THE EFFECT OF FATIGUE ON THE PERFORMANCE OF A SIMULATED ANESTHETIC MONITORING TASK

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ABSTRACT. In a simulated monitoring situation, 21 anesthesia residents were tested for their ability to detect significant changes in four critical variables in the presence of a concurrent distraction. Each resident was tested after a night without clinical responsibility (rested) and after 24 hours of in-house call (fatigued). When fatigued, the residents scored significantly worse on the vigilance test than when rested (57.2 ± 15.4 versus 65.9 ± 10.9, $P < 0.02$). Despite the small population size, the possibility of subject and investigator bias, and the artificial setting, these results support the intuitive proposition that a fatigued person is less likely than a rested person to detect important changes in monitored variables.

KEY WORDS. Medicolegal. Monitoring: vigilance. Psychologic responses. Records, anesthesia. Education, residents: sleep deprivation; fatigue.

Without human vigilance in operating rooms, the display of hazardous conditions on monitors will not lead the clinician to take corrective actions. Yet, the role of vigilance in the field of monitoring has received little attention, except that it has been noted that vigilance falters in fatigued medical personnel [1–3]. Because vigilance is important in the practice of anesthesia [4], we designed and performed an experiment to assess the effect of sleep deprivation on the performance of anesthesia personnel during a simulated anesthesia monitoring task.

METHODS

Twenty-one resident anesthesiologists, ranging in age from 27 to 37 years, volunteered to participate in the study. All had completed at least four months of their training and had been judged competent to administer anesthesia without continuous supervision. Each resident was tested twice in a randomized fashion, once after a night without clinical responsibilities (rested), and once after 24 hours of in-hospital service (fatigued).

Two 30-minute videotapes were prepared. Each displayed the oxygen and nitrous oxide flowmeters of an Ohio Modulus 1 anesthesia machine and simulated electrocardiogram and arterial blood pressure tracings on a Datascope 2000 monitor. Digital numerical displays for systolic pressure and heart rate were also visible on the Datascope monitor. The gauges and monitors were familiar to the residents from their clinical work. The display was arranged to fill a 48-cm color television screen and could easily be read from a distance of 1.5 m. The physiologic variables were generated either by an

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electronic simulator (electrocardiogram and blood pressure) or by manual adjustment of gas flow rates. A digital clock was placed immediately beneath the television screen.

During the 30 minutes of each video tape, the variables were kept within a normal range except for 4 substantial changes in the gas flow rates and 12 gradual changes in heart rate and blood pressure. Heart rate was simulated to fluctuate between 60 and 100 beats per minute; systolic blood pressure was simulated to fluctuate between 100 and 140 mm Hg. On six occasions these values drifted, during a 90-second period, to values considerably outside these limits and were maintained at a considerably abnormal level for a minimum of 120 seconds before returning to the normal range (i.e., a total of 12 substantial changes). The sequence of these changes was different on the two tapes.

The test was performed in a quiet room adjacent to the operating room suite. The subject sat 1.5 m from two color television monitors placed at a 90-degree angle to each other. A video tape of a lecture relating to anesthesia was projected on one of the two screens to simulate distractions that might occur during a surgical operation. The second screen displayed the monitors and flowmeters as described above. Before each test, the resident filled out a brief questionnaire. During the test, the subject was asked to record the time, in minutes and seconds, at which he or she first noted a significant deviation from base line in gas flow, heart rate, or blood pressure as displayed on the monitoring screen. No definition of "significant deviation" was provided. Unlike an anesthesia form, the data sheet for recording these changes did not require that variables be plotted, but merely that the time of the change be recorded and a statement be made about the nature of the change.

Each resident, starting either fatigued or rested, was tested on both video tapes by a randomized design with either video tape and a matched distractor tape. A minimum of five days elapsed between tests, and all tests were given between 7:30 and 11:00 AM. The responses were scored on a scale from 0 to 5, a perfect score being a correct response within 10 seconds of the actual event (5 points). For each 10-second delay in response, 1 point was subtracted from the score. Entries delayed by more than 50 seconds received no points. False-positive responses were defined as those that occurred within 10 seconds before a substantial change in a monitored variable, and these resulted in a 0 score on that change. This scoring technique was used to penalize overreaction to minor alterations in monitored values as much as failure to observe a substantial change.

The data were analyzed without knowledge of the name or condition of the test subjects. Statistical analysis was peformed by the Wilcoxon signed-rank test. Significance was assumed for a P value of less than 0.05.

Characteristics of Rested and Fatigued Residents before Testing

Characteristic	Rested[a]	Fatigued[a]
Breakfast consumption (%)	72	42
Coffee consumption (%)	59	61
Hours of sleep (mode)	6–7	2–4
Felt rested (%)	67	5.5
Time since last period of sleep (mean min)	205	161

[a]n = 17

RESULTS

Eight of 42 tests were excluded from the study because of errors in testing or because the resident failed to follow directions. The data culled from the questionnaire describing the subjects are presented in the Table. Only 5.5% of the fatigued residents reported feeling rested, compared with 67% of the rested residents. The vigilance scores were significantly lower ($P < 0.02$) when residents were fatigued than when they were rested (57.2 ± 15.4 versus 65.9 ± 10.9, respectively).

DISCUSSION

This article is an initial step in demonstrating the detrimental effect of fatigue on vigilance as it relates to monitoring ability. The study is limited in that the number of subjects was small, the definition of a "significant change" was arbitrary, the changes programmed into the video tape were either rapid (gas flowmeter settings) or gradual (heart rate and systolic pressure), and the rates of change were not defined in detail. Also, the setting of the experiment was artificial; thus, the residents were deprived of other clues or monitors that, in an operating room, can aid in the discovery of changes in a patient's condition. Although an attempt was made to simulate the distractions that may occur in an operating room, the failure to observe changes in monitored variables might be even greater in the actual setting, where distractions may be more intrusive and vigilance may lapse during long and monotonous surgical procedures. Because they knew the test was designed to discover the effects of fatigue, we cannot rule out bias among the subjects, to whom a demonstration of impaired performance after a night of in-hospital service might have been a subconscious or even conscious aim. Finally, there are difficulties with assessing fatigue [5] and there is a question as to whether other psychologic factors [6,7] may have been operative.

Despite the possible flaws in the study, these data support the intuitive proposition that fatigue from sleep deprivation can impair performance. Schmidtke [7] has reviewed the problems of research on vigilance and has found that fatigue does not impair performance during a sudden challenge. Test situations requiring vigilance, however, must last at least 30 minutes (W. B. Webb, personal communication, 1984). We believe that the frequency of substantial changes in this study was comparable with that in an operating room environment. It has been shown in previous studies that the frequency of changes [8,9] will affect vigilance. This was not explored in our study but deserves further attention. Future studies are also needed to characterize and quantify the impairment effected by fatigue. Such information can then be applied to the development of sophisticated alarm systems for intraoperative monitors, and to the establishment of guidelines concerning acceptable levels of fatigue in personnel delivering anesthesia.

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