Ruptured Multiple Intracranial Aneurysms; Surgical Experience

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ABSTRACT

Background: Multiple intracranial aneurysms are not infrequent disorder and represent a great challenge to vascular neurosurgeons. The surgical management should be based on the localization of the correct offending aneurysm among multiple aneurysms for occlusion and deciding the type of surgery either one stage or two stages surgery. Objective: This is a retrospective case series study analyzes the postoperative clinical and radiological outcome of twelve patients with ruptured multiple intracranial aneurysms operated upon. Patients and Methods: Patient selection: twelve patients with ruptured multiple intracranial aneurysms were operated upon and followed up clinically and radiologically for six months. Operation: Microsurgical clipping of multiple aneurysms in a one-stage operation in eight patients and in two-stages operations in four patients. Results: In the Neurosurgery Department, Cairo University Hospitals; from January 2011 through December 2014, twelve patients with ruptured multiple intracranial aneurysms underwent microsurgical clipping using classic pterional approach and followed up clinically and radiologically for six months. The total number of aneurysms in all patients was twenty seven aneurysms. Eight patients (66.7%) underwent one-stage operation for clipping of all aneurysms while four patients (33.3%) underwent two stages operation. Total aneurysm occlusion was accomplished in 100% of the patients. With 6 months follow up interval ten patients (83.3%) regained their full activity (GOS 5) and two patient (16.7%) suffered from moderate disability (GOS4). No mortality was encountered. Conclusion: Microsurgical clipping of multiple intracranial aneurysms allows safe, effective and permanent repair in one-stage or two stages operations. The craniotomy should be performed on the side of the ruptured aneurysm in order to be exposed and clipped first and when the unruptured aneurysms are difficult to be repaired, a contralateral craniotomy is recommended at a later stage.

INTRODUCTION

Intracranial aneurysms are pathological dilatations of the cerebral arteries which are present in 2%-5% of the general population with an annual risk of rupture of 0.7%-1.9% causing subarachnoid hemorrhage.1,2,3,4 Multiple intracranial aneurysms are two or more intracranial aneurysms that exist in the cranium. They present in 14 to 34% of patients with intracranial aneurysms and in 20-40% of these patients, the aneurysms are bilateral. This means that 3 to 13% of patients diagnosed with aneurysms have bilateral disease. Multiple intracranial aneurysms is still unclear, however it can be associated with IgE syndrome. Patients with atrial myxoma and cerebral vascular malformations could be suffering from multiple intracranial aneurysms. Hypertension, drinking alcohol and smoking can induce multiple aneurysms.5,6,10,11,12 Intracranial aneurysms can cause subarachnoid hemorrhage, resulting in morbidity of 8-20% and mortality of 37-57%.13 The risk of rebleeding on patients with multiple aneurysms is higher and occurs earlier in this group of patients.14 The clinical presentation of patients with multiple intracranial aneurysms is not different from patient with single aneurysm varying from mild headache to deep coma. The initial subarachnoid hemorrhage impact and vasospasm account for the morbidity and mortality.15 Multiple intracranial aneurysms can be treated with surgical and/or endovascular coiling.16 The surgical management of patients with multiple intracranial aneurysms should be based on the localization of the correct offending aneurysm among multiple aneurysms for occlusion and deciding the type of surgery either one stage or two stages surgery according to the location of aneurysms.17 Clipping of the contralateral aneurysms...
PATIENTS AND METHODS

This study was approved by the ethical committee of the Neurosurgery Department, faculty of medicine, Cairo University and performed in accordance with institutional ethics committee guidelines.

Between January 2011 and December 2014, twelve patients with ruptured multiple intracranial aneurysms were admitted and managed by microsurgical clipping in the Neurosurgery Department, Cairo University Hospitals.

The diagnosis was established on the basis of clinical picture as well as CT scan and CT angiography. All patients underwent complete neurological examination, Hess and Hunt grading system evaluation and Fisher grading scale evaluation.

All the patients underwent routine medical treatment for SAH, which included calcium antagonist; either oral nimodipine (60 mg 4-hourly) which continued for 21 days if the patients can swallow, or by the intravenous route (0.5-2 mg /h) if the patient’s conscious level is disturbed. Clinical monitoring of daily fluid and electrolyte balance, anticonvulsants and deep venous thrombosis prophylaxis.

CSF diversion via Ventriculo-peritoneal shunt was done only in the presence of hydrocephalus. The aneurysm clipping was carried out as early as possible once the patient’s diagnostic tools were fulfilled.

Surgical approach

The operative approach in this study was the classical Pterional approach. It represents an approach where most of aneurysms of the anterior circulation and several of the upper posterior circulation can be reached simultaneously with less obstruction and wider surgical corridor.

Proper anesthesia preparation is crucial and includes placement of a central line, arterial line, preoperative antibiotics and anticonvulsants, hyperventilation to a pCO2 of 30-35, mannitol and frusemide and proper brain protection if temporary clipping is anticipated and good control of blood pressure intraoperative.

The choice of the side of the surgical approach should be based on the site of ruptured aneurysm in order to be exposed and clipped first. The ruptured aneurysm is more likely to be associated with: larger and irregularly shaped aneurysm, intracerebral and subarachnoid hemorrhage and the site of cerebral edema. All the ipsilateral aneurysms should be clipped using the same craniotomy while the contralateral aneurysms will be performed using contralateral craniotomy in another stage four weeks after the first operation.

The patient is placed supine with the head in three-point fixation device and slightly extended such that the malar eminence is the uppermost. The degree of head rotation should be adjusted to the angle to ruptured aneurysm because it will be clipped first then the angle of head could be changed by rotation of the table according to the aneurysm will be clipped next. After performing the classic pterional craniotomy, hemostasis of the extradural portion of surgery should be meticulous in order to prevent interference of blood during microsurgical dissection which can slow down the operation, reduce visibility and increase the risk of neurologic injury. It is mandatory to do an adequate sphenoid ridge drilling and generous arachnoid dissection to allow maximal brain relaxation and minimal retraction. This involves wide opening of the Sylvian fissure, extending the arachnoid dissection to the carotid cistern, chiasmatic and lamina terminalis cistern. Exposure of the parent vessels and aneurysm neck should be performed in standard fashion. Clips can be removed and reapplied as many times as necessary to optimally obliterate the aneurysm, while preserving the parent vessels.

The following microsurgical procedure and events were noted: difficulties of aneurysm dissection, inraoperative rupture, temporary clipping, brain plasticity and operation time for each patient.

Patients were awakened immediately after operation, the conscious level and signs of focal deficit were assessed. Proper postoperative monitoring was performed in the intensive care unit for 48 hours. The patient was kept in an euvolemic state, with blood pressure allowed to rise to the patient’s high normal pressure together with fluid balance and serum electrolytes monitoring. Vasospasm in each case was assessed clinically. Postoperative complications were also recorded.

Glasgow outcome scale was used to evaluate the clinical outcome immediately postoperative, during the hospital stay, and at 2 and 6 months intervals. Work status at last follow up was also recorded.32

Postoperative CT scanning was routinely performed on the second day postoperatively to assess the ventricular size, the ischemic areas and the general outlook of the brain tissue. Follow up CT angiography was performed three weeks postoperatively.

RESULTS

Between January 2011 and December 2014, eight females (66.7%) and four males (33.3%) with a mean age of 45.3 years (range from 30-61) were admitted to Cairo University Hospitals with ruptured multiple intracranial aneurysms.

All the patients (100%) had a history of sudden headache which vary from mild to severe, nausea and vomiting in ten patients (83.4%), disturbed conscious...
level in two patients (16.7%). Two patients (16.7%) experienced oculomotor paralysis and one patient (8.3%) had monoparesis. All patient were evaluated according two Hunt and Hess grading system of subarachnoid hemorrhage (Table 1).

An admission CT brain revealed subarachnoid hemorrhage in all patients, intraventricular hemorrhage in two patients and parenchymal hemorrhage in one patient. According to Fisher grading for Subarachnoid hemorrhage, three patients (25%) had grade 2, six patients (50%) had grade 3 and three patients (25%) had grade 4 (Table 2).

Table 1: Hunt and Hess grades distribution

<table>
<thead>
<tr>
<th>Hunt and Hess score</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7 (58.34%)</td>
</tr>
<tr>
<td>2</td>
<td>4 (33.33%)</td>
</tr>
<tr>
<td>3</td>
<td>1 (8.33%)</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
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<tr>
<td>5</td>
<td>0</td>
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Table 2: Fisher grades distribution

<table>
<thead>
<tr>
<th>Fisher grade</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>3 (25%)</td>
</tr>
<tr>
<td>3</td>
<td>6 (50%)</td>
</tr>
<tr>
<td>4</td>
<td>3(25%)</td>
</tr>
</tbody>
</table>

The total number of aneurysms in all patients were twenty seven aneurysms, thirteen middle cerebral artery bifurcation aneurysms (MCA), nine anterior communicating artery aneurysms (ACoA) and five posterior communicating artery aneurysms (PCoA). Out of twenty seven aneurysms, twelve were ruptured and fifteen unruptured. The ruptured aneurysms were seven MCA aneurysms, three ACoA and two PCoA. (Fig. 1) The mean size of aneurysms was 6.5 mm (range from 4 mm to 15 mm).

Eight patients (66.7%) underwent one-stage operation for clipping of all aneurysms while four patients (33.3%) underwent two stages-operation, the second operation was four weeks after the first craniotomy. One stage operation was performed for clipping all the aneurysms in the same side of ruptured one while two stages—operation were performed for aneurysms located on the contralateral side of ruptured aneurysm.

All patients underwent standard surgical clipping using classic Pterional approach (Right craniotomy in five patients, left craniotomy in three patients, both right and left craniotomies in four patients).

Intraoperative rupture of the aneurysm occurred in two patients (16.7%) and managed by proximal control of the parent vessel and appropriate clipping of the aneurysm after proper dissection of the neck.

Ventriculo-peritoneal shunt was performed in five patients, two patients presenting with hydrocephalus so they underwent shunting at the time of clipping and three patients developed hydrocephalus 4–7 days following clipping which necessitated shunting. Two patients developed hemiparesis; one patient had parenchymal hematoma at presentation and the other patient developed vasospasm which worsened the final outcome. One patient developed hyponatremia secondary to cerebral salt wasting syndrome which was managed by hypertonic saline and excess oral salt intake and resolved in a couple of weeks (Table 3).

Table 3: Postoperative sequelae and complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>Number of patients</th>
</tr>
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<tbody>
<tr>
<td>Neurological</td>
<td></td>
</tr>
<tr>
<td>- Vasospasm</td>
<td>2(16.7%)</td>
</tr>
<tr>
<td>- Hydrocephalus</td>
<td>5(41.7%)</td>
</tr>
<tr>
<td>- Electrolyte imbalance (cerebral salt wasting syndrome)</td>
<td>1(8.3%)</td>
</tr>
</tbody>
</table>

The average hospital stay for patients was 10-14 days.

At 6 months follow up interval ten patients (83.3%) regained their full activity (GOS 5) and two patients (16.7%) suffered moderate disability (GOS4), one patient underwent evacuation of parenchymal hematoma during clipping and the other patient developed vasospasm. (Table 4) No mortality was encountered in this study. Total occlusion of aneurysms was accomplished in all patients (100%). (Fig. 2,3 & 4)

Table 4: Functional outcome at the time of discharge and at six months follow up interval

<table>
<thead>
<tr>
<th>Glasgow outcome score</th>
<th>At discharge</th>
<th>At last follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>9 (75%)</td>
<td>10(83.3%)</td>
</tr>
<tr>
<td>4</td>
<td>2 (16.7%)</td>
<td>2(16.7%)</td>
</tr>
<tr>
<td>3</td>
<td>1(8.3%)</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
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<tr>
<td>1</td>
<td>0</td>
<td>0</td>
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</table>
Fig. 2a-f: Showing patient with 4 aneurysms (Rt MCA, ACoA, Lt PCoA, Lt MCA). a&b: Preoperative CT angiography. c,d,e,f: Intraoperative pictures showing clipping of the RT MCA, ACoA, Lt PCoA, Lt MCA aneurysms respectively.

Fig. 3a-e: Patient with three aneurysms (RT MCA, ACoA, Lt MCA). a&b: preoperative CT angiography. c,d,e: Intraoperative pictures showing clipping of RT MCA, ACoA, Lt MCA aneurysms respectively.

Fig. 3a-e: Patient with 2 aneurysms (Rt MCA, ACoA). a&b: Preoperative CT and CT angiography. c&d: Intraoperative pictures showing clipping of Rt MCA, ACoA aneurysms e: Postoperative CT scan.
DISCUSSION

Patients with multiple intracranial aneurysms present a great challenge to neurosurgical practice. The presence of two or more additional aneurysms with subarachnoid hemorrhage profoundly changes the outcome and alters the timing and strategy of surgery. The neurological grade on admission is the most important factor determining the outcome. One-stage or two-stage surgery should be determined based on the distribution of multiple aneurysms and the intraoperative situation to achieve ideal treatment effects. 

The aim of management is to eliminate the ruptured aneurysm and all the coexisting aneurysms from the circulation as early as possible either in one-stage or two-stage operation to prevent rebleeding and to facilitate the treatment of vasospasm without adding any damage to the brain. 

In this study we surgically treated twelve patients (mean age 45.3) with ruptured multiple intracranial aneurysms. The total number of aneurysms in all patients was twenty seven aneurysms with predominance of MCA aneurysms. Eight patients (66.7%) underwent one-stage operation for clipping of all aneurysms while four patients (33.3%) underwent two stages-operations. Total aneurysm occlusion was accomplished in 100% of the patients. With six months follow up interval ten patients (83.3%) regained their full activity (GOS 5) and two patients (16.7%) suffered from moderate disability (GOS 4). No mortality was encountered in our study.

Sucoheng and Yazhou reported 23 patients (14 female, 9 males) with age ranging from 36 to 71 years. All patients in their study had SAH. According to Hunt and Hess classification, 3,11,6,2 and 1 patients belonged to levels 1,2,3,4,5 respectively. Thirty-one craniotomies were performed and 54 aneurysms were occluded. Fifteen patients underwent one-stage surgery and eight patients underwent two surgeries for occlusion of all aneurysms. According to GOS score, 19 patients (82.6%) had good recovery (GOS 5), 2 patients (8.7%) had moderate disability (GOS 4) and two patients (8.7%) had severe disability (GOS 3). All aneurysms were totally occluded and no mortality was encountered in their study. Sucoheng and Yazhou had similar results to the current study except they had two patients with GOS 3 and this is attributed to the three patients with Hunt and Hess above 3 they had.

Imhof and Yonekawa studied 124 patients (80% females, 20% males) with age ranging from 30 to 89 years. All the patients in their series suffered SAH and presented with a total of 323 aneurysms. The highest rate of rupture was in middle cerebral artery aneurysms (29.8%) followed by aneurysms of anterior communicating artery (27.4%) finally the internal carotid artery (23.4%). Immediately after admission three patients died. The initial Hunt and Hess clinical classification was 72 patients (59.5%) had score 1,2,3 and 41 patients (33.9%) had score 4 and 5 and 8 patients (6.6%) had unknown score. In 57 patients, all the aneurysms were clipped in one session and 64 patients in two sessions. The GOS score of the surgically clipped patients at 12 months follow up interval was 40.2% of patients had GOS 5, 38.4% had GOS 4,13.3% had GOS 3, 4.5% had GOS 2 and 3.6% had GOS 1.

The results obtained by Imhof and Yonekawa slightly differ from the current study mainly in the less rate of improvement and four more cases of mortality. This is attributed to the more patients they had with age ranging from 60 to 89(33%), the posterior circulation aneurysms in their study were 15 ruptured and 20 unruptured posterior circulation aneurysms underwent clipping and they had 41 patients with Hunt and Hess score above 3 which worsened the final outcome and increased the mortality rate. 

Shen et.al studied 36 patients with multiple intracranial aneurysms. Out of 36 patients, 6 had SAH, 4 patients with history of SAH one to four months before treatment, 26 patients with unruptured multiple intracranial aneurysms. They performed endovascular embolization using detachable coils in all patients. Four patients (11.1%) developed complications, three patients with intastent thrombosis and one patient with aneurysmal rupture during the procedure. Out of these four patients, two patients developed permanent paralysis and aphasia. The Overall clinical outcome was excellent in 33 patients (91.7%), good in one (2.8%) and fair in two (5.5%).Angiographic follow up was performed on 31 patients with 57 aneurysms. 47 aneurysms (82.5%) were initially occluded, one of them showed coil compaction on follow up and was reembolized to achieve complete occlusion. The initially incompletely occluded aneurysms were followed up, one of them reembolized and the remaining patients were followed up.

In this study, endovascular embolization was not performed and all aneurysms were surgically clipped. Shen et al study had relatively better clinical outcome, this is attributed to the lower number of patients with recent SAH in their study (16.6%) than the current study (100%). The initial occlusion rate in their study on follow up angiogram was 82.5% while we had 100% occlusion rate.

There are some controversies about the usage of unilateral approach for clipping of contralateral aneurysms (ophthalmic, posterior communicating, internal carotid, middle cerebral artery). Several authors reported clipping of contralateral aneurysms but there is agreement that it can be performed in selected cases with unruptured aneurysms that may have benefit in saving the patient a future craniotomy. Contralateral exposure can be difficult and hazardous in aneurysmal SAH due to brain swelling, hydrocephalus and limited cisternal spaces. The added time, dissection, retraction, limited operative space and relative deep location to reach the distal lesions will result in neurovascular injury.

The coexisting aneurysms of all sizes in patients with SAH due to another treated aneurysm carry a
higher risk for future hemorrhage than the similar sized aneurysms without a SAH history. Some studies advocated the elimination of all aneurysms within one session even with two craniotomies. The unstaged procedure has several advantages over the staged one in cases of difficulties in identifying the ruptured aneurysm, clipping of all aneurysms will prevent further bleeding and allowing aggressive treatment of vasospasm but it carries risk of additional ischemic damage to the brain, caused by increased manipulation of cerebral arteries and brain tissue. In this study, we performed clipping of all aneurysms in one-stage operation in eight patients (66.7%) and in two stages-operation in four patients (33.3%). Some authors performed clipping of aneurysms according to the order of exposure to avoid intraoperative rupture of non ruptured aneurysms caused by surgical retraction. In this current study we clipped the ruptured aneurysm first then the unruptured aneurysms in order to avoid intrapreoperative rupture of already newly ruptured aneurysm and there were no patients with intraoperative rupture of the unruptured aneurysm.

**CONCLUSION**

Microsurgical clipping of multiple intracranial aneurysms allows safe, effective and permanent repair in one-stage or two–stages operation. The craniotomy should be exposed and clipped first and when the unruptured aneurysms allows safe, effective and permanent repair in multiple intracranial aneurysms to avoid intraoperative rupture of already newly ruptured aneurysm and there were no patients with intraoperative rupture of the unruptured aneurysm.

**Disclosure:**

The authors have no personal, financial or institutional interest in any of the drugs, materials, or devices described in this article.

**REFERENCES**