

# Case-series analysis of intracranial saccular aneurysms treatment

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Nowadays, selection of the best treatment method for intracranial aneurysms is one of the most discussed topics. We report our operative and coiling experience of 128 cases – series with 106 ruptured and 22 unruptured aneurysms. The aim of the research was to identify the factors influencing the optimal radical method for treatment of intracranial aneurysms and to compare the neurosurgical and neuroradiological activity of our hospital with that of other regions of the world.

Of 128 aneurysms the clipped group was 94 patients (mean age  $\pm$  SD: 52.21  $\pm$  13.34 years, 73.4%) while 34 patients underwent aneurysm embolization (mean age  $\pm$  SD: 61.59  $\pm$  13.34 years, 36.6%). Most of the aneurysms were located at the anterior communicating artery ( $n = 36$ , 28.13%), the middle cerebral artery ( $n = 34$ , 26.56%) and the internal carotid artery ( $n = 20$ , 15.63%). Comorbidity, neurology status at admission, clinical outcomes, operative complications, aneurysm localization, size and condition were analysed.

According to our experience, surgical clipping of aneurysms is more efficient and safe for patients with no or mild comorbidity, with less severe neurological symptoms, ruptured aneurysms, and anterior cerebral circulation aneurysms.

**Key words:** intracranial aneurysm, surgical clipping, embolization

## INTRODUCTION

Nowadays, selection of the best treatment method for intracranial aneurysms is one of the most discussed topics in neurosurgeons' daily practice. Aneurysms can be treated by clipping the base of the aneurysm with a specially-designed titanium clip or by coiling the aneurysm sack with platinum

coils (1–4). The prevalence of intracranial saccular aneurysms by radiographic and autopsy series is estimated to be 3.2 (1.8–5.0) percent in a population without comorbidity (5–9). The aneurysm rupture rate is about 6–10 cases per 100,000 population per year (3, 10). The first month mortality of ruptured aneurysm is about 50%, whereas it reaches 80% after aneurysm re-rupture (3, 11). Anterior cerebral circulation aneurysms are more frequent than posterior cerebral circulation aneurysms: about 95% versus 5% (1–7). The most frequent location for intracranial aneurysms is

the anterior communicating artery (AcomA) and represents an increased risk of rupture as compared to aneurysms in other locations (12–16). The purpose of this study was to identify the factors influencing the optimal radical method of intracranial aneurysm treatment. The aneurysm localization, size of the aneurysm sac and neck, diagnostic imaging method, comorbidity, neurology status at admission and clinical outcomes are specified and presented.

## MATERIALS AND METHODS

We retrospectively analyzed 128 patients from March 2011 through March 2013, who underwent the radical treatment of a cerebral artery aneurysm at the Neurosurgery Section of Vilnius University Hospital. The patients were divided into 2 groups: a) the clipped group – patients who underwent the operative treatment ( $n = 94$ ) and b) the coiled group – patients who underwent aneurysm embolization ( $n = 34$ ). These groups were compared estimating the aneurysm location, condition (ruptured or unruptured), size of the sac and neck, age of the patient, Glasgow Coma Scale (GCS) and outcomes according to the Glasgow Outcome Scale (GOS).

The Pearson correlation test was used to analyse correlations between variables studied. The univariate logistic regression analysis was used to determine which of many factors should be entered into the multivariate analysis. The Statistical Package for the Social Sciences software (SPSS, Chicago, IL, USA) was used for statistical calculations. A  $p$  value of less than 0.05 was considered statistically significant.

We have searched articles published from 2005 to 2013 in electronic databases such as Ovid-Medline, Ovid-Embase, Neurointervention with keywords – intracranial aneurysm, intracranial aneurysm treatment, intracranial aneurysm coiling, intracranial aneurysm embolisation, intracranial aneurysm clipping, etc.

## RESULTS

From March 2011 through March 2013 one hundred twenty eight (128) patients underwent treatment of a cerebral artery aneurysm at the Neurosurgery Section of Vilnius University Hospital.

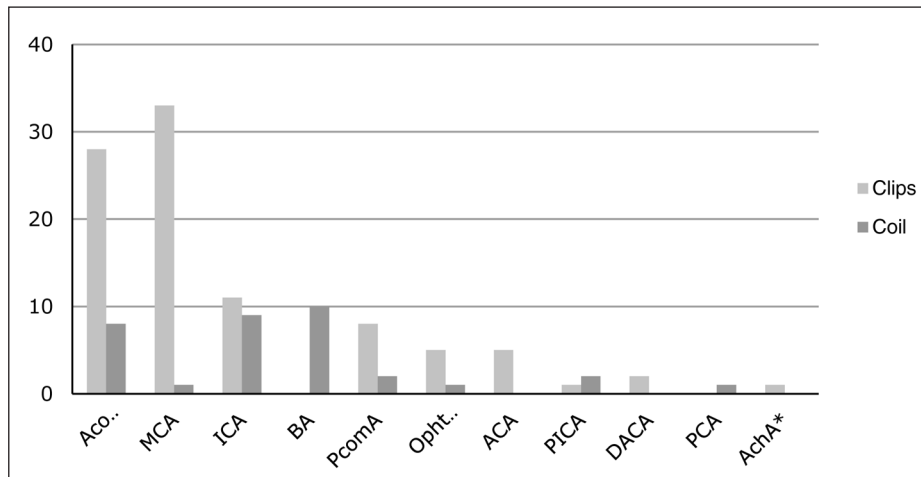
Ninety four (94) patients were selected for surgical treatment (the clipped group;  $n = 94$ , 73.4%) while thirty four (34) patients underwent aneurysm embolization (the coiled group;  $n = 34$ , 36.6%). The average of the patients' age was reported both in the clipped group (mean  $\pm$  SD:  $52.21 \pm 13.34$  years) and in the coiled group (mean  $\pm$  SD:  $61.59 \pm 13.34$  years) ( $p = 0.043$ ). Males accounted for 40.43 percent ( $n = 38$ , 40.43%) of all patients in the clipped group while in the coiled group they accounted for 35.29 percent ( $n = 12$ , 35.29%) ( $p = 0.599$ ). CTA was assigned as the main diagnostic method for 85 patients (90.34%) of the clipped group, angiography for 8 patients (8.59%) and MRA only for 1 patient (1.07%). However, CTA was assigned as the main diagnostic method for 21 patients (61.76%) of the coiled group, angiography for 11 patients (32.35%) and MRA for 2 patients (5.89%) ( $p = 0.005$ ).

Most aneurysms were located at the anterior communicating artery ( $n = 36$ , 28.13%), the middle cerebral artery ( $n = 34$ , 26.56%) and the internal carotid artery ( $n = 20$ , 15.63%). Aneurysms of the arteries, which belong to the posterior cerebral circulation, accounted only for 10.94 percent ( $n = 14$ , 10.94%). Clipping was assigned unambiguously for these aneurysms, which were placed at the anterior cerebral artery (and its distal segment) and at the anterior choroidal artery (100%). However, coiling was attributed unreserved for complex anterior cerebral circulation aneurysms, f. ex. posterior position aneurysms of the anterior communicating artery embolization method was applied exclusively (6 cases out of 6, or 100% of cases), at the basilar artery ( $n = 10$ ) and at the posterior cerebral artery (100%). Both of treatment methods were used for the aneurysms of other locations (the anterior and posterior communicating arteries, the middle cerebral artery, the internal carotid artery, the ophthalmic artery and the posterior inferior cerebellar artery) ( $p < 0.001$ ). Detailed figures about the location of aneurysms are presented in Table 1 and Figs. 1, 2.

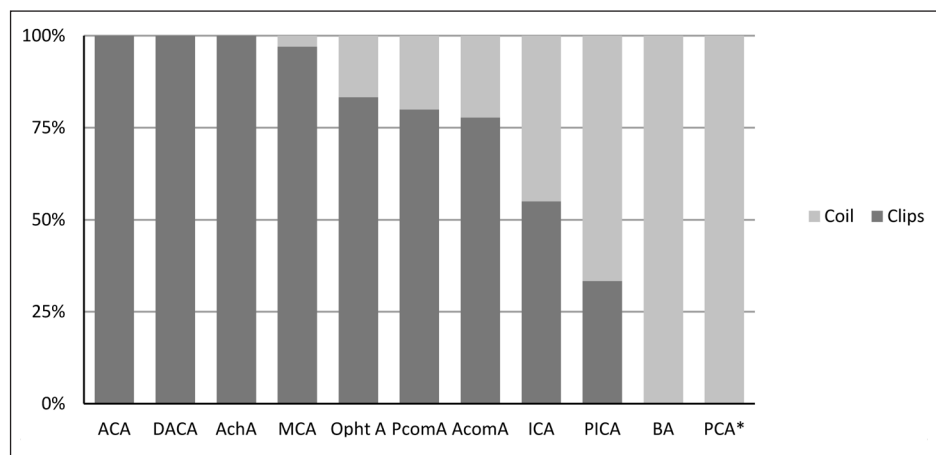
The condition of an aneurysm was evaluated in both groups. There were 83 patients (88.3%) with ruptured aneurysms and 11 (11.7%) patients with unruptured aneurysms in the clipped group. Detailed figures about the size of aneurysms and their necks are presented in Table 2.

**Table 1.** Methods of intracranial aneurysm treatment

Method of treatment	Anterior cerebral circulation		Posterior cerebral circulation	
	Amount	Frequency, %	Amount	Frequency, %
Operation	93	81.6	1	7.1
Embolization	21	18.4	13	92.9
All	114	100	14	100



**Fig. 1.** Location (number) of aneurysms. AcomA – anterior communicating artery, PcomA – posterior communicating artery, ACA – anterior cerebral artery, DACA – anterior cerebral artery (distal segment), PCA – posterior cerebral artery, MCA – middle cerebral artery, ICA – internal carotid artery, BA – basilar artery, PICA – posterior inferior cerebellar artery, OphtA – ophthalmic artery, AchA – anterior choroidal artery



**Fig. 2.** Treatment method by location of aneurysms (frequency %). AcomA – anterior communicating artery, PcomA – posterior communicating artery, ACA – anterior cerebral artery, DACA – anterior cerebral artery (distal segment), PCA – posterior cerebral artery, MCA – middle cerebral artery, ICA – internal carotid artery, BA – basilar artery, PICA – posterior inferior cerebellar artery, OphtA – ophthalmic artery, AchA – anterior choroidal artery

**Table 2.** The size of aneurysms and their necks

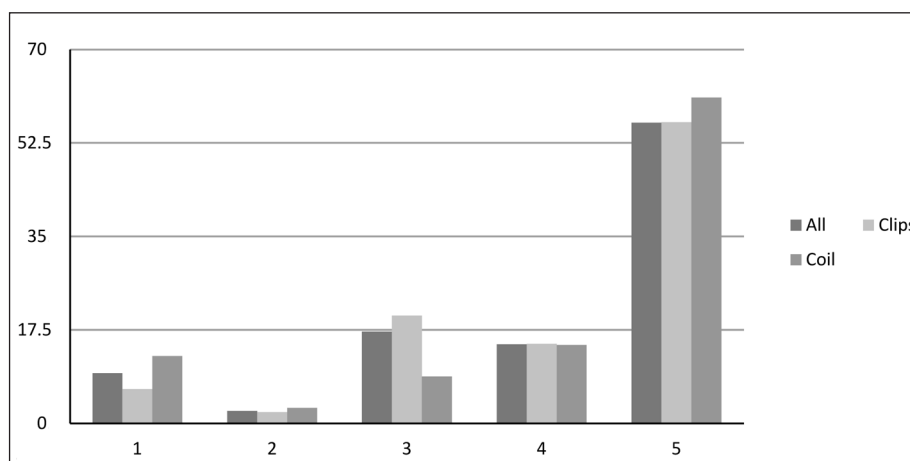
Method of treatment	Size of aneurysm, mm		Size of aneurysm neck, mm	
	Mean	SD	Mean	SD
Operation	9.24	5.16	4.09	2.09
Embolization	9.21	4.21	4.44	4.21

Distribution of patients according to GCS was similar for both the clipped and the coiled groups. The score was about 13.3 points (mean  $\pm$  SD:  $13.31 \pm 2.51$ ) in the clipped group and about 13.44 points (mean  $\pm$  SD:  $13.44 \pm 2.73$ ) in the coiled group. Testing comorbidity (primary arterial hypertension, diabetes, pneumonia, urinary tract infection) and motor deficits (paresis or plegia of extremities, ataxia, aphasia, dysarthria, injuries of III, IV, VI cranial nerves) of patients before surgery or embolization there were 54 patients (57.45%) with comorbidity and 30 patients (31.91%) with motor deficits in the clipped group while in the coiled group the data distributed in this way: 27 patients (79.41%) with comorbidity and 14 patients (41.18%) with motor deficits ( $p = 0.020$ ).

In the clipped group there were 13 patients (13.8%) with positive change, 43 patients (45.8%) with negative change and 38 patients (40.4%) with no change of neurological symptoms and outcomes according to the GOS. However, there were 6 patients (17.6%) with positive change, 7 patients (20.6%) with negative change and 21 patients (61.8%) with no change of neurological symptoms in the coiled group ( $p = 0.043$ ). Detailed figures about outcomes according to the GOS are presented in Fig. 3.

## DISCUSSION

Surgical clipping has been the gold standards in the treatment of cerebral aneurysms. In 1990, the Guglielmi detachable coil was introduced into clinical use, and was approved by FDA in 1995. After the International Subarachnoid Aneurysm Trial (ISAT) in 2002, endovascular coil embolization of cerebral aneurysms has been accepted and regarded as an equal or better alternative (17). Over the past 23 years, the aneurysm coiling procedure has been increasingly gaining ground in practice. For this purpose, numerous studies are conducted in order to discover new gold standards – which method under what circumstances to choose. On the basis of meta-analysis, the following trends of the aneurysms surgery practice are established in the developed countries: 1) patients with unruptured intracranial aneurysms are often treated to prevent subarachnoid hemorrhage (SAH), and these prophylactic treatments include neurosurgical clipping and endovascular coiling; 2) neurosurgical clipping of the aneurysm was the standard treatment prior to the introduction of detachable coils, but endovascular coiling has recently been increasing; 3) neurosurgical clipping is recommended over endovascular coiling for young patients

**Fig. 3.** Glasgow Outcome Scale (GOS) (number of patients)

and for small or anterior circulation aneurysms; 4) neurosurgical clipping is an order of magnitude more durable than endovascular coiling, but endovascular coiling is less invasive than neurosurgical clipping (18).

The majority of studies recognize that elective coiling is a better procedure than elective clipping. According to the U. S. study 2010, the trend of U. S. hospitals use of the coiling procedures has increased during recent years. This is due to the conclusions that elective coiling of unruptured intracranial aneurysms is associated with fewer deaths and perioperative complications compared with elective clipping (19). After 3 years, another researchers of U. S. added to the first scientists and announced that among patients treated for unruptured intracranial aneurysms in a large sample of hospitals in the United States, clipping was associated with similar mortality risk but significantly higher periprocedural morbidity risk compared with that of coiling (20). According to our research results, coiling was associated with higher periprocedural and postprocedural mortality risk (GOS = 1) but significantly lower periprocedural morbidity risk compared with that of clipping. Such a high coiling mortality risk could be explained by the fact that the first aneurysm coiling procedure in our hospital was performed only in 2011. Moreover, the coiling procedure in our hospital was more often designated for patients with comorbidity and more severe neurological symptoms.

Not only the scientists from the U. S. prefer coiling rather than clipping, but also the researchers from other countries, for example, Korea. From 2003 to 2007, numbers of endovascular coil embolization of cerebral aneurysms has increased two-fold while surgical clipping has remained stable in Korea (17). The scientists from Korea in their article compared endovascular coiling and neurosurgical clipping in patients with unruptured intracranial aneurysm in 2012. They came to the essential conclusion that coiling is a better procedure for treatment of unruptured intracranial aneurysm in terms of disability, complications, especially in the short term (18). The situation is the same in our hospital – according to our research results, coiling is a better procedure for treatment of unruptured intracranial aneurysms. Moreover, the coiling procedure performed in our hospital is annually increasing.

On the other hand, the researchers of another U. S. study critically evaluated a coiling procedure and they were in favour of collaboration by a highly experienced cerebrovascular team of microneurosurgeons and endovascular neurosurgeons. This team should use a decision-making paradigm designed to offer only low-risk treatments (21). The similar rule is followed in our hospital – the patient's treatment is mainly governed by the general decision of surgeons and radiologists' team.

In terms of the situation of ruptured aneurysms in the U. S., the researchers of the study 2013 provide the data base of multiple hospitals in the United States, which demonstrates that clipping of ruptured cerebral aneurysms resulted in greater adjusted morbidity compared with that of coiling (20). In addition, similar tendencies continue in other countries. For patients in good clinical condition with ruptured aneurysms of either the anterior or posterior circulation the researchers of the Netherlands have firm evidence that, if the aneurysm is considered suitable for both surgical clipping and endovascular treatment, coiling is associated with a better outcome (22). However, according to our research results, there were more frequently selected operations for ruptured aneurysms treatment – clipping was associated with a lower periprocedural and postprocedural mortality risk.

Moreover, one of the most important aspect of choosing a method of aneurysm treatment is an aneurysm location. There are some specific arteries, which aneurysms for some reason are suitable for one or other treatment method. These reasons are usually aneurysm achievement path complexity, frequency of complications, etc. As most famous Finnish neurosurgeons described in the article their experience in operating aneurysms of the vertebral and basilar artery, it concludes that the surgical path of the vertebral and basilar artery is difficult enough. For example, lower cranial nerve deficits are common in the immediate postoperative period even when carefully handled intraoperatively; septicemia complications were more common than at other aneurysm locations; blood flow to vital medullary perforators may be compromised and this can be fatal or lead to a poor outcome; intraoperative aneurysm rupture (7%) was rare but dangerous (23).



However, Finnish neurosurgeons described in another article that aneurysms of the distal anterior cerebral artery are perfectly suitable for microsurgery operation. As they described, microsurgical treatment of the distal anterior cerebral artery aneurysms showed the same complication rates as for other ruptured aneurysms. At 1 year after subarachnoid hemorrhage, they had a similar favourable outcome as other ruptured aneurysms, but their mortality rate was lower (24).

Because of many various scientific researches and articles, the consensus about the selection of intracranial aneurysm treatment method is not reached. There are also written several meta-analyses trying to solve this problem. Despite the fact that it was based on different sources, the essential conclusion of these meta-analyses is the same. And these findings may serve as a supplement to the previously mentioned provisions, which are established such as trends of the aneurysms surgery practice in the developed countries: 1) there is a strong evidence to indicate that endovascular coil embolization is associated with better outcomes compared with surgical clipping in patients amenable to either therapeutic strategy; 2) coiling yields a better clinical outcome, the benefit being greater in those with a good preoperative grade than those with a poor preoperative grade; 3) however, coiling leads to a greater risk of rebleeding (25, 26). However, because of the fact that our study was retrospective, it is difficult to definitely state that endovascular coil embolization is associated with better outcomes compared with surgical clipping. According to our research results, the best outcomes after coiling were observed in older ailing patients with unruptured aneurysms.

Finally, although elective coiling selection frequency is increasing throughout the world, but there is substantial regional variation in the adoption of endovascular techniques (27). Dissemination of endovascular procedures appears widespread across patient and hospital subgroups. For example, the majority of unruptured aneurysms in the USA are now treated with endovascular coiling. Although surgical clipping is used for treatment of most ruptured aneurysms, its use is decreasing over time. The use of coiling spreads from primarily large, teaching hospitals to smaller, non-teaching hospitals (28). Similar trends are in Korea, Australia and Singapore (17, 18, 29, 30).

In addition, the researchers from Czech Republic wrote an article about aneurysm treatment in Europe in 2010. According to this article, the main finding was that clipping was used significantly more often in Eastern Europe than in the rest of Europe to treat ruptured and unruptured aneurysms of the anterior circulation. Posterior circulation aneurysms are treated predominantly by coiling, regardless of the aneurysm status or geographical location (31). The same conclusion was obtained in our study – better outcomes after the coiling procedure were observed in patients with posterior cerebral circulation or complex anterior cerebral circulation aneurysms and in cases in which the surgical path was difficult enough.

According to the researchers from Czech Republic, the average number of coilers versus surgeons per centre was 2.5:3.0 in Western, 1.9:3.6 in Southern, 1.9:4.3 in Eastern and 2.7:3.1 in Northern Europe (31). The capacity in the treatment of intracranial aneurysms in our hospital is 73.4% (clipping versus coiling; 2:1). Summing up the situation in Europe, it should be mentioned that the way in which intracranial aneurysms are treated correlates with the economic development of European countries. It is also affected by the lack of experienced coilers in Eastern Europe (31).

## CONCLUSIONS

Even after 23 years, there is no straight answer what is the most appropriate method of aneurysm treatment. Also, the management of unruptured cerebral aneurysms remains one of the most controversial topics in neurosurgery.

According to our research, surgical activity in operating intracerebral aneurysms is 73.4%, embolization of aneurysms is more suitable for more complex cases: 1) older patients; 2) patients with comorbidity, more severe neurological symptoms; 3) unruptured aneurysms; 4) posterior cerebral circulation (especially the basilar artery) or complex anterior cerebral circulation aneurysms; 5) cases in which the surgical path is difficult enough (the basilar artery). However, surgical clipping of aneurysms is more suitable for less complex cases: 1) younger patients; 2) patients with no or mild comorbidity, less severe neurological symptoms; 3) ruptured aneurysms; 4) less complex anterior cerebral circulation aneurysms; 5) cases in which

the surgical path is perfectly suitable (for example, a distal segment of the anterior cerebral artery).

Received 4 May 2015

Accepted 5 November 2015

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## INTRAKRANIJINIŲ ANEURIZMŲ GYDYMO ATVEJŲ ANALIZĖ

### *Santrauka*

Šiais laikais geriausio intrakranijinių aneurizmų gydymo metodo pasirinkimas yra viena iš labiausiai diskutuotinių medicinos temų. Šiame straipsnyje pristatome 128 intrakranijinių aneurizmų chirurginio gydymo ir embolizavimo atvejus: 106 pacientus su plyšusiomis ir 22 – su neplyšusiomis aneurizmomis. Mūsų tyrimo tikslas – nustatyti veiksnius, nulemiančius optimalaus ir radikalaus intrakranijinių aneurizmų gydymo pasirinkimą, ir palyginti neurochirurginį bei neuroradiologinį mūsų ligoninės aktyvumą su įvairių kitų pasaulio regionų ligoninėmis.

Tyrimo metu buvo ištirti 128 pacientai: 94 asmenys (vidutinis amžius  $\pm$  SD: 52,21  $\pm$  13,34 metai, 73,4 %) sudarė klipuotų pacientų grupę, o 34 asmenys (vidutinis amžius  $\pm$  SD: 61,59  $\pm$  13,34 metai, 36,6 %) – embolizuotų. Dažniausios aneurizmų lokalizacijos: priekinė jungiančioji arterija ( $n = 36$ , 28,13 %), vidurinė smegenų arterija ( $n = 34$ , 26,56 %) ir vidinė miego arterija ( $n = 20$ , 15,63 %). Išanalizuota gretutinių ligų įtaka, neurologinio ištyrimo duomenys, gydymo rezultatai, operacinės komplikacijos, aneurizmų lokalizacija, dydis ir būklė.

Remiantis mūsų patirtimi, chirurginė aneurizmų gydymo taktika yra efektyvesnė ir saugesnė pacientams su kliniškai nereikšmingomis gretutinėmis ligomis arba be jų, su mažiau išreikštais neurologiniais simptomais, plyšusiomis priekinės smegenų kraujotakos aneurizmomis.

**Raktažodžiai:** intrakranijinė aneurizma, chirurginis gydymas, embolizavimas