Aviation and Cardiac Surgery: What Can Be Transferred from One to the Other To Improve Safety?

Introducción

En 1984, Perrow establece su teoría de “Normal accidents” y describe las interacciones complejas, donde las catástrofes son inevitables en sistemas complejos estrechamente acoplados. Predice que los errores se producirán de muchas maneras inesperadas. El error de un componente puede tener múltiples efectos en cascada. En estos sistemas, hay pocas posibilidades para sustituir o reasignar personal debido a su alta especialización, contacto personal cerrado y escaso entendimiento de algunos procesos. Hay un punto en la organización, que, una vez transgredido, resulta en la colapsación del nivel siguiente. Cuando se alcanza este punto, un cambio, insignificante en sí, puede ocurrir, pero que puede llevar a una transformación masiva, rápida y catastrófica del sistema. (1) Accidentes aéreos o pacientes complicados que sufran ciclos de errores o derivación de sangre pulmonar y cardiaca (CPB) causados por el olvido de la administración de heparina antes de su inicio, son ejemplos de este tipo de accidentes. La integralización de los accidentes muestra que estos resultan de la alineación de condiciones y eventos, cada uno de los cuales es necesario, pero ninguno solo es suficiente para provocarlos.

Dos ejemplos relacionados con la aviación y la cirugía cardíaca. En ambos, los actores no entienden la complejidad existente debido a la falta de un enfoque sistemático.


2. En 1980’s, una serie de pacientes operados en una institución local, que estaban conscientes y activos neurológicamente, fueron desconectados de la ventilación mecánica. Tras la toma de muestras de sangre para análisis y purga del catéter, los pacientes sufrieron de convulsiones y coma. Un investigador externo fue invitado para esclarecer el problema, que inicialmente se había atribuido a fallos de oxigenación cardíaca o CPB. Sin embargo, el investigador encontró que la introducción de un nuevo método de purga arterial postoperatorio introdujo burbujas a una presión tan alta que superaba la presión aórtica, introduciendo burbujas en la arteria carótida.

Complejidad en el quirófano

El quirófano es un ambiente caracterizado por alto grado de complejidad en cuanto a las interacciones humano-tecnológica y humano-humano. Los procedimientos requieren el esfuerzo coordinado de múltiples grupos, bajo estrés. En el quirófano, en contraste con la aviación, la composición humana está en constante cambio, y por lo tanto, pueden surgir problemas de comunicación con desastrosas consecuencias. Durante la CPB, en caso de requerirse flujo bajo o paro cardíaco, un error mínimo puede ser fatale. Se ha confirmado que los cirujanos cardíacos toman decisiones de vida o muerte cada 10 segundos durante una operación. La mayoría de los cirujanos cardíacos estarían de acuerdo en que el 75% de los resultados se atribuyen a decisiones correctas (por ejemplo, la eliminación de aire del corazón) y el 25% al artefacto (por ejemplo, los parches de un corazón en el corazón coronario). Marvil, en 1917, sugiere mantener una situación de conocimiento permanente, definida como la precisión con la cual la percepción copia la realidad. (2) La ecocardiografía esofágica es similar a los controladores de vuelo, ya que permite el control paso a paso de los resultados funcionales durante la cirugía.

Semejanzas y diferencias entre la cirugía cardíaca y la aviación

La cirugía cardíaca se practica con una “puerta abierta” para muchas personas, whereas the latter, is conducted within a closed cockpit. The number of aircraft staff is lower than that of an operating room: while 3 pilots work in a jet cockpit, more than 10 persons of different specialties do so in the operating room, increasing the complexity as the number of people increases. Surgical teams are heterogeneous, including their modes of communication; however, complementarity is greater due to...
subspecialties. The intricacy of human relationships increases exponentially and not linearly with the number of actors involved, decreasing the quality of leadership (Pendharkar, 2007). (3) The lack thereof may hamper the recovery of errors in critical circumstances. Cardiac surgery is “aviation and something else”: the human being is more complex than an aircraft. Both fields require celerity to manage situations of crisis or emergency, sometimes, with little information. Cardiac surgeons often face these situations, frequently aortic ruptures or dissections. In the surgical emergency, it is necessary to “fly with bad weather”, differentiating it in part from aviation, even though emergencies may arise during the flight. An example of excellence in aviation critical management was the pilots’ conduct during US Airways flight 1549. The commander trained all his life for a contingency that perhaps would never happen, the predictable of the unpredictable: to land in the water (Eisen, 2009). (4)

In the cockpit, the function of the pilots is to a certain degree overlapped (they are interchangeable); in the operating room, due to organizational and economic reasons, this does not always occur. If the plane falls, the pilot falls with it. In commercial aviation, many lives are at risk during a flight; in surgery, only one. Airplane accidents are public, highly visible and generate demands for investigation and repair. As a result, more resources are destined for research, whereas iatrogenic adverse events are kept in reserve (Bogner, 1994). (5)

TRANSLATIONAL MEDICINE FROM AVIATION TO CARDIAC SURGERY: AIRWAY SAFETY TAKEN TO THE PATIENT

1. Incident reporting (CHIRP) and observational audit (LOSA)
   The impossible safety rate reached by commercial aviation (in USA fatal accidents are minimal: 0.017/100,000 flights/year) seduces translational medicine, especially when the US Institute of Medicine estimates that each year between 44,000 and 98,000 persons die due to medical errors (Hemreich, 2000). (6) The science of human factors, cornerstone of aviation safety, has not yet found its place in Medicine, but could greatly change the understanding and execution of medical decisions (Schappell, 2007, Eltorai, 2018) (7, 8) The factor associating aviation and medicine that is indispensable or complex enough is the human error. In the current era, the new technological wonders have created an expectation of total perfection. The patients, who have the understandable need of considering the physician to be infallible, have colluded (agreed) with them to deny the existence of error and reject uncertainty, sometimes the only certain thing. Analyzing the cardiac surgery system, Wiegmann postulates that error is related with disruptions in the surgical flow produced by communication mistakes, external distractions and hardware faults. (9)

   The report not only of accidents, but near misses is essential in the CHIRP (Confidential Human Fac-
   tors Incident Reporting) program. This allows making no punitive reports (Eidt, 2012). (10) Helmreich, a psychologist dedicated to human factors in aviation and surgery, has observed numerous surgeries and recorded suboptimal communication and workteam instances, similar to those found in the cockpit. (6)

   Another element that can be transferred to surgery is LOSA (Line Operations Safety Audit) an observational audit project developed by Helmreich (www psy. utexas.edu/psy/helmreich/nasaut.htm), where expert observers sit in the cockpit of normal flights to register threats to security, errors and their management. These results confirm an average of two threats and two errors per flight, with an unexpected over half of errors due to violation of established regulations.

2. Sterile cockpit protocol
   Aviation has instituted a mandatory “sterile cockpit” protocol during periods of high mental stress, that is, take-off and landing. These are standardized communication, phrasing and call back protocols to reduce ambiguity. This protocol was transferred to the Mayo Clinic in 2010, where eight critical events were defined during CPB and a NASA-like protocol was implemented (NASA Task Load Index). Thus, altered communication decreased significantly (Wadhena, 2010). (11) It was emphasized that “non-verbal” actions, such as aortic clamping and unclamping be reduced when communicating them. The authors concluded that, different from aviation, cardiac surgery has no exact time that can be conveniently defined as the main high mental risk and stress period from the point of view of the complete human team. Figure 1, taken from Wadhera, shows the difference in mental load in the operating room; contrary to aviation, the highest stress for each component of the team occurs at different moments.

   The surgeon should highlight focusing on critical events: heparin administration/CPB initiation, clamping/cardioplegia/unclamping/CPB weaning, more than in critical periods.

3. “Threat and error” NASA model
   The pediatric surgeon Hickey suggests considering each surgery as a flight. He analyzed 524 flights/patients and found 763 “preoperative threats” (atypical morphology, multiple lesions, comorbidities) in 72% of cases. He recorded 430 proficiency or judgment errors, which were consecutive in 67% of cases and in 21% of the total number of patients, subsequent cycles of additional error were produced. These cycles, which contained multiple mistakes, were associated with surgical complications and, even, death in 1.3% of cases. He concluded that an unsolved error leads to cycles of errors and severe complications (Hickey, 2015). (12)

4. Mission analysis: Crew resource management (CRM)
   At the beginning of the 80’s, due to several aviation disasters, The Crew Resource Management (CRM)
was developed in the USA to improve performance and promote safety. These improvement strategies can be transferred to surgery. In 2007, McGreevy suggests two steps. In the first part or briefing (instructions), the pilots explain beforehand not only what is going to be done or expect that will happen, but also the measures to be taken in each case. A surgical example would be: if after a sternotomy a patient decompen-sated, how to immediately start CPB. The second step, or debriefing (reflections) is a deep introspection about what went well and what did not, to avoid repeating the error. (13)

5. Simulators

In aviation, each major incident is followed by the simulation of its causes to avoid another posterior event; this has become part of the training and the hardware is redesigned. In surgery, complications are considered a routine and besides being mentioned in a clinical seminar, they are not reported. Simulators constitute a structured part of training in aviation and in surgery it is progressing thanks to the former. Practice is without risks and surgeons develop skills to recover from the error. Pilots do not fly in a plane for which they have not been trained in a simulator, and in which they are periodically examined. In cardiovascular surgery, a surgeon must operate, in many instances, a case for which he has not been trained. Unfortunately, the complexity of biological systems is almost impossible to “simulate” with the same level of realism. The future in surgical education are hybrid simulators combining plastic material and biological organs. Gaba, pilot and leader of simulation in Medicine, believes that although aviation concepts and practices cannot be directly transferred, translation or adaptation is possible and necessary (Gaba, 2011). (14)

SUMMARY AND CONCLUSIONS

1. The possibilities of error in cardiac surgery are more unpredictable.
2. In aviation, a better systematization of procedures has been implemented to improve safety, and the inevitability of error is accepted.
3. Physicians tend not to acknowledge error, or fatigue, and together with patients they make a deal (collusion) to deny the former.
4. Transferring the systematics mentioned for aviation to surgery helps to come close to their safety standard, though it does not completely solve the problem.
5. Investigating the human factors affecting error is essential in surgery.

Conflicts of interest

None declared.

(See authors’ conflicts of interest forms on the website/Supplementary material).

REFERENCES