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Human factors in anaesthesia: lessons from aviation

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Key points

- The aviation safety experience has useful lessons for healthcare and anaesthesia.
- Effective human factors improvements will also need simple and strong safety systems.
- Safe hospital practices will have similarities with those in aviation, but also important differences.

Summary. Aviation safety has evolved over more than a century and has achieved remarkable results. Applying some of the lessons learned may help make healthcare safer. From the perspective of an anaesthetic background and some thousands of hours of airline flying, I offer a personal perspective, try to give a sense of the place of human factors in airline operations and some of the current problems, and make some suggestions as to what the NHS and anaesthesia might learn from this. Although many of the ingredients for safe operation are frequently already present in our hospitals, and some individual clinical areas and departments achieve high levels of reliability and safety, I will emphasize my firm belief that we cannot expect improvements in human factors training and awareness to be fully effective in the healthcare setting without the parallel development of a simple and strong safety system across organizations. In the process, we may find that the safe hospital turns out somewhat differently to the safe airline.

Keywords: anesthesiology; aviation; psychology, industrial; quality of health care; safety

Data continue to show that flight crew actions or inactions remain the largest single causal factor in aviation accidents and that human factors also have a major influence on safety in other areas, such as maintenance and air traffic control. However, and unlike in the past, current concepts in accident causation accept that error is inevitable and a result of human physiological and cognitive limitations. Furthermore, human involvement in complex systems is also both necessary and beneficial, by reason of our ability to adapt and be flexible.

Equally relevant in accident causation are organizational factors—such as organizational culture (production *vs* protection), the work environment, processes, and equipment—and also the understanding that all accidents are context-specific.[1] This leads to the idea that there can be resilient, high-reliability organizations, which are both fearful and flexible, and which aviation may approach in some respects.

Over the years, aviation has developed a number of defensive strategies and has achieved remarkable success in improving safety. Citing aviation as an example of practice from which healthcare could draw, three well-known authors described the process thus: 'Aviation safety . . . was not built on evidence that certain practices reduced the frequency of crashes (but) relied on the widespread implementation of hundreds of small changes in procedures, equipment and organization (to produce) an incredibly strong safety culture and amazingly effective practices. These changes made sense; were usually based on sound principles, technical theory or experience; and addressed real-life problems, but few were subjected to controlled experiments'.[2] They go on to single out anaesthesia as an area of practice in which safety has

advanced by comparable means, and suggest that healthcare as a whole should learn from this.

Why anaesthesia in particular should have evolved in this way is an interesting question in itself, and some speculative reasons include the observation that anaesthesia can be dangerous but has no therapeutic benefit of its own.[3] There is also the oft-quoted analogy between the three phases of flight (takeoff, cruise, and landing) and anaesthesia (induction, maintenance, and emergence) and the tongue-in-cheek description of both as 'hours of boredom punctuated by moments of sheer terror'. What *is* clear is that anaesthesia has been an early adopter of aviation techniques, including the use of simulation and checklists, and is in the forefront of the promotion of human factors in clinical practice.

Human factors in aviation

The relevance of human factors in improving safety cannot be overstated and this was realized and acted upon in aviation more than two decades ago with the introduction of human factors training (Fig. 1)[4–6] and the subsequent development of the NOTECHS system for assessment using observation of behavioural markers.[7] Similar developments have occurred in anaesthesia with the use of Crisis Resource Management training[8] and the Anaesthetists' non-technical skills system for behavioural marker assessment.[9]

The importance of a safety system

Despite the interest in, and enthusiasm for, the development of 'human factors' in healthcare, what often seems to be
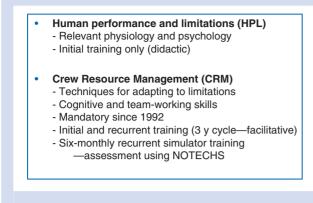
- **Human performance and limitations (HPL)**
  - Relevant physiology and psychology
  - Initial training only (didactic)

- **Crew Resource Management (CRM)**
  - Techniques for adapting to limitations
  - Cognitive and team-working skills
  - Mandatory since 1992
  - Initial and recurrent training (3 y cycle—facilitative)
  - Six-monthly recurrent simulator training
    —assessment using NOTECHS

Fig 1 Human factors training in aviation.

overlooked when using aviation as an example is that aviation and most other high-reliability organizations achieve results through a systematic approach to safety. Without this, the effectiveness of human factors training and awareness would necessarily be limited.

At the organizational level, this takes the form of a Safety Management System (SMS), which most airlines already implement and which is currently in the process of becoming mandatory for all commercial air operators.[10][11] The features of an SMS are very similar to those of clinical governance, but with the crucial addition of the requirement for an organizational manual (Fig. 2).

At the operational and individual level, this results in safety practices that are, increasingly, already present or are appearing in clinical settings (Fig. 3). However, if safer

- Safety policy
- Senior management accountable for safety
- Hazard identification and Risk management
- Organization manual
- Trained and competent personnel
- Reporting system
- Compliance monitoring system

Fig 2 Features of an SMS.

- Training, testing, licensing, revalidation
- Standard operating procedures
- Briefings
- Checklists and other aids
- Automation
- Non-normal strategies
- Fatigue risk management system (FRMS)
- Fatigue awareness and countermeasures training (FACT)
- CRM—cognitive and team-working skills

Fig 3 Aviation safety practices at the operational level.

healthcare is to be achieved and sustained, these will have to be underpinned by systematic reform across organizations to make safety integral to processes within medicine.

Standard operating procedures

These are formal processes, essential in aviation in allowing the formation of *ad hoc* teams, implementing best practice, and permitting monitoring, learning, and sanction. Although we may not always agree with them, they are generally welcomed by pilots as they serve to make life easier and also safer.

Although there is a fair amount of discussion of standard operating procedures (SOPs) in medical settings, particularly in the operating theatre, there seems to be a certain amount of reluctance to embrace them in practice, perhaps caused by a fear of being constrained in exercising clinical judgement and practical techniques.

What may not be realized is that, in the current mix of tradition, guidelines and protocols, 'best practice', 'private' routines, and several acceptable options, SOPs are already present. However, they are rarely developed, formalized, or made explicit to the degree that they are in aviation, and we still, unfortunately, read of avoidable accidents where failure to follow accepted practice is a feature.

Frequently, when processes *are* formalized, even those initially most sceptical, resistant, or uncomfortable, are appreciating unexpected benefits. This has occurred, for instance, when the introduction of preoperative briefings has resulted in reports of a better atmosphere in theatre, with staff feeling included and empowered, lists running more smoothly, and problems being anticipated earlier resulting in fewer interruptions and delays. Similar effects have been found when care packages or targeted initiatives have been applied in selected areas (such as preventing central line infections), when unfailing and close adherence to a standard procedure has resulted in significant improvements in outcome.[12]

Finally, SOPs are not immutable—they are servants, not masters. They can be developed and changed and can also be overridden when justifiable circumstances dictate.
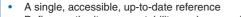
The role of the operations manual and checklists

One important means of implementation and expression of the components of the safety system in aviation is the Airline Operations Manual (AOM).

This incorporates not only the SOPs but also a wealth of information and guidance in an up-to-date, accessible, and highly structured format. Although pilots are not expected to know and remember everything contained in the AOM, they should be able to rapidly retrieve any required information.

For ease of distribution, access, and revision, the AOM is nowadays usually published electronically and can be made available on physical media or on a company intranet. It will be revised periodically and, for urgent updates between revisions, supplemented by regular 'crew notices'. Although the AOM is the formal source of operational

- A single, accessible, up-to-date reference
- Defines authority, accountability, and responsibility
- Incorporates Department of Health, College and governance requirements
- Standard procedures made explicit
- Origin of derived tools—e.g. checklists
- Allows learning and (rapid) implementation of change
- Facilitates monitoring and sanction

Fig 4 Features and benefits of a hospital operations manual.

information, newsletters, flight safety magazines, training presentations, and, of course, recurrent simulator and line training are all used to augment and reinforce knowledge.

I have suggested elsewhere that a Trust-wide operations manual would be an important tool in implementing systematic improvement in patient safety within the NHS (Fig. 4).[13]

The AOM also gives rise to checklists, both normal and abnormal (emergency), which are reproduced in easily accessible form for use in the flight deck. Unlike the way in which checklists are being used in some medical settings, checklists used by pilots are never ticked, signed, or directly audited—they are simply tools used to assist pilots to correctly complete and verify procedures. However, aviation engineering checklists, which are used for process control and audit, are frequently of the tick-box type.

The normal checklists may seem surprisingly brief and are presented on a laminated card. Abnormal and emergency checklists are usually found in a tab-indexed booklet, the Quick Reference Handbook (QRH). In addition to the checklist items, there is also sometimes a brief explanation of the reasons for actions, in order to aid situational awareness. A few checklists, for situations where immediate vital actions are required (such as decompression), also contain some items to be completed from memory.

The concept of a QRH could be readily and usefully applied in anaesthesia.[14] Rather than such information being available in notices stuck to the wall or cupboard doors or in diverse folders, a copy of a universal QRH might be present in each anaesthetic room or theatre. It would contain emergency drills for a variety of situations, presented in a standardized and practical format, perhaps with some memory items and a little explanation, as in the aviation version. Additionally, there could be some generic checklists—for example, for unexplained hypotension—and selected physiological and physical data. It would of course require trial and careful evaluation to ensure that it became a useful and effective tool.

Human factors and current problems in flight safety

One of the great achievements of aviation has been the development of comprehensive reporting and learning systems. Although their effectiveness may be limited to a variable degree by the perceived presence or absence of a

'just culture', these provide large amounts of flight safety data, which is supplemented by monitoring and recording of flight parameters.

As a result, flight safety is continually monitored and re-evaluated not only at a local level, but also nationally and internationally and is currently undergoing some degree of re-examination, prompted in part by the fact that the fatal accident rate which, although very low (at about 35 per year worldwide), appears to have stopped decreasing year-on-year.[15]

Worrying trends include:

- disregard of or failure to follow SOPs;
- loss of control and flight handling errors;
- lack of position awareness;
- poor judgement;
- lack of faith in a 'just culture', resulting in less effective reporting and learning.

Clearly, human factors issues are prominent here, and these, and other areas of concern, are among problems being addressed in a worldwide initiative to improve air transport safety. In Europe, this takes the form of the European Strategic Safety Initiative, a 10 yr programme focusing on 18 areas of concern for commercial aviation, including Safety Management Systems and Safety Culture.[16]

A personal perspective

Some personal observations may help illustrate not only the similarities but also the differences between the perspective of the anaesthetist in theatre and the airline pilot, and (hopefully) highlight the importance of good interpersonal and cognitive skills in aviation.

For the pilot, although there can be great views and often interesting sights or phenomena to observe, as in anaesthesia, the hours are often long and the role both technical and demanding, but with an additional degree of isolation. Unlike in theatre, there are limited opportunities to get up and walk around, receive visitors, and make phone calls, and although it is often not appreciated, an important function of the cabin crew is to make regular checks on pilots' wellbeing and ensure that they are kept well hydrated.

As a pilot, you are literally, and also metaphorically, at the sharp end. In the event of an accident, you will be the first to arrive and be very personally involved, and there is no doubt that this knowledge permeates everything one does.

Furthermore, although it might seem easier to work with a reliable and understandable machine rather than an alarming and unpredictable patient, this can be a misperception. First, we are working in a complex and changing environment of machines, people, airspace, weather, and operational requirements. The technology is highly reliable but can go wrong and, when it does, the complexity of the situation can escalate very rapidly. Design, documentation, and training, although comprehensive, primarily take account of predicted failure scenarios. However, as some accidents regularly remind us, it is not that uncommon for failures to occur

in new or unexpected ways and, on these occasions, protective technology and automation sometimes compound the situation.

In this environment, two heads are better than one and indeed you never 'do a list on your own'. There is always someone to share a problem with, but it is an unusual relationship. Most of the time it works well—even with someone you have not met before; the SOPs are effective in taking care of the technical aspects of co-operation. Nevertheless, however well you get on, you are trapped with this person for the duration of the flight and this can be quite challenging.

Occasionally, you may find yourself with someone inexperienced, with attitude problems, having a bad day or just plain difficult to get on with. Non-technical skills become particularly important and it helps to remember that good CRM is defined as making best use of *all* available resources. Your colleague is indeed a resource, and your life and that of everyone on board may depend on him or her. Therefore, it is in everyone's interests that you leave your ego behind and get the best out of them. Similar considerations apply to the relationship with the cabin crew, who also have a quite different culture to the flight deck (and it is clearly tempting, at this point, to draw an analogy between this and the differing cultures and perspectives of medical and nursing staff).

Thus, contrary to the perception of the captain as primarily a skilled and experienced pilot, his or her role and ability as a manager is of equal, if not greater, importance—both a manger of people who is able to make everyone feel welcome, valued, and empowered to speak up, and a strategic thinker and leader who is always aware of the big picture.

More and better training is required

Although aviation training in human factors, as described above, may seem very comprehensive compared with medical practice, ongoing training in this area does vary in depth and quality and with the culture of each organization. Non-technical skills are assessed in the simulator and 'on the line' and there is widespread acceptance among crew and (even) management of the importance of CRM. However, in general, there is probably insufficient ongoing formal training and practice in further developing individual skills so that it is even possible that some airlines could be bettered in this respect by anaesthetic departments where Crisis Resource Management training is well advanced.

It has been suggested that the main requirement to address current problems in flight safety is better training and mitigation of factors such as stress and fatigue.[15] Cost is clearly an issue, but a number of changes are currently taking place. One has been the introduction, in the USA, of the Airline Safety and Pilot Training Improvement Act 2009.[17] Another is a change in current training practice underway in some airlines. Known as ATQP (Alternative Training and Qualification Programme), this augments a fixed recurrent training syllabus with training more focused on

the individual company's needs, as determined by flight data monitoring and safety reports.

Another positive development is the more widespread use of training based on threat and error management (TEM) techniques. The TEM model was first developed as a tool for line operational safety audit (LOSA), where expert observers collect data on threats, crew behaviours, and outcomes during routine flights. This can then used to guide organizational strategy/CRM training.[18]

Are SOPs fit for human consumption?

The use of SOPs may bring issues around autonomy. LOSA has shown that violations—that is, deliberate failure to follow SOPs—are relatively common but are usually inconsequential[19] and can even, on occasion, be the stimulus for beneficial change.

Possible reasons for violations include interesting behaviours such as risk compensation[20] and system migration to boundaries,[21] but for a fuller discussion, see Reason.[22] Pilots may be seen as subject to conflicting demands: on the one hand, they are required to operate in a formalized way, surrendering some autonomy in the process, yet at the same time—and especially when things go wrong—they are required to be knowledgeable, innovative, and flexible. Most pilots seem to accommodate this dichotomy, regarding their ability to do so as a mark of their professionalism. If a more formalized healthcare system is needed to improve patient safety, clinicians may increasingly be required to do the same.[23] In the meantime, it will be interesting to see whether aviation or other industries come up with any other solutions or whether systems based on rule-based behaviours will always suffer from this weakness.

Dealing with loss of control

In aviation, loss of control can occur both literally and metaphorically when unusual or stressful situations occur. Our reaction to such events may be seen as a mixture of technical and non-technical responses, which are mostly under our conscious control. However, to this must be added our emotional and physiological responses, which are largely involuntary but always present and much harder to deal with. These responses are rarely discussed or specifically trained for, yet are capable of severely disabling our ability to think and act correctly.[24]

Most of the time, we avoid or successfully mitigate such situations using a combination of experience and training, together with procedures, checklists, and other props; the most experienced practitioners rarely find themselves in difficulty. However, should their strategies fail, even they may discover themselves to be no better equipped than new trainees. Furthermore, although the arrival of a colleague to assist in the event of difficulty in theatre or in the anaesthetic room is not an uncommon scenario and often helps, it has also been known to fail to ameliorate or even compound the situation.

Training reduces stress by providing practice and familiarization with specific situations. Perhaps it would also be

possible to specifically train generic self-rescue and team-rescue techniques for situations where this may fail: gaining knowledge of our own responses and how to mitigate their effects, and learning how best to give help to others.

Conflict of interest

None declared.

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