MY VISION OF ANAESTHESIA IN 2050

Surg Lt Cdr (Dr) George Cherian Ambooken
Junior Resident (Anaesthesiology and Critical Care)
Armed Forces Medical College, Pune

Anaesthesia is a young specialty, with its organized foundations being laid a mere 150 years back when WTG Morton, in his famous public demonstration at the Massachusetts General Hospital, showed that alleviation of pain in surgery was possible(1). Despite it being in relative infancy when compared to many other branches of medicine, anaesthesia has grown leaps and bounds during its short-lived life. From the days of soporific sponges(2), mandragora, and Indian hemp(3) dominating anaesthestic practice in the world, we have now reached a state wherein the anaesthetist assumes complete control of the human body, including the respiratory and circulatory functions. And while many would see the absolute mastery the anaesthetist of today possesses over the physiological functions of the body as the ultimate end-point of the specialty, it would be naïve to think that the subject would not develop even further. And, while the possibilities for the subject are endless, this article examines the developments which are likely to become a reality over the next three decades.

Due to the fast pace of development of the subject, there already exists a varied assortment of drugs and equipment in the anaesthetist's arsenal, which seemed a distant dream only a few years back. Additionally, this rapid rate of development of the subject shows no signs of abating. From using Halothane inhalation in the not so distant past, we have moved on to better and safer agents such as Sevoflurane and Desflurane. Similarly, newer induction agents and muscle relaxants have also revolutionized the way we practice the subject. Even the much-hallowed Nitrous Oxide, which has endured the test of time for over fifteen decades, is likely to give way to Xenon in the near future(4). Monitoring in anaesthesia has also seen significant advances, with the present day anaesthetist being equipped with devices such as cerebral oximeters, bispectral index monitors, and neuromuscular junction monitors, which have greatly enhanced the efficiency and decreased the adverse events associated with anaesthesia. However, despite the newer agents and monitoring techniques being currently introduced, the future of the subject is less likely to be revolutionized by better anaesthetic agents or observer-dependent monitors as it is by the ingress of technology into the field.

The biggest development that is likely to radicalize the practice of anaesthesia over the next thirty years is the use of Artificial Intelligence (AI) in everyday anaesthesia. The foundation stones for the use of AI in the practice of anaesthesia and critical care have already been laid, as is evidenced by the various studies which have already shown prospective benefit in its application to patient care. For example, recent experiments done in an Operation Theatre setting have shown that AI was able to accurately predict the occurrence of hypotension five minutes before the actual occurrence of the same(5). Similarly, studies with Fuzzy Inductive Reasoning methodology have shown that AI was able to produce a reasonably good control of performance of the anaesthetic agent delivery system, which provides the possibility of

completely machine-controlled delivery of anaesthetic agents to the patient based on his/her BIS readings(6). A recent study was also able to demonstrate improved performance of automated anaesthesia drug delivery vis-à-vis the conventional manual method. While there has been significant criticism regarding the use of AI in medical care, not least that AI does not provide/ predict anything that an experienced clinician could not, there is not circumventing the fact that the existing system is highly dependent on manual the availability of skilled clinicians, and is highly manpower dependent. Therefore, the existing system has potential pitfalls when a single clinician provides care to multiple patients. With the focus of the present-day world being on improved efficiency, combined with an emphasis on less reliance on manpower, AI is likely to rear its head into mainstream anaesthesia over the next decade, and is likely to be the standard of care in anaesthesia monitoring in another two decades.

While it looks inevitable that Artificial Intelligence, equipped with the latest machine learning tools is likely to bear a huge chunk of the monitoring aspect of anaesthesia over the next three decades, procedural anaesthesia proves to be a different ball game. While a computer, equipped with machine learning, thereby capable of advanced mathematics and logarithms can predict the occurrence of certain events prior to their occurrence, it is significantly more difficult to teach a computer-controlled robot to perform a procedure, especially in patients with a deranged anatomy. This is a result of the unique challenges posed by patients with a deranged anatomy wherein the clinical acumen and procedural experience of the anaesthetist plays an important role in successful management of the patient. While there have been significant advances in the field of robotic procedural anaesthesia, with manual robots (mechanical robots which are designed to replicate manual gestures of a proceduralist) such as the Kepler Intubating Robot which uses video-laryngoscopy to intubate a patient using a robotic arm (7), and the DaVinci robot which is capable of administering regional anaesthesia (8,9). However, these robots, while being excellent aids to procedural anaesthesia, are not programmed to lead independent existences, and require the mind behind the machine for successful anaesthesia.

That being said, the above demonstrations showed that a remotely located operator was able to successfully perform the procedures on patients with the help of manual robots. The success of these demonstrations has left us with the distinct possibility of complete robot controlled anaesthesia, with wherein a manual robot could be used for procedural anaesthesia and pharmacological robots controlling the depth of anaesthesia thereafter. Therefore, a robot equipped with complex machine learning and deep learning algorithms, if combined with a manual robot, could take over the entire ambit of providing monitored anaesthesia care. This would mean that the robot takes over the complete care of a patient, starting from induction, proceeding to maintenance of the anaesthetic state and onwards to reversal and recovery. While the possibility of complete robotic anaesthesia exists, the gap between a good clinician and a robot seems too large to circumvent over the next three decades. One could expect AI assisted complete robotic anaesthesia becoming a reality in probably another five to seven decades.

Apart from Artificial Intelligence, the other exciting technology that it likely to completely transform everyday anaesthetic practice is nanotechnology. While nanotechnology has encompassed a wide range of fields over the past few decades, the medicine has remained relatively immune to its advances. However, the past decade has seen a greatly increased focus on nanotechnology in the field of medicine, not least in anaesthesiology. Nanotechnology enables the creation of extremely minute engineered 'nano-robots', which have different advantages, including extremely specific site of action, modifiable pharmacokinetic characteristics, and reduced adverse effects. A literature search on the advances in nanotechnology based anaesthesia gives us a glimpse into the future, with promising results being seen in several studies such as minor modifications in the structure of existing drugs to make them more specific as well as efficacious (10,11), and development of specific antidotes to drugs which previously had none (12). While these technologies are only in the formative stages at present, they are likely to be in common use within the next thirty years. The advent of nanotechnology would open many new avenues for the anaesthesiologist, wherein the extremely specific action would enable them to use anaesthetic agents which were hitherto unused due to their systemic adverse effects. This would mean that anaesthesiologists would be able to provide the best possible care with minimum side effects and maximum benefit to every single patient. This technology would make anaesthesia safer, better and more interesting than ever.

It is evident that exciting times lie ahead for every anaesthesiologist. Even though the ingress of technology into the field of medicine has had its fair share of detractors, the fact remains that technology aided medicine is likely to be the standard of care in a few decades from now. Man being replaced by machine is not a new phenomenon in the world, and the time is nigh when the change is about to embrace the medical field as well, especially in the branch of anaesthesiology. However, rather than being a cause for concern, this is an opportunity for the specialty to grow, for every anaesthesiologist to embrace change, and a prospective opening for realizing the dream of providing the best conceivable care to each and every patient a firm reality.

"Change is inevitable in life. You can either resist it and potentially get run over by it, or you can choose to cooperate with it, adapt to it, and learn how to benefit from it. When you embrace change you will begin to see it as an opportunity for growth."

~ Jack Canfield

COUNTERSIGNED

Brig (Dr) Rangraj Setlur
Professor and HoD
Dept of Anaesthesiology and Critical Care
Armed Forces Medical College, Pune

References:

1. Desai SP, Desai MS PC. The discovery of modern anaesthesia-contributions of Davy, Clarke, Long, Wells and Morton. Indian J Anaesth 2007;51472-8. 2007;
2. Juvin P, Desmonts JM. The ancestors of inhalational anesthesia: The soporific sponges (XIth- XVIIth centuries): How a universally recommended medical technique was abruptly discarded. Anesthesiology. 2000;
3. Houghton IT. Some observations on early military anaesthesia. Anaesth Intensive Care. 2006;
4. Moppett I. Inhalational anaesthetics. Anaesthesia and Intensive Care Medicine. 2015.
5. Hatib F, Jian Z, Buddi S, Lee C, Settels J, Sibert K, et al. Machine-learning Algorithm to Predict Hypotension Based on High-fidelity Arterial Pressure Waveform Analysis. Anesthesiology. 2018;
6. Nebot A, Cellier FE, Linkens DA. Synthesis of an anaesthetic agent administration system using fuzzy inductive reasoning. Artif Intell Med. 1996;
7. Hemmerling TM, Taddei R, Wehbe M, Zaouter C, Cyr S, Morse J. First robotic tracheal intubations in humans using the Kepler intubation system. Br J Anaesth. 2012;
8. Wehbe M, Giacalone M, Hemmerling TM. Robotics and regional anesthesia. Current Opinion in Anaesthesiology. 2014.
9. Tighe PJ, Badiyan SJ, Luria I, Boezaart AP, Parekattil S. Robot-assisted regional anesthesia: A simulated demonstration. Anesth Analg. 2010;
10. Wang H, Cork R, Rao A. Development of a new generation of propofol. Current Opinion in Anaesthesiology. 2007.
11. Gou M, Wu L, Yin Q, Guo Q, Guo G, Liu J, et al. Transdermal anaesthesia with lidocaine nano-formulation pretreated with low-frequency ultrasound in rats model. J Nanosci Nanotechnol. 2009;
12. Powell E, Lee YH, Partch R, Dennis D, Morey T, Varshney M. Pi-Pi complexation of bupivacaine and analogues with aromatic receptors: implications for overdose remediation. Int J Nanomedicine. 2007;