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Anaesthesiology as a model for patient safety in health care

David M Gaba

Although anaesthesiologists make up only about 5% of physicians in the United States, anaesthesiology is acknowledged as the leading medical specialty in addressing issues of patient safety.[1] Why is this so?

Firstly, as anaesthesia care became more complex and technological and expanded to include intensive care it attracted a higher calibre of staff. Clinicians working in anaesthesiology tend to be risk averse and interested in patient safety because anaesthesia can be dangerous but has no therapeutic benefit of its own. Anaesthesiology also attracted individuals with backgrounds in engineering to work either as clinicians or biomedical engineers involved in operating room activities. They and others found models for safety in anaesthesia in other hazardous technological pursuits, including aviation.[2 3]

Secondly, in the 1970s and '80s the cost of malpractice insurance for anaesthesiologists in the United States soared and was at risk of becoming unavailable. The malpractice crisis galvanised the profession at all levels, including grass roots clinicians, to address seriously issues of patient safety. Thirdly, and perhaps most crucially, strong leaders emerged who were willing to admit that patient safety was imperfect and that, like any other medical problem, patient safety could be studied and interventions planned to achieve better outcomes.

Summary points

- Anaesthesiology is acknowledged as the leading medical specialty in addressing patient safety
- Anaesthesia is safer than ever owing to many different types of solutions to safety problems
- Solution strategies have included incorporating new technologies, standards, and guidelines, and addressing problems relating to human factors and systems issues
- The multidisciplinary Anesthesia Safety Foundation was a key vehicle for promoting patient safety
- A crucial step was institutionalising patient safety as a topic of professional concern
- Although anaesthesiology has made important strides in improving patient safety, there is still a long way to go

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Accomplishments in patient safety in anaesthesiology

Anaesthesia: safer than ever

It is widely believed that anaesthesia is much safer today (at least for healthy patients) than it was 25 or 50 years ago, although the extent of and reasons for the improvement are still open to debate. Traditional epidemiological studies of the incidence of adverse events related to anaesthesia have been conducted periodically from the 1950s onwards.[4–6] Many of these studies were limited in scope, had methodological constraints, and cannot be compared with each other because of differing techniques. An important outcome has been the emergence of non-traditional investigative techniques that aim not to find the true incidence of adverse events but to highlight underlying characteristics of mishaps and to suggest improvements in patient care.

Such techniques have included the "critical incident" technique adapted by Cooper from aviation[2 7]; the analysis of closed malpractice claims[8]; and the Australian incident monitoring study (AIMS).[9–12] These approaches analyse only a small proportion of the events that occur but attempt to glean the maximum amount of useful information from the data.

Technological solutions

Once the range of patient safety problems in anaesthesiology had been defined, several strategies have been used to improve safety. One is to apply technological solutions to clinical problems. Anaesthesiologists have become expert at realtime monitoring of patients (both electronically and via physical examination). In the industrialised world electrocardiography, pulse oximetry, and capnography (analysis of carbon dioxide in exhaled gas) have become standards and are thought to have contributed substantially to safety. No study to date, however, has had sufficient power to prove an outcome benefit from the use of these

technologies.[13] Another technological strategy is the use of "engineered safety devices" that physically prevent errors from being made. There are many of these in anaesthesiology, but a classic example is the system of gas connectors that prevent a gas hose or cylinder from being installed at the wrong site.[14]

New technologies have also been developed for managing the patient's airway, resulting in a plethora of useful devices. In particular, the adoption of fibreoptic laryngoscopy has revolutionised the management of patients with known anatomical difficulties in endotracheal intubation, and the laryngeal mask airway has secured important niches in both routine and emergency airway management.

Standards and guidelines

A second strategy adopted by anaesthesiologists in the United States in the 1980s was the promulgation of "practice parameters" (standards and guidelines) developed to provide guidance or direction for the diagnosis, management, and treatment of specific clinical problems.[15] The first set of standards for basic monitoring was developed by the Harvard hospitals,[16] and similar ones were later adopted by the American Society of Anaesthesiologists. These standards included such basic requirements as the continuous presence of a qualified anaesthetist, the use of electrocardiographic monitoring, and assessment of ventilation. The standards have since been updated to require pulse oximetry for patients during anaesthesia of all types and during post-anaesthesia recovery, as well as the use of capnography during general anaesthesia.

The monitoring standards, though voluntary, are thought to have been effective in ensuring that these basic practices are followed and represent a de facto standard of care. They have also been matched by similar standards in other countries. Other standards from the society with important implications for patient safety have dealt with the management of the difficult airway, sedation and analgesia by non-anaesthesiologists, and office based anaesthesia.

Human factors and the systems approach to patient safety

Anaesthesiologists have also been leaders in applying techniques and lessons from human factors engineering and the systems approach to safety. Analysis of anaesthesiologists' tasks dates back nearly 30 years[17] and has grown in sophistication.[18] Investigators have analysed the decision making processes in anaesthesiology with various methods, including direct observation,[19] review of videotapes of real cases,[20] assessing the descriptions of cases presented at morbidity and mortality meetings, and the use of patient simulators.[21] Much of the work has been conducted by academic anaesthesiologists who adopted the techniques of the human factors field. This "inside out" approach—in which the practitioners are also the researchers—has been powerful both for generating knowledge and for generating a cadre of safety experts. These "insiders" have also succeeded in generating interest among a number of well known "outside" human factors researchers—most of whom develop close links with anaesthesiologist collaborators.

Anaesthesiologists have been leaders in looking at safety from the standpoint of systems as well as individuals. In 1987 the work of Charles Perrow on systems issues in accidents was applied to anaesthesiology,[3 22] and, soon after, the work of James Reason on the latent error model systems accidents was incorporated.[23 24] In 1990 the Anaesthesia Patient Safety Foundation and the US Food and Drug Administration sponsored a groundbreaking expert workshop on human error in anaesthesiology. This brought together experts in human performance, human error, and organisational safety and experts on error and safety in anaesthesiology. Currently, anaesthesiologists are also involved in considering the theory of high reliability organisations (see article by Reason, p 768) as a model for performing highly hazardous activities with very low failure rates.

Applications of patient simulation

Anaesthesiologists have been pioneers in developing and applying patient simulators for research and training (see box and figure). Helmreich's article (p 781) deals with some of the simulation based, teamwork oriented training in more detail.

Simulation for research and training

Anaesthesiologists pioneered the development of computer screen and mannequin based interactive patient simulators and also have created most of the training plans for their use.[25–33] Use of patient simulators has become widespread in anaesthesiology and has expanded into other areas.

Advantages of simulation for research, training, and performance assessment

- No risk to patients
- Many scenarios can be presented, including uncommon but critical situations in which a rapid response is needed
- Participants can see the results of their decisions and actions; errors can be allowed to occur and reach their conclusion (in real life a more capable clinician would have to intervene)
- Identical scenarios can be presented to different clinicians or teams
- The underlying causes of the situation are known
- With mannequin based simulators clinicians can use actual medical equipment, exposing limitations in the human-machine interface
- With full re-creations of actual clinical environments complete interpersonal interactions with other clinical staff can be explored and training on teamwork, leadership, and communication provided
- Intensive and intrusive recording of the simulation session is feasible, including audiotaping, videotaping, and even physiological monitoring of participants (such as electrocardiography or electroencephalography); there are no issues of patient confidentiality—the recordings can be preserved for research, performance assessment, or accreditation

Applications and target groups

- Education of students (high school and professional school in physiology, pharmacology, or physical assessment)
- Training for allied health professions
- Training of clinical students in routine procedures and specialty specific medical issues
- Training of junior doctors (residents) in routine procedures and in critical events
- Training of healthcare staff in crisis management
- Preprocurement assessment of clinical equipment
- Staff training in the use of clinical equipment
- Performance assessment of all grades of medical staff
- Research on decision making by clinicians, on human-machine interactions, and on factors that affect performance (such as fatigue)

Patient safety in anaesthesiology—a glass only half full

Anaesthesiologists are justly proud of how their profession has acknowledged and begun to tackle tough issues in patient safety. The glass of patient safety in anaesthesiology, however, although fuller than in other healthcare fields, is still only half full:

- The overall reduction in negative outcomes that are related to anaesthesia may not be as great as the purported drop in mortality resulting from anaesthesia alone for healthy patients having routine surgery. Errors, mistakes, and system failures continue to plague anaesthesiology as well as the other healthcare fields
- Death or brain damage still occurs from hypoxaemia after oesophageal intubation or from other easily detectable and correctable events, even when modern monitoring technologies are in place
- The most basic standards are not followed uniformly—reliable anecdotes persist of anaesthetised, paralysed, and ventilated patients being left without an anaesthetist in the room, even in reputable hospitals
- Advanced simulation training is available only to a tiny minority of anaesthetists, and no certification requirement exists for continuing skills training or performance assessment
- Clinicians still practise when fatigue, illness, or stress prevent them from performing optimally
- Even modern equipment remains beset by human error; knowledge levels and training of clinicians about equipment remain suboptimal.
- It is therefore important to recognise that the various safety advances that have been made in anaesthesiology are an important model for the rest of health care, but they remain a work in progress and will require long term commitment to achieve their full promise.

Institutionalisation of safety

In the long term the most important contribution of anaesthesiology to patient safety may be the institutionalisation and legitimisation of patient safety as a topic of professional concern. The formation in 1985 of the Anesthesia Patient Safety Foundation was a landmark. Unlike other professional trade organisations, such as the American Society of Anesthesiologists, the foundation can bring together many constituencies in health care that may well disagree over economic or political issues but which all agree on the goal of patient safety.

The foundation has several prominent activities. Its quarterly newsletter is mailed to every anaesthesiologist and nurse anaesthetist in the United States. The newsletter is currently the pre-eminent publication in the world on anaesthesia and patient safety and is thought to have the widest circulation of any publication in anaesthesiology. The foundation also runs a programme of research grants, which has funded many important projects that would probably never have been funded by a "traditional" agency. In the first 13 years of the programme, for an investment of about $1.5m (£937 500), 159 publications resulted directly or indirectly from such funding. Among the important topics of investigation have been patient simulation, human factors or human performance, outcome assessment, and the formation of carbon monoxide in the anaesthesia breathing circuit.

Simulation room of the simulation centre at VA Palo Alto Health Care System, California, with arthroscopic knee surgery in progress. The computerised patient mannequin and associated equipment provides clinical cues and electronic data to patient monitoring devices. The simulator is controlled from an adjoining control room

Yet the most influential outcome of the grants programme may be not the knowledge gained but the new cadre of investigators and scholars it has fostered by creating a source of funds and an intellectual home for individuals devoting their careers to patient safety. A similar story can be told for the Australian Patient Safety Foundation, whose relative influence has far exceeded the size of the Australian population.

Recently, the American foundation has taken a stand on several policy issues based on the principle of establishing a burden of proof regarding practices or policies that seem to deviate from existing norms. The foundation believes that in all cases the default policy should be the one that at face value seems to yield maximum patient safety (a "fail safe" approach). If clear and convincing data are presented showing that an alternative policy is equally safe, it can be adopted. In the absence of such data the apparently safer policy should prevail. The foundation has recently advocated, for example, that a single standard of safety for surgical and anaesthetic procedures should exist, whether these take place in a hospital, an outpatients unit, or a physician's office. The default assumption is that achieving this unified standard will require functionally equivalent organisational features including equipment, staff, emergency backup, and accreditation in each of the practice settings. The burden of proof to provide convincing data to overturn this assumption rests with those who believe that the physician's office can be a safe site for anaesthesia and surgery without these features.

It is no wonder that when the American Medical Association decided to create a National Patient Safety Foundation it did so in open imitation of the methods and success of the Anesthesia Patient Safety Foundation.[34] If the national foundation and other similar organisations throughout the world can replicate the cadre forming aspects of the anaesthetists' foundation (as well as its roles in education and research), patient safety in all areas of health care will probably make great leaps forward. None the less, this will only be achieved with hard work—the price of patient safety is eternal vigilance.

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Competing interests: The author is the secretary of the Anesthesia Patient Safety Foundation. He also licensed simulation technology to CAE-Link in 1992, for which he received a licence and royalties on the sale of patient simulators. He is also, periodically, a paid consultant to MedSim, the company that now owns the rights to the licensed simulation technology.

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Using information technology to reduce rates of medication errors in hospitals

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Data continue to show that medication errors are frequent and that adverse drug events, or injuries due to drugs, occur more often than necessary.[1–4] In fact, the frequency and consequences of iatrogenic injuries seems to dwarf the frequency of other types of injuries that have received more public attention, such as aeroplane and automobile crashes.[2] A recent meta-analysis reported an overall incidence of 6.7% for serious adverse drug reactions (a term that excludes events associated with errors) in hospitals.[4] Between 28% and 56% of adverse drug events are preventable.[3 5–7]

Though the reasons this issue has received so little attention are complex, the reasons that medical injuries occur with some frequency are perhaps less so; medicine is more or less a cottage industry, with little standardisation and relatively few safeguards in comparison to, say, manufacturing. In fact, most of the systems in place in medicine were never formally designed, and this holds for the entire process of giving drugs.

Take, for example, the allergy detection process used in our hospital several years ago, which was similar to that used in most hospitals at the time. Physicians, medical students, and nurses all asked patients what their

Summary points

Although information technologies are widely used in hospitals, relatively few data are available regarding their impact on the safety of the process of giving drugs

Exceptions are computerised physician order entry and computerised physician decision support, which have been found to improve drug safety

Other innovations, including using robots to fill prescriptions, bar coding, automated dispensing devices, and computerisation of the medication administration record, though less studied, should all eventually reduce error rates

The medication system of the future will include these and other technologies, all electronically linked