The Prospective Profile of Endovascular Coiling of Cerebral Aneurysms: The Impact of Clinical Presentation, Procedural Results, Aneurysm Rupture and Location

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Abstract

Purpose: To report the prospective profile and outcome of a consecutive series of patients with cerebral aneurysm with respect to clinical presentation, procedural results, aneurysm rupture and location.

Methods: We performed a prospective study of cerebral aneurysm cases that were referred to our hospital and underwent endovascular treatment. After endovascular coiling, the patients were followed up at the first day, 1st, 6th and 12th month, along with a secondary angiographic study in month 12. The outcome and adverse event of the treatment were studied.

Results: Out of 120 patients studied, about 58.3% had ruptured aneurysm and 16.5% had aneurysm at posterior circulation. The mortality rate (all within the first month of treatment) was 7.1%. The rate of morbidity in the 1st day and month 12 after procedure was 16.7% and 6.9%, respectively. Total or subtotal occlusion of the aneurysm was performed in 91.7% of patients and the procedural results remained stable in 89.3% of patients in the secondary angiographic study. The presence of aneurysm at posterior location, failure of complete aneurysm occlusion, and worse clinical presentation (based on Hunt and Hess scale) were significantly (p<0.05) associated with higher mortality and morbidity. Aneurysm rupture was significantly associated with higher morbidity (p<0.05).

Conclusion: We demonstrated the feasibility and clinical efficacy of endovascular coiling in management of cerebral aneurysms. The outcome of the endovascular coiling is better in unruptured aneurysms and in anterior location, and is worse in patients with worse clinical presentation and those with failure of endovascular procedure in complete occlusion.

Keywords: Endovascular procedures; Intracranial aneurysm; Circle of willis

Introduction

Cerebral aneurysm is a cerebrovascular disorder in which weakness in the wall of a cerebral artery or vein results in a localized dilation or ballooning of the blood vessel. Overall, prevalence rates of intracranial aneurysms are reported between 0.5%- 6% in epidemiological studies [1]. Most unruptured aneurysms remain undetectable. A minority of aneurysms are detected when they cause symptoms either by cranial nerve compression or when they rupture causing Subarachnoid Hemorrhage (SAH). Between 5-15% of all strokes can be attributed to SAH from a ruptured aneurysm [1]. Ruptures of intracranial aneurysm are devastating, and half of the patients die and up to half of those who survive are disabled [2].

Complete aneurysm obliteration has been the treatment of choice for cerebral aneurysms. In 1991, a detachable coil as an alternative to surgical treatment in the management of cerebral aneurysm was introduced [3]. Although microsurgical clipping is usually effective in complete aneurysm obliteration, this approach is generally more difficult than endovascular coiling [4]. Endovascular coiling is proposed as the primary treatment option in certain anatomical locations or when surgery fails [5].

Many studies have evaluated the efficacy of endovascular coiling in comparison to conventional neurosurgical treatment of cerebral aneurysms [6-9]. In a prospective randomized trial (international subarachnoid aneurysm trial: ISAT), Molyneux et al. [10] showed that endovascular coiling of ruptured intracranial aneurysm was associated with better outcome and lower morbidity when compared with surgical clipping [10]. Consistently, in the International Study of Unruptured Intracranial Aneurysms (ISUIA), Wiebers et al. [11] showed that combined treatment morbidity and mortality at 1 year was 10.1% for patients without prior subarachnoid hemorrhage and 12.6% for patients with prior subarachnoid hemorrhage in surgical group, and was 7.1% in patients without prior subarachnoid hemorrhage and 9.8% in patients with prior subarachnoid hemorrhage in endovascular group [11]. Moreover, a recent non-randomized retrospective study showed that adverse outcomes following endovascular treatment of unruptured intracranial aneurysm were less frequent than those following surgical treatment [8]. The results of these studies have led to development of certain recommended indications for choosing endovascular treatment.

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vs. surgical treatment for ruptured and unruptured cerebral aneurysms [12].

While most of the previous studies are focused on comparison of the efficacy of endovascular treatment vs. surgery, data on the efficacy, outcomes and adverse events of endovascular treatment based on the primary characteristics of the cerebral aneurysms (e.g. posterior vs. anterior location; ruptured vs. unruptured aneurysms; size; and clinical presentation) is scare [13,14]. Here, we aimed to report the prospective profile and outcome of a consecutive series of patients with cerebral aneurysm who were selected, by neurologist, for endovascular coiling based on the recommended indications [12].

Methods

We performed a prospective study of 120 consecutive cases with cerebral aneurysm that were referred, from January 2008 to January 2010, to our hospital. Patients with recommended indications for endovascular treatment were included in this study [12]. Pretreatment clinical status of the patients and clinical evaluation of the patients in follow-up steps were recorded by a single neurologist (MM). All patients were stratified according to the Hunt and Hess (H and H) scale [12]. Any new neurologic symptoms after the treatment were also recorded. Standard CT imaging was performed for the participants and location of bleeding was determined. All patients were evaluated by four-vessel angiography (GE4100 inova flat panel Advantex) to determine the shape, size, and location of the aneurysm. The location of the aneurysm was recorded according to Lister et al. classification [15]. After endovascular coiling, the patients were followed up at the first 24 hours, 1st-, 6th- and 12th-month, along with a secondary angiographic study in month 12 after the procedure. The outcome of the treatment and the mortality and morbidity (defined as any type of focal neurological deficit or loss of consciousness due to rupture of the coiled aneurysm, thromboemboli, or vasospasm after the procedure) after treatment were recorded. All patients provided written informed consent before participation in the study. The study protocol was approved by the ethics review committee of the Tehran University of Medical Sciences.

Endovascular coiling procedure

Endovascular coiling was performed with the patients awake under intravenous sedation or under general anesthesia as appropriate.
All of the procedures were performed via the transfemoral route in an angiographic suite with Monoplane imaging capabilities. One interventional radiologist (HG) was involved in all the treatments. After selective catheterization of cerebral arteries with guiding catheter, microcatheter was advanced into aneurysm sac. Initially, a 3D coil and then 2D soft coils were induced in the aneurysm. In cases with wide necks, the neck of the aneurysm was narrowed with solitaire intracranial stent (EVT3) before the coil was placed.

Strategy of coiling was determined on the basis of the location and morphology of the aneurysm. Selective embolization of the aneurysmal sac with parent artery preservation was preferred if an acutely ruptured dissecting aneurysm was excluded and the aneurysm had a reasonable neck to allow endosaccular packing with coils. Otherwise, the parent artery was considered to be sacrificed. In each case, the capability of the patient to tolerate permanent artery occlusion was assessed on the angiographic criteria based on the presence and size of potential collateral vessels. Occlusion test before permanent occlusion was performed by temporary inflation of a balloon in the vertebral artery over the origin of the affected vessel. Detachable platinum micro coils were used in endovascular packing of the aneurysmal sac. Parent artery occlusions were performed with coils (GDC: Guglielmi detachable coil). Figures 1 and 2 presents right middle cerebral artery and basilar tip aneurysm, before and after embolization.

The patients were heparinized during the procedure with activated clotting time targeted from 200 to 300 seconds. Heparin was started after the microcatheter was inserted into aneurysm sac. If coiling was performed alone, and there was no vasospasm or other complications, we stopped heparin prescription, 6 hours after the procedure. After the microcatheter was advanced into aneurysm sac, initially a 3D coil and then 2D soft coils were induced in the aneurysm. In cases with wide necks, the neck of the aneurysm was narrowed with solitaire intracranial stent (EVT3) before the coil was placed. Intravenous heparin was continued during the procedure. The patients were monitored in an intensive care unit or in a postoperative recovery unit for at least one day. The post procedural CT and MR images were analyzed with the intention to detect new lesions. All the patients were advised to do a secondary angiography at month 12 after the procedure to evaluate any changes in the prior aneurysm and visit the neurologist if they have any new complaint.

Angiographic evaluation

Raymond scale was used for the occlusion grade: angiograms were categorized as complete occlusion (no visualization in angiograms), subtotal occlusion (neck remnant in angiograms), incomplete occlusion (neck remnant and body filling in angiograms) and failure of the procedure (residual aneurysm) [16-18]. Angiography was repeated in the month 12 after the procedure and the results were compared with the initial angiograms (categorized as; without change; re-growth; and widening of the neck of the aneurysms).

Statistical analysis

Statistical Package for Social Sciences (SPSS) 17 for windows (Chicago, Illinois, USA) was used for analysis. Quantitative variables are presented as mean ± Standard Error of Mean (SEM). For comparison of the studied variables between patients with and without mortality or morbidity independent sample t test (for normally distributed continuous variables), and chi square analysis (for categorical variables) were employed. P<0.05 was considered statistically significant.

Results

Demographic

Baseline characteristics of the participants are presented in (Table 1). There were 120 patients (70 women, 50 men) with the mean age of 47.8 years (Range: 14.0-77.0 years). Eight of them were H and H: 0, 22 were H and H: 1, 70 were H and H: 2, 16 were H and 3: 4 of them were H and H: 4 when presented to our ward. Seventy patients had ruptured aneurysm at the presentation, 3 had hydrocephaly and 1 had shift when referred (Table 1).

Aneurysm characteristics

There were 34 (26.8%) saccular aneurysm, 74 (61.7%) saccular non-pedunculated aneurysm and 8 (6.7%) fusiform aneurysms (Table 1). The neck size was less than 4 mm in 72 (60%) of the patients, and more than 4 mm in 48 (40%) of the patients. The mean of neck size was 1.38 mm. None of the aneurysms were treated previously.

Procedural results

Regarding the postoperative aneurismal occlusions (Table 2), 98 aneurysms (81.7%) had complete occlusion; 12 (10%) had subtotal occlusion, 6 (5%) had partial occlusion and in 4 (3.3%) the procedure was not performed (due to vasospasm or rupture). Intra-procedural aneurismal rupture occurred in 3 cases.

Mortality and morbidity in the follow-up steps: Overall, morbidity was recorded in 20 patients (16.7%) in the first 24 hours after procedures (Table 2). Nine of these cases were due to vasospasm, 6 due to rupture and 5 due to thromboemboli. There was no mortality in the
first 24 hours of treatment. No new morbidity or mortality was found beyond 1 month. The mortality rate was about 7% (in 8 patients: 2 were due to basilar vasospasm, 4 were due to aneurysm rupture and 2 were due to thromboemboli and massive cerebral infarction). The morbidity rate was 12.4% (eight due to vasospasm, 2 due to the aneurysm rupture and 4 due to the thromboemboli) in the first-month and 6.9% (three due to vasospasm, 2 due to aneurysm rupture and 1 due to thromboemboli) in the 6th-month follow up steps. No new morbidities were reported at the 12th month follow up step. The participation rate was 100% in the first 24 hours, 94.2% in the first month and 77.7% in the 6th-month and 75% in the 12th-month follow-up step (Table 2).

Angiographic follow up: Patients were advised to undergo a secondary angiography 12 months after the endovascular treatment. Of those who accepted to do the follow-up angiography (n=84; 75% rate of participation), 75 patients (89.3%) had no change from the angiographic status at the time of procedure (Table 2).

The impact of the clinical presentation, procedural results, aneurysm rupture, location and size on the outcome of the endovascular treatment: We compared the morbidity and mortality according to the aneurysm location (anterior circulation vs. posterior circulation). There were a significantly higher rate of first 24 hours morbidities in the aneurysm of the posterior circulation compared to the anterior circulation (10/100 vs.10/20; p<0.001). Likewise, there were a significantly higher rate of mortality in aneurysms of posterior circulation compared with the aneurysms of anterior circulation (4/18 vs. 4/95; p<0.05).

The rate of mortality (7/70 vs. 1/50; P=0.13) was higher in the patients with ruptured aneurysm vs. unruptured aneurysm. The rate of morbidities in the first 24 hours (16/70 vs. 4/50; p<0.05), the first-month (12/65 vs. 2/48; p<0.05) and at the 6th-month follow up steps (6/50 vs. 0/37; p<0.05) were significantly higher in the patients with ruptured aneurysm vs. unruptured aneurysm.

The mean (± SEM) H and H scale in the expired participants was significantly higher than the survived (3.1 ± 0.28 vs. 1.9 ± 0.17, p<0.05). Similarly, the mean H and H scale was significantly higher in patients with 24 hour morbidity than those without morbidity (2.8 ± 0.2 vs. 1.7 ± 0.17, p<0.05).

In 2 of the expired patients endovascular treatment could not be performed. In 4 of the expired patients the aneurysm was totally occluded, and in 2 the aneurysm was partially occluded. The rate of mortality was significantly (p<0.01) lower in patients with total and subtotal occlusion (4 out of 110) compared with those with procedure failure and incomplete occlusion (4 out of 10).

There was not any significant difference in the mean (± SEM) aneurysm size (2.13 ± 0.12 vs. 2.25 ± 0.12) and neck size (1.4 ± 0.09 vs. 1.33 ± 0.33) of the expired than the survived participants. The mean aneurysm size (2.2 ± 0.08 vs. 2.3 ± 0.16) and neck size (1.39 ± 0.07 vs. 1.33 ± 0.16) was similar between patients with 24 hour morbidity and those without morbidity.

Discussion

In this study, we evaluated the outcome of endovascular coiling in a large sample of Iranian patients with indication of endovascular treatment. Our results are of clinical value because show the outcome of endovascular treatment of patients who undergo endovascular treatment based on the current established recommendations [12]. The mortality rate was 7.1% and all occurred within the first month of treatment. The rate of morbidity in the 1st day after treatment was 16.7% and at month 12 after the procedure was 6.9%. Total or subtotal occlusion of the aneurysm was performed in 91.7% of patients. The procedural results were rechecked with a secondary angiography in month 12 after the treatment. The procedural results remained stable in 89.3% of patients. Our findings generally point to good outcome of endovascular coiling in our patients. The presence of aneurysm at posterior location; failure of the procedure or incomplete aneurysm occlusion; and worse clinical presentation (based on H and H scale); were significantly (p<0.05) associated with higher mortality and morbidity. Also, aneurysm rupture was significantly associated with higher morbidity (p<0.05).

Endovascular treatment was first considered as a safe method in treatment of unruptured cerebral aneurysms and SAH [19]. Later on, it was widely used in patients with ruptured aneurysms [20]. Studies have shown that endovascular therapy is of particular benefit in patients with a poor grade and patients with ruptured aneurysm [5,21]. Most of previous studies have compared the efficacy of endovascular coiling vs. surgery [22], and less data is available on the efficacy of endovascular coiling in aneurysms with different properties and clinical presentations. As an instance, Nam et al. [23] demonstrated that surgical clipping was more effective in the management of the patients with ruptured aneurysm, whereas there was not such a difference between endovascular coiling and surgery in un ruptured aneurysms [23]. In a systematic review of observational studies on embolization with coils, it was suggested that in patients with a ruptured aneurysm, 52% of aneurysms will be completely occluded and the mortality rate is about 1.1% [24]. To our best knowledge, our study is the first to show that the aneurysms located in the posterior circulation have a worse outcome compared with those located in the anterior circulation. This

<table>
<thead>
<tr>
<th>Procedural Result (n=120)</th>
<th>N (%)</th>
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<tr>
<td>Total occlusion</td>
<td>98(81.7%)</td>
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<tr>
<td>Subtotal occlusion</td>
<td>12(10%)</td>
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<tr>
<td>Incomplete occlusion</td>
<td>6(5%)</td>
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<tr>
<td>Failure of procedure</td>
<td>4(3.3%)</td>
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<tr>
<td>The first 24 hours (n=120)</td>
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<tr>
<td>Morbidity</td>
<td>20(16.7%)</td>
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<tr>
<td>Mortality</td>
<td>0(0.0%)</td>
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<td>The first month (n=113, 94.2% rate of participation)</td>
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<tr>
<td>Morbidity</td>
<td>14(12.4%)</td>
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<tr>
<td>Mortality</td>
<td>8(7.1%)</td>
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<tr>
<td>The 6th-month follow-up (n=87, 77.7% rate of participation)</td>
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<tr>
<td>Morbidity</td>
<td>6(6.9%)</td>
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<tr>
<td>Mortality</td>
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<tr>
<td>The 12th-month follow-up (n=84, 75% rate of participation)</td>
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<tr>
<td>Morbidity</td>
<td>6(6.9%)</td>
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<tr>
<td>Mortality</td>
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<tr>
<td>Angiography results in month 12 (n=84, 75% rate of participation)</td>
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<tr>
<td>Without change</td>
<td>75(89.3%)</td>
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<td>Re-growth</td>
<td>6(7.1%)</td>
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<tr>
<td>Widening of the neck</td>
<td>3(3.6%)</td>
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</table>

*aNo new mortalities were reported after the first month of the procedure
bNo new mortalities were reported after the 6th month of the procedure
cIn comparison to the angiographic results at the time of procedure

Table 2: The outcome of procedure (n=120).
finding may be partially due to the point that posterior circulation is responsible for feeding the vital parts of the brain. We also showed that the outcome of endovascular coiling is significantly better among patients with unruptured intracranial aneurysms. We could not find such data in previous reports.

The procedural results of the aneurysm occlusion in our study are comparable with those of previous studies. In a study by Pierot et al. [20] on 169 patients who underwent endovascular coiling with detachable coils, complete occlusion was achieved in 73% of the aneurysms, subtotal occlusion in 0.08% of the aneurysms, and incomplete occlusion was reported in 0.014% of the aneurysms [18]. Recurrence occurred in 20 (14%) of the 148 totally occluded aneurysms [18]. In a multicenter study of detachable on 705 aneurysms, 422 aneurysms (73.9%) demonstrated complete occlusion, 148 aneurysms (25.9%) demonstrated subtotal occlusion, and only 1 aneurysm was incompletely occluded. Overall mortality was 11.4% for all patients [4]. Kessler et al. [25] showed that the use of balloon expandable stents in management of intracranial aneurysms is associated with a high rate of hemorrhagic and ischemic complications, more specifically when used in the anterior circulation. There were excellent outcome in 53 patients (70.6%), good outcome in 12 (16%) patients, poor outcome in 5 (6.7%), and mortality in 5 of patients (6.7%) [25]. In a study by Pierot et al. [26] on 261 aneurysms, complete occlusion was achieved in 102 aneurysms (44.0%); neck remnant was reported in 58 aneurysms (25.0%); and aneurysm remnant was reported in 72 aneurysms (31.0%). Mortality rate was 0.8% and permanent morbidity was 2.5%, with the notion that they excluded the patients with giant aneurysm and poor clinical condition [26]. We showed a complete occlusion rate of 81.7% which is comparable to similar studies. Our study also showed that mortality and morbidity is significantly higher in patients with incomplete occlusion of aneurysm or with failure of procedure [27-30]. It should be taken into account that the different outcomes of endovascular treatment in previous studies can be result of differences in the inclusion criteria and baseline characteristics of patients. In our study, the procedure was performed on patients who were not suitable for surgery and were selected for endovascular treatment based on the current recommendations.

An important limitation of endovascular treatment method is the incidence of aneurysm recanalization. It has been shown that recanalization after coil embolization may be seen in approximately 8-38% of cases [31]. Therefore, we followed-up our patients with a secondary angiography 12 months after endovascular treatment. The results showed that in nearly 90% of the patients, there was not any change in the coiling status. Limited data on the outcome of endovascular coiling based on baseline properties of the cerebral aneurysms is available; therefore, we encourage future studies, with large sample size, to more investigate this practically important topic.

In conclusion, we showed the efficacy and clinical outcome of endovascular coiling in patients with cerebral aneurysms. Our results are of clinical value in determining the prognosis of patients who undergo endovascular coiling, based on their clinical presentation, procedural results, aneurysm rupture and location.

**Conflict of Interest**

The authors declare that they have no conflicts of interests.

**References**


