancy for systolic BP and HR reported in this study is greater than the values reported by others.[5,8,9] We reported ranges of discrepancy for HR and systolic BP of 11.2% - 20.6% and 20.6% - 34.2% respectively. Differences in study methodology such as the use of a standardized patient and operative conditions may explain the discrepancies in the results of the two studies.

This study has several limitations that may have affected our findings. First, participants in this study were subjected to a sequence of major events which occurred in a short period of time and it is possible that they became overwhelmed and focused on the immediate tasks at hand.[10] Our clinical scenario may not have represented reality in that the complexity of patient management in our simulated case resulted in charting being relegated to a lower priority by the participants. The study findings would seem to support an argument that high demand operating room conditions resulted in a much greater discrepancy and lower completeness of charting.[5,9,10] A number of other studies have shown that when the patient care demand on the anesthesiologist increases (e.g. induction and emergence) the accuracy of charting decreases considerably.[3,9,10]

A second limitation may be that the number of adverse events may not have allowed sufficient time for charting. Although a number of physiological aberrations were presented to the participant, at least five minutes were allowed to elapse between each event to give the participants time to chart the data. Further, the participants had access to the electronic memory on the physiological monitor as a tool to review the actual physiological values and had the choice whether or not to use the monitor to help them complete the chart. However, use of the electronic memory did not appear to influence completeness or accuracy in our study.

There are several possible reasons to explain why anesthesia record keeping is poor. Record keeping may frequently be perceived as a secondary task, and is often completed after an event has occurred.[2,3,5] Since anesthesiologists are involved with direct patient care during induction, emergence and shifts in physiological stability, it is difficult for them to record events as they occur. Rather, some time after the event, the anesthetist will re-construct and chart the vital signs in support of what they perceived as having happened in the preceding events. If the record is completed after the event, external environmental factors, inattention and sleep deprivation may influence the final charting.[3] Lapses in short-term memory may lead to omission or erroneous reporting of the actual physiological variables.[3] This was illustrated in the study by Lerou *et al.* who reported error fractions four times larger for systolic BP, HR and SpO_2 during induction and at the end of the procedure than in the maintenance phase.[9]

Another reason may be due to artifacts that are common in the monitoring of physiological variables.[6,8,9] Since their presence is rare in the hand recorded anesthetic record, it is likely that it has become accepted practice for the anesthetist to adjust or eliminate these errors when charting physiological variables.[4,8,9] Kroll reported that in medico-legal confrontations a lawsuit is not lost because of an accurate and complete record, but through lack of full and concise documentation of all vital signs available.[8] Nevertheless, anesthesiologists' concern that charted artifacts may lead to accusations and possible liability may result in smoothing and omission of intra-operative physiologic data.[3,11] The anesthetic record is important not only in the anesthesiologist's evaluation of the patient's progress in the operating room, but as a journal allowing for the reconstruction of all intra-operative events. The accurate recording of events can be critical in allowing for the extraction of reliable data, in contributing to clinical research, patient safety, quality improvement or medico legal issues. Anesthetic trainees should be taught early in their medical training program that artifacts are common and reporting of transient values has little legal consequence.[6,8]

What can be done to improve anesthesia record keeping? New, intra-operative demands on anesthesiologists, coupled with the already well-known inadequate handwritten anesthetic record has led to the development and marketing of a number of anesthesia information management systems (AIMS).[4] These technological devices have been developed to aid with the collection of physiological data and monitor trends.[1,9,12] However, these automated devices have been plagued by high cost and strong user resistance.

Automated record keeping through AIMS offers a number of advantages. Some include improved accuracy of data, increased completeness and legibility, decreased anesthetic workload, and recording of all physiological data. Potential disadvantages include the reporting of artifacts, decreased vigilance because the anesthesiologist is not required to process the information as it is being recorded, and concerns for increased legal liability.[12] These potential disadvantages have been investigated in long-term studies and were found to be unimportant.[11,12,13]

Through the use of simulated operating room conditions and the standardization of the patient's physiological course, we found that charting of data to a paper record remained incomplete and inaccurate in all four groups of anesthesiologists regardless of level of training, age and number of years in practice. The use of AIMS in the operating room may be helpful in overcoming these charting deficiencies.

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