ENDOCOPY IN NEUROSURGERY
The DECQ Neuroendoscope

Philippe DECQ
Endoscopy in Neurosurgery

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1.0 History

The history of endoscopy in neurosurgery is closely related to the treatment of hydrocephalus. The first attempt at removing the choroid plexus to treat communicating hydrocephalus was not made by a neurosurgeon but rather by a courageous urological surgeon from Chicago, Victor Darwin Lespinasse (Fig. A), known more for his work on testicular transplantation. In 1910, Lespinasse cauterized the choroid plexus in two children with the aid of a pediatric cystoscope, and then described the technique in 1913 (Grant, 1996). In 1918, Walter Dandy (Fig. B) resumed this approach of plexectomy and used it on five patients (Dandy, 1918). In 1922, Dandy replaced the nasal speculum which he introduced into Monro’s foramen of the first four patients with an open Kelly cystoscope for his fifth patient (Dandy, 1922). On this occasion, he used the term “ventriculoscopy” for the first time. The results of the five operations were very frustrating, probably due to cortical collapse after ventricle drainage. To avoid this complication, twelve years later Putnam (Putnam 1934, 1935, 1943) followed by Scarf (Scarf, 1936, 1952, 1959) used the technique of electrocoagulation under irrigation. They reported positive results from this approach as did later Dereymaeker (Dereymaeker 1961) and Feld (Feld, 1956, 1957, 1958). This operation fell into disuse resulting from the preliminary implementation of various systems for CSF drainage in the treatment of communicating hydrocephalus.

It was again Dandy in 1922 who developed the approach of ventriculocisternostomy by perforating the floor of the third ventricle; he described four cases of obstructive hydrocephalus which he treated in this way (Dandy 1922). It was, however, Mixter (Fig. C) who performed this operation on February 6, 1923 using a ureteroscope under endoscopic guidance for the first time (Mixter, 1923). The poor quality of illumination and the size of the endoscope accounted for the fact, that only a few cases were published later (Mixter, 1923; Scarf, 1936; Dereymaeker, 1961).
In 1954, the work of Fourestier and Vulmière on light sources at the Optical Institute of Paris formed the basis for further developing the material of the endoscope and improved the light sources while reducing the size of the endoscope (Fourestier, 1954). The approach was adopted in which the light source was accommodated in a separate housing and offered a considerably higher level of light intensity that could be adjusted as required. This novel concept was an important step forward because instead of attaching the light source to the distal tip of the endoscope, the light was guided through a thin silicone rod into the endoscope (Diagram 1).

This technical improvement (that allows photographs and films to be made) was used by Guiot (Fig. D) to explore the possibilities of “modern” endoscopy in neurosurgery. In 1963, he described his experiences with endoscopy in ventriculocisternostomies, in puncturing colloid cysts, and in endoscope-assisted surgery of pituitary adenoma via the rhinoseptal access. He also studied the advantages and indications for biportal endoscopic access (Guiot, 1963). Gérard Guiot can therefore be justifiably viewed as a pioneer of neurosurgical endoscopy in its present form.

Diagram 1
The universal endoscope of Fourestier-Vulmière (Patent C.N.R.S.).
Fig. 0
Neuroendoscope with its three operating sheaths, blunt obturators, inner tube, HOPKINS® telescope and articulated arm.

Fig. 1
The core components of the DECO Neuroendoscope: the autoclavable HOPKINS® 2.9 mm-telescope with operating sheath and inner tube.

Diagram 2
HOPKINS® rod lens system.
2.0 The Neuroendoscope

2.1 High Quality Optical System

The HOPKINS® Rod Lens System
The quality of an endoscope is determined by the quality of its optical system. The HOPKINS® rod lens system makes it possible to obtain images with high resolution and optimum contrast with a wide field of vision (Diagram 2).

The Optical System of the Neuroendoscope
An autoclavable telescope (outer diameter 2.9 mm, length 30 cm) is the best compromise between the length required for neurosurgical procedures, the sterility requirements of this discipline (the material must be able to endure a minimum of 134° in an autoclave to prevent proliferation of Creutzfeld-Jacob disease), and a high-quality image (Figs. 0, 1).

30° Direction of view
The preferred neuroendoscope features a forward-oblique direction of view (30°) which, in comparison to the 0° telescope, allows a greater field of view to be obtained by on-axis rotation of the shaft (Diagram 3). The telescope therefore allows the ventricular compartments to be extensively inspected with even minimal on-axis rotation. Intraventricular navigation is not difficult with the 30° telescope, and it can be quickly mastered after a minimum of training.

Diagram 3
Vision obtained by on-axis rotation of the 30° telescope.
Rigid Endoscopes Versus Flexible Fiberscopes

In view of the present state of technical progress, a flexible scope cannot deliver endoscopic images at the same level of quality as a rigid HOPKINS® rod-lens telescope. Besides, the visually guided, highly accurate movements of endoscopes in neurosurgery must be performed under constant endoscopic visualization at the highest possible resolution that can only be provided by a rigid lens system. Intraventricular navigation is also very difficult with a fiberscope; the field of vision is reduced, and the pressure points of the system cannot be controlled when it is moved and deflected. A final argument is that, according to the present standards of practice dictated by law for the disinfection and sterilization of medical devices, application of flexible fiberscopes in neurosurgery is only validated for single use, which substantially limits their desirability.

2.2 Minimum Outer Diameter

Taking into account that the endoscope must be introduced through the brain to access the ventricular system, it must be used with an operating sheath that has the narrowest-possible outer diameter. Basically, the diameter of the endoscope is determined by the diameter of the telescope and by that of the surgical instruments (Diagram 4). The size of the instruments that are used for conventional indications for neurosurgery of the ventricles vary between 1 mm and 3 mm. To retain the smallest possible outer diameter and still be able to use the operating instruments, the shape of the operating sheath must be oval with a variable linear diameter that is solely a function of the instrument that is used. Another advantage is that the oval shape allows space between the telescope and the instrument, and the volume of the space is sufficient for irrigation. Dividing the endoscope into separate working channels is only possible if the outer diameter is enlarged.

Diagram 4
Principle of least volume. The operating sheath follows the form of the telescope and the outer diameter of the instruments. The remaining space is used for irrigation.
2.3 Adapted Length

Most indications for neurosurgical endoscopy include access through a dilated frontal horn of a dilated lateral ventricle. This is one of the simplest maneuvers in neurosurgery and may be performed manually without any particular difficulty. When the ventricular system is only moderately dilated, or if the axis of the selected access deviates from that of a normal coronal route, or if the access is for another site of the ventricular system, the endoscope must be guided either with a conventional stereotactic frame or another system of intracerebral navigation. The neuroendoscope therefore has a working length of 20 cm (Fig. 2), and this length is sufficient for adapting to the different stereotactic frames (Fig. 3) that differ by the height of the circle that bears the instrument. Furthermore, the operating sheath’s distal section is graduated over a length of 15 cm (Figs. 4a–c) which allows the intracranial and intracerebral penetration depth of the endoscope to be under constant control.

The distal section of the obturator is apertured to enable visually controlled advancement into the ventricular cavity. In this way, it is possible to visually confirm the presence of cerebrospinal fluid before entering the ventricular cavity.
2.4 Minimum Weight and Volume

The neuroendoscope is manufactured from a special alloy with a minimum thickness to reduce weight. The proximal part of the operating sheath has been reinforced, however, to deal with the force exerted by the connecting piece of the endoscope holder (Figs. 5–7).

Fig. 6
Only a portion of the operating sheath is reinforced to save as much weight as possible.

Fig. 7
Endoscope holder with articulated arm.
2.5 The Modular Design Endoscope

The neuroendoscope has three operating sheaths with different outer diameters (Figs. 8, 9) that allow the use of operating instruments with diameters of 1 mm (3 Fr), 1.7 mm (5 Fr) or 2.5 mm (8 Fr). The small operating sheath (3.5 /4.7 mm) is sufficient for a ventriculocisternostomy. The medium-sized operating sheath (3.5/5.2 mm) makes it possible to insert larger instruments – primarily biopsy forceps whose diameter is large enough to collect specimen for histopathological assessment. The largest operating sheath (4/7 mm) allows the introduction of yet larger surgical instruments, above all, suction catheters with a sufficient diameter to aspirate colloid cysts. Each operating sheath can be connected to the same inner tube (28160 GE) through which the instruments are introduced and to which the telescope is attached (Fig. 10). Depending on the clinical picture for which treatment is planned, the most appropriate operating sheath is selected.
Figs. 11a–f
The channels for the operating instruments are part of the working insert.
2.6 Several Working Channels for Surgical Instruments and Irrigation

Each operating sheath has an irrigation port with stopcock that allows inflow to be interrupted at any time, as desired (Fig. 12). The working insert has two channels for surgical instruments. Depending on the size of the operating sheath chosen for the procedure, one or even two instruments can be introduced (Figs. 11a–f). The simultaneous use of two instruments is restricted, however, by their coaxial position (Fig. 13).

Fig. 12
Each operating sheath has an irrigation port.

Fig. 13
Simultaneous use of two operating instruments.
The articulated arm of the endoscope holder is mounted prior to surgery.

The endoscope holder with its articulated arm allows the neuroendoscope, the video camera and the fiber optic light cable to be held in a particular position.

The assistant can readjust or lock the articulated arm corresponding to the surgeon’s requirements.

The neuroendoscope holder can be locked to interrupt the operation at any point, for instance, to explain the next steps of surgery.
2.7 Adjustable Endoscope Holder

It has proven very helpful to maintain or readjust the position of the neuroendoscope with the aid of an endoscope holder (Fig. 14). The reinforced proximal part of the operating sheath is attached to the connecting piece of the holder. The position of the neuroendoscope can be adjusted or locked by turning a central screw that loosens or tightens the pivot joints of the arm (Figs. 15a, b). This simple mechanism prevents the arm from executing gross movements and allows the necessary fine-tuning of neuroendoscopic maneuvers. The ability to lock the neuroendoscope holder in any desired position prevents inadvertent movements during various maneuvers, above all while introducing an instrument (Fig. 16). Immobilizing the neuroendoscope with the articulated arm eliminates the need for manually holding the endoscope when problems arise (for example, when it is difficult to localize specific anatomical landmarks), and it helps avoid physical fatigue during long operations which can impair decision-making and can give rise to improper movements (Fig. 17).

3.0 Operating Instruments

The instruments are available in three sizes depending on which operating sheath is used.

3.1 Coagulation Electrodes

Unipolar coagulation electrodes are available in three different shapes, specially designed for their purpose: Atraumatic tips, that are more suited for perforating membranes than for coagulation (Fig. 18), a rounded, standard tip for any type of coagulation (Fig. 19, 27), and spatula-shaped tips for dissecting and coagulating the cyst surface (Fig. 20).

These electrodes have a color-coded proximal end which indicates the surgeon when the distal tip is about to exit the operating sheath at the surgical site; the color changes when the electrode tip reaches the operating field (Fig. 21).
Fig. 22
Three different sizes of biopsy forceps that are used depending on the selected operating sheath.

Fig. 23
Biopsy forceps.

Figs. 24 and 25
Biopsy taken from an epiphyseal metastatic lesion (the size of the specimen along with the magnification property of the telescope allow it to be identified).

Fig. 26
Grasping forceps.

Fig. 27
Coagulating electrode.
3.2 Biopsy Forceps

It is very important to pay attention to the size of the biopsy forceps (Figs. 22, 23) since it determines the volume of the excised biopsy to be investigated by the pathologist. Specimens that are too small can lead to diagnostic uncertainty; on the other hand, the risk of subsequent bleeding increases in proportion to the size of the forceps. These factors must be taken into consideration before an operating sheath is selected (and hence the size of the biopsy forceps) (Figs. 24, 25).

3.3 Grasping Forceps

Long, thin grasping forceps are indispensable operating instruments for dissection (Fig. 26). They can be used for a ventriculocisternostomy or for enlargement of the created cavity.

3.4 Microscissors

The microscissors, suitable for endoscopic surgery have fine, pointed tips (Fig. 28). They are primarily used to open walls of arachnoid or colloid cysts (Fig. 29).

3.5 Puncture Needles and Suction Cannulas

The puncture needles have very sharp tips and are essential in puncturing colloid cysts (Fig. 30). The transparent catheter allows to keep control of puncture and aspiration. The sharp tip allows the needles to be used as a scalpel as long as care is taken to never damage a vessel. Given proper use, suction cannulas are less dangerous (Fig. 31) and can completely drain a colloid cyst once the cyst wall has been opened. Frequently, the largest operating sheath is needed for insertion of large suction cannulas because the contents of colloid cysts are usually very viscous.
Fig. 32
The articulated arm of the endoscope holder is installed.

Fig. 33
Operating room set-up for a ventriculocisternostomy. The head is slightly bent.

Figs. 34a–c
An extension is placed next to the head to hold the articulated arm. The articulated arm is fixed to the head support.
4.0 The Operating Technique: Access via the Anterior Horn of the Lateral Ventricle

Most operations that involve the use of a neuroendoscope are conducted via the anterior horn of the lateral ventricle to access the foramen of Monro.

Patient Positioning
The patient is placed in a dorsal position, and the head is bent slightly by approximately 30° (Fig. 33). An extension is attached to the operating table close to the head (Figs. 34a–c) for fixation of the endoscope holder’s articulated arm (Fig. 32).

Opening the Skull
The skin incision is made in the precoronal region (Figs. 35a, b). The entry site is located just anterior to the coronal suture (Figs. 36a, b). The size of the trephination opening must be tailored to avoid iatrogenic damage to cortical veins following dura mater opening (Figs. 37a, b).

Figs. 35a, b
Drawing of the precoronal incision.

Figs. 36a, b
Trephination of the skull.

Figs. 37a, b
The trephination opening is large enough to avoid iatrogenic damage to cortical veins while introducing the neuroendoscope.
Inserting the Neuroendoscope

The operating sheath with the obturator, held by the adjustable articulated arm, is manually inserted into the lateral ventricle (Figs. 41a, b) while monitoring the depth by the graduation on the operating sheath. The operating sheath is securely fixed in place by the articulated arm so that the neuroendoscope can be safely inserted. The obturator (Fig. 38) is removed, and the inner tube is mounted (Figs. 39a, b). The telescope, to which the fiber optic light cable (Figs. 40a, b) and the video camera (Fig. 42) are connected, is then introduced in the operating sheath of the neuroendoscope. The encountered structures are identified first before the articulated arm is screwed off, and the neuroendoscope is further introduced or handled by manual control. The articulated arm can be moved by the assistant or again screwed tight (Figs. 15, 16) according to the needs of the operation. It is easy to rotate the neuroendoscope; one only has to get used to rotating the video camera into a new position each time to not loose orientation during the maneuver.
Wound Closure

A tight wound closure is essential to avoid any problems from liquor fistulas during the postoperative phase. As soon as the endoscope is withdrawn, the cortical defect is filled with a small piece of Surgicel® (Figs. 43, 44). The trephination opening is filled up with bone dust (Figs. 45a, b). The skin is then sutured in a conventional manner (Fig. 46).
5.0 Using the Neuroendoscope under Stereotactic Guidance

Most neuroendoscopic indications include access through a dilated anterior horn of the lateral ventricle. This is a simple neurosurgical maneuver that can be carried out manually without any particular difficulties. However, if the ventricular system is only moderately dilated and if the axis of the selected access deviates from that of a normal coronal access, and if in particular another section of the ventricular system is affected, the neuroendoscope must be inserted toward the predefined target site with the aid of a stereotactic frame or another method of navigation.

It is easy to use the neuroendoscope with a stereotactic frame. The operating sheath is advanced through the stereotactic frame towards the target area (Figs. 47, 48). The neuroendoscope is then easily mounted since the expansion of the system is very limited (Fig. 49). The neuroendoscope which is still held by the frame is then grasped by the articulated arm (Fig. 50).

Figs. 47, 48
The operating sheath is inserted with the aid of the stereotactic frame.

Fig. 49
The neuroendoscope is in the correct position.

Fig. 50
The articulated arm is brought close and attached to the operating sheath.
As soon as the specific anatomical landmarks are clearly visible, the stereotactic frame can be removed (Fig. 51) since the neuroendoscope is held fast by the articulated arm. The operation can be continued with the usual maneuverability and safety offered by the neuroendoscope holder with articulated arm (Fig. 52).
6.0 Indications

The indications for neuroendoscopy are derived from the clinical picture of the ventricles and subarachnoid cavities. The use of an endoscope on the cerebral level assumes that the ventricular systems are dilated. The spinal subarachnoid cavities are accessible with a rigid endoscope. The indications for endoscopy on a spinal level are yet to be defined. The primary indication for neuroendoscopy is a ventriculocisternostomy in the treatment of non-communicating hydrocephalus (Tab. 1). The other indications for which endoscopy is useful are limited at present to the treatment of colloid cysts and the marsupialization of arachnoid cysts. Finally, endoscopy allows biopsies to be taken of intraventricular processes after a ventriculocisternostomy.

6.1 General Rules

Navigation of the neuroendoscope inside the ventricular system requires slow and gentle movements. Since the field of vision is monocular, a slow approach can provide information on the depth of the traversed area. Monro’s foramen and the third ventricle are small structures that can only be observed at slow pace. The instruments are introduced sequentially, and one has to wait until the previous instrument is removed before the next instrument can be inserted into the operation sheath. This is the reason why the articulated arm is used to allow the surgeon time to carefully execute every single step of the procedure. It is possible to simultaneously use two operating instruments (depending on which operating sheath is selected; this cannot be done when the smallest one is used); however, this procedure is very limited since the two instruments are inserted coaxially. When a slight amount of pressure is exerted on the tip of a coagulation electrode, the action of two simultaneously-used instruments can be optimized. In general, however, the neuroendoscope only permits effective use of a single operating instrument.

6.2 Contribution of Neuroradiology

Magnetic resonance imaging is a very important indication for neuroendoscopy, and it greatly assists in monitoring results. More than morphological data (essential in and of themselves), CSF flow analysis MR imaging sequences are instrumental for interpreting the results. The most used sequence analyses the rostral-caudal flow within a sagittal midsection (Fig. 53). The data are usually measured in an interval between two R waves or two QRS complexes in the ECG.

The kinetic curve of the liquor shows a systolic peak in the caudal direction that arises approximately after 30% of an R-R interval and that is followed by a diastolic peak in the rostral direction. An important factor is the perfect synchronization of the liquor flow between the ventricular paths (sylvian aqueduct and the fourth ventricle) and the subarachnoid cavities that are distributed around the brain and the medulla. The slightest loss of synchronization indicates an occlusion of the ventricular paths and allows conclusions to be drawn regarding the communication or absence of communication between the paths. The kinetic study of the CSF flow also allows a morphological picture to be obtained of the flow through a ventriculocisternostomy.
6.3 Ventriculocisternostomy

In our experience, ventriculocisternostomies represent 74% of the cases in which neuroendoscopy is indicated. In 1992 – 1993, ventriculocisternostomies represented 19% of cases in which surgical treatment of hydrocephalus were indicated. In 1996 – 1997, this percentage had risen to 34%. In our experience, ventriculocisternostomies are suggested for one third of cases of hydrocephalus requiring surgical treatment. This somewhat high percentage is probably related to our referrals since our interest in endoscopy is well-known. In general, one can assume that ventriculocisternostomies will be suggested for approximately 20% of adult patients with hydrocephalus.

6.3.1 Indications

Ventriculocisternostomies make it possible to reestablish the liquor flow between dilated, obstructed ventricles of the brain and the prepontine subarachnoid space by creating an opening in the anterior aspect of the floor of the third ventricle. For this to be carried out, the obstruction must be located beyond this structure, i.e., either in the area of the posterior third ventricle, or near the pineal region, the Sylvian aqueduct, the fourth ventricle, or Magendie’s foramen (Diagram 5). In all of these cases, a ventriculocisternostomy is given preference over the placement of a liquor shunt.

Diagram 5
Schematic drawing of cerebral ventricles, with the passage of the neuro-endoscope through the ventriculocisternostomy.
6.3.2 Technique

Access to the Third Ventricle
The access is a precoronal craniotomy as described above. The dilated Monro’s foramen is identified. The posterior margin is defined by the choroid plexuses that are easily identified. Anteriorly, it is delineated by the anterior pillar of the fornix. At its posterior-internal angle, the choroid, thalamostriate and septal veins converge (Fig. 54). The neuroendoscope is then advanced into the third ventricle. The two elevated mamillary bodies can be localized without difficulty; in front of them is the thinnest part of the floor of the third ventricle where the fenestration can be made (Fig. 55). At times, the trunk of the basilar artery can be visualized endoscopically due to the transillumination effect. Further anteriorly, the infundibular recess with its pink-colored adjacent structures, is delineated by the optic chiasm.

6.3.3 Performing Ventriculocisternostomy

The floor is penetrated with the aid of a blunt-tipped coagulation electrode. The use of this electrosurgical instrument is recommended because of its atraumatic properties that allow coagulation to be performed at the lowest possible energy output. Precautions must be taken to prevent, that the floor of the third ventricle, i.e., the hypothalamus, be exposed to iatrogenic thermal effects caused by conduction of heat from the site of electrocoagulation. The initial mechanical perforation of the floor of the third ventricle can also be made with grasping forceps (Fig. 56). The opening is then dilated with the grasping forceps (Fig. 57). Occasionally, a single or double balloon catheter must be used to create a sufficiently large opening. Once the stoma is complete, it should be approached to view the dura mater of the clivus and the trunk of the basilar artery (Fig. 58).
The stoma can only be assessed adequately when the aforementioned anatomical landmarks can be visualized (Fig. 59). Not infrequently, a second membrane is found when the opening is approached (Liliequist’s membrane); this membrane can impede the straight flow of cerebrospinal fluid and even account for a secondary obstruction of the ventriculocisternostomy (Fig. 60). We have discovered such a membrane in approximately one-third of cases and believe that it should always be opened to yield a positive result (Fig. 61). Ventriculocisternostomy is a simple and effective operation. We feel that it is dangerous to replace it with other operations, such as shunt placement which is associated with greater risk primarily to functional ocular motility, with the added drawback of leaving foreign material in the brain.

6.3.4 Endoscopic Inspection of the Third Ventricle

As soon as the ventriculocisternostomy is complete, the operation is paused. Care must be taken to avoid any inadvertent, surgically inappropriate off-axis deflection of the endoscope to prevent iatrogenic damage to adjacent structures, particularly in the immediate circumference of the foramen of Monro. It is important to maintain this principle because it is sometimes found to be difficult not to become captivated by the endoscopic images of the ventricles. It is, however, possible to visualize the posterior third ventricle by on-axis rotation of the neuroendoscope given the 30° telescope (Fig. 62). Viewing this region also allows the occlusion to be closely inspected and its precise nature to be determined. The interthalamic commissure can vary largely in size and may even be absent in cases of severe hydrocephalus.

Fig. 59
The dura mater of the clivus, the basilar artery and a few of its branches can be clearly seen through the opening of the ventriculocisternostomy.

Fig. 60
A second membrane, Liliequist’s membrane, is sometimes visible through the opening of the ventriculocisternostomy.

Fig. 62
View of the posterior portion of the third ventricle obtained by on-axis rotation of the 30°-telescope: The floor of the ventricle is on the top, the roof is on the bottom. From top to bottom: the choroid plexus of the roof, the interthalamic commissure, the whitish elevation of the posterior commissure, and the stenotic Sylvian aqueduct.

Fig. 61
Liliequist’s membrane must also be punctured for ventriculocisternostomy to adequately drain the liquor.
6.3.5 Intraoperative Biopsy Sampling

Once the ventriculocisternostomy is complete, the next step may involve collecting a biopsy sample. This is feasible as long as the lesion is located along the longitudinal axis of the endoscope (anterior horn of the lateral ventricle, adjacent structures of Monro’s foramen, anterior third ventricle) (Figs. 63, 64). Accordingly, biopsy sampling can be difficult to achieve in the presence of tumors of the pineal region. Biopsy sampling of an epiphyseal tumor during a ventriculocisternostomy is only feasible if the tumor has invaded the lumen of the third ventricle and the level of the interthalamic commissure (Figs. 65, 66). If the tumor is located more posteriorly, there is an incompatibility between the axis of the operating sheath for the ventriculocisternostomy and the axis leading to the target site of biopsy sampling, with the exception of anatomical variations; normally the anatomical structures that border Monro’s foramen can be damaged. Generally, a ventriculocisternostomy and an intervention at the level of or in the Sylvian aqueduct cannot be performed simultaneously during the same transcerebral operation.

6.4 Treatment of Colloid Cysts

If the colloid cysts are located at Monro’s foramen, they are usually amenable to an endoscopic approach (Fig. 67). Even though endoscopic neurosurgical treatment is still controversial, it still should be suggested as the therapy of first choice. The axis of the approach is only slightly different from that of a ventriculocisternostomy since it is directed primarily toward the base of the cysts that are located precisely posterior to the foramen of Monro. The neuroendoscope is hence introduced slightly more anteriorly and in a somewhat more lateral direction.
The distinct cyst capsule is first coagulated (Fig. 68), and then the cyst is punctured with an aspiration needle (Fig. 69). Aspiration is more or less easy and depends on the viscosity of the colloid material. To facilitate drainage of the cyst content, the opening in the cyst wall can be enlarged with the microscissors (Fig. 70). It is then very easy to insert a suction cannula into the cyst. If the contents are rather solid, the cyst can be removed as a whole by aspiration instead of grasping it with the grasping forceps or a biopsy forceps which frequently cannot find a sufficient grip. The entire visible cyst wall is then carefully coagulated (Fig. 71). Finally, only a remainder of the coagulated cyst wall is left that communicates over a wide area with the lumen of the third ventricle. In some cases, the cysts present marked posterior extent and displace the median structures toward the lumen of the lateral ventricle and Monro’s foramen to the front (Fig. 72). In these cases, the cyst can be partially drained by puncturing the posterior, most projecting aspect (Fig. 73), and exposing the foramen of Monro through which the operation can be continued (Fig. 74).
6.5 Marsupialization of Arachnoid Cysts

Arachnoid cysts are of rare occurrence and do not always have a symptomatic course. They can grow until they impair the normal CSF flow (as is the case with other suprasellar cysts) or compress the adjacent neurological structures (such as temporal cysts). The marsupialization of these cysts into the ventricular system or into the subarachnoidal cavities can ideally be managed with the endoscopic technique (Fig. 75). The cyst walls are opened with an aspiration needle or microscissors (Fig. 76), and then dilated because they shrink as a result of coagulation (Fig. 77). If the natural valve function is affected by the pathogenesis, it is important to open the cyst as much as possible. The cysts usually directly contact large vessels – the trunk of the basilar artery for suprasellar cysts and the medial cerebral artery for temporal cysts.

Fig. 75 View of the base of a temporal arachnoid cyst. Through the transparent cyst, one of the oculomotor nerves and the origin of the medial cerebral artery can be seen.

Fig. 76 After coagulation, the wall of the arachnoid cyst is opened with microscissors.

Fig. 77 At the end of the operation, the cyst has been opened far into the basal cistern.
## Recommended Literature

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2. **DANDY, WE.**
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3. **DECQ, P., YEPES, C., ANNO, Y., DJINDJIAN, M., NGUYEN, JP., KERAVEZ, Y.**
   L’endoscopic neurochirurgicale. Indications diagnostiques et thérapeutiques.

4. **DECQ, P., BRUGIERES, P., DJINDJIAN, M., KERAVEZ, Y., NGUYEN, JP.**
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6. **DEREYMAEKER, A., VANDENBERGH, R., STROOBANDT, G.**
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7. **FELD, M.**
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8. **FELD, M.**
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9. **FOURESTIER, M., GLADU, VULMIERE, J.**
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10. **GUIOT, G., DEROME, P., HERTZOG, E., BAMBERGER, C., AKERMAN, M.**
    Ventriculocisternostomie sous contrôle radioscopique pour hydrocéphale obstructive.
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14. **PUTNAM, TJ.**
    Results of treatment of hydrocephalus by endoscopic coagulation of choroid plexus.
    Arch Pediat 1935, 52:676–85

15. **PUTNAM, TJ.**
    Surgical treatment of infantile hydrocephalus.
    Surg Gyn Obst 1943, 76:171–8

16. **PUTNAM, TJ.**
    Treatment of hydrocephalus by endoscopic coagulation of choroid plexus: Description of new instrument and preliminary report of results.

17. **SCARFF, JE.**
    Endoscopic treatment of hydrocephalus: Description of ventriculoscope and preliminary report of cases.
    Arch Neurol Psychiat 1936, 38:853–61

18. **SCARFF, JE.**
    Nonobstructive hydrocephalus. Treatment by endoscopic cauterization of choroid plexus.
    Long term results.
    J Neurosurg 1952, 9:164–76

19. **SCARFF, JE.**
    Treatment of nonobstructive (communicating) hydrocephalus by cauterization of the choroid plexus.
    Long term follow-up.
The DECQ Neuroendoscope

HOPKINS® Forward-Oblique Telescope 30°, diameter 2.9 mm, length 30 cm, autoclavable
Inner tube 28160 GE for use with operating sheath 28160 G/GK/GM

Operating Sheath 28160 GK, small size, oval
Outer Diameter 3.5 mm x 4.7 mm

Flexible Operating Instruments:

- 28160 ZJ Biopsy Forceps, double action jaws, flexible, diameter 1 mm, working length 30 cm
- 28160 TJ Grasping Forceps, double action jaws, flexible, diameter 1 mm, working length 30 cm
- 28160 TV Ventriculostomy Forceps, flexible, diameter 1 mm, working length 30 cm
- 28160 SE Suction Catheter, flexible, for single use, diameter 1 mm, working length 45 cm
- 28160 KA Ball Electrode, unipolar, flexible, diameter 1 mm, working length 53 cm
- 28160 KS Spatula-shaped Electrode, unipolar, flexible, diameter 1 mm, working length 53 cm

It is recommended to check the suitability of the product for the intended procedure prior to use.
Operating Sheath 28160 GM, medium size, oval
Outer Diameter 3.5 mm x 5.2 mm

28160 GM Operating Sheath, medium size, oval, O. D. 3.5 mm x 5.2 mm, working length 14 cm, with blunt obturator, with stopcock, for use with operating instruments, size 1.7 mm in conjunction with inner tube 28160 GE

28160 GML Optical Obturator for 28160 GM, with channel for use with operating sheath 28160 GM

Flexible Operating Instruments:
- 28160 EK Scissors, single action jaws, semirigid, diameter 1.3 mm, working length 34 cm
- 28162 FL Biopsy Forceps, double action jaws, semirigid, diameter 1.3 mm, working length 30 cm
- 28162 FK Grasping Forceps, double action jaws, semirigid, diameter 1.3 mm, working length 30 cm
- 28160 SB Suction Catheter, flexible, for single use, diameter 1.7 mm, working length 45 cm
- 28160 KC Ball Electrode, unipolar, flexible, diameter 1.7 mm, working length 53 cm
- 28160 KM Bipolar Coagulation Electrode, semi-rigid, O.D. 1.3 mm, working length 35 cm

Operating Sheath 28160 G, large size, oval
Outer Diameter 4 x 7 mm

28160 G Operating Sheath, large size, oval, O. D. 4 mm x 7 mm, working length 14 cm, with blunt obturator, with stopcock, for use with operating instruments, size 2.5 mm in conjunction with inner tube 28160 GE

28160 GL Optical Obturator for 28160 G, with channel for use with operating sheath 28160 G

Flexible Operating Instruments:
- 28160 ZG Biopsy Forceps, double action jaws, flexible, diameter 2.3 mm, working length 40 cm
- 28160 TG Grasping Forceps, double action jaws, flexible, diameter 2.3 mm, working length 40 cm
- 28160 SF Suction Catheter, flexible, for single use, diameter 2.5 mm, working length 45 cm
- 28160 KD Bipolar Coagulating Electrode, flexible, diameter 2.0 mm, working length 35 cm
Endoscopy in Neurosurgery – The DECQ Neuroendoscope

**Neuro-Fiberscope, 2.5 mm**

*Working length 40 cm, Outer Diameter 2.8 mm, steerable*

Movements of the distal tip:
- up: 170°
- down: 120°
- Angle of view: 90°

**Application Range – Indications**

- For direct examination of all cerebral ventricles from caudal to cranial or vice versa including passage of the normally dilated cerebral aqueduct offering the possibility of manipulations such as biopsy, ventriculostomy and septostomy
- Endoscopy of the subdural and subarachnoid region
- Endoscopy of the spinal canal combined with the opportunity for operative manipulations, e. g. extradural, intradural-extradurally, but also particularly for the treatment of a cystic intramedullary process such as syringomyelia
- Very suitable for endoscopic-assisted micro-neurosurgery in narrow spaces of the cerebral ventricles

**11161 C1 Neuro-Fiberscope, steerable**

- working channel
- outer diameter: 1.2 mm
- bending: 170°/120°
- direction of view: 0°
- angle of view: 90°
- working length: 40 cm
- total length: 70 cm
- outer diameter: 2.8 mm

**Following accessories are included:**
- 27677 BB Case
- 11025 E Pressure Compensation Cap
- 13242 XL Leakage Tester
- 27651 AK Cleaning Brush
Endoscope Holder
for Fixation of Flexible and Rigid Endoscopes

28272 RKB  **Holding System**, autoclavable, including:
- **Rotation Socket**
  to clamp on the operating table, for use with European and United States standard rails, with lateral clamping element for height and angle adjustment of the articulated stand
- **Articulated Stand**, reinforced version, L-shaped, with one mechanical central clamp for all five joint functions, height 48 cm, operating range 52 cm
- **Clamping Jaw**, metal, with axial intake, for use with instrument and telescope sheaths, clamping range 4.8 up to 12.5 mm
IMAGE1 S Camera System

Economical and future-proof
- Modular concept for flexible, rigid and 3D endoscopy as well as new technologies
- Forward and backward compatibility with video endoscopes and FULL HD camera heads
- Sustainable investment
- Compatible with all light sources

Innovative Design
- Dashboard: Complete overview with intuitive menu guidance
- Live menu: User-friendly and customizable
- Intelligent icons: Graphic representation changes when settings of connected devices or the entire system are adjusted
- Automatic light source control
- Side-by-side view: Parallel display of standard image and the Visualization mode
- Multiple source control: IMAGE1 S allows the simultaneous display, processing and documentation of image information from two connected image sources, e.g., for hybrid operations

Dashboard

Live menu

Intelligent icons

Side-by-side view: Parallel display of standard image and Visualization mode
IMAGE1 S Camera System

Brilliant Imaging
- Clear and razor-sharp endoscopic images in FULL HD
- Natural color rendition

- Reflection is minimized
- Multiple IMAGE1 S technologies for homogeneous illumination, contrast enhancement and color shifting

FULL HD image

FULL HD image

FULL HD image

FULL HD image

FULL HD image

FULL HD image

SPECTRA A*

SPECTRA B**

* SPECTRA A: Not for sale in the U.S.
** SPECTRA B: Not for sale in the U.S.
TC 200EN

**IMAGE1 S CONNECT**, connect module, for use with up to 3 link modules, resolution 1920 x 1080 pixels, with integrated KARL STORZ-SCB and digital Image Processing Module, power supply 100–120 VAC/200–240 VAC, 50/60 Hz including:
- **Mains Cord**, length 300 cm
- **DVI-D Connecting Cable**, length 300 cm
- **SCB Connecting Cable**, length 100 cm
- **USB Flash Drive**, 32 GB, USB silicone keyboard, with touchpad, US

*Available in the following languages:* DE, ES, FR, IT, PT, RU

**Specifications:**

<table>
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<tr>
<th>Feature</th>
<th>Specification</th>
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<td>HD video outputs</td>
<td>- 2x DVI-D &lt;br&gt; - 1x 3G-SDI</td>
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<td>Format signal outputs</td>
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<td>LINK video inputs</td>
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<td>SCB interface</td>
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**TC 300**

**IMAGE1 S H3-LINK**, link module, for use with IMAGE1 FULL HD three-chip camera heads, power supply 100–120 VAC/200–240 VAC, 50/60 Hz, **for use with IMAGE1 S CONNECT TC 200EN** including:
- **Mains Cord**, length 300 cm
- **Link Cable**, length 20 cm

**Specifications:**

<table>
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* **SPECTRA A**: Not for sale in the U.S.  
** **SPECTRA B**: Not for sale in the U.S.
For use with IMAGE1 S Camera System
IMAGE1 S CONNECT Module TC 200EN, IMAGE1 S H3-LINK Module TC 300
and with all IMAGE1 HUB™ HD Camera Control Units

### Specifications:

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<th>IMAGE1 FULL HD Camera Heads</th>
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<td>standard eyepiece adaptor</td>
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### Specifications:

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<tr>
<td>Min. sensitivity</td>
<td>F 1.4/1.17 Lux</td>
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<tr>
<td>Grip mechanism</td>
<td>standard eyepiece adaptor</td>
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<tr>
<td>Cable</td>
<td>non-detachable</td>
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<tr>
<td>Cable length</td>
<td>300 cm</td>
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Monitors

9619 NB

19” HD Monitor, color systems PAL/NTSC, max. screen resolution 1280 x 1024, image format 4:3, power supply 100–240 VAC, 50/60 Hz, wall-mounted with VESA 100 adaption, including:
External 24 VDC Power Supply
Mains Cord

9826 NB

26” FULL HD Monitor, wall-mounted with VESA 100 adaption, color systems PAL/NTSC, max. screen resolution 1920 x 1080, image format 16:9, power supply 100–240 VAC, 50/60 Hz including:
External 24 VDC Power Supply
Mains Cord
Monitors

### KARL STORZ HD and FULL HD Monitors

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<th>Product no.</th>
<th>19&quot;</th>
<th>26&quot;</th>
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<td>Wall-mounted with VESA 100 adaption</td>
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<td>9826 NB</td>
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#### Inputs:

- **DVI-D**: ● ● ●
- **Fibre Optic**: – – –
- **3G-SDI**: – ● ●
- **RGBS (VGA)**: ● ● ●
- **S-Video**: ● ● ●
- **Composite/FFBAS**: ● ● ●

#### Outputs:

- **DVI-D**: ● ● ●
- **S-Video**: ● – –
- **Composite/FFBAS**: ● ● ●
- **RGBS (VGA)**: ● – –
- **3G-SDI**: – ● ●

#### Signal Format Display:

- **4:3**: ● ● ●
- **5:4**: ● ● ●
- **16:9**: ● ● ●
- **Picture-in-Picture**: ● ● ●
- **PAL/NTSC compatible**: ● ● ●

#### Optional accessories:

- **9826 SF**  **Pedestal**, for monitor 9826 NB
- **9626 SF**  **Pedestal**, for monitor 9619 NB

### Specifications:

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Fiber Optic Light Cables
for Cold Light Fountains

- **495 NA**
  - Fiber Optic Light Cable,
  - with straight connector, diameter 3.5 mm, length 230 cm

- **495 NB**
  - Same, size 4.8 mm, length 180 cm

- **495 NCS**
  - Same, size 4.8 mm, length 250 cm

Cold Light Fountain XENON 300 SCB

- **20133101-1**
  - Cold Light Fountain XENON 300 SCB
  - with built-in antifog air-pump, and integrated KARL STORZ Communication Bus System SCB
  - power supply: 100–125 VAC/220–240 VAC, 50/60 Hz
  - including:
    - Mains Cord
    - Silicone Tubing Set, autoclavable, length 250 cm
    - SCB Connecting Cord, length 100 cm

- **20133027**
  - Spare Lamp Module XENON
  - with heat sink, 300 watt, 15 volt

- **20133028**
  - XENON Spare Lamp, only, 300 watt, 15 volt

Cold Light Fountain XENON NOVA® 300

- **20134001**
  - Cold Light Fountain XENON NOVA® 300,
  - power supply: 100–125 VAC/220–240 VAC, 50/60 Hz
  - including:
    - Mains Cord

- **20133028**
  - XENON Spare Lamp, only, 300 watt, 15 volt
Data Management and Documentation
KARL STORZ AIDA® – Exceptional documentation

The name AIDA stands for the comprehensive implementation of all documentation requirements arising in surgical procedures: A tailored solution that flexibly adapts to the needs of every specialty and thereby allows for the greatest degree of customization.

This customization is achieved in accordance with existing clinical standards to guarantee a reliable and safe solution. Proven functionalities merge with the latest trends and developments in medicine to create a fully new documentation experience – AIDA.

AIDA seamlessly integrates into existing infrastructures and exchanges data with other systems using common standard interfaces.

WD 200-XX*
AIDA Documentation System, for recording still images and videos, dual channel up to FULL HD, 2D/3D, power supply 100–240 VAC, 50/60 Hz including:
USB Silicone Keyboard, with touchpad
ACC Connecting Cable
DVI Connecting Cable, length 200 cm
HDMI-DVI Cable, length 200 cm
Mains Cord, length 300 cm

WD 250-XX*
AIDA Documentation System, for recording still images and videos, dual channel up to FULL HD, 2D/3D, including SmartScreen® (touch screen), power supply 100–240 VAC, 50/60 Hz including:
USB Silicone Keyboard, with touchpad
ACC Connecting Cable
DVI Connecting Cable, length 200 cm
HDMI-DVI Cable, length 200 cm
Mains Cord, length 300 cm

*XX Please indicate the relevant country code (DE, EN, ES, FR, IT, PT, RU) when placing your order.
Equipment Cart

**Equipment Cart**
wide, high, rides on 4 antistatic dual wheels equipped with locking brakes 3 shelves, mains switch on top cover, central beam with integrated electrical subdistributors with 12 sockets, holder for power supplies, potential earth connectors and cable winding on the outside,

*Dimensions:*

- **Equipment cart:** 830 x 1474 x 730 mm (w x h x d),
- **Shelf:** 630 x 510 mm (w x d),
- **Caster diameter:** 150 mm

*Including:

- **Base module equipment cart,** wide
- **Cover equipment,** equipment cart wide
- **Beam package equipment,** equipment cart high
- **3x Shelf,** wide
- **Drawer unit with lock,** wide
- **2x Equipment rail,** long
- **Camera holder**

---

**Monitor Swivel Arm,**
height and side adjustable, can be turned to the left or the right side, swivel range 180°, overhang 780 mm, overhang from centre 1170 mm, load capacity max. 15 kg, with monitor fixation VESA 5/100, for usage with equipment carts UG xxx
Recommended Accessories for Equipment Cart

**Isolation Transformer**, 
200 V–240 V; 2000 VA with 3 special mains socket, expulsion fuses, 3 grounding plugs, dimensions: 330 x 90 x 495 mm (w x h x d), for usage with equipment carts UG xxx

**Earth Leakage Monitor**, 
200 V–240 V, for mounting at equipment cart, control panel dimensions: 44 x 80 x 29 mm (w x h x d), for usage with isolation transformer UG 310

**Monitor Holding Arm**, 
height adjustable, inclinable, mountable on left or right, turning radius approx. 320°, overhang 530 mm, load capacity max. 15 kg, monitor fixation VESA 75/100, for usage with equipment carts UG xxx

Please note that the described products in this medium may not be available yet in all countries due to different regulatory requirements.