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Anterior communicating artery aneurysm rupture and functional outcome in short-term: clipping versus coiling

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Our research aims to assess the change in the grade of responsiveness using the Hunt and Hess score as well as the modified ranking scale in patients suffering from anterior communicating artery rupture. We retrospectively analyzed data from 11-patients who suffered from an anterior communicating artery aneurysm rupture that caused a subarachnoid hemorrhage. Severity was assessed using the Hunt and Hess scale grade and modified ranking scale. Anterior communicating artery rupture caused a subarachnoid hemorrhage in 40.81% of all aneurysm ruptures that took place at the Circle of Willis. Unfortunately, 4-patients deceased (3.4%) at a median age of 52-years (range 34-75-years), three of which deceased after coiling and one after clipping. In 71-patients (61.2%) endovascular coiling was performed - 33-males and 38-females - and in the remaining 45-cases, (38.8%) clipping was indicated - 24-males and 21-females. Overall, the pre-interventional median Hunt and Hess scale was 2, which remained after the intervention. When relating the outcome score to the intervention performed, we found that the Hunt and Hess scale score was 3 before coiling and 2 before clipping, whereas afterward, there was a slight increase to 2 and 2, respectively. The modified ranking scale was 2 after clipping, respectively, coiling (P = 0.218). No significant differences were observed between the different groups. Our results show that clipping is as effective as coiling in terms of the Hunt and Hess scale and the rate of mortality in the short-term.

Keywords

Subarachnoid hemorrhage; intracranial aneurysm; vascular disorders; neurological surgery

1. Introduction

Acute subarachnoid hemorrhages are often a result of a ruptured saccular intracranial aneurysm. These saccular aneurysms are found in the Circle of Willis (Gasparotti and Liserre, 2005) in 85% of patients, most frequently within the anterior communicating artery (ACoA) (30 to 40%) (Pierot et al., 1996). Patients with ruptured ACoA present with a variety of different dome projec-

tions, the involvement of branch and daughter vessels, which may result in different parenchymal damages, as well as neurological symptoms (Moon et al., 2015). The mortality rate for non-ruptured aneurysm intervention is described to be between 1.0% and 1.1% in coiling and between 2.6% to 3.8% in clipping (Keedy, 2006). In ruptured aneurysms, it is stated to be between 25% and 50% (Keedy, 2006).

Treatment procedures typically vary between wrapping, trapping, clipping, coiling, and sometimes proximal (Hunterian) ligation. Today, clipping and coiling are favored and therefore performed most frequently. For the last century, the gold standard was microsurgical clipping. However, in recent years, endovascular coiling has become more prevalent in clinics (Alreshidi et al., 2018; Deruty et al., 1996; Raftopoulos et al., 2003; Regli et al., 1999).

Coiling is typically thought to be slightly less invasive than clipping, due to the avoidance of large incisions and craniotomies. Therefore, authors have described morbidity and mortality in non-ruptured aneurysm prevention surgery to be at a lower risk in coiling than in clipping (Smith et al., 2015).

To assess the postoperative outcome, a variety of scores have been described. Today, the most common scales include the Hunt and Hess score (HH) (Hunt and Hess, 1968), the modified ranking scale (Broderick et al., 2017), and the World Federation of Neurological Surgeons Grading system (WFNS) [1].

The Hunt and Hess score was first described in 1968 and is one of the most frequently employed scores for identifying a changed state of responsiveness (Hunt and Hess, 1968; Van Gijn et al., 1994). It utilizes both a neurological examination and the patient's anamnesis to identify and correlate an appropriate responsiveness grade, especially before intervention (Singer et al., 2017).

2. Patients and methods

Inclusion criteria for our study consisted of patients older than 18 years who presented with ACoA rupture to the National Institute of Neurosurgery, Budapest, Hungary, who underwent either

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[1] 1988 Report of World Federation of Neurological Surgeons Committee on a Universal Subarachnoid Hemorrhage Grading Scale. Neurosurgery vol 68, pp. 985-986.

coiling or clipping. The diagnosis was revealed by radiological imaging - computed tomography, and the indication was made based on an interdisciplinary decision between the neurosurgeon and the interventional neurologist. Patients with severe neurological deficits were more likely to be coiled endovascularly. Exclusion criteria consisted of patients with aneurysm ruptures in any other location, patients who underwent a different treatment procedure, or patients younger than 18 years. Immediately after the intervention, patients were monitored in an intermediate care unit and transferred to a standard recovery room if the patient was stable without any significant neurological symptoms.

A total of 116 patients that fit our criteria were identified between 2010 (63 patients) and 2011 (53 patients). The radiological imaging and medical documentations were critically reviewed by a single investigator. Demographic data of the patients, including gender, ethnicity, age, residency aneurysm location, type of intervention, and comorbidities, were noted. Based on the anamnesis and clinical examinations at admission, the pre-interventional Hunt and Hess score was assessed in each case to minimize bias. Five days after the intervention, the anamnesis, clinical examinations, HH grade, and modified ranking scale were noted. When the HH was between two grades, we assumed the worse was present.

For calculations, Microsoft Excel and IBM SPSS Statistics 25 were used. For categorical variables, the median and range were used. For normally distributed continuous variables, the mean and standard deviation (SD) were calculated and presented to one decimal place. In our statistical analysis, a Mann-Whitney U test was performed to calculate the differences between the categorical variables. For normally distributed continuous variables, a t-test was applied. Furthermore, Hunt and Hess scores and the modified ranking scales percentages are presented.

3. Results

In total, 294 subarachnoid hemorrhage (SAH) resulted from non-traumatic aneurysm rupture and underwent treatment at our center between 2010 and 2011. The most common affected artery was the ACoA in 40.8%, followed by the middle cerebral artery in 31.0%, and basilar artery in 13.3%. In 9.2% of cases, a vertebral artery aneurysm rupture was identified as a cause of the SAH, and the remaining 5.8% were related to a posterior communicating artery aneurysm rupture.

Within the 116 patients who suffered from ACoA aneurysm rupture, gender was equally distributed; females were affected in 50.9% of cases ($P = 0.476$). The median age was 50 years (range 28 to 75 years). The median age for basilar artery aneurysm ruptures was 52 years (range 23 to 74years), middle cerebral artery aneurysm ruptures was 53 years (range 1 to 75years), vertebral artery aneurysm ruptures was 54 years (range 32 to 69 years) and posterior communicating artery aneurysm ruptures was 56 years (range 32 to 83years).

Unfortunately, 4 patients (one female and three male patients) deceased (3.4%) after intervention at a median age of 52 years (range 34 to 75 years). The endovascular coiling intervention had previously been performed in three patients, and the clipping procedure had been performed previously in one patient. In the instances of morbidity, the patients deceased in the mean of 12 days after hospital admission (range from 6 to 19 days) and 8.5 days

after surgery was performed (range from 3 to 19 days).

When looking at the type of intervention performed, 71 patients (61.2%) underwent endovascular coiling, 33 men and 38 women, and in the remaining 45 cases (38.8%), the clipping procedure was performed (24 males and 21 females). There was a mean delay time of 2.3 ± 4.0 days between presentation to the emergency department and intervention. Although patients who underwent clipping were operated on slightly earlier (1.4 ± 2.0 vs. coiling 2.8 ± 4.7), no significances were found ($P = 0.536$).

In assessing neurological symptoms at admission, aphasia was present in the coiling group (n = 3). However, this improved after the intervention. Furthermore, facial paresis was observed in both groups (2 cases for each). Postoperatively, aphasia was observed in 4 patients, the clipping group, and paresis was observed in 9 patients that underwent coiling, and 3 that underwent clipping (delayed ischemic neurological deficit). The pre-interventional median responsiveness grade was 2 overall (range 1 to 4), which remained equivalent between pre- and postintervention in the median. Concerning the type of intervention, the Hunt and Hess grade was 3 (range 1 to 4) before the coiling procedure, whereas afterward, it improved slightly to 2 (range 1 to 4). Before the clipping procedure, the median pre-interventional grade was 2 (range 1 to 4), which remained the same after surgery (median 2; range 1 to 5). No significant difference was observed in the post interventional modified ranking scale (both medians 2 range 1 to 6; $P = 0.218$).

In 25 cases (21.6%), a ventricular drain was inserted to control the postoperative intracranial pressure, as these were Grade 4, according to Fisher Grade. Comorbidities included 51 patients suffering from hypertension, which has already been described in the literature as a predisposing factor, without any differences between the groups ($P = 0.295$). In 5 cases, the patients suffered from an aneurysm re-rupture. Females were predisposed, with 3 cases (40.0%) at a median age of 54 years (range from 54 to 65years). Out of these rerupture cases, 4 underwent coiling, and 1 underwent the clipping procedure. Unfortunately, one patient died after performing the coiling intervention.

All results are illustrated in Table 1.

4. Discussion

According to the literature, it seems that coiling procedures are becoming more and more popular. Since 2012, more coiling procedures are performed than clipping surgeries, leading to a replacement of the conventional surgical maneuvers (Suh, 2017). At our center, we identified that the coiling procedure had been performed more in 2010 (65.15%) than in 2011 (49.12%). Why such an increase in this particular period is of special interest for further investigation.

According to the literature, females over the age of 60 are at the highest risk for SAH. However, our data suggest that both genders are equally at risk, with males approximately 5.35 years younger (median 46 years) than females (54 years). One possible explanation for this may be the protecting effect of estrogen in females.

To evaluate patient responsiveness, we used the Hunt and Hess grade, as it is easy to apply and assess. Postoperatively, we assessed the modified ranking scale for clinical outcomes, even though some terms are instead somewhat vague, and symptoms

Table 1. Patient characteristics' and neurological state; percentages presented in brackets

	Clipping	Coiling	Significances	Overall
No. of patients	45 (38.8)	71 (61.2)		116
Female sex, in no. (%)	21 (46.7)	38 (53.5)	0.476	59 (50.9)
Median age median (range)	53 (28-75)	49 (33-70)	0.967	50 (28-75)
No. of deaths	1 (2.2)	3 (4.2)	0.58	4 (3.4)
Mean Hunt and Hess score median	2 (1-4)	3 (1-4)		2 (1-4)
Hunt and Hess score, no. before			0.203	
1	22 (48.9)	19 (26.8)		41 (35.3)
2	11 (24.4)	16 (22.5)		27 (23.3)
3	9 (20.0)	25 (35.2)		34 (29.3)
4	3 (6.7)	11 (15.5)		14 (12.1)
5	0	0		0
Mean Hunt and Hess score median	2 (1-5)	2 (1-4)	**0.006**	2 (1-5)
Hunt and Hess score, no. after				
1	11 (24.4)	9 (12.7)		20 (17.2)
2	19 (42.2)	36 (50.7)		55 (47.4)
3	12 (26.7)	14 (19.7)		26 (22.4)
4	2 (4.4)	12 (16.9)		14 (12.1)
5	1 (2.2)	0		1 (0.9)
Modified Ranking Scale median	2 (1-6)	2 (1-6)	0.218	2 (1-6)
0	9 (20.0)	11 (15.5)		20 (17.2)
1	9 (20.0)	9 (12.7)		18 (15.5)
2	11 (24.4)	17 (23.9)		28 (24.1)
3	6 (13.3)	14 (19.7)		21 (18.1)
4	3 (6.7)	11 (15.5)		14 (12.1)
5	6 (13.3)	6 (8.5)		12 (10.3)
6	1 (2.2)	3 (4.2)		4 (3.4)
Diabetes mellitus	2 (4.4)	1 (1.4)	0.307	3 (2.6)
Hypertension	17 (37.8)	33 (46.5)	0.295	51 (43.1)

may fit into different grades. Aulmann et al. (1998) performed a systematic review and found a suboptimal sensitivity, specificity, and predictive value. The interobserver variability for the scale is moderate and stated to be between 0.41 and 0.48 (Degen et al., 2011; Lindsay et al., 1983; Oshiro et al., 1997). Additionally, it has been stated that there are significant differences in the outcome on follow-up, depending on the grades. Overall, grades 1 to 3 had better outcomes compared to grades 4 and 5 (Proust et al., 1995). This may explain why sometimes the Hunt and Hess grade I to III are merged to "good grade" and grade IV and V to "poor grade" (Schuss et al., 2013). However, we assume that it is better to present the cumulated average of the HH grade. Currently, the World Federation of Neurological Surgeons Grading Scale is accepted worldwide, since it is easy to use and compatible with formerly employed scales (Ducati, 1998). However, there are some limitations since aphasia can create confusion as this would be classified as verbal 1 in the Glasgow Coma Scale, and there-

fore graded as WFNS 4 instead of grade 2 or 3. On the other hand, patients with a focal deficit involving expressive language function with focal deficits may score verbal 5, but a WFNS grade 1 (Ogungbo, 2003).

In performing our literature review, the clipping technique seems to show a higher cumulative burden, like encephalomalacia in the frontal lobes (Hadjivassiliou et al., 2001), or mortality rate (Keedy, 2006) among patients compared with those who undergo coiling (Heit et al., 2017). These findings could not be confirmed in our study. Not surprisingly, coiling shows a higher incidence in ischemic, embolic infarction due to puncture of the vessels and symptomatic vasospasm (Jones et al., 2015). In contrast to the findings of Keedy (2006), Xia et al. (2017) and Krings et al. (2006) concluded that the risk and mortality in coiling are still greater. On the other hand, Heit et al. (2017) stated that the incidence of cerebral infarction in the vascular distribution of the recurrent artery of Heubner during clipping procedure was signifi-

cantly higher than coiling related embolization, leading to a lesion in the medial and basal striatum (mainly the caudate head), memory dysfunction, and behavioral deficits (Martinaud et al., 2009; Mizuta and Motomura, 2006). Based on neuropsychological tests, it is postulated that the cognitive outcome after clipping has a more negative impact than coiling (Chan et al., 2002; Hadjivassiliou et al., 2001; Heit et al., 2017; Molyneux et al., 2005).

When considering the costs of hospitalization and intervention - i.e., devices - into account, it seems that coiling is still more expensive than in clipping, even though the patient's overall hospital stay is shorter (Chang et al., 2016; Duan et al., 2015).

At our center, the short-term results revealed no improvement in the Hunt and Hess score before versus after the procedure for clipping (median H&H 2). In the coiling procedure, the pre-interventional grade was calculated to be 3 with an improvement to 2 after intervention. Likewise, the HH scale showed no significant differences in the modified ranking scale, which was 2 for clipping and coiling. The most common comorbidity was hypertension, which effected 51 patients. Seven patients deceased in total, three of them after initiating palliative/observational treatment and 4 after performing a procedure (3 after coiling, 4.22% and 1 after clipping, 2.22%). As far as the complications that were identified, symptomatic vasospasm was observed after coiling more often than after clipping procedure (11.3% versus 4.4%, overall 11.6%). Typically, it occurs between 4 and 14 days after the initial occurrence of subarachnoid hemorrhage and is symptomatic between 17 and 40% overall (Bracard and Schmitt, 2008). However, little is known about the impact of coiling or clipping on the incidence (de Oliveira et al., 2007).

Until today, no consensus on a gold standard in treatment exists so far. When summarizing the different results and comparing the literature, it seems that coiling and clipping are still comparable based on the clinical outcome in both short and long-term follow up (Bekelis et al., 2016; Wadd et al., 2015; Zhao et al., 2016).

Based on its retrospective design, no blinded allocation of patients was performed, and a relatively small population was available for this single-center study. The intervention was performed after a delay of 1.4 ± 2.0 days for clipping, respectively, 2.8 ± 4.7 days for coiling. The postinterventional Hunt and Hess, as well as modified Ranking scores, were assessed five days after, which change tremendously over time, especially in the first few days. Our results suggest that clipping may still be slightly superior in the mortality rate and Hunt and Hess score than coiling, which may have changed in the recent years due to more physician experience and more specialized institutions.

Additionally, as stated earlier, the Hunt and Hess score itself may lead to some bias related to the interobserver variability. In 9 patients, the Hunt and Hess score was between 2 grades due to its definition. Therefore, we assumed the worse one. However, this also shows the limitation of the score. Although the WFNS is commonly used to assess the neurological status, we decided not to apply this. We only performed a short-term follow up within the hospitalization after the incidence, without long-term data. Therefore, complications such as pneumonia and heart diseases were not included.

Further investigation should be performed for long-term follow-up, i.e., 5 years after the intervention, which is why further

research is ongoing. Neurocognitive deficits were not measured due to lack of long term follow up, resulting in a lack of information related to behavioral outcomes. Furthermore, according to the literature, there is a direct positive relation to the body mass index, which we did not assess. Rinaldo et al. (2018) determined that patients with a body mass index of greater than 32.3kg/m^2 (as well as metabolic syndrome) had a lower frequency of poor functional outcome after 90 days or more.

Finally, we did not assess the Raymond-Roy occlusion classification after endovascular coiling, which can give information about the occlusion of the aneurysm. This has an impact on the risk of rupture, as well as the neurological outcome after intervention.

5. Conclusions

The highest incidence of aneurysm ruptures leading to subarachnoid hemorrhage occurs at the ACoA. Overall, females are predisposed, and males are approximately 5.35 years younger than females. Within the two years, no significant differences were observed between the clipping procedure and the coiling intervention, and thus far, no gold standard exists. This may be related to the limitations of the Hunt and Hess scale, which is not the optimal tool to assess outcomes after intervention. Further research is required to establish a gold standard in treatment as well as in the assessment of the outcome and for follow-up.

Author contributions

HCB, JV, and IN designed the research study. HCB performed the research. SCS provided help and advice on the experiments. HCB analyzed the data. HCB, SCS, and IN wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

This research was retrospectively conducted with blinded data, and approved by the Internal Review Board of Semmelweis University.

Conflict of Interest

The authors declare that they don't have any conflict of interest related to this study.

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