Special Article

The effects of fatigue on physician performance - an underestimated cause of physician impairment and increased patient risk

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Evidence is reviewed demonstrating the high level of drug and alcohol abuse and marital disharmony among physicians and the particularly high rate among anaesthetists. The relationship between these factors and the effects of fatigue is explored. The current evidence for reduction in physician performance and vigilance resulting from fatigue and sleep loss is reviewed. Supplementary indirect evidence is surveyed which suggests that increased experience may not compensate adequately for this reduced performance. Since hours of work can be controlled, it is essential that anaesthetists, their professional organizations and regulatory agencies ensure that pressure for efficiency does not result in fatigue and the consequent compromise of both patient and physician health and safety.

The anaesthetist, like all physicians, is subjected daily to a multiplicity of stress factors affecting both his (or her) ability to provide medical care and his own health and well-being. While other specialists commonly receive positive public recognition of their success, the anaesthetist is more likely to receive publicity only from the disastrous effects of an error of judgement. All anaesthetists work daily with the knowledge that a mistake on their part can result in patient death or injury. While most physicians cope satisfactorily with work-related stresses, the incidence of physician suicide and drug and alcohol dependence testifies to the failure of many to compensate effectively.

Suicide has been reported to be two to three times more common among physicians than in the general public,[1,2] and is the leading cause of premature death in physicians.[3] Studies of the cause of death in male members of the American Society of Anesthesiologists between 1947 and 1976 revealed a three to four times higher suicide rate than age-adjusted comparable socio-economic control groups.[4,5] Alcohol and drug dependency are common among physicians,[6-8] with anaesthetists at particularly high risk;[9] while approximately four per cent of U.S. physicians are anaesthetists, 9.6 per cent of physicians treated in the Medical Association of Georgia Disabled Doctor's Program, the largest in the U.S., have been anaesthetists.[10]

Since anaesthetists are exposed to a high level of stress, it would appear prudent to examine contributing factors which can be controlled.

Key words
PSYCHOLOGIC RESPONSES: sleep deprivation, fatigue;
ANAESTHETISTS: performance, fatigue.

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Fatigue as a stress factor

Fatigue is a fact of life for all physicians involved in acute care medicine, whatever their specialty. It is most extensively experienced during the intern and resident years. Once specialist status has been attained there is a wide variation of working hours both within and between specialties.

The anaesthetist is particularly vulnerable to long hours of work and considerable sleep loss since services are provided to patients on behalf of a large number of surgical specialties. In the fee-for-service system, increased workload means increased income, encouraging both individuals and associates to maintain a high case load. In addition, there may be institutional, governmental, and peer pressure to provide more "efficient" services (that is to say more anaesthetic procedures with fewer anaesthetists). Given rapidly escalating malpractice litigation and increasing fiscal pressures on the provision of medical care it is vitally important to clarify what constitutes a reasonable workload for a given physician. When reasonable limits are exceeded, stress and fatigue are inevitable: does this then contribute to impairment? Does fatigue play a significant role in the production of errors and patient morbidity?

Can risk factors and risk markers be identified in individuals and constructive action be taken to eliminate what has become a significant hazard to patient and physician alike?

The stereotype of the physician as a superior individual who can cope with long hours without rest, maintain the highest standards in the face of fatigue, and consistently sacrifice personal and family life to patient care, is still well entrenched. The Puritan work ethic has been taken to extremes, and even those physicians who believe in reasonable work habits praise their colleagues who sacrifice their personal lives to their profession. At a recent graduation dinner a guest speaker told the new graduates: "As interns you will be working at times for 20 or 30 hours without sleep; it will be hard but you will be the better physicians for it."*

The facts suggest that this is not true. Studies of interns acutely and chronically deprived of sleep demonstrated impairment of efficiency and learning,[11] difficulty in thinking, irritability, recent memory deficit, depersonalization, and inappropriate humour.[12,13] Deficits in cognitive function have been recorded in interns with less than five hours of sleep in a 24 hour period,[14–16] suggesting that interference with adequate learning occurs. Decreased work satisfaction and reduced self concept have also been described.[17] Depression, described in Friedman's report,[12] was not found by Uliana *et al.*[13]

Marital and sexual dysfunction attributable to fatigue and work habits are common.[18–20] Such dysfunction may be a secondary cause of fatigue and altered work habits producing a vicious cycle of stress: suicide not only occurs more frequently with physicians but also at an increased rate in their spouses.[21] Clearly fatigue, and the work habits that produce it, reduce the quality of the physician's work, affect patient safety, and potentially lead to physician impairment with damage to personal mental and physical health.

*Personal observation: University of Saskatchewan Medical College Graduation Banquet, 1986.

Fatigue: how much affects performance?

The effects of faigue on the performance of military and industrial personnel have been extensively studied. Similar studies have been made rarely of physician performance and then, only of interns and residents. I found no evidence that consultant specialists in private or academic practice have ever been studied. Three differing approaches have been used to study these effects in the few reports that exist:

1 Questionnaires documenting subjective evidence of loss of efficiency.[22]
2 Experiments measuring the effects of hours of work and sleep loss on work related tasks.[11,23–25]
3 Psychomotor tests of various types attempting to show deterioration in performance.[14–16,26,27]

Goldman *et al.*[11] videotaped surgical procedures and critiqued the efficiency and quality of surgical performance; they identified deterioration in both these areas. Friedman *et al.*[23] had their subjects view a 20-minute taped ECG and identify, without interpretation, the occurrence of arrhythmic episodes. For those subjects who had been working for the 24-hour period preceding the test and who had had less than four hours of sleep during that period, the mean number of errors was 9.64 ± 1.41 (SEM) as compared to a mean of 5.21 ± 0.93 errors in the rested state ($p < 0.01$). In contrast, Christensen *et al.*[24] studied the quality of *x*-ray interpretation in residents working 16-hour days with no sleep loss and found no evidence of deterioration. These studies are particularly relevant because performance was evaluated in normal work-related tasks lasting for a relatively extended period.

Beatty *et al.*[25] had their anaesthetist subjects monitor six vital sign parameters displayed on a video screen during a 50-minute period of simulated surgery. Seventy-two queries were presented at random intervals during the 50-minute period, half following an abnormal signal and half in the presence of normal findings. The subjects were tested after a night of normal sleep and after a day on call when they had slept for less than two hours. Performance deteriorated in four of the six subjects.

Others have utilized a variety of cognitive function tests to quantify performance following sleep loss. Poulton *et al.*[15] used a card sort test of grammatical reasoning[28] and a laboratory report test which consisted of 24 laboratory report forms, each with eight or nine entries. Six of the 24 reports contained two grossly abnormal readings. The score was the total number of forms completed in three minutes less four points for each abnormal reading missed and one point for each normal reading called abnormal. Those physicians in the group who performed the card sort test only, showed reliable and significant deterioration following three hours or more of sleep deficit. They also showed deterioration when the duration of their work exceeded 18 hours with no preceding sleep deficit, suggesting a reduction in performance when the work period reduced the normal sleep period. Work periods of less than 17 hours with no loss of sleep in the preceding 24 hours was associated with no significant effects.

The group who were tested with both the laboratory forms test and the grammatical reasoning test surprisingly demonstrated a small but statistically insignificant improvement in scores with sleep loss of less than five hours and only showed a significant deterioration with sleep loss of greater than eight hours. There was, however, a significant increase in variability in the rate of work during the test, suggesting an attempt to compensate for their fatigue.

The researchers felt there were two reasons for these rather surprising results. Firstly, the group doing the laboratory forms test saw this as a more "important" test and made a special effort to do well. Secondly, the physicians in this group were given the results of their tests and were thus motivated to try to improve their performance, a situation known to improve test scores. They felt that this effect carried over to the more "simple" grammatical reasoning test. A number of such test interactions are described in the literature,[15,29–31] and must always be considered when comparing studies. The authors concluded that, during the brief three-minute period of the test, the subjects could compensate for the reduction in performance which occurs with sleep loss of up to five hours. They also pointed out that the more challenging laboratory forms test produced a marked compensation effect and that it took eight hours of sleep deficit to ensure reliable deterioration. Beatty *et al.*[25] showed a significant deterioration in the Baddeley card sort in all subjects.

Leighton and Livingston[16] using a serial addition test, Klose *et al.*[26] using a card sort, digit symbol, manual dexterity and colour-word tests, and Hawkins *et al.*[14] using Raven's Progressive Matrices[32] and a trail-making task[33] have all shown deterioration in performance following sleep loss.

These tests all require the collection and processing of information and the use of short-term memory and higher cortical function for their successful completions. They can reasonably be expected to be affected in the same general way by fatigue and sleep loss as the cognitive and interpretive aspects of anaesthetic practice.

Many of the tests used in the military and industrial studies focused on the sensory–perception and sensory–motor aspects of fatigue. Critical Flicker Fusion Frequency (CFFF) and Choice Reaction Time (CRT) are representative of these groups. CFFF requires the subject to view a flashing light from a distance of one metre. The flashing rate is increased from 12 Mz at a step rate of $1\ \mathrm{Hz \cdot sec^{-1}}$. The end point is taken as the point at which the subject sees the light as a steady source. A second end point is measured by reducing the flash rate from 50 Hz at a step-rate of $1\ \mathrm{Hz \cdot sec^{-1}}$ until the light is seen as a flashing source. A number of observations are taken and a mean end point calculated. The test is very sensitive to changes in both ambient light intensity and the intensity of the source. It is quite resistant to sleep loss and affected by the degree of arousal and the time of day. The CRT is obtained by requiring the subject to move his/her finger from a central button to one of six peripheral buttons as quickly as possible. A light adjacent to each button is lit randomly indicating which button the subject is required to press. Two times are measured, from the illumination of the light to release of the central button (CRT1) and from release of the central button to contact with the peripheral button (CRT2).

The mean time for a series of tests is reported. CRT reported in this way is quite insensitive to sleep loss, more than 30 hours without sleep loss being required to significantly change mean times and the CRT is only doubled after 78 hours without sleep.[34]

Narang and Laycock[27] used these two tests to study 16 on-call junior anaesthetists at three times during the working day, between 1400–1600 and at 2300 and 0200 hours. They used a mean of six CFFF measurements and a mean of 30 attempts at the CRT for each occasion and showed no change in CRT and a significant reduction in CFFF at 2300 and 0200 hours. They observed that not all their subjects showed a reduction in CFFF at 2300 and 0200 hours.

They concluded that arousal levels are impaired in the majority of anaesthetists by 2300 hours but that no further impairment occurs after this time and that there is no deterioration of psychomotor performance as assessed by the CRT.

Given the known insensitivity of these tests to loss of sleep[34,35] and the very short sleep loss involved, plus the effects of diurnal variation[35,36] it is impossible to draw valid conclusions from this study concerning overall cognitive performance.

Examination of the relationships between the shortest and longest CRT on each occasion and the variability in end point of CFFF which has been shown to be more sensitive to sleep loss[34] might have produced interesting information.

Thus, there is evidence that the performance of physicians, during their intern and residency years, deteriorates with work-related sleep loss. It is also clear that the subjects could compensate for this for short periods, particularly in tests which are perceived by the subject to be "important."

Extrapolation of fatigue studies from military and industrial sources to anaesthetic practice must be done with caution. For example, there are several studies that apparently show no deterioration in performance with up to 48 hours of continuous work.[37–39] These studies have been performed on young, highly motivated military personnel carrying out repetitive tasks requiring a standardized response, and who were not fatigued prior to the test.

Fatigue: a factor in vigilance?

The work reviewed to this point deals with the effects of fatigue on the ability to perform tasks requiring relatively complex intellectual function for their solution. While successful problem-solving of a wide variety of pathological and physiological changes is essential for the safety of the patient, the anaesthetist faces another equally important challenge: maintenance of vigilance to detect changes during the course of an anaesthetic.

Vigilance has been defined as "the detection of changes of a stimulus during long monitoring periods when the subject has little or no prior knowledge of the sequence of the changes."[40] The anaesthetist's task is complicated by the need to monitor more than one stimulus at a time.

Friedman *et al.*,[23] using a 20-minute ECG tape, and Beatty *et al.*,[25] using a video of vital signs readouts from 50 minutes of simulated surgery, demonstrated a reduction in performance related to deteriorating vigilance following sleep loss.

Paget *et al.*,[41] in an extensive review, concluded that sleep deprivation is an important factor affecting the quality of vigilance. They also point out that environmental factors such as pollution with trace anaesthetic gases and noise may have detrimental effects.

Studies of the effects of trace anaesthetic agents on performance have yielded conflicting evidence. Bruce *et al.*[42,43] suggested that there might be detrimental effects, a finding not confirmed by other workers.[44–47] Studies involving noise also indicated conflicting results. Quiet, broadband noise or industrial noise all produced performance decrements on vigilance tasks while music produced no change in performance.[48,49] Other writers have suggested that environmental factors may have an arousal effect improving performance.[50,51]

The stimulus deprivation produced by working in a windowless environment has also been implicated as a cause of increased stress and reduced attention.[52–54] While no definite conclusions can be drawn, environmental conditions found in modern operating rooms have the potential for negative effects on both vigilance and performance.

Compensation and recovery from fatigue

The ability of physicians to compensate for the effects of fatigue for short periods of time has been suggested by some studies,[15,23] but there has been no documentation of either the duration or effectiveness of such compensation. In a study of prolonged truck driving in convoy, Fuller[55] showed no change in objective performance parameters. However, the more experienced drivers increased the interval distance between themselves and the truck in front, thus reducing their task demands. The quality of the compensation is an open question, particularly when the loss of sleep is a consistent and recurring event. For example, the fact that 46 per cent of single vehicle accidents involving interstate truck drivers occur during the eight-hour period from midnight to 8 am[56] suggest that compensation may not always be sufficient. One of the difficulties involved in testing for compensation and recovery from fatigue is that the fatigued human subject does not "run down" like a battery or steadily produce less performance like an engine wearing out. Instead, performance becomes more inconsistent. The best performance remains the best but randomly variable period of poor performance becomes more frequent and more severe as fatigue increases.[57]

There is conflicting evidence about the rate of recovery from sleep loss. Tests conducted on the day after the sleep period terminating the period of sleep deprivation showed complete recovery in one study[39] and incomplete recovery until two normal sleep periods in another.[34] In both of these results, the recovery from sleep loss was only a secondary aspect of the study which was designed to demonstrate the effects of sleep loss and no attempt was made to assess significance. In a study designed to look specifically at the recovery period, Wilkinson's[58] subjects were kept awake for 36 continuous hours and then allowed a 12-hour recovery period of rest and sleep. They were then tested with a one-hour vigilance test on the following morning.

All the subjects showed deterioration in performance against the rested state. Unlike the progressive deterioration occurring with acute sleep loss the "aftereffect" was greatest in the morning and showed little change through the day leading the author to conclude that the reduction in performance was more in keeping with interference in circadian rhythm rather than failure to recover from fatigue.

A review of the extensive literature concerning the effect of changes in diurnal rhythm associated with fatigue is beyond the scope of this article but it is certain that the effects of chronic disruption in sleep–work ratios have additive effects to those of acute fatigue.

Increasing age and the use of alcohol, tobacco or drugs will also effect the rate of recovery.

While fatigue and loss of sleep are clearly shown to have a detrimental effect on both vigilance and cognitive performance, compensation for this performance deficit can occur for short periods, even after considerable sleep loss.

Fatigue: a threat to patient safety?

Disastrous mishaps in anaesthesia are infrequent events in relation to the total numbers of anaesthetics given. They are associated with failure to recognize and deal with problems arising from equipment, anaesthetic technique, or the patient's physiology. When reviewing adverse events one is often comforted that there was "negligence" or "carelessness" and that "it could not happen to me, a competent anaesthetist." Cooper *et al.*,[59] in a study of 70 serious incidents, demonstrated that potentially dangerous incidents are actually common but are usually detected and corrected by the vigilance of the anaesthetist. Of these incidents 28 were assessed as "technical errors" on the part of the anaesthetist, 23 as errors of judgement, 16 as monitoring or vigilance lapses, and three as equipment failures. While increased experience or training might have prevented the "technical errors," more than half the critical incidents were caused by factors known to be potentiated by fatigue. Those who take comfort from the idea that seniority and experience allows them to avoid the performance deterioration documented in the fatigued intern and resident should heed these results.

Experience and well-established habits may also play an unexpected part in the production of disasters. In 1977, a Boeing 747 taking off from Tenerife failed to wait for take-off clearance from the control tower in the conditions of poor visibility. The pilot started his take-off run and crashed at 150 miles an hour into another 747 still taxiing on the runway, killing 577 of the 637 passengers and crew on the two aircraft. The very experienced pilot of the Dutch aircraft who did not wait for take-off clearance was the head of KLM's flight-training department and during the previous six years had spent some 1,500 hours in a simulator. He had not flown for twelve weeks prior to the flight. In the simulator, to reduce operational costs, he, as the instructor, would issue the take-off clearance to the student pilot who was never required to hold on the runway. It is likely that, under the stress of the situation, he reverted to the behaviour pattern of the predictable world of the simulator instead of reacting to the real circumstances. An appropriate habit in the normal working day of this pilot had been applied in inappropriate circumstances with disastrous results. It is probable that reversion to habits which are normally quite appropriate, but not when applied in situations requiring specific behaviour adapted to the situation, is more common than suspected.[60] The loss of adaptability and reduction in cognitive function associated with fatigue may well contribute to a catastrophe. The accident demonstrates that reliance on well-established habits at times of increased stress may not always produce desirable results. Those physicians who claim to be able to compensate for any degree of sleep loss by the greater experience may well be taking just this risk.

Conclusions

Physicians have both a professional and moral obligation to ensure that factors under their control do not jeopardize the well-being of their patients. Fatigue is one stress factor that is uniquely amenable to control, either voluntarily or by legislation, by the limitation of hours of work and the provision of adequate numbers of physicians.

There are very high costs to errors in medical practice, not only from the monetary aspects of litigation but also the hospital costs of complications in our patients,[61] and the psychological cost associated with a disaster devastating the practice of a responsible physician. A considerable body of evidence exists concerning the deleterious effects of fatigue and sleep loss on the function of the physician. These effects are important in relation to both the physician and the patient's well-being and deserve further study and clarification. There is evidence that any deviation from the standard eight hours of work followed by 16 hours of rest and recovery results in the disruption of human efficiency and reliability in task performance.[62] Only by appropriate documentation will rational limits to work habits be accepted.

There are ways to limit and alleviate such effects. Time management techniques[20] and stress management[63] instruction should be a part of every physician's training. The fiscal and administrative pressures to increase workloads beyond reason must be acknowledged. The pressures of fee-for-service often encouraging high volume practice, must be recognized as potentially counterproductive to patient safety.

While efficiency, as defined by cost considerations, is greatest under high workload, effectiveness is highest under moderate workloads.[64] Effectiveness in anaesthetic practice results in increased patient safety. To assure their ability to give high quality care at all times, anaesthetists should try to ensure that their level of fatigue does not reach a point that affects their performance. While any attempt to set standards for maximum hours of work is quite arbitrary, the hours suggested below have at least the merit of being less than those shown reliably to produce performance deficits that can be measured:

1 Any anaesthetist working with a procedure lasting more than three hours should be relieved for short periods every two hours.

2 No anaesthetist should regularly work more than a 16-hour work day without a full 12-hour recovery period.
3 No anaesthetist should be on call for more than 24 hours without a full 24-hour recovery period.
4 Anaesthetists, particularly those in small or solo practices, must learn to say "no" to unreasonable workload demands.

While the ability to limit practice will depend on local and personal circumstances, anaesthetists and their professional associations must resist pressures which affect both their own and their patients' well-being.

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Résumé

On présente de l'évidence du niveau élevé d'abus de médicaments et d'acool, de problèmes familiaux parmi les médecins, et tout particulièrement parmi les anesthésistes. On examine la relation entre ces facteurs et les effets de la fatigue. L'évidence actuelle de la perte de performance et de vigilance du médecin, causée par la fatigue et la perte de sommeil est révisée. On examine d'autre évidence indirete qui laisse entendre que l'expérience de l'anesthésiste ne compense peut être pas pour cette perte de performance. Puisqu'il est possible de contrôler des heures de travail, il est essentiel que les anesthésistes, et leurs organisations professionnelles et régulatrices s'assurent que la production n'entraîne pas une fatigue qui compromettrait la santé et la sécurité du patient et du médecin.