



Editorial

Awake craniotomy versus piloting an aircraft: What medicine and aviation can learn from one another?

Vini G. Khurana¹, Praveen Vats²

¹CNS Neurosurgery, Woolloomooloo, NSW, ²Royal Australian Air Force Reserves, Mount Waverley, Victoria, Australia.

E-mail: *Vini G. Khurana - reception@cnsneurosurgery.com.au; Praveen Vats - vatsy@me.com



*Corresponding author:

Vini G. Khurana,
Neurosurgeon and Director,
CNS Neurosurgery,
Woolloomooloo, NSW,
Australia.

reception@cnsneurosurgery.
com.au

Received : 26 March 19
Accepted : 07 April 19
Published : 07 June 19

DOI
10.25259/SNI-215-2019

Quick Response Code:



The “miracle of flight” and the “miracle of awake brain surgery” have numerous similarities. Both are founded on innumerable person-years of invention, trial, error, and considered refinement. For flight success, almost every step needs to go right. Rules must be followed based on cumulative learning from the past incidents and experience. Innumerable technical, technological, environmental, and interpersonal interactions must also converge to facilitate the completion of the mission. In neurosurgery and neuroanesthesia, similar protocols apply to perform awake craniotomies. Having been on “both sides” as medical practitioners and pilots, we can compare piloting an aircraft to carrying out an awake craniotomy in the context of our experience and the relevant medical and aviation literature.^[1-12] We have found that an intuitive comparison can be made between “flight mission” and “operative mission” (in this instance awake craniotomy) utilizing seven “T-factor” groups: task, training, technique, technology, teamwork, terminus, and tuning [Table 1].

The key reason we have chosen “awake craniotomy” (as opposed to a “regular” asleep craniotomy) to make our comparison with aviation is this: in an awake craniotomy, the patient is an active participant during the procedure, adding a new dimension to the operative mission.^[7] Although all of the “T-factors” are relevant to both types of craniotomy, we have found that “technique” (e.g., awake mapping and sequential intubation phases), “teamwork” (e.g., streamlined communications between surgical and anesthetic teams and the awake patient during awake resection and neurotesting), and “terminus” (e.g., a finite “awake” time of around an hour due to patient comfort and position limits) take on special significance in this comparative scenario, from both a neurosurgical and anesthetic perspective.

WHAT THE OPERATING TEAM CAN LEARN FROM AVIATION

The 10 factors we have identified that the operating room team can learn from aviation are as follows:

1. Crew Resource Management (CRM): The formal teaching of cockpit and cabin workflows and communication,^[2,5,6,11] and the nurturing of team or group “intelligence,”^[3]
2. IMSAFE: Safe aviation begins with self-evaluation of whether or not factors such as pilot/crew illness, medication, stress, alcohol, fatigue, and eating, could adversely affect the conduct of a safe flight. These are part of an “IMSAFE” mnemonic that pilots are instructed to use to confirm, by self-assessment, that they are in a fit condition to fly before each and every flight;
3. Checklists: Surgery has started to implement certain checklists,^[10-12] such as for “surgical timeout,” pioneered by the World Health Organization.^[12] However, in aviation, as found in aircraft-specific pilot operating handbooks, there are checklists for almost everything.

This is an open-access article distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

Table 1: Comparison between flight mission and awake craniotomy (asterisks highlight key differences).

T-Factor	Flight mission	Awake craniotomy
Task (plan and goal)	Aviate, navigate, communicate Mission goal awareness Flight planning “Plan B” in case of diversion, e.g., weather, fuel	Operate, navigate, communicate Operative goal awareness Surgery and anesthesia planning “Plan B” if unexpected physiological response or complication
Training (skills development)	Learning aerodynamic and engineering theory Proficiency in use of planning charts, tablet applications, Google Earth, flight simulator Instructor-based learning CRM*	Learning neuroanatomy and physiology, pharmacology Proficiency from anatomical atlases, laboratory dissection, and in imaging review, neuronavigation Subspecialization fellowship, colleague mentorship No formal equivalent of CRM (but potential for expertise based on crisis experiences)*
Technique (approach)	IMSAFE* Numerous procedural checklists* Optimal hand-eye-foot coordination for flight controls Crisis management in the cockpit (rare life critical emergencies per individual pilot)* “Sterile cockpit” measures* Flight logbook data recording (written and/or digital)	No formal equivalent of IMSAFE* Few procedural checklists* Optimal hand-eye-foot coordination for instruments, microscope, bipolar, drill and ultrasonic aspirator; awake mapping Crisis management in theatre (frequent life critical emergencies per individual surgeon or anesthetist)* No formal equivalent of “sterile cockpit”* Surgical and anesthetic log/data recording
Technology (operational systems)	Basic: flight controls and switches, navigation screens, communication controls Advanced: flight monitoring sensors/systems, autopilot Numerous system backups, redundancies built in*	Basic: operating microscope, neuronavigation screens, electrocortical stimulator, anesthetic machine and intubation equipment Advanced: neuromonitoring, intraoperative imaging, surgical robots, advanced life support kit No formal equivalent of built-in backups*
Teamwork (interpersonal coordination)	Formal pilot, copilot, and air traffic control lingo* At least two experienced pilots in the cockpit (one pilot in command)* Communication skills between crew members	No formal equivalent of aviation lingo* Typically one surgeon and assistant, and one anesthetist and technician in theatre* Communication skills in theater (surgeon, anesthetist, nurses, technicians, device representatives, and an awake craniotomy patient being neurologically tested)
Terminus (limits)	Aircraft performance limitations Airframe tolerances Passenger comfort and safety Fatigue, anxiety, stress, illness, distraction, fixation errors, pilot mindset, age-related physiological changes Mandatory regular health checks (aviation medicals)*	Surgeon, anesthetist performance limitations Equipment limits Patient positioning and comfort, particularly during “awake” phase (s) of surgery and for intubation/extubation ^[7] Similar bio-psycho-social considerations apply No formal equivalent of aviation medicals*
Tuning (improvement mechanisms)	Regular postflight debriefing* Compulsory retraining and periodic “flight checks”* Oversight by inter/national regulators Comprehensive accident and near-miss investigations and related directives	Infrequent morbidity and mortality (<i>post hoc</i>) meetings* Maintenance of proficiency (continuing professional development) but no periodic proficiency checks* Oversight by regulatory colleges, medical boards Occasional systemic audits/inquiries with recommendations

CRM: Crew resource management

4. Sterile cockpit: The key feature of “sterile cockpit” measures^[6] is the avoidance of unnecessary fixations and distractions (including conversations), but facilitation of fine-tuned workflow during critical phases of flight, in particular, the minutes around takeoff and landing;
5. Redundancy: Aviation systems are built with duplications or “backups,” from aircraft manual controls and airfoil surfaces, to communication, navigation, and flight data systems;
6. Lingo: Clear and concise communications, particularly between pilot and copilot, and the pilots and air traffic control, represent an essential component of good airmanship;
7. Duality: There is a great inherent safety and efficiency value of having two experienced pilots (one designated as “pilot in command” and the other as “copilot”) in commercial aviation. In Western aviation at least, this is the norm, along with a well-trained crew in operation throughout the flight;
8. Flight checks: Mandatory retraining and periodic piloting proficiency check with a “check pilot” or pilot instructor observing;
9. Medicals: Mandatory yearly medical examinations for commercial aviation pilots to ensure their health and well-being are maintained given their responsibilities;^[11]
10. Debriefing: Postflight “debriefing” between pilots is a simple and exemplary means of enhancing situational awareness and promoting self-improvement.^[9,10]

THE SINGLE MOST IMPORTANT FACTOR THAT AVIATION CAN LEARN FROM THE OPERATING ROOM TEAM

Life-threatening crises are relatively rare for any given pilot, although if and when they happen, their casualty implications are on a large scale. On the other hand, life-threatening crises are almost “routine” for surgeons and anesthesiologists alike in areas such as neurosurgery, trauma surgery, cardiothoracic surgery, and vascular and transplant surgery. We learn to manage crises with the expected proficiency of “CRM”^[2,5,6,11] benchmarks due to the nature, variability, and frequency of dealing with critically ill and injured human beings (as opposed to production line machines). Examples of this include difficult or failed airways; seizures during awake electrocortical stimulation; idiosyncratic anaphylactic responses to medications; air embolism; intraoperative aneurysmal rupture; posterior fossa or hemispheric cerebral edema with impending herniation; anticoagulant-mediated extra-axial hematomas that just would not cease bleeding; road accident or gunshot complex polytraumas with different teams working simultaneously; and so forth. In the authors’ operating theater, every effort is made toward effecting timely and clear communications. At critical waypoints in the surgery, the words “you need to hear this” from either the neurosurgeon or the anesthesiologist are an indication for all of the team to acutely attend, in addition to our usual procedures akin to the “sterile cockpit.”^[6] We also try to utilize two experienced surgeons side by side

in complex surgeries (duality), with educational postsurgery debriefing following such operations.^[9,10]

CONCLUSION

There are substantial similarities and some key differences between awake craniotomy and piloting an aircraft. We have attempted to compare the two procedures according to the seven T-factors of task, training, technique, technology, teamwork, terminus, and tuning. The medical sector can learn much from the aviation sector, particularly with regard to CRM, debriefing, duality, sterile cockpit, lingo, and system redundancy. Such learning can be expected to facilitate a reduction in avoidable complications and suboptimal patient outcomes. The aviation sector can benefit from the “regularity” and scope of crisis management experience that is a feature of operating rooms where neurosurgery, cardiothoracic surgery, vascular and transplant surgery, and polytrauma surgery are carried out.

A PDF of this conference presentation delivered orally by the corresponding author on August 25, 2018, at the annual meeting of the Australasian Society of Aerospace Medicine in Alice Springs, Northern Territory, Australia, has been uploaded at the following URL and contains images of relevance to this manuscript:

https://drive.google.com/open?id=1eNyC_L1_HhV1BsJBcekGoEIgWGg9S95

Acknowledgments

This manuscript was delivered as an oral presentation at the 2018 Annual Meeting of the Australasian Society of Aerospace Medicine, Alice Springs, Northern Territory, Australia. The authors would like to thank Ms. Lauren Williams and Ms. Cathy Zhou for their invaluable assistance in the preparation of this manuscript.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Disclaimer

The views and opinions expressed in this article are those of the author and do not necessarily reflect the official policy or position of the Journal or its management.

REFERENCES

1. Caldwell J. Crew schedules, sleep deprivation, and aviation performance. *Curr Dir Psychol Sci* 2012;21:85-9.
2. Flin R, Maran N. Identifying and training non-technical skills for

- teams in acute medicine. *Q Saf Health Care* 2004;13:80-4.
3. Gordon S, Mendenhall P, O'Connor BB. *Beyond the Checklist: What Else Health Care Can Learn From Aviation Teamwork and Safety*. New York: ILR Press; 2013.
 4. Helmreich RL. On error management: Lessons from aviation. *BMJ* 2000;320:781-5.
 5. Kao LS, Thomas EJ. Navigating towards improved surgical safety using aviation-based strategies. *J Surg Res* 2008;145:327-35.
 6. Kapur N, Parand A, Soukup T, Reader T, Sevdalis N. Aviation and healthcare: A comparative review with implications for patient safety. *JRSM Open* 2015;7:1-10.
 7. Manchella S, Khurana VG, Duke D, Brussel T, French J, Zuccherelli L. The experience of patients undergoing awake craniotomy for intracranial masses: Expectations, recall, satisfaction and functional outcome. *Br J Neurosurg* 2011;25:391-400.
 8. Reader TW, Cuthbertson BH. Teamwork and team training in the ICU: Where do the similarities with aviation end? *Crit Care* 2011;15:313.
 9. Schelkun SR. Lessons from aviation safety: Plan your operation-and operate your plan! *Patient Saf Surg* 2014;8:38.
 10. Singh N. On a wing and a prayer: Surgeons learning from the aviation industry. *J R Soc Med* 2009;102:360-4.
 11. Sommer KJ. Pilot training: What can surgeons learn from it? *Arab J Urol* 2014;12:32-5.
 12. Weiser TG, Haynes AB, Lashoer A, Dziekan G, Boorman DJ, Berry WR, *et al*. Perspectives in quality: Designing the WHO surgical safety checklist. *Int J Q Health Care* 2010;22:365-70.

How to cite this article: Khurana VG, Vats P. Awake craniotomy versus piloting an aircraft: What medicine and aviation can learn from one another?. *Surg Neurol Int* 2019;10:93.

Commentary

The authors have provided a fascinating analysis of the similarities between piloting an aircraft and performing an awake craniotomy. My one criticism of the article is that I do not see a meaningful difference between awake craniotomy and asleep craniotomy in

terms of the analogy drawn by the authors. Nevertheless, I enjoyed the authors' insights. Duke Samson famously called neurosurgeons the "fighter pilots of the mind." I suppose this article builds on his colorful description.

Eric Nussbaum