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# COMPLEX PARACLINOIDAL AND GIANT CAVERNOUS ANEURYSMS

## Importance of preoperative evaluation with temporary balloon occlusion test and SPECT

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ABSTRACT - In the treatment of complex paraclinoidal and giant cavernous aneurysms, preservation of the patency of the internal carotid artery (ICA) is not always possible, and therapeutic occlusion of the carotid is still an important option for their management. A complete preoperative evaluation of the carotid reserve circulation, including the use of temporary balloon occlusion test and single photon emission computerized tomography (SPECT) should be included in the current paradigms of paraclinoidal and intracavernous aneurysms management. We present a series of fifteen patients with sixteen giant or complex carotid cavernous or ophthalmic aneurysms that were treated following a protocol for our preoperative decision-making analysis. Extracranial to intracranial saphenous vein bypass was reserved to the cases where carotid occlusion would be associated with high risk of ischemic complications and was performed in three patients. Besides the difficulties in dealing with those complex aneurysms, good clinical outcome was possible in our experience with the designed paradigm.

KEY WORDS: intracranial aneurysm, cavernous aneurysm, SPECT, balloon occlusion.

**Aneurismas paraclinoideos complexos e cavernosos gigantes: importância da avaliação pré-operatória com teste de oclusão temporária com balão e SPECT**

RESUMO - No tratamento de aneurismas paraclinoideos complexos e cavernosos gigantes, a preservação da patência vascular nem sempre é possível, e a oclusão terapêutica da carótida ainda é uma opção importante no seu manejo. Uma avaliação pré-operatória completa da reserva circulatória carotídea, incluindo o uso do teste de oclusão temporária por balão associado à tomografia computadorizada por emissão de fóton único (SPECT) podem ser de grande utilidade para definir a opção terapêutica a ser adotada. Nós apresentamos uma série de quinze pacientes com dezesseis aneurismas complexos ou gigantes do segmento oftálmico e cavernoso da artéria carótida, que foram tratados de acordo com determinado protocolo de investigação pré-operatória. Anastomose com enxerto de veia safena entre a carótida extra e intracraniana foi reservada para os casos em que a oclusão carotídea estaria associada a um alto risco de complicações isquêmicas e foi realizado em três pacientes. Apesar das dificuldades em lidar com aneurismas complexos como os aqui relatados, é possível obter um bom resultado clínico nestes pacientes com o paradigma desenhado.

PALAVRAS-CHAVE: aneurisma intracraniano, aneurisma cavernoso, SPECT, oclusão com balão.

Advances in surgical techniques and cranial base approaches have greatly improved surgical outcomes with paraclinoidal aneurysms. However, they still represent a challenge for surgical management. A significant number of paraclinoidal aneurysms present as giant and complex aneurysms. Although most of them are manageable by direct clipping, occasionally proximal and distal temporary occlusion and defla-

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tion of the pulsating mass might be required. In addition they may prove difficult to be clipped with maintenance of the patency of the ICA because of atherosclerosis and calcification at the neck and dome of the aneurysm. Endovascular procedures have become an alternative treatment[1,2], although complete obliteration of the large and giant paraclinoidal aneurysms will not be feasible in many cases.

Symptomatic giant cavernous aneurysms are not amenable to direct surgery and are still nowadays candidates to carotid occlusion[3,4]. Therapeutic carotid occlusion remains an important treatment option for those difficult lesions but the most common and feared complication is cerebral ischemia[5].

Extensive preoperative evaluation with the temporary balloon occlusion (TBO) test and SPECT may improve the detection of the patients at risk for permanent carotid occlusion.

## METHOD

Fifteen patients with sixteen giant or complex aneurysms of the cavernous carotid or paraclinoidal aneurysms treated at the Hospital Universitário Clementino Fraga Filho (HUCFF) - UFRJ between March 1998 and March 2004 were included. Small carotid-ophthalmic and cavernous aneurysms were excluded of the present series. All the patients were submitted to the protocol for evaluation of the reserve of the collateral carotid circulation with the (TBO) followed by the study of the cerebral blood flow (CBF) with SPECT.

Appropriate balloon catheters were introduced via femoral artery and selective catheterization of the carotid artery under fluoroscopy was achieved with the Seldinger technique. In our Hospital, experience has been gained with two different non-detachable balloon occlusion catheters: Swan Ganz 5F and Meditech balloon catheters (Boston Scientific, Watertown, Mass, USA). Temporary complete occlusion of the internal carotid artery was hold during thirty minutes with continuous monitoring of the neurological status. The complete interruption of the blood flow in the internal carotid was checked by proximal injection of the contrast. If any neurological deficit occurred, the test was immediately interrupted and the balloon deflated. During temporary carotid occlusion collateral circulation was also studied by angiographic criteria with simultaneous injection of the contrast in the contra lateral carotid artery. The cross filling of the arteries were studied and special attention was paid to the simultaneous or delayed filling of the veins in the occluded side. Before deflation of the balloon, technetium-99m L,L-ethyl cysteinate dimer (ECD) radioisotope was injected intravenously. After deflation of the balloon and withdraws of the catheter, the patient was sent to the SPECT suite. The SPECT study of the cerebral blood flow can be obtained until three hours after the injection of the radioisotope and reflects the blood flow at the exact moment of the injection of the technetium-99m during temporary carotid occlusion.

Definitive treatment strategy was decided after discussion among the members of the neurovascular team of neurosurgeons, neurologists and interventional neuroradiologists. The final approach was planned on a case-by-case basis according with the preoperative evaluation and the intraoperative findings. The ideal goal was the complete occlusion of the aneurysm with preservation of the carotid patency, and decompression of the neural structures in the giant and symptomatic lesions. Therapeutic carotid occlusion with surgical trapping or endovascular occlusions were reserved for the cases where the patency of the carotid could not be preserved. Prophylactic extracranial-intracranial bypass was performed only in the cases where the pretreatment evaluation showed that the patient has a moderate to high risk for carotid occlusion.

## RESULTS

There were fifteen patients, fourteen female and one male, treated in the last five years, with sixteen giant or dismorphic paraclinoidal aneurysms included in the present series (Figs 1 and 2). All of them, with the exception of one young lady with a severe displasia of the cervical and petrous carotid artery associated with a fusiform aneurysm, were submitted to TBO. There were no complications related to the TBO. The summary of the results is demonstrated on the Table. Eleven patients were submitted to therapeutic carotid occlusion, eight with trapping and three with endovascular detachable balloon occlusion. In the fifteen patients treated in this series, twelve had an excellent clinical outcome without permanent deficits. Three patients had motor deficits. A 53 years-old lady passed the TBO-SPECT test but sustained a permanent motor deficit secondary to unintended surgical occlusion of perforator branches. A 42 year-old female patient had TOB-SPECT that showed mild defect and it was decided for occlusion and hypervolemic management in the intensive care unit. She developed hemiparesis in the fourth post-operative day of trapping of the carotid. Her motor deficit improved with hypervolemic and hypertensive therapy. The third patient that developed deficit, a 30 year-old female, was not able to have the TBO-SPECT test even though harboring a large petrocavernous aneurysm because of severe fibromuscular dysplasia of the parent carotid artery. She developed transient hemiparesis secondary to safenous vein bypass trombosis. One patient died of pulmonary sepsis in the seventh post-operative day, secondary to complications related to intraoperative rupture of a giant aneurysm with frontal lobe hematoma. In this particular case intraoperative bleeding secondary to the rupture of the aneurysm was controlled with trapping of the carotid, and an EC-IC bypass was

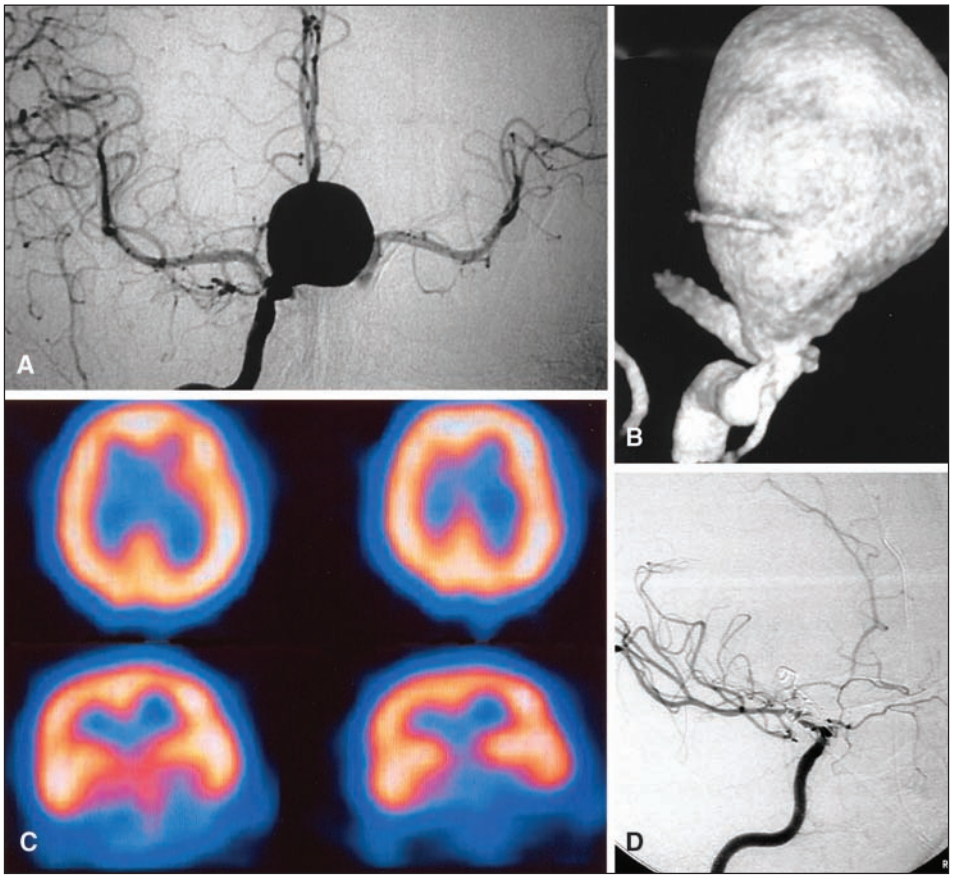


*Fig 1. Case 14. Preoperative cerebral angiogram of the right internal carotid artery (A). 3-D angiogram (B). SPECT during the occlusion test showing simetry of the cerebral perfusion (C). Postoperative cerebral angiogram (D).*

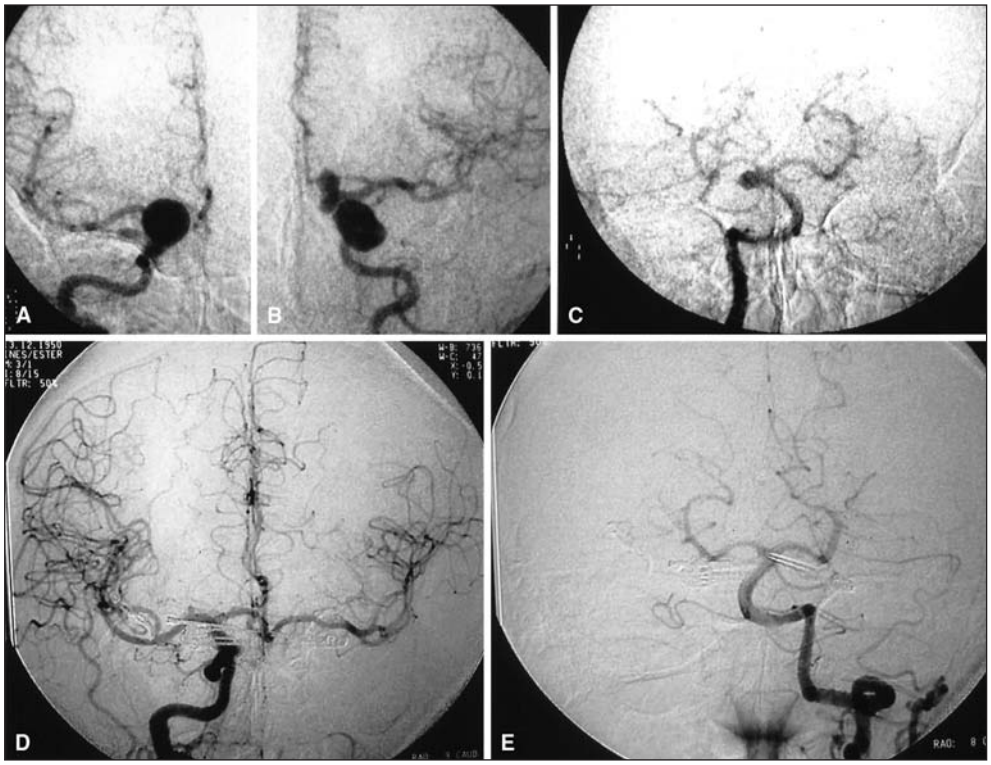


*Fig 2. Case 10. Preoperative cerebral angiograms of the right and left internal carotid arteries and basilar artery (A,B,C). Postoperative cerebral angiograms showing clipping of the multiple aneurysms and occlusion (trapping) of the left internal carotid artery with good crossfilling (D,E).*

*Table. Patient characteristics and management.*

| Patient | Age (years) | Gender | Aneurysm | Preoperative evaluation | Treatment | Outcome |
|---|---|---|---|---|---|---|
| 1 | 53 | F | Giant intracavernous | TBO normal | Detachable balloon occlusion | Excellent |
| 2 | 45 | F | Intracavernous | TBO normal + asymmetry on SPECT | Trapping + bypass EC-IC | Excellent |
| 3 | 28 | F | Intrapetrous and intracavernous | * Displasia in the cervical carotid artery | Trapping + bypass EC-IC | Good. Thrombosis of the bypass. Transient hemiparesis with total recovery |
| 4 | 46 | F | Giant ophthalmic | TBO normal | Trapping | Fair. hemiparesis. Perfurant branches infarct |
| 5 | 57 | F | Intracavernous | TBO normal | Trapping | Excellent |
| 6 | 54 | F | Giant ophthalmic | TBO normal | Trapping | Excellent |
| 7 | 56 | M | Giant ophthalmic | Failed in TBO | Trapping + bypass EC-IC after intraoperative rupture | Dead in the 7th post-operative day Sepsis |
| 8 | 50 | F | Intracavernous | TBO normal | Detachable balloon occlusion | Excellent |
| 9 | 27 | F | Giant ophthalmic | TBO normal | Clipped | Excellent Carotid thrombosis with no symptoms |
| 10 | 56 | F | Left intracavernous + right ophthalmic | TBO normal | Right side clipped + left side trapping | Excellent |
| 11 | 44 | F | Intracavernous pseudoaneurysm | TBO normal | stent | Excellent |
| 12 | 51 | F | Giant ophthalmic | TBO normal | Clipped | Excellent |
| 13 | 47 | F | Giant ophthalmic | TBO normal + asymetric SPECT | Trapping | Regular Hemiparesis with partial recovery. |
| 14 | 53 | F | Giant ophthalmic | TBO normal | Clipped | Excellent |
| 15 | 11 | F | Intrapetrous and intracavernous | TBO normal | Detachable balloon occlusion | Excellent |

performed since the patient did not tolerate the TBO preoperative test. Even with this unfavorable evolution in this patient, EC-IC bypass was patent postoperatively and CT scan did not evidenced any cerebral ischemic infarction. At completion of this article there was no patient with delayed ischemic event

## DISCUSSION

Giant paraclinoidal and cavernous aneurysms traditionally have been difficult lesions to treat surgically. They are rare aneurysms and large experience can be achieved only in neurovascular reference centers. Paraclinoidal aneurysms are much more commonly find in females than in males, accounting for about 74 to 86% of patients in some surgical series[6]. In our series, females accounted for 92% of the patients. The association of the paraclinoidal aneurysms with multiple aneurysms is also common. Whenever possible, direct obliteration of the aneurysm is the most preferable treatment approach, given the fact that endovascular techniques continue to evolve and are still not satisfactory in the giant aneurysms. Combined ipsilateral and contra lateral clipping of bilateral paraclinoidal aneurysms by a single approach has been reported. Despite the continuing advances therapeutic carotid occlusion is still used for treatment of symptomatic intracavernous carotid aneurysms. The main indications for treatment are bleeding from rupture of the aneurysm to the sphenoid sinus, progressive ophtalmoplegia and untreatable pain. Direct surgical repair of intracavernous aneurysms is associated with high morbidity of the intracavernous nerves and is rarely used nowadays. Endovascular therapy with preservation of the patency of the parent vessel in these frequently giant aneurysms with broad necks is still not satisfactory with current

endovascular technology and is unable to deal with the mass effect symptoms.

The majority of large and giant supraclinoidal aneurysms can be managed by direct surgical clip ligation using a variety of technical adjuncts including temporary occlusion with cerebral protection, and aneurysm deflation with retrograde suction[7-12]. However, some giant and dimorphic paraclinoidal aneurysms are simply not amenable to direct clip ligation or endovascular obliteration because of very large neck, proximal extension into the cavernous sinus, dense calcification of the neck, intraluminal organized thrombus, or other physical factors that preclude obliteration of the sac with preservation of the parent vessel. In these cases, therapeutic carotid occlusion should be considered, with or without prophylactic extracranial-intracranial (EC-IC) bypass.

Despite the fact that many complex supraclinoidal aneurysms can be obliterated surgically or with endovascular procedures, pretreatment evaluation of the risk of carotid occlusion is mandatory. Appropriate flow augmentation procedures may be planned as needed or performed prophylactically. Even with all those technical advances morbidity and mortality is still high in direct surgery of giant paraclinoidal aneurysms.

Carotid balloon occlusion is an accepted method for the treatment of large and giant carotid aneurysms, with relatively low procedural complications[13]. In almost all patients, the treatment will lead to a complete thrombosis of the aneurysm improving the symptoms of mass effect, and shrinkage of aneurysms on MRI. Although carotid balloon occlusion or trapping of the aneurysm are safe and effective treatment for the aneurysm itself, the outcome mainly depends on the patient's long-term tolerance to carotid occlusion[14-19]. In a review of the literature comprising 516 patients, brain infarction occurred in 26% and mortality was 12% after permanent carotid occlusion without previous TBO[17]. The acute ischemic stroke rate can be reduced to 4.7% with no mortality in the group evaluated preoperatively with TBO[20,21]. Thus, TBO in awaked patients is reliable in predicting which patients are in high risk of acute ischemic complications after permanent carotid occlusion. In our series there was no morbidity associated to the TBO. The permanent complication rate described in the literature is 1.6%, comparable with the conventional angiography[21]. However, reduced cerebral perfusion still leads to delayed infarctions in regions of marginal cerebral blood flow in 13% of patients, despite clinical tolerance during the TBO test period.

The use of systemic anticoagulation and pharmacologically induced hypertension in the immediate post-operative period in an intensive care unit can reduce the incidence of acute ischemic stroke after permanent occlusion of the carotid[20,22]. This procedure was very helpful in the only patient in our series that developed ischemic deficit after occlusion of the ICA, with a significant improvement of the deficit after a few weeks.

The information provided with the preoperative evaluation of the tolerance of carotid occlusion with the temporary occlusion test and SPECT has been very helpful to evaluate the risk of permanent carotid occlusion and to decide the best strategy to treat those lesions. Evaluation of the CBF during the TBO test with Xe computed tomography[21] or technetium-99m hexamethylpropylene amine oxamine single-photon emission computed tomography can help to predict which patients are in risk of delayed ischemia. Although SPECT does not provide a quantitative evaluation of the CBF, it has some advantages compared with the XE TC[23]. SPECT is available in many hospitals, and there is no need to send the patient to the SPECT suite with the catheter in place.

In our institution we have been using the radioisotope technetium-99m ECD for brain SPECT that is pharmacologically similar and less expensive than technetium-99m HMPAOt[24]. Prophylactic bypass procedures have been reserved to the high risk patients who do not tolerate the temporary occlusion or showed a consistent asymmetry on the CBF in the SPECT study[20,25].

The policy of universal revascularization procedures for all the patients candidates to therapeutic carotid occlusion has been recommended by some authors[26-28], especially in the young patients, with higher cumulative risk of ischemia but there are no solid evidences to corroborate such recommendation[28].

Patency rates for EC-IC bypasses with saphenous vein grafts in previously published studies varied from 66 to 90%. The best results published show patency rates of 90% to 98% with the adoption of intraoperative angiography[29]. However, these outstanding results would be difficult to duplicate at many neurosurgical centers[20]. The long term patency of the saphenous vein grafts is also unknown. In a series of 202 vein grafts monitored for a mean of 6.5 years at the Mayo Clinic, 10 patients (8%) experienced late graft occlusions, with a calculated annual occlusion rate of 1 to 1.5%[30].

In a review of the literature on permanent occlusion of the carotid artery, the estimated long term risk for ischemic deficits is 0.8% / per year of follow-up and the estimated risk for subarachnoid hemorrhage secondary to the development of de novo aneurysms is 0.4% / per year[19]. These low cumulative risks are insufficient to support the recommendation of universal revascularization. Carter, in a literature review, showed that the benefit of prevention of ischemic stroke in the patients submitted to EC-IC bypass is off-set by procedure-related infarctions secondary to problems like graft thrombosis[31]. Another complications associated to an EC-IC bypass described are epidural hematoma (8%) and myocardial infarction (2%)[27]. Furthermore, procedure related mortality seems to be higher in the series of the patients submitted to universal revascularization versus therapeutic carotid occlusion after TBO evaluation and without bypass[31].

In conclusion, satisfactory clinical outcomes can be achieved in the management of the giant and complex paraclinoidal and cavernous aneurysms by direct surgery, trapping or endovascular carotid occlusion based on an extensive preoperative evaluation with TBO-SPECT.

Prophylactic EC-IC bypass should be used only for the uncommon high risk patients with limited hemodynamic reserve. Our paradigm for internal carotid artery reserve evaluation proved to be safe, reliable and should be added, whenever possible, to the management of the patients harboring those difficult lesions.

## REFERENCES


1. DeBrun G, Fox A, Drake C, Peerless S, Girvin J, Ferguson G. Giant unclippable aneurysms: treatment with detachable balloons. AJNR 1981; 2:167-173.
2. Higashida RT, Halbach VV, Dowd C, et al. Endovascular detachable balloon embolization therapy of cavernous carotid artery aneurysms: results in 87 cases. J Neurosurg 1990;72:857-863.
3. Hacein-Bey L, Connolly SE Jr, Duong H, et al. Treatment of inoperable carotid aneurysms with endovascular carotid occlusion after extracranial-intracranial bypass surgery. Neurosurgery 1997;41:1225-1234.
4. Thornton J, Aletich VA, Debrun GM, et al. Endovascular treatment of paraclinoid aneurysms. Surg Neurol 2000;54:288-299.
5. Larson JJ, Tew JM Jr, Tomsick TA, et al. Treatment of aneurysms of the internal carotid artery by intravascular balloon occlusion: long-term follow-up of 58 patients. Neurosurgery 1995;36:23–30.
6. Hoh BL, Carter BS, Budzik RF, Putman CM, Ogilvy CS. Results after surgical and endovascular treatment of paraclinoid aneurysms by a combined neurovascular team. Neurosurgery 2001;48:78-90.
7. Almeida GM, Shibata MK, Bianco E. Carotid-ophthalmic aneurysms. Surg Neurol 1976;5:41-45.
8. Silveira RL, Gusmão S, Pinheiro N, Andrade GC. Aneurisma paraclinoideo: técnica cirúrgica e resultados em 51 pacientes. Arq Neuropsiquiatr 2004;62:322-329.
9. Arnautovic KI, Al-Mefty O, Angtuaco E. A combined microsurgical skull-base and endovascular approach to giant and large paraclinoidal aneurysms. Surg Neurol 198;50:504-520.
10. Dolenc VV. A combined epi- and subdural direct approach to carotid-ophthalmic artery aneurysms. J Neurosurg 1985;62:667-672.
11. Batjer HH, Samson DS. Retrograde decompression of giant paraclinoidal aneurysms: technical note. J Neurosurg 1990;73:305-306.
12. Yasargil MG, Gasser JC, Hodosh RM, Rankin TV. Carotid ophthalmic aneurysms: direct microsurgical approach. Surg Neurol 1977;8:155-165.
13. Drake CG, Peerless SJ, Ferguson GG. Hunterian proximal arterial occlusion for giant aneurysms of the carotid circulation. J Neurosurg 1994; 81:656-665.
14. Abruzzo T, Joseph GJ, Owens DS, Dawson III RC, Reid J, Barrow DL. Prevention of complications resulting from endovascular carotid sacrifice: a retrospective assessment. Neurosurgery 2000;46,:910-917.
15. DeVries EJ, Sekhar LN, Horton JA, et al. A new method to predict safe resection of the internal carotid artery. Laryngoscope 1990;100:85-88.
16. Eckert B, Thie A, Carvajal M, Groden C, Zeumer H. Predicting hemodynamic ischemia by transcranial Doppler monitoring during therapeutic balloon occlusion of the internal carotid artery. AJNR 1998;19: 577-582.
17. Linskey ME, Jungreis CA, Yonas H, et al. Stroke risk after abrupt internal carotid artery sacrifice: accuracy of preoperative assessment with balloon test occlusion and stable xenon-enhanced CT. AJNR 1994;15: 829-843.
18. Standard SC, Ahuja A, Guterman LR, et al. Balloon test occlusion of the internal carotid artery with hypotensive challenge. AJNR 1995;16: 1453-1458.
19. van Rooij WJJ, Sluzewski M, Metz NH, et al. Carotid balloon occlusion for large and giant aneurysms: evaluation of a new test occlusion protocol. Neurosurgery 2000;47:116-122.
20. Link MJ, Tomsick TA, Tew JM Jr. Therapeutic carotid occlusion. Clin Neurosurg 1998;46:326-338.
21. Mathis JM, Barr JD, Jungreis CA, et al. Temporary balloon test occlusion of the internal carotid artery: experience in 500 cases. AJNR 1995;16:749-754,
22. Polin RS, Shaffrey ME, Jensen ME, et al. Medical management in the endovascular treatment of carotid-cavernous aneurysms. J Neurosurg 1996;84:755-761.
23. Yamamoto Y, Nishiyama Y, Toyama Y, Satoh K, Irie K, Ohkawa M. Preliminary results of Tc-99m ECD SPECT to evaluate cerebral collateral circulation during balloon test occlusion. Clin Nucl Med 2002;27: 633-637.
24. Marcondes J, Aversa A, Peçanha M, et al. Reversal of severe SPECT asymetry after venous extra-intracranial high flow bypass in a patient submitted to therapeutic internal carotis occlusion. Arq Neuropsiquiatr 2001;59:797-801.
25. Field M, Jungreis CA, Chengelis N, Kromer H, Kirby L, Yonas H. Symptomatic cavernous sinus aneurysms: management and outcome after carotid occlusion and selective cerebral revascularization. AJNR 2003; 24:1200-1207.
26. Jafar JJ, Russell SM, Woo HH. Treatment of giant intracranial aneurysms with saphenous vein extracranial to intracranial bypass grafting: indications, operative technique and results in 29 patients. Neurosurgery 2002;51:138-146.
27. Lawton MT, Hamilton MG, Morcos JJ, Spetzer RF. Revascularization and aneurysm surgery: current techniques, indications, and outcome. Neurosurgery 1996;38:83-92.
28. Lee S, Awad IA. Therapeutic carotid occlusion: current management paradigms. Clin Neurosurg 2000;46:326-338.
29. Sekhar LN, Bucur SD, Bank WO, Wright DC. Venous and arterial bypass grafts for difficult tumors, aneurysms and occlusive vascular lesions: evolution of operative management and improved results. Neurosurgery 1999;44:1207-1224.
30. Regli L, Piepgras DG, Hansen KK. Late patency of long saphenous vein bypass grafts to the anterior and posterior cerebral circulation. J Neurosurg 1995;83:806-811.
31. Carter BS, Ogilvy CS, Putman C, Ojemann RG. Selective use of extracranial-intracranial bypass as an adjunct to therapeutic internal carotid artery occlusion. Clin Neurosurg 2000;46:351-362.