Suction decompression assisted clipping of large and giant internal carotid artery aneurysms - An experience in 13 cases and review of literature

Ténica de descompressão e sucção assistidas na clipagem de aneurismas grandes e gigantes. Experiência de 13 casos e revisão da literatura

SUMÁRIO

Introdução: O tratamento microcirúrgico de aneurismas grandes e gigantes traz um grande desafio, sendo a clipagem direta ainda a melhor opção, embora de difícil execução e com riscos de ruptura transoperatória. A clipagem microcirúrgica com posicionamento angioplástico dos cliques no colo, juntamente com aspiração retrógrada do sangue na artéria carótida interna e no aneurisma tem sido proposta com o intuito de evitar estes problemas.

Metodos: Este é um estudo retrospectivo de 13 pacientes com 13 aneurismas grandes e gigantes da artéria carótida interna que foram submetidos a tratamento cirúrgico com aspiração retrógrada e clipagem assistida em nosso centro no período dos últimos dois anos. O quadro clínico, detalhes do manejo cirúrgico, complicações e evolução pós-operatória são analisados; na avaliação pré-operatória foram utilizadas técnicas de imagem como tomografia computadorizada e angio-RM.

Conclusões: A aspiração retrógrada e a clipagem assistida através de aspiração de sangue na artéria carótida e no aneurisma é uma técnica eficaz e segura para o tratamento de aneurismas grandes e gigantes da artéria carótida interna.
Angiography by resonancia magnética e tomografia computadorizada 3D, juntamente com angiografia diagnóstica e teste de oclusão com balão. A técnica cirúrgica é descrita em detalhes.

Resultados: A idade dos pacientes variou entre 36 e 79 anos de idade, sendo 7 masculinos e 6 femininos. Onze deles apresentavam aneurismas não-rotos, enquanto 2 manifestavam-se como hemorragia subaracnóide. Não ocorreram complicações peri-operatórias. No pós-operatório, não houve mortalidade e apenas um paciente apresentou comprometimento significativo, com hemiparesia direita decorrente de fenômeno trombo-embólico; os demais tiveram excelente evolução.

Palavras-chave: aneurisma cerebral, oclusão por balão, descompressão-sucção.

ABBREVIATIONS

RSD: Retrograde Suction Decompression
MRI: Magnetic resonance Imaging
MRA: Magnetic resonance angiography
3D-CT: 3 Dimensional Computed Tomography Angiography Scan
ICA: Internal carotid artery
DSA: Digital Subtraction angiography
GOS: Glasgow outcome score

INTRODUCTION

The microsurgical clipping of large and giant aneurysms pose a significant challenge to cerebrovascular neurosurgeons all over the world. There are various treatment modalities for the management of these aneurysms—direct clipping, trapping with or without bypass, or endovascular coiling. Out of various treatment strategies, direct clipping is still considered the gold standard by many, as this is definitive, radical and also preserves the parent vessels. These aneurysms have large necks, often involving a portion or whole circumference of the parent vessel. Their microsurgical anatomy generally requires clip reconstruction by using angioplastic arrangement of clips for adequate reconstruction of the neck while maintaining the parent vessel patency at the same time. This direct method of clipping these large aneurysms is very difficult and risks intraproductive rupture, as these aneurysms are under great tensile stress, even if aneurysm have been trapped, because of rich collateral supply from the adjacent branches.

In order to avoid these problems, techniques such as direct needle puncture with continuous suction evacuation of the blood inside the aneurysm and retrograde suction evacuation of the blood from the proximal ICA have been advocated by various authors in the literature. Presently, with the advances in the endovascular techniques, retrograde suction decompression is possible by advancing a catheter transfemorally up to the cervical ICA. The purpose of this article is to report this procedure in two cases of large ICA aneurysms, and to discuss the advantages and disadvantages of this technique along with the review of existing literature.

PATIENTS AND METHODS

In this series, 13 patients with 13 large and giant internal carotid artery aneurysms were included for the purpose of the study. There were 7 males and 6 females and the age ranged from 38–79 years old. Two patients presented with subarachnoid hemorrhage (Hunt and Hess grade II and grade III each), while the rest of the patients presented with various features of mass effect. The patients presented with visual deterioration (6 patients), ptosis (4 patients) and headache only (3 patients). The communicating segment aneurysms were the most common location, present in 7 patients. The other locations were at the carotid ophthalmic segment in 4 patients and carotid bifurcation in 2 patients.

PREOPERATIVE WORKUP

MRI/MRA brain along with 3D-CTA scan of the head was performed in all the patients. These investigations provided all the necessary information, on basis of which future preoperative planning of the operative strategy was done and in large and giant aneurysms, if microvascular clipping was planned, then consideration was given to using the technique of suction decompression. 3D-CTA evaluates the ophthalmic artery and distance of the aneurysm from the clinoid process, as clinoectomy may be added to expose the proximal ICA in order to gain proximal control in large and giant aneurysms. However, if flow control was being planned by means of balloon occlusion, then these procedures were skipped for aneurysms farther from the skull base; if the most proximal clip is located near the distal dural ring, then these procedures are necessary. Additionally, diagnostic angiography along with balloon occlusion test was done in all the patients in order to know the status of collateral circulation and tolerance of the neural tissue to ICA occlusion.
Suction Decompression - Technical Details of Operative Procedure

After induction of general anaesthesia and prior to craniotomy, a 5-7 French double lumen balloon catheter is guided transfemorally up to the cervical ICA (Fig. 1). A control digital subtraction angiography is then taken to evaluate the best working angle (Fig. 2). A pterional craniotomy was routinely performed and the sylvian fissure was widely opened. The anterior clinoid process was resected for the satisfactory visualization of the proximal ICA. When required, the distal dural ring was opened allowing better visualization of the aneurysm neck (Fig. 3). After the aneurysm has been exposed, the balloon was inflated proximal to the aneurysm and a temporary clip is applied distal to it (Fig. 4). The aneurysm still fills and remains tense due to the collateral flow through ophthalmic artery and cavernous collaterals.

Thereafter, repeated episodes of suction decompression of aneurysm are required in order to deflate and shrink the aneurysm sac, and finally, the aneurysm is then clipped (Fig. 5). The volume of the sucked blood depends on the status of the collateral circulation. In the presence of adequate collateral circulation, a greater amount of blood needs to be sucked to deflate the aneurysm sac. Even if the volume of the aneurysm does not change, the tensile pressure over the wall is greatly reduced so as to permit safe clipping. The degree to which the aneurysm will shrink depends upon the thickness of its wall, hence the force of the suction has to be calibrated accordingly. Excessive suction evacuation leading to the collapse of the ICA is to be avoided as it disturbs safe clipping and preservation of the ICA. In the end, a check DSA was done in order to che-
ck for any residual neck and patency of the parent vessel and perforators after the clipping procedure (Fig. 6). Microvascular doppler ultrasound was also used in order to assess the status of blood flow in the parent vessels and perforators following clipping of the aneurysm. The entire procedure of clipping was performed under the assistance of the endoscope (Fig. 7).

Fig. 4. Application of the first fenestrated clip. The balloon has been inflated. Note the deflation of the aneurysm after the suction is applied. The temporary clip distal to the aneurysm can also be seen.

Fig. 5. Final microscopic view after the application of all the three fenestrated clips and complete obliteration of the aneurysm.

All the patients underwent systemic heparinization immediately after the balloon occlusion. Systemic heparin was transfused at the rate of 3000 units in the first hour, and thereafter 1000 units every hour if required. After the procedure, the heparinization was reversed with protamine (dose- 15-20 mg).

Fig. 6. Endoscopic view of the completed clipping showing complete neck obliteration and parent vessel reconstruction without jeopardizing the critical perforators.

Fig. 7. Final check DSA showing complete aneurysm obliteration and patent PcommA and AChA. [DSA-Digital subtraction angiography, ICPC-internal carotid artery communicating segment, SAH-subarachnoid hemorrhage, PcommA-posterior communicating artery, AChA-anterior choroidal artery].

[Raw Text]
Surgical Results and Outcome (Table 1)

<table>
<thead>
<tr>
<th>Nº</th>
<th>Age/ Sex</th>
<th>Location</th>
<th>Size/ Shape</th>
<th>Clinical Presentation</th>
<th>Complications</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>79/F</td>
<td>Lt C2</td>
<td>Giant/Saccular</td>
<td>SAH gr.3</td>
<td>Thromboembolism</td>
<td>Severe disability</td>
</tr>
<tr>
<td>2</td>
<td>63/F</td>
<td>Lt C2</td>
<td>Large/Saccular</td>
<td>Unruptured</td>
<td>None</td>
<td>Excellent</td>
</tr>
<tr>
<td>3</td>
<td>65/F</td>
<td>Lt IC</td>
<td>Giant/Saccular</td>
<td>Unruptured</td>
<td>None</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>45/M</td>
<td>Rt C2</td>
<td>Giant/Saccular</td>
<td>Unruptured</td>
<td>None</td>
<td>Excellent</td>
</tr>
<tr>
<td>5</td>
<td>45/F</td>
<td>Lt C2-3</td>
<td>Large/Saccular</td>
<td>Unruptured</td>
<td>None</td>
<td>Excellent</td>
</tr>
<tr>
<td>6</td>
<td>38/M</td>
<td>Rt C2</td>
<td>Giant/Saccular</td>
<td>Unruptured</td>
<td>None</td>
<td>Excellent</td>
</tr>
<tr>
<td>7</td>
<td>56/F</td>
<td>Rt C2-3</td>
<td>Large/Saccular</td>
<td>Unruptured</td>
<td>None</td>
<td>Excellent</td>
</tr>
<tr>
<td>8</td>
<td>51/M</td>
<td>Rt C2-3</td>
<td>Large/Saccular</td>
<td>Unruptured</td>
<td>None</td>
<td>Excellent</td>
</tr>
<tr>
<td>9</td>
<td>36/M</td>
<td>Lt M1</td>
<td>Large/Saccular</td>
<td>Unruptured</td>
<td>None</td>
<td>Excellent</td>
</tr>
<tr>
<td>10</td>
<td>68/M</td>
<td>Lt ICPC</td>
<td>Large/Saccular</td>
<td>SAH gr.2</td>
<td>None</td>
<td>Mild disability</td>
</tr>
<tr>
<td>11</td>
<td>59/M</td>
<td>Lt C2</td>
<td>Large/Saccular</td>
<td>Unruptured</td>
<td>Lt Hp dt past SAH from Rt MCAA</td>
<td>None</td>
</tr>
<tr>
<td>12</td>
<td>62/F</td>
<td>Rt C2</td>
<td>Large/Saccular</td>
<td>Unruptured</td>
<td>None</td>
<td>Excellent</td>
</tr>
<tr>
<td>13</td>
<td>62/M</td>
<td>Rt C2</td>
<td>Large/Saccular</td>
<td>Unruptured</td>
<td>None</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

The microsurgical treatment of large and giant aneurysms has been plagued with difficulties in exposing the aneurysm neck for safe clip placement and achieving proximal control, despite significant advances in the endovascular and surgical techniques in the management of these aneurysms. These lesions frequently require temporary interruption of local circulation to facilitate safe clipping. Several authors have pointed out that proximal control of the cervical ICA is an important first step and prerequisite for clipping proximal carotid aneurysms, particularly in cases of large and giant aneurysms. Earlier, Drake has advocated simple cervical carotid artery compression to soften aneurysm sac for safe clipping. But, due to brisk flow through ophthalmic and cavernous branches, even trapping of these aneurysms by proximal and distal temporary clips may not adequately soften the lesion. The feasibility of microsurgical clipping of these aneurysms has been enhanced by the development of the technique of suction decompression. The technique of open suction decompression was first described by Flamm et al in six cases of giant aneurysms, where they punctured the aneurysm with N° 21 scalp vein needle attached to the operating room suction device. Butjé and Samson simultaneously reported open retrograde suction decompression in giant paraclinoid aneurysms, where a N° 18 catheter was inserted into the cervical carotid artery after temporary trapping of the aneurysm. Shucart et al described temporary balloon occlusion of the parent vessel as an aid to clipping basilar and paracerebral aneurysms. Scott et al described the combination of two techniques of proximal balloon occlusion with a double lumen catheter and retrograde suction decompression in clipping these aneurysms. With continued advancements in endovascular techniques and intraoperative imaging and the ability to visualize the adequacy of clipping at the end of the procedure, the incidence of residual aneurysms and compromise of the parent vessel would be potentially minimized. Puay Yong et al assessed the safety and feasibility of proximal control, suction decompression and intraoperative angiography in a series of 24 cases with paraclinoid aneurysms. They reported complete aneurysm obliteration in 20 cases. Subsequent clip readjustment was required for 7 cases, including 3 cases for residual aneurysm filling and 4 for ICA compromise. These authors concluded that endovascular methods provide a safe and reliable clipping of these difficult aneurysms. Steiger et al suggested a more controlled temporary blockage of aneurysm flow and decompression by blocking the entire aneurysmal orifice used a long and flexible ellipsoid balloon, to assist with the clipping and suggested this...
to be a valuable alternative to retrograde suction decompression method.

Thus, there are several benefits of this technique as cervical incision is avoided and it is possible to achieve proximal control early during the procedure before aneurysmal dissection, so that at the time of clip application, the aneurysm is soft and this allows safe clipping of the aneurysm without any compromise of the parent vessel. In unfortunate event of intraoperative rupture, suctioning of the blood flow can establish quite good hemostasis. Secondly, the adequacy of aneurysm clipping and any parent vessel compromise can be immediately assessed by intraoperative angiography, and any necessary readjustments made before the wound closure. The incidence of residual aneurysm and parent vessel occlusion with the use of intraoperative angiography have been reported to be 6% and 9% respectively\textsuperscript{15,17,20}. The frequency of the need for clip readjustment varies from 29-100%\textsuperscript{13,15,21}.

The use of endovascular techniques is not without the risk of complications: the patients run the risk of developing thrombo-embolic phenomena and the use of intraoperative angiography exposes the personnel to the hazard of being exposed to radiation. However, according to Derdeyn and colleagues, the amount of radiation exposure is not certainly more than established guidelines of National Council on Radiation protection and Measurements\textsuperscript{22}. Secondly, the addition of endovascular procedure and intraoperative angiography adds to the operating time by 30-55 minutes in the reported literature\textsuperscript{17,20}. However, with more and more experienced endovascular personnel, there will certainly be reduction in this time in future. Another recognized risk of this technique is the development of thrombo-embolic phenomenon and potential for traumatic injury to the vascular endothelium, resulting in carotid dissection. The overall risk of developing thrombo-embolic event in various series reported in literature till date is about 16%\textsuperscript{12,13,21,23}. However, all the thrombo-embolic events can not be attributed solely to the endovascular procedure. The complication rate for use of ICA balloon catheterization and temporary occlusion by experienced teams is reported to be 1.7% to 3.7%,\textsuperscript{24,25}. In order to reduce the incidence of thrombo-embolic events, Puay Yong et al used a modified technique of suction decompression where they occluded the ECA to allow effective suction decompression of the aneurysm\textsuperscript{15}. This technique has also been previously described by Fan et al\textsuperscript{3}.

**REFERENCES**


**CONCLUSION**

In conclusion, retrograde endovascular suction decompression is an effective technique in the management of complex large and giant aneurysms. It is an extremely useful adjunct for obtaining early proximal control during the procedure and clipping can be safely done, with preservation of the parent vessel and critical perforators. Intraoperative angiography can be easily performed to check the adequacy of the aneurysm clipping. The integration of endovascular techniques has advanced the therapeutic armentarium in the management of complex aneurysms: this has evolved from a cooperative practice at our center between the neurosurgeons and neuro-interventionists.


