

# Microsurgical clipping of the anterior circulation aneurysms: study of a personal series and a critical literature review.

## *Clipagem microcirúrgica de aneurismas cerebrais de circulação anterior: estudo de uma série pessoal e revisão crítica da literatura.*

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### ABSTRACT

**Introduction:** The authors present the analysis of the microsurgical clipping of 100 cerebral aneurysms of the anterior circulation and compare the series data with the literature.

**Methods:** Eighty-eight patients presenting with 100 anterior circulation aneurysms operated on microsurgical techniques between 2002 and 2008 by the first author (CES) were retrospectively reviewed. **Results:** A total of 88 patients with 100 aneurysms of the anterior circulation were treated in a six years period. Fifty eight female (66%) and thirty male (34%) with nine patients (10.2%) presenting with multiple aneurysms. The mean age was 52 years (range from 26 to 76 years). Eighty five percent of the cases were ruptured aneurysms. The mean follow-up was 52.4 months (range from 5 to 76 months). The topography of the aneurysms was distributed as it follows: Anterior communicating artery (ACoA) 25%; posterior communicating artery (p-comm) 29%; middle cerebral artery (MCA) 27%; paraclinoidal aneurysms 8%; pericallosal artery 6% and internal carotid artery (ICA) tip 5%. The mortality was 7.9%, and such cases presenting with Hunt Hess graduation 3 and 4. The permanent morbidity was 4.5%, cases with Hunt Hess graduation 3 and 4. Perioperative rupture occurred in 17% of the cases, only in previous ruptured aneurysms. There was no clinical evidence of rebleeding during the follow-up period of the series. **Conclusions:** The microsurgical clipping of cerebral aneurysms of the anterior circulation is a safe and curative treatment for most of such lesions. At present, studies suggest evidences of superior results of surgery compared to the endovascular techniques in the rates of total occlusion of the aneurysms, lesser rates of rebleeding of the treated cases. The results of the present series are similar to the rates of the most relevant literature.

**Key-Words:** Cerebral aneurysms, microsurgery, aneurysms clipping.

### SUMÁRIO

**Introdução:** Os autores apresentam a análise da clampagem microcirúrgica de 100 aneurismas cerebrais da circulação anterior e comparam os dados da casuística com os da literatura. **Métodos:** Oitenta e oito pacientes com 100 aneurismas da circulação anterior operados por técnicas microcirúrgicas entre 2002 e 2008 pelo primeiro autor (CES) foram retrospectivamente revisados. **Resultados:** Um total de 88 pacientes com 100 aneurismas da circulação anterior foram tratados em um período de seis anos. Cinquenta e oito do sexo feminino (66%) e 30 masculinos (34%) com 9 pacientes (10,2%) apresentando aneurismas múltiplos. A idade média foi de 52 anos (variação de 26 à 76 anos). Oitenta e cinco por cento dos casos foram aneurismas rotos. O tempo médio de seguimento foi de 52,4 meses (variação de 5 à 76 meses). A topografia dos aneurismas foi a seguinte: Artéria comunicante anterior 25%; artéria comunicante posterior 29%; artéria cerebral média 27%; paraclinoideos 8%; pericalosos 6%; topo da artéria carótida interna 5%. A mortalidade global foi de 7,9% e todos os pacientes com graduação de Hunt Hess 3 e 4. A morbidade definitiva foi de 4,5% e todos os casos com graduação de Hunt Hess 3 e 4. A ruptura transoperatória ocorreu em 17% dos casos, somente em aneurismas rotos. Não houve evidência clínica de ressangramento durante o período de seguimento da casuística. **Conclusões:** A clipagem microcirúrgica dos aneurismas cerebrais da circulação anterior é um tratamento seguro e definitivo para a maioria destas lesões. Os estudos atuais apresentam evidências de resultados superiores da cirurgia comparados aos das técnicas endovasculares nos percentuais de oclusão total dos aneurismas e menores índices de ressangramentos dos casos tratados. Os resultados da presente casuística são similares aos encontrados na literatura.

**Palavras-chave:** Aneurismas cerebrais, microcirurgia, clipagem aneurismas.

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## INTRODUCTION

Microsurgical clipping of the cerebral aneurysms have been compared with the coiling endovascular procedures in order to define which one is the most effective option for the treatment of such lesions. After the publication of the International Subarachnoid Aneurysm Trial (ISAT), there is a progressive tendency to offer the endovascular procedures as the first choice to manage the ruptured aneurysms in many centers around the world. The first author's experience (CES) in 100 consecutive cases of cerebral aneurysms of the anterior circulation treated by microsurgical techniques is presented and the authors discuss the data proposing a critical evaluation compared to the literature. (23,24)

## METHODS

A retrospective analysis of 100 consecutive cases of ruptured and unruptured cerebral aneurysms of the anterior circulation treated by microsurgical clipping in 88 patients during the period between October 2002 and October 2008 was done. The patients were graduated in their neurological status using the Hunt-Hess (HH) scale. (13) The amount of blood seen in computed tomography (CT) was evaluated by the Fisher grading. (11) Patients with Hunt Hess grades 1, 2 and 3 at the admission were treated as soon as possible. Patients with HH 4 and 5 were operated on if there were life threatening associated hematomas. Aneurysms of the anterior circulation were treated by microsurgical clipping as the first choice except the complete intracavernous lesions which were treated by endovascular techniques or patients in very poor neurological conditions whom were treated by endovascular methods or observed.

All patients were interviewed at least one time after surgery to be included in the follow up group.

## RESULTS

Eighty-eight patients with 100 aneurysms of the anterior circulation were treated in a period of six years: 58 female / 30 male, with nine patients (10,2%) presenting with multiple aneurysms. Three patients presented three aneurysms and six presented two aneurysms. The mean follow up was 52.4 months (range from 5 to 76 months). The aneurysms were distributed according to their locations in: anterior communicating artery

(ACoA) 25%; posterior communicating artery (p-comm) 29%; middle cerebral artery (MCA) 27%; paraclinoidal aneurysms 8%; pericallosal artery 6% and internal carotid artery (ICA) tip 5%. ( Table 1 ) Paraclinoidal aneurysms were classified according to Sekhar et al. (28).

Topography	%
p-comm	29
MCA	27
AcoA	25
paraclinoidal	8
pericallosal	6
ICA tip	5

**Legends:** AcoA - anterior communicating artery; p-comm - posterior communicating artery; MCA - middle cerebral artery; ICA - internal carotid artery

There were 5% of giant aneurysms (diameter > 2.5 cm) : 2 cases of p-comm aneurysms, 2 cases of paraclinoidal aneurysms and 1 case of ICA tip.

Ruptured aneurysms comprised of 85% of the series.

The distribution of the patients according with their Hunt Hess modified classification at the time of surgery was: HH 0: 10%; HH 1: 28%; HH 2: 18%; HH 3: 35%; HH 4: 9%; HH 5: 0%. (14) (Table 2) It is important to observe that patients presenting with multiple aneurysms were operated on for both ruptured and unruptured lesions at the same procedure. Such aspect explains the difference between the percentages of HH grade 0 and unruptured clipped aneurysms.

HH	%
0	10
1	28
2	18
3	35
4	9
5	0
<b>TOTAL</b>	<b>100</b>

**Legends:** HH- Hunt Hess graduation of the patients at the time of the surgery

The CT Fisher grade distribution was: F 1: 14.8%; F 2: 1.2%; F 3: 53%; F 4: 31%.

The transoperative rupture rate was 17%. There rate of transoperative rupture in each aneurysm topography were: 6 cases in ACoA (24%), 5 cases in p-comm (17%), MCA 4 cases (14%), paraclinoidal aneurysm 1 case (12.5%) and pericallosal artery 1 case (20%). All the transoperative bleeding occurred in previous ruptured aneurysms. The global risk of transoperative bleeding for the ruptured aneurysms was 20%.

Global mortality was 7.9%, all cases with Hunt Hess grade 3 and 4 distributed as follows: two cases of ACoA aneurysms, 1 patient with HH 4 and 1 patient with HH graduation 3. There were 3 cases of p-comm aneurysms, all patients with HH graduation 3. One case of pericallosal aneurysm and 1 patient presented with MCA aneurysm, both with HH grade 3.

Morbidity rate at the discharge was 12.5%. However, during the follow-up period, most patients recovered their normal functions. The final morbidity was 4.5%, and these patients were operated on Hunt-Hess grade 3 and 4. There were 3 patients still with hemiparesis and one with aphasia. Two transient hemiparesis were observed in patients with unruptured aneurysms. Such cases presented cardiac and pulmonary complications and prolonged ICU period. (Table 3) The global morbidity and mortality rate was 11.5%.

Data	%
Ruptured aneurysms	85
Transoperative rupture	17*
Unruptured aneurysms	15
Mortality	7,9*
Definite morbidity	4,5*
* All patients with Hunt Hess graduation 3 and 4.	

There was no clinical evidence of rebleeding during the follow-up period. There were three patients who needed CSF shunts for hydrocephalus. (3.4%)

### LEARNING CURVE ANALYSIS

The analysis of the learning curve was done dividing the series in two halves, with 50 aneurysms in each one. The learning curve evidences the progressive improvement of the results of the microsurgical clipping in the series. The first 50 aneurysms were treated in 40 patients and they cursed with 13 transoperative ruptures (26%). The last 50 lesions were operated on 48 patients

with 4 ruptures during the operation (8%). Mortality rate was 6 cases in the first 40 patients (15%) and 1 case in the last 48 (2%). Even when the HH graduation was considered in the analysis, the improvement of the results are evident ( Table 4).

First half (50 aneurysms / 40 patients)	%
Transoperative rupture	26
Mortality	15
HH3	38
HH4	14
Second half (50 aneurysms / 48 patients)	%
Transoperative rupture	8
Mortality	2
HH3	28
HH4	4

**Legends:** HH - Hunt Hess graduation of the patients at the time of the surgery

## DISCUSSION

The International Subarachnoid Aneurysm Trial (ISAT) presents the endovascular procedure as an alternative with better immediate outcomes and at 1 year after procedure concerning to the relative risk of death and dependency. However, several methodological aspects of such study have been criticized in the last analysis. Most centers included in the ISAT were located in Europe, Australia and Canada. The U.S., Central and South America centers present different characteristics that could modify the final results of the study. The most relevant critic is that only 20% of the 9559 cases included in the ISAT were randomized. The selection of the majority of cases for one treatment could create some introducing bias. (23,24)

The present series has a mortality of 7.9%, all patients with HH 3 and 4. The inclusion of such patients increases the surgical mortality but the goal was to reduce the final mortality avoiding the natural selection performed by the conservative approach waiting for the patient's improvement. There was no definite morbidity or mortality in the patients with Hunt Hess graduation 1 and 2.

All the aneurysms included in the present series were clipped during the first surgical procedure. There was no case of failed approach.

The patients followed in the present series have no clinical evidence of rebleeding after microsurgical clipping. All patients had at least one post-operative interview to be included in the follow up group. Only 12 patients (13.6%) were submitted to postoperative angiography in the series, with total occlusion of the aneurysms in all of them. Nevertheless, even in the ISAT study, angiography was performed in only 47% of patients treated by microsurgical clipping because it is not a standard clinical practice in all centers. Rebleeding is the most serious risk for the patients that undergone endovascular procedures compared with microsurgical clipping. The ISAT data are: rebleeding in 28 patients of 1073 cases after endovascular treatment up to 1 year and rebleeding in 10 patients of 1070 cases with microsurgical clipping in the same period. After the first year an additional group of 7 patients have bled their aneurysms in the endovascular group and 2 patients in the microsurgical group. A recent study suggests that the initial benefit of the endovascular procedure evidenced by the ISAT cannot be assumed for patients younger than 40 years-old because of the better long-term results of the microsurgical clipping for such patients. In fact, the ISAT's technical outcome evidenced 92.5% of complete occlusion of the aneurysms in the endovascular group and 96.4% of total occlusion in the microsurgical group during the first treatment. Nevertheless, in the first angiography after treatment the total occlusion rate of the target aneurysm was 66% for endovascular and 82% for microsurgical clipping. Is it advantageous to offer a procedure with higher risk of incomplete occlusion for younger patients? (21,23,24)

In the ISAT, the experience of the surgeons and the endovascular interventionists were not clearly reported and could not be comparable. Different centers present microsurgeons and interventionists with different skills according to the characteristics of the departments and their routines. Interventionists were allowed to work in the study after having performed at least 30 endovascular procedures. The questions are: Is this number sufficient to allow a safe learning curve for all professionals? Can the final results be achieved if the endovascular procedures are performed by interventionists with less experience? Can the rates of total occlusion be higher in most experienced endovascular surgeons? (23,24,25)

Another interesting question is: Which are the morbidity and mortality rates for the patients who bled their aneurysms during the endovascular procedures compared with the cases when the aneurysms ruptured during the microsurgery?

When both procedures are presented to the patients as alternatives for the treatment, all these statistical data should be presented. The risk of not to be cured by the endovascular procedure is higher. There is a general risk of 33 % of fail in exclusion of the aneurysm of the circulation in such method compared with 18% in the microsurgery, using the same ISAT study as a

reference. There is an additional risk of periodical angiography that should be done to check the risk of aneurysm refilling in patients treated by endovascular techniques. Angiography after the microsurgical clipping usually is the final procedure if the aneurysm was excluded.

There were 15 unruptured aneurysms operated on in the present series, with no mortality. In this group, there was no transoperative rupture even in the first 50 aneurysms, and no definite morbidity. There were 2 transient hemiparesis (13.3%). In the International Study of Unruptured Intracranial Aneurysms (ISUIA) the overall rate of surgery-related morbidity and mortality was 17.5 % at 30 days and 15.7% at 1 year for patients with unruptured aneurysms without history of subarachnoid hemorrhage from a different aneurysm. (4,15,22,26)

In the last decade the number of endovascular interventionists is growing up, and there is a general tendency to indicate the method as the minimally invasive solution for all cases of ruptured aneurysms. The technical advances of such procedures are improving the results and it is superior to the microsurgical clipping in selected cases, especially in the posterior circulation and intracavernous aneurysms. (1,2,9,10,16,18,19,29,32) Older patients, the patients with poor neurological conditions at the initial hospital management are treated with lesser risks by endovascular coiling. The complexity of the microsurgical training to prepare a neurosurgeon to deal with aneurysms of the brain circulation is higher than to the endovascular procedures and it can be an attractive situation for choosing the second alternative to the youngest surgeons. (3,5,6,7,30,31) On the other hand, if the microsurgical skills are not encouraged, a considerable number of patients will be treated by endovascular procedures with a doubtful indication in the future. (8,27)

There is a special group of patients with ruptured aneurysms which needs microsurgery in almost all circumstances: patients with intracranial hematoma with mass effect needing evacuative surgery and direct control of the aneurysms. Such cases need a skilled microsurgeon to treat the intracranial hypertension and the rupture of the aneurysms during the surgical procedures should be controlled. It is another goal during the education of the neurosurgeons in order to avoid the dangerous situation of not being prepared to treat such emergency cases.

The costs of the methods of treatment of cerebral aneurysms are clearly favorable to the microsurgery. The coils and other technologies should improve their costs to be competitive with the clips and it is another important element to consider. (12,17,20)

The individual learning curve is a subjective data which modify the results in all medical procedures. In the present series, the second group of 50 patients presented better results in all the evaluated aspects.

## CONCLUSIONS

The microsurgical clipping of cerebral aneurysms of the anterior circulation is a safe and curative treatment for most of such lesions. Exceptions are the complete intracavernous aneurysms of the ICA which are better managed by endovascular techniques. At present, studies suggest evidences of superior results compared to the endovascular techniques in the rates of total occlusion of the aneurysms and lesser rates of rebleeding of the treated cases. The surgical repair of such lesions should be considered especially for the younger patients (age < 40). The results of the present series are similar to the rates of the most relevant literature.

## REFERENCES

- Batjer HH ( comments ) in: Haccin-Bey L, Connolly ESJr., Mayer SA, Young WL, Pile-Spellman J, Solomon SA. Complex intracranial aneurysms: combined operative and endovascular approaches. *Neurosurgery*. 1998; 43: 1304-12.
- Bendok BR, Ali MJ, Malisch TW, Russell EJ, Batjer HH. Coiling of cerebral aneurysm remnant after clipping. *Neurosurgery*. 2002; 51: 693-8.
- Cavalheiro S, Rogano LA, Braga FM. Aneurismas da artéria pericalosa. *J Bras Neurocir*. 1990; 2: 60-4.
- Chang HS. Simulation of the natural history of cerebral aneurysms based on data from the International Study of Unruptured Intracranial Aneurysm . *JNeurosurg*. 2006; 104:188-94.
- Chemale IM, Maciel ED, Andrade C. Anatomia microcirúrgica da artéria recorrente de Heubner. *J Bras Neurocir*. 1992; 3: 75-8.
- Chemale IM. Anatomia microcirúrgica dos segmentos A1 e A2 da artéria cerebral anterior. *J Bras Neurocir*. 1992; 3: 113-20.
- Chemale IM. Considerações hemodinâmicas sobre abordagem dos aneurismas da artéria comunicante anterior. *J Bras Neurocir*. 1996; 7: 22-30.
- Coert B, Chang S, Do H, Marks M, Steinberg A. Surgical and endovascular management of symptomatic posterior circulation fusiform aneurysms *J Neurosurg*. 2007; 106:855-65.
- Cristino Filho G, Braga FM. Complicações precoces da hemorragia subaracnóide por ruptura de aneurisma. Parte II – vasoespasmo sintomático. *J Bras Neurocir*. 2002; 13: 16-31.
- Diaz FG, Ohaegbulam S, Dujovny M, Ausman JI. Surgical alternatives in the treatment of cavernous sinus aneurysms. *J Neurosurg*. 1989; 71: 846-53.
- Fisher CM, Kistler JP, Davis JM. Relation of cerebral vasospasm to subarachnoid hemorrhage visualized by CT scanning. *Neurosurgery*. 1980; 6:1-9.
- Hoh B, Chi YY, Dermott MA, Lipori PJ, Lewis SB. The effect of coiling versus clipping of ruptured and unruptured cerebral aneurysms on length of stay, hospital cost, hospital reimbursement, and surgeon reimbursement at the university of Florida. *Neurosurgery*. 2009; 64:614-21.
- Hunt WE, Hess RM. Surgical risk as related to time of intervention in the repair of intracranial aneurysms. *J Neurosurg*. 1968; 28: 14-20.
- Hunt WE, Kosnik EJ. Timing and perioperative care in intracranial aneurysm surgery. *Clin Neurosurg*. 1974; 21: 79-89.
- International Study of Unruptured Intracranial Aneurysms Investigators: Unruptured intracranial aneurysms—risk of rupture and risks of surgical intervention. *N Engl J Med*. 1998; 339: 1725-33.
- 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: 138-46.
- Javadpour M, Jain H, Wallace CM, Willinsky RA, ter Brugge KG, Tymianski M. Analysis of Cost Related to Clinical and Angiographic Outcomes of Aneurysm Patients Enrolled in the International Subarachnoid Aneurysm Trial in a North American Setting. *Neurosurgery*. 2005; 56:886-94.
- Kato Y, Agrawal A, Sano H, Watabe T, Nagahisha S, Kanno T. Neuroendoscope in aneurysm surgeries: past, present and future. *J Bras Neurocir*. 2008; 19(2):36-41.
- Lawton MT, Quinones-Hinojosa A, Sanai N, Malek JY, Dowd CF. Combined microsurgical and endovascular management of complex intracranial aneurysms. *Neurosurgery*. 2003; 52: 263-75.
- Maset AL, Veiga JC, Saad N. Uma avaliação sobre a problemática dos cliques de aneurismas no Brasil. *J Bras Neurocirurg*. 2004; 15: 41-52.
- Mitchell P, Kerr R, Mendelow D, Molyneux AJ. Could late rebleeding overturn the superiority of cranial aneurysm coil embolization over clip ligation seen in the International Subarachnoid Aneurysm Trial? *J Neurosurg*. 2008; 108:437-42.
- Mocco J, Komotar RJ, Lavine S, Meyers P, Connolly ES, Solomon A. The natural history of unruptured intracranial aneurysms *Neurosurg Focus*. 2004; 17 (5):E3.
- Molyneux AJ, Kerr RSC, Stratton I, Sandercock P, Clarke M, Shrimpton J, Holman R, et al. International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomised trial. *Lancet*. 2002; 26(360): 1267-74.
- Molyneux AJ, Kerr RSC, Yu LM, Clarke M, Sneade M, International subarachnoid aneurysm trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomised comparison of effects on survival, dependency, seizures, rebleeding, subgroups, and aneurysm occlusion. *Lancet*. 2005; 366: 809-17.
- Nguyen T, Raymond J, Guilbert F, Roy D, Bérubé M, Mahmood M, et. al. Association of endovascular therapy of very small ruptured aneurysms with higher rates of procedure-related rupture. *JNeurosurg*. 2008; 108:1088-92.
- Prestigiacomo CJ, He W, Catrambone J, Chung S, Kasper L, Pa-

- supuleti L. et al. Predicting aneurysm rupture probabilities through the application of a computed tomography angiography-derived binary logistic regression model J Neurosurg. 2009; 110:1-6.
27. Proust F, Martinau O, Gérardin M, Derrey S, Levêque S, Bioux S, et al. Quality of life and brain damage after microsurgical clip occlusion or endovascular coil embolization for ruptured anterior communicating artery aneurysms: neuropsychological assessment. J Neurosurg. 2009; 110:19-29.
  28. Sekhar LN, DeJesus O. Clinoid and paraclinoid aneurysms. In: Shekar LN, Oliveira E. Editors. Cranial microsurgery: approaches and techniques. New York, Thieme. 1999; p. 151-75.
  29. Sinha S, Watabe T, Kato Y, Oguri D, Imizu S, Oda J et al. Suction decompression assisted clipping of large and giant internal carotid artery aneurysms – Na experience in 13 cases and review of literature. J Bras Neurocir. 2008; 19: 14-20.
  30. Stefani MA, Marrone ACH, Severino AG, Schneider FL. Importância Clínica e cirúrgica dos ramos corticais distais da artéria cerebral anterior. J Bras Neurocir. 1997; 8: 41-50.
  31. Stoodley MA, Steinberg GK. Aneurysm retreatment after Guglielmi detachable coil and nondetachable coil embolization: report of nine cases and review of literature. Neurosurgery. 1999; 44: 719.
  32. Tedeschi H, Castro JM, Ferreira MAT, Wen HT, Oliveira E. Aspectos técnicos e resultados do bypass de alto fluxo com veia safena para aneurismas complexos. J Bras Neurocir. 1999; 10: 5 - 14.

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