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Review

You Have Control: aviation communication application for safety-critical times in surgery

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Abstract

High-risk organisations (HRO), including aviation, undergo formal communication training, with emphasis on safety-critical moments. Such training is not widespread or mandatory in healthcare, and while there are many differences both share the ‘human element’ with circumstances leading to an increased risk of harm. A typical operating theatre consists of an operating surgeon, and an assisting surgeon, roles that may change throughout the course of a procedure. Similarly, a training aircraft or multi-crew cockpit (flight deck) has a pilot in control, or ‘pilot flying’, and a ‘pilot not flying’. Both interact with wider teams, for example the scrub team and air traffic controllers, respectively. Surgical error is the second most prevalent cause of preventable harm to patients after drug errors. Every year in the UK National Health Service (NHS), there are typically 500 never events, 21,000 serious incidents, and many more episodes of physical or psychological harm. Ineffective communication (46%) is the most common behavioural factor leading to a never event. In this review, we examine the concept of ‘sterile cockpit’, use of unambiguous terminology, call signs, important information readback, sharing of mental models, and the mini-brief, and how these may be used to reduce patient harm during safety-critical moments.

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Introduction

During a surgical procedure, there are safety-critical times which have a significant possibility of causing patient mortality or morbidity. These include surgical site selection, injection of local anaesthetic, use of surgical instruments and implantable materials, and dissection of critical structures.

In aviation, routine safety-critical times include those within the vicinity of an aerodrome, such as taxi, takeoff and landing plus weather avoidance along with non-normal system management when the aircraft systems are not performing correctly.

Both healthcare and aviation are safety-critical industries where risk is unavoidable. However, risk must be reduced to an acceptable level. In 2020 in the UK, all serious incidents (SI) and never events in healthcare are reported nationally via the Strategic Executive Information System (StEIS). In 2017–2018, NHS Improvement reported 21,000 serious incidents, and almost 500 never events.^{1,2}

Although there is no definitive list of SI, they have been broadly defined as ‘events in health care where the potential for learning is so great, or the consequences to patients,

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families and carers, staff or organisations are so significant, that they warrant using additional resources to mount a comprehensive response'.³ A never event is a largely preventable occurrence which should not occur. Never events directly applicable to surgery include wrong site operations, wrong implant or prosthesis, and retained foreign objects post-procedure.⁴ Wrong site surgery, which includes wrong tooth extraction, continues to occur, highlighting that current strategies are not completely effective and must therefore be developed.⁵

The 'Opening the Door to Change' review published in 2018 by the UK Care Quality Commission (CQC) examined safety culture in the NHS,⁶ and identified that 96% of issues require human factors-based solutions. The Human Factors Analysis and Classification System (HFACS) found inadequate communication (46%) as the most common behavioural factor leading to a never event.⁷ Observational studies have shown that 30% of dialogue between operating theatre team members contains errors such as poor timing, incomplete information, or instructions to the wrong staff members, with 36% of these failures resulting in visible effects on system processes. These include inefficiency, team tension, resource waste, delay, patient inconvenience and procedural error.⁸

Strategies to address communication HF include the 'sterile cockpit' approach, callsigns, unambiguous communication, readbacks, mini-briefs and checklists. Use of the widely accepted World Health Organisation surgical checklist has been examined extensively in the literature, so will not be considered here.

Developing safe communication

In order to operate a radio, a trainee pilot must pass a language proficiency test, theoretical and practical communication examinations, and hold a Flight Radiotelephony Operator's Licence (FRTOL). The Multi-Crew Co-Operation Course (MCC) teaches standardised communication between a pilot and co-pilot, and has both theoretical and practical simulator elements.

In the UK, communication between clinicians and patients/colleagues is taught during undergraduate medical training, and examined at postgraduate level by the Royal College of Surgeons (RCS) at both Membership (MRCS) and Fellowship (FRCS) level. However, no modules specifically examine safety-critical communication within the operating theatre. Basic Surgical Skills (BSS) courses introduce some terminology used by surgeons and assistants, but are mainly concerned with technical skills. The Non-Technical Skills for Surgeons (NOTSS) courses run by the Royal College of Surgeons of Edinburgh are not widespread or mandatory.

There is a diversity of educational backgrounds and experience within the surgical workforce, who have often trained within multiple international systems. Furthermore, the wider surgical team consists of scrub nurses, anaesthetists, operat-

ing department practitioners, porters, radiographers, health care assistants, amongst other allied professionals. While the diversity of experience in a team has many advantages, it also poses challenges for developing consistent, safe communication.

The preoperative team brief is the main opportunity to improve communication strategies within the team, and is an ideal time for the team to identify any parts of the operation which may be of concern and require specific enhanced communication or use of specific terminology. It is also a time to agree on general principles for communication during the operating list, such as the 'sterile cockpit' during safety-critical moments.⁹

Sterile cockpit

Aviation uses the term 'sterile', and applies it to the aircraft flightdeck environment reducing unnecessary noise and conversation during safety critical periods below 10,000 feet. This simple measure improves situational awareness, and reduces potentially dangerous distractions.

In comparison, the operating theatre is not an environment that is always protected from distraction. External distraction sources including questions from the surgical 'on call' team or other department members increase the likelihood of poor performance and team stress.¹⁰ Surgical errors increase significantly with flow disruptions and communication failures within the team carry the strongest predictor of surgical error.¹¹

Analysis of recorded theatre transcripts shows that 'irrelevant conversations' form the largest proportion of dialogue.¹² This is followed closely by questions about defective or missing equipment, or misunderstanding about how devices should be used. These are questions that should be addressed early in the team brief, rather than during critical phases of the operation.

Acoustic barriers to communication include theatre noise from suction or laminar flow, telephones and pagers, and enhanced Personal Protective Equipment (PPE), as in the wearing of FFP-3 masks and visors used during the current COVID-19 pandemic.¹³ Two-way radios have been used to communicate with staff outside theatre during high-risk surgical tracheostomy procedures for COVID-19 intensive care unit (ICU) patients. This reduces potential virus exposure to staff and other patients, but is an additional barrier to communication.¹⁴

Music is commonly played in the operating theatre. Although surveys have shown that staff feel music may have a calming influence,¹⁵ and perhaps even improve technical performance if selected carefully,¹⁶ requests have been found to be five times more likely to be repeated whilst music was playing in theatre.¹⁷

The sterile cockpit must be balanced with maintaining an effective working atmosphere, and maintaining team morale. Focus groups have highlighted that brief, standard-

ised communication in theatre may be interpreted as being unfriendly, or even rude, and may not be required as frequently as in aviation.¹⁸ When established in the cruise part of a flight, pilots often talk about non-flying matters while staying vigilant and maintaining situational awareness. Similarly, surgeons should signpost safety-critical moments of the procedure where distractions should be minimised, music switched off, and questions and queries saved until after the phase of operating in question. All of these can be agreed at the team brief.

Callsigns

In a busy aviation environment, it is crucial to be able to identify aircraft on the radio, and to obtain the pilot's attention in an urgent situation. Each radio transmission is prefaced with a callsign. In the UK, this is generally the registration of the aircraft, read using the phonetic alphabet. In any encounter with air traffic control (ATC), the pilot must use their full callsign until the controller has established there are no other aircraft with similar callsigns, at which point they will use an abbreviated version. The full callsign G-ABCD 'Golf-Alpha Bravo Charlie Delta' would be abbreviated to 'Golf-Charlie Delta'. The callsign is displayed on the flightdeck instrument panel. ATC will write down callsigns, often on paper slips, to ensure accuracy.

Addressing individuals directly in the operating theatre by name in a critical or emergency situation is preferable to asking for 'someone' or 'you' to complete a task. The team brief is an opportunity for individuals to introduce themselves and their role in full. However, the team are unlikely to be able to recall every name in the theatre in an urgent situation. Solutions include using a whiteboard with names and roles, or better, using printed theatre caps with bold type first names.¹⁹ If required, even using specific role titles such as 'anaesthetist, scrub nurse, assistant, radiographer' in an emergency is preferable to announcing to the room.

Reducing ambiguity

In aviation, the pilot operating the controls, known as 'in control' or 'pilot flying' is not necessarily the Pilot in Command (the Captain) who is responsible for the operation and safety of the aircraft at all times.²⁰ A pilot will commonly use the expression 'You have control,' acknowledged with the reply 'I have control'. The aircraft controls may be taken rapidly by the Pilot in Command during safety-critical moments by issuing the command 'I have control', if, for example, the aircraft is in a dangerous unstable approach to land.

When two or more surgeons are operating, ambiguity over who is actually performing the operation at any one time may cause harm to patients or surgeons. Although the senior surgeon (usually a consultant) has overall responsibility for the patient and may make the operative decisions,



Fig. 1. Safe and effective communication with air traffic control (ATC) is vital for safety when flying in controlled airspace, especially in a light aircraft as seen here over East London, UK.

they will frequently act in an 'assisting' capacity during training cases, rather than an 'operating' one. During or prior to safety-critical moments within the procedure, the surgeon 'operating' or 'assisting' may change. Uncertainty could lead to both, or neither surgeon attempting to control bleeding, to correct an incorrectly positioned and rapidly setting cemented implant, or to control vascular clamps, for example. In the UK non-medical practitioners (NMPs) are increasingly taking on the role of the surgical assistant.²¹ In these scenarios, the operating surgeon/assistant roles are less likely to change during the operation, but care must still be taken.

Harm to the surgeon could also occur from sharps injuries, with up to 44% of British surgeons anonymously admitting to injuries over a 12-month period, a figure underreported to Occupational Health departments.²² Confusion between operating surgeons may result in placing scalpels, needles, drills, or other sharp instruments into the surgical field whilst the other has a hand or finger present, risking a sharps injury.

We suggest that the phrases 'my operation' or 'your operation' are appropriately unambiguous at the start of a procedure. During surgery, unclear phrases such as 'do you mind if I show you this?', or 'I'll help you', or even placing sharp instruments or fingers into the surgical field unannounced can have potential safety implications. We have much to learn from the clear unambiguous commands and phrases in aviation. Ambiguity over who is controlling the head could result in displacing an anaesthetic airway. The clear phrases 'I have the limb/head' or 'you have the limb/head' guards against these risks.

During any radio exchanges between a pilot and ATC, (Fig. 1) certain words must not be used unless either party is issuing or confirming a clearance for the action. The words 'TAKE-OFF' are used only when an aircraft is cleared for take-off. At all other times the word 'DEPARTURE' is used. For example, the pilot will state 'ready for departure' rather than 'ready to take-off'. An aircraft accidentally taking off with other traffic ahead has clear serious implications. If a

pilot is descending towards the runway, the instruction ‘CONTINUE APPROACH’ is issued by ATC until such time as the runway is free of all traffic, rather than ‘LAND’.

Potentially ambiguous phrases in surgery can cause confusion. For example, asking the team to ‘get ready to mix the tissue glue’ may result in the team simply hearing ‘mix the glue’ resulting in waste, harm, or increased anaesthetic time caused by premature preparation. Stating ‘unpack the tissue glue’ in the first instance, and only using the word ‘mix’ at the time when this is required reduces ambiguity.

The position of surgical devices such as stents or clips is often irreversible once they are deployed. Using a phrase such as ‘deploy’ or ‘clip’, rather than an ambiguous ‘yes’ or ‘go’ makes it clear to the assistant or scrub nurse exactly what is required. As discussed above, a good opportunity to agree on these phrases is at the team brief.

Reading back safety critical information

In aviation, certain phrases and clearances must be read back by the pilot to the controller. These include the runway in use, altimeter pressure settings (important to give the correct height of the aircraft above the ground, for example), and clearance to taxi, take off, or land.

The use of readbacks is not an infallible system for safety-critical information. In both aviation and surgery, noise, ‘muffled’ speech, and regional accents may all contribute to misunderstanding.²³ Readbacks by pilots may be incorrect, and not corrected by ATC. A correct readback might therefore be followed by an incorrect action on the flightdeck.²⁴

An inability to challenge colleagues due to hierarchy gradients in the operating theatre can lead to patient harm.²⁵ Readbacks are a way of flattening hierarchy in the operating theatre, and improving situational awareness, as they allow a member of the team to challenge another to confirm safety critical information. As in aviation, if there is any doubt about if the information has been understood, team members should feel empowered to repeat it back.

Readbacks are already commonly in use in UK operating theatres when the surgeon checks expensive orthopaedic implants with the scrub team prior to them being opened, or local anaesthetic prior to it being drawn up. However, readbacks are not commonly used during other safety critical moments.

With safety critical information we suggest information should always be read back. Any implants, or drugs to be administered by the surgeon should be read back to the scrub nurse or the anaesthetist before they are given. Any surgical procedure which is about to be undertaken which could cause physiological disturbance, such as injecting local anaesthetic, or other substances, or working around the carotid bulb should be read back by the anaesthetist. A team member reading a time to the surgeon which could cause tissue ischaemia,

including tourniquet time during free flap harvest should be read back to ensure this has been acknowledged.

Sharing mental models

In multicrew commercial aviation operations, pilots routinely keep one another updated on their perception of what is going on and how it relates to their expectation. Since individual situational awareness cannot be directly measured, such verbalisation remains the sole dynamic means of building a real time understanding of perception of others. By setting one’s understanding like this, others have the opportunity to challenge perceptions and reduce errors.

Care needs to be taken not to lead others in doing so, since authority gradients and assertive statements of perception can form barriers to others’ independent thought, or willingness to challenge. Use of open questions is a highly effective means of encouraging others to present their understanding of the situation, especially when posed ahead of one’s own thinking.

Mini-briefs

The value of the mini-brief can be lifesaving. For example, the Royal Air Force (RAF) Elementary Flying Training (EFT) Syllabus mandates an additional brief in the air prior to one of the most dangerous manoeuvres, the spin, which has resulted in many fatalities.²⁶

Spinning is physiologically disorientating, increases workload to high levels, and requires assertive actions in order to recover. If the aircraft does not recover, it will quickly continue to descend uncommanded towards the ground, giving little time for discussion over correct actions.

The mini-brief is in addition to routine stalling or aerobatic checklist items, and is given by the aircraft commander prior to each spin. It includes, the actions the student pilot should take to recover, a minimum height to enter the manoeuvre, and emergency actions.

This mini-brief format can be adapted for intraoperative use prior to safety-critical moments in surgery. Examples of areas for consideration are provided in [Table 1](#). These might be relevant prior to complex parts of a procedure such as prior to microvascular anastomosis or before completing osteotomies, insertion of plates or other prosthesis (e.g. TMJ replacement).

Table 1

Areas that can be discussed at a mini brief at safety critical or other ‘high risk’ steps of a surgical procedure.

| |
|---|
| The conditions required for safe progression of the surgery |
| The actions to be taken |
| Emergency or ‘bail out’ procedures and options if required |
| Check understanding and invite questions |

Conclusion

In this article, we have examined how potential poor communication can contribute to patient harm and given examples of proven methods from aviation that improve communication during critical times.

Although there are important differences between aviation and surgery, and standardised phraseology across surgical specialties or teams may not be feasible, as healthcare professionals we should endeavour to reduce risk to acceptable levels. While there is currently no standard training for teaching intraoperative safety-critical communication in surgery, by using team briefs, and longer-term working within interdisciplinary teams, we have an opportunity to improve intraoperative patient care as well as morale in healthcare.

Ethics statement/confirmation of patients' permission

Not required.

Conflict of interest

We have no conflicts of interest.

References

- Panagioti M, Khan K, Keers Rn, et al. Prevalence, severity, and nature of preventable patient harm across medical care settings: systematic review and meta-analysis. *BMJ* 2019;**366**:l4185. Published 2019 Jul 17.
- Never Events reported as occurring between 1 April 2017 and 31 March 2018 – final update, NHS Improvement, April 2019.
- Serious Incident Framework. *NHS England Patient Safety Domain, March*; 2015.
- Provisional publication of Never Events reported as occurring between 1 April and 30 April 2020, NHS Improvement, June 2020.
- Pemberton MN. Wrong tooth extraction: further analysis of never event data. *Br J Oral Maxillofac Surg* 2019;**57**(9):932–4.
- 'Opening the Door to Change: NHS Safety Culture and the need for transformation, Care Quality Commission, December 2018.
- Thiels CA, Lal TM, Nienow JM, et al. Surgical never events and contributing human factors. *Surgery* 2015;**158**(2):515–21.
- Lingard L, Espin S, Whyte S, et al. Communication failures in the operating room: an observational classification of recurrent types and effects. *Qual Saf Health Care* 2004;**13**(5):330–4.
- Hicks CW, Rosen M, Hobson DB, Ko C, Wick EC. Improving safety and quality of care with enhanced teamwork through operating room briefings. *JAMA Surg* 2014;**149**(8):863–8.
- Wheelock A, Suliman A, Wharton R, et al. The Impact of Operating Room Distractions on Stress, Workload, and Teamwork. *Ann Surg* 2015;**261**(6):1079–84.
- Wiegmann DA, ElBardissi AW, Dearani JA, Daly RC, Sundt 3rd TM. Disruptions in surgical flow and their relationship to surgical errors: an exploratory investigation. *Surgery* 2007;**142**(5):658–65.
- Garosi E, Kalantari R, Zanjirani Farahani A, Zuaktafi M, Hosseinzadeh Roknabadi E, Bakhshi E. Concerns About Verbal Communication in the Operating Room: A Field Study published online ahead of print, 2019 Jul 15. *Hum Factors* 2019.
- Ellis R, Hay-David AGC, Brennan PA. Operating during the COVID-19 pandemic: How to reduce medical error. *Br J Oral Maxillofac Surg* 2020;**58**(5):577–80.
- Broderick D, Kyzas P, Sanders K, Sawyerr A, Katre C, Vassiliou L. Surgical tracheostomies in Covid-19 patients: important considerations and the ŠTsöf safety. *Br J Oral Maxillofac Surg* 2020;**58**(5):585–9.
- Padmakumar AD, Cohen O, Churton A, Groves JB, Mitchell DA, Brennan PA. Effect of noise on tasks in operating theatres: a survey of the perceptions of healthcare staff. *Br J Oral Maxillofac Surg* 2017;**55**(2):164–7.
- Muhammad S, Lehecka M, Huhtakangas J, Jahromi BR, Niemelä M, Hafez A. Meditation music improved the quality of suturing in an experimental bypass procedure. *Acta Neurochir (Wien)* 2019;**161**(8):1515–21.
- Weldon SM, Korikiakangas T, Bezemer J, Kneebone R. Music and communication in the operating theatre. *J Adv Nurs* 2015;**71**(12):2763–74.
- Pal A, Lal R, Frizelle F. Aviation-based teamwork skills work for surgeons: time for an 'aviation bundle'? *ANZ J Surg* 2018;**88**(12):1231–5.
- Burton ZA, Guerreiro F, Turner M, Hackett R. Mad as a hatter? Evaluating doctors' recall of names in theatres and attitudes towards adopting #theatrechallenge. *Br J Anaesth* 2018;**121**(4):984–6.
- Rules of the Air. *Annex 2., International Civil Aviation Authority*. tenth edition; 2005. July.
- Abraham J, Whiteman B, Coad J, Kneafsey R. Development and implementation of non-medical practitioners in acute care. *Br J Nurs* 2016;**25**(20):1129–34.
- Thomas WJ, Murray JR. The incidence and reporting rates of needle-stick injury amongst UK surgeons. *Ann R Coll Surg Engl* 2009;**91**(1):12–7.
- Tiewtrakul T, Fletcher SR. The challenge of regional accents for aviation English language proficiency standards: a study of difficulties in understanding in air traffic control-pilot communications. *Ergonomics* 2010;**53**(2):229–39.
- Prabhakar H, Cooper Jb, Sabel A, Weckbach S, Mehler Ps, Stahel Pf. Introducing standardized feedbacks to improve patient safety in surgery: a prospective survey in 92 providers at a public safety-net hospital. *BMC Surg* 2012;**12**:8. Published 2012 Jun 19.
- Green B, Oepfen Rs, Smith Dw, Brennan Pa. Challenging hierarchy in healthcare teams - ways to flatten gradients to improve teamwork and patient care. *Br J Oral Maxillofac Surg* 2017;**55**(5):449–53.
- GASCo Stall/Spin Working Group. *A Study of Fatal Stall or Spin Accidents to UK Registered Light Aeroplanes 1980 to 2008*. General Aviation Safety Council; 2010.