Anterior Communicating Artery Aneurysms: microsurgical clipping and pitfalls. An overview

Aneurismas da Artéria Comunicante Anterior: clipagem microcirúrgica e armadilhas. Visão geral

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ABSTRACT
The authors reviewed the technical details of microsurgical clipping of non ruptured anterior communicating artery aneurysms. Details of the dissection are emphasized as well as the main indications. Discussion of anatomical aspects and landmarks were developed and the endovascular treatment was also concerned in this overview. The microsurgery of brain anterior communicating aneurysms remains a challenge and all efforts to keep the knowledge and concepts of microsurgical approach ought to be preserved, being the main goal of this article.

Keywords: Anterior communicating cerebral artery aneurysm; Microsurgical clipping; Endovascular treatment; Flow divert; Anterior communicating artery

RESUMO
Os autores revisaram os detalhes técnicos da clipagem microcirúrgica de aneurismas da artéria comunicante anterior não rotos. Os detalhes da dissecção são enfatizados, bem como as principais indicações. A discussão dos aspectos anatômicos foi desenvolvida e do tratamento endovascular também foram abordados nesta visão geral. A microcirurgia de aneurismas cerebrais continua sendo um desafio e todos os esforços para manter o conhecimento e os conceitos da abordagem microcirúrgica devem ser preservados, sendo este o objetivo principal deste artigo.

Palavras-chave: Aneurisma da artéria comunicante anterior; Clipagem microcirúrgica; Tratamento endovascular; Diversor de fluxo; Artéria comunicante anterior
INTRODUCTION

Certainly anterior communicating artery (ACoA) aneurysms are the most common intracranial aneurysms. They comprise 23-40% of all intracranial aneurysms. Due to their anatomical and hemodynamic stress characteristics they have a high risk of rupture1-3.

The ACoA aneurysms seem to be the most complex aneurysm to be treated by means of microsurgical clipping in the anterior circulation, because nowadays the paraclinoid aneurysms, the most complex in the past, are in the majority treated by means of endovascular procedures. The techniques involve the opening of Sylvian fissure and the anterior cerebral artery in the first segment A1, bilaterally it must be exposed as well as the second segment A2 bilaterally. In the middle, the anterior communicating segment is found and the Heubner recurrent artery showing an H shape of arteries in the surgical view. The anterior cerebral artery and its branches must be identified in the dissection in order to exposure the feeding of aneurysm placed in communicating segment in order to accomplish the complete occlusion of aneurysm by clipping4,5. For many years microsurgical clipping was the single treatment, however in the last decade the endovascular procedures are occupying an important space in the treatment.

The authors show the surgical technique as well as discuss and analyze the microsurgical anatomy. The aspects of aneurysm shape, blister and lenticle striated position are reviewed.

ANATOMICAL CONSIDERATIONS

Yasargil proposed in many articles that a anterior communicating aneurysm shall arise from the side of the ACoA that receives the largest A1 segment, or from the midle segment of the ACoA when the bilateral A1 are equal in diameter1,2,6. Yasargil also classified the projections of ACoA aneurysms as anterior, superior, posterior, inferior and complex8-12.

The ACoA is a small and short arterial vessel that links the two anterior cerebral arteries. It is localized just above the optic chiasm and it is connected to the door of the lamina terminalis1. Many authors10-13 classified ACoA in two groups according to anatomical complexity. Therefore, ACoA connects to the A1 segment of the both anterior cerebral artery. As a rule, the minority of trunks is single1. The complex type frequently comprises 2 branches, the Y, H or X types, as well as fenestration deformity, or the diple or “O” type, accounting for the majority of trunk types. Moreover, in many anatomical specimens the A1 segment of the bilateral anterior cerebral arteries might be single, showing the absence of ACoA, which comprises of around 4.5% of trunk types1. The anatomical variation index for ACoA is quite high, over 60%4. Serizawa et al.14, 1997, classified the types and frequency as plexiform in 33%, diple in 33%, and at last as fenestration variation in 21%14. Misdiagnosed aneurysm has been related to angiotomography images which reconstruction 3D may show an image of aneurysm4,15. International Study of Unruptured Intracranial Aneurysms Investigators16 advocated that digital subtraction angiography must be performed in the diagnostic hypothesis of anterior communicating artery aneurysm in order to avoid the misdiagnosis4. The knowledge of anatomical variations must be taken into concern previously to the surgery during the surgical preoperative plan even for placement of temporary clipping17. Also the 3D print study of the anterior cerebral artery may be very useful17,18.

SURGICAL TECHNIQUE

The surgical planning must be performed by means of angiogram through digital images, MRI or digital 3D angiogram in order to identify the side of main feeding or the strongest flow (Figures 1, 2, 10, 18). Angio CT is also important to understand the bone relation to the arterial vessels.

Nowadays there are 3 types of main approaches: anterior approach by minimal invasive frontal supraciliary or minifrontal craniotomy19,20 (Figures 3, 4, 5, 6, 7, 8A, 8B, 9) or key hole access by subfrontal approach3; lateroanterior approach by pterional craniotomy22; and anterior interhemispheric approach by bifrontal craniotomy23. Recently, the International Study of Unruptured Intracranial Aneurysms Investigators group24 has described an endoscopic endonasal approach for ACoA aneurysm clipping24,25 what we consider unnecessary due to so much risk.

The patient is placed in horizontal dorsal position using a head fix holder under general anesthesia (Figure 19), intratracheal
intubation, with the head lightly turned laterally, in 5 degrees and deflected 5 degrees. Many departments have been using intraoperative neurophysiological monitoring with evoked potential (sensitive and motor) in order to identify irritability or loss of motor curve. In this condition the repositioning of the clip must be considered in a fast decision. Asepsis and antisepsis must be performed, with iodine or chlorhexidine, and sterilized surgical fields must also be placed. Sterile drape must be positioned over

Figure 1. Case 1-52 year-old woman with a non ruptured anterior communicating artery aneurysm. Anterior posterior image of digital angiography that shows an anterior communicating artery cerebral artery aneurysm fed by left A1 and large neck. Courtesy from Professor Paulo Henrique Pires de Aguiar.

Figure 2. Case 1-Sagittal image of digital angiography that shows an anterior communicating artery cerebral artery aneurysm fed by left A1. Courtesy from Professor Paulo Henrique Pires de Aguiar.

Figure 3. Case 1-Minifrontal cupraciliar craniotomy for minimal invasive approach to anterior communicating artery aneurysm (taken from with permission the archives of Professor Paulo Henrique Pires de Aguiar).

Figure 4. Case 1-Surgical microscopical view showing the sub frontal drainage of cerebrospinal fluid (CSF) in the olfactory cistern as necessary for cerebral relaxing in this minimal invasive approach. Courtesy from Professor Paulo Henrique Pires de Aguiar.
the marked incision, as role for anterior cerebral artery aneurysm or ACoA an arched anterior incision or curvilinear (Figure 19). In the minimal approach a 3 cm craniotomy is placed just above the eyebrows (Figure 3). The craniotomy is performed with only 1 hole and the craniotome completes an oval craniotomy. The dura-mater is opened in arch turned down and with a blade the frontal lobe is pushed up and the chiasmatic cistern and optic cistern can be achieved and CSF can be drained (Figures 3-8A). It is very easy to access the A1 segment and A2 for this approach and the neck also may be rapidly dissected. The clipping is placed in a narrow surgical window (Figures 8B, and 9).

In the pterional craniotomy the skin is pulled by means of surgical hooks, and the temporal fascia is exposed. Interfacial dissection is accomplished in order to preserve the facial nerve. The temporal muscle is cut in the temporal line, anterior to the stephanium and posterior, as well as dissected until the peristium with a rongeur, and then pulled back with surgical hooks. A craniotomy centered in the pterion must be performed with 3 holes, one in the frontotemporo zygomatic junction as the key hole, and another posterior 3.5 cm hole in the temporal bone in conjunction with a frontal hole behind the temporal line. It is very important to understand that the stephanium limits the inferior frontal gyrus, and the junction of the coronary suture with the squamous suture in the point related to the largest point of the Sylvian fissure in the inferior Rolandic point (Figures 19, 20, 21, 22). The holes are done with high speed drill and the connections among the holes through a craniotome. In each hole we must separate the bone of the dura-mater using a dissector, preferably a Penfield number 4. The dura-mater must be anchored by means of 4 border sutures with prolene 4-0, and then opened with a triangle shaped scalpel number 11 or 16 turned down. Posteriorly it should be held by a mononylon 4-0 suture in the inner surface of temporal muscle. In this moment the surgical microscope is introduced to continue the surgery. The sphenoid wing must be drilled with...
diamond burr in a high speed drill. Constant irrigation has to be done during the whole procedure. The Sylvian fissure has to be opened with a sharp dissection, normally with insulin tip needle or scalpel number 11 in the largest point of the Sylvian fissure, as a role below to opercular gyrus. It is important to perform a cerebral spinal fluid drainage through the dissection, in order to relax the encephalon. The Sylvian veins can be allocated to the temporal side, and must be preserved during the dissection. It is easier to identify the branches of M2 first, and then, follow the branches to the limen of insula where generally this trunk is divided between M1 and M2. We go on dissecting along the middle cerebral artery till the internal carotid bifurcation where we can find the A1 segment of anterior communicating artery (Figures 11, 12, 13, 14).

We must open the optic carotid cistern in order to drain CSF and relax the brain as well as the Sylvian cistern.

The optic nerve bilaterally can be viewed and the contralateral A1. In this point is necessary to consider the angiography regarding the orientation of the aneurysmatic domus. If turned up in the interhemispheric cistern, if turned back which lies on the lamina terminalis membrane, if turned anteriorly also in interhemispheric cistern or at last turned down to skull base. The shape and the size need to be analyzed before, because the domus and neck may involve the parental arteries A1 unilaterally or bilaterally. Following the dissection, the recurrent artery of Heubner can be observed leaving A1 in the majority of cases or in the minority A2. In order to view the neck completely hidden by the rectum gyrus (Figures 15, 16, 17, 22, 23, 24, 25) we need to coagulate and suck the gyrus and after that we are almost ready to clip.

Normally we approach the aneurysm by the side of main feeding of aneurysm visible on the angiogram except if visible a gyrus rectum hematoma, and in this case we approach by the side of hematoma. It is also necessary to find and dissect bilaterally the A2 segment (Figures 23, 24). Then in the field it is possible to identify an H arterial formation and the aneurysm is in the middle.

Temporary clips may be useful in giant, multilobulated and ruptured aneurysms. We prefer to avoid them based on the risk of ischemia if the duration of the clipping be excessive.

We use normally titanium clips, straighted or curved, multiples to reconstruct the neck avoiding A1 or A2 occlusion (Figure 25).
The surgery in this point needs to be checked using Indocianine Green (ICG) injected intravenously by the anesthesiologist or specialized practitioner (Figure 26). This technique verifies if the clipping was adequate or not and is assisted by IONM investigation. Any change in evoked potential must be responded with repositioning of the surgical clip.

The osteosynthesis is performed with 3 miniplates and 9 miniscrews as well as the temporal muscle is reconnection to its insertion with mononylon 3-0 vascular needle suture. Subcutaneous or subgaleal drainage is not used in this procedure. The aponeurotic galea is closed using monocryl 3-0 vascular needle separated sutures. The skin is closed and sutured with 4-0 mononylon. At last compressive bandage is done. The patient is then awakened after the removal of head fix and later taken to intensive care unit.
Additional care must be taken when facing blister aneurysms or multilobulated aneurysms as intraoperative rupture is not uncommon.

**DISCUSSION**

There are two options of treatment of anterior communicating artery aneurysm: endovascular treatment and microsurgical clipping.

The majority of anterior communicating artery aneurysms have been clipped for many years but in the last two decades, with the development of more efficient flow diverters and coils, aneurysms were also treated with endovascular procedures with relatively similar risks and patient outcomes. Remodeling is also a useful technique for specific category of aneurysms, and in other specific cases Onyx embolization was shown to be still effective and presents good outcomes.

Ruptured anterior communicating artery aneurysm regarding the best approach and surgical treatment is not thoroughly discussed in this article. Although the majority of the centers seem to treat ruptured aneurysms in acute phase by means of endovascular therapeutic as preconized by Connolly et al.28, 2012.
If in an elective surgery of anterior communicating cerebral artery aneurysm a multilobar domus is found, it is necessary to be understood that the best choice is still controversial, given that treatment is as difficult for endovascular procedures as for surgical clipping. The choice of intraoperative transitory clipping must be taken into concern and often considered a challenge to avoid.

Pterional craniotomy is considered to be the Gold Standard for many centers. Although the mini craniotomies and key-hole approaches seem to have relatively high effectiveness and good outcomes, due to the low risk of facial nerve damage during the dissection of temporal fascia, beyond any doubt the endonasal endoscopic approach to such aneurysm comprises risks despite of papers have been published in such topic. We are completely against this technique because it is not possible to obtain the proximal and distal control just in case of intraoperative rupture.

We use to open the lamina terminalis and it seems to be useful in CSF drainage during the surgery to relax the brain and also imperative in surgery of ruptured aneurysms of this region.

Figure 18. Case 3-Anterior posterior digital angiography showing a non ruptured multilobulated aneurysm in a 53 year-old woman. Courtesy from Professor Paulo Henrique Pires de Aguiar.

Figure 19. Case 3-Head position with 5 grade angle rotation and 5 grade angle deflection. Anterior curvilinear incision is marked. Courtesy from Professor Paulo Henrique Pires de Aguiar.

Figure 20. Generic case-Dissected temporal muscle in a single plane. It must be pulled by means of multiple surgical hooks, exposing of the pterium. Courtesy from Professor Paulo Henrique Pires de Aguiar.

Figure 21. Case 3-We can use 3 to 4 burrholes for the craniotomy or only one using a high speed drill craniotome. Oval shaped craniotomy (oval black line) and drilling the sphenoid wing is the surgical routine. Courtesy from Professor Paulo Henrique Pires de Aguiar.
Microsurgical clipping in elderly patients ought to be considered because of increased rate of comorbidities and probable worst post-operative outcomes\textsuperscript{17,18}.

The development of 3D printed models and virtual reality reconstruction can be a pathway for better surgical planning\textsuperscript{17,18}.

Anterior communicating cerebral artery aneurysms with size less than 3 mm can be observed, notably in elder population\textsuperscript{30}. Although endovascular treatment has shown to be an option for this group if the aneurysm is bigger than 3 mm, the patient is using antiplatelet and anticoagulants.
The coagulation and suction of rectum gyrus is useful only for aneurysm with the domus turned up and anterior in interhemispheric cistern hidden by it. The need of identification of the anatomical H is also imperative for the ACoA to control the feeding in an eventual bleeding. The perforating branches can be damaged by the clip during microsurgical dissection if the domus is turned back or to the lamina terminalis, this way it is necessary to have so much care with it and the dissection and clipping shall be meticulous and not so fast.

The main complications associated with surgical treatment are ischemia in the cerebral artery region and occlusion of their perforating branches due to cognitive disturbances and motor deficits, mainly in ruptured clipped aneurysms. Intraoperative aneurysmal rupture and infection can be listed as possible risks of this kind of surgery. The control of blood pressure by the anesthesiologist is correlated to lower rupture rate, and ICG and evoked potential might identify earlier the need of rearrangement or repositioning of the clip.

REFERENCES


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