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REVIEW

Neuroendoscopy

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Abstract: The discovery of optic bulb paved the way for the development of safe endoscopic systems not only with diagnostic ability, but also suitable for treatment. At the beginning of the 20th century, the first attempts to use an endoscope in the treatment of hydrocephalus have been made with encouraging results. Although the invention of an implantable shunt system slowed down the development of neuroendoscopy, the progress in fiberoptics and image processing has established the potential for the neuroendoscopy boom. Together with microneurosurgery, neuroendoscopy has established the concept of minimally invasive neurosurgery *(Fig. 4, Ref. 16).* Full Text (Free, PDF) www.bmj.sk.
Key words: neuroendoscopy, Walter Dandy, Jason Mixter, endoscopic third ventriculostomy.

Early diagnostic devices

The history of endoscopic technique dates back to 1806. One year after the Austerlitz battle, a German doctor Bozzini gave a lecture at Vienna Medical Academy on the study of human body inlet and outlet foramina using a special device (Lichtleiter) for a direct inspection of the evaluated orifices. The main part of the device was light-mirroring tube. A set of mirrors in his device directed the light of candle in such a way that the areas hidden behind the corners were amenable for inspection. But the article has also dealt with the possibility of the inspection of body cavities and facilitation of surgeries.

In 1853, Desormeaux combined glass optic lenses and alcohol illumination for the purpose of diagnostic investigation. Moreover, this Frech urologist pioneered the term "Endoscope". The technical progress started considerations about the use of an electric light for the purpose of surgical site illumination. The principal problem of all the systems mentioned above was an excessive heat production with the resulting possibility of thermal injury to the investigated cavities (1).

The breakdown is dated to 1879. This year, German doctors Nitze and Leiter created an endoscopic system suitable for simple urological procedures, for instance a removal of urinary bladder stone. Their original cystoscope was a crude device, consisting of a complex of lenses, with the light source at its distal end. Regardless of the drawbacks, the principle became soon accepted for the inspection of other body cavities. The needs to maintain the surgical field clear, has brough the requirement for irrigation and draining tubes. The invention of a light bulb (Thomas Alva Edison 1879) profoundly influenced not only the neuroendoscopy.

First therapeutic results

An enthusiasm for endoscopic technique and terms like ventroscopy, coelioscopy, esophagoscopy, gastroscopy, peritoneoscopy, thoracoscopy, and endometroscopy appeared at the beginning of the 20-th century. Moreover, in 1910, Jacobaeus described the use of endoscope not only for the diagnostic verification of tuberculosis, but also for adhaesiolysis in serous cavities.

The birth of neuroendoscopy dates back to 1910, when Victor Lespinasse – Chicago urologist performed the first neuroendoscopic surgery in the history. Using a paediatric endoscope he inspected the cerebral ventricular system in two hydrocephalic children and apart from diagnostic ventriculoscopy he dared to coagulate choroid plexus in attempt to reduce the production of cerebrospinal fluid. The procedure would pass unnoticed in the history if it had not been discussed on a local urological meeting. His bravery and handedness is supported by the fact, that one of the severely sick infants survived 5 years after the procedure. Unfortunately the brave surgeon abandoned neuroendoscopy claiming it to be a resident stunt and shifted his attention to other problems – testicular transplantation for the purpose of reiuvenation (much more closer to urological specialization and undoubtedly more tentative regarding finantial incomes) (2, 3).

Early neuroendoscopy

A similar surgical procedure using a nasal speculum was performed by the American neurosurgeon Walter Dandy in 1918. This innovative neurosurgeon further shifted the possibilities of neurosurgery introducing a contrast ventriculography. A scientific

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Fig. 1. Trajectory planning for the endoscopic third ventriculostomy for the hydrocephalus treatment.

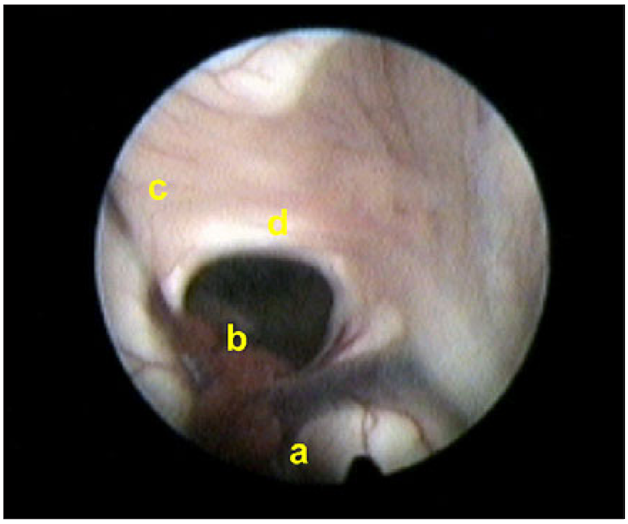

Fig. 2. An endoscopic view of structures around foramen Monroi: a) thalamostriate vein, b) choroid plexus structures, c) anterior septal vein, d) fornix.

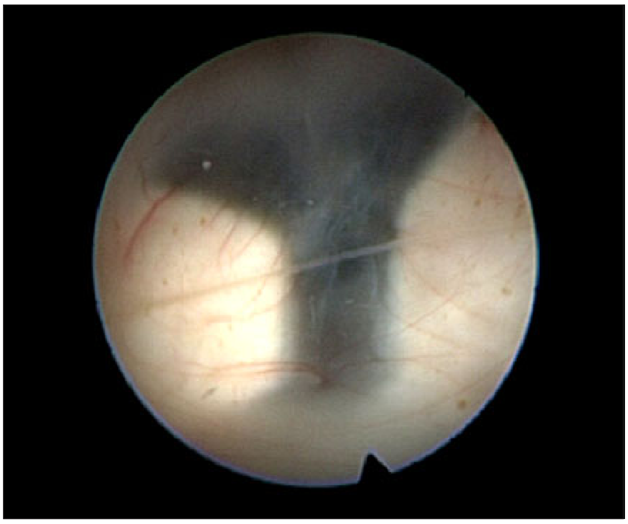

Fig. 3. The optimum site for the endoscopic third ventriculostomy.

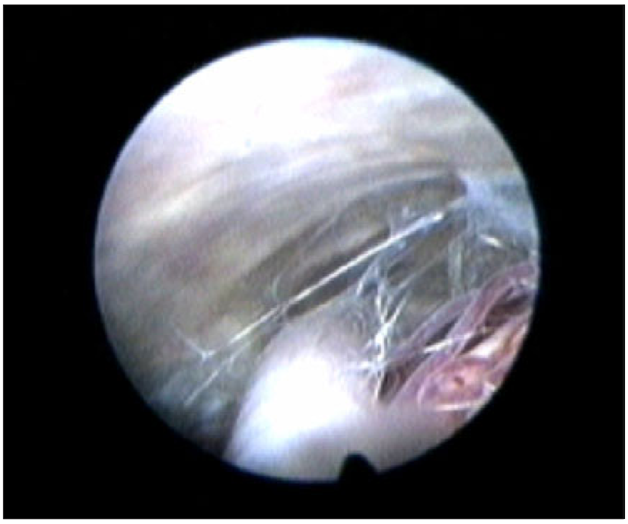

Fig. 4. The basilar artery view after the third ventricular floor fenestration.

treatment of hydrocephalus has its roots in the classification, created by Dandy and Blackfan. It is necessary to underline the role of Harvey Cushing because the research work on hydrocephalus mentioned above was completed in Hunterian Laboratory, John Hopkins School of Medicine, Baltimore, under his direct leadership. The principle of Dandy's classification is the difference between an obstructive (caused by cerebrospinal fluid flow blockage) and a communicating hydrocephalus (no obstacle verified, the cause is either cerebrospinal fluid hypersecretion or decreased resorption).

The term "ventriculoscopy" (endoscopic inspection of cerebral ventricles) is attributed to Dandy. In 1922, he described the third ventriculostomy as an operation bypassing cerebrospinal fluid circulation block and establishing a direct communication between the third ventricle and basal cisterns. He used frontal approach for the lamina terminalis fenestration. In the same year, the first endoscopic plexectomy was done by the same author – the choroid plexus exstirpation in order to reduce cerebrospinal fluid production in communicating hydrocephalus. To illustrate immense work and benefits of Dandy`s work regarding surgical treatment of hydrocephalic patients, it is also necessary to mention a direct aquaeductal cannulation via the fourth ventricle.

Another neurosurgical inventor, continuing the tradition of Massachussetts General Hospital surgeons – Jason Mixter performed the first purely endoscopic third ventriculostomy (communication between the third ventricular cavity and cisterns at the base of the brain) in 1923. Opposed to W. Dandy, who proceeded from basal cisterns to the third ventricular cavity, Mixter inverted the direction of surgical approach. A small urethroscope was inserted through the patent fontanelle to the dilated lateral ventricle cavity and through the foramen of Monro to the third ventricle towards the third ventricular floor. The third ventricular floor fenestration in front of the mamillary bodies was accomplished using a special probe (Figs 1, 2, 3, 4). Mixter presented an excellent surgical success. Before surgery, he injected the indigocarmine dye to cerebral ventricles. As expected in obstructive hydrocephalus, a lumbar punture performed before surgery excluded the presence of dye in the lumbar cerebrospinal fluid. But after the surgery, the presence of dye in the lumbar cerebrospinal fluid became immediately apparent. Moreover there was a marked reduction of the head,s circumference and fontanelle became soft (4, 5). Mixter‘s special endoscopic set already contained a movable coagulation probe and irrigation system preventing the ventricular walls from collapse and keeping the surgical media clear. His surgical algorrhytm fully employs the basal principles of the minimally invasive surgery, valid today. Surgical trajectory takes the advantage of natural cerebrospinal fluid pathways (cerebral ventricles with hydrocephalic dilatation) and endoscopic approach through the thinned white matter of the frontal lobe inflicts only minimal damage to the brain parenchyma.

A technical limitation did not prevent Hugh Grant and Temple Fay from performing an intraventricular photography in hydrocephalic child in 1923. The quality was hampered by an insufficient illumination and resulting long exposition times, varying between 30 and 90 seconds. The authors underlined the possible benefit of diagnostic ventriculoscopy in paraventricular lesions (6, 7).

In 1935, John Scarff employed ventriculoscope with an angular view, enabling the surgeon to perform more extensive choroid plexus coagulation.

In 1942, Tracy Putnam published his experience with 42 endoscopic plexectomies. He presented the mortality of 25 %, but intracranial hypertension was controlled in 17 patients. The choroid plexus coagulation is not an abandoned surgery even nowadays. The operation can be beneficial in hydrocephalic patients with a free flow of cerebrospinal fluid and without symptoms of marked intracranial hypertension.

Dandy described another group of 52 patients after the endoscopic third ventriculostomy with 12% mortality. The results achieved by the pioneers of neuroendoscopy should be considered oustanding regarding the technical limitations and the situation in neurosurgery at that time.

The surgeon did not have the possibility of easy control of the surgical procedure by the TV screen, situated in his visual field. The only possibility to observe the surgical field was through the optical eyepiece of the endoscope. Bipolar coagulation was not available.

Microsurgery did not exist, open direct surgeries were performed to alleviate clinical symptoms in patients with Parkinson disease with a high mortality (caused both by the surgery and severe condition of the patients operated on). Frontal lobotomy was already described and performed by Moniz and Fiamberti and its boom was ahead. All these facts must be taken into consideration, when discusing the achievements of neuroendoscopy before WW II.

It is difficult to comment on the surgical technique used by McNickle (1947) for an endoscopic third ventriculostomy. The author described a percutaneous technique, and finally abandoned the use of endoscope to maintain the orientation within the intraventricular space. The device was targeted by X rays imaging and during the phase of third ventricular floor fenestration he entirely relied on tactile feedback without visual control. Surprisingly the number of reported complications was low (1, 8).

Temporary drop of neuroendoscopy

The invention of an unidirectional valve as a part of cerebrospinal fluid drainage systems become a breakthrough in the treatment of hydrocephalus and cerebrospinal fluid expansions (e.g. arachnoid cysts). Neuroendoscopic surgeries were replaced with seemingly easier drainage surgeries, requiring a “simple” ventricular or cyst puncture with subsequent implantation of the shunt system, draining cerebrospinal fluid to regions, where the fluid could be resorbed – peritoneal cavity, right heart atrium and some exceptional sites (stomach, biliary pathways, pleural cavity, ureter…).

Although this comment may fall outside the neuroendoscopy it is necessary to mention, that the first polyethylen drainage system with a unidirectional valve in hydrocephalic patient was implanted in 1949 by Frank Nulsen and Eugene Spitz (ventriculo-atrial drainage to the right cardiac atrium). Another step forward was the use of polyvinyl chloride described by Pudenz in 1955 and Spitz Holter system introduced in the same year. History will never forget the son of one of the inventors (John Holter), whose severe condition (meningomyelocele with hydrocephalus) became a direct stimulus leading his father to work on the valve system.

With an increasing numbers of implanted shunts it became evident, that the use of drainage systems inevitably led to serious complications. The opinion expressed by one of the top neurosurgeons „Who has implanted 100 cerebrospinal fluid shunts will have enough work to do for the lifetime (when correcting them)“ is valid even in the era of programmable shunts, antisiphoning devices and the most modern biocompatible materials. Shunt malfunctions, infections, symptoms of overdrainage, underdrainage, and slit ventricle syndrome are important chapters of neurosurgical textbooks.

Technological development before the renaissance of neuroendoscopy

Despite these facts there was a certain retreat of endoscopic surgeries in 1950-ties and 1960-ties. Hidden beneath the curtain, significant achievements were made in optics, electronics and image processing. The term „zoom lenses“ was first used in Harold Hopkins work dated to 1948 and in 1960 the same author patented rod lenses, substantially improving Nitze’s system of glass lenses by replacing the air among between them by an inert gas (1, 9).

Another comparable achievement was the invention of CCD (charge coupled devices), transforming optical stimuli to an electrical current (Bell laboratories, 1969). This technique has proven to be excellent for use in poorly lightened environment. New CCD system cameras replaced the original Vidicon system with resulting improvement of image resolution and quality.

Articles describing the concept of optical fibers technology appeared in Hopkins work in 1950-ties. However, a light transmission by means of optic fibers was patented by John Logie Bard in 1926, famous due to another invention, profoundly influencing human society in the past, present and future – television. The concept of fibroscope was presented by Basil Hirschowitz at the meeting of American Gastroscopic Society. He combined fiberoptic image transmission with a single illumination light bulb on the proximal end of the scope. In 1965, Karl Storz patented his concept of fiberoptic illumination by means of cold light transferred from the external source combined with the rod lens. The final result was the separation of the light source from the other parts of the endoscope. Guiot and Scarff pioneered the new technology in 1963 (10).

An attempt to improve the surgical field observation appeared in the work of Forestier and Vulmier in 1954. The only previous possibility was to look directly into the endoscopic optic. Later endoscope was coupled with videocamera and screen projection. The current state of art are helmet like systems – head mounted device (similar to jet fighter pilot helmets) used at several departments.

Neuroendoscopy outside cerebrospinal fluid space

After the period of a relative suppression of neuroendoscopy in the original indication – treatment of hydrocephalus – there was an expansion of neuroendoscopy not only in the field of cerebrospinal fluid expansion but this minimally invasive method is used outside cerebrospinal fluid space (11, 12, 13, 14) and finally also outside cranial space. Skull base surgery is an elementary example. In 1990-ties, an endoscopic transsphenoidal surgery was prepared as a result of cooperation between a neurosurgeon and ENT specialist. In 1992, Jankowski with co workers from Nancy University published their experience with 3 patients, in whom a transnasal endoscopic transsphenoidal approach to sellar area was used. In 1995, Sethi and Pillay from Singapur described a transsphenoidal endonasal technique for surgeries in the sellar region. The approach was not strictly endonasal, the authors described a transnasal transseptal approach with bilateral muko perichondral flap formation and bone septum removal. A purely endonasal transsphenoidal hypofysectomy was therefore first described by the members of the Pittsburgh group – Jho and Carrau (15, 16). In 1997, these authors published their results in the group of 50 patients. The surgical approach can be applied for the treatment of other sellar and parasellar lesions, as supported among others by de Diviitis (14).

Conclusions

The aim of this article was to present the history of neuroendoscopy in connection with the level of pathophysiological knowledge about neurosurgical diseases, the influence of technical equipment available during the defined time period and personal achievements of neurosurgical leaders.

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