Endovascular coil embolization of ruptured and unruptured intracranial aneurysms: Review of a 15 year single center experience in Pakistan

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Endovascular coil embolization of ruptured and unruptured intracranial aneurysms: review of a 15-year single center experience in Pakistan

Misha Khalid Khan, Muhammad Danish Barakzai, Mustafa Belal Hafeez Chaudhry, Tanveer ul Haq, Ehsan Bari, Raza Sayani

Abstract

Objective: To assess the outcome of endovascular treatment of intracranial aneurysm over 15 years.

Methods: The retrospective study was conducted at the Radiology Department of Aga Khan University Hospital, Karachi, and comprised medical records from April 2003 to April 2018 of patients who received endovascular treatment for intracranial aneurysm. Multiple variables reviewed included demographics, clinical presentation, aneurysm morphology, technique used, technique outcome and clinical outcome. Data was analysed using SPSS 22.

Results: Of the 242 patients, 111 (45.8%) were males and 131 (54.1%) were female. The overall mean age was 46.3 +/- 13.543 years (range: 9-78 years). Aneurysm size was <5mm in 95 (40.4%) patients, 5-10mm in 98 (41.7%) and >10mm in 42 (17.9%) patients. Aneurysms were located in the anterior communicating artery in 93 (38.4%) patients, internal carotid artery 48 (19.8%) patients and posterior communicating artery 26 (10.7%) patients. Patients with higher initial Hess and Hunt grade were more likely to have higher modified Rankin scale score after treatment (p=0.001). Overall, 222 (91.7%) patients were treated successfully. Complications were noted in 37 (15.2%) patients and 10 (4.0%) patients died.

Conclusions: No correlation was found between Hess and Hunt grades and aneurysm severity based on aneurysm size, neck and ruptured/unruptured cases.

Keywords: Intracranial aneurysm, Ruptured aneurysms, Endovascular procedures, Therapeutic embolisations.

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absolute risk reduction of 6.9%. Regarding endovascular treatment, a large multicentre study, called the Clinical and Anatomic Results in the Treatment of Ruptured Intracranial Aneurysms (CLARITY), showed that the rate of thromboembolic complications in patients treated for ruptured aneurysm was not influenced by the location of the aneurysm, but was affected by aneurysm size and neck size. It was further mentioned that the rate of intraoperative rupture is linked to aneurysm location, but not aneurysm size.10

There are limited hospitals and technically-skilled doctors in Pakistan using endovascular treatment for IAs. The current study was planned to assess the outcome of endovascular treatment of IAs over 15 years at the first centre that started endovascular management of aneurysms in Karachi, Pakistan.

**Materials and Methods**

The retrospective 15-year audit was conducted at the Radiology Department, Aga Khan University Hospital (AKUH), Karachi, Pakistan, and comprise medical records from April 2003 to April 2018. After approval from the institutional ethics review committee, hospital computer records were searched to gather a list of all the patients diagnosed with IAs. Based on the inclusion criteria, all asymptomatic and symptomatic as well as emergency and elective patients who were diagnosed with ruptured intracranial saccular aneurysms of size >2mm and unruptured intracranial saccular aneurysm of size >3mm, and received endovascular management were included. Those excluded were records related to patients with fusiform aneurysms, severe vascular spasm, more than 80% neck-to-body ratio in acute ruptured aneurysm, and having difficult anatomy like very tortuous internal carotid artery (ICA).

Each patient’s medical record was thoroughly assessed by an expert radiologist specialising in neuro-imaging. Multiple variables were reviewed, like patients’ demographics, initial clinical presentation using Hess and Hunt (H&H) grading, angiographic characteristics, like rupture/unruptured aneurysms, location of aneurysm, size of aneurysm, wide/narrow neck of aneurysm, endovascular technique used and outcome, post-procedure success rate and complications, post-procedure modified Rankin Score (mRS), and mortality. Based on initial clinical presentation, each patient was graded using H&H.21 Initial HnH scores were compared to assess initial severity with post-treatment mRS.

Wide neck was defined as neck >50% neck-to-body ratio or >4mm. All the measured aneurysm sizes were categorized in ≤5mm, 5-10mm and ≥10mm groups. Successful outcomes were reported in patients who had better clinical and imaging outcome after endovascular procedure and did not develop any complications. Patients with deteriorating clinical and imaging outcome or those who developed complications were categorised as unsuccessful outcome.

Data was entered in Excel and analysed using SPSS 22. Chi square analysis was conducted. P<0.05 was considered significant. To the best of our knowledge, there has not been any research regarding this topic in Pakistan.

**Results**

Of the 260 records reviewed, 242(93%) were included; 111(45.9%) males and 131(54.1%) females. The overall mean age was 46.3±13.543 years (range: 9-78 years). Mean aneurysm size was 7.5±5.3mm (range: 2-50mm). Aneurysm size was ≤5mm in 95(40.4%) patients, 5-10mm in 98(41.7%) and >10mm in 12(17.9%). Of the total, 175(84.5%) emergency patients with ruptured aneurysms were treated immediately on arrival, while 26(15.5%) with unruptured aneurysms had planned elective treatment. There were 126(55.3%) wide and 102(44.7%) narrow neck aneurysms.

### Table 1: Ruptured and unruptured aneurysms categorized in 3 groups based on size.

<table>
<thead>
<tr>
<th>Aneurysm sizes/ mm</th>
<th>Total number of patients with aneurysm sizes</th>
<th>Total of ruptured and unruptured aneurysm</th>
<th>Ruptured Aneurysm</th>
<th>Unruptured Aneurysm</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 5</td>
<td>95</td>
<td>85</td>
<td>76</td>
<td>9</td>
</tr>
<tr>
<td>5 to 10</td>
<td>98</td>
<td>88</td>
<td>77</td>
<td>11</td>
</tr>
<tr>
<td>≥ 10</td>
<td>42</td>
<td>34</td>
<td>22</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>235</td>
<td>207</td>
<td>175</td>
<td>32</td>
</tr>
<tr>
<td>Missing data</td>
<td>7</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td>242</td>
<td>242</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chi-Square Tests</td>
<td>Value</td>
<td>Df</td>
<td>Asymp. Sig. (2-sided)</td>
<td>0.001</td>
</tr>
<tr>
<td>Pearson Chi-Square</td>
<td>13.682a</td>
<td>2</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>11.45</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>207</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.06.
Table-2: Location of aneurysms with ruptured and unruptured aneurysms.

<table>
<thead>
<tr>
<th>Location of aneurysms</th>
<th>Total Number</th>
<th>Total of ruptured and unruptured aneurysm</th>
<th>Patients with Ruptured Aneurysm</th>
<th>Patients with Unruptured Aneurysm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Comm artery</td>
<td>93</td>
<td>82</td>
<td>73</td>
<td>9</td>
</tr>
<tr>
<td>ICA</td>
<td>48</td>
<td>38</td>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>P Comm artery</td>
<td>26</td>
<td>20</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Basilar artery</td>
<td>18</td>
<td>16</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>MCA</td>
<td>16</td>
<td>15</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>A1</td>
<td>12</td>
<td>9</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Vertebral artery</td>
<td>10</td>
<td>9</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>DACA</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>PCA</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>PICA</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>ICA/MCA/Basilar artery</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Trigeminal artery</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>242</td>
<td>207</td>
<td>175</td>
<td>32</td>
</tr>
<tr>
<td>Missing data</td>
<td>-</td>
<td>35</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Chi-Square Tests:
- Value: 7.102 (a)
- Df: 6
- Asymp. Sig.: 0.079

Chi-Square Tests:
- Value: 6.778 (a)
- Df: 3
- Asymp. Sig.: 0.046

Note: a. 3 cells (54.2%) have expected count less than 5. The minimum expected count is 1.07.

Table-3: Initial Hess and Hunt grading with aneurysm sizes, neck type and post-treatment outcome.

<table>
<thead>
<tr>
<th>Before Endovascular procedure</th>
<th>Hess and Hunt (H&amp;H) Grading</th>
<th>Aneurysm measurements/ mm</th>
<th>Aneurysm Neck</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ 5</td>
<td>5 to 10</td>
<td>≥ 10</td>
</tr>
<tr>
<td>Successful</td>
<td>82</td>
<td>91</td>
<td>40</td>
</tr>
<tr>
<td>Unsuccessful</td>
<td>13</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>98</td>
<td>42</td>
</tr>
</tbody>
</table>

Chi-Square Tests:
- Value: 14.840 (a)
- Df: 8
- Asymp. Sig.: 0.062

H&H Grade * Size
- Pearson Chi-Square: 4.381 (a)
- Likelihood Ratio: 4.429 (a)
- Linear-by-Linear Association: 0.045

N of Valid Cases: 235

Note: a. 3 cells (20.0%) have expected count less than 5. The minimum expected count is 1.07.

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Chi-Square Tests  Value df Asymp. Sig. (2-sided)
---  ---- ---  ---------------------
Total  106  71  16  ...  10  231  4  235
3  22  20  10  6  7  2  2  69  3  72
1  4  5  1  3  3  5  44  0  44
5  0  0  0  0  1  3  5  1  6
Total  183  12  11  11  6  10  231  4  235

Hess and Hunt and Hunt grade
Grading  0  1  2  3  4  5  6  Total  Missing data  Total known Hess
---  ---- ---- ---- ---- ---- ---- ----  ----------  ---------------------
1  48  5  1  0  0  0  0  54  0  54
2  22  35  1  1  0  0  0  59  0  59
3  22  20  10  6  7  2  2  69  3  72
4  14  11  4  4  3  3  5  44  0  44
5  0  0  0  0  1  3  5  1  6
Total  106  71  16  11  11  6  10  231  4  235

Asymptotic significance of the chi-square test is greater than .05.

Hess and Hunt grade
Grading  0  1  2  3  4  5  6  Total  Missing data  Total known Hess
---  ---- ---- ---- ---- ---- ---- ----  ----------  ---------------------
1  48  5  1  0  0  0  0  54  0  54
2  22  35  1  1  0  0  0  59  0  59
3  22  20  10  6  7  2  2  69  3  72
4  14  11  4  4  3  3  5  44  0  44
5  0  0  0  0  1  3  5  1  6
Total  106  71  16  11  11  6  10  231  4  235

Table 4: Initial Hess and Hunt grade and Post treatment modified Rankin scores.

<table>
<thead>
<tr>
<th>Locations</th>
<th>Coiling only</th>
<th>Balloon Remodeling</th>
<th>Flow Diverter</th>
<th>Stent Assisted</th>
<th>Successful</th>
<th>Unsuccessful</th>
<th>Total Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Comm artery</td>
<td>77</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>82</td>
<td>11</td>
<td>93</td>
</tr>
<tr>
<td>A1</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Basilar</td>
<td>16</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>DACA</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>ICA</td>
<td>22</td>
<td>2</td>
<td>4</td>
<td>15</td>
<td>43</td>
<td>5</td>
<td>48</td>
</tr>
<tr>
<td>ICA/MCA/Basilar</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>MCA</td>
<td>14</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>16</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>P Comm artery</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>2</td>
<td>26</td>
</tr>
<tr>
<td>PCA</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>PICA</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Trigeminal artery</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Vertebral artery</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>183</td>
<td>12</td>
<td>5</td>
<td>20</td>
<td>222</td>
<td>20</td>
<td>242</td>
</tr>
</tbody>
</table>


There were 7(2.9%) patients with missing information about aneurysm size, and 35(14.4%) patients had missing rupture/ unruptured data, 14(5.8%) had unruptured data, 14(5.8%) had unknown neck orientation, 7(2.9%) had unknown H&H score, and 11(4.5%) had unknown mRS.

Further, 193(82.1%) patients presented with aneurysm size <10mm. Patients with aneurysms >10mm had greater proportion of ruptured aneurysms compared to patients with aneurysms <10mm (Table-1).

Aneurysms were located in the anterior communicating artery (A

Figure 1: Digital subtraction angiography (DSA) of right internal cerebral artery (ICA) in oblique projections, before (A) and after (B) conventional coil embolisation: a large narrow-neck bilobed aneurysm of the anterior communicating artery (arrows) is seen, which was successfully coiled (arrowheads) using the conventional technique.
Comm) in 93 (38.4%) patients, ICA 48(19.8%) patients and posterior communicating artery (P Comm) 26(10.7%) patients (Table-2).

Initial H&H grading with aneurysm sizes, neck type and post-treatment outcome were noted (Table-3).

Findings suggested that patients with higher initial H&H grade were more likely to have higher mRS post-treatment (p=0.001) (Table-4).

Endovascular technique applied at different locations and their outcomes were recorded separately (Table-5). Overall, 20(8.2%) patients had unsuccessful results due to anatomical and technical difficulties. Post procedure complications were seen in 37(15.2%) patients. Of them, 21(8.6%) patients had major complications that included disabling stroke in 9(3.7%), coil migration in 4(1.7%), rupture in 6(2.4%) and spasm with poor outcome in 2(0.8%) patients. There were 10(4.1%) patients who died during follow-up: 4(1.6%) were procedure-related to, 1(0.4%) had infarction noted post-embolisation with an occluded clot in the left pericallosal main trunk, 1(0.4%) died of severe spasm in distal ICA and left anterior cerebral artery (ACA), and 2(0.8%) died due to rupture from basilar artery aneurysms.

Digital subtraction angiography (DSA) in different patients was carried out using the conventional technique Figure-1), the balloon-assisted technique (Figure-2), and the flow-diverter-assisted technique (Figure-3).
Endovascular coil embolization of ruptured and unruptured intracranial aneurysms... 

Discussion

To the best of our knowledge, the current study is the first on this topic conducted in Pakistan. Since the 1990s, treatment for intracranial aneurysm has seen drastic changes. New advancements are seen in both surgical and endovascular treatment modalities. In the developed countries, like the United States, different modalities like flow diverter and balloon-assisted techniques have been compared with traditional endovascular coiling techniques. As a developing country, the real challenges and limitations in Pakistan are with respect to the availability of required endovascular equipment, microsurgical techniques and surgical skills. This is the reason behind having few cases that involve use of stenting, balloon remodelling and flow diverters. Only 183 (75.6%) patients were treated with coiling in the current study. Hence, it is not possible to compare different assisted modalities with traditional coiling endovascular technique.

However, compared to other studies, the study showed a large number of successful outcomes (91.7%) after therapeutic endovascular treatment, with low mortality (4.1%). This is comparable to a multi-centre study that had 96.9% and 94%, successful results of aneurysm coiling in ruptured and unruptured aneurysms, respectively, and mortality of 8.6% in ruptured aneurysms and 7.7% in unruptured aneurysms. The current study saw greatest number of aneurysms arising from A Comm (93 cases) followed by ICA (48 cases). Similar findings were reported by other studies.

IAs are mostly silent, but can rupture unpredictably, leading to grave consequences and even immediate death. Even in developed countries, like the United Kingdom, deaths are reported in 10-15% patients with ruptured aneurysm before they reach hospital. Similarly, many patients die before reaching hospitals in Pakistan. In 2009, a 5-year retrospective review was done at the AKUG on the success, safety and outcome of coiling, reporting only 43 aneurysm cases. The current 15-year audit had a much larger study population of 242 patients, indicating an increase in the number of reported cases of ruptured and unruptured aneurysm since 2009. In the current study, patients with aneurysm size >10mm had lesser proportion of ruptured aneurysm compared to patients with aneurysm size <10mm. This could be one of the reasons explaining why no significant increase was seen in the number of ruptured aneurysms as the aneurysm size increased from 5mm to 10mm and more.

Several scales have been designed based on patient's initial clinical presentation at the time of admission to predict patient’s future functional outcome. Multiple clinical assessors are involved in a research and the inter-rater variability should be considered when interpreting the results. A study on inter-observer variability in grading scale of SHAs included grading scales, like the World Federation of Neurological Surgeons (WFNS) scale, the H&H scale and the Prognosis on Admission of Aneurysmal Subarachnoid Haemorrhage (PAASH) scale, and showed H&H scale to have the lowest inter-observer agreement. In the current study, no large number of patients were seen with aneurysm size 5-10mm or >10mm. Likewise, wider necks having higher H&H grades were not seen. This could be due to the involvement of multiple clinical assessors for grading and inter-observer variability.

Studies based on Nationwide Inpatient Sample (NIS) (n=148,958) to analyse NIS SAH Severity Score (NIS-SSS) and NIS-SAHI Outcome Measure (NIS-SOM) concluded that NISSS and NIS-SOM significantly correlated with H&H grade and mRS respectively. Compared to other grading systems, the study found NIS-SSS and NIS-SOM to be better and provided valid measure of severity and outcome respectively. In relation to this, the results of the current study further prove that patients with lower initial H&H score were more likely to have better clinical outcome with lower mRS scores, while patients with higher initial H&H grade were more likely to have higher mRS after receiving endovascular treatment.

The Food and Drug Administration (FDA) and the European Medicines Agency (EMA) have approved pipeline embolisation device (PED) for the treatment of large or giant, wide-neck intracranial aneurysms of ICA from the petrous to the superior hypophyseal segments. However, the flow divertor does not have the approval to be used for posterior circulation, treatment of aneurysmal SAH, or in the anterior circulation beyond the ICA superior hypophyseal segment. This device is only approved for use in the United States. Additionally, in Europe, PED, silk flow diverter, flow-redirection endoluminal device (FRED), p64 (phenox), surpass streamline and derivo are the available therapies. Due to lack of enough studies, it is not possible to comment on long-term outcomes of these new devices. A recent study concluded that since there has been rapid development of endovascular therapy treatment for IAs, the challenge for the physicians is to adapt accordingly.

In future, further research can be done exploring the type of aneurysm in greater detail, comparing pre-existing risk factors in South-Asian population in ruptured aneurysms, and having greater number of patients treated with assisted modalities, like endovascular balloons, stents, flow diverters and glue-assisted treatments.

One of the limitations of the current study, however, is missing data. All possible efforts were made to extract the relevant required data, but considering this is a 15-year retrospective data review, it was expected that some degree
of missing data records will be encountered. As the current study was an audit of the Interventional Radiology (IR) department, hence it focussed on morphology of aneurysm that appeared on imaging at the time of presentation and the outcomes after therapeutic endovascular treatment. Other secondary demographic details that were not relevant to the study’s objectives were not recorded. Moreover, there were only a few patients with aneurysm >10mm (42/235; 17.9%) and mostly coiling was practised (75.6%), which accounts for the similarities seen in success rates among different aneurysm sizes.

**Conclusion**

Large number of patients with intracranial aneurysms showed successful outcome after treatment with endovascular coiling alone. No correlation was seen between H&H grades and aneurysm severity based on aneurysm size, neck orientation and ruptured/unruptured nature. Patients with higher initial H&H scores were more likely to have higher post-treatment mRS.

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**Conflict of Interest:** None.

**Source of Funding:** None.

**References**