

My own experience in performing ether anaesthesia

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I first started performing general anaesthesia in the L. Rydygier Hospital in Wrocław in 1957.

CHLOROFORM

Having been given a practical training by nuns, I started performing anaesthesia using the open-drop technique with chloroform. Chloroform did not irritate the airways as much as ether and had a more pleasant scent; therefore, induction was calm and uneventful if full doctor-patient cooperation had been established. The course of the anaesthetic procedure was undisturbed and fully controlled. However, it required careful clinical monitoring of the patient's state (blood pressure, respiration, status of pupils, character of breathing and muscle relaxation). The phase of surgical anaesthesia could be rapidly achieved and its stability was maintained if the chloroform dosage was correct (the necessity of counting drops at the right time).

ETHER

I worked in the L. Rydygier Hospital for 14 months and during that time I mostly performed anaesthesia with diethyl ether. As a young doctor, I was expected to make a name for myself by introducing some innovations and, although the nuns had performed anaesthesia with chloroform correctly, my duty was to modernise and update anaesthetisation. Having been briefly trained by Dr Antoni Aroński at the 2nd Department of Surgery, I was ready to start performing anaesthesia with ether. We received a Chirana apparatus for general anaesthesia (cabinet type), which even had a ventilator (*bag in a box*), together with diethyl ether of Polish production (in those days the purchase of equipment was not necessary as it was allotted).

Ether anaesthesia with the use of the open or half-open method did not cause any difficulties. We used the same type of face masks as in chloroform anaesthesia; two masks were needed for each anaesthetic procedure; when one got covered in frost, it needed to be replaced by the other. The masks were

changed roughly every 25 minutes. Each Schimmelbusch face mask had to be covered with six layers of gauze evenly trimmed at the mask's edges (to prevent cheek frostbite). The size of the mask was to match the size of the face. I used either the open or half open method, which required the use of multilayered gauze. In order to reduce the dead space of the mask, oxygen flowing at a volume of approx. 3 L min⁻¹ was supplied through a tube under the mask. It was mandatory that atropine was always administered prior to anaesthesia.

The induction of anaesthesia was the hardest part. Firstly, standard dark 200 mL-bottles with an aluminium foil-coated cork had to be checked (e.g. for the expiry date or visible impurities). Next, the cork was removed (a corkscrew was included in the anaesthetist's set of equipment). In the cork two grooves were made with a scalpel, a piece of gauze inserted into one of them and then, the cork was placed in back into the neck of the bottle and acted as a dropper. Adult patients, as well as older children, had to be thoroughly informed about the course of the anaesthetic procedure, proper breathing and the irritating scent of ether.

The anaesthetist sat while performing the procedure. It was always mandatory that the patient's arterial blood pressure was taken, easy access to the upper part of the chest was safely secured and eye contact was established with the patient. During induction, verbal communication with the patient was of the utmost importance.

Induction began by putting the face mask on (multilayered gauze had to be placed under the mask to prevent frostbite) and a few drops of ether were applied onto the mask. Respiratory arrest, coughing and nausea had to be avoided at all cost. When ether was well tolerated, the speed of its administration had to be increased until the patient became unconscious and verbal communication was lost. This was followed by a stimulation period of a varying duration and, despite the patient's anxiety, the speed of ether administration had to be increased at this time. The next step after sedation was the onset of automatic respiration (phase

1 of stage III according to Guedel's classification), which was followed by phase 2 of surgical anaesthesia, namely the eyeballs were in the central position, the pupils were narrow, movements of the upper chest were appropriate. In phase 3 of Stage III, gradual paralysis of the upper chest muscles took place. In phase 2, the surgical procedure could be performed. It was essential that airway patency was maintained, either manually or with the use of an oropharyngeal airway.

The maintenance of anaesthesia required decreasing ether administration. In order to determine how fast ether drops were to be administered, the anaesthetist's level of experience was essential. With some experience on the anaesthetist's part, the course of anaesthesia was stable with only slightly lowered arterial blood pressure and pulse rate, automatic respiration as well as abdominal and limb muscle relaxation.

The alarming symptoms signalling too deep anaesthesia included a drop in blood pressure, bradycardia, pupil dilation and the absence of respiratory muscle movements in the middle and upper parts of the thorax. In this case, the amount of ether poured on to the face mask had to be reduced. The duration of coming round from anaesthesia depended mostly on the mass of the adipose tissue in which the ether had been dissolved. Awakening from anaesthesia sometimes lasted even up to an hour, during which the patient had to be continuously monitored, especially during the stage of excitement. Even though dedicated recovery rooms were unheard of in those days, the patients were kept in post-operative rooms and were monitored (by ECG when they became available) until they were fully awake and verbal communication with them could be established. The patient was positioned on their side and a nurse was always present.

Ether anaesthesia performed in this way, both in adults and children, was safe, although not very pleasant due to its relatively long induction. Children tolerated the induction phase far better when the open-drop method was applied. This step of anaesthesia was pleasantly remembered because of the conversations about the irritating and intense scent of ether. Many a time, on the tram taking me home after a long day of applying the open-drop technique of anaesthesia, I was continually asked (especially by young ladies) what this pleasant smell was. It was the ether being removed from my adipose tissue and exhaled by myself. This kind of question used to start small talk, since in those days people did talk to one another as there were no smartphones, iPads and other such gadgets. The scent of ether was also noticeable at home after my long working day.

ETHYL CHLORIDE

In a very short time we had learned to perform induction with the open-drop method and with the use of ethyl

chloride. Ethyl chloride, which has a pleasant scent, is less irritating for the airways than ether while its inhaling does not bring about respiratory arrest, coughing or increased mucus secretion. Unfortunately, as it is poorly tolerated, it can be easily overdosed, which may cause respiratory or even cardiac arrest. Thus, performing induction initially required the slow administration of ethyl chloride drops on to the mask which then it had to be speeded up until rhythmic respiration was obtained while the pupils were still narrow. At this stage, ethyl chloride was replaced by diethyl ether while inhaled anaesthesia was continued with careful monitoring of its depth according to Guedel's classification. In my later practice, I frequently used this method in children.

COMPLEX ANAESTHESIA

Two months into my work, the hospital received a Chirana anaesthesia machine, a cabinet-type apparatus with a wick vaporiser for ether and a surgical respirator. Although the apparatus was supposed to be put into use as soon as possible, we had had no experience of using this type of equipment. The difference between this method and the open-drop method was fundamental, namely the ether vaporisation in the vaporiser had a relatively low level of efficiency. During ether vaporisation, the vaporiser cooled down and, therefore, the speed of vaporisation rapidly decreased. Performing induction while preserving the patient's own breathing was especially difficult. Patients barely tolerated rubber masks, as well as the increased airway resistance. After we had just started using the machine, I remember one patient, already in the induction phase, getting off the operating table with the mask still on and leaving the operating room dragging the apparatus behind. However, anaesthesia with this apparatus was comfortable and precise once we had started performing induction with barbiturate (at that time this was evipan), while the induction and maintenance of anaesthesia were performed by means of the apparatus. Even without endotracheal intubation, the anaesthetic procedure was easy to monitor (evaluation of frequency and depth of respiration), and safe if the oxygen concentration was correct. This is why this method became the most popular one and why the anaesthetist gained respect and esteem for performing this important procedure.

Together with this apparatus for performing anaesthesia, we received a McIntosh-type laryngoscope with a set of rubber tubes and connectors. Initially, we needed to learn the ropes of performing intubation with the patient in phase 2 of Stage III of ether anaesthesia and with the preserved patient's own breathing. An anaesthetist capable of performing anaesthesia and possessing intubation skills became indispensable, with surgeons being more and more appreciative of these skills.

The possibility applying relaxants, which we introduced when we were sure we had gained mastery in performing intubation, was a genuine turning point and advancement in our practice. As a relaxant for intubation we used suxamethonium (an American product). As we were unaware of the existence of so-called difficult airways, while acting in haste and overcoming difficulties, injuries, especially to the teeth, were quite common. We were able to spare our patients other complications though. Muscle relaxation during maintenance of anaesthesia was achieved either by administration of repeated doses or a continuous infusion of suxamethonium. From then on, the surgeons' satisfaction was complete, i.e. none of the patients' additional movements caused any disturbances while performing a demanding surgical procedure. We rarely used a ventilator, securing alternative respiration with compression respiration bag which allowed for full cooperation with the operator. The surgeons expressed their positive opinion with the observation that with complete muscle relaxation the operative access could be smaller, while the surgery time was shorter, albeit not always. As with the use of ether, diathermy was forbidden, while haemostasis was performed by using underpins and ligatures. Surgeons were very skilful practitioners of these methods. The anaesthesiologist prided themselves on this advancement in anaesthesiology and their cooperation with the operating team became indispensable. A little while later we received d-tubocurarine (an American product), and since then anaesthesia has become a classical combined procedure.

Here, although ether was the main anaesthetic agent, nitrous oxide was also in use (on condition it was available at the time of surgery). As the application of relaxants did not allow for the assessment of the muscle tone and application of Guedel's classification, the patient's pulse rate and blood pressure needed to be especially carefully assessed. Thus, monitoring the depth of anaesthesia became more difficult and required much more of the anaesthetist's attention.

ANAESTHESIA WITH ETHER IN DEEP HYPOTHERMIA

In 1959, I started work at the Department of Surgery of the Medical Academy in Wrocław (under Prof. Kazimierz Czyżewski) where I was responsible for performing anaesthesia. At that time I had completed a 3-month basic course in anaesthesiology conducted by Mieczysław Justyna, M.D., Ph.D. I also performed surgical procedures. I was not the first specialist performing anaesthesia, as I had had a predecessor. The department had Dräger (Tiberius-type) anaesthesia machines, as well as monitoring equipment and a recovery/awakening room that met all the modern standard requirements. Ether was still the main anaesthetic agent applied in agreement with the principle of combined anaesthesia with nitrous oxide and relaxants.

We also had cyclopropane at our disposal. It should be remembered that after the Second World War, Poland received help from American anaesthesiologists in the form of apparatuses for performing anaesthesia (Heidbrink, McKesson) which were supplied free of charge together with cyclopropane.

Cyclopropane was contained in orange, 5-litre cylinders under the pressure of 5 atmospheres. It was an odourless, non-irritant gas which in a 70%-concentration with oxygen was capable of inducing sleep (induction) within 1 min (after 2–4 breaths). Unfortunately, as it was flammable and extremely explosive, the system in which it was used had to be airtight. We readily used cyclopropane for anaesthesia in the Waters system. No adverse reaction while inhaling was an asset in induction of children; in a doll there was a tube through which cyclopropane with oxygen was administered. With no adverse reaction, the child fell asleep while playing with the doll. Extensive anaesthetic procedures were performed at the department in patients with portal hypertension, among others. The procedures were performed under pharmacological hibernation. This method, introduced by Hugenard and Laboritt, involved the use of litic cocktails of varying composition. Their administration resulted in a decrease in body temperature, which was not always closely monitored. In those days the principle formulated by Bigelow applied and stated that each body organ possesses so-called biological zero point, at which temperature it suspends its activity. This temperature for the heart was 28°C and at this temperature a cardiac arrest occurred [1].

One day, my two colleagues and I were summoned by the professor. The summoning itself was a great event. As we entered the office, the professor said: "They are lying". We nodded in agreement even though we had no idea what it was about. The professor then handed over a copy of Ishikawa and Okamura's publication to us. In it, the authors reported experimentally confirmed findings that the body of a dog could be cooled down to a temperature of 4°C with its own, preserved and undisturbed cardiac function [2]. Then the professor said: "I want you to check it, and you'd better be quick". In this experimental work, which was based on a study conducted in 12 dogs, ether played the basic role. The dogs were anaesthetised with the use of ether vapour, as well as oxygen at a concentration of approx. 25–30%. The ether vaporiser had to be heated in hot water (approx. 70°C). Concomitantly, active cooling in water with ice was performed. After a body temperature of 4–6°C was achieved, the cooling was stopped, the thorax was opened and the aorta was clamped for 1 hour in the thoracic segment. The heart was still beating (1 beat/2 min). Next, the aorta clamp was removed, the thorax was closed, the dog was warmed up, and the next day the dog was fully conscious and its

motor activity returned to normal. This experiment both proved that Bigelow had not been correct and that the Japanese authors had not been lying. I had a pleasure to give an account of these findings in a preliminary report on this issue presented at the 1st Congress of the Polish Society of Anaesthesiology in Warsaw [3]. The key to success in these experimental animals was a high ether concentration which blocked all responses from the nervous system and the heart. From that moment on, we were not afraid to reduce the body temperature, even to below 28°C.

At the 1st Department of Surgery I once witnessed the explosion of an anaesthesia machine while an anaesthetic procedure with the use of ether was being performed. I was scrubbing myself up for a procedure, separated by a window pane, my head turned towards the Operating Room where my colleague was performing anaesthesia for neurolysis in the popliteal fossa. The patient was in the prone position, intubated with a rubber tube, connected to a Tiberius apparatus with which anaesthesia with ether was to be conducted. The patient was only being manually ventilated with a breathing bag as the anaesthetic procedure had not been started yet. At a certain moment, an explosion took place and we dashed into the Operating Room. The glass of the vaporiser had shattered, its shards wounding the anaesthesiologist while the wick of the vaporiser was burning with an open flame. The pieces of the breathing bag had got stuck to the ceiling and the walls; the connector made of corrugated pipes was disconnected from the endotracheal tube. My colleague was still holding his hands as if he were compressing the breathing bag. We put out the fire promptly, turned the patient to the supine position and ventilated him until he was awake. No harm was done to the patient. The professor assigned me to report this, and as I understood it, the reason for the explosion was electrostatic electricity because the apparatus had not been earthed. Therefore, the combustibility and explosiveness of the ether vapour posed a real threat. Since this incident, anaesthesia machines have always been earthed, with the so-called Horton's intercoupler being included in the equipment kit of each machine. Many years later, I watched anaesthetic procedures performed by Mieczysław Justyna, M.D., Ph.D. He applied anaesthesia in the circle system without an ether vaporiser. He administered ether with a syringe, injecting the correct volumes into the corrugated pipes. He used this method of anaesthesia for thoracoscopic procedures where surgeons were using diathermy. The point of this was that the administered dose was to saturate the adipose tissue in the patient; in order to numb the pain, the ether doses were smaller and its concentration was below the combustibility and explosiveness threshold. The trick, which demanded utmost precision, was that Mieczysław

Justyna achieved the desired purpose without measuring the ether concentration in the breathing gases.

ANAESTHESIA IN CHILDREN

In 1960, I started work at the Department of Paediatric Surgery at the Medical Academy in Warsaw (under Prof. Jan Kossakowski). This department had also employed Dr. Izabella Poklewska — the first anaesthesiologist concerned with children's anaesthesia. She was the first to perform an endotracheal intubation in a child in Poland. I had no opportunity of meeting her because she had left the clinic and gone abroad before I came to work there.

At the department all the anaesthetic methods, including the endotracheal method, were already in use. However, anaesthesia with ether was still readily applied in all the anaesthetic techniques. This type of anaesthesia was safe, had secured stability in the circulatory system and was easy to perform. For monitoring, we routinely used a precordial stethoscope and measured systemic pressure. Anaesthetic procedures were performed only by the doctors assigned to administering anaesthesia. For extensive surgical procedures, anaesthesia with ether was applied with the use of endotracheal methods. Although the induction of anaesthesia was facilitated by the use of ethyl chloride, it had to be used with caution and, once automatic breathing was established, needed to be replaced by anaesthesia with ether. At that time, we widely used basic sleep (*hipnosis basalis*) together with barbiturates administered by rectum. The child fell asleep on the bed and sleep induction was much easier and faster.

Special conditions and difficulties were common in plastic surgery procedures of the cleft lip or palate. The anaesthesia needed to be administered by the operator. The Schimmelbusch facemask was sterile, a bottle with ether was sheltered in a special metal casing, also sterile. The operator interrupted the surgical procedure once in a while, deepened the anaesthesia and had a little more than 10 minutes' time to continue the procedure. Nevertheless, this technique was promptly replaced by the endotracheal technique, although intubation in these defects was difficult and was performed under ether anaesthesia with patient's breathing maintained.

Special difficulties also occurred in laryngological surgical procedures. As laryngologists feared losing airway patency, most tonsillectomies were performed either under short general anaesthesia with ethyl chloride, or with no anaesthesia at all. A lot of time went by before they became convinced to use general anaesthesia with new anaesthetic agents other than ether and keep the operated child in the supine position during a tonsillectomy.

We applied diethyl ether in paediatric anaesthesia until the end of 1963. Then, halothane came into being. It was

a great advancement in anaesthesia as its scent was less irritating than ether and it was well tolerated by children. Unfortunately, halothane required administration from precise vaporisers and we had only one of this kind. Because of this, we recalibrated the ether vaporisers to become halothane vaporisers [4]. This was not very safe and demanded careful clinical monitoring. The problem was solved when we received new anaesthesia machines and then halothane became the only anaesthetic agent for general anaesthesia in combined and simple anaesthetic methods. Since halothane was introduced, we usually applied nitrous oxide with oxygen following currently approved principles. Having become skilled at intubation with the use of relaxants, the doctors were able to perform anaesthesia in children which corresponded to the combined anaesthesia method performed at present.

Summing up, on the basis of my own experience I can say that diethyl ether, as an anaesthetic agent, was safe for the patient and, in general, there were no complications resulting from its application, even in long-lasting anaesthetic procedures. Unfortunately, it did have flaws: for example, its scent was irritating, causing trouble during induction. In longer anaesthesia procedures it was indisputably toxic since it required higher concentrations to induce muscle relaxation. Unfortunately, at that time no other medication was available for this purpose; therefore, its safety mainly depended on the experience of the doctor performing the anaesthetic procedure. Indeed, the correct performance of anaesthesia sometimes needed greater precision and

skill than the surgical procedure being performed by the surgeon. From time to time, Prof. Kossakowski allowed the doctors performing anaesthesia replace surgeons and conduct surgical procedures under the supervision of the actual surgeon assigned to the operation. This allowed personal evaluation of the anaesthetic conditions and difficulties the surgeon deals with when the anaesthesia is incorrectly conducted. Indeed, closing the peritoneum in a newborn or infant was the moment of truth.

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