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REFLECTIONS

Artificial intelligence *versus* the art of anesthesia: a long and winding road ahead

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We have noted with interest that the US Food and Drug Administration recently approved the marketing of an anatomy software for ultrasound-guided regional anesthesia using artificial intelligence (AI) to help clinicians perform peripheral nerve blocks.[1] It would seem that the term AI has different meanings in different contexts, because there is no definitive definition of AI. But, AI generally refers to the simulation of human intelligence processes (behaviour) by machines, especially computer systems.[2]

Does this mean our practice will soon become increasingly automated? Is this a change to be embraced with enthusiasm, or rather a change that might have an unexpected, unintended, but predictable negative impact? In a keynote speech at the Web Summit in 2017, renowned physicist, Stephen Hawking, warned the emergence of AI could be the "worst event" in the history of our civilization. Admittedly, Hawking was referring to the danger of technology evolving into an out of control and irreversible predominance, but should we be concerned that our increasing dependence on AI might be endangering our anesthesia specialty and posing a risk to patients in more subtle ways?

In June 2018, Dr. Richard Harris, an anesthesiologist and an expert cave diver, was asked by the Thailand government to help in rescuing twelve children who were trapped in the Tham Luang Nang Non cave system. After assessing the trapped children, and considering all available options and resources, he advised the team that the safest approach was to sedate, or anesthetize, each child. This would allow the children to be brought out of the cave by a pair of expert cave divers. Anesthesia was needed because it was felt that the children would panic and so could not co-operate during the rescue dive, which was anticipated to be about three hours for each child.

After fasting, each child was placed in a diving suit. Anesthesia was induced by oral alprazolam, and *im* injection of ketamine and atropine (to decrease secretions), and maintained by repeated *im* ketamine injections during the dive, as needed to restrain the children's movement.[3] Each child was placed under anesthesia and tightly fitted with a mask, connected to a circuit and a diving tank. To protect the childrens' limbs, and for ease of going through narrow passages, their hands and feet were bound to their body in one tight unit. To minimize the risk of an upper airway obstruction, the children were placed in prone position with a head tilt during the transport dive. Neither intravenous access nor monitoring was available during the dive. Since visibility was poor, the divers navigated through the passageway guided by ropes which had been placed for them along the route. The rescue diver swam with one hand grasping the rope as a guide and the other hand pulling or pushing the child through the muddy water. These non-medical expert

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divers would pause at each air chamber in order to assess the children and administer more *im* ketamine through the wetsuits as needed. The most challenging aspect of the transport dive was to balance the safe use of an anesthetic drug, and the "co-operation" of the children with no monitoring equipment and no vascular access or means of managing the airway. One by one, all children were brought up safely from the cave. This remarkable rescue, which could accurately be described as anesthesia-in-the-dark, truly highlighted innovative improvisation in the art of anesthesia. By applying knowledge of pharmacology, physiology, and the understanding of airway management (oxygenation), anesthesia was safely provided, with no AI assistance and in one of the most difficult environments imaginable.

During the last century, the practice of anesthesia has dramatically changed from very intimate physical connection with a patient (by seeing, feeling, touching, and listening), to securing the airway after administration of anesthetics and muscle relaxant, and more remotely to monitoring the patient's vital signs and depth of anesthesia using technology such as electrocardiography, noninvasive blood pressure monitoring, pulse oximetry, capnography, neuromuscular transmission monitoring, transesophageal echocardiography, and processed electroencephalography (EEG). During the last several decades, the advances in technology have allowed anesthesiologists to move further and further away from "connecting" with the patient, while monitoring remotely using medical technology.

While advances in technology over time, without a doubt, have improved outcomes of patients under general anesthesia, there is an inherent risk associated with failures in technology, or failures in accessing technology. Unfortunately, many anesthesiologists might encounter difficulties when the technology fails. For example, many newly-trained anesthesiologists might not know, without the use of an ultrasound, how to perform an internal jugular venous catheterization, or a femoral arterial catheterization.

There is also a danger that newly-trained anesthesiologists may not have been taught how to use palpation techniques to identify landmarks, and some would not know how to manage a patient with a challenging airway without a flexible bronchoscope. In fact, some anesthesiologists do not know even how to perform a proper direct laryngoscopy, using either a straight blade (Miller or Phillips laryngoscope), or a curved blade (Macintosh laryngoscope), having disproportionally relied on the use of videolaryngoscopes in their clinical practice.[4] This failure to teach the basics of anesthesia cannot be ignored.

Others have expressed concerns that technical advances might be accompanied by a gradual deterioration of physicians' skills in the basics of the art of anesthesia with the adoption of newer technology. In 1951, in response to the post-war developments in the science of anesthesiology, Dr. Harold Griffith elegantly penned "A Plea for the Art of Anesthesia."[5] We applaud Dr. Griffith's insights that "*… the modem art of anesthesia, like all forms of art, … is hard to define but one might say it includes all that comprises the practice of the science of anesthesia. This means all the factors which influence the relationship of the anesthesiologist to his patient, to his colleagues, to surgeons, nurses, hospitals and to the community.*"

In the spirit of Dr. Griffith, and in the context of the major advances in medical technology, we would like to amplify the definition of the "art of anesthesia" to include the achievement of a positive or favourable outcome using available resources and skills (both art and science) for a specific context. While advances in medical technology have helped to improve patient outcomes, major efforts need to be made to continue the teaching of the art of anesthesia, including expertise with a myriad of options should specific technologies become unavailable.

For example, we would hope to ensure that we all support and adhere to the "standard of care" of ultrasound use for placing an internal jugular vein (IJV) central venous catheter in a nonobese patient while ensuring that practitioners are able to function in the absence of such adjuvants. Perhaps, we could use the ultrasound to scan the neck vascular anatomy, to ensure no abnormality, before preparing and draping the site. We would then proceed with the IJV catheter placement with palpation of the carotid artery and a 22G finding needle to locate the IJV. After the insertion of the guidewire, we would use the ultrasound to confirm the guidewire placement inside the IJV. If there is difficulty in locating the IJV using the finding needle after two attempts or when the palpation technique is challenging (e.g., patients with a thick short neck), we would then use the real-time ultrasound to perform the IJV catheterization. If this became a routine teaching practice, we could maintain skills in the art of palpation techniques, as well as the ultrasound-guided technique, to meet the "standard of care" as recommended by the established guidelines.

Similarly, we could teach trainees to routinely perform and practice direct laryngoscopic intubation using a videolaryngoscope with a Macintosh blade with a direct line-of-sight view and changing to the videolaryngoscopic display view when encountering difficulty in viewing the glottis.

During our global health work in low-income countries, most advanced medical technology is not available. Since they do not have Penrose drains, clinicians use the finger portion of a sterile glove as a drain following surgery. A fluid-filled 4.5-L water bottle is used as a weight for traction of femoral fracture. Blowing air into a rubber glove has been used as a method of spirometry. These are just some of the examples of practicing the art of medicine or anesthesia within the available resources, clinicians' skills, and contexts.

We understand that there is a growing concern for introducing "homemade" or "do-it-yourself" medical devices[6] in the absence of evidence or robust randomized controlled trials (RCTs), and that there is a demand for an evidence-based practice of medicine. Nevertheless, the practice of medicine cannot be always evidence-based, particularly within the context of resource-poor medical emergencies or crises. Sometimes, without evidence and robust RCTs, we must use what is at hand and what art, science, logic, and common-sense dictate. Parachutes have been used for centuries; however, there has never been a single RCT to show that parachutes save lives.[7]

In other words, while we embrace AI technology to help us to care for patients, we cannot ignore the importance of keeping our basic skills at an expert level. When we "drive" a self-driving car, we are expected to be able to take over in any and all circumstances.[8] We constantly monitor the car and the road conditions for unforeseen events, and we have the skills to take over as needed. Similarly, when we place a processed EEG monitor to assess the "depth" of anesthesia when administering a total intravenous anesthetic to a patient, we simultaneously continue to monitor the "depth" of anesthesia using the patient's vitals and movement, throughout the anesthesia, to minimize the risk of awareness under anesthesia. This is particularly important when the processed EEG monitor becomes nonfunctional during anesthesia (e.g., the leads come off during craniotomy when cleaning solution, or blood weakens the stickiness of the leads).

The art of anesthesia is the integration and synthesis of all of our knowledge, tools, and skills depending on our resources and context. Without doubt, anesthesia outcomes over the last 70 years have improved dramatically. Much of this is related to applied technology, but much is also related to cognitive, attitudinal, psychological, educational and behavioural evolution of the art of anesthesia. Perhaps one of the best examples to illustrate the art of anesthesia is when we examine Dr. Harris' cave rescue.[3] He provided safe anesthesia to those pediatric patients, in the dark muddy water, and with no helpful medical AI assistance, using "only" his basic knowledge of pharmacology, physiology, ventilation, and oxygenation. While AI can help us to improve the care of our patients, we must teach what to do when technology fails. Because it will fail as surely as your driverless car needs your corrections.[8] In the movie Space Odyssey 2001, HAL 9000, the AI computer, prioritized self-preservation and refused to help the crew. This threat is not just in an imaginative movie. It was grim reality for the pilots who were unable to correct, or override, AI error in the Maneuvering Characteristics Augmentation System in the Boeing 737 MAX airliner which caused two separate plane crashes in 2018 and 2019.[9] While expecting the best and preparing for the worst, we know that medical catastrophe due to technical failure is preventable for those of us who are well-trained in the art and practice of anesthesia. Expert knowledge and skill in the basic art of patient care are fundamental and will provide the foundation for safe practice as our technical advances revolutionize our current practices.

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