Review paper

Achievements of Polish doctors in gastrodiaphanoscopy at the turn of the 19th and 20th centuries

Andrzej Kierzek, Małgorzata Paprocka-Borowicz, Andrzej Pozowski, Jadwiga Kuciel-Lewandowska

Department of Physiotherapy, Wroclaw Medical University, Wroclaw, Poland

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Address for corrrespondence: Prof. Andrzej Kierzek DMSc, Department of Physiotherapy, Wroclaw Medical University, 2 Grunwaldzka St, 50-355 Wrocław, Poland, phone: +48 71 322 17 60, mobile: 693 52 17 60, e-mail: andrzejkierzek@wp.pl

Abstract

Diaphanoscopy/transillumination, the method of shining a bright light through tissues, was devised in the mid-19th century and developed after the invention of the light bulb by T.A. Edison. Benjamin Milliot was the first to examine the stomach by means of an incandescent platinum wire. The experiments conducted by Max Einhorn using a device consisting of a Nelaton catheter with an inserted light bulb, were valuable. In Poland the method of gastrodiaphanoscopy was popularized by Teodor Heryng, Mikołaj Rejchman and by Warsaw doctors. They used a diaphanoscope consisting of a gutta-percha probe distally equipped with a metal attachment with a light bulb hidden in it and with a so-called cooling device. The examination would usually be conducted in the standing position after the stomach had been filled with water. Light patches corresponding to the stomach's lower and side boundaries would be obtained. Rejchman's observation, that such a contractile and flexible organ as the stomach, changing its volume and position, is bound to change its light image, was correct. Heryng's and Rejchman's research inspired the foreign researchers Renvier, Leopold Kuttner and John Jacobson. Extensive research was subsequently conducted by C.A. Meltzing and Wilhelm Schwartz. Diaphanoscopy would also be performed by Walery Jaworski, the pioneer of gastrology. He was particularly interested in transillumination of the stomach, peritoneum and omentum tumours. Eugeniusz Kozierowski, a practicing physician from Gorlice, diagnosed neoplastic pylorostenosisusing this method. Gastrodiaphanoscopy is a historical method, now of no value against gastroendoscopy and the state-of-the-art methods of image diagnostics.

The use of electricity to produce light and the patenting of the light bulb by Thomas Alva Edison (1847–1931) in 1879 aroused hope among scientists that it would be possible to develop new diagnostic methods, such as the transillumination of body tissues. A hope arose that it would become possible to transilluminate bones, the structure of various tumours, and above all, certain body cavities, and so on. One should note that X-rays began to be used for diagnostic purposes in November 1895, i.e. since the epoch-making discovery by Wilhelm Conrad Roentgen (1845–1923). Also, diaphanoscopy of the stomach – an organ difficult to diagnose – was then considered. One should bear in mind that already in those times attempts were being made to examine the stomach with an endoscope and that the inventor of the gastroscope and the initiator of this diagnostic method was Jan Mikulicz-Radecki (1850–1905), professor of surgery in Cracow, Królewiec and Wrocław. The idea germinated in his mind during his work in the Vienna University Surgical Clinic headed by Theodor Billroth in the years 1875–1881 [1–3]. But the method was not properly popularized at that time.

The credit for introducing diaphanoscopy into healthcare should be given to Johann N. Czermak (1828–1873), an Austrian physiologist. Fascinated by the achievements of Aubinais, Ludwik Neugebauer (1821–1890), a doctor in the Holy Spirit Hospital in Warsaw, a gynaecologist and obstetrician, and professor at the Main Warsaw School and Imperial University Warsaw, using a strange apparatus consisting of a small box shaded with a glass pane, a system of tubes, a candle holder with a stearin candle, and a magnesium light (emitted by a burning magnesium wire), since 1866, made attempts to diagnose abdominal cavity tumours, such as ovarian cysts, and to identify the foetus in a pregnant uterus [4–6]. In 1867 Benjamin Milliot from Kiev, born in Volhynia, using an incandescent platinum wire placed in a glass tube, attempted to transilluminate the stomach and the urinary bladder in animals and in human cadavers. The problem in the experiments was the overheating of the device, which, when introduced into the stomach, a person could tolerate for a maximum of 1 min [7, 8]. Laczinov, instead of platinum used carbon, which emitted much (60 times) stronger light. The necessity of using a galvanic battery consisting of at least 30 cells posed considerable difficulty. Similarly, Lazarkievicz in Kharkov used this method to transilluminate the reproductive organs, particularly the ovaries and the urinary bladder in women [9, 10].

The experiments carried out by Max Einhorn (1862–1953) were also very valuable. This American physician of Russian origin was the first to carry out a stomach biopsy and was the first to use a soft tube to aspirate duodenum contents. The examinations, performed towards the end of the 1880s, were presented at a meeting of the New York Medical Society in November 1889. His device for examining the stomach consisted of a Nelaton catheter into which a small light bulb (an Edison lamp) was inserted. He examined the details of this organ after filling it with one or two glasses of water. Through the abdominal integuments one could see the lower boundary of the stomach in the patient being demonstrated [11–13].

In February 1889, after a successful attempt at transilluminating the maxillary sinuses [14–17], Teodor Heryng (1847–1925), head of the first rhino-laryngological department in Warsaw, one of the pioneers of Polish laryngology, suggested to Mikołaj Rejchman (1851–1918), the author of the textbook "The science of digestive system diseases" (Warsaw 1890), that hetry to transilluminate different organs, mainly the stomach. They assumed that since the maxillary sinus, surrounded with bone walls and covered with subcutaneous tissue and skin, allows "relatively large amounts of light rays to pass through it, so that even the edges of the lower eyelid and the eye pupil are strongly transilluminated", the more so in slim persons, one should succeed in transilluminating the internal organs. The results of the research were published in *The Medical Gazette* in 1892.

The then existing methods of determining the boundaries of the stomach and its location relative to the other organs "not always yielded accurate results". The above doctors expected to determine the boundaries of the liver and the spleen. They were encouraged by the fact that the individuals affected by stomach diseases were usually slim, with a thinner fatty tissue substrate, so the results of transillumination should have been satisfactory.

For this purpose, Teodor Heryng carried out several experiments with the transillumination of a cat's stomach in the laboratory of Feliks Nawrocki (1838–1902), Professor of Physiology at Imperial University Warsaw. After a tracheotomy, artificial respiration was applied and the animal was injected with curare. Having opened the abdominal cavity via an opening in the duodenum, he inserted a thick catheter, with a "5-candle power Edison lamp" hidden in it, into the stomach and sewed up the abdominal integuments. Through the oesophagus he introduced about 80 cm^3 of water into the stomach. Having put the animal in a dark room, he illuminated the light source. The contours of the stomach became visible as a vivid red patch [18, 19].

Heryng thought that the lack of proper tools made it impossible to develop this method properly. In his opinion, in order for the illuminating device to be easily introducible into the oesophagus its diameter should not be larger than that of the ordinary stomach probe, i.e. about 12 mm.

The difficulty lay in "designing such an incandescent lamp which would have a diameter of 8–10 mm and a very low internal resistance so that it could be brought to shine white by means of Stoehrer battery with 20 cells and still yield the highest amount of standard candles". After many efforts Heryng managed to order such a lamp from Blänsdorf & Co. of Frankfurt. The whole illuminating device was made in Krzykowski's optical plant in Warsaw. It consisted of quite a hard gutta-percha probe distally equipped with an open metal attachment, which could slide out if required, in which a "6-standard candle, 8-volt" lamp was hidden. After the examination the attachment would be drawn into the tube in order to prevent the oesophagus from overheating, but tests showed that the lamp heated up too much and the light still was not strong enough. Thus it was necessary to use larger and longer lamps, which, however, could not be hidden in the probe. Therefore a device with a cooling jacket made of strong glass was built; a stream of water would flow between the lamp and this lamp shade. The device was cooled by means of a glass irrigator, holding one litre of water, located at a height. Without going into detail about how the device was started, one should mention that the end of the water feeding tube, tipped with a gutta-percha tap, would be attached to the illuminating device. After it was connected to the Stoehrer battery, the device, lubricated with glycerine, would be introduced into the stomach and the light source would be switched on [18, 19].

Such a diaphanoscope in all detail is shown in Figures 1 A and 1 B. More or less according to this model, diaphanoscopes would be manufactured under the name of Heryng's diaphanoscope by the Blänsdorf Works mentioned above. The diaphanoscope met the following requirements: 1) it could be easily introduced into the stomach, 2) it was safe and 3) it produced light of proper intensity [11].

The method was mainly used to examine (in a darkened room) patients who "had got used to tolerating the probe", and in cases of excessive sensitivity of the mucous membrane the throat would be rinsed earlier with a potassium bromide solution with morphine or the pharyngeal mucosa would be swabbed with a 20% cocaine solution.

The best results would be achieved by examining the patient in a standing position since in the recumbent position the water with which the stomach was filled would move away from its anterior wall. Filling the stomach with other liquids, e.g. milk or air, did not give positive results. Optimal results would be obtained after filling this organ with 500–2000 cm^3 of water atroom temperature; the more water in the stomach, the larger the translucent surface. Once the diaphanoscope was introduced into the stomach, a vivid red patch, corresponding to the stomach's lower and side boundaries, would become visible on the anterior abdominal wall. In a patient with gastric dilation, the light patch would elongate upwards and left wards only when the stomach was filled with 2000 cm^3 of water, obliquely intersecting the left lower ribs for a width of 2–3 fingers and reaching the anterior axilla line or extending slightly behind it.

Pulling the device up and halting it just before the cardia, one could obtain, in the upper part of the chest, a similar luminous patch in the form of finger-like streaks, the lighter of which corresponded to the intercostal spaces and the darker ones to the ribs. At the same time, the contours of the lower boundary of the stomach would either disappear or be very dimmed.

When performing a gastrodiaphanoscopy one could distinguish the two most luminous places, corresponding to the area closest to the lamp and to the navel region (devoid of muscles and fat). On the left side, immediately by the navel, a darker streak, corresponding to the straight muscle of the abdomen, would be visible against a bright background. In a certain case, in a considerably emaciated individual with a giant gastric dilation, where the lower stomach boundary reached the pubic symphysis, one could identify, on both sides of the navel, the course of the dilated veins, particularly the internal iliac vein. Neither the liver nor the spleen could be transilluminated after the device had been introduced into the stomach. In order to verify the accuracy of the obtained results the boundaries of the light patch were marked with an aniline pencil and then checked by percussion. Then accuracy of the stomach wall determination would be ensured in this way [18, 19].

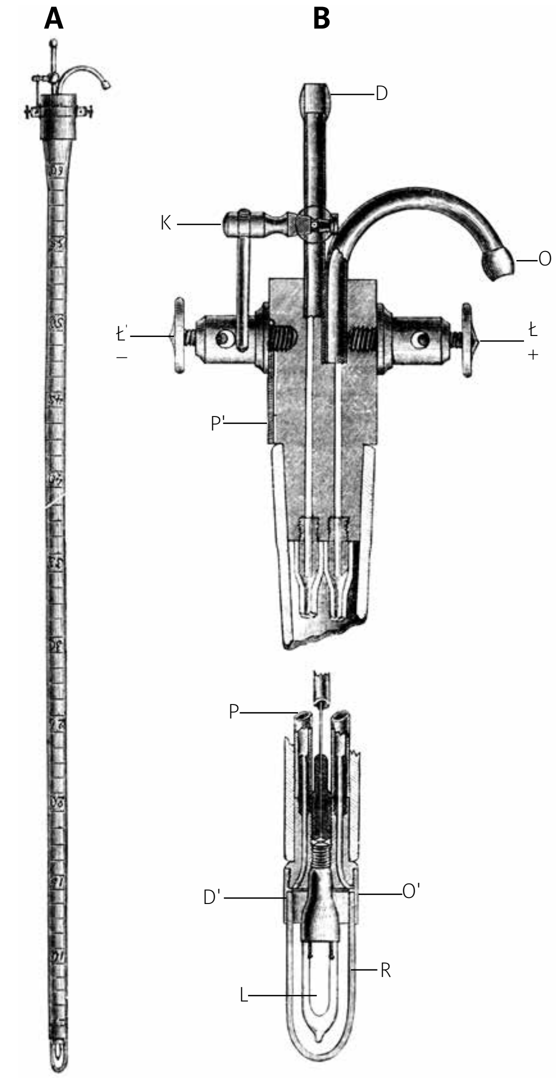

Figure 1. A – Diaphanoscope in 1/6 of full-size. **B** – Attachment and tip of full-size device – in cross section

D – inflow tube, O – outflow tube, Ł, Ł' – metal connectors to battery, P', P – insulated conductors hidden in probe, connecting lamp with connectors Ł' and Ł, D', O' – holes of tubes feeding water to glass bowl, R – glass bowl, L – electric lamp, K – tap allowing water to flow through glass bowl and constituting switch which when pressed lights up electric lamp

Heryng and Rejchman claimed that while the lower boundary of the stomach and its side boundaries could always be determined by the percussion method (percussing the stomach in its fasting state, the stomach filled with a gas or water; of course, in different positions of the patient), the upper stomach boundary was difficult to determine by percussion since when percussing Trabue's space it was hard to decide whether the obtained percussion sound originated from the stomach or from the intestines. That is why in those times many clinicians would diagnose gastroptosis only when the stomach was distended.

In the same year, 1892, the research inspired Renvier from Berlin and, in the following year, Leopold Kuttner and John Jacobson, who examined the stomach using an improved Heryng and Rejchman device. In the Berlin Medical Society, Kuttner presented the results of the transillumination of the stomach in 72 patients, and also in 15 cadavers. Using this method Kuttner and Jacobson managed to detect cancerous thickenings in the anterior stomach wall, which could not be detected by palpation [20]. Extensive research on this method was conducted by, among others, Karl Vohsen from Frankfurt am Main and Hugo J. Loebinger.

Transillumination examinations werecarried out not only in the Warsaw centre. Walery Jaworski (1849–1924) from the clinic run by Edward Sas-Korczyński (1844–1905), professor of pathology and detailed therapy at the Jagiellonian University, became interested in them. Jaworski, one of the pioneers of Polish gastrology, was one of the first to describe *Helicobacter pylori,* called *Vibrio rugula* by him, suggesting the bacterium played a role in gastropathy. However, he could not manage to culture the bacteria in laboratory conditions. The discovery passed unnoticed because it was published in Polish. Coming back to the main point, to transilluminate the stomach he used a soft gastric tube at the tip of which there was an 8-volt light bulb cooled with cold water. He claimed that gastrodiaphanoscopy constituted a reliable diagnostic method, not just an "elegant toy". Jaworski was particularly interested in the transillumination of the tumours of the stomach, the peritoneum or the omentum, situated within the area being transilluminated. Such tumours would appear as more or less dimmed places against a brighter background. He confirmed, in accord with Kuttner's findings, that only stomach wall thickenings amounting to 1.5 cm produced visible dimming effects [21]. Eugeniusz Kozierowski (born in 1865), a practitioner in Gorlice, at a meeting of the Cracow Medical Society announced that using this method he had managed to diagnose, among other things, neoplastic pylorostenosis. He noted difficulties in this examination in the case of obese patients [22].

The year 1895 sawreports by C.A. Meltzing and Wilhelm Schwartz, physicians from Rostock. According to Meltzing, the low location of the light patch depended on the ptosis of not only the stomach, but also the liver. He noted the quite frequent occurrence of physiologically determined large stomachs (*physiologische Megalogastrie*). In his opinion, it was possible to detect pylorus cancers [23]. Schwartz would conduct systematic research on the transillumination of not only body cavities, but also particular tissues, tumours and so on. He presented detailed results on the transillumination of particular tissue layers, i.e. the stomach wall, the peritoneum, the abdominal muscles, the subcutaneous tissue, the bones (ribs) and the skin, which the bulb light had to penetrate on its way to the human eye. Cysts, lipomas, fibromas and myxomas lent themselves well to transillumination. He wrote: "Cancers strongly absorb light rays so that in a 1 cm thick layer at a light intensity of 1 standard candle they are not translucent". According to Schwartz the light image could be larger or smaller than the stomach (a smaller image would appear when a certain part of the stomach was masked by the liver and the spleen, i.e. organs impervious to light) [24].

Having got acquainted with the reports of Meltzing and Schwartz, in 1896 Rejchman published an article in *The Medical Gazette*, in which he included further practical observations concerning the problem. He claimed that filling the stomach with a considerable amount of water may trigger vomiting reflexes and choking, making the examination difficult. The light images obtained daily by introducing the diaphanoscope into the stomach each time filled with the same amount of water would not always be identical since this depended on many circumstances, mainly on the contractility of the stomach, the condition and position of the intestines and the amount of gases present in the stomach. Rejchman was right to note that such a flexible and contractile organ as the stomach, surrounded on many sides by intestinal loops, every now and then changing itsvolume and situation, cannot remain in the same position in the abdominal cavity and so the light image is bound to keep changing. After the stomach is filled with water its lower boundary, i.e. its greater curvature, does not come down as expected, but moves up. Only in atonic stomachs is the lower boundary of the stomach filled with water at the same level (or below it) as the lower boundary of the so-called empty stomach. In cases of increased peristaltic movements the boundaries of the light patch can be wider. When the stomach is excessively distended with air, the examination, besides being painful, may sometimes cause fainting [11].

Gastrodiaphanoscopy was animatedly discussed at a meeting of the Warsaw Medical Society in 1896. The objection levelled at Rejchman, concerning the dependence between the light patch and the distance of the diaphanoscope from the abdominal walls, Heryng considered to be unfounded. According to him, the different distance of the device did not affect the extent of illumination, but its intensity. Mikołaj Ludwik Brunner (1840–1914), one of the founders of Polish radiology, claimed that at least a 60-volt bulb "with a power of

16 candles" should be used. Ignacy Baranowski (1833–1919), a professor at Imperial University Warsaw, an outstanding cardiologist and phthisiologist, was rather unconvinced by the gastrodiaphanoscopy method. He thought that the percussion of this organ was more trustable [25].

The gastrodiaphanoscopy method, in which not only outstanding Polish clinicians, but also provincial physicians were engaged, has rightly become athing of the past. It has been supplanted by endoscopy and by other modern image diagnostics methods. Whereas the diaphanoscopy of maxillary sinuses still found its modest place in the reissued (in 1977) work "Hals-Nasen-Ohrenheilkunde in Praxis und Klinik" by J. Berendes, R. Linck and F. Zöllner, valued by the oto-rhino-laryngological world.

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