Rupture of intracranial aneurysms during treatment with Guglielmi detachable coils: incidence, outcome, and risk factors

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Object. The aim of this study was to assess the incidence and outcome of procedure-related rupture of intracranial aneurysms in patients treated with Guglielmi detachable coils (GDCs) and to identify risk factors for this complication.

Methods. Procedure-related rupture occurred in seven of 264 treated aneurysms in 239 consecutive patients. Aneurysm size, history of previous subarachnoid hemorrhage (SAH) caused by the treated aneurysm, timing of treatment after SAH, and the use of a temporary occlusion balloon in the seven procedures in which rupture occurred were compared with the remaining 257 procedures, and these findings were correlated with data from 13 studies in the literature, in which results of 2030 aneurysm treatments were reported.

Conclusions. Procedure-related rupture of intracranial aneurysms during GDC treatment occurs in 2.5% of cases and is responsible for 1% of treatment-related deaths. Risk factors are as follows: small aneurysm size, previous SAH, and probably the use of a temporary occlusion balloon.

KEY WORDS • subarachnoid hemorrhage • cerebral aneurysm • ruptured aneurysm • Guglielmi detachable coil • endovascular therapy • outcome

S ELECTIVE occlusion of intracranial aneurysms with detachable coils is a widely accepted treatment modality with a procedure-related permanent complication rate of 3.7%. The main causes of procedure-related complications during endovascular treatment of intracranial aneurysms with detachable coils are ischemic events and aneurysm perforation. In this study we report on seven patients with procedure-related aneurysm rupture in a group of 239 consecutive patients harboring 264 intracranial aneurysms that were treated with GDCs (Target Therapeutics Corp., Fremont, CA). We assessed the incidence and outcome of this potentially catastrophic event in our own patients as well as those reported in other selected studies. We tried to identify risk factors with emphasis on aneurysm size, history of SAH caused by the treated aneurysm, and the use of a temporary occlusion balloon in wide-necked aneurysms.

Clinical Material and Methods

Between November 1994 and April 2000, 286 GDC placement procedures were performed to treat 264 aneurysms in 239 consecutive patients. The decision to treat by the endovascular method was made in a joint meeting of neurosurgeons, neurologists, and interventional radiologists and was predominantly based on aneurysm characteristics. Procedure-related rupture, defined as the extrusion of coil, microcatheter, or guidewire outside the lumen of an aneurysm with extravasation of contrast material demonstrated on concurrent angiography, occurred in seven cases. In all seven cases heparin therapy was reversed and delivery of coils was continued until cessation of bleeding was demonstrated angiographically. The aneurysm size, history of treated aneurysm–induced SAH, timing of treatment after SAH, and use of a temporary occlusion balloon in these seven patients with ruptured lesions were compared with the same factors in the rest of the group. We assessed whether the rupture was caused by the guidewire, microcatheter, or coil and determined how many additional coils were placed to stop the bleeding.

We identified 13 studies in which data were provided on the incidence of and outcome after aneurysm rupture during GDC treatment in series of more than 50 consecutive patients, and these data were correlated with our findings. Moreover, we attempted to extract data on the following possible risk factors for procedure-related rupture: aneurysm size, history of SAH, and timing of treatment after SAH.

Results

In the study period 286 GDC treatments were performed for 264 aneurysms in 239 patients. The patient population consisted of 163 women (68%) and 76 men (32%), with a mean age of 53 years (range 26–79 years). Previous SAH was the indication for treatment in 182 (69%) of the 264 aneurysms, and the average treatment delay was 14.5 days after SAH (range 1–60 days). Of the treated aneurysms, 178 (67%) were small (< 12 mm), 73 (28%) were large (12–25 mm), and 13 (5%) were giant (> 25 mm).
Aneurysm rupture during coil placement

The characteristics of the seven patients with procedure-related aneurysm rupture are listed in Table 1. The incidence of procedure-related rupture per treated aneurysm in our patient group was 2.65% (seven of 264; 95% CI 1.1–5.4%). Five patients survived with no neurological deficit, and two patients died within 24 hours after this complication, resulting in a mortality rate of 0.84% (two of 239; 95% CI 0.1–3.3%). All seven aneurysms were smaller than 13 mm, and four of the seven were 4 mm or smaller. These seven aneurysms were smaller than the 257 remaining aneurysms that did not rupture, and this difference was statistically significant according to the Mann–Whitney U-test (p < 0.05). All seven patients had previously suffered SAH from the treated aneurysms; therefore, seven of the 182 aneurysms treated after SAH were ruptured during coil placement, and none of the 82 treated aneurysms without previous SAH ruptured during treatment. This difference was not statistically significant. There was no significant difference in treatment delay after SAH in either group. In 43 wide-necked aneurysms a temporary occlusion balloon was used during delivery of the GDCs, and in three (7%) of these cases aneurysm rupture occurred. In the remaining 221 aneurysms four procedure-related aneurysm ruptures occurred (1.8%), indicating that the use of a temporary occlusion balloon was a risk factor for procedure-related rupture, although this difference did not quite reach significance on the chi-square test (p = 0.05367). In six of the seven patients the rupture was caused by a coil, and in one patient it was caused by the microcatheter.

The results of our review of studies in which data were provided on procedure-related aneurysm rupture during GDC treatment are summarized in Table 2. Procedure-related rupture occurred in 51 of 2030 treated aneurysms, yielding an incidence of 2.51% (95% CI 1.9–3.3%). Of these 51 patients with aneurysm ruptures, 31 had a good outcome and 20 died as a direct result of this complication (mortality rate 0.99%; 95% CI 0.6–1.5%). In the 10 studies in which data were provided on the proportion of aneurysms treated after previous SAH was identified, 38 of 1116 aneurysms that were treated after a previous SAH ruptured during coil placement, whereas only one of 458 without previous SAH ruptured. This difference was significant according to the chi-square test (p < 0.00022), thus identifying previous SAH as a risk factor for procedure-related rupture. We were unable to extract data from the literature on other possible risk factors for procedure-related rupture, such as aneurysm size and timing of treatment.

### Discussion

**Incidence and Outcome**

The data from the present study and those from our

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Aneurysms Treated</th>
<th>No. of Prior SAHs/Unruptured Lesions</th>
<th>No. of Perforations</th>
<th>No. of Deaths</th>
<th>No. W/ Good Outcome</th>
<th>Proportion of Prior SAH to Perforations</th>
<th>Size of Lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Byrne, et al., 1995</td>
<td>83</td>
<td>83/0</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3/3</td>
<td>unknown</td>
</tr>
<tr>
<td>Houdart, 1996</td>
<td>315</td>
<td>235/80</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>4/4</td>
<td>unknown</td>
</tr>
<tr>
<td>Malisch, et al., 1997</td>
<td>104</td>
<td>*</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Raymond &amp; Roy, 1997</td>
<td>75</td>
<td>75/0</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>6/6</td>
<td>5 of 6 &lt;15 mm</td>
</tr>
<tr>
<td>Viñuela, et al., 1997</td>
<td>403</td>
<td>403/0</td>
<td>11</td>
<td>5</td>
<td>6</td>
<td>11/11</td>
<td>9 of 11 &lt;10 mm</td>
</tr>
<tr>
<td>Cognard, et al., 1998</td>
<td>236</td>
<td>150/86</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>6/6</td>
<td>unknown</td>
</tr>
<tr>
<td>Debrun, et al., 1998</td>
<td>152</td>
<td>*</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Kuether, et al., 1998</td>
<td>77</td>
<td>31/46</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>2/2</td>
<td>unknown</td>
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<tr>
<td>Leber, et al., 1998</td>
<td>134</td>
<td>61/73</td>
<td>2</td>
<td>2</td>
<td>2/2</td>
<td>unknown</td>
<td></td>
</tr>
<tr>
<td>McDougall, et al., 1998</td>
<td>200</td>
<td>*</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>*</td>
<td>7, 7, &amp; 10 mm, giant</td>
</tr>
<tr>
<td>Murayama, et al., 1999</td>
<td>120</td>
<td>0/120</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0/1</td>
<td>unknown</td>
</tr>
<tr>
<td>Solander, et al., 1999</td>
<td>79</td>
<td>26/53</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1/1</td>
<td>unknown</td>
</tr>
<tr>
<td>Vanninen, et al., 1999</td>
<td>52</td>
<td>52/0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>3/3</td>
<td>3, 3, &amp; 12 mm</td>
</tr>
<tr>
<td>total (incidence rate)</td>
<td>2030</td>
<td>1116/458</td>
<td>51 (2.51%)</td>
<td>20 (0.99%)</td>
<td>31</td>
<td>38/39</td>
<td></td>
</tr>
</tbody>
</table>

* In these studies data were incomplete, and the results for this section of the table could not be assessed.
literature search indicate that procedure-related rupture of intracranial aneurysms during endovascular treatment with detachable coils occurs in 2.5% of procedures. Although reversal of heparinization and further delivery of coils will usually stop the angiographically observed bleeding, more than one third of this group of patients will die as a direct result of the complication, a 1% mortality rate. If it is assumed that a 2% mortality rate is acceptable for detachable coil–treated cerebral aneurysms, it is clear that rupture during treatment is a substantial cause of procedure-related deaths. It is remarkable that the outcome after procedure-related rupture seems to be an all or nothing phenomenon: in the literature as well as in our series, patients either die or survive without sequelae. Reports of intraoperative rupture rates during surgery vary from 15 to 53%. Minor leaks are generally well managed, but major intraoperative bleeding is associated with poor outcome, particularly in situations in which proximal control is difficult.

Risk Factors

Regarding risk factors for aneurysm rupture during therapy with GDCs, we found that small aneurysm size is associated with a higher incidence of procedure-related rupture. Although this is well known among interventional neuroradiologists based on their experience, to our knowledge this is the first time that small aneurysm size has been actually proven to be a risk factor for procedure-related rupture. Data in the literature were too scarce to support this finding. Why would smaller aneurysms be more at risk for rupture than larger ones during coil placement? It is known that smaller aneurysms tend to have a thin, fragile wall. Moreover, there is little space in small lesions to allow the “paintbrush” movement of the tip of the microcatheter during coil delivery, from which the following situation can arise: the coil cannot conduct its force to the microcatheter and will take a direction of lesser resistance, this being the aneurysm wall. This unfavorable mechanical situation is even more dangerous if the microcatheter’s position is fixed by a temporary occlusion balloon that may be used in wide-necked aneurysms, explaining the higher incidence of procedure-related rupture when this method is used. It is noteworthy that except for the 2-mm aneurysm it was never the first coil that perforated the sac. This may be explained by the fact that visual control during the placement of the first coil is not hampered by a coil mesh. It is our impression that a rupture may occur when a loop of the coil is forced between the coil mesh and the aneurysm wall, which is increasingly difficult to see as the coil mesh becomes more dense.

Based on our data we were not able to identify previous SAH as a risk factor for procedure-related rupture. However, in the studies we reviewed this relation was statistically very strong. The timing of treatment after SAH as a risk factor for procedure-related rupture could not be demonstrated from our own data or from those reported in the literature.

Conclusions

Procedure-related rupture during treatment with GDCs occurs in 2.5% of procedures and is responsible for 1% of treatment-related deaths. Risk factors are small aneurysm size, previous SAH, and probably the use of a temporary occlusion balloon. In choosing between surgery and endovascular therapy of cerebral aneurysms these risks have to be considered.

References