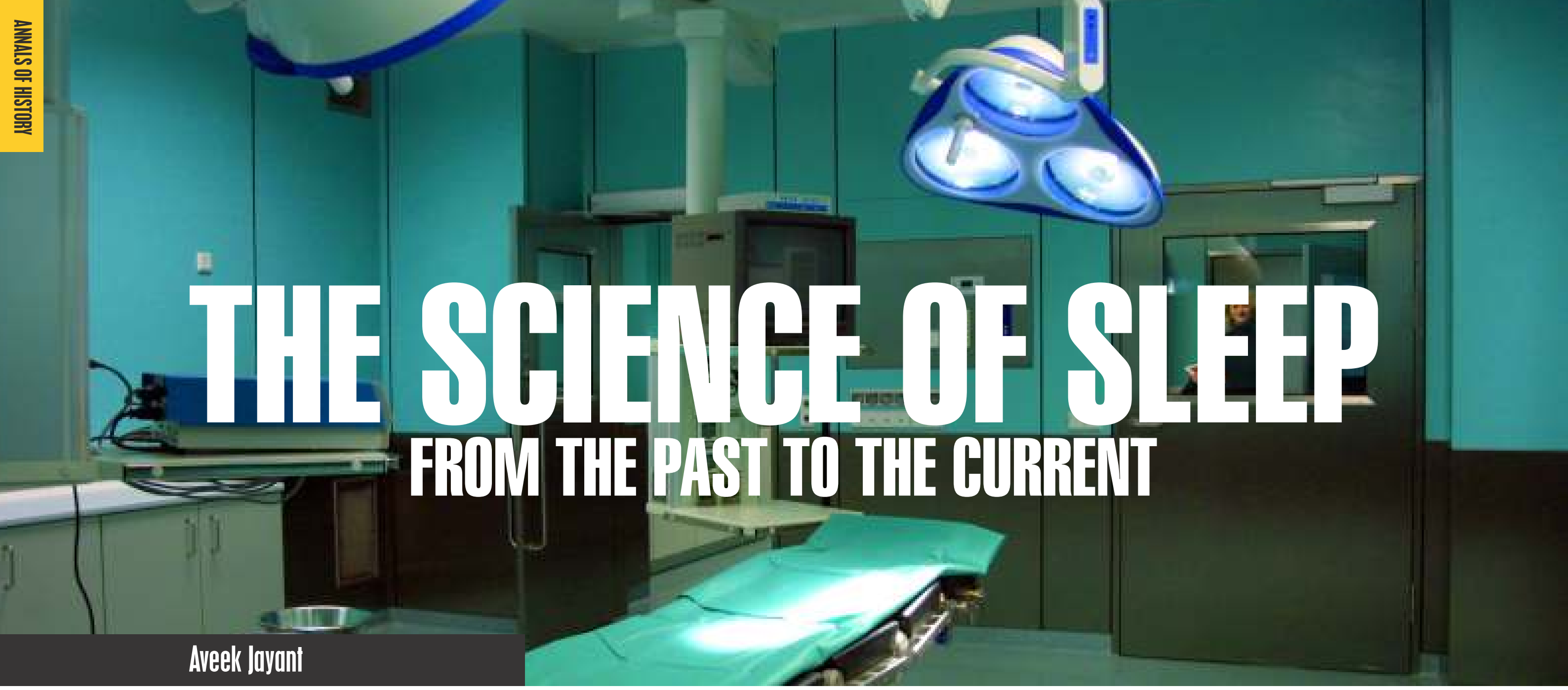


THE SCIENCE OF SLEEP

FROM THE PAST TO THE CURRENT

Aveek Jayant

How long has the use of anaesthetics during surgical procedures been in existence? What were the pitfalls encountered in finding an ideal anaesthetic? How is an ideal anaesthetic defined? Who were the main scientists and doctors involved in getting anaesthesia to the present level of sophistication? This article throws light on the history of this important medical aid.

Introduction

"To trace successfully the evolution of any one of the learned professions would require the hand of a master- of one, who like Darwin, combined a capacity for patient observation with philosophic vision. In the case of medicine, the difficulties are enormously increased by the extraordinary development…. the rate of progress has been too rapid for us to appreciate, and we stand bewildered…" (Sir William Osler, 1849-1919, address to the British Medical Association 1897)

On terra firma- what I do and what I am about to do!

All of us have, at one time or the other, been either moved to tears or made to laugh out loud by the actors in a play or a film. When the play is in motion or the film reel rolls, it seems as if only the main characters on stage are there for the performance. Yet each of these performances is actually made real by the tremendous efforts of those who are behind the scene-those who handle the lights or costume, or prompt an actor when he or she forgets, even those who make sure the curtains come off and go on at the right times. The discipline of anaesthesia is akin to these backstage players. While removal of teeth or nails appears simple, surgery can be complicated - such as mending a broken heart.

I currently spend the greater part of my working life putting people to a state of painless sleep, particularly when their hearts are repaired. This is in addition to monitoring and maintaining, as close to health as possible, their other organs. I also assist in imaging the heart during the procedure, and finally, have a key role in ending the operation in delinking life support and getting a patient back to his feet in the intensive care unit. In this article, I propose to take you on a journey through modern anaesthetics, a snapshot of its evolution, and through it all, convince you of how interconnected the world of knowledge actually is!

From ancient times

The concept of enabling sleep as one went about refashioning an organ is actually ancient. The Bible refers to how the Creator induced a temporary sleep to remove a rib from Adam[1]. Sumerian artefacts depict the use of opium poppy in 4000 BC (the use of opioids as analgesics continue to be the mainstay of anaesthesia even to this day) [2]. Susruta, the pioneer Indian surgeon, refers to the use of wine as a soporific[#] to induce temporary sleep[3]. He is also believed to have initiated the use of cannabis[2] in 600 BC; probably extrapolated from the sleep inducing effects of bhang, consumed on festivals like Holi! The Latin Americans used home grown coca, which is refined to produce modern day cocaine[2], also one of the first local anaesthetics. Yet others, not as observant, would advise people to chew on lettuce or bite on a stick or used a blow to the head to dull the pain that any surgery would bring forth[4]!

A statue dedicated to Sushruta at the Patanjali Yogpeeth institute in Haridwar.

Source: https://en.wikipedia.org/wiki/Sushruta_Samhita CC BY-SA 3.0.

#= drug that causes sleep.

Over time, alcohol and opium became the predominant drugs to be used, but had many problems, among which were the possibility of both inadequate and over dosing (the latter, deadly). Neither was enough to completely ablate the pain of surgery[5]. All in all, the eminent anatomist and surgeon, John Hunter described surgery as a *"humiliating spectacle of the futility of science"* and that of the practitioner as a *"savage with a knife"*[6].

The birth of inhalational anaesthesia

Modern day anaesthetic practice seems largely focused on the administration of medicinal gases via a device into the trachea and from there on the lungs. This began in the mid-18th century when William Morton demonstrated the use of ether at the Massachusetts General Hospital (MGH) in Boston.

The first use of ether as an anaesthetic in 1846 by Morton.

Source: Ernest Board - http://catalogue.wellcome.ac.uk/record=b1203716. Public domain.

However, halogenated alkanes, and not ether, are the main anaesthetic gases in use today. Components of the admixture that have not changed are oxygen and carbon dioxide. Anaesthesiologists have always been preoccupied with the administration, control and composition of these two gases in the breathing mixture since they would inevitably be present at all times.

Joseph Priestley[7] (1742-1786) showed that heating mercuric oxide could keep mice alive longer in a closed space while Robert Hooke managed to keep animals alive by blowing into their lungs[8]. Priestley's communication across the English Channel to the French chemist Antoine Lavoisier (1743-94) led the latter to suggest that the heating of mercuric oxide released an enigmatic new element which he called 'oxygen'. It was left to Humphry Davy (1778-1829), a school dropout, to show that the currency of metabolism was the uptake of oxygen and the production of carbon dioxide. John Haldane provided the logical experimental evidence to this theory by designing apparatus that could accurately measure these gases as they made their way in and out of living things; he coined a phrase that an editorialist in the anaesthesia textbook, 'Miller's Anaesthesia', stresses is the primary training of every modern day anaesthesiologist: "*anoxemia* (an abnormal reduction in the oxygen content in the blood) *not only stops the machine but wrecks the machinery*". As the first year doctoral student enters our portals, we teach her that the primary religious duty of anaesthesia is to monitor, correct and maintain adequate supply of oxygen to tissues as our surgical colleagues play challenge to the processes of nature. Failure means cardiac compromise and ominous hypoxic (caused by lack of oxygen) damage to the brain as cells die from failure of cellular respiration. So, even as anaesthesiologists focus on putting people to sleep, they have the important function of maintaining the stability of the cardiovascular and respiratory systems, a theme that we will deal with in some depth later.

The actual birth of modern day anaesthesia has a longer history than in the public imagination, and like other momentous events in general history, not free of controversy. If one were to cite a figure who was the most apt to be the father of anaesthetics, it would probably be Humphry Davy[9] (1778-1829), and not Horace Wells (1815-48) or William Thomas Green Morton (1819-68). It is however, Morton's demonstration at the MGH on October 16, 1846 that is celebrated all over the globe as World Anaesthesia Day. Davy was not an ordinary person - at 15 years when the death of his father had left him and his family in extreme poverty, he decided to commence a life of self-learning. His study plans at that time detail that he wanted to be a chemist, physician, geographer, mathematician, astronomer and logician - all at the same time! Davy did contribute to each of these fields through the discovery of six elements in the periodic table; or through inventions to facilitate mining, improve agriculture, and art conservation[9]. It is his study of biologic gases as a physician at the Bristol Pneumatic Institute that set the ball rolling for anaesthesia. As a preliminary step, Davy set out to study on himself which gases were safe to inhale without causing serious injury - some were truly risky, such as, his experiments to inhale carbon monoxide, which he described as an agent that would cause his pulse to become 'rapid and thread like', nearly killing him. We all know that this gas is deadly[10], as it is colourless and odourless and inhibits the oxygen transport function of haemoglobin (Hb) (its affinity for Hb is 200 times greater than that of oxygen), besides inhibiting cellular respiration[11]. His efforts to use carbon dioxide to dull the senses were funnier - it does (and his was one of the first descriptions of this effect)[12] in patients with chronic lung disease causing them to lose full consciousness. It is his adventures with nitrous oxide, however, that are of direct consequence for anaesthesia. Breathing pure nitrous oxide, as he demonstrated to himself, completely abolished his toothache. It was incremental to suggest its potential use in surgery[13]. He was all of 21 years old, and the psychotropic[#] effects of that gas were demonstrated by his writing poetry under the influence of nitrous oxide.

Psychotropic = drugs that affect behaviour/mood/activity.

"Gentlemen, this is no humbug"

Across the Atlantic, another entirely different agent was being used in country fairs to produce a similar transformed state, which was entirely reversed when one stopped breathing the vapour that caused this. These were in the form of 'ether frolics', and the agent was diethyl ether. At the forefront of these endeavours were a motley crowd of physicians, chemists and dentists - Gardner Quincy Colton, Horace Wells, Crawford Long, Charles Jackson and William Thomas Green Morton. In as much as their efforts, singly and together, laid the foundations of the whole science of inhalational anaesthesia, they undid much of their effort in attempting to gain individual fame and money over any sense of collective scientific achievement. If there was going to be a 'first' person to have used a true anaesthetic (which nitrous oxide was not) in the form of 'etherisation', it is near certain that it was Crawford Long (1815-78)[14]. Long, a physician, noted that injuries sustained during the ether frolics were often associated with painlessness. In 1842, he successfully used diethyl ether as an anaesthetic to remove a cyst from the neck; his second attempt was only part successful. Unsure of reproducibility, he put off any publicity till he himself was sure that anaesthesia was produced by the ether and "not the effect of the imagination".

Horace Wells, a dentist, was the next in this line of daring men. He successfully used nitrous oxide in dental extraction, but his attempts to seek public recognition at a demonstration at Massachusetts General Hospital (MGH) in early 1845 was met with some moans and groans from the patient (a feature of this anaesthetic though not proof of its total lack of efficacy) and scepticism from the audience. A pupil, Morton, in the audience now jumped into the fray and set out to better his teacher's effort. Morton was sure it would work, but wished to be the high priest at a new ritual - he would refuse to share the composition of his "Letheon" (it was diethyl ether mixed with a dye and some additional scents to make it feel and seem an invention that he alone owned) but successfully used it at the MGH on October 16, 1846. In hindsight he was very lucky - he used a contraption that would resemble a modern day teapot (the nature of the exact device used is mired in controversy) to anaesthetise a young male with a large, vascular tumour of the neck, to be excised by John Warren, the chief surgeon at MGH. A modern day anaesthesiologist would be cautious - blood loss, loss of airway control, air embolism… but for Morton, fortune favoured the brave. At the heart of his success were the very different physical-chemical properties of ether as compared to nitrous oxide. The offset of actions of ether would be much more gradual than nitrous oxide. Thus, in the days of approximate action, when small errors such as disconnection, dosing, and premature cessation could mean that the patient suddenly woke up in the middle of surgery, to his horror and that of his treating physicians, these errors were more likely of this dramatic kind, when the agent was nitrous oxide than ether. Morton, however, never really lived to enjoy his success: the mad fallout of who should get credit for this success (his as against the claims of Wells, Long and the others) coupled with his passionate desire to promote himself, ensured that he died very young, at 49 years of age, unhappy and insolvent!

Recollections from a long while ago

What determines how gas delivered into a patient's lung will cross the alveolar membrane into the bloodstream and then be carried by the cardiovascular system via the left heart to the brain and spinal cord to exert its actions in anaesthesia? In mixtures of gases, the relative contribution of each gas to the whole pressure exerted by the gaseous mix is in proportion to their presence in the gas (Dalton's law of partial pressures). Thus, if the atmospheric pressure at sea level is 760 mm Hg, nitrogen (which makes up about 78% of this mix we call "air") contributes 78/100 X (760), i.e. 592.8 mm Hg of the total pressure of 760 mm Hg exerted by this mixture.

The total pressure in a gas mixture is the sum of the partial pressures of each individual gas

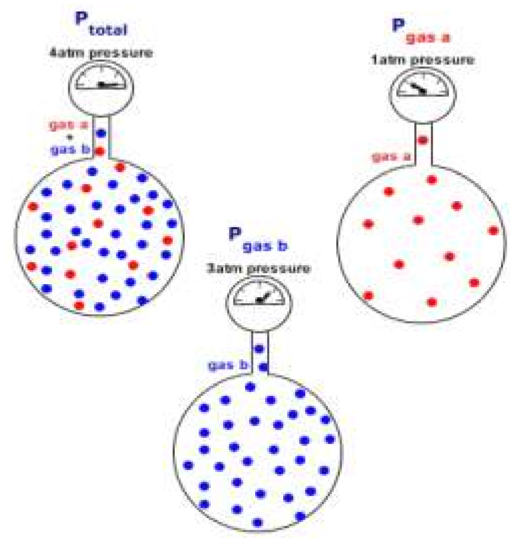


Illustration of Dalton's Law of Partial Pressures

Just as we think of the diffusion of water into the root of a plant from the soil as a result of the higher concentration of water (when we pour it into a flower pot) in the soil relative to the root, we can think of gaseous exchange being determined by the relative **partial pressures** of a gas. These diffusion processes govern the transfer of oxygen across the alveolar membrane from atmospheric air to the haemoglobin in our blood: the venous blood has low oxygen tensions relative to the air in the breathing mixture and passive transfer occurs across the alveolar capillaries which are designed to be thin and ready to allow this. What complicates the picture, somewhat, is the presence of two different states of matter:

Solubility is the volume of gas that dissolves in unit volume of liquid at a given temperature; it is usually measured as the Ostwald coefficient or a partition coefficient - δ. Imagine a gas in a closed chamber in contact with a liquid; the ratio of the concentrations of the gas in the liquid phase to that in the gas at equilibrium (i.e. when the partial pressures equalise and bring the transfer to a stop obeying the more general laws of all diffusive transfers across a concentration gradient) is the partition coefficient δ.

liquid and gas - blood as liquid and atmospheric air as gas. Apart from partial pressure, the transfer of gas from a gaseous phase across a membrane into a liquid is also influenced by its *solubility* in that liquid.

Now the δ value of diethyl ether which Morgan used is 12 whereas that of poor Wells' nitrous oxide is only 0.47; at any given time there is about 12/0.47 = 25 X as much ether dissolved in blood as nitrous oxide at the same partial pressure. Suppose Mr Wells were to suddenly stop or run out of nitrous oxide, there is very little nitrous oxide to well out of the blood to sustain the partial pressure of nitrous oxide needed to maintain anaesthesia; Mr Morgan however, even if he were to fall asleep, has a huge volume of diethyl ether within the patient's bloodstream. This can diffuse out as gas even if her physician were to stop administration and this diffused gas would continue to keep the patient asleep for a while, explaining the two different courses of those historical anaesthetics.

However, there is a flip side to the diethyl ether (it has virtually no place in modern anaesthesia). Imagine attempting to put a hypothetical patient to sleep using the ether - now what acts on the brain to cause anaesthesia is the undissolved 'free' gas in blood that crosses the blood brain barrier. When a very soluble gas like ether is used, a whole lot of it is just guzzled by the large blood volume in the patients as dissolved (and hence of no utility) ether, before any significant undissolved concentration is achieved for reaching and dulling the patient. Etherisation, therefore, while offering a large safety margin in keeping patients asleep once they are anaesthetised, takes a long while to achieve - enough to give hospitals, anaesthesiologists and surgeons the funny smell that many of us associate with hospitals (this is historical, since the era of etherisation is virtually over). Further, in a busy world like today, where hospital facilities are vastly outpaced by patients needing to use them, it would be a big waste of time waiting for them to wake up from the dissolved ether in their body.

"In sorrow thou shalt bring forth children"

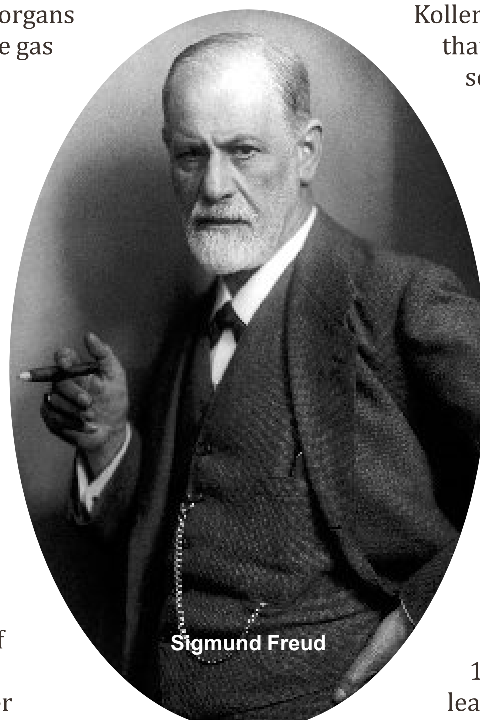
A parallel drama was being enacted in Britain just about the same time that Morgan et al. were playing it out in the United States. At the heart of this enactment was James Young Simpson; primarily an obstetrician, but a very clever and versatile one. Simpson (1811-90) was also acutely interested in drugs that would abolish pain. When etherisation was described in the US, he was quick to obtain a sample, and use it in a complicated childbirth in preference to mesmerism. A witness was to remark *"this Yankee dodge beats mesmerism hollow".* Meanwhile, organic chemists had started to synthesise many more compounds, and chloroform arrived in the 1830s. It had a slightly lower blood gas partition coefficient than ether (which was already getting on everyone's nerves given its 'volatility') and was also not as inflammable. Simpson used it first on himself, then on his niece, and gradually on women to abolish the pain of childbirth[14]. Simpson apparently encountered opposition to its use as theologians suggested that child birth was meant to be painful as punishment for the original sin (as stated in the Bible); it is currently believed that this theologic opposition was mild[14]. Another key figure in Britain was the legendary John Snow - the father of modern epidemiology (the statistics of modern medicine, and its foundation of using experiments to decide what is right instead of the whim of a caregiver) who would define the stages of a typical anaesthetic and warn of the hazards of excess. However, chloroform and ether, their historical importance notwithstanding, would probably never have stood the test of time: low potency, long times to effect and wearing off, inflammability (since the use of oxygen as also the cauterisation of surgical wounds using electrical energy can make a dangerous mix to set off fires in operating rooms) would be their disadvantages. The demand for pure agents, and the neighbouring revolution in chemical synthesis in the early 20th century would mean their replacement by potent, relatively non-toxic agents such as the fluorinated hydrocarbons in use today. The latter have much better blood gas partition coefficients (with 0.42 being that of desflurane, the newest, which is the fastest to act and disappear and 1.15 that of isoflurane which is among the most commonly used today), do not support combustion, are quick to act, and also fast in wearing off, such that most people could have an operation in the morning in hospital, and help make dinner at home in the evening[15]!

The Hindi film discourse and real being different from reel

Most depictions of anaesthesia on television and in the theatrics surrounding accident or childbirth in our films are far from real. They usually begin with a masked man or woman stuffing the victim's nose and mouth with a gas and as she thrashes about in pain from the original trauma or from being so restrained, she dulls to sleep. Whether or not she will wake up is usually decided by the plot - there is either dramatic recovery as we approach the end or an agonising wait for the missing hero who would then wave his magic wand. In contrast, most anaesthesia commencements today are made using intravenous drugs, in the quiet of hundreds of operating rooms all over the world.

Unlike gas, there were several impediments to the development of *intravenous* anaesthesia - some of which were the disastrous effects of inadvertent microbial contamination (leading to sepsis), the complicated apparatus required, in the form of needles and syringes, and the dependence on metabolism by organs for termination of action (unlike gas which could just be breathed out). The first recorded intravenous anaesthetic was the injection of alcohol using a contraption of dog bladder and goose quill into a dog who went to sleep and yet managed to awake and survive the onslaught; the hero in question was Christopher Wren, founder of the Royal Society in Britain in 1656[16]. The development of injectable apparatus in the form of needles (Francis Rynd 19th century) and syringes (Alexander Wood, also the same time) would be of no avail till the synthetic chemistry revolution in the later part of that century. Alexander von Baeyer (1835-1914)[17], chemist and Nobel Laureate (1905) was one such giant who synthesised indigo, fluroscein, and barbituric acid (the parent of modern day barbiturates used to anaesthetise and stop seizures). The industry - science complex in the first part of the 20th century then took over in the synthesis of a variety of agents with diverse structures - propofol, etomidate and the benzodiazepines. Today, these agents are either used to make the induction of the anaesthetic state pleasant, transiting to gas anaesthesia thereafter, or used as the sole anaesthetic. Gaseous anaesthesia appears to still be the most commonly used - easy administration, non-dependence on metabolism, elimination in those who have diseased livers or kidneys (the main sites for all drug metabolism), faster offset because of these properties - all these gives it an edge. Since like all diffusion, this ends with a state of equilibrium, measuring the concentration of these gases in the breathing mixture is an estimate of their concentration in the brain where they act. This measurement can aid in correcting both over and under-dosing.

New arms in the inventory: local anaesthesia


Sigmund Freud

It was known in the mid18th century that cocaine applied to the tongue would numb it. However it was the psychedelic experimentation of Sigmund Freud and his colleague, Carl Koller at the Vienna General Hospital that would bring anaesthesia a new set of arms. Koller's colleague, who accidentally licked cocaine off a pen knife, found his tongue numbed. His account to Koller, immediately prompted instillation of cocaine into the eyes of a frog and a guinea pig (Koller was an aspirational ophthalmologist), which made the conjunctiva and cornea insensate. A presentation to the Heidelberg Ophthalmological Society in 1884 started a new train - injection into nerves (Halsted, the great surgeon) or into the spinal canal (Bier 1897). The latter approach would lead to numbing of a whole set of nerves at one go. Local anaesthesia was once believed to be safer and superior to general anaesthesia. Whilst there are many limitations on the complexity and anatomic extent of surgical work that can be accomplished with local or regional anaesthesia, this tool has come to stay - from offering superior pain relief than achieved with intravenous drugs[18], to enabling faster surgical recovery[19], preventing persistent pain after surgery[20], or preventing lung complications from breathing and coughing better when the lung or regions nearby are operated upon[21].

Trail blazing science in the middle of war

The 20th century was a violent epoch, with two world wars scarring its first half. With these events in the background, the demand for complicated surgery surged more than ever before. In addition to attending to casualties of war, surgeons were now attempting to remove complicated organs such as the lungs during peacetime or performing palliative surgery for life threatening heart conditions[22]. Precise control over the cardiac and respiratory systems in the interim period of surgery meant demand for sophisticated machines that could deliver exact concentrations of gas, accurate volumes of air at just the right composition, instruments akin to weather gauges predicting an impending crisis and so on. The immediate periods of the Wars often meant a standstill for peace - time science (economic squeeze and conscription in the War for scientists and physicians alike), but the birth of quantum mechanics during this period, describing the behaviour of subatomic particles would spurn a revolution in the development of devices and technologies that lie at the heart of our modern lives: transistors, computers, the electron microscope and magnetic resonance imaging. Anaesthesia is among those disciplines in medicine that are most heavily reliant on these technological revolutions.

Modern ventilators use microprocessors to time the onset of a ventilator cycle or end a mechanical breath. The science of spectrophotometry lies at the heart of the continuous measurement of blood oxygen (thus warning anaesthesiologists of low levels well before their ominous effects on the central nervous system can occur), sophisticated monitors mean providers can focus on other tasks, such as detecting cyanosis (appearance of blue colour on the skin due to lack of oxygen) with the naked eye, or provide minute to minute data on the prevailing blood pressure or filling and emptying of the human heart.

Anaesthesia and technology: the harmony is proven by our report card

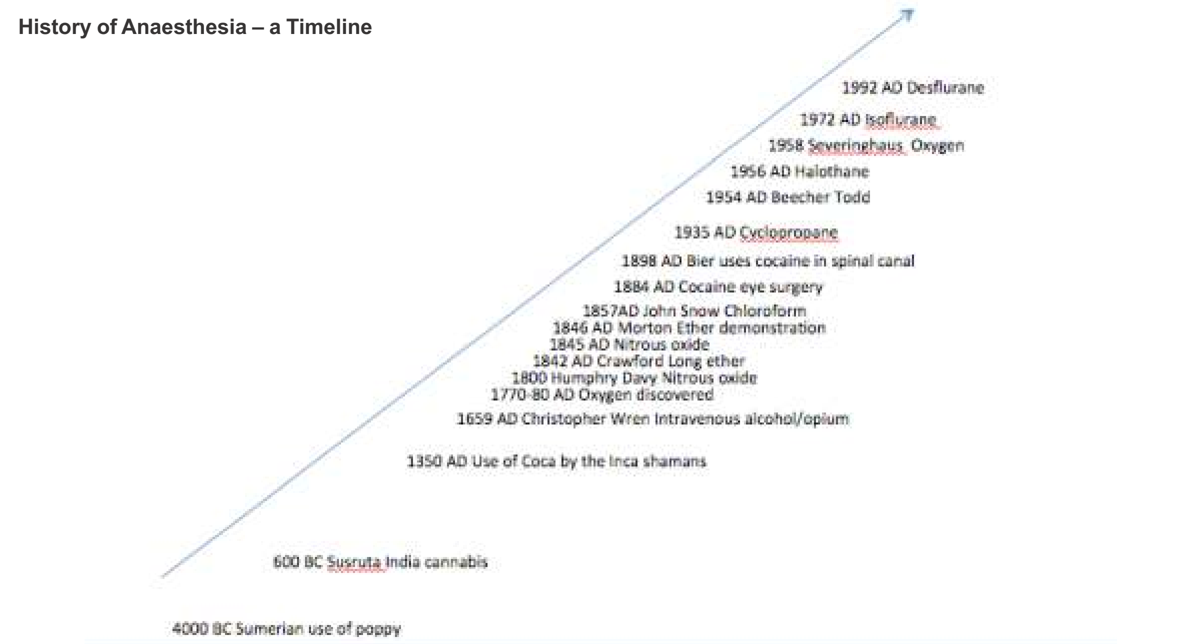
Anaesthesiologists would first recognise low oxygen levels from the colour of the tongue or mucous membranes, or the blue colour of deoxygenated blood. During surgery, this could, often, be a little late in the day for meaningful action. Today a pulse oximeter analyses the relative concentrations of oxygenated and deoxygenated blood non-invasively from the finger tip on a beat- to- beat basis; the instrument uses spectrophotometric principles to deduce this value and alert the physician to quick action. Infrared spectrophotometry identifies whether or not a tube is placed correctly in the trachea instead of the oesophagus (anaesthesia trainees and experts can accidentally intubate the food pipe instead of the trachea - thus the stomach gets ventilated, instead of the lungs).

Electrocardiograms are generated from surface electrodes on the chest; blood pressure measurements are automatic using the principles of oscillometry; and the anaesthesia provider can also use a number to quantify consciousness (allowing him to titrate the quantity of anaesthetic to be delivered). There are various indices used today to quantify conciousness[23]. These indices are developed using the raw electroencephalogram data (EEG, akin to the ECG these are surface waves reflecting electrical activity within the human cortical cells of the brain). They are a measure of the order in the brain[24], which increases with deepening anaesthesia. A research group I have worked with has developed a computer based system that automatically increases or reduces the amount of anaesthesia, without requiring the anaesthesiologist to do this manually[25].

However, if one were to be driven to think that anaesthesia is inherently safe, the Russian army experience in 2002 would caution us. In 2002, a hostage crisis confronted the army in Moscow in an opera house; it sprayed fentanyl, an analgesic opioid (besides causing analgesia it also causes sleep and potent dose dependent respiratory depression) to end the impasse. A good 129 attendees (15% of the total attendance) – including the innocent as well as terrorists, died[26].

Henry Beecher and Donald Todd were the first to systematically assess the risks of anaesthesia; their study determined that about 1:2000 deaths in the operation theatre were directly related to anaesthesia management. If a particular technique (muscle relaxation to facilitate surgery) was used, the number was 1:370[27]. Neuromuscular blocking drugs (that work at the nerve terminal with muscles, like botulinum toxin or nerve gas) can be deadly, if their residual action is not detected. This study proved that if one was more careful and monitored the effects of these drugs, it could lead to more anaesthesia safety. In

History of Anaesthesia – a Timeline



a large country, such as the United States of America, 2,211 patients died from an anaesthesia related cause in the period 1999-2005; the study estimated that the risk of anaesthesia was of the order of 1.1 per million population per year, probably lower than that of a terrorist strike![28]. Similar impressive numbers are reported from Australia[29]. In our country, roughly 12 people per 100,000 population die of a road accident per year[30]! Thus travelling in a bus or a car may be more unsafe than being put to sleep for surgery. The synthesis of human skill and technology has made anaesthesia a safe specialty, and this success story is evidence of the potential of good science in human life. We might, however, end this section with caution: while anaesthesia related mortality has steeply fallen all over the world, there is a big divergence between countries in the developed world and the underdeveloped or emerging economy status countries like ours[31]. This may be due to a combination of poor technology use, bad science (and by extension inadequate science education by educators) and poor economic spending on healthcare.

Beyond anaesthesia: from an enabling specialty to a therapeutic partner

Anaesthesia is an enabling specialty: it helps perform surgery safely, but the actual therapeutic benefit is that of the surgical procedure itself, not the anaesthetic. It thus behoves us to be as safe as possible. However anaesthesia can also have therapeutic effects. Curare, a dangerous drug has been used to abolish the excruciatingly painful spasms associated with tetanus[32]. Anaesthetics have been shown to prepare the heart for disaster - a term called pre-conditioning, just like how we save money in a bank to prepare for tough times in the future[33]. A polio epidemic in Denmark was the impetus for an anaesthesiologist Bjork Ibsen to keep children with respiratory failure alive (secondary to the paralysis induced by polio virus) by use of positive pressure ventilation[34]. In the spirit of our highest traditions as doctors whose sole aim is to cure and help others in need, this ventilation was provided by hundreds of volunteer anaesthesia trainees, anaesthesiologists and other medical doctors round the clock manually! In Ibsen's action lay the nucleus for founding our modern day intensive care units[34]. Virginia Apgar, an anaesthesiologist formulated the first score[35] to sort newborns into those who would need further attention and those who could manage alone - her score continues to be in use to this day, and is taught to all doctors during their first paediatric rotation. Anaesthesiologists, driven by their own need to accurately measure oxygen tension in blood, have contributed substantially to the development of technologies, such as electrodes for the measurement of arterial oxygen[36]. Anaesthesia management can affect the rates of tumour recurrence after cancer surgery[37], or the rate of heart attacks in patients with cardiac disease after non-heart surgery[38].

Extending the knowledge frontier: can being asleep teach you about what it is to be awake?

The quantum mechanics era, and the giant steps made in medical imaging as a result of these studies, has already been referred to; today, it is possible to use appropriate tools, such as functional Magnetic Resonance Imaging (fMRI) or Positron Emission tomograms (PET), to correlate brain function with anatomic areas - in health or in disease[39], [40]. Imagine an anesthetised patient who is undergoing fMRI – his visual cortex is active during the drug induced hypnotic state. Does it not tell us that the visual cortex activity has no correlation with the awake or asleep state? Likewise, anaesthesia appears to be associated with functional uncoupling of the parietal-frontal cortical loop. What this means literally is that, although, these individual areas may or may not be active, their cross talk is what causes cognition (simplistically the parietal area is the sensor, the frontal the interpreter of sensation). Cognition is broadly the way we see, think, feel or hear the world around us. All of these sensations are abolished with anaesthesia. Anaesthetic drugs do not impact the activity of individual regions but abolish their cross talk. Thus, anaesthesia processes provide an insight into how the brain works when awake.

Ahoy ! Ahead.

Our quest to understand the natural world within and outside ourselves continues in an unbroken tradition from pre-historic times. This quest asks us to forever persevere in furthering the frontiers of knowledge; today anaesthesiologists guide heart repair during surgery, use ultrasound to inject local anaesthetic in the proximity of nerves etc. Anesthesiology is a super-specialised branch with sub- specialties in paediatrics, cardiology, neurology, pain and intensive care. There is only one way forward - to be constantly awake and alive in the primeval spirit that science is all about.

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