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Editorial

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

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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.

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	Operate, navigate, communicate
	Mission goal awareness	Operative goal awareness
	Flight planning	Surgery and anesthesia planning
	"Plan B" in case of diversion, e.g., weather, fuel	"Plan B" if unexpected physiological response or complication
Training (skills development)	Learning aerodynamic and engineering theory	Learning neuroanatomy and physiology, pharmacology
	Proficiency in use of planning charts, tablet applications, Google Earth, flight simulator	Proficiency from anatomical atlases, laboratory dissection, and in imaging review, neuronavigation
	Instructor-based learning	Subspecialization fellowship, colleague mentorship
	CRM*	No formal equivalent of CRM (but potential for expertise based on crisis experiences)*
Technique (approach)	IMSAFE*	No formal equivalent of IMSAFE*
	Numerous procedural checklists*	Few procedural checklists*
	Optimal hand-eye-foot coordination for flight controls	Optimal hand-eye-foot coordination for instruments, microscope, bipolar, drill and ultrasonic aspirator; awake mapping
	Crisis management in the cockpit (rare life critical emergencies per individual pilot)*	Crisis management in theatre (frequent life critical emergencies per individual surgeon or anesthetist)*
	"Sterile cockpit" measures*	No formal equivalent of "sterile cockpit"*
	Flight logbook data recording (written and/or digital)	Surgical and anesthetic log/data recording
Technology (operational systems)	Basic: flight controls and switches, navigation screens, communication controls	Basic: operating microscope, neuronavigation screens, electrocortical stimulator, anesthetic machine and intubation equipment
	Advanced: flight monitoring sensors/systems, autopilot	Advanced: neuromonitoring, intraoperative imaging, surgical robots, advanced life support kit
	Numerous system backups, redundancies built in*	No formal equivalent of built-in backups*
Teamwork (interpersonal coordination)	Formal pilot, copilot, and air traffic control lingo*	No formal equivalent of aviation lingo*
	At least two experienced pilots in the cockpit (one pilot in command)*	Typically one surgeon and assistant, and one anesthetist and technician in theatre*
	Communication skills between crew members	Communication skills in theater (surgeon, anesthetist, nurses, technicians, device representatives, and an awake craniotomy patient being neurologically tested)
Terminus (limits)	Aircraft performance limitations	Surgeon, anesthetist performance limitations
	Airframe tolerances	Equipment limits
	Passenger comfort and safety	Patient positioning and comfort, particularly during "awake" phase (s) of surgery and for intubation/extubation[7]
	Fatigue, anxiety, stress, illness, distraction, fixation errors, pilot mindset, age-related physiological changes	Similar bio-psycho-social considerations apply
	Mandatory regular health checks (aviation medicals)*	No formal equivalent of aviation medicals*
Tuning (improvement mechanisms)	Regular postflight debriefing*	Infrequent morbidity and mortality (*post hoc*) meetings*
	Compulsory retraining and periodic "flight checks"*	Maintenance of proficiency (continuing professional development) but no periodic proficiency checks*
	Oversight by inter/national regulators	Oversight by regulatory colleges, medical boards
	Comprehensive accident and near-miss investigations and related directives	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 anesthetists 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 anesthetist 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_HhV1BsJBcekGooEIgWGg9S95

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Conflicts of interest

There are no conflicts of interest.

Disclaimer

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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