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ARTICLE

Surgical clipping is still a good choice for the treatment of paraclinoid aneurysms

A clipagem cirúrgica é uma boa opção para o tratamento de aneurismas paraclinóideos

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ABSTRACT

Paraclinoid aneurysms are lesions located adjacent to the clinoid and ophthalmic segments of the internal carotid artery. In recent years, flow diverter stents have been introduced as a better endovascular technique for treatment of these aneurysms. **Method:** From 2009 to 2014, a total of 43 paraclinoid aneurysms in 43 patients were surgically clipped. We retrospectively reviewed the records of these patients to analyze clinical outcomes. **Results:** Twenty-six aneurysms (60.5%) were ophthalmic artery aneurysms, while 17 were superior hypophyseal artery aneurysms (39.5%). The extradural approach to the clinoid process was used to clip these aneurysms. One hundred percent of aneurysms were clipped (complete exclusion in 100% on follow-up angiography). The length of follow-up ranged from 1 to 60 months (mean, 29.82 months). **Conclusion:** Surgical clipping continues to be a good option for the treatment of paraclinoid aneurysms.

Keywords: intracranial aneurysm; endovascular treatment; surgery.

RESUMO

Aneurismas paraclinóideos são lesões localizadas adjacentes aos segmentos clinóideos e oftálmicos da artéria carótia interna. Os stents desviadores de fluxo tem sido crescentemente aplicados com sucesso. **Métodos:** De 2009 a 2014, um total de 43 aneurismas paraclinóideos foram clipados em 43 pacientes. Analisamos retrospectivamente os dados dos pacientes e desfechos clínicos. **Resultados:** Vinte seis aneurismas (60,5%) foram de artéria oftálmica e 17 de artéria hipofisária superior (39,5%). O acesso extradural à clinóide foi utilizado para todos aneurismas. Cem por cento dos aneurismas foram clipados com oclusão de 100% na angiografia controle. O tempo de follow-up oscilou de 1 a 60 meses, com media de 29 meses. **Conclusão:** A clipagem cirúrgica é uma opção boa e segura para o tratamento de aneurismas paraclinóideos.

Palavras-chave: aneurisma intracraniano; tratamento endovascular; cirurgia.

Paraclinoid aneurysms are lesions located adjacent to the clinoid and ophthalmic segments of the internal carotid artery, distal to the proximal dural ring and proximal to the posterior communicating artery origin. They are usually divided into clinoid segment aneurysms and ophthalmic-hypophyseal segment aneurysms. Frequently, part of an ophthalmic segment aneurysm occupies the clinoid segment. Paraclinoid aneurysms are an uncommon cause of aneurysmal subarachnoid hemorrhage, and, in large series, account for approximately 1.4–9.1% of all patients with ruptured aneurysms[1,2,3,4,5].

Because of their location close to the skull base, paraclinoid aneurysms can be challenging to repair surgically, due to proximity with the optic apparatus, bone structures, and cavernous sinus; surgery often requires extensive drilling of the roof of the optic canal, anterior clinoid process (ACP) and optic strut to obtain proximal control and expose the aneurysm neck in its entirety[6,7,8,9,10]. The difficulty of proximal control and the narrow operative field might lead to a higher frequency of failed clipping procedures, as well as to higher surgical morbidity and mortality. Because of these challenges, paraclinoid aneurysms have been one of the most common indications for endovascular treatment. Nevertheless, despite availability of adjunctive techniques, such as balloon-assisted and stent-assisted coiling, coil embolization continues to be associated with a high rate of residual/recurrent aneurysm filling[11,12,13,14,15].

In recent years, flow diverter stents (FDS) have been introduced as an alternative and more effective endovascular technique than coil embolization, and in April 2011, the Pipeline Embolization Device (Chestnut Medical Technologies, Menlo

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Park, CA) was approved by the FDA for treatment of large or giant wide-neck intracranial aneurysms in the proximal intracranial ICA, including the ophthalmic segment[1,13,16,17].

Good results have been published in the literature with the use of FDS, with occlusion rates of up to 90% and complications lower than 5%, however surgical clipping remains an acceptable option to achieve high occlusion rates with average complications[1,2,3,4,5,18,19,20].

The purpose of this study is to expose our surgical results and match them with those of the FDS era.

METHOD

This paper describes the surgical results of a senior vascular neurosurgeon (Pahl, FH). Indications for neurosurgical treatment of paraclinoid aneurysms were unruptured aneurysms with 5mm or above, symptomatic aneurysms (visual deficits) and/or associated subarachnoid hemorrhage (SAH).

From 2009 to 2014 (5 years), a total of 43 paraclinoid aneurysms in 43 patients were surgically clipped. We retrospectively reviewed the records of these patients to analyze clinical outcomes, which are expressed as modified Rankin scale (mRs). Additionally, we divided aneurysms in two groups according to size (< 10 mm and 10 mm or above) to compare surgical results in both groups.

Data distribution was evaluated with Kolmogorov-Smirnov test when applicable. Statistical analysis was performed using Chi-Square test and multiple variate analysis.

Sample data (Table 1)

Of the 43 patients, 37 (86%) were women and 6 (13%) were men. Overall, ages ranged between 34 and 74 years old, with the mean age of 53.18 years and a standard deviation of 8.2 years. The mean age was 53.3 years among men and 53.1 years among women.

Twenty-six aneurysms (60.5%) were ophthalmic artery aneurysms, while 17 were superior hypophyseal artery aneurysms (39.5%). Among men, four aneurysms were superior hypophyseal and two were ophthalmic; among women, 13 were superior hypophyseal and 24 were ophthalmic. Sixteen aneurysms were located on the right (37.2%) and 27 (62.8%) on the left.

Aneurysm size ranged from 2 to 25 mm (mean, 12.3 mm). Eighteen (41.8%) were smaller than 10 mm, 20 (46.5%) were in the 10 to 24 mm range, and 5 (11.7%) were 25 mm or larger. Five (11.7%) of the 37 patients suffered SAH, including the case with a 2mm aneurysm. The other 38 patients had unruptured aneurysms.

Four patients (9.3%) had preoperative vision loss: three ipsilateral to the aneurysm and one with bitemporal hemianopia. Three patients recovered vision after surgical decompression of the optic apparatus.

RESULTS

Surgical technique

The extradural approach to the ACP was used to clip these aneurysms (Figure 1). In ophthalmic segment aneurysms, the last part of the ACP was taken out intradurally, facing the aneurysm itself. In superior hypophyseal aneurysms, the ACP was taken out in completely extradural fashion, because of the low risk of damaging the aneurysm during drilling.

Proximal control of the neck was used in aneurysms with clinoid segment extension only, because of the high risk of drilling with the aneurysm under the ACP; otherwise, proximal control was achieved at the clinoid segment of the ICA.

Complications

There were seven complications in seven patients (Table 2). Complete vision loss occurred in two patients, and vision loss in the ipsilateral inferior nasal field occurred in two others. There were two cases of postoperative carotid thrombosis. The first occurred at the site of proximal control in the neck, with contralateral hemiparesis and aphasia due to intimal dissection, and the second was due to accidental injury of the right carotid with trapping, which resulted in contralateral left hemiparesis. In the latter case, the patient also developed a cerebrospinal fluid (CSF) leak, which was treated successfully with lumbar drainage for 1 week.

Table 1. Summarized demographic of patients submitted to microneurosurgical treatment of paraclinoid aneurysms.

Parameter	Number (%)
Gender	
Female	37 (86%)
Male	6 (14%)
Age	53.1 ± 8.2
Site	
Ophthalmic	26 (60.5%)
Hypophyseal	17 (39.5%)
Side	
Right	16 (37.2%)
Left	27 (62.8%)
Size	
< 10 mm	18 (41.8%)
10-24 mm	20 (46.5%)
= or > 25 mm	5 (11.7%)
Details	
SAH	5 (11.7%)
No SAH	38 (88.3%)
Pre operative vision loss	4 (9.3%)

SAH: subarachnoid hemorrhage.

Outcome (Table 2)

The length of follow-up ranged from 1 to 60 months (mean, 29.82 months). One hundred percent of aneurysms were clipped (complete exclusion in 100% on follow-up angiography – Figure 2). Twenty-two (51.1%) patients were discharged with a mRs of 0, and 14 patients (32.5%) with a mRs score of 1. In five patients (11.6%), the mRs was 2, and in two patients (4.6%), the mRs was 3.

Two patients with no previous visual deficits lost vision in the ipsilateral eye, and two others had partial visual loss in the nasal field. Conversely, three patients with preoperative visual loss recovered their sight postoperatively.

There were no deaths in this case series, despite the complexity of the lesions.

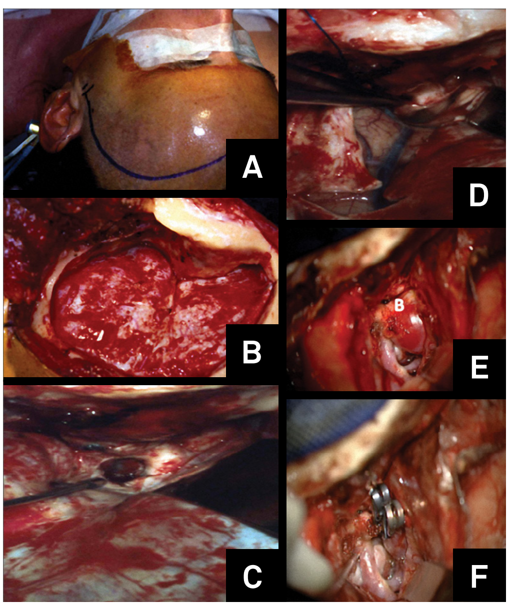

Figure 1. Standard surgical approach to paraclinoid aneurysms. In (A) positioning and incision to pterional craniotomy. In (B) pterional craniotomy and drilling of orbital roof. In (C) Clinoidal space after ressection of anterior clinoidal process. In (D) opening of duramater. In (E) Ophthalmic artery aneurysm revealing proximal and distal neck. In (F) aneurysm after clipping.

Table 2. Surgical data of patients (complications and outcomes).

Parameter	Number (%)
Complications	
Complete vision loss	2 (4.6%)
Vision loss in the ipsilateral inferior nasal field	2 (4.6%)
postoperative carotid thrombosis	2 (4.6%)
Cerebrospinal fluid leak	1 (2.3%)
Outcome	
mRs 0	22 (51.1%)
mRs 1	14 (32.5%)
mRs 2	5 (11.6%)
mRs 3	2 (4.6%)

mRs: modified Rankin scale.

Small aneurysms (< 10mm) versus large aneurysms (10mm or above) (Table 3)

In the small aneurysm group, from the eighteen patients, five were men (27.7%) and thirteen were women (72.3%). Mean age was 49.2 years old and aneurysm were of ophthalmic artery in 12 patients (66.6%) and hypophyseal in 6 patients (33.4%). There were four complications in four patients. Eight (44.4%) patients were discharged with a mRs of 0, 5 patients (27.7%) with a mRs score of 1. In three patients (16.6%), the mRs was 2, and in two patients (11.1%), the mRs was 3. SAH happened in three patients (1 male and 2 females), being one hypophiseal aneurysm and two ophthalmic.

In the large aneurysm group, from the twenty-five patients, twenty-four were women (96%) and just one man (4%). Mean age was 55.8 years old and aneurysm were of ophtalmic artery in 14 patients (56%) and hypophyseal in 11 patients (44%). There were three complications in three patients. All patients three patients with post operative vision recovery were from this group. Fourteen (56%) patients were discharged with a mRs of 0, and nine patients (36%) with a mRs score of 1. In two patients (2%), the mRs was 2. SAH happened in two female patients, being one hypophiseal aneurysm and one ophthalmic.

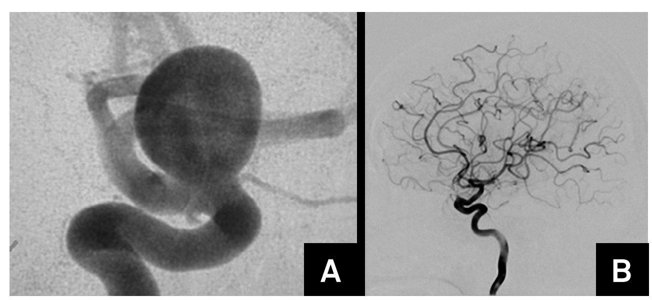

Figure 2. Typical subject from the sample. In (A) pre operative angiography revealing large aneurysm. In (B) post operative angiography, with complete exclusion of aneurysm.

Table 3. Comparison between small and large aneurysms.

Parameter	Small aneurysms (< 10 mm)	Large aneurysms (10 mm or >)
Number of patients	18	25
Gender*		
Male	5	1
Female	13	24
Mean age (years)*	49.2	55.8
Aneurysmal site		
Ophthalmic	12	14
Hypophyseal	6	11
Number of SAH	3	2
Number of complications	4	3
Aneurysmal occlusion	100%	100%
Percentage of good outcome (mRs 0 or 1)	73%	92%

* = statistically significant difference ($p < 0.05$). SAH: subarachnoid hemorrhage; mRs: modified Rankin scale.

After performing multivariate analysis, there was no statistically significant difference between both groups when evaluating aneurismal site, complications, SAH and outcome in mRs ($p > 0.05$). There was statistical association of age and size of aneurysm and gender and size of aneurysm ($p < 0.05$). Large aneurysms were more frequent in women than in men and patients with large aneurysms were older than those with small aneurysms.

DISCUSSION

SAH following intracranial aneurysmal rupture is a major cause of morbidity and mortality[23,24,25]. Several factors may interfere with the probability of rupture, such as smoking, use of alcohol, size, shape, location of the aneurysm, presence of intraluminal thrombus and even the gender of the patient. Korja et al.[18] disclosed that even patients with small (< 7 mm) unruptured aneurysms could have a lifelong risk for rupture of up to 25%, depending on many factors.

Although being uncommon causes of SAH, paraclinoid aneurysms may promote varied symptomatology, especially due to compression of optic nerve and surrounding structures[24,25]. Their treatment is challenging and demanding, whether by surgical or endovascular approaches. Recent endovascular advances, such as FDS, have been introduced as a promising treatment alternative, being more effective than coil embolization. In experienced hands, surgical treatment of these lesions can be accomplished with quite high success rates, but carry significant morbidity[1,2,3,4,5].

In our sample of 43 patients, 100% of aneurysms were clipped (complete exclusion in 100% on follow-up angiography). ICA occlusion occurred in two cases (4.6%) and was unrelated to clipping itself. There were no cases of rebleeding during the follow-up period. A good outcome (mRs of 0 or 1) was achieved in 84% of patients, with no difference related to aneurysm size. There was no mortality. The rate of vision loss was 9% (4.5% total ipsilateral vision loss; 4.5% partial ipsilateral vision loss), and the rate of vision recovery, 7%. The rate of vision recovery among patients with previous visual deficits was 75% (three out of four patients). There was no statistically significant difference between small and large aneurysms when evaluating aneurysmal site, complications, SAH and outcome in mRs ($p > 0.05$). Conversely, there was a clear trend for more complications in small aneurysm group. There is no apparent rationale for such finding, and we believe it is an aleatory finding, without statistical significance.

Several series have reported the outcomes of patients undergoing surgical or endovascular treatment. In endovascular approaches with stent-assisted coiling, balloon-assisted coiling, coiling without adjunctive techniques, and stenting alone, complication rates approach 15%, and total aneurysm occlusion is achieved in up to 50-85% of patients. All above endovascular techniques appear equally successful. Procedure-related complications may be observed in 10% of patients, visual complications in 8% and the recurrence rate may be up to 20% during follow-up[1,2,3,4,5,20,21,22,23,24,25,26]. Some authors propose endovascular treatment as an effective mean for small paraclinoid aneurysms (≤ 10 mm) with a low rate of recurrence. In contrast, large paraclinoid aneurysms (> 10 mm) may exhibit a high rate of recurrence[27,28,29].

Increasing evidence on FDS in paraclinoid aneurysms have demonstrated successful application in up to 100% of aneurysms, near 90% complete or near-complete obliteration on angiographic follow-up, preserved patency of the ophthalmic artery, and minor procedure-related complications, clearly qualifying FDS as an endovascular approach with superior results compared to other endovascular treatments, without an increased rate of complications[1,30].

The largest experience to our knowledge treated 107 patients with only one procedure related complication and 9% of recurrence[15]. On the other hand, some complications are described but poorly understood, such as post-procedure aneurismal bleeding and occlusion of the ophthalmic artery at its origin, which may produce undesirable outcomes[1,19,20,21,22,23,24,25,26].

In a study by Zanaty et al.[30], forty-one patients harboring 44 paraclinoid aneurysms were treated by flow-diversion. At final angiographic follow-up, 77.2% had complete occlusion, 6.8% had near-complete occlusion and 15.9% had incomplete occlusion[30]. Of the 22 symptomatic, complete resolution or significant improvement was noted in 72.7%, while worsening of symptoms occurred in 4.5%[30]. Five patients out of 22 (22.7%) had no significant changes in their symptoms. The complication rate was 2.2% and mortality rate was 0%[30].

Another study by Moon et al.[1] evaluated 29 patients with 38 aneurysms submitted to FDS. It was successfully deployed for all lesions, with 92.1% complete or near-complete obliteration rate at angiographic follow-up[1]. All but one patient were found to have a patent ophthalmic artery at short-term follow-up and 100% of patients retained intact vision[1]. Five patients had minor periprocedural hemorrhagic complications but no permanent morbidities. There were no intracranial hemorrhages, thromboembolic phenomena, vessel dissections, or mortalities[1].

Despite sample heterogeneity, the results of surgical repair of paraclinoid aneurysms are well documented. Surgical success can be high (over 90%), with acceptable complications, morbidity and mortality. Good outcomes are achieved in 70-90% of patients, with progressive improvement of immediate postoperative deficits on late follow-up. The proximity of paraclinoid lesions to the ophthalmic artery and optic nerve is the main concern, with risk of visual loss. However, the possibility of direct decompression of the optic nerve after aneurysmal treatment may reverse visual deficits. Furthermore, surgical treatment is associated with the lowest recurrence rates (< 5%)[2,3,4,5,6,7].

Restoration of eyesight in patients with preoperative visual loss is a surgical advantage less reported in endovascular series, but can be achieved with clipping. In our series, three of four patients with preoperative visual loss recovered their sight[1,2,4,7,23].

Although our results with surgical treatment were animating, they still disclose significant morbidity rates, like 4.6% of complete and 4.6% partial ipsilateral vision loss and are not strong enough to provide evidence of superiority of surgery over endovascular means.

Besides, even in expert hands, paraclinoid aneurysms do have significant surgical morbidity. Lower endovascular morbidity and widespread availability of endovascular therapy make this the chosen alternative for many of these aneurysms, however lower complete obliteration rate and individual anatomical anomalies suggest the need for surgical options[1,30].

Anyway, potential outcome predictors in paraclinoid aneurysms include the presence of SAH, vasospasm, infarcts, hydrocephalus and patient age. A multidisciplinary, combined surgical and endovascular team can formulate individualized treatment strategies for patients.

CONCLUSIONS

In conclusion, surgical clipping is a good option for the treatment of paraclinoid aneurysms, especially in experienced hands. Surgical clipping may facilitate improvements in vision by decompression of the visual apparatus.

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