

Internal carotid artery bifurcation aneurysm

Internal carotid artery bifurcation aneurysms are subtype of internal carotid artery aneurysm.

Considering that the incidence of these aneurysms is relatively low, references in the literature on this subgroup of aneurysms are very scarce ^{1) 2) 3) 4) 5) 6) 7) 8)}.

Sakamoto et al. studied the location of the aneurysm sac and showed that they somewhat deviate towards the exit of the A1, where hemodynamic stress would be higher ⁹⁾.

Some cases have been described associated with agenesis or internal carotid fenestration ¹⁰⁾.

Epidemiology

Internal carotid artery bifurcation aneurysms represent between 2.4% and 4% of all intracranial aneurysms ^{11) 12) 13) 14)}.

Clinical Features

They are characterized clinically by their tendency to occur at a younger age.

The most frequent clinical presentation is subarachnoid hemorrhage, although in the Gonzalez-Darder et al. series most of the intervened cases were discovered by chance. In the literature, it is described that some patients present with the ophthalmologic clinic by compression of the optic belt. Since the aneurysm is buried in the sinus of the frontal lobe, the association of a frontal hematoma that rises towards the caudate is typical and can open to the lateral ventricle, often associating long-path deficits. As in the series described, most of our patients were female and many of them young. This last fact implies the need to study associated risk factors, especially vascular dysplasias, connective diseases, and polycystic kidney disease. At the time of diagnosis, aneurysms are usually medium or large in size, giant aneurysms being exceptional ¹⁵⁾.

Complications

They frequently rupture at a younger age compared to other intracranial aneurysms ¹⁶⁾.

Additionally, the increased hemodynamic stress at this level translates into a higher rate of recurrent aneurysm compared with aneurysms in other locations ^{17) 18)}.

Classification

Small intracranial aneurysm.

Large intracranial aneurysm

Giant intracranial aneurysm

Projection

Superior

Anterior

Posterior

Treatment

Treatment is recommended since they tend to bleed at a lower age than other aneurysms ¹⁹⁾.

The presence of multiple perforators in this area along with the angle of origin often skewed toward the MCA or the anterior cerebral artery primarily can make treatment challenging ²⁰⁾.

They are surgically characterized by the technical difficulties posed by their domes being adherent to the frontal lobe, their location at the apex of the sylvian fissure, and their relation to myriad perforator complexes ²¹⁾.

Surgical treatment

They settle in an area of great hemodynamic stress. This characteristic, together with the fact that it affects young individuals, a tendency to growth and bleeding, a high rate of early bleeding and an unfavorable neck-bottom relationship, make these brain aneurysms good candidates for microsurgical treatment versus endovascular treatment.

The surgical treatment of ICA bifurcation aneurysms is particularly challenging, due to their location at the highest point of the ICA and the presence of multiple perforators at this level that may be adherent to the back side of the aneurysm ²²⁾

Endovascular treatment

Endovascular treatment of ICA bifurcation aneurysms is feasible and effective and is associated with high immediate angiographic occlusion rates. However, retreatment rates and procedure-related morbidity and mortality are non-negligible ²³⁾.

Periprocedural complications following endovascular treatment of ICA terminus aneurysms are not negligible. Aneurysms at this location are at a high risk of ischemic stroke in the territory of the ipsilateral MCA (either from distal emboli during the procedure or clot formation at the level of the neck with impairment of distal MCA flow), a potential source of serious morbidity and mortality ^{24) 25)}

²⁶⁾

In the meta-analysis of Morales-Valero et al., perioperative morbidity rates were approximately 4% and mortality rates were 3%. Perioperative stroke was a major contributor to morbidity and mortality, occurring in approximately 3% of patients. Although good long-term neurologic outcome was achieved in 90% of patients regardless of aneurysm rupture status, the periprocedural complication rate reported is not trivial. Particularly worrisome is the procedure-related mortality of 4% for unruptured and 6% for ruptured ICA bifurcation aneurysms. These findings stress the importance of proper patient selection because these aneurysms are often adequately and effectively treatable with surgical clip ligation. The high retreatment rate observed in the meta-analysis and in the own series is similar to that reported for aneurysms located in other bifurcation points ²⁷⁾.

Outcome

The direction of the dome of aneurysm and temporary clipping do not affect the treatment outcomes. These aneurysms have excellent outcomes following surgery ²⁸⁾.

Videos

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Case series

In a retrospective analysis of data of patients who underwent surgery for ICA bifurcation aneurysm between the period of 1st January 2011 to 31st December 2015 at our institute. Demographic variable, clinical grade, radiological finding was assessed. Outcome was measured using modified Rankin score (mRs) at discharge and at 6 months follow up. All ICA bifurcation aneurysms were clipped using a standard pterional craniotomy.

A total of 28 patients were included in the study out of which 4 had bilateral ICA bifurcation aneurysms. Mean age was 44.15 (age range 14-65) years, with 43.75% of patient were < 40yrs.

Multiple aneurysms were seen in 11 (39.28%) patients, with superior projection being the most common in 53.12%. Vasospasm was seen in 12 (42.85%) with 4 patients undergoing chemical angioplasty. At discharge good outcome (mRs < 3) was seen in 4/5 (80%) patients in the un-bleed category, whereas 18/23 (78.2%) in bleed category. At 6 months follow up, mRs < 3 was seen 4 (100%) patients in unbleed category, and 84.21% (16 of 19) patients in bleed group.

The findings of the present study have shown an increased incidence of bilaterality and multiplicity for ICA bifurcation aneurysms. The direction of the dome of aneurysm and temporary clipping do not affect the treatment outcomes. These aneurysms have excellent outcomes following surgery ²⁹⁾.

2018

Fifty-one patients with ICabifAs were treated in the study period out of which 40 patients underwent microsurgical clipping. The median age was 48 yr (range 14-68 yr). Nearly 95% of the patients presented in a good clinical grade (World Federation of Neurological Surgeons grade 1 and 2). At 6-mo follow-up, 36 patients (90%) had good clinical outcome (Glasgow Outcome Scale 4 and 5). According to their direction, ICabifAs were grouped as anteriorly directed (10 cases), superiorly directed (23 cases), and posteriorly directed (7 cases). Operative techniques and nuances utilized depend on aneurysmal direction and are presented here.

An appropriate surgical strategy based on the direction of ICabifAs as per the preoperative radiology, meticulous dissection of aneurysmal wall from adjacent perforators, and clip application with the aim of remodeling the ICA bifurcation are integral to achieving a good outcome ³⁰⁾.

2016

Fifty-nine patients with 61 unruptured ICabifAs were included. Seven aneurysms were treated surgically (11.5 %), 22 underwent endovascular treatment (36 %), and 32 were managed conservatively (52.5 %). In the surgical group, short- and long-term complete aneurysm occlusion rates were 100 % with no cases of perioperative or long-term permanent morbidity or treatment-related mortality. In the endovascular group, two patients (11.7 %) with giant aneurysms had perioperative thromboembolic events with transient morbidity. There was one case of aneurysm rupture at follow-up in a giant aneurysm treated with partial coil embolization. Complete/near-complete occlusion rates were 63 %. There was one case of aneurysm rupture after 114 aneurysm-years of follow-up in the conservative management group (0.89 %/year), but no ruptures were observed in small aneurysms selected for conservative management.

Unruptured small ICabifAs have a benign natural history. In patients selected for treatment, excellent results can be achieved in the vast majority of patients with judicious use of endovascular and surgical therapy ³¹⁾.

2015

A total of 58 patients with ICA bifurcation aneurysms were treated. By interdisciplinary consensus, 30 aneurysms were assigned for coiling and 28 for clipping. Patients who underwent surgical clipping were younger and had larger aneurysms. More patients were assigned to coiling if their aneurysms

originated only from the ICA bifurcation or projected superiorly. For the combined angiographic endpoint, complete and nearly complete occlusion (Raymond-Roy I + II), similar rates of 96% (coiling) or 100% (clipping) could be achieved. Raymond-Roy I occlusion occurred more often after clipping (79% vs 41% coiling). Follow-up of the endovascular group showed minor recanalization of the aneurysm neck (Raymond-Roy II) in 42%. One patient (4%) showed a major recanalization (Raymond-Roy III) and needed re-treatment. For incidental findings, no bleeding complications or new persistent neurological deficits occurred during follow-up.

Treatment of ICA bifurcation aneurysms after interdisciplinary assignment to clipping or coiling is effective and safe. Despite significantly more minor recanalizations after coiling, the re-treatment rate was very low, and no bleeding was observed during follow-up. Multivariate analysis revealed that origin only from the ICA bifurcation was an independent predictor of aneurysm recanalization after endovascular treatment ³²⁾.

2014

The records of 65 patients with 66 ICA BA were retrieved from data prospectively accrued between September 1999 and July 2013. Clinical and morphological outcomes of the aneurysms were assessed, including technical aspects of treatment.

The aneurysms under study were directed either superiorly (41/66, 62.1%), anteriorly (24/66, 36.4%), or posteriorly (1/66, 1.5%), and all were devoid of perforators. Aneurysmal necks were situated symmetrically at the terminal ICA (37/66, 56.1%) or slightly deviated to the proximal A1 segment (29/66, 43.9%). The steam-shaped S microcatheter (73.8%) was most commonly used to select the aneurysms, and the single microcatheter technique was most commonly applied (56.1%) to perform coil embolization, followed by balloon remodelling (21.2%), multiple microcatheter (15.1%), and stent-protection (7.6%). Successful aneurysmal occlusion was achieved in 100% of cases, with no procedure-related morbidity or mortality. Imaging performed in the course of follow-up (mean duration 27.3 months) confirmed stable occlusion of most lesions (47/53, 88.7%).

Through tailored technical strategies, ICA BA are amenable to safe and effective endovascular coil embolization, with a tendency for stable occlusion long-term ³³⁾.

Morales-Valero et al. performed a comprehensive literature search for reports on contemporary endovascular treatment of ICA bifurcation aneurysms from 2000 to 2013, and we reviewed our experience. We extracted information regarding periprocedural complications, procedure-related morbidity and mortality, immediate angiographic outcome, long-term clinical and angiographic outcome, and retreatment rate. Event rates were pooled across studies by using random-effects meta-analysis.

Including our series of 37 patients, 6 studies with 158 patients were analyzed. Approximately 60% of the aneurysms presented as unruptured; 88.0% (95% CI, 68.0%-96.0%) of aneurysms showed complete or near-complete occlusion at immediate postoperative angiography compared with 82.0% (95% CI, 73.0%-88.0%) at last follow-up. The procedure-related morbidity and mortality were 3.0% (95% CI, 1.0%-7.0%) and 3.0% (95% CI, 1.0%-8.0%), respectively. The retreatment rate was 14.0% (95% CI, 8.0%-25.0%). Good neurologic outcome was achieved in 93.0% (95% CI, 86.0%-97.0%) of patients.

Endovascular treatment of ICA bifurcation aneurysms is feasible and effective and is associated with high immediate angiographic occlusion rates. However, retreatment rates and procedure-related morbidity and mortality are non-negligible ³⁴⁾.

2007

Internal carotid artery (ICA) bifurcation aneurysms are relatively uncommon and frequently rupture at a younger age compared to other intracranial aneurysms.

Gupta et al treated a total of 999 patients for intracranial aneurysms, of whom 89 (8.9%) had ICA bifurcation aneurysms, and 42 of the 89 patients were 30 years of age or younger. The study analyzed the clinical records of 70 patients with ICA bifurcation aneurysms treated from mid 1997 to mid 2003. Multiple aneurysms were present in 15 patients. Digital subtraction angiography films were studied in 55 patients to identify vasospasm and aneurysm projection. The aneurysm projected superiorly in most of these patients (37/55, 67.3%).

They preferred to minimize frontal lobe retraction, so widely opened the sylvian fissure to approach the ICA bifurcation and aneurysm neck. Elective temporary clipping was employed before the final dissection and permanent clip application. Vasospasm was present in 24 (43.6%) of 55 patients. Forty-eight (68.6%) of the 70 patients had good outcome, 14 (20%) had poor outcome, and eight (11.4%) died. Patients with ICA bifurcation aneurysms tend to bleed at a much younger age compared to those with other intracranial aneurysms. Wide opening of the sylvian fissure and elective temporary clipping of the ICA reduces the risk of intraoperative rupture and perforator injury. Mortality was mainly due to poor clinical grade and intraoperative premature aneurysm rupture ³⁵⁾.

2002

A series of 25 patients treated by clipping under the operating microscope are analyzed and compared with previous cases. Twenty-five patients, 11 men and 14 women (mean age 51 years), were treated by the same neurosurgeon. Seventeen patients presented with subarachnoid hemorrhage (Hunt & Kosnik Grade I in three, II in five, III in two, IV in seven), five with unruptured ICA bifurcation aneurysms, and three with unruptured ICA bifurcation aneurysms but another ruptured aneurysm. There were 23 small, one large, and one giant ICA bifurcation aneurysms. The projection was superior in 12, anterior in seven, and posterior in six cases. Pterional approach was employed for all cases. Outcomes were evaluated at discharge with the Glasgow Outcome Scale. Favorable outcomes (good recovery (GR) and moderate disability (MD)) were obtained in ten of 17 patients with ruptured ICA bifurcation aneurysm. Favorable outcomes were significantly greater in Grades I and II (three in I, four in II) than in Grades III and IV (one in III, two in IV; $P=0.0498$). Seven of eight patients with unruptured ICA bifurcation aneurysm had favorable outcomes. Temporary clipping and projection of the aneurysm did not affect the outcome. Causative factors of unfavorable outcomes were primary brain damage in cases of small and large aneurysms and perforator damage in the case of giant aneurysm. Poor clinical grade and vasospasm are the causative factors of poor outcome in patients with ruptured ICA bifurcation aneurysm. Preservation of perforators is crucial in cases of giant aneurysm. Clipping of unruptured ICA bifurcation aneurysms is recommended since they tend to bleed at a lower age than other aneurysms ³⁶⁾.

Case reports

Mahajan et al. reported a unique case of recanalized left internal carotid artery aneurysm with thrombus adherent to the aneurysm neck and M1 origin diagnosed on 2-dimensional angiography causing embolic stroke in a 66-year-old female who was successfully treated with stent-assisted coiling. This is important to recognize as a cause of embolic stroke ³⁷⁾.

2015

A 70-year-old man with progressive visual disturbances, left superior quadrantanopsia, and right-sided papilledema underwent imaging that demonstrated a right internal carotid artery (ICA) terminus aneurysm with third-ventricle mass effect and ipsilateral optic nerve and chiasm compression. We performed a right modified orbitozygomatic craniotomy, with proximal control and dissection of the aneurysm and small perforator arteries. Temporary ICA and anterior cerebral artery (ACA) clips allowed placement of a large curved permanent clip, reconstructing the ICA bifurcation and maintaining adequate patency of the ACA and middle cerebral artery. Complete aneurysm obliteration was confirmed by intraoperative indocyanine green angiography and postoperative CT angiography. The video can be found here: <http://youtu.be/5WEEgmA-g2A> ³⁸⁾.

A 64-year-old woman, with visual deficit, harboring a large wide-necked aneurysm located at the junction between left internal carotid artery and left A1 segment of anterior cerebral artery, was submitted to endovascular treatment. As she had pre-existing occlusion of left internal carotid, approach from the contralateral internal carotid was used to advance the pipeline embolization device through the anterior communicating artery and place the flow diverter horizontally across the neck (from M1 to A1). Coil embolization was also performed through a microcatheter navigated via posterior communicating artery. The intervention was uneventful, with total aneurysm occlusion. Patient presented with visual improvement on follow-up.

Horizontal deployment of pipeline embolization device appears to be an acceptable and feasible alternative to treat internal carotid bifurcation aneurysms. Long-term follow-up and a greater number of cases are mandatory to establish the safety of this strategy ³⁹⁾.

In a video presentation, a 68-year-old male with a large ruptured right ICA bifurcation aneurysm is presented. The patient's neurological exam was rapidly deteriorating, therefore the patient was transferred to the operating theater after initial evaluation by CT and CT angiogram. A pterional craniotomy was performed, the frontal hematoma was partially removed and the aneurysm was clipped. Residual hematoma was removed after securing the aneurysm and the aneurysm dome was punctured (detail of surgical clipping in the video). Patient made a good recovery at 2 weeks post-op with complete recovery of left sided weakness, and some remaining cognitive deficit. The video can be found: <http://youtu.be/dKFWptdgC4M> ⁴⁰⁾.

Cikla et al. presented a 66-year-old man with seizures, aphasia, and hemiparesis. Work-up revealed a

giant partially thrombosed aneurysm of the internal carotid artery bifurcation with surrounding vasogenic edema. He underwent clip reconstruction of the aneurysm via a cranio-orbital approach. Although they prepared for bypass with the radial artery and/or the superficial temporal artery, they were able to clip-reconstruct the aneurysm without bypass. The patient improved upon his pre-morbid state after surgery and made an excellent recovery. The video can be found in http://youtu.be/P_10hRQFuPo ⁴¹⁾.

2012

A report of Zhang et al. documented the treatment of a giant aneurysm of the internal carotid artery bifurcation with a fistula to the cavernous sinus, which appeared following closed head trauma. A 39-year-old man suffered from blunt head trauma in an automobile accident. Two weeks after the trauma, progressive chemosis of the left eye was presented. Four months after the trauma, digital subtraction angiography showed an internal carotid artery bifurcation aneurysm, with drainage into the cavernous sinus. The lesion was successfully obliterated with preservation of the parent artery by using coils in conjunction with Onyx. Follow-up angiography obtained 3 months postoperatively revealed persistent obliteration of the aneurysm and fistula as well as patency of the parent artery. Endovascular treatment involving the use of coils combined with Onyx appears to be a feasible and effective option for treatment of this hard-to-treat lesion ⁴²⁾.

2011

A 55-year-old man presented with intracerebral hemorrhage (ICH) without subarachnoid hemorrhage (SAH) manifesting as acute onset of consciousness disturbance and right hemiparesis. Computed tomography showed ICH mainly localized in the left putamen, but no evidence of SAH. Magnetic resonance angiography demonstrated a cerebral aneurysm originating from the bifurcation of the left internal carotid artery, which was considered to be responsible for the ICH. The patient underwent emergent intravascular surgery for coil embolization of the aneurysm, and his neurological symptoms gradually recovered with rehabilitation after surgery. Although ICH without SAH is a rare presentation of a cerebral aneurysm, ruptured cerebral aneurysm should be considered as a potential cause of ICH. The localization and extent of ICH may be suggestive of a latent cerebral aneurysm in such cases ⁴³⁾.

2009

A surgical case of an eleven year old boy with excellent outcome is reported, with a subsequent review on the subject. Patients may present with classical subarachnoidal hemorrhage, but also with compressive signs with bigger and unruptured lesions. Initial management of these cases is basically the same of older patients, considering their age, weight and special intensive care for infants ⁴⁴⁾.

2006

A 58-year-old hypertensive woman presenting with mild headaches underwent computed tomography, which showed a nonruptured aneurysm of the left internal carotid artery. She subsequently underwent cerebral angiography, confirming that the aneurysm was located at the left

terminal carotid segment with a wide neck. INTERVENTION: Using a cross-over approach from the contralateral internal carotid artery, a new self-expandable stent was advanced through the anterior communicating artery and placed horizontally across the aneurysm neck. Aneurysm occlusion was performed by subsequent trans-stent catheterization of the aneurysm and coil packing.

Successful stent placement allowed subtotal coil occlusion of the aneurysm with a good anatomic and clinical result. No complications were encountered. The new self-expandable stent is a highly flexible, low-profile device that can be safely navigated through tortuous intracranial vessels even in a crossover technique. Its radial force and closed cell design is suitable for stent-assisted coiling and may be superior to stents with an open cell design ⁴⁵⁾.

2005

Spontaneous pure acute subdural haematoma (ASDH) without intraparenchymal or subarachnoid haemorrhage caused by a ruptured cerebral aneurysm is extremely rare. The present case is the first report of an internal carotid artery bifurcation aneurysm presenting as pure ASDH. Suitable diagnostic investigations and therapeutic strategies are discussed. Arterial origin of bleeding should be considered in all cases of non-traumatic ASDH and a vascular anomaly has to be excluded. The neurological status on admission dictates the appropriate timing and methodology of the neuroradiological investigations ⁴⁶⁾.

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