

Effects of Intraoperative Reading on Vigilance and Workload during Anesthesia Care in an Academic Medical Center

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Background: During routine cases, anesthesia providers may divert their attention away from direct patient care to read clinical (e.g., medical records) and/or nonclinical materials. The authors sought to ascertain the incidence of intraoperative reading and measure its effects on clinicians' workload and vigilance.

Methods: In 172 selected general anesthetic cases in an academic medical center, a trained observer categorized the anesthesia provider's activities into 37 possible tasks. Vigilance was assessed by the response time to a randomly illuminated alarm light. Observer- and subject-reported workload were scored at random intervals. Data from Reading and Non-Reading Periods of the same cases were compared to each other and to matched cases that contained no observed reading. The cases were matched before data analysis on the basis of case complexity and anesthesia type.

Results: Reading was observed in 35% of cases. In these 60 cases, providers read during $25 \pm 3\%$ of maintenance but not during induction or emergence. While Non-Reading Cases ($n = 112$) and Non-Reading Periods of Reading Cases did not differ in workload, vigilance, or task distribution, they both had significantly higher workload than Reading Periods. Vigilance was not different among the three groups. When reading, clinicians spent less time performing manual tasks, conversing with others, and recordkeeping.

Conclusions: Anesthesia providers, even when being observed, read during a significant percentage of the maintenance period in many cases. However, reading occurred when workload was low and did not appear to affect a measure of vigilance.

ROUTINE intraoperative anesthesia care, like aviation, has been described by some as consisting of "hours of boredom punctuated by moments of terror." What is considered acceptable or professional behavior and activities during the uneventful periods of low clinical

workload are a source of controversy and occasionally passionate debate.¹⁻¹¹ When workload is low, anesthesia providers have been observed to do a variety of nonpatient care activities (e.g., converse with other providers, use the telephone, etc.). While it is accepted practice for anesthesia providers to peruse materials that are directly related to patient care (e.g., review medical records), intraoperative reading of materials unrelated to the current case is more controversial. Such nonpatient care reading can be of clinical (e.g., medical textbooks, peer-reviewed medical journals) or nonclinical (e.g., newspapers, novels) materials.

Some decry the practice of intraoperative reading because they claim it reduces vigilance and lowers the quality of anesthesia care delivered.^{1,6} They further argue that independent of its impact, anesthesia providers who read give the appearance of being less attentive. We previously suggested, however, that reading may actually improve vigilance under some circumstances by keeping the anesthesia provider intellectually occupied and clinically stimulated, thus averting boredom or mental inactivity.² Evidence from studies of monitoring tasks in other domains supports the notion that the addition of a secondary task during low stimulation periods can improve vigilance and overall task performance.^{12,13}

The lack of *any* data on the effects of intraoperative reading on anesthesia care has protracted this debate. Moreover, there are no published data on the incidence of the practice. To study this issue, behavioral task analysis and workload assessment were conducted during anesthesia care in two teaching hospitals to measure the effects of intraoperative reading on vigilance, workload, and task distribution.

Materials and Methods

After receiving approval from the Institutional Review Board at the University of California San Diego and the Veterans Administration San Diego Healthcare System's Human Subjects Committee as well as informed consent from the subjects, routine surgical cases involving general anesthesia were studied between April 1998 and April 2002 at two teaching hospitals in San Diego, California. Of these observed cases, we first identified elective cases receiving general rather than regional anesthesia or monitored anesthesia care, which yielded 234 cases. From these cases, we screened out all cases with which we had technological difficulties (e.g., computer-related problems) and consequently did not have com-

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plete data. In addition, we selected all cases that had a specified duration (≥ 0.75 and ≤ 6 h), patients with an American Society of Anesthesiologists physical status categorical rating of no more than 3, occurred during daytime work hours, and complete data; this produced 172 cases. It was only after this screening process that we segregated cases into those that contained any reading ($n = 60$) and those that contained no reading. From the set of 112 cases in which no intraoperative reading occurred, 78 (of the 112 remaining non-reading) cases were then selected without knowledge of the dependent measures of interest to serve as our comparison (control) group on the basis of average case duration, clinician experience level, patients' American Society of Anesthesiologists physical status ratings, case start time, case difficulty, and type of surgery. The relatively small sample of qualifying cases did limit our ability to do a case-by-case matching procedure.

Anesthesia providers studied were residents, certified registered nurse anesthetists, postdoctoral fellows, and faculty anesthesiologists. Neither the clinician participants nor the observers were informed that intraoperative reading was a specific topic of interest of the study. The participants were told that we were conducting a study to learn more about the task patterns, vigilance, and workload of anesthesiologists while they are providing anesthesia care. In addition, they were told that the research could help guide the optimization of work schedules and the design of new anesthesia equipment.

A trained observer sat in the operating room (OR) and categorized the clinician's activities into 37 possible tasks. Procedures for task classification, observation methods, observer training, and reliability assessment have been previously described¹⁴⁻¹⁷ but are summarized here.

Observer Training and Certification

All 9 observers who conducted task analysis during the course of the larger project from which the study cases were obtained underwent rigorous structured training. Initial observer training included didactic reading and a minimum of 20 h in the OR paired with anesthesia providers before mentored practice data collection on a minimum of 6 OR cases and 6 video cases. The paired experienced observer/trainer provided immediate feedback and ongoing evaluation. Interspersed with these joint-viewing sessions, the trainees also practiced independently on videotaped cases. The trainee's data from these cases were compared with data obtained from the same case by experienced observers. After achieving subjective assessment of proficiency, the observer trainee was required to pass a certifying examination in which data from three standardized videotapes were compared with the results obtained by a panel of experienced observers who previously scored the same vid-

eos. An observer was only certified when his/her data met reliability criteria measured by their Intraclass Correlation Coefficients.¹⁴ Overall, the observers in the present study had a high level of agreement for the percentage of time (average intra-class coefficient, 0.97) and number of occurrences data (average intra-class coefficient, 0.92) and modest agreement for task duration data (average intra-class coefficient, 0.69).

Observations began once the patient entered the OR and ceased when the patient departed the OR after surgery. No data were collected when the study participant was on break. The observer noted each event (*e.g.*, reading/not reading, phases of the anesthetic) and task as well as initiating (upon computer prompt) workload ratings and alarm light latency measurements. Each event or task occurrence was recorded by clicking with a mouse on the appropriate button of the computer display. The software then automatically logged the time and task initiated. If two tasks occurred simultaneously, the observer recorded the dominant task first and then toggled between the two tasks based on the frequency with which each dominated the provider's time. If the participants were reading or reviewing case-related material (*e.g.*, preoperative and anesthesia records) while in the process of recordkeeping (medical documentation), then this was categorized as recording and not reading. When intraoperative reading did occur, the task analysis software coded it categorically as the idle task along with the reading event marker.

End of induction was defined as the time when the patient had been intubated and the endotracheal tube had been secured or when the anesthesia provider had told the surgeons that they could begin operating, whichever occurred first. Beginning of emergence was defined as occurring when the anesthesia provider shut off all anesthetic agents and began delivering 100% oxygen.

In cases where intraoperative reading occurred (*i.e.*, reading cases), data from the periods of intraoperative reading were compared to periods *during the same case* when the same clinician was *not* reading (*i.e.*, Non-Reading Periods [NRP]). In addition, the entire maintenance period of 78 Non-Reading Cases (NRC) was compared to the entire maintenance period of the Reading Cases as well as to the Reading and Non-Reading Periods of the Reading Cases during maintenance. Only data from maintenance, the phase in which all reading was found to occur, were included in these analyses. To examine the effects of reading on the number of task occurrences (*i.e.*, Reading Periods [RP]) while accounting for the more brief reading durations, task occurrence data were adjusted for the average duration of comparable RP when analyzing the data from Non-Reading Periods and Cases, rather than comparing the occurrence total for the entire Non-Reading Period or maintenance phase.

Vigilance

The anesthesia provider's vigilance was measured by the time it took to respond to the random illumination of a red alarm light based on software prompts at 7- to 15-min random intervals. Depending on the OR and the clinical equipment configuration, the vigilance light was either placed atop the physiologic monitor or between the vital signs monitor and the gas analysis monitor.^{15,16} When prompted by the custom data collection software to illuminate the light, the observer would simultaneously activate the electrical switch located next to the observer's laptop computer and select a radio button on the software interface to log the illumination time into the case data file. Participants were instructed to, either verbally or by hand signal (participant's preference), indicate their detection of the illuminated light. With the participant's signal, the observer would click the "light-detected" button in the software interface to record the stop time. The calculated response time between light illumination and its detection provided a measure of the response latency to a new (secondary) task demand. Since the illumination prompts occurred within random intervals, the number of response latency measurements depended on case duration.^{15,16} This type of probe detection task is well-supported in the literature as an indirect measure of perceptual or cognitive workload.^{18,19}

Workload

In addition, at 7- to 15-min random intervals, psychological (*i.e.*, perceived) workload was measured using the Borg Workload (6 to 20) scale,^{15,16,20} first by the observer and then independently by the participant. Workload density was also calculated continuously throughout each case.²¹ Workload density is a technique that permits real-time assessment of procedural workload per unit time whereby the incremental contribution of each task (as it is actually performed) is calculated as an aggregate measure. Workload density was calculated in 5-min intervals by multiplying the amount of time (in seconds) spent on each individual task by its workload factor score (a numerical value for each possible task derived in a previous study in which the relative workload associated with 71 anesthesia tasks was determined using statistical methods^{21,22}). Dividing the summed workload density values throughout maintenance by the total maintenance duration generated a normalized cumulative workload density for the entire maintenance period of each study case.

Statistical Analyses

Task data were analyzed using two-way mixed ANOVA. In addition, the 37 granular task categories were lumped into five larger task categories (manual, observing, conversing, recording, and other/miscellaneous) as described previously¹⁶ and shown in figure 1.

Workload density, vigilance, and self-reported and observer-scored workload data were analyzed using one-way ANOVA. A Bonferroni correction was applied to adjust for multiple comparisons. A corrected *P* value of less than 0.05 was used as the criterion for statistical significance. For all comparisons between reading and non-reading segments for the Reading Cases, repeated measures ANOVA were conducted. The Huynh-Feldt correction²³ was used for any effects that violated the assumption of sphericity. Data are presented as mean \pm SD.

Results

Intraoperative reading occurred in 60 of the 172 selected cases (35%). As was intended from the prospective case matching process, the reading and non-reading case cohorts did not differ significantly on any of the matched case or provider variables. Case start time was similar (8:23 AM \pm 76 min for reading and 8:33 AM \pm 82 min for non-reading) as was case duration (159 \pm 63 min for reading and 152 \pm 66 min for NRC). The average duration of maintenance was 107 \pm 124 min for Reading Cases (29 \pm 36 min reading and 78 \pm 43 min not reading) and 92 \pm 114 min for NRC. The distribution of types of surgical case, patient acuity, and provider type (83% residents in both case groups), as is shown in tables 1-3, did not significantly differ between the two case groups.

In the Reading Cases, anesthesia providers read 25 \pm 20% of the maintenance period. When reading, the clinicians spent 44 \pm 24% of the time reading while time-sharing with a variety of other tasks. The distribution of non-reading tasks differed significantly between RP and NRP in the same case, as described below in Task Distribution.

Workload and Vigilance

The observer-rated workload and participant-reported workload values were significantly lower during RP when compared with either NRP of the same cases or cases without any intraoperative reading (table 4). Overall, cases in which any reading occurred had significantly lower workload than cases without any reading. When comparing the complete maintenance phase of the Reading Cases (*i.e.*, RP plus NRP) to the maintenance data for NRC, there were significant between-group differences for both workload measures (*P* < 0.001). Similarly, workload density values were significantly lower during RP than during either NRP or in NRC. In contrast, there were no significant differences in the alarm light response latency (a measure of vigilance) among the three groups, averaging just under 30 s (table 4).

Anes Activity Log 2.61 alpha

MANUAL TASKS

- Adjust Anes Mach
- Adjust Monitors
- Position Patient
- IU's Adjustment
- IU Meds Given
- Medication Prep
- Lead/Transducer Adj
- Line Placement
- Mask Ventilation
- Bag Ventilation
- Laryngoscopy
- Intubation
- Secure/Manip Airway
- Auscultating Breathing
- Suction
- Extubation
- Recording
- Prep for Next Case
- Tidying Up
- Drawing Blood

OBSERVING

- Anes Machine
- Monitors
- Patient
- IU's/Fluids
- Surgical Field
- Airway
- Other Obs
- Nurse
- Attending
- Surgeon
- Patient
- Anes Tech
- Teaching (active)
- Other Care Provider
- Other Conv

CONVERSING

- Other Task
- Other Care Task
- Special Task
- Idle
- Sleep
- Obstructed View

MARKERS

- End of Induction
- Incision
- End of Surgery
- Start of Emergence

CONDITIONS

- Attending Absent
- Attending Present
- Subject Standing
- Subject Sitting
- Not Reading
- Reading
- Start Break
- End Break

USER OPERATIONS

- Begin Time for Next
- Replace Last w/ Next
- Delete Last

EVENTS

- Event
- Non-Routine Event
- Possible Error
- Inefficient Action
- Possible Adverse Event

1. Set-Up

Case Time: **0:04**

Current Task: **<< see task list >>**

Task List

2:46:23 PM	3075115583	Obs Patient
2:46:25 PM	3075115585	Attending Conv
2:46:26 PM	3075115586	Obs Surgical Field
2:46:32 PM	3075115592	Obs Patient
2:46:33 PM	3075115593	Obs IV's/Fluids
2:46:34 PM	3075115594	Position Patient
2:46:38 PM	3075115598	Obs Monitors
2:46:38 PM	3075115598	Obs Patient
2:46:39 PM	3075115599	Obs IV's/Fluids
2:46:39 PM	3075115599	Adjust Monitors
2:46:40 PM	3075115600	IV's Adjustment
2:46:40 PM	3075115600	Other Obs
2:46:43 PM	3075115603	Toggleing
2:46:44 PM	3075115604	Obs IV's/Fluids
2:46:44 PM	3075115604	Adjust Monitors
2:46:45 PM	3075115605	Obs IV's/Fluids
2:46:45 PM	3075115605	Position Patient
2:46:48 PM	3075115608	Obs Surgical Field

WORKLOAD

Investigator's Rating:

Subject's Rating:

VIGILANCE LIGHT

Hide

Store Data **Stop** **Quit** **About...**

Fig. 1. Data collection software screen shot. The Reading and Not Reading event buttons are highlighted.

Task Distribution

In Reading Cases, clinicians read for a total of 29 ± 7 min per case. Compared with NRP of the same cases or with cases without any reading, clinicians spent significantly less time when reading ($P < 0.01$) on record keeping and on other care tasks (*i.e.*, patient care-related manual tasks, such as emptying the urine bag, that did not fall into more specific categories) (table 5). When considering grouped task categories, participants spent significantly less time during RP performing manual tasks and more time on other tasks than during NRP (Huynh-Feldt criterion used) or NRC (table 6). The participants

Table 1. Surgical Case Demographics

	Reading Cases		Non-Reading Cases	
	No. of Cases	% of Cases	No. of Cases	% of Cases
Orthopedics	19	31.7%	23	29.5%
General	12	20.0%	15	19.2%
Urology	7	11.7%	10	12.8%
Otolaryngology	7	11.7%	9	11.5%
Neurosurgery	5	8.3%	8	10.3%
Vascular	4	6.7%	6	7.7%
Gynecology	4	6.7%	4	5.1%
Cardiothoracic	1	1.7%	2	2.6%
Plastics	1	1.7%	0	0.0%
Oral surgery	0	0.0%	1	1.3%

also spent significantly less time on conversation tasks during RP than during NRC ($P < 0.05$). The task distribution for NRP of Reading Cases and for NRC was not significantly different. Thus, these two "control" groups were similar in all major measurement attributes.

Participating anesthesia care providers had significantly shorter task durations (dwell time per task occurrence) during RP than either NRP or NRC on manual (RP 31 ± 31 s *vs.* NRP 108 ± 70 or NRC 99 ± 42 s; $P < 0.001$) and conversational tasks (RP 24 ± 32 s *vs.* NRP 66 ± 57 or NRC 51 ± 46 s; $P < 0.001$). Compared with RP of Reading Cases, participants had significantly longer dwell times during NRC when performing other tasks (RP 49 ± 37 s *vs.* NRC 34 ± 26 s; $P < 0.05$). When reading, clinicians spent significantly less time preparing

Table 2. American Society of Anesthesiologists (ASA) Physical Status Classification System Demographics

	Reading Cases*		Non-Reading Cases*	
	No. of Cases	% of Sample	No. of Cases	% of Sample
ASA1	10	16.67%	11	14.10%
ASA2	41	68.33%	54	69.23%
ASA3	8	13.33%	12	15.38%

* One case per group was missing ASA data.

Table 3. Provider Demographics

	Reading Cases		Non-Reading Cases	
	No. of Cases	% of Sample	No. of Cases	% of Sample
First year residents	18	23.08%	26	25.00%
Second year residents	15	25.00%	24	30.77%
Third year residents	17	28.33%	15	19.23%
All residents	50	83.33%	65	83.33%
CRNAs	6	10.00%	8	10.26%
Postdoctoral fellows/faculty	4	6.67%	5	6.41%

CRNA = certified registered nurse anesthetists.

medications for the current case (RP 5 ± 12 s vs. NRP 16 ± 13 s; $P < 0.05$) and for the next case (RP 3 ± 10 s vs. NRP 26 ± 51 s; $P < 0.05$). Clinicians also conversed with their attending (RP 5 ± 14 s vs. NRP 18 ± 38 s; $P < 0.05$) and with other care providers (RP 6 ± 17 s vs. NRP 19 ± 24 s; $P < 0.05$) for shorter intervals when reading.

Discussion

These results suggest that anesthesia providers read selectively during low workload periods, and their vigilance may not be impaired when they do read. Although three different measures of clinical workload were significantly lower during RP, intraoperative reading did not affect the response time to the random illumination of an alarm light. When reading, these anesthesia providers spent less time conversing with others, performing manual tasks, and recordkeeping. The implications of these findings will be discussed.

Why Do Anesthesia Providers Read?

In preparation for this study, during informal observations of anesthesia providers (including private-practice anesthesiologists), we noted that many participants added additional tasks during low workload periods. These secondary tasks included clinically relevant activ-

ities such as rechecking the composition or organization of the anesthesia workspace. Alternatively, during uneventful periods, it was common to observe anesthesia providers reading, listening to music, attending to personal hygiene, talking on the telephone, perusing the internet, or conversing with their intraoperative colleagues about matters unrelated to patient care. In all of the cases we observed (including some performed by private-practice anesthesiologists), intraoperative reading accounted for a significant proportion of time spent on such nonpatient care secondary tasks. Intraoperative reading may be more prevalent than our findings suggest because the study clinicians were aware they were being observed (but not that reading was a variable of interest). The present study corroborates our initial observations. To study the effects of such activities and practices, it is important to understand why these otherwise skilled, experienced, and presumably dedicated clinicians spend time on nonpatient care tasks while they are responsible for the lives of their anesthetized patients.

Most of the time during the administration of an anesthetic, there are many patient-care tasks to perform, and the diligent anesthesia provider will prioritize and undertake these tasks appropriately. If the task demands of every case were fully and continuously cognitively absorbing, then there would be a high risk of provider stress, fatigue, and burnout.²⁴ Instead, there are typically periods during the maintenance phase of most anesthetics that are characterized by few task demands, low workload, and stable patient physiology.^{15,16,25} Early task analysis studies called periods when the clinician was doing no observable clinically relevant task “idle periods” and reported that they could occupy up to 40% of routine cases.^{15,16,26,27} During idle periods, the anesthesia provider may, for example, remain attentive to acute changes in patient status, relax, reflect on events that have transpired, and plan for emergence or other future activities. However, excessive idle time could be associated with boredom, inattention, and sleepiness.^{24,28-30} Thus, intraoperative reading (and other clinician-initiated secondary tasks) may represent an intentional strategy to alleviate boredom and stay alert during uneventful periods. If true, then one would expect reading to only occur when no other tasks

Table 4. Workload Ratings and Vigilance During Maintenance

	Reading Cases					
	Reading Periods		Non-Reading Periods		Non-Reading Cases	
	Mean \pm SD	Range	Mean \pm SD	Range	Mean \pm SD	Range
Observer workload*§	7.64 \pm 0.77	7-11	8.61 \pm 1.14	7-14	8.55 \pm 1.03	7-12
Participant workload*§	7.92 \pm 1.08	7-12	8.86 \pm 1.49	7-15	9.01 \pm 1.64	7-16
Workload density†§	0.66 \pm 0.33	0.01-1.86	1.21 \pm 0.13	0.8-21.42	1.26 \pm 0.16	0.81-1.90
Vigilance latency§‡	27.93 \pm 38.12	1-207	29.42 \pm 44.33	1-506	26.51 \pm 39.89	1-433

* Psychological workload rated on 6-20 scale. † Workload density is normalized. ‡ Vigilance light response is in seconds. § All data are presented as mean \pm SD. || Significantly different from Reading Periods, $P < 0.001$, after Bonferroni correction.

Table 5. Percentage of Time Spent on the Most Common Tasks during Anesthesia Maintenance

	Reading Cases			
	Reading Periods, Mean \pm SD	Non-Reading Periods, Mean \pm SD	Reading and Non-Reading Periods Combined (Total Case Time), Mean \pm SD	Non-Reading Cases, Mean \pm SD
Observe monitors	14.60 \pm 9.27	15.3 \pm 7.55	15.62 \pm 7.25	15.37 \pm 7.44
Reading or idle/not reading	43.48 \pm 23.87	1.09 \pm 3.14†	11.28 \pm 11.00*	0.54 \pm 1.65‡
Recording	5.08 \pm 6.88	15.69 \pm 7.50§	12.98 \pm 7.06	16.19 \pm 8.51§
Other care task	2.89 \pm 4.05	10.80 \pm 7.81§	8.82 \pm 6.61†	12.33 \pm 6.96§
Observe surgical field	5.67 \pm 6.77	8.64 \pm 6.80	7.93 \pm 5.62	8.04 \pm 8.32
Other task	7.18 \pm 14.57	7.09 \pm 9.48	6.73 \pm 8.24	3.91 \pm 6.80
Other care provider converse	2.40 \pm 7.37	5.66 \pm 9.28	5.31 \pm 8.57	5.83 \pm 11.69
Attending conversation	3.30 \pm 12.98	5.06 \pm 7.74	4.37 \pm 6.73	5.48 \pm 10.70
IV adjustment	1.59 \pm 2.50	3.65 \pm 2.96	3.17 \pm 2.53	4.34 \pm 3.70
Preparation for next case	0.31 \pm 1.16	4.37 \pm 5.13	3.35 \pm 3.85	3.83 \pm 5.65
Medication preparation	1.13 \pm 3.10	3.53 \pm 3.08	2.92 \pm 2.44	3.06 \pm 2.57
Adjust anesthesia machine	1.34 \pm 2.31	2.32 \pm 1.83	2.02 \pm 1.75	2.48 \pm 1.64

All data are presented as mean \pm SD.

* After Bonferroni correction, significantly different from Non-Reading Cases, $P < 0.001$. † After Bonferroni correction, significantly different from Non-Reading Cases, $P < 0.05$. ‡ After Bonferroni correction, significantly different from Reading Periods, $P < 0.001$. § After Bonferroni correction, significantly different from Reading Periods, $P < 0.01$.

(other than patient monitoring) were required. The results of this study are consistent with this hypothesis.

Boredom is a problem of information underload, insufficient work challenge, and understimulation.^{24,31} Boredom results from the need to maintain attention in the absence of relevant task information³¹ and may be most likely to occur in semiautomatic tasks that prevent mind wandering but are not fully cognitively absorbing. Boredom has been documented as a factor contributing to human errors in locomotive driving and in prolonged routine flight in military and commercial aircraft.³²⁻³⁴ Low workload may result in a low arousal state that can impair performance.³⁵ In laboratory experiments, increased effort in the presence of boredom is necessary to suppress distracting stimuli and a generalized feeling of fatigue.³⁶ Adding tasks to a monotonous job can decrease boredom, and dividing attention among several tasks (time-sharing) will improve monitoring performance in some circumstances.^{12,13}

Few studies have defined the actual incidence of boredom during anesthesia or intraoperative reading. Some years ago, we asked 105 anesthesia providers (University of California San Diego) to complete a 278-item ques-

tionnaire on a variety of performance-shaping factors in anesthesia practice (unpublished survey data; Matt Weinger, M.D., 1998). The 57 clinicians (54% response rate) reported being bored infrequently. However, almost 90% admitted to occasional episodes of "extreme" boredom. Reading was the most common way these providers relieved their intraoperative boredom (other strategies included thinking about things, conversing, and busying oneself with manual tasks). When asked how often they read while administering anesthesia, 19% stated that they frequently read, and 46% said they sometimes read. Only one respondent claimed to never read in the OR. These survey data are consistent with the present findings; we observed reading in 35% of all cases studied. Moreover, in a separate recent pilot study, 28% of 204 clinicians interviewed in the recovery room reported having read during their just completed cases.

Vigilance

There was no difference in the clinicians' response time to the random but frequent illumination of the alarm light mounted within the monitoring array. One would have predicted that this simple probe, which has

Table 6. Percentage of Time During Maintenance Spent on Grouped Task Categories

Grouped Task Categories	Reading Cases		
	Reading Periods,* Mean \pm SD	Non-Reading Periods,* Mean \pm SD	Non-Reading Cases, Mean \pm SD
Manual tasks	7.22 \pm 10.38	19.69 \pm 6.88‡	20.46 \pm 9.12†
Observing tasks	24.47 \pm 15.33	28.75 \pm 10.94	27.87 \pm 11.94
Conversing tasks	9.67 \pm 15.29	16.77 \pm 12.49	18.61 \pm 17.06§
Other tasks	53.56 \pm 24.23	19.09 \pm 10.30†	16.86 \pm 9.31†
Recordkeeping	5.08 \pm 6.88	15.69 \pm 7.50§	16.19 \pm 8.51†

* Huynh-Feldt criterion applied to comparison between reading and non-reading sections of the Reading Cases. † After Bonferroni correction, significantly different from Reading Periods, $P < 0.001$. ‡ After Bonferroni correction, significantly different from Reading Periods, $P < 0.01$. § After Bonferroni correction, significantly different from Reading Periods, $P < 0.05$.

been found to be sensitive to other performance-shaping factors such as fatigue,³⁷ the use of new technology,¹⁶ and intraoperative teaching,²⁵ would have detected impaired vigilance if reading significantly caused it. The potential novelty effect of the alarm light could have affected response latencies. We have utilized this probe for more than 10 yr.^{15,16} Almost all of the participants were familiar with the study methods and had responded to the light during previous study cases. Notably, there were no significant differences in participants' alarm light responses between Reading and Non-Reading Periods of the same cases.

The detection of the alarm light is an artificial, albeit pseudorealistic, task that can be intentionally neglected by providers. However, prior results with our probe^{15,16} were consistent with the findings of Loeb and colleagues,^{38,39} who used a more realistic probe in which a new variable (Vigilance) was incorporated into the actual physiologic monitor, and clinicians were expected to report when the Vigilance probe changed from a normal to an abnormal value. Thus, while the latency of response to such experimental probes may not be predictive of how anesthesiologists would respond to real situations, the results can provide information regarding subjects' spare capacity to detect and process new stimuli while caring for patients intraoperatively.

The interpretation of alarm light response latency as a measure of vigilance is confounded by excessive workload,^{15,16,25} but this is probably not relevant to the present findings because workload was quite low. Vigilance is defined as "a state of readiness to detect and respond to certain specified small changes occurring at random intervals in the environment,"⁴⁰ and it can be adversely affected by many factors, including experience, motivation, task complexity, workload, and faulty equipment or system design.^{24,41} Anesthesiologists' vigilance to auditory⁴² and visual^{15,16,38,39} alarm cues as well as to changes in clinical variables^{43,44} have been studied in both the laboratory and the OR.

There is probably tremendous individual variability in the impact of reading on anesthesia vigilance and task performance. Anesthesia providers do not receive any formal training in time-sharing methods, although resource allocation and divided attention skills are likely learned informally. For some anesthesia providers, reading during low-workload periods could enhance intraoperative vigilance, while other clinicians' ability to detect acute events could be impaired. The presence of other performance-shaping factors, especially fatigue and sleep deprivation,^{24,45} could play a significant mediating role.

Study Limitations

This study has many limitations. A primary study goal was to ascertain the true incidence of intraoperative

reading; therefore, group allocations could not be randomized and the incidence data are retrospective. Previous studies have shown that many factors affect our measures of workload, vigilance, and task distribution.^{14,25,46-49} These factors (*e.g.*, clinician experience, case complexity) also could not be prospectively manipulated; therefore, we attempted to control for potential covariates by matching the cohort of Reading Cases with a similar cohort of Non-Reading Cases. This was accomplished before any analysis of the intended dependent measures. However, case matching could not be done on a case-by-case basis; regardless, the two cohorts could differ in unknown ways. Therefore, it is possible that between-group differences in patient, surgical, anesthesia care, or other factors might have affected the results.

The results may have been affected by the presence of an observer (*i.e.*, the Hawthorne Effect). This study was part of a larger project being conducted to ascertain the effects of a variety of performance-shaping factors (*e.g.*, experience, teaching, clinical devices, fatigue, *etc.*) on the task patterns, vigilance, and workload of anesthesia providers.^{14,25,46-49} Neither participants nor observers were informed that intraoperative reading was a specific topic of interest of the investigators. In previous intraoperative studies,¹⁵⁻¹⁷ including those involving videotaping,^{25,48} anesthesia providers appeared to largely ignore the observer. Nevertheless, if there were a Hawthorne Effect, it should have decreased the incidence of intraoperative reading suggesting that our results may underestimate the incidence in this population. The possibility of observer bias seems unlikely. Again, the observers were unaware of specific study hypotheses. Moreover, the observer was expected to log the occurrence of a number of events besides reading (*e.g.*, attending present/absent, provider sitting *vs.* standing, teaching, *etc.*).

Workload and vigilance are only surrogate process measures of outcome or quality of care.

Although no adverse events were observed during this study, it was not powered, nor did we attempt, to systematically detect nonroutine or adverse events or compare clinical outcomes between the Reading and Non-Reading Cases or NRP. Larger studies would be required to determine if intraoperative reading or other interruptions and distractions adversely affect patient outcomes.

This study was conducted in an academic hospital setting where reading may be more (or potentially less) common than in community hospitals. At least theoretically, the choice of reading material could affect the influence of reading on vigilance and other performance measures. For example, nonmedical reading materials (*e.g.*, fiction novels) may be more engrossing than reading ANESTHESIOLOGY, thus leading to greater inattention. Qualitatively, it appeared that a majority of our participants more often read clinical materials. On the other hand, the choice of secondary tasks may be less impor-

tant than how those tasks are integrated with the primary tasks of caring for the patient and how the secondary tasks are shed (*i.e.*, set aside) when patient care demands increase.^{24,50} The distribution of reading materials chosen and the ability to concurrently manage several tasks may differ in other practice settings.

Clinical Implications

These data were derived from a single academic department where intraoperative reading was permitted; the results may not generalize to other clinical sites. A total of 80% of our participants were anesthesia residents; different results might be obtained in more experienced anesthesia providers, although the data from our cohort of experienced providers appeared to be similar to the residents' data. The incidence of reading among private practice anesthesiologists has not been systematically surveyed. However, informal observations and polls of colleagues suggest that reading is a common practice during long routine cases in the community. There are probably significant differences between hospitals in different geographic regions or even within the same city. Nevertheless, it seems safe to assert that during anesthetic cases that are long and impose minimal physical and cognitive demands, the addition of nonpatient care tasks, including reading, is probably ubiquitous.

Independent of its measurable effects on *routine* (*i.e.*, uneventful) care, intraoperative reading has sociopolitical and medicolegal implications. Even in the absence of evidence of actual negative impact, reading may look bad and give the appearance of inattention and boredom. In the event of a negative patient outcome, it may be difficult to defend the occurrence of intraoperative reading if an acute critical event was not detected or managed appropriately due to such activities. Although we know of no malpractice claims in which intraoperative reading was asserted to be a causative factor in the outcome, some medical malpractice groups have recently explicitly asked anesthesiologists to refrain from such behavior during patient care.⁵¹ Some anesthesiology residency programs have explicit policies prohibiting intraoperative reading.

If Not Reading, What Else Might Providers Do?

In addition to reading, we observed anesthesia providers doing many other nonpatient care tasks, including personal conversations with OR personnel, talking on the telephone, and computer interactions. With electronic patient care information increasingly available intraoperatively, the opportunities and allure of electronic nonpatient care activities (*e.g.*, Web surfing) is also increasing.⁵²⁻⁵⁵

There are a number of issues that must be considered when deliberating on the perils or possible benefits of intraoperative activities that are not directly related to

patient care. Policies that forbid an activity without fully understanding the reason behind it are not only doomed to failure but may have unintended adverse consequences. All anesthesiologists would agree that (1) the patient must be the foremost priority and (2) being distracted or performing noncritical tasks during critical or unstable situations is inappropriate and dangerous. On the other hand, this study could not demonstrate adverse effects on workload or new signal detection of intraoperative reading selectively performed during routine uneventful periods of anesthesia care. Moreover, reading is but one of many possible intraoperative distractions, and mandating no distractions at any time (which would by definition include nonpatient care conversations and perhaps music) is unrealistic and potentially detrimental.

This is the first objective evidence to inform practice and policy for this important issue, and more studies are clearly needed. For example, future work should examine the effects of other nonpatient care activities (*e.g.*, use of electronic information technology), the incidence and effects in other practice settings, and perhaps most importantly, the association between intraoperative distractions/interruptions and patient outcomes.

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