ELSEVIER
SAUNDERS

Neurosurg Clin N Am 15 (2004) 1–7

NEUROSURGERY
CLINICS
OF NORTH AMERICA

History of neuroendoscopy

Rick Abbott, MD

Clinical Neuroendoscopy, INN, Beth Israel Medical Center, 170 East End Avenue, New York, NY 10128, USA

The insertion of tubes into the body for either the deliverance of a therapy or diagnostic purposes has taken place throughout recorded medicine. The first documented instance of the use of a tube to inspect the rectum was in Hippocrates' time. Natural light was used to illuminate the field [1]. The Babylonians described using vaginal speculums in 500 AD, with illumination being provided by ambient light [2]. Abulkaism (980–1037) and Giulio Cesare Aranzi (1530–1589) reported on the use of mirrors to reflect ambient light down their "endoscopic" tubes to allow for the inspection of deeper body cavities [3]. In 1805, the Alert Faculty in Vienna heard Philippe Bozzini's report on an instrument he had developed, which used candle light reflected by a concave mirror for the inspection of the bladder and rectum [4]. They were not impressed, censoring Bozzini for his inappropriate curiosity and rejecting the "magic lantern."

In 1867, Antonin Desormeaux published a description of an endoscope whose illumination had been improved by using an alcohol and kerosene burning candle with a chimney [5]. The light this candle generated was collected and focused down the shaft of the scope using a lens. This was to be the first successful design for a cystoscope, and it was presented to the Academy of Medicine in Paris. Shortly thereafter, there were several reports of therapeutic uses for endoscopes. First, Bevan reported on successfully using an endoscope to extract foreign material from the esophagus, and Pantaleoni then reported on using a scope to inspect the uterus of a women bothered by postmenopausal bleeding, discovering an intrauterine polyp and cauterizing it with silver nitrate [4]. In 1870, Kussmaul demonstrated using a rigid scope to inspect the stomach [5]. The assistance of a professional sword swallower was required for this, however.

All these described systems suffered from a lack of magnification. They were simply tubes that directed illumination down to their distal tip. In 1879, Max Nitze described the first system that contained a series of lens [6]. Working with several opticians, he described a scope with an illumination source to the distal tip, a platinum wire that glowed when current was conducted through it. The light produced was then projected through a prism. This wire produced heat, however, necessitating a water coolant system. Shortly thereafter, Edison invented the light bulb, and Newman then described modifying Nitze's scope in 1883 by substituting a small light bulb at the distal tip for the platinum wire [7]. Boisseau du Rocher was the next to modify the system by fabricating an outer sheath to contain the telescope, reporting on this in 1889 [4]. This modification allowed the surgeon to interchange different scopes during a procedure without having to renavigate through the body to the working site.

By the turn of the century, the promise of endoscopy had been demonstrated, but its acceptance was slowed because of the poor illumination. Indeed, Pantaleoni's students remarked on not being able to appreciate his work, claiming an inability to see anything with his hysteroscope [4]. The light source evolved during the first half of the twentieth century, and by 1950, it consisted of a tungsten bulb at the distal tip of the scope [8]. Even this was inadequate, providing poor illumination and significant color distortion. In large part, these difficulties were the result of design flaws inherent in the Nitze endoscope design (ie,

E-mail address: Rabbott@bethisraelny.org

doi:10.1016/S1042-3680(03)00065-2

a telescope containing a series of lens housed in an air-filled tube) [9]. The conduction of light in an endoscope is a function of the refractory index of the conducting medium, in this case, air. The refractory index is defined as the difference in the speed of light conduction in a vacuum and the medium in question. As it turns out, the refractory index for glass is 1.5 times greater than that for air. Harold Hopkins, a British optical physicist, used this observation to construct a new endoscope designed to improve on light conduction. His scope interchanged glass for air and vice versa, resulting in a series of "air lens" housed in a glass tube, or a series of glass rods. Not only did this result in an increase in the system's refractory index but also in an increase in the scope's field of view because of a decrease in spherical aberration at the perimeter of the lens (thus increasing the lens's light gathering capacity). The net gain in light transmission of Hopkins' scope design over Nitze's design was ninefold. Hopkins also used coating on the lens to minimize refraction of light at the lens interface with the glass rods and calculated the layout of the lens to eliminate ghosting and chromatic distortion in addition to further increasing light transmission. With these improvements, serious attention could be given to using scopes within the human body, such as the brain's ventricles, where ambient light could not be directed.

An additional problem with the Nitze design was the heat generated by its illumination source housed at the distal tip of the scope. The answer seemed to be using a light generator outside of the body and conducting the light down to the distal tip. The first report of use of an external light source was by Fourestier, Bladu, and Valmier in 1952, when a scope design was described where light was transmitted down a quartz rod from the scope's external light source [8]. This transmitted enough light to make endoscopic photography possible. An improvement on this shortly followed based on work done by Heinrich Lamm in 1932 [4]. At that time, Lamm had demonstrated that light could be conducted through a bundle of glass fibers. In 1954, Harold Hopkins picked up on this idea and with a colleague, N.S. Kapany, discussed applying this finding to design a more effective light conducting system [10]. They described two types of fiber bundles, so-called "incoherent" and "coherent" bundles. Incoherent bundles referred to bundles of glass fibers whose orientation with neighbors was chaotic or without order. This type of bundle could be used to transmit light for illumination. Conversely, a coherent bundle maintained the orientation of fibers through its length so that any given fiber would maintain its exact orientation to it is neighbors throughout the length of the bundle. This type of bundle could be used to transmit an image from one end of the bundle to the other. Hopkins and Kapany observed that this type of bundle could be used in the design of a "flexible" endoscope whose shaft could be bent to a degree and still allow for the conduction of an image from one end of the scope to the other. In the same issue of *Nature*, there was a paper describing a technique for coating the fibers to minimize loss of light and degradation of image quality [5].

Hirschowitz visited Hopkins' laboratory shortly after the publication of his paper in 1954 and was impressed with the promise of the observations made by Hopkins and Kapany [5]. He returned to the University of Michigan, where he collaborated with Wilbur Peters and Lawrence Curtiss to develop a fiberoptic gastroscope. By the end of 1956, Curtiss had developed a glass coating for the optical fibers that was permanently adherent and capable of conducting an image for over a meter. In January 1957, they completed construction of their first fiberoptic gastroscope. The next month, it was used to inspect a gastric ulcer in the wife of a dental student. Within 3 years, a commercial fiberoptic endoscope, American Cystoscope Makers' No. 4990 (American Cystoscope Makers, New York, NY), became available. By 1962, Hirschowitz was able to publish a series of 500 gastroesophageal endoscopies.

In 1963, Guiot described an endoscope developed for intracranial work that had a powerful external light source whose illumination was conducted via a quartz rod to the scope's distal tip [9]. This allowed for color photography of the ventricle. That same year Scarff described improving his ventriculoscope by substituting a "fiber lighting" system with an external light source for the previously used incandescent bulb at the scope's distal tip [9]. In 1983, the Welch Allyn Company (Skaneateles Falls, NY) released the first endoscope with the charged couple device, allowing for conduction of a high-quality image from the scope to a television screen [5]. Other companies quickly followed with miniaturization of the scopes, resulting in an improved ability to document and teach. The ability to introduce rigid and flexible endoscopes into the body and to obtain good-quality images was thus established.

As the use of endoscopes for diagnostic purposes increased, not surprisingly, so too did the desire to render therapy. In 1887, Felix M. Oberländer described the first scope designed to treat postgonorrheal strictures [6]. The scope allowed for direct visualization of the urethra and contained an instrument channel allowing for the introduction of various knives for cutting the strictures under direct vision. In 1910, L'Espinasse reported to a local medical society in Chicago on the use a cystoscope to fulgurate the choroid plexus in two infants with hydrocephalus [11]. One child died immediately after surgery, but the other lived for 5 years; thus was reported the first therapeutic neuroendoscopic case. Erich Wossidlo, a German urologist, reported on using a galvanocaustic hook to treat urethral strictures [6]. In 1937, Ruddock introduced a scope that contained an electrocautery unit and biopsy forceps as well as ancillary biopsy instruments for use in the peritoneal cavity [12]. In 1939, Crafoord and Frenckner described using sclerotherapy to treat esophageal varices [4]. In the 1970s, lasers were introduced into the armamentarium of medicine. In 1973, Nath and his colleagues [13] experimentally used an Nd:YAG laser fiber with an endoscope to demonstrate its feasibility. Two years later, Frühmorgan et al [14] reported on its use on a patient.

Although not as aggressive as some specialists, neurosurgeons have been actively engaged in the development of endoscopic applications for the central nervous system. As mentioned earlier, L'Espinasse first described use of the endoscope in the central nervous system in 1910. In 1922, Dandy [15] reported performing an endoscopic choroid plexectomy after a previously reported experience in performing open choroid plexectomy on four patients. The attempt to perform the endoscopic choroid plexectomy was unsuccessful, and he did not attempt any further such cases. The next year, Fay and Grant [16] reported on successfully photographing the interior of the ventricles of a hydrocephalic child. The fact that a 40-second exposure was required speaks to the rather poor illumination available at that time. In the same year, Mixter [17] performed the first successful endoscopic third ventriculostomy using a cystoscope. This did not gain acceptance, presumably because of the poor visualization. In 1932, Dandy [18] reported on using a cystoscope to remove the choroid plexus. His results were similar to those experienced when he did the surgery via a formal craniotomy. Shortly thereafter, Putnam [19] reported on the effectiveness of simply cauterizing the choroid plexus using a scope of his design. Scarff [20] then wrote a paper on his experience in developing a ventriculoscope that allowed cauterization of the choroid plexus. He went on to develop a scope that contained a movable electrode for cauterization of the plexus. In 1943, Putnam [21] reported on performing endoscopic choroid plexectomy on 42 patients. There were 10 (25%) perioperative deaths. Fifteen of the patients failed to respond to the treatment, but 17 experienced success in relief of their intracranial hypertension. In 1970, Scarff [22] reviewed all available series of endoscopic choroid plexus cauterization for the treatment of hydrocephalus. Of 95 patients so treated, 14 (15%) had died, whereas 52 (60%) had initial successful results. Scarff also looked at his patients (39 of the 95 patients) at more than 5 years after their surgery and found that 7 had died of causes unrelated to their hydrocephalus and the rest required no further treatment. More recently, Bucholz and Pittman [23] reported on using the Nd:YAG laser to cauterize the choroid plexus of a shunted infant with ascites, effectively decreasing cerebrospinal fluid (CSF) production by 50%. Pople and Griffith [24] commented on their 20-year experience treating 156 individuals with choroid plexus cauterization, finding a 35% long-term success rate.

As stated earlier, Guiot reported on an endoscope with a powerful external light source sufficient to allow for color photography of the ventricle. Guiot reported on using this system to perform third ventriculostomy. The difficulty with his system was its diameter, 9.1 mm. This prevented a wider use of his scope, and Guiot ultimately ceased performing third ventriculostomy with his instrument. Vries [25] described his experience with five hydrocephalic patients on whom he performed endoscopic third ventriculostomies in 1978. Although he showed that the procedure was technically feasible, none of his patients remained without a shunt over the long term. Jones et al [26] reported a different experience in 1990, describing a 50% success rate in long-term management of hydrocephalus in 24 patients who underwent a third ventriculostomy. Modern series have improved on this figure, with most now reporting 60% to 90% long-term success with the technique [27–33].

Neurosurgeons have used endoscopes for other indications in the central nervous system. In 1938, Pool [34] reported on using an endoscope, termed a *myeloscope*, to visualize dorsal nerve roots of the cauda equina. Several years later, he described using the instrument to view the spinal cord and its conus. In 1990, the group at Hôpital Necker in Paris described their evolution in the treatment of suprasellar arachnoidal cysts [35]. From first performing stereotactically guided fenestration of the cyst, they moved to performing the procedure endoscopically. Others have reported on endoscopically fenestrating other arachnoidal cysts [36–41].

Although technically more challenging, the endoscope can be used to fenestrate other intraventricular cysts such as arise after severe ventriculitis. In 1986, Powers [42] described two infants with postinfectious multicystic ventricles who he managed using a flexible endoscope and argon laser. He was able to fenestrate the cysts into the ventricles successfully and cure the lingering infections. In 1992, Zamorano et al described using a stereotactically guided endoscope to treat cystic ventricles and other entities [64]. The endoscope has also been used to assist in the evacuation of intracranial hematomas [43–45]. The greatest success has been with chronic hematomas, but surgeons have described attacking even acute clots [11,46,47].

There are now numerous reports in the literature of the successful biopsying or removal of intracranial mass lesions endoscopically. In 1983, Powell et al [48] first reported on the removal of a colloid cyst using the endoscope. There have been many reports since [40,49–51,53], and in 1994, Lewis et al [52] showed that this type of resection required less surgical time and postoperative convalescence for their patients. Fukushima [54] reported on using a flexible endoscope to biopsy tumors in 1978. Many have reported similar success over the past several decades [55–60]. Endoscopic surgery has also been used to manage cystic tumors, such as craniopharyngiomas, fenestrating the cysts into ventricles or cisternal spaces [61–65]. One particular successful application for the neuroendoscope has been to biopsy pineal region tumors when performing third ventriculostomies to treat the associated hydrocephalus [66,67]. There has been one report, however, of secondary seeding of the endoscope's tract after such a biopsy [68]. As early as 1979, surgeons reported on using the endoscope to resect pituitary lesions, and this has become extremely popular over the last decade [65,69–81]. Finally, there are several surgeons investigating the utility of using an endoscope as an assisting set of eyes when performing microneurosurgery [60,61]. This has allowed for a much narrower surgical corridor and for the surgeon to ''look around corners'' or on the back side of structures, such as arteries. Fries and Perneczky [11] have also spoken of improved appreciation of microanatomy not apparent with the microscope.

Other applications are finding their way into the literature as neurosurgeons gain comfort in using endoscopic equipment. Jimenez and Barone [82,83] have reported on using the endoscope to perform sagittal strip craniectomies in conjunction with molding helmets for the treatment of scaphocephaly. As early as 1993, neurosurgeons reported on using endoscopes to perform thoracic sympathectomies in a minimally invasive fashion [84–89]. In 1994, Schaffer [90] reported on resection of an intervertebral disk using an endoscope, and several surgeons have described using the endoscope to perform various spinal surgeries since [91–95].

It seems clear that the endoscope is a unique tool and that it has a place in the armamentarium of the modern neurosurgeon. Its applications will only broaden as we gain instrumentation and experience in using this system.

References

[1] Rosin D. History. In: Rosin D, editor. Minimal access medicine and surgery. Oxford: Radcliffe Medical Press; 1993. p. 1–9.
[2] Gorden A. The history and development of endoscopic surgery. In: Sutton C, Diamond M, editors. Endoscopic surgery for gynaecologists. London: WB Saunders; 1993. p. 3–7.
[3] Gotz F, Pier A. The history of laparoscopy. In: Gotz F, et al, editors. Color atlas of laparoscopic surgery. New York: Thieme; 1993. p. 3–5.
[4] Lau W, Leow C, Li A. History of endoscopic and laparoscopic surgery. World J Surg 1997;21:444–53.
[5] Hirschowitz B. Development and application of endoscopy. Gastroenterology 1993;104:337–42.
[6] Schultheiss D, Truss M, Jonas U. History of direct vision internal urethrotomy. Urology 1987;52(4): 729–34.
[7] Dameword M. History of the development of gynecologic endoscopic surgery. In: Azziz R, Murphy A, editors. Practical manual of operative laparoscopic and hysteroscopy. New York: Springer-Verlag; 1992. p. 7–14.
[8] Bordelon B, Hunter J. Endoscopic technology. In: Green F, Ponsky J, editors. Endoscopic surgery. Philadelphia: WB Saunders; 1994. p. 6–17.
[9] Griffith H. Endoneurosurgery: endoscopic intracranial surgery. In: Symon L, editor. Advances and

technical standards in neurosurgery. New York: Springer-Verlag; 1986. p. 2–24.
[10] Hopkins H, Kapany N. A flexible light transmitting tube. Nature 1954;173:39–41.
[11] Fries G, Perneczky A. Intracranial endoscopy. In: Symon L, editor. Advances and technical standards in neurosurgery. New York: Springer-Verlag; 1999. p. 21–60.
[12] Haubrich W. History of endoscopy. In: Sivak M, editor. Gastroenterologic endoscopy. Philadelphia: WB Saunders; 1987. p. 2–18.
[13] Nath G, Gorish W, Kiefhaber P. The first endoscopy via a fiber-optic transmission sytem. Endoscopy 1973;5:208–12.
[14] Fruhmorgan P, et al. The first endoscopic laser coagulation in the human GI tract. Endoscopy 1975;7:156–60.
[15] Dandy W. Cerebral ventriculostomy. Johns Hopkins Hospital Bull 1922;33:189.
[16] Fay T, Grant F. Ventriculostomy and intraventricular photography in internal hydrocephalus. JAMA 1923;80:461–3.
[17] Mixter W. Ventriculoscopy and puncture of floor of third ventricle. Boston Med Surg J 1923;188:277–8.
[18] Dandy W. The brain. In: Lewis D, editor. Practice of surgery. Hagerstown: WF Prior Company; 1932. p. 247–52.
[19] Putnam T. Treatment of hydrocephalus by endoscopic coagulation of the choroid plexus. Description of a new instrument and preliminary report of results. N Engl J Med 1934;210:1373–6.
[20] Scarff J. Endoscopic treatment of hydrocephalus. Description of ventriculoscope and preliminary report of cases. Arch Neurol Psychiatry 1936;35: 853–60.
[21] Putnam T. The surgical treatment of infantile hydrocephalus. Surg Gynecol Obstet 1943;76:171–82.
[22] Scarff J. The treatment of nonobstructive (communicating) hydrocephalus by endoscopic cauterization of the choroid plexus. J Neurosurg 1970; 33:1–18.
[23] Bucholz R, Pittman T. Endoscopic coagulation of the choroid plexus using the Nd: YAG laser: initial experience and proposal for management. Neurosurgery 1991;28:421–6.
[24] Pople I, Griffith H. Control of hydrocephalus by endoscopic choroid plexus coagulation—long-term results and complications. Eur J Pediatr Surg 1993; 3(Suppl 1):17–8.
[25] Vries J. An endoscopic technique for third ventriculostomy. Surg Neurol 1978;9:165–8.
[26] Jones RF, Stening WA, Brydon M. Endoscopic third ventriculostomy. Neurosurgery 1990;26(1): 86–92.
[27] Choi JU, Kim DS, Kim SH. Endoscopic surgery for obstructive hydrocephalus. Yonsei Med J 1999; 40(6):600–7.
[28] Elbabaa SK, Steinmetz, Ross J, Moon D, Luciano MG. Endoscopic third ventriculostomy for obstructive hydrocephalus in the pediatric population: evaluation of outcome. Eur J Pediatr Surg 2001; 11(Suppl 1):S52–54.
[29] Jones RF, Kwok BC, Stening WA, Vonau M. Neuroendoscopic third ventriculostomy. A practical alternative to extracranial shunts in non-communicating hydrocephalus. Acta Neurochir Suppl (Wien) 1994;61:79–83.
[30] Murshid WR. Endoscopic third ventriculostomy: towards more indications for the treatment of non-communicating hydrocephalus. Minim Invasive Neurosurg 2000;43(2):75–82.
[31] Panigrahi M, Vinas FC, Guthikonda M. Endoscopic third ventriculostomy: outcome analysis of 100 consecutive procedures. Neurosurgery 2000; 46(6):1534–5.
[32] Rieger A, Rainov NG, Brucke M, Marx T, Holz C. Endoscopic third ventriculostomy is the treatment of choice for obstructive hydrocephalus due to pediatric pineal tumors. Minim Invasive Neurosurg 2000;43(2):83–6.
[33] Tuli S, Alshail E, Drake J. Third ventriculostomy versus cerebrospinal fluid shunt as a first procedure in pediatric hydrocephalus. Pediatr Neurosurg 1999; 30(1):11–5.
[34] Pool J. Direct visualization of dorsal nerve roots of the cauda equina by means of a myeloscope. Arch Neurol Psychiatry 1938;39:1308–12.
[35] Pierre-Kahn A, Capelle L, Brauner R, Sainte-Rose C, Renier D, Rappaport R, et al. Presentation and management of suprasellar arachnoid cysts. Review of 20 cases. J Neurosurg 1990;73:355–9.
[36] Santamarta D, Morales F, Sierra JM, de Campos JM. Arachnoid cysts: entrapped collections of cerebrospinal fluid variably communicating with the subarachnoid space. Minim Invasive Neurosurg 2001;44(3):128–34.
[37] Hopf NJ, Perneczky A. Endoscopic neurosurgery and endoscope-assisted microneurosurgery for the treatment of intracranial cysts. Neurosurgery 1998; 43(6):1330–7.
[38] Paladino J, Rotim K, Heinrich Z. Neuroendoscopic fenestration of arachnoid cysts. Minim Invasive Neurosurg 1998;41(3):137–40.
[39] Decq P, Brugieres P, Le Guerinel C, Djindjian M, Keravel Y, Nguyen JP. Percutaneous endoscopic treatment of suprasellar arachnoid cysts: ventriculocystostomy or ventriculocystocisternostomy? Technical note. J Neurosurg 1996;84(4):696–701.
[40] Hellwig D, Bauer BL, List-Hellwig E. Stereotactic endoscopic interventions in cystic brain lesions. Acta Neurochir Suppl (Wien) 1995;64:59–63.
[41] Caemaert J, Abdullah J, Calliauw L, Carton D, Dhooge C, van Coster R. Endoscopic treatment of suprasellar arachnoid cysts. Acta Neurochir (Wien) 1992;119(1–4):68–73.
[42] Powers SK. Fenestration of intraventricular cysts using a flexible, steerable endoscope and the argon laser. Neurosurgery 1986;18(5):637–41.

[43] Auer LM. Ultrasound stereotaxic endoscopy in neurosurgery. Acta Neurochir Suppl (Wien) 1992; 54:34–41.
[44] Bauer BL, Hellwig D. Minimally invasive endoscopic neurosurgery—a survey. Acta Neurochir Suppl (Wien) 1994;61:1–12.
[45] Karakhan VB, Khodnevich AA. Endoscopic surgery of traumatic intracranial haemorrhages. Acta Neurochir Suppl (Wien) 1994;61:84–91.
[46] Auer LM, Holzer P, Ascher PW, Heppner F. Endoscopic neurosurgery. Acta Neurochir (Wien) 1988; 90(1–2):1–14.
[47] Hellwig D, Bauer BL. Minimally invasive neurosurgery by means of ultrathin endoscopes. Acta Neurochir Suppl (Wien) 1992;54:63–8.
[48] Powell MP, Torrens MJ, Thomson JL, Horgan JG. Isodense colloid cysts of the third ventricle: a diagnostic and therapeutic problem resolved by ventriculoscopy. Neurosurgery 1983;13(3):234–7.
[49] Rodziewicz GS, Smith MV, Hodge CJ Jr. Endoscopic colloid cyst surgery. Neurosurgery 2000;46(3): 655–62.
[50] King WA, Ullman JS, Frazee JG, Post KD, Bergsneider M. Endoscopic resection of colloid cysts: surgical considerations using the rigid endoscope. Neurosurgery 1999;44(5):1103–11.
[51] Deinsberger W, Boker DK, Samii M. Flexible endoscopes in treatment of colloid cysts of the third ventricle. Minim Invasive Neurosurg 1994; 37(1):12–6.
[52] Lewis AI, Crone KR, Taha J, van Loveren HR, Yeh HS, Tew JM Jr. Surgical resection of third ventricle colloid cysts. Preliminary results comparing transcallosal microsurgery with endoscopy. J Neurosurg 1994;81(2):174–8.
[53] Heikkinen ER, Heikkinen MI. New diagnostic and therapeutic tools in stereotaxy. Appl Neurophysiol 1987;50(1–6):136–42.
[54] Fukushima T. Endoscopic biopsy of intraventricular tumors with the use of a ventriculofiberscope. Neurosurgery 1978;2(2):110–3.
[55] Greenberg IM. Intraoperative ultrasonography with a cystoscope for the biopsy of a deep-seated brain lesion: case study. Neurosurgery 1986;19(1):49–58.
[56] Otsuki T, Yoshimoto T, Jokura H, Katakura R. Stereotactic laser surgery for deep-seated brain tumors by open-system endoscopy. Stereotact Funct Neurosurg 1990;54–55:404–8.
[57] Zamorano L, Chavantes C, Moure F. Endoscopic stereotactic interventions in the treatment of brain lesions. Acta Neurochir Suppl (Wien) 1994;61:92–7.
[58] Cohen AR. Ventriculoscopic surgery. Clin Neurosurg 1994;41:546–62.
[59] Jallo GI, Morota N, Abbott R. Introduction of a second working portal for neuroendoscopy. A technical note. Pediatr Neurosurg 1996;24(2):56–60.
[60] Fries G, Perneczky A. Endoscope-assisted brain surgery: part 2—analysis of 380 procedures. Neurosurgery 1998;42(2):226–32.
[61] Cheng WY, Chang CS, Shen CC, Wang YC, Sun MH, Hsieh PP. Endoscope-assisted microsurgery for treatment of a suprasellar craniopharyngioma presenting precocious puberty. Pediatr Neurosurg 2001;34(5):247–51.
[62] Abdullah J, Caemaert J. Endoscopic management of craniopharyngiomas: a review of 3 cases. Minim Invasive Neurosurg 1995;38(2):79–84.
[63] Caemaert J, Abdullah J, Calliauw L. Endoscopic diagnosis and treatment of para- and intra-ventricular cystic lesions. Acta Neurochir Suppl (Wien) 1994;61:69–75.
[64] Zamorano L, Chavantes C, Dujovny M, Malik G, Ausman J. Stereotactic endoscopic interventions in cystic and intraventricular brain lesions. Acta Neurochir Suppl (Wien) 1992;54:69–76.
[65] Halves E, Bushe KA. Transsphenoidal operation on craniopharyngiomas with extrasellar extensions. The advantage of the operating endoscope [proceedings]. Acta Neurochir Suppl (Wien) 1979;28(2):362.
[66] Ferrer E, Santamarta D, Garcia-Fructuoso G, Caral L, Rumia J. Neuroendoscopic management of pineal region tumours. Acta Neurochir (Wien) 1997;139(1):12–21.
[67] Ellenbogen RG, Moores LE. Endoscopic management of a pineal and suprasellar germinoma with associated hydrocephalus: technical case report. Minim Invasive Neurosurg 1997;40(1):13–6.
[68] Haw C, Steinbok P. Ventriculoscope tract recurrence after endoscopic biopsy of pineal germinoma. Pediatr Neurosurg 2001;34(4):215–7.
[69] Liston SL, Siegel LG, Thienprasit P, Gregory R. Nasal endoscopes in hypophysectomy. J Neurosurg 1987;66(1):155.
[70] Gamea A, Fathi M, el-Guindy A. The use of the rigid endoscope in trans-sphenoidal pituitary surgery. J Laryngol Otol 1994;108(1):19–22.
[71] Rodziewicz GS, Kelley RT, Kellman RM, Smith MV. Transnasal endoscopic surgery of the pituitary gland: technical note. Neurosurgery 1996;39(1): 189–99.
[72] Jho HD, Carrau RL. Endoscopic endonasal transsphenoidal surgery: experience with 50 patients. J Neurosurg 1997;87(1):44–51.
[73] Heilman CB, Shucart WA, Rebeiz EE. Endoscopic sphenoidotomy approach to the sella. Neurosurgery 1997;41(3):602–7.
[74] Aust MR, McCaffrey TV, Atkinson J. Transnasal endoscopic approach to the sella turcica. Am J Rhinol 1998;12(4):283–7.
[75] Moreland DB, Diaz-Ordaz E, Czajka GA, Zugger CM. Endoscopic resection of pituitary lesions through the nostril. Semin Perioper Nurs 1998; 7(3):193–9.
[76] Moses RL, Keane WM, Andrews DW, Goel R, Simeone F. Endoscopic transseptal transsphenoidal hypophysectomy with three-dimensional intraoperative localization technology. Laryngoscope 1999;109(3):509–12.

[77] Shen CC, Wang YC, Hua WS, Chang CS, Sun MH. Endoscopic endonasal transsphenoidal surgery for pituitary tumors. Zhonghua Yi Xue Za Zhi (Taipei) 2000;63(4):301–10.
[78] Moreland DB, Diaz-Ordaz E, Czajka GA. Endoscopic endonasal hemisphenoidotomy for resection of pituitary lesions confined to the sella: report of 3 cases and technical note. Minim Invasive Neurosurg 2000;43(2):57–61.
[79] Jho HD. Endoscopic pituitary surgery. Pituitary 1999;2(2):139–54.
[80] Jarrahy R, Berci G, Shahinian HK. Assessment of the efficacy of endoscopy in pituitary adenoma resection. Arch Otolaryngol Head Neck Surg 2000;126(12):1487–90.
[81] Ogawa T, Matsumoto K, Nakashima T, Okano M, Ono Y, Fukushima K, et al. Hypophysis surgery with or without endoscopy. Auris Nasus Larynx 2001;28(2):143–9.
[82] Barone CM, Jimenez DF. Endoscopic craniectomy for early correction of craniosynostosis. Plast Reconstr Surg 1999;104(7):1965–75.
[83] Jimenez DF, Barone CM. Endoscopic craniectomy for early surgical correction of sagittal craniosynostosis. J Neurosurg 1998;88(1):77–81.
[84] Wang YC, Sun MH, Lin CW, Chen YJ. Anatomical location of T2–3 sympathetic trunk and Kuntz nerve determined by transthoracic endoscopy. J Neurosurg 2002;96(1 Suppl):68–72.
[85] Kim BY, Oh BS, Park YK, Jang WC, Suh HJ, Im YH. Microinvasive video-assisted thoracoscopic sympathicotomy for primary palmar hyperhidrosis. Am J Surg 2001;181(6):540–2.
[86] Wahlig JB Jr, Welch WC, Weigel TL, Luketich JD. Microinvasive transaxillary thoracoscopic sympathectomy: technical note. Neurosurgery 2000;46(5):1254–8.
[87] Vanaclocha V, Saiz-Sapena N, Panta F. Uniportal endoscopic superior thoracic sympathectomy. Neurosurgery 2000;46(4):924–8.
[88] Chung HY, Seo CG, Lee SG. Video endoscopic sympathectomy using a fiberoptic CO_2 laser to treat palmar hyperhidrosis. Neurosurgery 1993;32(2):327–9.
[89] Kao MC. Percutaneous radiofrequency upper thoracic sympathectomy. Neurosurgery 1997;40(1):216–7.
[90] Schaffer JL. Endoscopic discectomy. J Neurosurg 1994;81(6):965–6.
[91] Adamson TE. Microendoscopic posterior cervical laminoforaminotomy for unilateral radiculopathy: results of a new technique in 100 cases. J Neurosurg 2001;95(1 Suppl):51–7.
[92] Jho HD. Endoscopic transpedicular thoracic discectomy. J Neurosurg 1999;91(2 Suppl):151–6.
[93] Karahalios DG, Apostolides PJ, Vishteh AG, Dickman CA. Thoracoscopic spinal surgery. Treatment of thoracic instability. Neurosurg Clin North Am 1997;8(4):555–73.
[94] Frank E. Removal of a lateral disc herniation with malleable endoscopic forceps: technical note. Neurosurgery 1997;41(1):311–3.
[95] Onik G, Richardson D, Amaral J, Jennings W, Sholes A. Percutaneous anterior discectomy under ultrasound guidance. Minim Invasive Neurosurg 1995;38(2):90–5.