Catalogue of human error

F. ARNSTEIN

“A life spent in making mistakes is not only more honourable but more useful than a life spent doing nothing.” George Bernard Shaw. *The Doctor’s Dilemma*, 1913.

To err is human. New skills are acquired and the existing improved by practise but intrinsic to all endeavour is the prevalence of error.

For discrete work-related tasks, workers average one error in every 1000 to 10 000 acts. This apparent low prevalence is misleading because many jobs average 20 000 acts per day and some approach 100 000. Examining the performance of first and second year anaesthetic trainees during simulation, De Ande and Gaba found an incidence of 6.9 unplanned incidents per case, of which 27% were considered critical. Currently, most errors recognized in anaesthetic practice are discussed locally. Wider debate may be provoked by the publication of case reports and articles, and in the courts. These processes are retrospective and inherently prone to misinterpretation. This article reviews human error terminology and examines some of the factors which influence the prevalence of error. It will be suggested that all of us make errors and are susceptible to misinterpreting information. The aviation industry has long recognized this and experience gained by that industry will be outlined, suggesting methods which may be usefully adapted to anaesthetic practice. To accept error as normal is a prerequisite to establishing systems to manage the risks. To study error is to not to apportion blame but to ask why. Understanding causality enables prevention.

Errors may be classified into two major categories: active and latent. Active errors are events which occur immediately before an incident or accident. Latent errors are systems containing unrecognized faults which become evident under specific circumstances.

Active errors

Active errors can be subdivided into contextual, modal or psychological.

Mistaking a 1-ml ampoule of adrenaline for atropine is a contextual error in that the mistake occurs during a particular activity. However, such a description inhibits comparison between different activities. Modal descriptions are context free and may be subdivided into errors of omission, repetition, substitution and insertion (commission), and allow easier comparisons. Such descriptors are broad so that focus may be lost and there is no attempt to describe error causation, making prevention strategies difficult to formulate. Psychological definitions aim to define cognitive mechanisms that lead to error and should make error causation predictable and comparable. Errors described in this manner have been divided into slips (action not intended) or mistakes (poor or faulty planning). Usefully, errors may be classified as knowledge, skill, or rule based, with some observers describing an additional group of technical errors.

Knowledge based errors

Knowledge based errors originate in a background of inadequate knowledge or experience. Experience is important because it enables the deployment of a generic solution to a novel situation. However, examining the role of experience on the response to simulated critical incidents, DeAnda and Gaba suggest that experienced staff are as likely as trainees to make errors (67.5% human error compared with 72.2% and 56.6% for first and second year anaesthetic residents, respectively).

Rule based errors

Rule based errors occur when there is a failure to apply a rule or an inappropriate rule is used, for example performing cardiopulmonary resuscitation when the electrodes of the electrocardiogram have become detached. Anaesthetic seniority may confer an increased risk of making errors of this type as more short cuts are used. Such deviations are also termed violations or intentional errors.

Key words
SKILL BASED ERRORS

Skill based errors which incorporate slips and lapses relate to errors in conscious and subconscious (automatic) cognition. Human information processing may be described by the model developed by Rasmussen (fig. 1). The mind may be viewed as an information processor provided by a series of filtering sensors and memory systems enabling comprehension of a data set without conscious recognition.

"These functional fuses have been developed after years of scientific investigation of electric phenomena, combined with the fruit of long experience on the part of the two investigators who have come forward with them for our meetings today."

Figure 1  A model of human information processing (reproduced with kind permission of Butterworths, London).

Figure 2  Redundancy in writing. How many times does the letter “f” appear in the top paragraph? (reproduced with kind permission of Robson Books, London).
of the whole. For example, the written word contains much redundancy both in content and form (fig. 2). Subconscious or motor programmes enable many tasks to be performed simultaneously and rapidly, freeing cognitive power for conscious effort. Although motor programmes are fast and efficient they are also rigid and occur by definition without awareness. Therefore, it is possible (and in daily life is common) to select the wrong motor programmes for the task or develop a programme with an in-built fault. Even conscious activity requires a balance between speed and accuracy but during emergencies the time available to perform a task is often limited.

TECHNICAL ERRORS

Technical errors are described in the anaesthetic literature but originate strictly from outside the individual. For example a “failed” extradural may result from performing the procedure correctly on a patient with atypical anatomy.

Within these broad categories, sub-classifications have evolved. Norman has described five types of slip.48

Capture errors: fault caused by the use of an inappropriate motor programme, for example giving a neuromuscular blocking agent to a patient with a known difficult airway.

Description errors: using the correct action on the incorrect object, for example turning off the oxygen instead of the nitrous oxide. Selecting the wrong ampoule has been described as a description error or simply absentmindedness. “Absentmindedness” may be interpreted by the layman as implying carelessness and fails to recognize that such errors are intrinsically normal.

Memory errors: omitting elements of an intended action sequence.

Sequence errors: performing task elements in the wrong sequence.

Mode errors: correct action used for equipment currently in the wrong mode, for example turning off the ventilator when the breathing system is in ventilation mode.

Additionally, three further forms of error are described as fixation errors: despite evidence to the contrary, continuing with an inappropriate plan, dealing with everything except the real problem and believing the evidence is falsely positive. These may be seen as “cognitive tunnel vision”.

Monitoring and control systems should be in place to advise the anaesthetist that he or she is failing. These should not impinge continuously on his conscious effort. To do so may interfere with cognitive function and induce irritation. Davies described a useful incident/accident model (“Human error—prevention and investigation”, Lecture given to the Royal College of Anaesthetists Anniversary Forum on Risk Management for Anaesthetists, 1995). This may be seen as an error train (fig. 3). Remaining on the correct and most direct track requires good internal control and when this fails, timely and accurate intervention by external monitors. Failure of both may lead to an incident or accident. The associated morbidity corresponds to the degree of deviation.

Human information processing systems may be unable to detect errors of recognition (illusions),
imagine external stimuli (hallucinations) or may make false cognitive hypotheses (delusions). Simple illusions may be powerful (fig. 4). Prolonged exposure to one set of stimuli may affect the perception of subsequent information. Some illusions are so powerful that they are impossible to resolve leaving the observer bemused but conscious of his fallibility (fig. 5).

Failing to maintain accurate contact with reality may lead to disorientation. In aviation, two forms of disorientation incidents are recognized. Type I is defined as when the pilot fails to recognize that his perception is incorrect whereas during a type II incident he senses that the cues presented to him may be inducing a false perception (fig. 6). The former represents a greater hazard in that an erroneous situation exists but the pilot remains unaware and this is supported by aviation accident mortality data. It would seem reasonable to extrapolate these modes of disorientation to other human activities, including the practice of anaesthesia.

External monitoring systems may assist in resolving the cognitive conflict but the disorientation may be so powerful that alarms are considered to be faulty and are ignored. In aviation it is recognized that it is best to avoid the circumstances which may be disorientating. Therefore, training emphasizes the early recognition of risk situations with the deployment of well rehearsed procedures to optimize the chance of maintaining accurate contact with reality. In a similar manner the use of algorithms during anaesthesia assists; 62% of anaesthetic difficulties can be resolved within 60 s by reference to basic ABCD management. The use of simulation should prepare anaesthetists for rare adverse events. However, it is recognized that memory deterioration demands that refresher courses should be offered at regular intervals and probably not exceeding 6–12 months. Unfortunately, during crisis management there may not be enough time for logical analysis and printed aide-mémoires can be invaluable while advances in computer technology is enabling the introduction of rapid access databases.

### Latent errors

Latent errors are inadequacies or failures of ergonomics or training, incorrect policies or protocols, inadequate assistance or supervision, social and cultural factors, including language, the physiological state of the patient and chance. Chance is analogous to fate, being defined as risks which have such low probabilities that estimates cannot be assigned. An example might be injury caused by metal fatigue in an operating table where such an event could not be foreseen during the design of the table or even after extensive use.

The risk associated with a latent error must be viewed with caution because to occur may require shaping or enabling factors. For example an anaesthetic monitor may cause no difficulty when used in optimal lighting conditions but the presence of screen reflections or an anaesthetist with defective colour vision may degrade the information it provides so that it fails to warn and may contribute to increased stress and wasted cognitive effort.

Examples of latent errors reveal the multitude of potential problems which may act singly or in combination to induce error. Equipment may be designed by those who will not use it. The development of anaesthetic monitors has been rapid but they are rarely integrated, and they often have many alarms of similar form but representing widely differing pathophysiological states; that is cues lack specificity. Displays may be too small, use inappropriate colours and have warning messages that appear on the periphery of the screen (fig. 7). Poor integration inhibits the flow of information to the observer who must make frequent body or head movements or use saccadic vision. Audible alarms may have similar tones, and without adequate separation in loudness between alarms and background noise may be inaudible.

Inappropriate default alarm settings may prevent the monitor from warning as may failure to set the alarms. Variations in equipment and lack of training in its use increase the likelihood of error and alter the
perceived stress. Special circumstances, for example neurosurgery or MRI scanning, may prevent direct anaesthetist–patient contact, increasing dependence on monitors. An aviation analogy would be transferring from visual to instrument flight rules during poor weather or night flying, a situation recognized to increase accident rates, stress and workload.

Even simple items of anaesthetic equipment may contain the properties of a latent error, for example the packaging of disposable items such as the Guedel oropharyngeal airway using materials which may occlude the airway (fig. 8). Drug ampoule labelling has been the attention of much debate and a comprehensive solution to the misinterpretation of ampoules has yet to be found.\textsuperscript{19,26,49,50}

Frequently latent errors cannot be identified before an activity and only vigilance and luck prevents more incidents becoming accidents. Case reports, safety notices and the roles of the Committee of Safety in Medicines and Medicines Control Agency are examples of systems which involve vigilance but also demand dissemination of important information accurately, expeditiously and with clarity.

PSYCHO-PHYSIOLOGICAL STATUS

The psycho-physiological state of the anaesthetist may influence considerably the incidence of error and his or her performance. Factors to consider include the effects of immediate and underlying stress and personality trait. Eysenck described three descriptors of personality type: extroversion (extroversion and introversion), neuroticism (stability) and psychotism. Extroversion and neuroticism have been identified as useful indicators of risk personalities in aviation and road traffic accidents but although personality tests are used by civil airlines, their use by the military is limited. Good pilots and perhaps good anaesthetists tend to be stable extroverts. Extroverts who are unstable make errors but of a different nature to introverts, tending to be risk takers enjoying the thrill of being near the edge. In contrast the unstable introvert gives in early when difficulties are mounting. In military aviation the latter may eject early with the unnecessary loss of the aircraft while the former does not eject at all with the loss of aircraft and pilot. Simple observation may identify anaesthetists who tend to fall into one category or another with associated risk taking and error prone behaviour.

**Personality**

The influence of personality must be viewed in the light of the presence of extraneous stressors. Although stress is usually viewed as a negative phenomenon this only describes those situations which are outside normality and necessity. In 1908 Yerkes and Dodson described a model of the

![Figure 7](image7.png)  
*Figure 7* Ergonomic design failures in an anaesthetic monitoring system. “Alarms suspended” shown at the screen periphery (upper monitor) or shown as remainder of screen information (lower monitor).

![Figure 8](image8.png)  
*Figure 8* A latent error in the packaging of a Guedel airway.

![Figure 9](image9.png)  
*Figure 9* The Yerkes—Dodson relationship between arousal and performance (reproduced with kind permission of Butterworths, London).
influence of stressors on performance demonstrating that the optimum performance of a task occurs at a particular stress level (fig. 9).69 Too little leads to drowsiness, reduced vigilance, errors of omission and slowed reactions. Too much results in increased response to false alarms, narrowing of attention, disruption of organized thought, startle reactions, increased speed but reduced accuracy of motor activity, and finally panic. Others support the view that excess workload results in a reduced capacity for information processing.41 However, the Yerkes–Dodson concept can be criticized.29 For example it suggests that an identical performance decrement will occur at high and low stress levels whereas it is recognized that these states produce opposite effects on attentional selectivity. Further, performance changes caused by heat-induced arousal are different from those caused by noise. Despite these reservations the inverted “U” relationship between arousal and performance represents a useful model.

Stress factors

Stressors appear in many forms. They may be immediate in time and place such as noise, heat, vibration and excess or too little light, or they may be more remote but no less intrusive: family and financial worries, career uncertainty, effects of unusual or excessive work schedules, poor team co-operation and the memory of prior incidents or accidents. Inadequate debriefing and support after the latter may induce a vicious cycle of increased endogenous stress and risk of accident recurrence. Stress, intrinsic to the task, may arise acutely if the task is not completed successfully. Consequently the performance of the individual may deteriorate inducing a vicious cycle of more stress and less success (synonymous with the headless chicken).

The effect of different extraneous stressors on performance has been subject to much study. Anaesthesia is often practised in noisy environments and the effects of noise have been reviewed by Kam, Kam and Thompson.40 The perception of sound is complex and several different scales have been derived to describe sound levels, human sound perception and noise.

Aural communication between the anaesthetist and his colleagues and monitors requires an acceptable signal to noise ratio. For all the elements of speech to be heard they must be spoken at least 15 dB above the ambient noise level. However, there is much sound redundancy in speech and intelligibility depends on the content, context and prior experience of the listener. Consequently, a 10-dB separation usually allows 100% reception. Sound levels exceeding 105 dB cause discomfort, and intelligibility may fall because of sound distortion by the ear itself. Auditory alarms may be subject to auditory masking. For a second alarm to be recognized the volume required increases as the sound frequencies of the two alarms approach each other.52

Abrupt changes in noise level may induce startle reactions reducing performance long after the sound and is the mechanism of action of the military stun grenade. High continuous noise levels increase arousal, reducing error in repetitive, monotonous tasks. However, performance of complex tasks decreases with reduced accuracy, poor response to the unexpected, increased annoyance and induction of fatigue. Additionally the effect of noise cannot be viewed in isolation to other stressors nor can the accuracy of hearing be isolated from the performance of other faculties.

Vibration is a stressor not commonly experienced by anaesthetists but can be of significance to those involved in patient transport, particularly in helicopters. Different structures of the human body have varying natural resonances, and exposure to vibration may impede sensory input and motor function (table 1). Helicopter flight may induce a disparity between the oscillation of the eye and the display of the monitor and intense effort may be needed in trying to obtain useful visual information. Additionally vibration may cause significant changes in arterial pressure, reduce tactile feedback, induce fatigue and motion sickness. MacNab and colleagues measured noise and vibration in emergency transport vehicles used for the transport of neonates (land, air and water) and recorded maximum vibration levels in excess of those considered extremely uncomfortable for adults.46

The effects of fatigue on performance and error have been assessed. Fatigue is linked to circadian influences and work schedules. Perhaps surprisingly studies have failed to show conclusively that fatigue is associated with a significant degradation in performance but some have suggested increased response times and reduced accuracy. An analysis of adverse occurrences in an intensive care unit demonstrated peak reporting between midnight and 01:00.1 Clearly, results depend on the level of fatigue which is influenced by the time of day, time since sleep or rest, time on task and nature of task. In addition, although fatigue may not induce failure it may reduce feelings of well-being.

In 1967 Holmes and Rahe evaluated and scored life stressors in terms of life change units.38 The development of the “schedule of recent experiences” enabled 42 life stressors to be weighted according to subjective assessments. There is a correlation between this score and the prevalence of physical and psychiatric illness. This scoring system has been criticized, particularly in its failure to separate

<table>
<thead>
<tr>
<th>Function</th>
<th>Organ or tissue resonant frequencies (Hz)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech</td>
<td>6–20</td>
<td>Loudness modulation with ↓ intelligibility</td>
</tr>
<tr>
<td>Vision</td>
<td>20</td>
<td>Intraocular structures vibrate. Facial flutter</td>
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<tr>
<td></td>
<td>30–40</td>
<td>Vestibulo-ocular reflex: compensation with ↑ effort to 25 Hz</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>Pursuit reflex: ↓ function &gt; 1 Hz or 40° s⁻¹</td>
</tr>
<tr>
<td>Motor</td>
<td>2–6</td>
<td>↓ control outstretched hands</td>
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</tbody>
</table>
“positive” experiences from “negative” and a further development by Sarason, Johnson and Siegel suggests that negative events are of much greater importance than change alone.57 Life stress has been demonstrated to be present in those blamed for aviation accidents but absent from those considered blameless.3

Excess or adverse stress may induce failure to cope. This may result in internalization of feelings leading to social withdrawal and depression. Conversely, externalization may be suspected by increased defensiveness, hostility, arrogance, projecting blame onto others (“acting out”) and risk taking. General behavioural and life style changes may develop with increased alcohol ingestion, drug misuse, fatigue and illness.

Vigilance by colleagues and managers may help identify those who are failing to cope with stress. The aviation world accepts that this is not a medical disorder in itself and has replaced the term “failing aviator syndrome” with “aviator at risk”.47 Most stress reactions are now viewed as a normal response to excess stress and are termed “adult situational reactions” with the emphasis on the transitory nature of the stressor. It is increasingly accepted that anyone could have such an experience.

A greater understanding of the effects of stress may produce an increased awareness that stress is normal, occurs in everyone’s lives and is usually transitory. However, circumstances may dictate that help is needed and the systems used by the aviation industry result in a high recovery rate. To encourage discussion, it is imperative that a request for help is needed and the systems used by the aviation world accepts that this is not a medical disorder in itself and has replaced the term “failing aviator syndrome” with “aviator at risk”.47 Most stress reactions are now viewed as a normal response to excess stress and are termed “adult situational reactions” with the emphasis on the transitory nature of the stressor. It is increasingly accepted that anyone could have such an experience.

Illness?
M Medication?
S Stress?
A Alcohol?
F Fatigue?
E Eating?

Figure 10 Retaining own responsibility for current competency by checking one is not adversely affected by any of the above.

Team effort
So far the emphasis has been on the individual and the man–machine interface. However, it is recognized that the anaesthetist represents just one part of a complex system. The Australian incident monitoring study demonstrated that the system directly contributed to 25% of problems and was implicated in 90%.55

Individuals may be expected to use guidelines and procedures which have been developed by others, often working as committees. The work of a committee might reasonably be expected to reach an average or measured response to a problem. However, this is not always so. “Risky shift” represents the effect of the group’s solidarity in promoting a view which would otherwise be considered too extreme by any one individual. “Group think”, a concept developed by Janis, is a phenomenon associated with very cohesive groups where
individuals act, albeit subconsciously, to preserve the integrity of the group rather than express dissent. Consequently sensitive issues may be ignored. Importantly the committee’s conclusions may be based on deliberations far removed from the situation under discussion.

Pilots work as members of a team which includes other aircrew and ground staff. Anaesthetist’s work similarly requires a co-ordinated effort with other theatre staff and anaesthetic colleagues. Sharing workload within a team has advantages and disadvantages. The benefits include the allocation of task elements to individuals with specific expertise and may enable the workload for any one person to be kept to an acceptable level. However, the successful division of labour requires good leadership, communication and co-ordination. The current approach to the early management of trauma demands a well practised and cohesive specialist team. To achieve this requires time and training. Without this investment personality differences, lack of common language and intention are likely to increase the probability of error with a suboptimal outcome. In contrast with the parallel design of the trauma team, traditional management structures have tended to be of a serial format. Although the latter may emphasize the hierarchical nature of responsibility, the longer lines of communication may reduce management’s awareness of the requirements of those in direct contact with patients.

Accidents may reflect the quality of senior management, a point emphasized in the official reports on the Piper Alpha explosion, the Kings Cross underground fire and Clapham Junction railway accident.

The need for formal training in team management was recognized in the civil aviation industry with the introduction of line orientated flight training (LOFT) by North West Airlines in the 1970s and since then cockpit or crew resource management courses (CRM) have become an integral part of commercial civil flying training. Foushee described several examples where failure of communication within the team and poor assignment of responsibilities led to an in-flight critical incident or accident (address to the Western Psychological Association, San Francisco 28 April, 1983). Within the industry it is recognized that developments in aviation technology present new challenges to aircrews and there is no reason to believe that anaesthetic simulators are considered expensive and are not commonplace. The high cost of aviation simulators is offset by the recognition that many situations cannot be safely created in the air, rare scenarios need to be practised and the high fidelity makes simulated flight essentially “real” and therefore cost effective. Ovassapian has shown that the initial acquisition of fibreoptic intubation skills using simulation can be more efficient than training with patients. Commercial aviation simulators are required to be licensed and it may be that the performance of anaesthetic simulators needs to be assessed formally if simulation is to become a routine part of training. In the medico–legal field, anaesthesia is considered to be a high-risk specialty. The growth in litigation may ensure that anaesthetic simulation becomes routine and cost effective.

The performance of the team depends significantly on the qualities of its leader. In the latter half of this century psychologists have focused much of their interest on the interaction between individuals and the psychology of leadership. In 1971 Fielder proposed two orthogonal leadership factors. Successful leadership requires a balance between the dual requirements of achieving the task (initiating structure) and good group relationships (consideration). Best productivity is achieved by leaders who score highly for both goal (G) and people (P) orientation. In comparison, low G and high P scores produce good quality but poor productivity and high G and low P scores result in more work achieved but of poor quality.

It is important to remind ourselves that error does not equate with negligence. However, error is often deemed culpable in retrospect. Retrospective analysis is fraught with difficulties, not least because memory degrades rapidly tending to simplicity and coherence, contemporaneous records cannot fully and accurately reproduce the actual event and investigators’ interpretation may be influenced by their own prejudices. The need to examine all the circumstances surrounding an error as they existed at the time is to be emphasized. This said, Caplan and colleagues demonstrated agreement between

![Image](reproduced with kind permission of Butterworths, London).
anaesthetists of widely differing backgrounds when asked to review anaesthetic mishaps. Memory may be
influenced by many factors, for example auditory cues can distort visual or other memory significantly
(fig. 11) and this failure is used to advantage by the legal profession. Culpability may only be
appropriate for situations where there was extreme departure from acceptable standard practice without any
extenuating circumstances.

**Identifying errors**

Current systems used to identify error in anaesthetic practice are manifold (table 2). However, all have
limitations, particularly in that they rarely aim to provide a complete answer to why an error occurs.
Anonymous critical incident reporting has been introduced and large studies such as the Australian
incident monitoring study have reached some comprehensive conclusions. In particular, it is
recognized that 80% of critical incidents may have their origins in 20 categories. The Royal College of
Anaesthetists has published findings from its critical incident pilot study but although this categorizes the
events it fails to focus on causation. Focusing resources on a limited number of problems may be
the most efficient method of reducing error. Critical incident reporting systems are often based on the use
of questionnaires but it is recognized that these must be very carefully designed. The use of closed
questions may impose rigidity resulting in loss of valuable information whereas free expression may
provide much data but no answers. The overall length and structure of the questionnaire is
important if the responder is to be motivated to complete it. Careful wording of the questions is
needed to minimize the problem of response sets (acquiescence: giving an answer as expected by the
question; social desirability: answering as the expected norm). Semi-structured interviews have
been used and may be more effective in capturing data. Researchers in ergonomics have used many
techniques for identifying human error: Kirwan compares 12. This suggests that a universally
applicable method has yet to be discovered.

Identification of an error prone situation may enable a detailed and prospective analysis of the
problem to be undertaken. Several techniques have been developed which can be used to assess the
workload associated with a particular flying task. The subjective workload assessment technique
(SWAT) involves subjective examination of three core elements: time load, mental effort and psycho-
logical stress. These are scored by the crew at regular time intervals and then the whole task can be
analysed to detect phases when workload is inappropriate and error becomes likely. Application
of these techniques in anaesthetic practice may help identify periods of risk. However, such analyses are
very labour intensive and the presence of an observer is likely to influence the behaviour of the
observed.

The review of anaesthetic mishaps should be made by those trained in seeking the truth in a
sympathetic and neutral manner. The keywords for investigators are accessibility, confidentiality and
advocacy. However, occasions may demand that public safety assumes priority. Anaesthetists should
be encouraged to record confidentially and anonymously their experiences as soon as possible after the
event without endeavouring to analyse or justify their actions. Investigation of individual incidents should
entail examination of contemporaneous records supplemented by questionnaires and interviews. The
data should be pooled to provide a database from which patterns of error may emerge encouraging
prevention.

The work of the anaesthetist exposes him or her to emotionally stressful situations. Involvement in cases
where patients suffer unexpected injury or death can be particularly difficult to cope with, especially if the
doctor considers him or herself to be at fault. Post-traumatic stress disorder (PTSD) is now a well
recognized clinical disorder and was accepted into UK law after the Herald of Free Enterprise disaster.
It is defined as “the development of characteristic symptoms in an individual after a psychological
traumatic event that is generally outside the usual range of human experience and one that would be
markedly distressing to anyone”. It may last indefinitely. To minimize the development of PTSD, those involved in anaesthetic mishaps may need to undergo critical incident stress debriefing.
After aviation accidents there are well established systems for helping all involved and guidelines have
been published.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Current mechanisms for investigation of error, critical incidents and accidents in anaesthesia and aviation</th>
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<tbody>
<tr>
<td><strong>Anaesthesia</strong></td>
<td><strong>Aviation</strong></td>
</tr>
<tr>
<td>Discussion with colleagues</td>
<td>Discussion with colleagues/line manager</td>
</tr>
<tr>
<td>Discussion with senior mentor</td>
<td>Discussion with aviation medicine specialist</td>
</tr>
<tr>
<td>Morbidity and mortality conferences</td>
<td>Confidential human factors incident reporting programme</td>
</tr>
<tr>
<td>Critical incident studies/reports</td>
<td>Case reports and hazard notices published in journals</td>
</tr>
<tr>
<td>Medical audit</td>
<td>Civil Aviation Authority investigations</td>
</tr>
<tr>
<td>National mortality surveys (Scottish mortality study)</td>
<td>Coroner or fiscal enquiries</td>
</tr>
<tr>
<td>Employing authority enquiries</td>
<td>Air accident Investigation Branch (Department of Transport)</td>
</tr>
<tr>
<td>Case reports and hazard notices published in journals</td>
<td>US National Transportation Safety board investigations</td>
</tr>
<tr>
<td>Coroner or fiscal enquiries</td>
<td>International Civil Aviation Organization reports</td>
</tr>
<tr>
<td>Confidential enquiry into peri-operative deaths</td>
<td>Media investigations</td>
</tr>
<tr>
<td>Medical Defence Organization reports</td>
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</tbody>
</table>
Prevalence of human error

To justify expending resources to reduce the incidence of human error it is important to assess the size of the problem. Mortality directly attributable to anaesthesia is quoted at 1 per 10 000 anaesthetics given to approximately 3 per 500 000.8,20 Morbidity is harder to estimate and is probably under reported. The risk of death in an aircraft accident is of a similar order. In 1982 there were just over 1000 fatalities in passenger aircraft accidents out of a total of approximately 755 million passengers journeys over 14 million flying hours (approximately 1 death per 75 500 passengers).39 It is difficult to estimate the incidence of critical incidents, particularly as definitions vary. Derrington lists 10 definitions from different studies.23 I propose the following: “a critical incident is a human error or equipment failure that if not corrected leads to an undesirable outcome. An accident is the consequence of a critical incident, which uncorrected, progressed to an undesirable outcome”.

It has been suggested that the word accident represents a conceptual ambiguity and should be disqualified from technical use.26

Despite differences in study design and definitions, estimates of the contribution of human error to critical incidents and accidents in anaesthesia and aviation during the past 15 yr are surprisingly similar (table 3). This supports the notion that there are fundamental mechanisms causing error. The prevalence has appeared to increase in both anaesthesia and aviation which may reflect growing complexity but may also be a result of increased recognition.

Improvements in equipment, training and regulation have failed to reduce the contribution of pilot error to aviation accidents. This may reflect the increasing complexity of the aviation world. The practice of anaesthesia has also become increasingly complex. Patients and their relatives have greater expectations as do our surgical and nursing colleagues. This is reflected by the growth in medical litigation. In the USA 80% of malpractice claims filed between 1935 and 1975 were filed during the last 5 yr of that period.11

For commercial pilots human factors education is incorporated into cockpit or crew resource management courses and both trainees and the qualified are taught how to recognize and manage stress. Anaesthetists may benefit from similar formal training with the potential for improved team effort, staff satisfaction and patient outcome.

Conclusions

In summary, although the practice of anaesthesia is commonly deemed safe, the profession rightly seeks for continual improvement in quality. Human error remains and will probably always be the primary cause of accidents. This error may be focused on the performance of the individual, the team or the system. Its origin is likely to be multifactorial and complex to resolve. Gaba and colleagues have proposed strategies for preventing anaesthesia accidents but there is a need to continue to research into the causes of error, both in the field of research psychology and specifically in the practice of anaesthesia.15,34 Error and critical incident terminology needs clarification so that comparative work becomes easier. There is also a need for anaesthetists to be formally trained in human factors, including team management. Finally, the appointment of an anaesthetic accident investigation team, working independently of any medico–legal process, could provide the necessary expertise to reach valid conclusions. To this end the establishment of the Critical Incident Pilot Study Steering Group by the Quality of Practice Committee of the Royal College is a useful step.

“The greatest mistake you can make in life is to be continually fearing you will make one.”

Elbert Hubbard. The Note Book, 1927.

Table 3  Prevalence of human error in critical incidents in anaesthesia and aviation. (m) = Military aviation, (s) = anaesthetic simulation. *64% for instant reporting and 70% for retrospective analysis; †58% aircrew error/47% supervisory error, ÷hot-air ballooning

<table>
<thead>
<tr>
<th>Anaesthetics (Reference)</th>
<th>Human error (%)</th>
<th>Aviation (Reference)</th>
<th>Human error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craig and Wilson 198117</td>
<td>65</td>
<td>Sanders and Hoffman 1975 (1949) (m)56</td>
<td>62.4</td>
</tr>
<tr>
<td>Cooper and colleagues 198416</td>
<td>64.70*</td>
<td>Sanders and Hoffman 1975 (1964–69)59</td>
<td>58</td>
</tr>
<tr>
<td>Currie 198958</td>
<td>82</td>
<td>Sanders and Hoffman 1975 (1958–72) (m)56</td>
<td>80</td>
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<td>De Ande and Gaba 1990 (s)22</td>
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<td>Wright and colleagues 199117</td>
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<td>Vyrnwy-Jones 1985 (1971–82) (m)63</td>
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<td>Williamson and colleagues 199396</td>
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<td>Guohua Li 199435</td>
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