Beyond the borders: Lessons from various industries adopted in anesthesiology

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Abstract

Since the first public demonstration of anaesthesia in Boston, USA which happened around 172 years back, the field of anesthesiology has rapidly progressed, with many developments that have improved the quality and safety of anesthesia care. This has enabled tremendous advances in the surgical disciplines and increasing the life expectancy and quality of life of humans. This is a result of learning and constantly evolving. There are several similarities between healthcare and other industries, though there are several distinguishing characteristics that set it apart from other industries. There are a number of safety and quality improvement measures in healthcare which have been influenced by safety practices in other industries. Anaesthesia has been the leader among the medical specialities in adoption of innovative practices from various industries in an effort to advance patient safety, enhance quality of care, reduce waste & inefficiency, and improve customer service and satisfaction. This article emphasises on learnings from other industries in the recent decades, focusing on aviation, high-reliability organizations, car manufacturing, telecommunication, car racing, entertainment, and retail. Learning and implanting the best practices from these industries can bring about a paradigm shift in health care industry. It has a potential to improve efficiency and make anaesthesia safer than ever before in the history of human kind.

Keywords: Anesthesia, aviation, checklist, clinical decision supp, dolphins, handover, industry, information systems, leadership, operating rooms, patient care, patient safety, quality improvement, risk management, simulation training, telecommunication, workflow

Introduction

It was on October 16, 1846 that WTG Morton performed the first public demonstration of anesthesia.[1] This marks a significant step in the history of humankind. Until then, surgery was performed only as a last and desperate resort. Conscious and with no pain relief, it was beset with unimaginable pain, unspeakable agony, and considerable risk. One could argue whether this is one of the greatest advances in medicine as this has resulted in the astonishing reduction in human suffering like no other medical discovery. During the past 172 years, the field of anesthesiology has rapidly progressed, with many developments that have improved the quality and safety of anesthesia care, which has enabled tremendous advances in the surgical disciplines.

Management guru Peter Drucker once described health care as the most difficult, chaotic, and complex industry to manage and suggested that the hospital is "altogether the most complex human organization ever devised."[2] It is true that health care has several distinguishing characteristics that set it apart from other industries. But, it is obvious that there are several similarities with other fields. Modern healthcare organizations have evolved a lot and specialities like anesthesia have adopted a number of best practices from other fields.

Atul Gawande in his book "The Checklist Manifesto: How to get things right" looked at the use of checklists in the real

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business world like the finance, construction, restaurant management, and aviation industries, and in the medical profession. He suggested that checklists in healthcare can significantly reduce errors in surgery and using it routinely can result in greater efficiency, consistency, and safety in healthcare.[3]

According to Clayton M. Christensen, a Harvard business school professor, a disruptive technology is a new emerging technology that unexpectedly displaces an established one. He has argued that health care can learn from other industries in implementing "disruptive innovations" that will result in cheaper, simpler, and more accessible health care services.[4]

Anesthesia has been the leader among the medical specialities in adoption of innovative practices from various industries in efforts to advance patient safety, enhance quality of care, reduce waste and inefficiency, and improve service and satisfaction. This article summarizes health care and anesthesia learning from other industries, focussing on aviation, high-reliability organizations, car manufacturing, telecommunication, car racing, entertainment, and retail; evidence suggests that most innovative practices originate within these fields [Figure 1]. Here are some examples from which practices have been adopted.

Aviation

The aviation industry has long been admired by health care organizations, especially because of the dramatic improvements
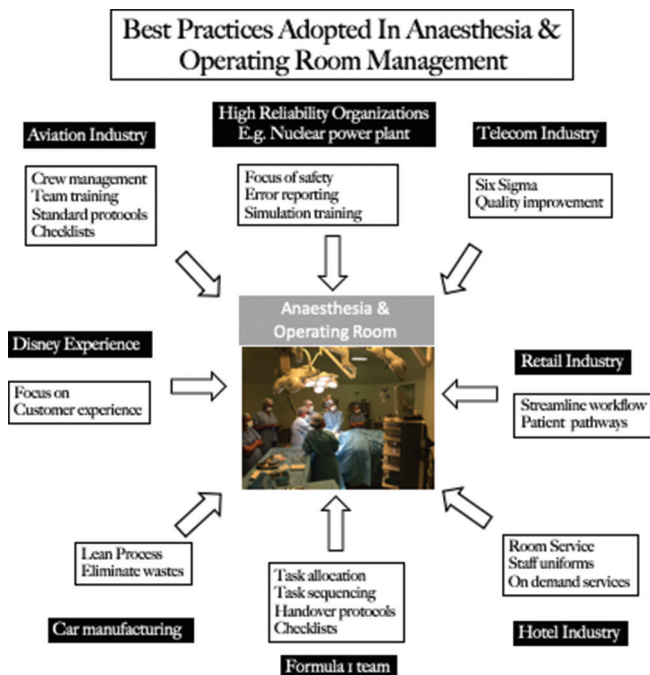

Figure 1: Best practices adopted in to anesthesia practice and operating room working from other industries

in safety that it has undergone.[5] Helmreich was among the first to suggest that lessons from aviation can help reduce errors in the operating rooms.[6] There are fundamental similarities between the two professions, and this presents unique opportunities for interdisciplinary learning.

Though aviation is practiced in airplanes on air and anesthesia in operating rooms inside a hospital, aviation and anesthesiology possess striking parallels. Both require high vigilance to identifiy and manage a crisis situation, where lives are at stake, often with a very short notice and sometimes with incomplete information. The crisis situation evolves at a rapid pace and can make executing even simple, routine actions feel harrowing. The demands are same in both, one needs to work well not just in calm moments but also when under duress. Both need to have meticulous, unwavering attention to detail to ensure that all components under their care are functioning properly, and errors are avoided to the greatest extent possible. The quality of care delivered by anesthesiologists extends far beyond medical knowledge.

Investigators of accidents in the aviation industry have studied the human factors responsible for aviation incidents. The aviation industry has successfully implemented and demonstrated that systematic error reporting and review, along with simulation-based studies of mechanisms leading to error and quality improvement interventions can decrease the errors. These represent two major areas for advancement within anesthesiology.[7] Research into a number of aviation accidents has shown that accidents are rarely produced by a single cause, but rather by a host of interacting ones. More than half are ascribed to "human error."[8] Human factors resulting in an error have not yet found the same place in medicine as in aviation industry, but it could change the understanding and execution of medical decision-making in profound ways.

Significant adoptions include crew resource management (CRM), team training techniques, and focus on systems and cultures rather than on individuals or failures. Crew resource management lays stress on working as teams and developing skills in briefing, inquiry, assertion, workload distribution, vigilance, and conflict resolution.[8] Applications of principles of CRM and other team training techniques are very evident in anesthesia practice. This is being adopted slowly in other "high-risk" health care areas such as the emergency department, the ICU, obstetrics and perinatal services, and neonatal resuscitation.

Focus on systems and cultures, rather than blaming individuals for failures has brought in focus about prevention of harm rather than managing it later. One will find nonpunitive

error-reporting systems in practice in most hospitals, especially anesthesia departments.[8]

Simulation-based studies have the obvious advantage wherein prospective interventions can be conducted without the obvious ethical and logistical challenges associated with executing such studies in real flying situations. Simulation has found an increasingly prominent role in anesthesiology education in the recent years, but it can also be utilized to study error mechanisms and identify effective quality improvement strategies. A number of anesthesiology training programs have incorporated simulation-based training into their curriculum. These simulation exercises are relevant not only for the trainee anesthesiologist, but also for anesthetists of all grades and seniority. Using simulation scenarios, we can bring the techniques we take for granted in other industries, notably aviation; to not only design new clinical systems but also to improve the existing systems. For example, improving team work in crisis scenario, identifying and eliminating latent errors, perfection of skills etc.

Other concepts and techniques that have crossed over from aviation include standardized protocols and checklists.[9] Standardized protocols have been regularly applied in preoperative work ups, anesthetic technique, postoperative pain relief, medication administration processes and management of medical emergencies like cardiac arrest etc.[10-12]

Checklists are very effective when time is not critical, the series of tasks is too long and difficult to memorize (or there are likely to be interruptions to execution of the task), and the environment enables a physical list to be accessed and used. For example, anesthesia equipment checklist. The most widely used checklist is the WHO Surgical Safety Checklist.[13] Though there are questions raised about how it is implemented, it has demonstrated that it is a relatively simple and an effective strategy for addressing surgical patient safety worldwide.

Helmreich himself has opined that the OR is a milieu more complex than the cockpit, with many medical specialties interacting to treat a patient whose condition and response may have unknown characteristics. Aircrafts and flying are more predictable than patients and their responses to treatment.[6]

High-reliability Organizations

High-reliability organizations (HRO) are organizations that function in hazardous, fast-paced, and highly complex technological systems while operating with no errors for long periods.[14]

HROs are similar to those from aviation and include a focus on safety systems, error reporting, and simulation training.[15] They include nuclear power plants, air traffic control systems, petrochemical plants, and naval aircraft carriers. Lessons adopted in the operating rooms and anesthesia from these industries include a focus on safety systems, error reporting, and simulation training.

Specifically, nuclear power plants represent a successful model to look up to. It is probably true that this industry represents a better analogy for anesthesia than aviation because of its high levels of complexity.[16]

A number of safety strategies have been developed in the nuclear power industry since its conception. They can be broadly summarized into five phases. All of these have relevance to the analogy with safety in anesthesia and each adding more robust and sophisticated safety approaches.[16]
1. A *priori* design of fail-safe facilities
2. Robust accident/incident reporting leading to small/minor equipment and procedure improvement
3. Simulation training to improve operator performance
4. Major system redesign based on in-depth analysis of previous failures (e.g., the design of inherently safer, new generation reactors) and
5. The lowering of the threshold for the reporting of incidents to include many events, other than accidents that may adversely affect the safe operation of the reactor.

In its pursuit of safety, the discipline of anesthesia has progressed through phases 1 and 2 of above, and has recently begun adopting phase 3. Anesthesia has been in use for over one and a half centuries and is considered as one of the most safety conscious branches of medicine, but it still lags behind the nuclear power industry which has just existed for approximately six decades. This slower progress in the safety journey of anesthesia almost certainly reflects the existence of blame-centered approach in medicine and the fact that disaster in anesthesia, although no less tragic, generally kills individuals one at a time, rather than en masse.

Car manufacturing

Toyota Production System (TPS) emphasizes frequent rapid problem solving and work redesign, with the goal of "delivering to customers exactly what they need, when they need it, every time, defect-free, in a safe environment at the lowest cost without waste".[17] This philosophy started to gain a following among health care organizations with an increasing number of hospitals and health systems adopting a version of TPS as their systematic approach to enhancing quality and improving efficiency.[18]

TPS became known as "Lean Systems," "Lean Manufacturing," or just "Lean."

These are a series of tools under the umbrella of "Lean" that are applicable to the improvement of patient care. The purpose of Lean measures is to eliminate all forms of waste and to constantly pursue perfection while ensuring continuous flow through a process. Lean strives to decrease or eliminate bottlenecks in process, many of which affect quality and safety. According to Lean methodology, the forms of waste that need to be addressed are:[17]

> *Defects*: anything that does not meet a required specification or need.
> *Overproduction*: creating too much of anything that is not used efficiently
> *Waiting:* by either patients or staff
> *Not using talent:* Putting the wrong people in the wrong jobs
> *Transportation*: when something or someone has to be moved for the next step in the pathway
> *Inventory*: Overstocking of drugs, equipment, or supplies
> *Motion:* supplies or people not where they are needed resulting in having to go looking
> *Extra processing or rework*: An activity that takes places as work around for something else that is broken in the process.

This concept is taking a hold in healthcare especially in operating theater management because of easily identified areas of waste.

Operating rooms have become one of the early adopters of "Lean health care". In a modern-day hospital, various procedures will need to be done in different specialities. Hospitals have adopted "Lean Systems" to improve the availability of right manpower, right equipment, and all that is needed for a particular patient. Lean tools emphasize that cooperation of multiple units is essential to ensure workflow or patent pathways are efficient.

Telecommunication

In the mid-1980s, a multinational telecommunication company, Motorola, developed "Six Sigma". It is a quality improvement concept that focuses on error reduction by establishing aggressive goals. It focuses on process improvement and variation reduction using the paradigm of define, measure, analyze, improve, and control. Sigma (σ) is the accepted symbol for 1 standard deviation from the mean of the "normal" distribution (bell curve). Since 1 sigma would exclude 31.8% of a normally distributed event under consideration and three sigma would exclude 0.3%, six sigma implies events of very low frequency (on the order of 3 per million. Several experts in

the healthcare have recognized the need for the application of Six Sigma in hospital care and operating room management. Using lean six sigma methodology, Roberts *et al*. were successful at identifying anesthesia supply chain deficiencies in a pediatric hospital and demonstrate sustained improvement in the quality of anesthesia supply chain.[19]

Other industries
Formula 1
Handover of patient after a complex surgery from the theater team to the intensive care team is an important event for continuity of care, recovery, and eventual outcome of high-risk patients.[20] During this period, care is transferred from the theater team who have intimate knowledge of the patient to the team in intensive care with limited knowledge of the patient. During this period, all the technology and support (ventilation, 2–4 monitoring lines, and multiple inotropes and vasodilators) is transferred twice, from theater monitoring systems to portable equipment, and then again to the intensive care systems, within 10–15 minutes. It is equally important that the knowledge of the patient gained by the anesthesia/surgical team during the procedure is handed over to the intensive care unit (ICU). It is the combination of tasks that make this process susceptible to error, at a time when the patient is most vulnerable.[21]

To improve safety and quality of care, the team at Great Ormond Street Hospital for Children in London got inspiration from an unlikely source: the pit-stop techniques of the Italian Formula One racing team Ferrari.[22] The pit-stop in Formula 1 motor racing stands as a model of how a multiprofessional team comes together as single unit to effectively perform a complex task (change four tyres, fill with fuel, and prepare driver) under huge time pressure (approximately 7 seconds) with minimal error [Figure 2]. This was identified as a learning concept from industry with analogy to the handover of patients from theatre to ICU where various treating specialists (anesthesiologists, surgeons, and ICU staff) reconfigure, as a single unit under time pressure, to safely transfer all equipment and information [Figure 3].

They devised a new handover mechanism combining their experience and the lessons learnt from Formula 1 pitstop with emphasis on leadership, task sequence, task allocation, prediction and planning, discipline and composure, briefing, situation awareness, training, and review meetings. The new simple, reliable, easily-trainable handover protocol was able to reduce technical errors and information handover omissions by 41% and 48%, respectively.[22]

In the current era, there is increasing reliance on shift work, and limited time available for training.[23] Team interfaces are

known to be an area of potential weakness. Appropriate and effective communication is a crucial component of handover to ensure seamless continuity of care.[21,23] As a result, technical errors, information handover omissions, and time taken for handovers were reduced.[22] These are being adopted in hospitals all across the world.

Retail industry

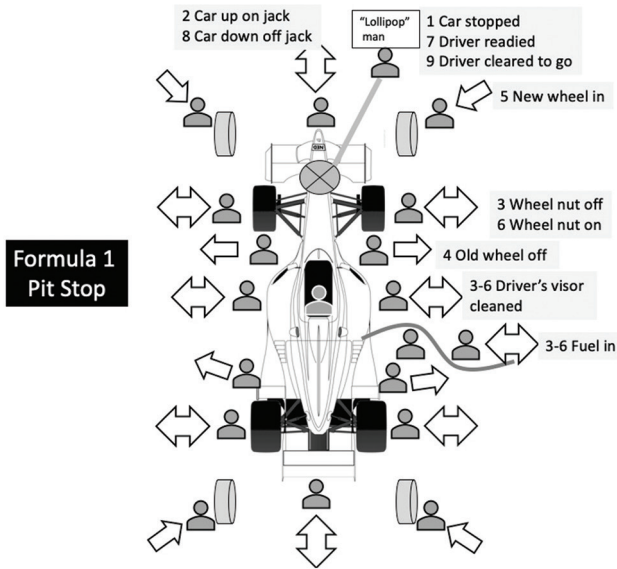Healthcare organizations have taken a cue from mass retail to streamline layers in supply chain and logistics and use purchasing volume to bring down the prices. Examples include in-house health clinics and low-cost generic drugs to cut costs in health care.[24] Patient pathways and value stream mapping have been adopted so that the flow of patients along the pathway is seamless, and improving the patient experience. For example, Day case pathway.

Hotel industry

It is not uncommon to find that the hospitals have already started to implement hotel-style room service in hospitals. Practices such as prompt meal delivery, a restaurant-style menu, tray assembly on demand, scripting, and staff uniforms have been successfully implemented to allow patients more control over their food choices.

Focus on 'customer experience'

Anyone who visits a Disney or Starbucks, will surely notice that there is lot of efforts focussed on creating a "positive customer experience".[25] Some leaders in healthcare organizations have shifted from a narrow focus on customer service to engaging patients at multiple level, i.e., emotional, physical, intellectual, and spiritual level.[25]

Hospitals are introducing amenities like waterfalls, gardens, aquariums, larger windows, more natural light, private rooms, better waiting areas and calming music, which one is used to see in a hotel or spa.

Banking

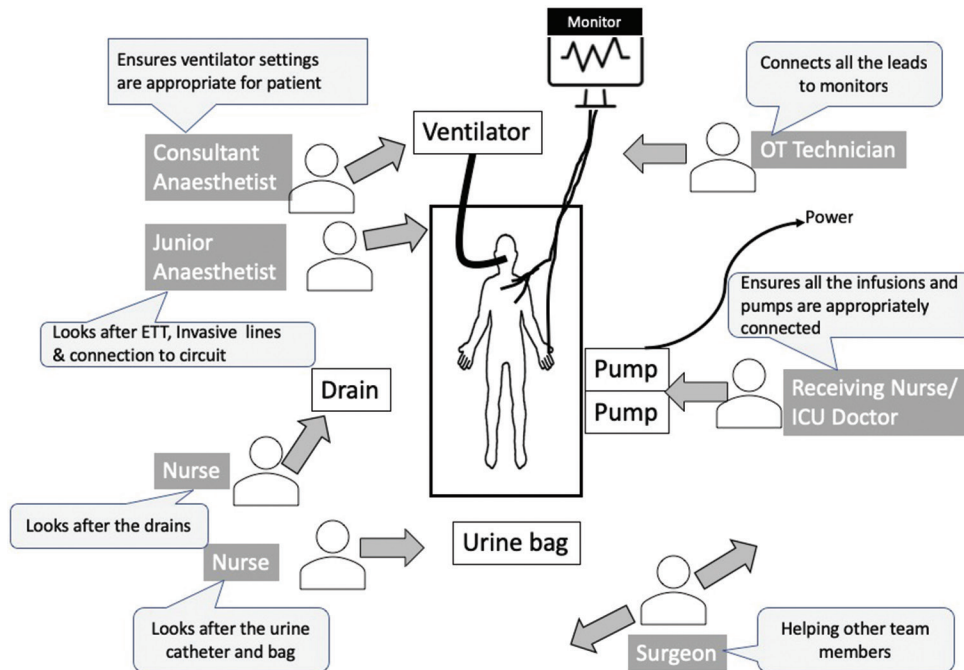Healthcare has a lot to learn from the banking industry when it comes to adopting digitization, data security, and

Figure 2: Formula 1 pit stop job allocation and sequencing

Figure 3: Handover technique from theater team to ICU team

interoperability. As a result of digitization and adoption of anesthesia information management systems (AIMS), a customized access to patient records (including anesthesia notes) are being worked out.

Industry as part of their corporate social responsibility has been encouraging what is known as "Innovisits" by healthcare staff. An "Innovisit" is an organized industry visit for health care staff to learn from other similar industries. Key questions are crafted in advance, and "innovistors" bring back their experience to the hospital.

Anesthesiology in the Digital Age

With the advent of AIMS, providing electronic "navigation," integrated monitoring systems, and electronic/computerized anesthesia machines, we have the opportunity to mimic the aircraft industry by integrating these multiple information sources. This will allow us to manage patients more specifically by using data from physiologic monitors, the anesthesia machine, and from the patient's medical history and laboratory data to develop the "multifunctional display". In medicine, this could be called "clinical decision support."

There are many examples of clinical decision support systems being used, such as reminders for antibiotic timing (pop-up displays on an information system), alerts for abnormal laboratory values, allergies and alerts for the potential of awareness during anesthesia.[26-28] The integration of these multiple sources of data provides us with the opportunity to move into a new era of perioperative care with powerful clinical decision support mechanism. We may have the opportunity to reduce the perioperative complications (e.g., myocardial infarction, renal failure, and stroke) by optimizing and individualizing the perioperative care based on patient- and procedure-specific personalized care plans. We will probably be able to reduce anesthesia-related mortality to lower than 1 in 100,000 individuals, which is where we stand now.[29]

Clearly, safety and quality improvement in healthcare has been influenced by safety practices in other industries. However, one would find that healthcare still lags behind in the safety improvement journey compared to other industries and this may be partly because of difficulties in successfully implementing the solutions and practices that work in other industries.

To make these ideas and practices work in health care, we need to go beyond simply introducing techniques and develop a deep understanding of what is required to make these ideas and practices work in this unique area. Efforts to make these techniques work are currently hampered by a tendency to only partially implement solution, a lack of knowledge and inadequate resourcing. Adopting these advances in safety in the health care might mean greater spending initially, but in the long run it will probably prove to be wise and cost effective initiative.

Conclusion

Anesthesia, operating rooms, and hospitals have adopted innovative practices from various industries in efforts to advance patient safety, enhance quality of care, reduce waste and inefficiency, and improve service and satisfaction. As a result of all these, anesthesia has never been safer and caring like it is now. Digital adoption will bring in platforms to develop powerful clinical decision support mechanism to make perioperative care even safer.

As we transition in the field of anesthesiology, we must recollect the words of Dr Ellison Pierce during the Emery Rovenstine 34th lecture: "Patient safety is not a fashion nor a preoccupation of the past. It is not a problem that has been solved, but rather an ongoing requirement."[30]

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