Short Comunication

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Anaesthesia Past, Present and Future

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Abstract

Rapid advances in Artificial Intelligence (AI) have led to diagnostic, therapeutic, and intervention based applications in the field of medicine. Today, there is a deep chasm between AI based research articles and their translation to clinical anaesthesia, which needs to be addressed. Machine learning (ML), the most widely applied arm of AI in medicine, confers the ability to analyse large volumes of data, find associations, and predict outcomes with ongoing learning by the computer. It involves algorithm creation, testing and analyses with the ability to perform cognitive functions including association between variables, pattern recognition, and prediction of outcomes. AI supported closed loops have been designed for pharmacological maintenance of anaesthesia and hemodynamic management. Mechanical robots can perform dexterity and skill based tasks such as intubation and regional blocks with precision, whereas clinical decision support systems in crisis situations may augment the role of the clinician. The possibilities are boundless, yet widespread adoption of AI is still far from the ground reality. Patient related "Big Data" collection, validation, transfer, and testing are under ethical scrutiny. For this narrative review, we conducted a PubMed search in 2020-21 and retrieved articles related to AI and anaesthesia. After careful consideration of the content, we prepared the review to highlight the growing importance of AI in anaesthesia. Awareness and understanding of the basics of AI are the first steps to be undertaken by clinicians. In this narrative review, we have discussed salient features of ongoing AI research related to anaesthesia and perioperative care.

Keywords: Advances in anaesthesia; Artificial intelligence; Machine learning; SEDASYS; Respirocytes; Telemedicine.

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INTRODUCTION

The modern practice of anaesthesiology is inextricably dependent upon technology. This dependence is not as strong among the other medical specialties and makes a review of recent advances particularly germane to the determination of our field's future. We cannot discuss the present day

scenario in anaesthesia without acknowledging the contributions of various esteemed personalities who have deemed their presence in the golden history of The Evolution of Anaesthesiology. Technology first made anaesthesia possible, then safe, and will seek to make it increasingly scalable and efficient in health care systems pressed for resources both economic and human. Herein, we discuss salient advances which have occurred over the century, focusing on automation, monitoring, and decision support systems. We lastly begin a discussion of innovation landscape in anaesthesiology during the 21st century and the recent advances in the field of Artificial Intelligence.

PAST

Till the late 18th century, all possible crude methods were used to supress pain and consciousness to perform procedures and surgeries. The first successful demonstration of ether anaesthesia on 16th October 1846 ranks as one of the most significant events in the history of medicine. This event took place at the Massachusetts General Hospital, Boston. ***William Thomas Green Morton*** (August 9, 1819 – July 15, 1868) was an American dentist and physician who first publicly demonstrated the use of inhaled ether as an anaesthetic and along with surgeon ***John Collins Warren*** and successfully removed a tumour from the neck of a ***Mr. Edward Gilbert Abbott***. Later in 1847, ***Sir James Young Simpson***, (7 June 1811 – 6 May 1870) was a Scottish obstetrician and was the first physician to demonstrate the anaesthetic properties of chloroform on humans and helped to popularise its use in medicine. ***John Snow*** (15 March 1813 – 16 June 1858), an English physician experimented with ether to see its effects on respiration and in 1847, published his work on ether- '*On the Inhalation of the Vapor of Ether*'. Snow also studied the case of *Hannah Greener*, a 15-year-old patient who died on 28 January 1848 after a surgical procedure that required the cutting of her toenail using chloroform and published his work on chloroform. Later in 1884, cocaine was first used as a local anaesthetic. The field of anaesthesia then saw a dramatic change in the field of in the 19th century, with the discovery of curare and its effect along with thiopental and other improved techniques in delivering anaesthesia. Later in 1950, halothane, the first inhalation agent to be discovered made its way into anaesthesia. 1977 saw the discovery of 'Milk of Amnesia' aka Propofol which changed anaesthesia practise on the whole. The late 19th century saw the improvement in monitoring techniques like pulse oximetry (1980) and capnography (1991). We thus witnessed "*The Evolution of Anaesthesia*" in the history of mankind though we still haven't discovered the precise mechanism with which general anaesthesia works on the body. As it was famously quoted:

"The mystery of Anaesthesia is now a history, but the history of anaesthesia is still a mystery"

PRESENT

The 21st century has seen a tremendous linear growth in Anaesthesia practises in the world. Advancements in drugs, techniques, machines and better education has made anaesthesia practise safe today in the course of providing safe anaesthesia, we have developed skills of multitasking being simultaneously involved in processing a lot of information, troubleshooting our monitors and machines, performing clinical invasive procedure, heading the OT room, jotting down our case notes all while being under high pressure keeping in mind our motto of 'safe anaesthesia, *safe surgery and safe patient*'.

Today our role has extended from being just ana anaesthetist to, being part of the emergency response team, resuscitation team in the ER, handling the ICU and the ventilated patients, palliative care and pain management. We have become the true sense of "physicians with nerves of steel', capable of handling all sorts of situations. An anaesthesiologist today has to play the role of a fine physician and intensivist weighing the indications and risks involved with each procedure. As a post graduate resident today, I feel that this branch has so much to offer! Smooth handling of the airway and judicious use of different drugs has been something constant over the past two hundred years and I believe it is something that will continue to be.

The present day Boyles machine has become so sophisticated enabling a uniform standard of anaesthesia machines let it be rural or urban areas and the anaesthesiologist will be at comfort at all places. With Artificial Intelligence and Augmented reality in anaesthesia (AI and AR) being the new hype in the surgical field, robots have taken over procedures such as securing central venous access, intubation (The Kepler Intubation System) and to assist the administration of regional anaesthesia. Robots fitted with sensors and safety systems which will allow them to work alongside humans. I cannot help thinking that these "collaborative

robots" will soon be assisting us in our daily tasks in the operating room.

The SEDASYS system, is a computer assisted personalized sedation system, that administers propofol for minimal to moderate sedation titrated to the processed EEG and vital signs to patients undergoing colonoscopy and endoscopy without direct supervision by an anaesthesia provider. It was recently approved by the Food and Drugs Administration.

The combination of Anaesthesia and Nanotechnology has been proposed which has wide applications in the future. A technique using anaesthesia containing nanoparticles which are drawn to the targeted area of body by magnets are providing a useful alternative to nerve block for local anaesthesia. This principle will reduce the overall drug consumption and side effects by depositing the active agent only in the targeted areas. Also, newer modalities like implantable drug delivery systems are advantageous over the current injectable drug delivery system because they do not follow first-order kinetics as injectables. As far as anaesthetic drugs are concerned, our drugs of the future may be target oriented without any side effects and they will carry out the required effects through modulations on the receptors. Recent studies involving the use of magnet derived nanoparticles local anaesthetic complexes have shown great promise in encountering problems faced by Anaesthesiologists with respect to local anaesthetic toxicity and complications.

Studies on *Respirocytes*, which are nanostructures that transport oxygen in human body similar to erythrocytes, are in full swing in research laboratories worldwide. Theoretically respirocytes can release almost 100% oxygen as compared to the erythrocyte which releases only one fourth of the gas it stores. Future use of these respirocytes will help faster weaning off from ventilators and this will help us bypass this dependency on ventilators, thus proving being great addition to the management option to the intensivists. Advances in Genetic Engineering to modulate bacterial genome to produce new drug modalities and synthetic blood products will surely transform "Transfusion protocols" drastically reducing drug toxicities and reactions to transfusions.

Preadmission anaesthesia consultations using telemedicine technology has already started and this offers the possibility of distant preoperative assessment and evaluation of the patient's fitness for anaesthesia. It can also help training personnel to perform anaesthetic procedures and while the control of delivery of anaesthesia is monitored from a distant location.

With the advent of different blocks, regional anaesthesia will develop further, reducing the indications of general anaesthesia to a handful few. Pain management although a well-established super specialization since the last 2-3 decades, still has a huge potential and its contribution to palliative medicine will hit a peak in the future.

FUTURE

With the technological advancements that we are seeing with each passing day, it is difficult to predict how advanced anaesthesiology might flourish out to be. Smartphones controlled anaesthesia practise is on the rise with everything in our hand. With advanced robotics and computerised monitoring, one may feel is this branch facing the fear of extinction by 2050? Well, that's absolutely not happening! As our senior faculty told us on the first day of residency, intubation is a skill, not very difficult to acquire, the real judgement and experience will tell you when to extubate! The adrenaline surge that every anaesthesiologist gets with each case he/she induces even after 20-30 years of work experience teaches him/her something new which later reflects as an 'intuition'. In my 3 years of PG, I have learnt it the hard way, the intuition of a senior anaesthesiologist can often be more useful than a 24-hour critical monitoring of a patient, so definitely no robot can ever replace a senior anaesthesiologist!

With the advent of the introduction of Artificial intelligence in the field of medicine, we have seen application of Artificial Intelligence in various aspects of medicine, ranging from largely diagnostic applications in radiology and pathology to more therapeutic and interventional applications in cardiology and surgery. In April 2018, the U.S. Food and Drug Administration approved the first software system that uses artificial intelligence a program that assists in the diagnosis of diabetic retinopathy through the analysis of images of the fundus. Anaesthesiology as a field is well positioned to potentially benefit from advances in artificial intelligence as it touches on multiple elements of clinical care, including perioperative and intensive care, pain management, and drug delivery and discovery.

Till date we have identified six main clinical applications of artificial intelligence research in anaesthesiology: (1) depth of anesthesia

monitoring, (2) control of anesthesia, (3) event and risk prediction, (4) ultrasound guidance, (5) pain management, and (6) operating room logistics.[1] *Depth of Anaesthesia Monitoring:* Use of artificial intelligence to improve depth of anaesthesia monitoring was identified in 42 papers. The majority of these papers focused on use of the BIS (Medtronic, USA) or electroencephalography to assess anaesthetic depth. In addition, careful monitoring of MAP has also been noted in the literature, likely due to the association of low MAP with postoperative mortality. *Control of Anaesthesia Delivery* Control systems that use machine learning have also been used to automate the delivery of neuromuscular blockade and these systems have also incorporated forecasting of drug pharmacokinetics to further improve the control of infusions of paralytics. *Event Prediction:* We refer to event prediction as any studies that engage in prediction of an effect or event (e.g., complication, length of stay, awareness, etc.). AI has also been used to predict the rate of recovery from neuromuscular blockade and hypotensive episodes post induction or during spinal anesthesia, while other machine learning approaches have been tested to automatically classify pre-operative patient acuity (i.e., ASA status), define difficult laryngoscopy findings, during conscious sedation, identify respiratory depression and to assist in decision-making for the optimal method of anesthesia in pediatric surgery.[1] In a single center randomized control trial comparing a machine learning alert system (using six vital sign parameters as features) versus an electronic health record based alert system that used other criteria for the prediction of sepsis, the machine learning alert system outperformed Systemic Inflammatory Response Syndrome criteria, Sequential Organ Failure Assessment score, and quick Sequential Organ Failure Assessment score in the detection of sepsis. Its use resulted in a 20.6% decrease in average hospital length of stay and, more importantly, a 58% reduction in in-hospital mortality.[2] Ultrasound Guidance Smistad *et al*.[3] used ultrasound images of the groin from 15 patients to train a convolutional neural network to identify the femoral artery or vein while distinguishing it from other potentially similar appearing ultrasound images such as muscle, bone, or even acoustic shadow. Closer investigation of the network found that it would analyze horizontal edges in the ultrasound with greater priority than vertical edges to identify vessels with an average accuracy of 94.5% ± 2.9%.[3] In addition to specific structure detection in ultrasound images, researchers have also used neural networks to assist in the identification of vertebral level and other anatomical landmarks for epidural placement.

At this point in time, it is hard to predict the full potentialof artificial intelligence applications as we continue to make significant strides in hardware and algorithm design as well as database creation, curation, and management advances that will undoubtedly catalyse even further advances in artificial intelligence. Before pulse oximetry, trainees were taught to recognize cyanosis and other signs of hypoxia; before automated sphygmomanometry, adapt tactile estimation of blood pressure from palpation of the pulse was a skill sought after by clinicians. Innovation led to devices that levelled the playing field for clinicians to be able to provide care based on reliable clinical metrics of oxygen saturation and blood pressure. Currently, the greatest near term potential for artificial intelligence is in its ability to offer tools with which to analyse massive amounts of data and offer more digestible statistics about that data that clinicians can use to render a medical decision. Artificial intelligence could thus provide anaesthesiologists at all levels of expertise with decision support whether clinical or procedural to enable all clinicians to provide the best possible evidence based care to their patients. As more and more elementsof clinical practice become digitized and accumulated into databases, we may one day see the development of artificial intelligence systems that have a more complete understanding of clinical phenomena and thus greater potential to deliver elements of anesthesia care autonomously.

The hype surrounding artificial intelligence has reached a fever pitch in the lay press, and unrealistic expectations can result in eventual disillusionment with artificial intelligence if clinicians, patients, and regulators do not see the expected revolution in healthcare that is anticipated with artificial intelligence technologies.

Medicine and the practice of anaesthesiology is still, at itscore, a uniquely human endeavour as both science and art. Although algorithms may one day exceed human capabilities in integrating complex, gigantic, structured datasets, much of the data that clinicians gather from patients comes from the clinician patient relationship that is established when patients bestow trust on their doctor. Although anaesthesiologists can develop the knowledge and training to trust artificial intelligence models, it remains to be seen to what extent patients will be willing to trust algorithms and how patients wish to have results from algorithms communicated

to them. Therefore, qualitative research will be needed to better understand the ethical, cultural, and societal implications of integrating artificial intelligence into clinical workflows.

Anesthesiologists should continue to partner with data scientists and engineers to provide their valuable clinical insight into the development of artificial intelligence to ensure that the technology will be clinically applicable, that the data used to train algorithms are valid and representative of a wide population of patients, and that interpretations of that data are clinically meaningful. Fresh to the branch, I feel our subject has a bright future! Apart from providing anaesthesia for surgery we will emerge as care givers in critical care centres and in pain management, making life saving intervention possible in each and every case ensuring that the health care system reaches new heights!

'One must believe that the more you know about the past in the present era, the better you are prepared for the future'.

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