Neuroendoscope in Aneurysm Surgeries: Past, Present and Future

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ABSTRACT

Even with the use of most sophisticated microscope sometimes the relationship between the aneurysm and the adjacent structures are not clearly defined. The straight line of view by microscope results in inadequate visualization of structures that lie immediately behind other structures like the neck, branches or perforators of the aneurysm. Hence exposure of these structures may require risky retraction either of the parent artery or the aneurysm itself, which can be overcome by clear anatomical information obtained by the use of endoscope instead of attempting extensive manipulation under the microscope. The endoscope permits close up, wide angled views of regional anatomic features and verification of the optimal clip position. Visual conformation of regional anatomy achieved using the rigid endoscope provides valuable information for subsequent microsurgical procedures and enhances the safety and reliability. Endoscopic-assisted microsurgery is an exceptional aid and using the PIP (picture-in picture) technology, simultaneous observation of microscope and endoscopic images can be viewed through the ocular system of microscope. The advantages of neuroendoscope include the ability to look around corners and behind obstructions. With less brain retraction, smaller operative exposures and better visualization, neuroendoscopy may reduce operative morbidity. However the surgeon should be familiar with this technique and be prepared for the inconveniences and risks during the procedure.

Key-words: Neuroendoscope, endoscope assisted microsurgery (EAM)

SUMÁRIO

A neuroendoscopia reflete a tendência da neurocirurgia moderna em buscar acessos mínimos, ou seja, acessar e visualizar lesões através de corredores o menor possível e com máxima efetividade ao objetivo, com mínima alteração do tecido normal. Embora o primeiro procedimento endoscópico intracraniano tenha sido realizado no início do século 20, esta técnica tornou-se popular entre os neurocirurgiões somente nos anos recentes, após o refinamento dos endoscópios e de seus instrumentos.

Mesmo com o uso de microscópios sofisticados, as vezes as relações entre os aneurismas e as estruturas vizinhas não é claramente definida. A visão reta oferecida pelo microscópio resulta em visualização inadequada de estruturas que se colocam imediatamente atrás, como o colo, ramos ou perfurantes do aneurisma. Assim, a exposição destas estruturas pode requerer retrações de risco para a artéria aferente ou o próprio aneurisma, o que pode ser superado por uma clara informação anatômica obtida com o endoscópio, ao invés de uma eventual manipulação extensa com o microscópio. O endoscópio permite “close-up”, amplas e anguladas observações das características anatômicas e verificação do posicionamento ótimo do clipe. A conformação visual da anatomia regional obtida com o uso do endoscópio rígido oferece aiosa informação para subsequentes procedimentos microcirúrgicos, aumentando a segurança e a confiabilidade. Microscopia assistida por endoscopia é um auxílio excepcional, e o uso de tecnologia PIP (quadro a quadro), permite a observação simultânea das imagens no microscópio e no endoscópio, através da ocular do microscópio. As vantagens da neuroendoscopia incluem a habilidade de olhar em volta de ângulos e atrás de obstáculos. Com menos retração cerebral, menores abordagens e melhor visualização, a neuroendoscopia pretende reduzir a morbidade operatoria. Para tal, o neurocirurgião deve estar familiarizado com a técnica e preparado para os inconvenientes e riscos do procedimento.

Palavras-chave: Neuroendoscopia, microcirurgia assistida por endoscopia.
INTRODUCTION

Results in treating cerebral aneurysms have dramatically improved since the introduction of microscopic surgery. Still, the morbidity and mortality rates in surgically treated aneurysms are considerably high. Constriction and occlusion of perforating branches peripheral to aneurysms caused by surgery is accounted as one of the major cause. In some situations, retraction of the parent artery or the aneurysmal dome may be required for identifying the perforating branch in clipping the aneurysm which can lead to damaged vascular flow, arterial injury, and rupture of the aneurysm. The neuroendoscope is a useful tool as an adjunct to microsurgical clipping of these aneurysms. It improves visualization of regional anatomy because of its ability in magnification, illumination and looking around blind corners, thus enhancing the safety and reliability of aneurysm surgery.1,5.

HISTORICAL PERSPECTIVE

The first neurosurgical endoscopic procedure was performed by V L’Espinasse6 in 1910, in which he had used a small rigid endoscope to coagulate the choroids plexus of hydrocephalic infant. Dandy in 1922 coined the term ventriculoscope7 and is also known as the ‘Father of Neuroendoscope’. While Mixter8 had described the first successful ETV procedure in 1923, Fukushima9 had introduced his ‘Ventriculofiberscope’ in 1973. The term ‘endoscope assisted microneurosurgery’ was coined by Hopf and Perneczky10, who had made major contributions in the field of neuroendoscopy. Since then there has been an increasing use of endoscopy in neurosurgery. Fischer and Mustufa11 had described their preliminary experience with the use of endoscope guidance during aneurysm surgery, while Perneczky and Fries elaborated general principles and guidelines for use of endoscope12,13.

RATIONALE FOR ENDOSCOPIC APPLICATION IN ANEURYSM SURGERY

The evolution of neurosurgical techniques indicates the effort to reduce surgery-related traumatization of patients which contributes to better postoperative outcomes. Given the most sophisticated microsurgical techniques, the visualization of important structures is still not adequate in many cases. Henceforth arises the need for retraction of brain parenchyma, vascular and neural structures or the aneurysm itself. Sometimes even the clip may have to be retracted to confirm its relative position to nearby structures.2,4,12. Recent advances in neuroendoscopic techniques have lead to their increased popularity not only for use in intraventricular procedures, but also for their complementary use during microneurosurgery.

BASIS FOR THE USE OF ENDOSCOPE

The goal of surgical management of intracranial aneurysms is to exclude the aneurysm from the circulation while preserving the parent artery and its branches along with the perforators and avoiding damage to the adjacent brain parenchyma and cranial nerves. The subarachnoid space around the lesion provides room for the endoscope introduction, while the air is an ideal intervening material between lens and target that provides excellent endoscopic viewing. The endoscope is maximally effective when used within an air or clear fluid filled cavity.

ENDOSCOPIC EQUIPMENTS

Highly advanced optical equipment enables endoscopic surgery to be performed in neurosurgery. Recent advances in supportive equipments have enhanced the safety and convenience of these procedures. The illumination can be provided by a neon light source. The endoscope can be attached to a 3 chip camera, and the images viewed on a video monitor. The 0 degree endoscope has a sufficiently straight view and ‘fish eye effect’, but this view can be achieved by the microscope alone. Thus 30, 70 or 110 degree scopes can be used for inspecting around the blind corners.25,14,15. In most of the cases, 4 mm endoscope with a 30/70 degree viewing angle can be preferred. The scope can either be handheld or fixed to a holding device to facilitate bimanual surgery. The disadvantages of holding devices are that they are bulky, cause obstruction in the operative field and increase risk of movement near the aneurysm, making it prone to rupture. Immobilization of scope is unnecessary except for clipping or during dissection of ‘blind’ microscopic corners. The potential advantages of angled lenses to visualize around blind corridors without retracting have proven to be an attractive feature. The limitation of endoscopy has been the inability to obtain a true three-dimensional perspective for which microscopy is ideal. Hence for complex cases the merger of the two technologies would prove to be ideal, which can be provided by the ‘image fusion technology’.12,16. It provides enough visualization not only for inspection but for performing surgeries as well. Aneurysms and surrounding anatomic structures can also be depicted by ‘virtual endoscopy’ in three dimensions with interactive fly-through views.17. This method can improve visualization of the aneurysm as well as increase surgical orientation. It can be very helpful to the surgeons and may reduce post-surgical complications.
TYPES OF ENDOSCOPES

The recent revival of interest in endoscopy can be attributed to the introduction of rigid rod lens scopes. They have been increasingly used during aneurysm surgery in which structures around the aneurysm can be detected with high quality imaging. After an initial exposure achieved with microscope, the rigid endoscope can be introduced to conform the regional anatomy, including the aneurysm neck and adjacent structures. Post clipping, the position of clip and surrounding structures can be inspected using endoscope.\(^4,14,15\). They are less flexible than fiberscope, and therefore require a viewing angle for surgical procedures, but have the advantage in that they provide high image quality, and make bimanual procedures possible provided an anchoring device is used. Flexible endoscopes, on the other hand have the advantage of steerability, although the image resolution is not as high as with rigid lens scopes\(^2\). Another disadvantage is of keeping them in a constant position.

TYPES OF ENDOSCOPIC SURGERY

The surgeries can be classified into ‘endoscopic surgery’ conducted under endoscopic visualization, and ‘endoscope-assisted microsurgery’ (EAM) in which the endoscope is used to assist microscopic imaging. Fischer et al\(^1\) reported the first study on application of the endoscope in aneurysms surgery in which structure around the aneurysm were detectable during fiberscope-assisted aneurysm surgery, contributing to reduced time for temporary clipping. Two methods can be employed wherein bimanual surgical manipulations can be performed utilizing both microscopic and endoscopic screens, with the endoscope fixed with a fixing device; and wherein the endoscope can be introduced before/after clipping, and without exerting excess pressure on brain tissue, cranial nerves, cerebral blood vessels or cerebral aneurysms; conditions surrounding the aneurysms can be observed and whether clipping is complete can be verified\(^1\).

Endoscope-assisted microsurgery, like all routine microsurgical procedures, is performed with both hands; the endoscope is fixed in its desired position via a mechanical arm to the headholder. Because of their superior optical quality and maneuverability, only rigid lens scopes are used for endoscope-assisted brain microsurgery. There are five ways of observing the endoscopic and microscopic images at the same time\(^12,13\):

1) Observation of the microscopic image through the oculars of the microscope and observation of the endoscopic image on a video screen placed in front of the surgeon,

2) Observation of the microscopic image through the oculars of the microscope and display of the endoscopic image on a head-mounted LCD screen,

3) Projection of both microscopic and endoscopic images on one screen in a picture-in-picture mode,

4) Projection of both microscopic and endoscopic images into specially designed microscope oculars, and

5) Transmission of both microscopic and endoscopic images into a head-mounted LCD screen.

Endoscope assisted surgery is used to inspect hidden corners, dissect perforators at the back on aneurysm, identify important vessels without retraction of either the aneurysm or arteries and access for completeness of clipping. It enables the surgeon to develop a mental 3D image of the aneurysm and its surrounding structures. Intra-operative problems such as undue retraction of aneurysm or extensive dissection of surrounding structures for observation of regional anatomical features which are persistent during use of microscope can be avoided by use of endoscope-assisted microsurgery.

ADVANTAGES AND RATIONALE FOR USE OF EAM\(^1,2,12\)

Higher magnification
Better observation
Additional illumination
Increased overview
Can ‘look around corners’
Extended viewing angles
Provides a ‘second prospective’
Short period of temporary clipping
Excellent visual quality in deep narrow fields

INTRA-CRANIAL ANEURYSMS SURGERY

With all the sophisticated procedures involved in microneurosurgery, the management of aneurysms, with preservation of perforators and surrounding vital structures during preparation and clipping of the aneurysm neck is still risky in certain instances (Fig 1). The endoscope can carry out a supportive role in planning surgical maneuvers and in verifying whether clipping has been performed correctly or not. When a pterional approach is carried out assisted by a microscope, the posterior communicating artery and anterior choroidal arteries are in the blind spot of the internal carotid artery. In these cases, retraction of the internal carotid artery or dome of the aneurysm is often required during the clipping procedure. The neuroendoscopic inspection can also provide detailed information concerning the course and origin of perforating vessels in ICA-poster-
rior communicating artery aneurysms, ICA- Anterior choroidal artery aneurysms, aneurysm anatomy such as neck position relative to the fibrous ring in ICA- ophthalmic artery aneurysms, Basilar artery aneurysms, as well as the extent of distal end of vertebral artery aneurysms. For anterior circulation aneurysms, it also provides additional information regarding the clinoidal segment, IC 2-3 segment, IC infundibular dilatation and IC-PC medial projections in case of large and giant sized aneurysms, along with the ACA perforators, posteriorly projecting AComA and early bifurcation MCA aneurysms. The period of temporary occlusion of the parent artery can also be significantly reduced as the dissection can be facilitated by the use of endoscope. Since the internal carotid artery is present in the carotid cistern which has sufficient space for insertion, used of the endoscope is relatively safe.

Figure 1 - Illustrative case of a 72 y female, who presented with grade II SAH. MRA/CTA revealed ruptured Basilar Tip aneurysm. Microscopic view images showing the aneurysm pre and post clipping. It's difficult to see the hidden adjoining vessels without undue retraction or manipulation.

During the use of endoscope in surgical treatment of posterior circulation aneurysms, tiny perforators or deeper lesions are better visualized with better illumination and magnification of endoscope. Though basilar bifurcation aneurysms are located at very shallow depths, inserting the endoscope toward the posterior cranial fossa, sufficiently enables without dissection of the tentorium cerebelli, detection of not only of the perforating branches from the basilar artery, posterior cerebral artery, superior cerebellar artery, basilar artery trunk and the oculomotor nerve (Fig 2), but also detection of contralateral V, VII/VIII complex and the flocculus. The concealed areas are identified without retraction, which prevents the possibility of the aneurysm being ruptured and also reduces the use of temporary clipping. From its earlier use as a supportive measure in surgeries for routine aneurysms, the endoscope has now become almost indispensable for almost all the cases, including the large and giant ones. Relatively clear visual fields can be obtained in the case of unruptured aneurysms, while frequent irrigation can be required for clear fields in subarachnoid bleeding cases, due to soiling of the endoscope tip.

Figure 2 - Endoscopic view images of the same patient, beautifully demonstrating the Basilar Tip aneurysm along with Posterior cerebral artery, superior cerebellar artery and the Third nerve. Note should be made of the bleb (arrow) which can be missed during the microscopic view.

STAGES IN SURGERY WHERE NEUROENDOSCOPE CAN BE USED

I) After craniotomy and exposure, the endoscope can be introduced in the surgical field near the area of interest. An initial view of the aneurysm and its surrounding structures can be obtained for assessment of regional anatomic features before extensive manipulation of the lesion.

II) After exposing and dissecting the aneurysm, it can be used to view the micro anatomy of the aneurysm including the perforators. Areas poorly visualized by the microscope include the back wall of the aneurysm and perforating arteries or their tiny branches.

III) After application of the temporary clip, it can again be used to obtain information on the relationship of the aneurysm to the parent vessel, its branches and perforators and adjacent cranial nerves. Sometimes the endoscope can be of significant help in reducing the timing of temporary clipping of the parent artery.

IV) Post clipping, it can be used to confirm the completeness of neck obliteration, clip position, inadvertent inclusion of the parent vessel in clip, sparing of the perforators and pressure on the surrounding vital brain parenchyma or cranial nerves.
USEFULNESS OF NEUROENDOSCOPE\textsuperscript{1,2,12}

Observation of anatomical features, branches and perforators
Observation of clip position
Observation of air sinus
For clip readjustment
Relief of neural compression
Reduction of duration of dissection and temporary clipping

PATIENT SELECTION CRITERIA

Although the endoscope can be used in all types of aneurysm surgeries, a clear operative field is a pre requisite to endoscopic surgery. Un-ruptured aneurysms or associated ruptured aneurysms after absorption of SAH are ideal cases for the use of endoscope.

CONCERNS ABOUT USE OF ENDOSCOPE

Endoscopic surgery requires special training and experience. The highly magnified and distorted view can be difficult in reconstructing with 3D anatomy. There is an inadvert risk of aneurysm rupture, trauma to nearby vessels, local injury like cerebral contusion to the surrounding structures or inherent risk of infection. There has been a report of transient oculomotor nerve palsy caused by antifogging liquid\textsuperscript{14}. The authors had experienced a case where the screw of the endoscopic holder got loose, resulting in tear of the vessel wall by the tip of scope and it required suturing, but did not influence the outcome of surgery.

CAUTION

Use endoscope close to the aneurysm (rather than distal viewing) and only after proximal temporary occlusion especially in ruptured cases\textsuperscript{2}.

DRAWBACKS\textsuperscript{1,3}

Rupture of unsecured aneurysms
3D view not possible
Steep learning curve
Bloody operative field (needs constant cleaning of lens)
Bimanual surgery is impeded with handheld scopes

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Drawing of Nitze’s first cystoscope. The light source, a platinum filament lamp, was situated at the terminal end of the endoscope. A water-cooling system was included. (From Jackson C. Bronchoscopy and Esophagoscopy: A Manual of Peroral Endoscopy and Laryngeal Surgery. WB Saunders, 1922.)