

Maximizing Safety in Aerospace, Aviation, and Anesthesia

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Only minutes after lifting off from LaGuardia Airport, two senior pilots were rapidly thrust into an emergency that threatened not only their lives but their passengers' lives and unknown numbers of ground casualties (asamonitor.pub/35PIt9e). Following take off, the airplane struck birds and lost both engines, which transformed the aircraft into a 70-ton glider. The pilots quickly and expertly handled the emergency by using crew resource management principles and the quick reference handbook (QRH) to review any relevant emergency procedures. This potential tragedy was averted safely in large part due to the pilots' knowledge and expertise in the use of resource management checklists. The incident became known as the "Miracle on the Hudson."

The aeronautical profession, like the aviation industry, also has a long history of using safety checklists as an integral part of emergency and routine operations. Prior to the Apollo 11 flight, each of the astronauts spent over 100 hours familiarizing themselves with onboard checklists. They repeatedly practiced using them for simulated emergencies and adapted them to increase their usability. Checklists were even printed on the sleeves of the suits they wore while doing spacewalks. Apollo 11 astronaut Michael Collins dubbed the safety checklists "the fourth crew member" (asamonitor.pub/3HI9xEI).

Crossover of checklists into anesthesia

Despite the long safety history in aviation and aerospace, checklists in anesthesia only gained momentum with the pioneering publication by Drs. Gaba, Fish, and Howard titled "Crisis Management in Anesthesiology" in 1990 (Crisis Management in Anesthesiology. 1st Edition, 1990; Crisis Management in Anesthesiology. 2nd Edition, 2015). Since then, numerous cognitive aids and checklists have been introduced into routine anesthetic and surgical practice worldwide.

Checklists consist of simple actions listed in order of completion or verification. An example is the World Health Organization surgical timeout. A cog-



Figure 1: A scene after the safe landing of U.S. Airways flight 1549 on the Hudson River. Reproduced with permission from the National Transportation Safety Board.



Figure 2: Stanford Emergency Manual Download QR code.

nitive aid is a series of clinical questions that will lead the user through a certain series of steps. An example of a cognitive aid would be the American Society for Regional Anesthesia and Pain Medicine's Local Anesthetic Systemic Toxicity algorithm. Emergency manuals are publications that contain a collection of anesthetic emergency checklists or cognitive aids. Emergency manuals may be printed out and used as hard copies, downloaded and used electronically, or incorporated into an electronic health record system.

Practitioner preferences and the clinical situation will dictate how an aid is used. For example, a practitioner may verify they have done all the correct actions after completing a series of steps, such as when setting up the anesthesia machine at the beginning of the day.

Alternatively, an aid may be used to direct care in real time when a critical event occurs. A cognitive aid may be used to assist in making a diagnosis as a reminder of the correct medication dosage, to highlight important procedural steps, to help practitioners confirm completion of all essential steps, or to highlight important differences from other emergencies so an appropriate and timely diagnosis is made.

Currently, several anesthesia training programs are teaching their residents to effectively use cognitive aids in emergencies. For example, at our institution (Stanford), residents are taught how to utilize the "reader role" as a crisis team member. The "reader" is a team member who reads through the checklist or cognitive aid and verifies that the team has completed the correct actions by cross-checking with the team leader. Then the leader can allocate their attention elsewhere, which has been shown by Burden et al. to improve team efficacy and mirrors how checklists are used in aviation (*Simul Healthc* 2012;7:1-9).

Do checklists help in anesthesia emergencies?

There is a wide and growing body of evidence that cognitive aids and checklists improve anesthetic emergency management. One recent study found only 34% of respondents felt comfortable managing rare emergencies using memory and experience alone (*Anesth Pain Med*



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2015;5:e26300). For example, malignant hyperthermia (MH) and local anesthetic systemic toxicity (LAST) are expected to occur only a handful of times over an anesthesiology professional's career. Therefore, recall of the dantrolene or intralipid dose under stress is difficult. A simulation-based study by Harrison et al. showed OR teams were significantly more likely to manage MH correctly if they used a cognitive aid (*Anesth Analg* 2006;103:551-6). Neal et al. suggested that correct management of LAST was significantly greater with cognitive aid use (76% vs. 51% correct) (*Reg Anesth Pain Med* 2012;37:8-15).

However, events need not be rare to benefit from the use of a cognitive aid. Arriaga et al. used simulation to test several more commonly occurring anesthetic critical events and found that the use of checklists led to a 75% reduction in errors (*N Engl J Med* 2013;368:246-53). Even when it would seem that there is no time to use a cognitive aid, such as with an unexpected difficult airway, there is still a benefit. Marshall et al. found that safe surgical airway performance among experienced anesthesiologists (>10 years of practice) was significantly quicker in a "can't intubate, can't ventilate" simulated scenario when a checklist was used (*Anaesthesia* 2014;69:669-77).

In a study of emergency manual use during real emergencies, Goldhaber-Fiebert et al. conducted post-event qualitative interviews with clinicians. According to clinicians, the emergency manual helped to decrease levels of stress, enable effective teamwork, con-

tribute to a calm atmosphere, and help catch errors of omission (*Anesth Analg* 2020;131:1815-26).

Cognitive aid resources

Several sites and organizations have produced emergency manuals, including Ariadne Labs (Brigham and Women’s Hospital and Harvard), the Association of Anaesthetists of Great Britain and Ireland, European Society of Anaesthesiology and Intensive Care, Society for Pediatric Anesthesia, and the Stanford Anesthesia Cognitive Aid

“Cognitive aids can be powerful patient safety tools. All institutions should aim to incorporate cognitive aids into perioperative care; however, the complexities of implementation are not to be minimized.”

Group. The Stanford program (Drs. Gaba, Howard, Goldhaber Fiebert, Harrison, Burian, Sultan, Austin, and Burden) has extensively revised the content and design of the previous version of its manual. The latest version (4.4) has launched and is available for download (Figure 2) at emergencymanual.stanford.edu.

Next steps

Cognitive aids can be powerful patient safety tools. All institutions should aim to incorporate cognitive aids into perioperative care; however, the complexities of implementation are not to be minimized. The Emergency Manuals Implementation Collaborative website (emergencymanuals.org) has a wealth of cost-free resources to help institutions choose and implement cognitive aids and is a great starting place for anesthesia professionals to explore. ■

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