

Microsurgery for the Aneurysms of the Basilar Artery Apex

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Rezumat

Microchirurgia anevrismelor apexului bazilar

Aneurismele apexului arterei bazilare (AAB) nu sunt frecvente. Experiența mea se bazează pe operarea, în clinica II Neurochirurgie Vasculară din București, în perioada 1979-2010, a 3340 pacienți cu aneurisme cerebrale. La 234 (7%) dintre ei aneurismele au fost situate la nivelul circulației posterioare. La 146, adică la 4,37% din totalul bolnavilor cu aneurisme cerebrale și la 62.39% din pacienții cu aneurisme localizate la nivelul circulației posterioare, aneurismele au fost de apex bazilar. Vârsta media a celor 146 bolnavi cu aneurisme ale apexului arterei bazilare (AAB) a fost de 45,2 ani cu extreme de 34 și 71 de ani. Cele mai multe cazuri (69 - 47,26%) s-au situat în grupa de vârstă de 41-50 de ani. În privința sexului 68 (46,57%) aneurismele au fost descoperite la bărbați iar 78 (53,42%) la femei, fapt care sugerează o lejeră predominanță feminină. Motivul internării bolnavilor a fost în principal hemoragia subarahnoidiană. Patru bolnavi au prezentat în decursul a trei luni dinaintea operației trei episoade de hemoragie subarahnoidiană. Perioada de timp scursă de la ultima hemoragie subarahnoidiană până la internarea în spital a fost în medie de 26 de zile, cu extreme de 1 și 62 zile. La internare, trei bolnavi au avut o stare generală și neurologică proastă (grad Hunt IV și V). Evaluarea diagnostică a acestor pacienți am început-o cu examenul

tomodensitometric urmat de angiografia cerebrală pe cele patru vase. Dificultățile tratamentului chirurgical al acestor leziuni se datorează anatomiei vasculare complexe a apexului arterei bazilare, rapoartelor directe a acestor aneurisme cu baza craniului și cu structurile neurale vitale din jurul fosei inter-pedunculare, precum și dificultăților de obținere a controlului lor proximal. Evoluția postoperatorie a fost excelentă și bună la 131 (89,72% din pacienți), în timp ce 8 pacienți (5,48%) au evoluat nesatisfăcător, iar 8 (5,48%) au decedat. Trei din cei 8 pacienți cu evoluție nesatisfăcătoare au prezentat hemibalism drept și pareză de nerv III, iar alți trei au rămas în stare vegetativă. Postoperator la 10 (6.8%) bolnavi s-a dezvoltat hidrocefalie.

Cuvinte cheie: aneurisme intracraniene, apexul arterei bazilare, tratament chirurgical

Abstract

The aneurysms of the Basilar Artery apex (ABA) are not very common. My personal experience derives from having performed surgery on a number of 3340 patients with cerebral aneurysms at the Department of Vascular Neurosurgery II in Bucharest between 1979 and 2010. In 234 (7%) of the aneurysms they were located in the posterior vasculature. In 146 patients, representing 4.37% of the total number of patients with cerebral aneurysms and 62.39% of those with aneurysms of posterior vasculature, the location was in the basilar artery apex. The mean age of the 146 patients with aneurysms of the basilar artery apex (ABA) was 45.2 years, varying between 34 and 71 years old. Most cases (69 -47.26%) were in the 41-50 years age group. Aneurysms were found in 68 males (46.57%) and 78 females (53.42%) suggesting a slight

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predominance in female patients. The main reason for hospitalization was subarachnoid haemorrhage. There were four reports of patients having three episodes of subarachnoid bleeding in the three months preceding the surgery. The mean time between the last subarachnoid bleeding and the hospital admission was 26 days, ranging between 1 and 62 days. On admission three patients were in a severe general and neurological state (Hunt IV and V, respectively). The diagnostic assessment for those patients started with computer tomography (CT) followed by brain angiogram for the four main vessels. The main challenges for the surgical treatment of such lesions are due to the complex vascular anatomy of the basilar artery apex, to the direct vicinity of these aneurysms with the base of the skull and with vital neural structures in the interpeduncular fossa as well as due to difficulties in gaining proximal control over them. The post-surgical evolution was excellent and good in 131 (89.72%) of patients, unsatisfactory in 8 patients (5.48%), while 8 patients (5.48%) died. Three of the 8 patients marked by an unsatisfactory evolution presented with right-side hemiballismus and paresis of the 3rd cranial nerve, while other three remained in a vegetative state. Post-operative hydrocephaly was reported in 10 patients (6.8%).

Key words: intracranial aneurysms, basilar artery apex, surgical treatment

Introduction

The aneurysms of the basilar artery apex (ABA) are less common. Prior to the sixties neurosurgeons used to avoid performing such surgery (1) since surgical interventions were marked by significant mortality and morbidity rates. Drake (2,3,4,5) performed a detailed assessment of ABA surgery in multiple publications.

Therefore, the 1990 review of Peerless and Drake (6)

described 545 patients treated with adequate results noted in 475 (87%). The main challenges for the surgical treatment of such lesions are due to the complex vascular anatomy of the basilar artery apex, due to the direct vicinity of such aneurysms with the base of the skull and with vital neural structures in the interpeduncular fossa as well as due to difficulties in gaining proximal control over them.

In spite of improved endovascular techniques, the results of which are less dependent of aneurysm location but still depend on their morphology, surgery still plays a key role in treating these patients since it yields better results than the natural history (7,8,9,10).

Several surgical approaches can be used in ABA surgery, but neither one can be deemed as convenient given their wide variability.

Material and method

Out of the total 3340 patients with cerebral aneurysms on which dr. Dănăilă performed surgery throughout 30 years (1979 - 2010), as part of the Department of Vascular Neurosurgery in Bucharest, in 234 (7%) patients the aneurysms were located in the posterior vasculature..

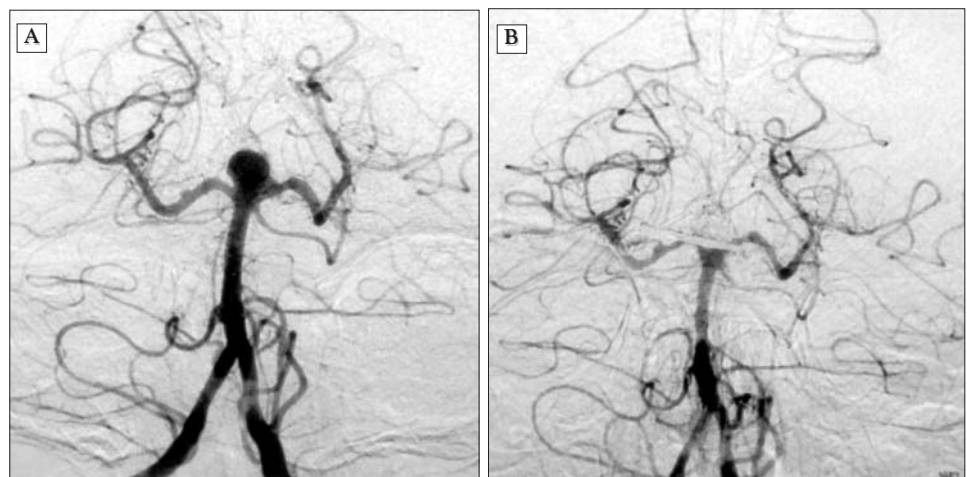
In 146 patients, representing 4.37% of the patients with cerebral aneurysms and 62.39% of those with posterior vasculature aneurysms, the aneurysms were located in the basilar artery apex (Fig. 1).

The mean age of the 146 patients with aneurysms of the basilar artery apex (ABA) was 45.2 years, ranging between 34 and 71 years old. Most cases were noted between 40 and 50 years of age (69 patients-47.26%). Aneurysms were found in 68 males (46.57%) and 78 females (53.42%) suggesting a slight predominance in female patients.

ABA Clinical presentation

The main reason for in-hospital admission was subarachnoid bleeding leading to headache, vomiting, photophobia, stiff neck, moderate fever and loss of consciousness (noted in 52 patients - 35.61%).

Figure 1. Anterior/posterior angiogram of the spine reveals one large aneurysm of the basilar artery apex (A) undergoing clipping (B)



There were four reports of patients having in the three months preceding the surgery three episodes of subarachnoid bleeding (SAB).

The sudden onset of subarachnoid bleeding and the loss of consciousness noted 46 patients (31.50%) matched the symptoms for aneurysms of carotid arteries.

Headache did not affect occipital or suboccipital regions, while all other clinical signs had low value in the localization of the lesion (10,11,12,13,14,15).

The neurological symptoms consisted of: loss of balance in 68 patients (46.57%), dysarthria in 39 patients (26.71%), right-side hemiparesis and mixed aphasia in 35 patients (23.97%), memory disorders in 16 patients (10.95%) and paresis of the third cranial nerve in 11 patients (7.53%).

The diagnostic assessment started with a computed tomography (CT) immediately following hospitalization. This investigation was useful for an imaging diagnostic of subarachnoid bleeding (SAB) and/or intraventricular bleeding (Fig. 2).

The mean time between the last SAB and the onset was 26 days, ranging between 3 and 62 days.

ABA Surgery

In order to achieve brain relaxation we drained the cerebrospinal fluid (CSF) via lumbar catheter, manitol (1-2 mg/Kg) and furosemide (30-40mg) given following anesthetic induction and prior to performing the skin incision.

While dissecting the aneurysm, handling it and applying the clip we sometimes lowered the blood pressure as low as 40-45mmHg, but only for periods of up to 20-25 minutes.

The temporal occlusion of the basilar artery was performed in order to lower the pressure in the aneurysm for dissecting and preparing the clipping set.

Prior to applying the temporary clips, usually above the superior cerebellar artery, the patient needed to reach normal blood pressure values and therefore was administered 20% manitol bolus dosed 1 up to 2 mg/Kg.

Under such circumstances, the occlusion of the basilar artery for around 10 minutes was adequately tolerated.

Occasionally, when we needed to exceed the one hour time-frame, we performed an intermittent occlusion of the basilar artery with 7-8 episodes of occlusion lasting 10 minutes each.

As for surgical access we most frequently used a pterional transylvian access or a subtemporal access.

Craniotomy was performed as close to the base of the skull as possible. It therefore allowed us to gain control over „bridge" and Labbé veins, right outside the posterior craniotomy line.

Following exposure the Labbé vein was covered in gelfoam for better protection.

However the small bridging veins connecting the surface of the temporal lobe with the tentorium were coagulated and sectioned, posing no threat for the patient. The larger superficial veins were never sacrificed due to the inherent danger for edema and infarction. Therefore, the veins yield a similar importance to the one of arteries.

For a better access to the middle region of the basilar artery we had to resource several times to sectioning the tentorium. Achieving an optimal visual access of the apex of the basilar artery required that the surgical table had to be rotated upwards, downwards and sideways.

Using the OR microscope we identified the third cranial nerve originating in deeper structures, passing by the uncus and entering the cavernous sinus. The trochlear nerve is posterior, attached to the arachnoid layer below the inferior side of the tentorium, for about 2cm; it then rounds in a lateral/anterior arch before entering the medial region of the cavernous sinus.

Occasionally there was need for inserting a 4.0 thread through the free edge of the tentorium in order to knot it to the upper ceiling of the medial cranial fossa. This tentorium-dragging maneuver enabled the creation of an additional 3-5mm space.

We only had to section the tentorium for a better view of the ABA in 8% of patients.

Following the sectioning of the arachnoid layer of Liliequist we visualized the posterior cerebral artery located

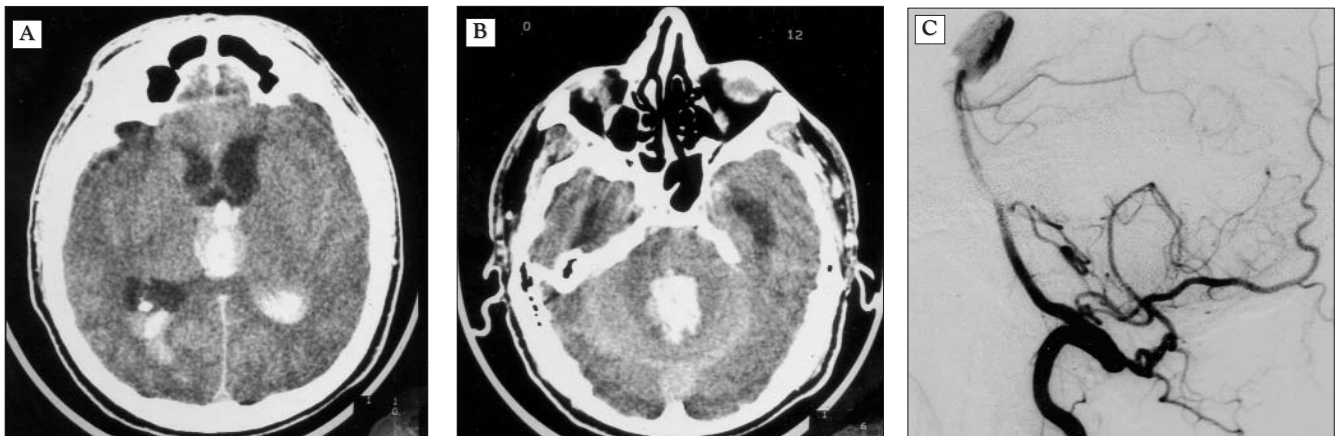


Figure 2. Computer tomography of a patient with basilar artery apex aneurysm (A,B), bleeding in the third and fourth ventricle and in the occipital horns (C)

above the third cranial nerve and its junction to the posterior communicating artery. Following its retrograde path lead us to the aneurism.

Whenever the third cranial nerve adhered to the aneurysmal dome, to the upper cerebellar artery or to the de posterior/inferior segment of the posterior cerebral artery, in order to achieve better clipping, we either had to sacrifice it or to microscopically dissect it.

In order to achieve an adequate view of the aneurysm, of the posterior cerebral artery and of the opposite-side third cranial nerve, as well as in order to remove blood clots from the interpeduncular fossa we needed to section the membrane of the anterior side of the pons. The branches of the superior cerebellar artery were easy to identify surrounding the peduncle and then easily traceable medially to the basilar artery.

Having identified the basilar artery we kept on dissecting the anterior and posterior planes and we used suction or tucks for removing the clots and for exposing the aneurysmal pack. Due attention being paid to the aneurysmal pack, to its vicinity with the posterior cerebral artery and to the opposite-side superior cerebellar artery, as well as to the perforating arteries, we established the proper direction for applying the clips so that the aneurysm gets completely occluded without

involving or damaging the perforating arteries.

The aneurysms of the basilar apex were small, sized up to 1 cm in diameter (Fig. 3), large, sized 1 to 1.75 cm (Fig. 4, 5, 6), very large sized 1.75 to 2.5 cm (Fig. 7) and gigantic sized over 2.5 cm (Fig. 8).

The count of small aneurysms was 41 (28.1%), for large ones was 73 (50%), for very large ones was 27 (18.50%) and for gigantic ones was 5 (3.42%).

The ABA was anterior, superior or posterior, orientation wise. For each orientation and size of the aneurysm as well as for each bifurcation level of the basilar artery apex (superior, at the same level and inferior to the posterior clinoid process) we used a different access and different dissection and clipping methods.

In almost half of the cases the bifurcation was located at the level of the posterior clinoid process; in one third of the cases it was located millimeters (up to one centimeter) above the posterior clinoid process; as for the remainders, it was located millimeters (up to one centimeter) below the posterior clinoid process (elongated basilar artery). Rarely, when the bifurcation was more upwards, the aneurysm was located at the floor of the third ventricle near the posterior hypothalamus. For extremely high bifurcation cases we needed to either perform a larger retraction of the uncus or to use a fronto-

Figure 3. Anterior/posterior angiogram of the spine reveals one small aneurysm of the basilar artery apex sized 6 mm (A), clipped (B)

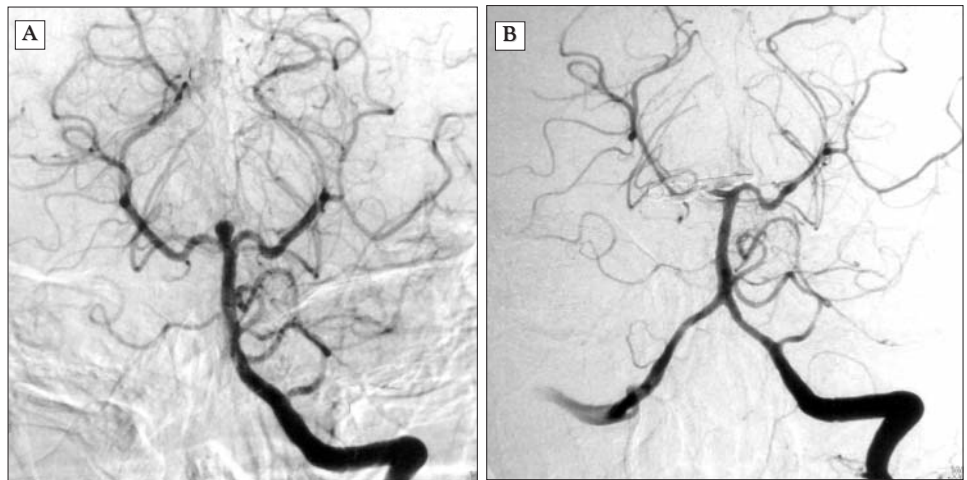


Figure 4. Right-side anterior / posterior angiogram of the spine reveals one aneurysm of the basilar artery apex sized 12 mm (A), clipped (B)

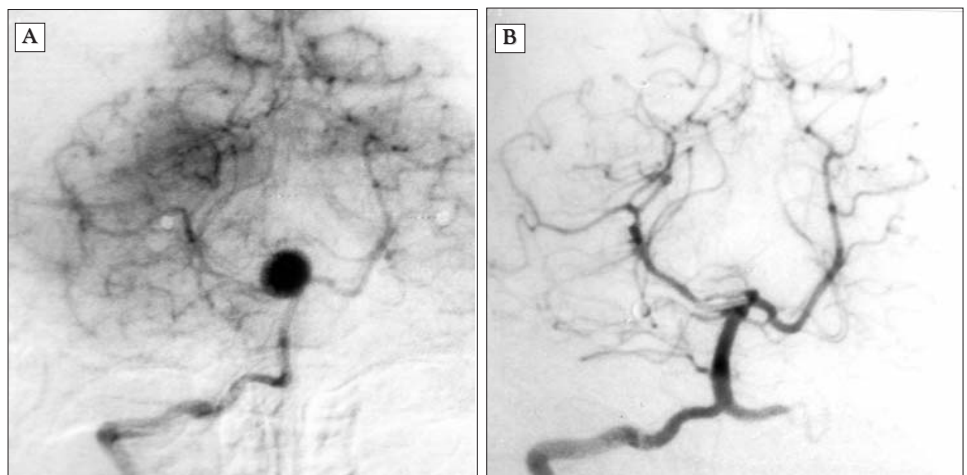


Figure 5. Left-side anterior/posterior angiogram of the spine reveals one aneurysm of the basilar artery apex sized 16 mm (A), clipped (B)

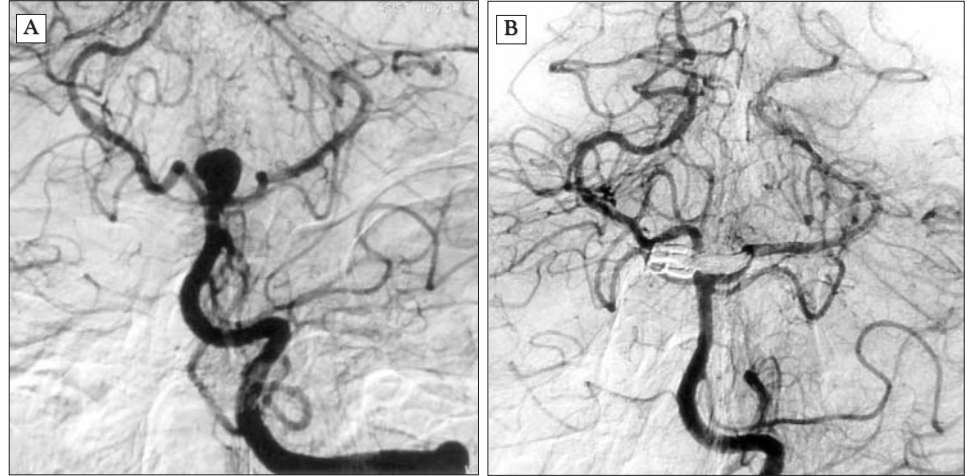


Figure 6. Lateral angiogram of the spine reveals one aneurysm of the basilar artery apex sized 14 mm (A), clipped (B)

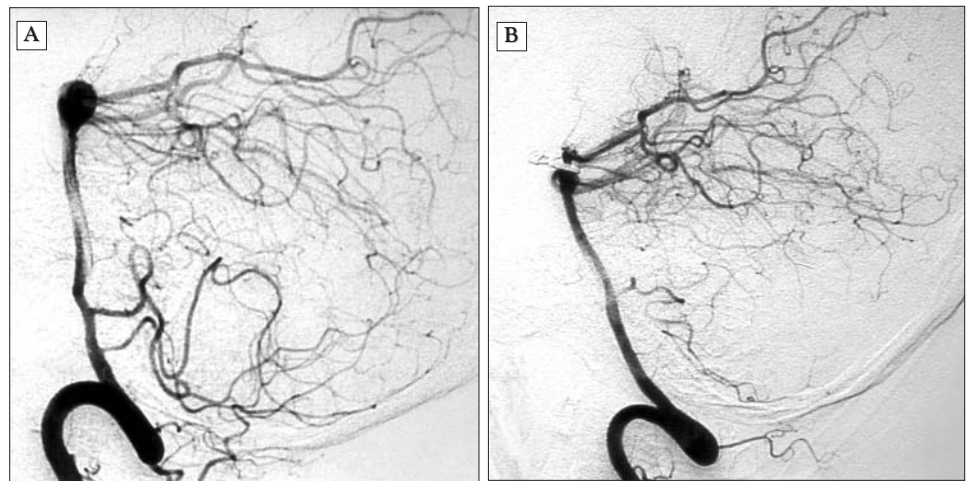


Figure 7. Right-side anterior/posterior angiogram of the spine reveals one very large aneurysm of the basilar artery apex leaning rightwards sized 23 mm (A), clipped (B)

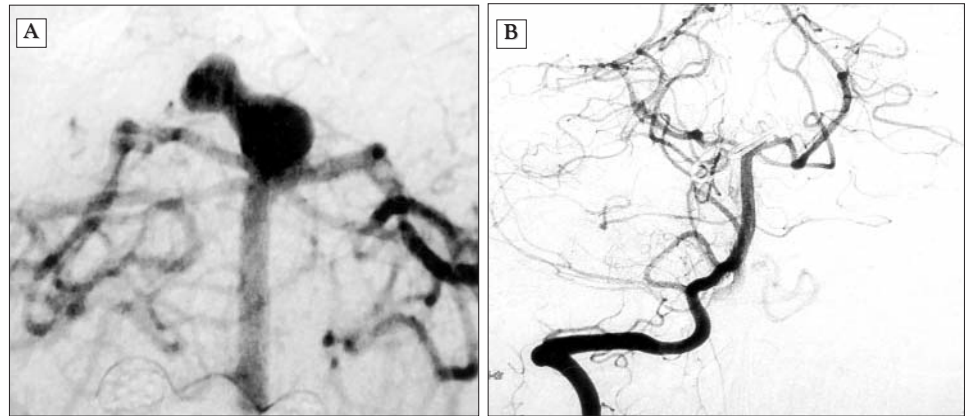
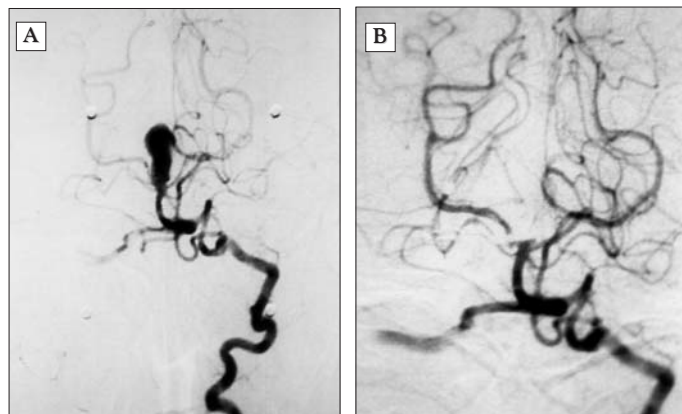


Figure 8. Left-side anterior/posterior angiogram of the spine reveals one gigantic aneurysm of the basilar artery apex, with partial thrombosis, sized 26 mm (A), clipped (B)



temporal access in order to expose it through the sylvian fissure (10,16,17,18).

For medium-sized aneurysms located at the same level as the clinoid process we initiated the dissection with their anterior side in order to better view the anterior and superior sides of the basilar artery, the right-sided posterior cerebral artery and the anterior view of the aneurysmal package and sack.

This manoeuvre required thorough attention since anterior aneurysms are usually conjoined with the clivus near the fissure point (Fig. 9). We further dissected in order to visualize the opposite-side cerebral artery and the third cranial nerve. Following the exposure of the frontal side of the aneurysm we further dissected towards the right lateral side of it for a better view of the posterior side of the aneurysmal sac and in order to identify and preserve the perforating arteries originating in the proximal end of the posterior cerebral artery heading posterior wise towards the perforating substance and peduncles.

In order to avoid clipping the opposite-side posterior cerebral artery we needed to identify the opposite-side third cranial nerve, which always crosses between the superior cerebellar artery and the posterior cerebral artery.

Having the bilateral confirmation of these anatomical

marks is of crucial importance for having a successful procedure (10). The posterior side of the clip should never damage or incorporate the perforating arteries or the root of the third cranial nerve. Applying the clip was the most critical time of the whole surgical process.

Following clipping the aneurysmal dome was punctured and its content was suctioned. In case of lower bifurcations, below the back of the sellae, the exposure was much more difficult and hazardous. The exposure of posterior aneurysms is much more difficult.

Most of the gigantic bulbous aneurysms of the basilar apex were vertical and associated an important dilation of the terminal basilar artery.

The aneurysms of the basilar apex are associated with aneurysms of the middle cerebral artery (2 patients) (Fig. 10), of the anterior cerebral artery (1 patient) and of the anterior communicating artery (2 patients). Clipping both aneurysms occurred in the same surgical session. The postoperative evolution was very good.

Results

The postoperative evolution was excellent and very good in 131 patients (89.72%), unsatisfactory in 8 patients (5.48%),

Figure 9. Anterior/posterior and lateral angiogram of the spine reveals one large aneurysm of the basilar artery apex projected anterior wise (A,B) clipped (C,D). Post-op patient evolution was excellent

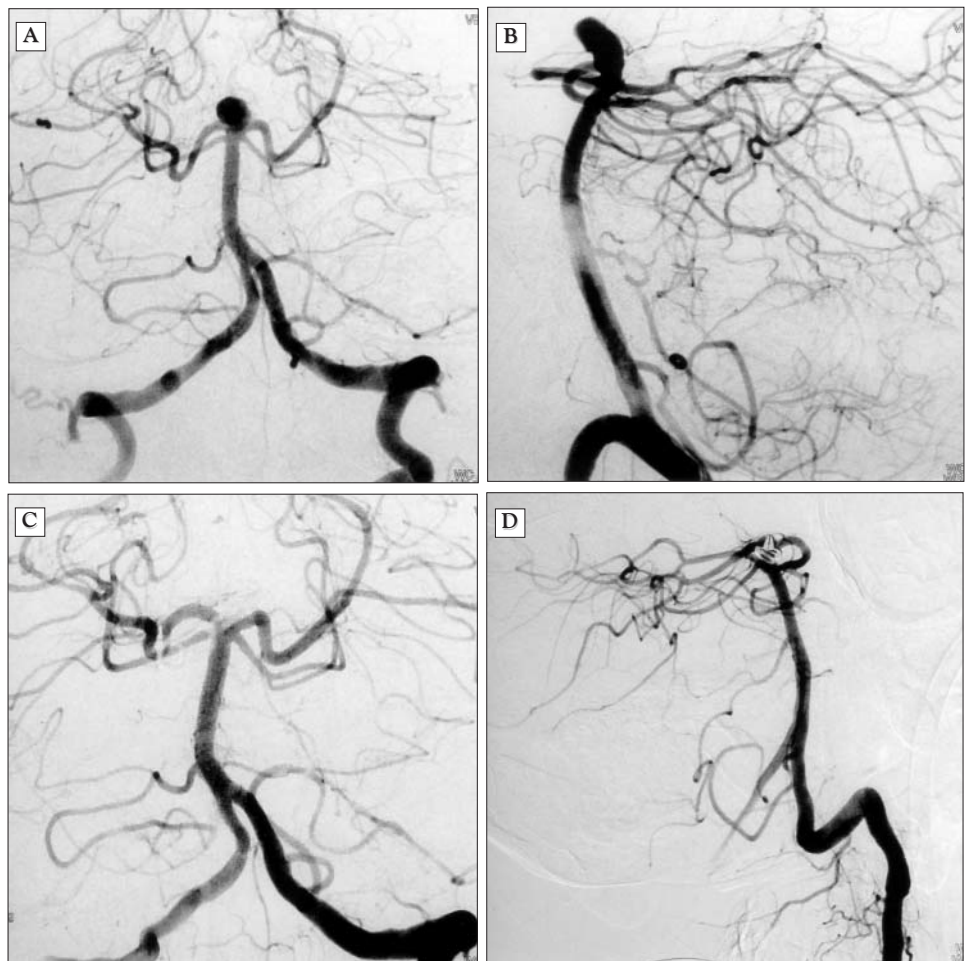
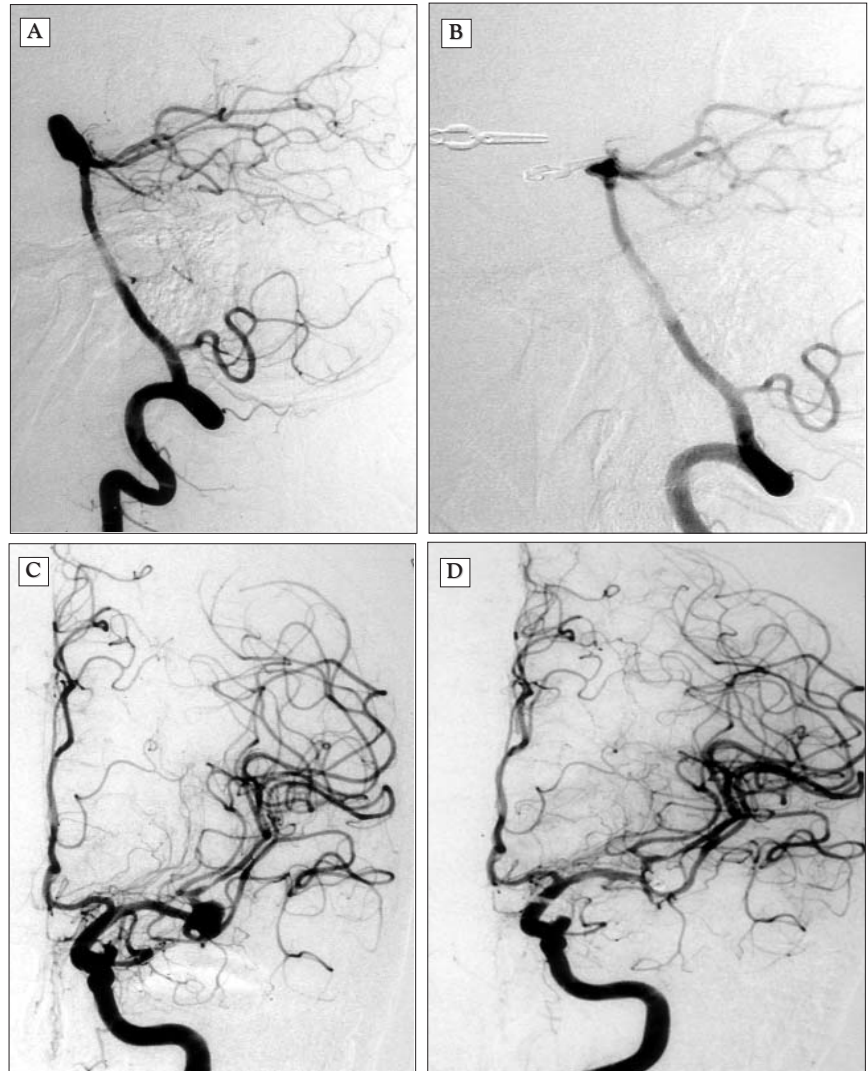


Figure 10. Lateral angiogram of the spine reveals one aneurysm of the basilar artery apex projected anterior wise (A) clipped (B). Post-op patient evolution was excellent. Same-patient anterior/posterior carotid angiogram reveals the presence of a mid-cerebral artery aneurysm (C), clipped (D) in the same surgical intervention as the basilar apex aneurism



and 8 patients (5.48%) died. Three of the 8 patients marked by an unsatisfactory evolution presented with right-side hemiballismus and paresis of the 3rd cranial nerve. Three patients admitted in a severe state (Hunt & Hess IV and V degree, respectively) remained in a vegetative state, while two more developed marked hydrocephalus with psychological, walking and balance disorder; the symptoms were slightly alleviated following ventriculo-peritoneal drainage. Overall, post-operative hydrocephaly was reported in 10 patients (6.8%).

Discussions

According to Troupp (1971) (1), Yasargil et al (1976) (19) and to Wilson (1976) (20), 5% to 8% of intracranial aneurysms are located in the proximity of the basilar artery bifurcation, while one third of these patients present different locations of aneurysms.

Aneurysms of basilar artery apex are more common in women in their sixties (21,22).

Natural history data suggests that within 3 to 6 years almost all patients with aneurysms of basilar artery apex either die or remain with severe disabilities induced by repeated bleedings

(22,23). Repeated bleeding is twice to three times more common for this type of aneurysms as compared to aneurysms located in the anterior vasculature (10,21,24).

Epidemiologic data suggests that cardio-respiratory arrests and worse outcomes are more frequent in patients with aneurysms of the bifurcation of the basilar artery as compared to ruptured aneurysms affecting the anterior vasculature (25,26).

Other symptoms and clinical presentations may be at least partly due to acute hydrocephalus and to intraventricular bleeding, which are more frequent following ruptures of aneurysms affecting the posterior vasculature than in those affecting the anterior vasculature (5,10,19,27,28,29).

The risk of a ruptured aneurysm depends on its position, size, and morphology, on the hemodynamic of the blood flow, on the surrounding anatomical areas and on the personal patient's history.

However, morphological parameters yield more effective measures for assessing the risk for aneurysmal rupture than the mere size of the aneurysm (30).

The parameters assessed by Chien and co. (2011) (31) include, for each aneurysm, the volume, the surface area and

the high curvature areas. Kimura and co. (2011) (32) stated that a thorough knowledge of the microanatomy of the region surrounding the aneurysm and especially of the perforating arteries and of cranial nerves is mandatory in aneurysmal surgery.

Unruptured aneurysms of the basilar artery apex may be accidentally identified but, when large, they usually induce dysfunctions in the oculomotor nerve, Weber syndrome, compression of the brainstem, hydrocephalus and/or walking disorders.

The basilar artery apex aneurysm clipping techniques are intimately related to the complex anatomy of the aneurysm, with the interpenduncular cistern and with the dissection of the deep, narrow tunnel required for safely accessing the respective lesions.

The key issues when performing neuroanaesthesia on patients subject to neurosurgical treatment for aneurysms are moderate hypothermia and the repression of electroencephalographic outbursts using barbiturates.

A hypothermic circulatory full stop is extremely rarely used during the surgery of aneurysms of the basilar artery apex.

The basilar artery apex aneurysm microsurgical clipping yields risks for neurological state aggravation due to an ischemic thalamus or mesencephalon. In order to avoid such complications as well as for some other reasons electrophysiological monitoring is often used, including the recording of somatosensory evoked potentials.

The perforating arteries surrounding the basilar artery apex irrigate the corticospinal tracts. Ischemia may occur following the temporary occlusion of the proximal end of the basilar artery in patients with poor collateral circulatory function due to poor posterior communicating arteries or following the permanent clipping of perforating arteries.

The aneurysms of the basilar artery apex can be cured using surgical or endovascular techniques, or a combination thereof. The therapeutic choice depends on several factors, including the anatomy of the aneurysm, patient's state and technological availability. When used in an interdisciplinary environment such techniques yield improved outcomes (33, 34,35).

Therefore, small-sized, non-gigantic aneurysms with no signs of intra-arterial thrombosis, not surrounding the P1 segment are more adequate for endovascular access. Elderly patients or those in a worse state also benefit more from endovascular access, regardless of the morphology of the aneurysm (36,37).

Spiotta and co. (2011) (38) treated 10 patients with aneurysms having a wide package with double, "Y"-shaped stents. Authors concluded that "Y"-stent reconstruction could be safely performed by experimented professionals and yields satisfactory mid-term results.

There is no consensus on when basilar artery apex aneurysms should be subjected to surgical intervention. Some however claim that early surgery is the best choice for patients in a good state. Most neurosurgeons however are against surgically treating such aneurysms in acute stages

since the significant retraction of an edematous brain is harmful, while perforating arteries of critical importance are hidden from the view due to the extravasation of blood.

Brain relaxation is decisive. The success of the surgical procedure depends more on preserving the perforating arteries than on the posterior aspect of the aneurysm.

Temporary arterial occlusion induced by temporarily clipping the basilar artery (between the superior cerebellar artery and posterior cerebral artery) as well as both P1 segments, reduces the incidence of damaged perforating arteries and improves success rates of aneurysmal occlusion.

Conclusions

As a distinct group the aneurysms of the basilar artery apex are the most complex type of aneurysms one can face. The data reported above suggests that not all of these lesions can benefit from endovascular access. Endovascular techniques can only be used on a selected group of patients.

Neurovascular surgeons should therefore use their operative skills for the purpose of treating patients with lesions of the utmost complexity. Partial embolization furthermore complicates issues.

The microsurgical cure of basilar artery apex aneurysms is difficult due to its deep location and to its tight contact with thalamic perforating arteries.

The most common surgical complication is the paresis of cranial nerves, and especially the paresis of the third cranial nerve, noted in about two thirds of patients undergoing surgery. Other significant complications, including ruptured aneurysms, ischemia induced by damaged perforating arteries, vascular occlusion, hydrocephalus and hematoma, occur in 13-15% of patients. The surgery of basilar artery apex aneurysms yields adequate results for 80% - 89% of patients, while 5-7% of patients die.

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