

FROM THE PAST

HISTORY OF ANAESTHESIA IN GHANA (2): DEVELOPMENT OF EQUIPMENT, CONSUMABLES AND ANAESTHETIC DRUGS

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Summary

This is the second instalment in the series on HISTORY OF ANAESTHESIA IN GHANA. The history of medicine in Ghana has been documented but there has not been any documentation of the history of anaesthesia in the country. Anaesthesia in Ghana has seen a number of changes in the last fifty to sixty years. These changes have been seen especially in the areas of anaesthetic drugs, anaesthetic techniques, the training of anaesthetic manpower and introduction of intensive care facilities. There has been an introduction of new and modern anaesthetic machines and monitors which

were completely absent some decades ago. This article seeks to highlight some of the major changes that have taken place in the specialty. The challenges facing the specialty in terms of the supply of consumables, the lack of maintenance of equipment and the low numbers of enrolment into the specialty by physicians are discussed. The role of international collaborations and the setting up of new specialised units like the National Cardio-thoracic Centre are also mentioned in this article.

Key Words: *Anaesthetic machines, Drugs, Monitors, Analgesics, Airway devices.*

Equipment and consumables

Anaesthetic machines

The anaesthetic machine used in the 1960s and 1970s was an early version of the “Boyles Machine”¹. This anaesthetic machine was developed by Dr Henry Edmund Gaskin Boyle, a pioneering anaesthetist who was born in Barbados. Another source however indicates that the original inventor was James T Gwathmey who was a reservist American Army officer. Dr Boyle modified the machine to make it more gas tight after importing two into England. The design included cylinders for medical oxygen, nitrous oxide and a “Boyle’s Bottle” to vaporise diethyl ether. In 1917, Dr Boyle published an article on the anaesthetic technique, crediting Gwathmey with the design of the machine he was using at that time. Until recently, anaesthetic machines were referred to as a “Boyle Machine” in honour of his contribution in this field. The Boyle’s machine is a continuous flow anaesthetic machine depending on a constant supply of oxygen and nitrous oxide. These essential gases, especially oxygen, were not readily available in the hospitals. Nitrous oxide currently is hardly available in

the country. These gases were manufactured and sold in huge cylinders by L’AIR Liquide, a French company.

Breathing systems

The initial breathing systems were made from black rubber corrugated tubes. The commonest were the Magill’s (Mapleson A), modified Ayre’s T-piece (Mapleson F) and the circle systems. Later the breathing systems were made from clear plastic. Additional breathing systems like Bain’s co-axial system have become available.

Vaporizers

The initial vaporizers were ordinary “bottles” which contained ether and trichloroethylene. These bottles did not give an accurate volume concentration of the agent being given to the patient. The safety factor was the wide safety margin of these agents. Halothane which used a “halox vaporizer” did not have such a safety margin. Epstein-Mackintosh Oxford (EMO) machines which delivered ether-in-air to the patient were widely used throughout the country. In KBTH, the EMO machine was used on a few occasions to teach medical students and sometimes when emergency cases needed to be done in the absence of oxygen.

With advances in technology, the “halox vaporiser” was changed to a “plenum” vaporiser. The development in the plenum vaporiser has improved from Mark 1 to Mark 7. Plenum vaporisers allow accurate delivery of volatile agents although they are

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complex, requiring compressed gas supplies and regular maintenance.

Vaporisers have gone through a series of transformations, from fixed vaporisers to the Selectatec version. The Selectatec version is not permanently fixed on the machine and therefore gives the anaesthetist the flexibility in terms of inhalational agents used for patients, without changing the anaesthetic machine. One of the potential problems associated with the use of the Selectatec system was highlighted in a case report from Korea where the vaporizer was accidentally tilted and lifted off the manifold leading to the interruption of breathing gas in a 1-month baby during anaesthesia². Agent specific and colour coded “fillers” for inhalational agents were introduced in the 1990s. The flow meter for the oxygen was a single tube. This has now changed to two parallel tubes to avoid giving patients hypoxic mixtures. A number of safety features like oxygen failure and disconnection alarms have been incorporated into modern anaesthetic machines.

Newer anaesthetic machines with some of the safety features were introduced into Ghana over the years. Some of the machines were obtained through bilateral relations with countries like Japan UK and Germany. The brand names of the anaesthetic machines included the Acoma, the Blease, the Ohmeda and the Drager anaesthetic machines. The major problem arising from this system of acquisition of anaesthetic machines, were different machines from different manufacturers being used in the same hospital and the lack of long term maintenance agreements for the machines. In most cases, the end users were not consulted before the purchases were made.

Oxygen concentrators

The supply of oxygen to the hospitals has always been problematic. Hospitals have to acquire the cylinders and vehicles or hire vehicles to transport the gas from the factory in Tema, Takoradi or Accra. This situation was made worse by the occasional breakdown of the machine at the factory. There were days when there was not even one cylinder of oxygen in KBTH.

The late Prof Oduro recommended that the management of KBTH should acquire an oxygen concentrator. Oxygen concentrators became commercially available during the late 1960s. They produce 95% oxygen from atmospheric air by the adsorption of nitrogen by zeolite. They were initially for military and domiciliary use. Early machines were bulky and relied on compressed air³. They are now available in various sizes. The first concentrator for KBTH was bought in 1985. It served the hospital well. About 10 years later, a bigger version was purchased by the hospital. Some other hospitals in the country like the Central Regional Hospital in Cape Coast, KATH and the 37 Military Hospital have purchased a concentrator. These concentrators have a facility to fill oxygen cylinders.

Maintenance of anaesthetic machines

The lack of maintenance of these machines put patients at risk. The output of the machines is never checked and the vaporizers are never re-calibrated. One does not know what is really administered to the patients during surgery. In the mid 1980's, the British government under one of her technical cooperation agreements, established the Biomedical Engineering Unit at KBTH. The first Ghanaian medically qualified Biomedical Scientist was trained in the UK through the recommendation of the late Prof. Oduro. With the establishment of this unit, some of the maintenance problems were solved. A number of technicians were also trained who went round the various hospitals to service the anaesthetic machines.

Airway devices

A variety of airway devices have been used in the country. These include face masks, endotracheal tubes and oropharyngeal airways. The face masks and oropharyngeal airways were originally black in colour, from impregnation with carbon, but have all been changed to clear plastic material. The carbon was to prevent the build-up of static electricity during anaesthesia because of the use of agents like ether which were both flammable and explosive. It was not uncommon to see a black mark on the face of patients who had had maintenance of anaesthesia using the black face mask.

Oropharyngeal airway

About 1930, Ralph Milton Waters developed a metal oropharyngeal airway incorporating a bite-block section⁴. Guedel later introduced an airway made of black rubber and incorporating a metal insert to prevent occlusion by biting⁵. There have been very few modifications of Guedel's airway since its introduction. The original rubber was later replaced by reusable or disposable plastic material.

Endotracheal tube

After the discovery of general anaesthesia, the most important advance was the development of endotracheal intubation by the Irishman Sir I.W. Magill with Dr. E.C. Rowbotham and other British colleagues in London⁶. The endotracheal tube enhanced the value, safety, and applicability of general anaesthesia. Endotracheal tubes were originally made of red rubber. This caused some degree of tissue reaction in some patients. Red rubber endotracheal tubes were used in Ghana until about the mid-1980s. These have been replaced by medical grade polyvinyl chloride tubes which cause fewer tissue reactions. There are some advantages of the clear plastic tubes over the red rubber tubes. Mist is produced on correct placement of an endotracheal tube and it is easy to see secretions or vomitus. It softens at body temperature to provide patient comfort. It also had graduations, Murphy's eye and a radio opaque marker. The Murphy eye, designed

and reported by Murphy in 1941⁷ is a side vent near the distal end of an endotracheal tube. It was created to prevent complete respiratory obstruction in the event that the open end of the endotracheal tube were to become sealed by contact with the tracheal wall or occluded by a mass or mucus plug. There are a number of problems associated with the use of plastic endotracheal tubes. These include its short life span and loss of curvature even with new tubes because of the poor storage conditions, making intubation difficult without the use of stylets.

Endotracheal tube connectors

Until 1990's there were a number of endotracheal tube connectors in use. These were made of metal and came in different shapes and sizes bearing the names of some of the pioneers in anaesthesia. These included Magill's⁸ Cobbs and Rowbotham connectors. They were interposed between the endotracheal tubes and catheter mounts. There were some instances where the connectors did not fit properly and became disconnected during the course of anaesthesia. Magill's connectors first appeared in oral and nasal versions around 1930⁸. These metal connectors were replaced about 30 years ago by 15mm universal connectors. These connectors are made of sturdy plastic which are easy to insert.

The Laryngeal Mask Airway

Dr A. I. J. Brain described the laryngeal mask airway (LMA) in 1983. The LMA was introduced into clinical practice in 1987. The original prototype was the "classic" one which was initially made in two sizes: 3 and 4. Later 2.5, 2 and 1 were introduced into clinical practice. Over the years, other prototypes such as the intubating LMA (LMA-Fastrach), armoured LMA and the Proseal LMA which allows intermittent positive pressure ventilation, have been introduced to meet specific clinical needs. The LMA was introduced in KBTH in 1990 and has been in use ever since. The initial set was a gift from one of the companies which supplied anaesthetic consumables to the department in KBTH. The author presented a preliminary report on the use of LMA at the Society of Anaesthetists of West Africa's annual scientific conference in KBTH in May 1991. The LMA is now available in all the departments the author has visited in the country. The newer prototypes are however not readily available in the country.

Monitors

Intra-operative monitoring of patients in the 1960s up till the early 1990s was mainly manual using a finger on the pulse, the stethoscope and mercury-type sphygmomanometers. A Pre-cordial stethoscope was used in paediatric cases as there were no appropriate cuffs to measure the blood pressure of the children. It is worth noting that during the entire training of the author in the UK in 1970s, the same methods of

monitoring were used. Electronic monitoring was introduced in the UK in the late 1970s. The first pulse oximeter was introduced in KBTH in 1990. It was also a donation from the same company which donated the LMAs. In November 1998, the re-furbished first floor surgical theatres were commissioned. Those theatres had monitors for non-invasive blood pressure (NIBP), heart rate, oxygen saturation (SpO₂) and electrocardiogram. Some of the machines had facilities for invasive monitoring of arterial blood pressure and central venous pressure. A recent survey by the author of anaesthetic services in the Central Region of Ghana showed that all the hospitals have some form of electronic monitoring device. Monitors were also introduced to the other areas in the country especially KATH.

Manual ventilation of patients has been replaced by mechanical ventilators in all the Regional and Teaching Hospitals. Some of the hospitals visited have ventilators most of which are not functioning because of lack of maintenance. A few problems arose with the acquisition of these rather expensive monitors. The consumables such as ECG electrodes and gel were sometimes not available. The users were not handling the equipment with care leading to a rapid deterioration of some of the cables like the pulse oximeter and ECG cables. As in the case of the anaesthetic machines, there are different brands from different countries. There was no regular maintenance of some of these equipment leading to their early "withdrawal" from circulation.

Anaesthetic drugs

In the 1960s and 1970s, premedication of patients was with parenteral opioids such as morphine, pethidine and atropine. Atropine was used to dry up secretions of patients, as the main inhalational agent used at that time was diethyl ether which caused a lot of pharyngeal secretions. Atropine caused dry lips and tongues of the patients. This led to a lot of complaints from the patients. The use of atropine as a premedicant has almost disappeared from anaesthetic practice. Another drug such as promethazine was used as an anti-emetic or as a prophylaxis against a blood transfusion reaction. The above drugs have now been largely replaced with oral benzodiazepines such as diazepam, midazolam and lorazepam.

Induction agents

Sodium thiopentone has been the main induction agent used in Ghana over the years. It is an ultra short acting barbiturate. It is still readily available in all hospitals even though its use has declined in developed countries. The drug was synthesised in 1932 and was administered to a patient in March 1934 at the University of Wisconsin. The successful introduction of the drug into clinical practice was as a result of the work done by John S Lundy at the Mayo Clinic.⁹ Ketamine is another induction agent which is still

available in the country. It was synthesised in 1962 and was introduced into clinical practice in 1972. There are two good properties of ketamine, namely, its analgesic effect which is obtained at sub-anaesthetic doses and its ability to maintain the blood pressure of the patient unlike thiopentone which drops the blood pressure.

Propofol was introduced into clinical practice in 1977⁹. The solvent used initially was Cremophor EL. With the known anaphylactic reactions induced by Cremophor EL in previous drugs, Propofol was prepared as 1% solution using egg-lecithin emulsion. Propofol was introduced into Ghana in the mid 1990s. Other formulations of propofol such as the one containing the anti-microbial sodium metabisulphite and aquavan, a water-soluble pro-drug are available in some countries. Other induction agents like etomidate have hardly being used in the country. A few centres in Ghana use etomidate and have been using it for the past 20 years. Currently propofol, ketamine and thiopentone are available in most hospitals in Ghana.

Induction agents of historical interest

The two drugs which will be mentioned are propanidid and althesin. They were available in the 1977s. Propanidid was presented as an aqueous solution containing sodium chloride and 20% or 12% solubilising agent Cremophor EL. It was rapidly broken down by esterases¹⁰. It was withdrawn in the 1970s due to the high incidence of reactions on injection most probably due to the Cremophor EL.

Althesin (Alfathesin) was a steroid induction agent prepared as a mixture of alphaxolone and alphadolone, with the former being more potent. Alphadolone was added to increase the solubility of the compound. As both agents were not water soluble, Cremophor EL was used to solubilise the compound. It was introduced into clinical practice in 1971 although anaesthetic steroids were first noted in 1942 by Hans Selye¹¹. Even though althesin had a good profile: smooth and pleasant induction, potent and short duration of action,¹² there were reports of anaphylactic and anaphylactoid reactions. There were even reports of deaths from an ICU in the UK when patients were sedated with infusions of althesin. It was later on found out that the deaths were due to adreno-cortical suppression of those critically ill patients. The drug was voluntarily withdrawn in 1984 by the company, 12 years after it had been introduced. These drugs were used in Ghana in the 1970s.

Inhalational agents

The inhalational agents commonly available up to the early 1980s were diethyl ether, trichloroethylene and halothane. Halothane was the first halogenated inhalational agent to be introduced into clinical practice. Charles Suckling, a British chemist, working at the Imperial Chemical Industries created the compound in 1953. It was introduced into clinical practice in 1956 by Michael Johnstone.⁹ Diethyl ether

was used extensively in Ghana until recently. Some mission hospitals still use ether. Halothane is still the most widely used inhalational agent in Ghana.

Methoxyflurane was briefly introduced in the 1970s, but it was withdrawn because of its nephrotoxicity. Both trichloroethylene and methoxyflurane have analgesic properties at sub-anaesthetic concentrations. This property was utilised in the provision of obstetric analgesia in the developed countries using specially designed vaporizers for self-administration by the user. The vaporizers used were Tecota MK6 and the Emotril. Both agents have both been withdrawn from clinical anaesthesia. Tricloroethylene was used in Ghana for some years with ether. Isoflurane has been available in Ghana since the end of the 1990s. Desflurane is not available in the country as far as I am aware. A small amount of sevoflurane has been donated to the anaesthetic department of KBTH for paediatric anaesthesia, and is also available from Abbott's (the company that makes sevoflurane) representatives. Desflurane was released in 1992 and sevoflurane in 1994⁹. It is important to note that it is becoming more difficult to obtain halothane as the developed countries are no longer using the agent so it is no longer profitable for the companies to produce it.

Muscle relaxants

There are two main types of muscle relaxants in clinical practice: the depolarizers and non-depolarizers. The introduction of these agents facilitates the mechanical ventilation of patients without the use of deep levels of inhalational agents with its attendant cardio-respiratory depression.

Depolarizing muscle relaxants

Succinylcholine is the "gold standard" for the depolarizing muscle relaxants. It was introduced as a muscle relaxant in 1949⁹. It was prepared by Hunt and Taveaux in 1906⁹. Even though succinylcholine is a good drug, it has a number of undesirable side effects, notable among them are the so called "scoline pain" and the hyperkalaemia in patients with muscle paralysis and old burns. A lot of research has been done over the years to find a substitute for succinylcholine, but this has not been successful. There are two preparations of succinylcholine, the liquid and the powder forms. The liquid form which has to be refrigerated is not suitable for Ghana because of the unreliable electricity supply. The powder form is reconstituted with either saline or sterile water ready for use and has to be used within 24-48 hours even when refrigerated. Suxamethonium especially the powder form is the most used in the country for the past 40 years.

Non-depolarizing muscle relaxants

The non-depolarizing muscle relaxants have been in use much longer than the depolarizers. Curare

(Tubocurare) the first to be used clinically has an interesting history. Curare, as it was called and properly named Tubocurarine; was sent from South America initially packed in tubes to keep it fresh, (Hence the name Tubo) it came from the vine and leaves of the plant *Strychnos Chondodendron* and *Chondodendron tomentosum*. It was used as arrow head poison by the South American Indians.

Dr Harold Randall Griffith

Dr Harold Randall Griffith (1894-1985), a Canadian anaesthetist born in Montreal and his colleague Dr Johnson did a lot of work on curare and placed it firmly in the practice of anaesthesia in 1942, one hundred years after the use of ether by Dr Crawford Long¹³. The introduction of curare improved surgical relaxation and encouraged anaesthetists to enlarge their vision.

Dr Griffith contributed so much towards the growth of anaesthesia. He was the first to be concerned with standards of patient care. He was one of those responsible for the inauguration of the WFSA and was the President of the First World Congress of Anaesthesiology in 1955¹³. So valuable was the contribution of Dr Griffith towards the specialty of anaesthesia, a memorial lecture is organized at WFSA congresses.

The shortage of supply of crude curare and the variable composition led to the search for various synthetic analogues. Gallamine triethiodide was one of such drugs. Its duration of action was shorter than that of curare and pancuronium which were available in the country in 1960s and 1970s. Gallamine was developed by Daniel Bovet in 1947¹⁴. It has a parasympatholytic effect on the cardiac vagus nerve leading to tachycardia and occasional hypertension. These two effects were useful when used in patients with hypotension caused by haemorrhage due to trauma or antepartum haemorrhage. From the 1980s, newer and intermediate acting non-depolarizing muscle relaxants became available. They include atracurium, vecuronium, rocuronium and cisatracurium. The first two drugs became available in Ghana from the 1990s. Because of the need to refrigerate atracurium, its use in the country became rather problematic. Vecuronium, a steroid agent like pancuronium, is now used by most hospitals because of its long shelf life due to its presentation in the powder form.

Short acting agents like mivacurium have hardly been used in the country. Occasionally, visiting anaesthetists bring a few vials which are then used mainly for teaching purposes. It is rather unfortunate that this agent is not available as it has such a short duration of action which is suitable for short procedures which require muscle relaxation, like tubal ligation. Another advantage of mivacurium is that it does not require reversal at the end of surgery as it is broken down by plasma cholinesterase.

Local anaesthetic agents

The Esters

Dr Carl Koller, a German Ophthalmologist, introduced cocaine as a topical anaesthetic for ophthalmic surgery. He reported his work to the Congress of German Ophthalmologists in Heidelberg on September 15, 1884⁹. Dr Koller's work marked the beginning of local anaesthetic techniques in clinical practice. Cocaine was derived from coca leaves. Unfortunately the use of cocaine in anaesthetic practice has been severely affected by its addictive properties. Cocaine has become a "forbidden word" among the law enforcement agencies and the general population all over the world. Synthetic local anaesthetic agents like procaine, chlorprocaine and benzocaine have been in use at various times. These synthetic ones like cocaine are all esters. Cocaine was in use in KBTH in the 1970s.

The Amides

The amides were introduced into clinical practice because of the side effects associated with the use of the esters. The amides include lidocaine, prilocaine, bupivacaine, L-bupivacaine and ropivacaine. Lidocaine and bupivacaine are available in most hospitals in the country including some district hospitals. Lidocaine is presented in a variety of concentrations and formulations including the gel and the spray. Five percent xylocaine or "heavy" was used for spinal anaesthesia but it has been withdrawn because of neurological complications. Heavy "marcain" (0.5% bupivacaine in dextrose) is the drug commonly used for spinal anaesthesia. These local anaesthetic agents have been used for various types of anaesthesia such as spinal, epidural, nerve blocks and infiltration of surgical wounds. Spinal anaesthesia is done in all the hospitals in the country as the nurse anaesthetists have also been trained to do them. The other types of blocks are done by mainly by Physician Anaesthetists. Apart from lidocaine and bupivacaine, the other amides are not available in the country and sometimes even these two drugs run out in some of the hospitals.

Analgesics

Opioids

Opioid is an all-inclusive term that describes drugs (natural and synthetic) and endogenous peptides that bind to morphine receptors¹⁵. Morphine is the "gold standard" for all opioids. It is the oldest and was originally derived from a plant. Synthetic opioids are now widely used. These include fentanyl and its analogues sufentanil and alfentanil, which are the most frequently used opioids in clinical practice. The clinical potency of fentanyl is 50-100 times that of morphine.

The use of opioids in Ghana has experienced a number of difficulties. In the 1960s and the 1970s the main drug that was used was pentazocine. Later morphine became available in the country. The supply of opioids can be best described as erratic. With the

local production of pethidine in Ghana by a Ghanaian company, the supply of that drug has improved considerably. Even though pethidine is not considered as the “best” of drugs, its availability has improved on the situation where there were sometimes no analgesics in KBTH let alone the rest of the country. Fentanyl and pethidine have now become the most commonly used opioids in the country. They are available in a number of district hospitals.

Non-opioids

Paracetamol has been available as an “over the counter” drug for quite some time now for the treatment of minor aches and pains and flu-like symptoms. It was introduced as one of the postoperative analgesic drugs in the early 2000s particularly in children. The suppository form is mostly used and in adults too. Together with paracetamol was the introduction of nonsteroidal anti-inflammatory drugs such as diclofenac. Diclofenac and paracetamol suppositories are available and are widely used throughout the country.

Intravenous fluids

In the 1960s and early 1970s, intravenous fluids were prepared at the Korle Bu hospital pharmacy. The main fluids prepared were five percent dextrose in water and normal saline. They were prepared in 500ml bottles with the frequent risk of breakages. There was also a constant shortage of the fluids in the hospital as the production capacity was very limited. The above problems were solved by the establishment of a Ghanaian company which makes intravenous infusions in 1974 in Koforidua, Eastern Region of Ghana. The company uses flexible collapsible bags and also has a wide variety of infusions including paediatric fluids.

Another change which has taken place is the “physiological” replacement of fluids and electrolytes during surgery. This was introduced in the mid 1985 from Sweden after the author had worked there for a few months. This was of course met with a lot of resistance from the surgical colleagues. It is worth noting that this practice has “survived” up till now and it is practiced in most hospitals in the country. Sambao and other brands are now in the market and compete with intravenous transfusions. Replacement of ions especially potassium and calcium produced at KBTH are worthy of mention.

One of the remarkable changes that has taken place is the introduction of single use plastic cannulae for intravenous infusion. Plastic needles were autoclaved and re-used until they became blunt.

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