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Socioeconomic Issues

Cost-effectiveness of clipping vs coiling of intracranial aneurysms after subarachnoid hemorrhage in a developing country—a prospective study

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Abstract

Background: Endovascular coil treatment is being used increasingly as an alternative to clipping for some ruptured intracranial aneurysms. The relative benefits of these 2 approaches have yet to be fully established. The aim of this study was to compare the clinical outcome, resource consumption, and cost-effectiveness of endovascular treatment vs surgical clipping in a developing country.

Methods: The study population consisted of 55 patients with aneurysmal subarachnoid hemorrhage (SAH) identified prospectively from January 2004 to June 2007. Of the 55 patients with ruptured intracranial aneurysms, 31 underwent surgical clipping, whereas 24 were treated via interventional coils. Clinical outcome at 6 months, using the modified Rankin Scale, and cost of treatment related to all aspects of the inpatient stay were evaluated in both groups.

Results: The average age of the patients in the endovascular group was 38 years, whereas in the surgical group, it was 45 years. Most patients (43) were found to be in grades (1 and 2). Of these patients, 18 received coils and 25 were clipped. The remaining 12 patients were of poor grades (3 and 4), of which 6 had coiling and 6 underwent clipping. Most the patients (46/55) had anterior circulation aneurysms, and the rest of the patients (9/55) had posterior circulation aneurysms. The clinical outcome was similar in comparison (good in 81% for clipping and 83% for coiling). The average total cost for patients undergoing endovascular treatment of the aneurysms was $5080, whereas the average total cost of surgical clipping was $3127.

Conclusion: Patients with aneurysmal SAH whom we judged to require coiling had higher charges than patients who could be treated by clipping. The benefits of apparent decrease in length of stay in the endovascular group were offset by higher procedure price and cost of consumables. There was no significant difference in clinical outcome at 6 months. We have proposed a risk scoring system to give guidelines regarding the choice of treatment considering size of aneurysm and resource allocation.

Keywords: Cerebral aneurysm; Clinical outcome; Cost; Guglielmi detachable coil; Modified rankin scale

1. Introduction

Aneurysmal subarachnoid hemorrhage (SAH) is a significant cause of mortality and continuing morbidity worldwide. The frequency of SAH due to rupture of intracranial aneurysm is 6 to 8 per 100 000 in most western populations [3,17]. Ruptured aneurysms can be treated by either a microsurgical technique or endovascular coiling. Neurosurgical intervention to clip the aneurysm entails a craniotomy and aims to prevent rebleeding of the aneurysm by placing a clip across its neck, thus, excluding the aneurysm from circulation. This procedure carries a 98% certainty of elimination of the threat of rerupture [10]. In the 1960s, McKissock et al [20,21] published a series of

Abbreviations: CT, Computed Tomography; GDC, Guglielmi Detachable Coil; ISAT, International Subarachnoid Aneurysm Trial; SAH, Subarachnoid hemorrhage.

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prospective trials, which showed that, depending on the location of the aneurysm, benefits of surgery outweighed the risks in most of the circumstances. With extensive refinement in microsurgical techniques in the 1970s and 1980s, clipping of intracranial aneurysms became the criterion standard in the treatment of intracranial aneurysms.

In 1990, a detachable platinum coil device, the Guglielmi Detachable Coil (GDC), was introduced. The detachable coil obstructs the aneurysmal lumen and induces secondary thrombosis of the aneurysm. The introduction of an alternative to neurosurgical clipping gave rise to the need for identifying the patient population suitable for receiving endovascular treatment. Globally, the frequency of use of this technique varies widely [13]. Hence, there is a need of high-quality evidence to establish the efficacy and safety of endovascular coiling, especially in a developing country such as Pakistan.

The International Subarachnoid Aneurysm Trial (ISAT) is the first multicenter prospective randomized trial comparing the 2 options [22]. A total of 2143 patients with ruptured intracranial aneurysms were randomly assigned to clipping (n = 1070) or coiling (n = 1073). At 1 year, the outcome was assessed by a modified Rankin Score to determine dependency and death in these patients. A significant difference was found between the groups, and the trial was abandoned; 22.7% of coiled patients were dependent or dead compared with 30.6% of those subjected to surgery. The annualized risk of rebleeding after coiling was 0.16% and zero for clipping.

International Subarachnoid Aneurysm Trial has affected the approach to patients with intracranial aneurysms in neurosurgical centers across the globe. The changes brought about by ISAT will affect not only the mode of treatment but also the resource allocation as well. However, the cost of treatment differs substantially worldwide. These cost variations may assume significant importance in developing countries. In many developing countries with low per capita income and very limited medical insurance, cost-effectiveness greatly influences decision making when choosing between 2 comparable treatment options.

At Aga Khan University Hospital, Karachi, Pakistan, endovascular coiling has been in use since 2004, and we are the only neurosurgical center in Pakistan offering this service. The objective of this study was to compare the clinical outcome and the cost of endovascular coiling vs neurosurgical clipping in this part of the world.

2. Patients and methods

The study population consisted of 55 patients with proven aneurysmal SAH who were actively treated for ruptured aneurysms at Aga Khan University Hospital between January 2004 and June 2007 by a team of specialists including neurosurgeons who are trained in microvascular surgery and interventional neuroradiologist trained in endovascular surgery. Patients with aneurysmal SAH were identified prospectively. The Department of Neurosurgery at our institution is the only neurosurgical unit in Pakistan providing both treatment facilities. The inclusion criteria for this study were as follows: (1) computed tomography–proven SAH, (2) demonstration of an intracranial aneurysm by intra-arterial or computed tomography angiography considered to be responsible for the recent SAH, (3) patient assessment by a neurosurgeon as well as by an interventional neuroradiologist.

Variables describing the risk factors, clinical presentation, preoperative status, severity of SAH, characteristics of the aneurysm, and the preoperative course were obtained from the institutional aneurysm registry. Variables indicating resource use in the intensive care unit (ICU), inpatient ward, radiology, and laboratory were obtained from the patient data management system.

Preoperative clinical status was assessed using the Hunt and Hess grading system for SAH. Postoperatively, patients were managed according to hospital protocol. According to this protocol, patients exhibiting an uncomplicated course of recovery were transferred to the special care unit after being monitored in the recovery room for a few hours. They were then transferred to the neurosurgical ward on the first postoperative day, provided they remained vitally and neurologically stable. The criteria for transferring the patient from special care unit to the ward were (1) complete recovery from anesthesia, (2) attainment of complete consciousness, (3) restoration of respiratory function, and (4) hemodynamic stability. Patients who required postoperative ventilatory support were admitted to the ICU.

The mean duration of follow-up available to us is 6 months after the day of discharge. Outcome was assessed on discharge and on follow-up according to the modified Rankin Scale.

2.1. Cost of treatment

All costs are in Pakistani Rupees (Rs.) (converted to US dollars with the current international conversion rate of Rs. 60 = $1). Cost of treatment was calculated for each patient to encompass their expenses incurred during the time spent as an inpatient for aneurysm treatment and the cost of radiologic follow-up. This consisted of the cost of the initial stay, bed occupancy in ICU and regular hospital bed, laboratory tests, imaging studies, and the cost of the neurosurgical clipping or endovascular coiling procedure, including materials (cost of aneurysm clip or endovascular coil and other surgical supplies), as well as the cost of any further procedures (delayed surgeries, follow-up angiograms, etc). The total cost of treatment was then manually calculated. We logged all components of the patient's care in which hospital cost was incurred to obtain the total cost of treatment for a given patient. This manual cost calculation was then checked against total cost and individual cost components by the billing department. All costs are presented in Pakistani Rupees and US dollars. The cost of treatment reported in this article does not include the expenditure on additional hospitalization in

another institution after discharge, rehabilitation in any institution other than Aga Khan University Hospital, or any anticipated expenditure regarding future procedures.

2.2. Clinical outcome

The clinical outcome was measured at the time of discharge and on follow-up visit 6 months after discharge using the modified Rankin Scale [18]. Scores of 0 to 1 indicate no disability, whereas 2 to 5 represent varying levels of disability and dependency and 6 corresponds to demise of the patient. Because the patients with score of 2 and 3 had minor disability with only a limited need of support, 0 to 3 was classified as good outcome and 4 to 6 as poor outcome for this study.

2.3. Statistical analysis

Statistical analysis was performed using SPSS 13.0 (SPSS, Chicago, Ill) for Microsoft Windows XP. Normally, distributed continuous variables were expressed as means and standard deviations, whereas non-normally distributed continuous variables were expressed as medians and ranges.

3. Results

Of the 55 patients included in our study, 31 patients underwent clipping and 24 received endovascular treatment.

Table 1
Patient's details

	Coiling	Clipping	Total
No. of patients	24	31	55
Mean age (y)	38	45	
Sex (male/female)	14/10	9/22	23/32
Hunt and Hess grade and mode of treatment			
Good grade			
Grade 1	8 (33%)	15 (47%)	23 (42%)
Grade 2	10 (42%)	10 (35%)	20 (36%)
Poor grade			
Grade 3	3 (13%)	4 (12%)	7 (13%)
Grade 4	3 (13%)	2 (6%)	5 (9%)
Aneurysm location and mode of treatment			
Anterior circulation	17 (37%)	29 (63%)	46
ICA	5	3	8
ACA	1	–	1
A-Com	9	10	19
MCA	2	16	18
Posterior circulation	7 (77%)	2 (23%)	9
PCA	–	–	–
P-Com	3	1	4
PICA	2	1	3
Basilar	2	–	2
Aneurysm characteristics			
<5 mm	5	8	13 (24%)
5-8 mm	13	20	33 (60%)
>8 mm	6	3	9 (16%)

ICA, internal carotid artery; ACA, anterior cerebral artery; A-Com, anterior communicating artery; MCA, middle cerebral artery; PCA, posterior cerebral artery; P-Com, posterior communicating artery; PICA, posterior inferior cerebellar artery.

Table 2
Complications

	Coiling	Clipping	Total
Stroke	4 (17%)	10 (32%)	14 (25%)
Aneurysm rupture	1 (4%)	2 (6%)	3 (5%)
Residual necks	1 (4%)	0 (0%)	1 (2%)
Death	1 (4%)	2 (6%)	3 (5%)

The mean age in years for coiling and clipping was 38 and 45, respectively, and the ratio of male to female was 1:1.3.

According to the Hunt and Hess system, most of the patients (43) were found to be in the range of 1 to 2. Of these 43 patients, 18 underwent coiling and 25 were clipped. The remaining 12 patients had a grade ranging from 3 to 4, making them high-risk candidates for surgery. Six of these 12 patients received endovascular coils, and 6 had their aneurysms surgically clipped (Table 1).

A large proportion of our patients (46) had anterior circulation aneurysms, whereas the remaining [9] were harboring posterior circulation aneurysms. Microsurgical clipping was the preferred mode of treatment in anterior circulation aneurysms, that is, 29 (63%) of 46 patients. However, in posterior circulation aneurysms, most underwent endovascular coiling, that is, 7 (77%) of 9 patients. The exact aneurysm location was variable. The commonest locations, in descending order of frequency, were the anterior communicating artery, middle cerebral artery, and internal carotid artery. Aneurysms of the posterior inferior cerebellar artery and basilar artery were infrequent (Table 1).

The average aneurysm size was 5 to 8 mm. Of the 33 patients in this category, 20 underwent surgical clipping and 13 were coiled. Thirteen patients had small aneurysms measuring less than 5 mm, and 9 had aneurysms assessed to be more than 8 mm.

Stroke and aneurysmal rupture were the 2 most common complications, the stroke being the major morbidity. Fourteen (25%) of 55 patients had stroke as a result of vasospasm. Vasospasm-related complications were more common after clipping. Aneurysmal rupture occurred in one patient during coiling, as a result of which, he had to undergo clipping. All patients treated via coiling underwent a follow-up angiography in 6 months' time. Residual neck formation was seen in only one patient (7%). Three patients died, one in the endovascular coiling group and 2 in the clip application group. All 3 had a poor Hunt and Hess grade preoperatively (Table 2).

The clinical outcome was assessed based on modified Rankin Scale, where grades ranging from 0 to 3 were considered good and ranges of 4 to 6 were declared as poor clinical outcome. The results of both modes of treatment were found to be comparable with 81% and 83% favorable outcome in clipping and coiling, respectively. The above-mentioned results are collectively summarized in Table 3.

Despite comparable outcomes, there is a significant difference in the cost of both procedures. A patient who was treated surgically spent an average of 12 days in the

Table 3
Clinical outcome based on modified Rankin scale

	Coiling	Clipping	Total
0	13	8	21
1	1	6	7
2	6	7	13
3	0	4	4
0-3 Good outcome	20 (83%)	25 (81%)	45
4	1	3	4
5	2	1	3
6	1	2	3
4-6 Poor outcome	4 (17%)	6 (19%)	10

hospital, whereas patients who were coiled spent only 7 days. Hospital bed charges were US$31 per day, and operation room charges were $120 per hour. The average time taken to clip an aneurysm was 3 hours. We are using Sugita and Yasargil clips. Price of one clip is approximately $80. The price of one GDC coil is $666, and the number of coils averaged to 5 coils in a single endovascular procedure. At our center, we use GDC coils by Boston Scientific/Target (Fremont, CA). Radiologic charges were also increased in the coiling group because of intraoperative angiography, as well as at 6 months' follow-up to asses the status of aneurysmal obliteration. The average total cost for an aneurysmal clipping was $3127, although it was $5080 for endovascular coiling (ie, 62% more expensive than clipping). Bed charges, drugs, and laboratory workup cost more in clipping, but it was medical equipment, including GDC coils, that shifted the balance of cost and made aneurysm coiling more expensive (Tables 4 and 5, Fig. 1).

4. Discussion

The ISAT trial demonstrated that for aneurysms suitable for both endovascular coiling and neurosurgical clipping, endovascular treatment results in better clinical outcomes measured at 2 months and 1 year of follow-up. Because the use of endovascular therapy increases in the treatment of intracranial aneurysms, resource allocation should be based on this new pattern of practice. A few studies have compared the cost of coiling and clipping of ruptured intracranial aneurysms, and none, to the best of our knowledge, has been performed in a developing or an underdeveloped country. A comparative analysis of cost-effectiveness of coiling vs clipping has been attempted by Bairstow et al [1], who analyzed 22 patients who were enrolled into ISAT in Perth, Australia. Ten patients were randomized to coiling and 12 to clipping. They suggested that although coiling was more expensive, it was compensated by the lower cost of postprocedure hospitalization. Ballet et al [2] in France drew a similar conclusion in a retrospective study. Johnston [15] from the University of California San Francisco performed a multivariate analysis on length of hospitalization. Total length of stay was longer (mean 7 days for surgical patients vs 5 days for endovascular patients), and hospital charges were greater ($38 000 for surgical patients vs $33 400 for endovascular patients) for surgical clipping. Javadpour et al [14] analyzed 62 patients who were randomized in the ISAT from the University of Toronto, Canada. There were no significant differences in the total cost of treatment between the endovascular group and the microsurgical clipping group. The benefits of apparent decrease in length of stay in the endovascular group were offset by higher procedure costs. There was no significant difference in clinical outcome at 2 months and at 1 year. At 6 months after coiling, 15 (50%) of 30 aneurysms were completely obliterated, and 19 (63%) of 30 were angiographically stable. However, these conclusions may not be applicable to aneurysm treatment in all countries.

Table 4
Cost analysis

Hospital resources used	Coiling		Clipping	
Bed charges	$250	Rs. 15 000	$375	Rs. 22 500
Laboratory	$150	Rs. 9000	$350	Rs. 21 000
Radiology	$1380	Rs. 82 800	$689	Rs. 41 340
Medical equipment	$3000	Rs. 180 000	$360	Rs. 21 600
Drugs	$300	Rs. 18 000	$770	Rs. 46 200
Surgeon fee	–	–	$583	Rs. 34 980
Average total cost	$5080	Rs. 304 800	$3127	Rs. 187 620

Table 5
Comparison summary

	Clipping	Coiling
Average cost	$3127	$5080
Total no. of patients	31	24
% of aneurysms >5 mm	69%	79%
Poor Hunt and Hess grade patients	6	6
Good outcome	81%	83%

The cost and availability of health care differ substantially between countries. All these studies originate from developed countries where medical insurance covers most of the medical expense, per capita income is higher than the world average and the surgical management, and interventional treatment has a different fee structure from rest of the world.

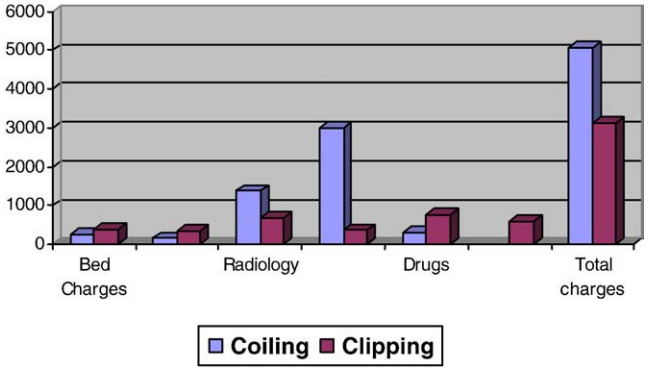

Fig. 1. Bar chart showing different expenses in clipping and coiling group. Bed charges, drugs, and laboratory workup cost more in clipping, but it was the medical equipment and radiology charges that made coiling more expensive.

Our institution is the largest contributor to comprehensive aneurysmal treatment in Pakistan. We receive referrals from other parts of the country, and each case is assessed individually and treated accordingly. This gives us an opportunity to compare the cost and clinical outcome of coiling vs clipping of ruptured intracranial aneurysm in a developing region of the world. The cost of coiling was found to be 62% more expensive than the cost of clipping without providing any additional benefit of decrease morbidity. The learning curve of endovascular surgery has not affected the cost of treatment. In this study, there was an apparent decrease in the duration and cost of hospitalization in the coiling group. However, this apparent decrease in the length of the hospital stay was more than compensated by higher procedure costs in the endovascular group compared with the surgical group. Our results suggest that in countries in which hospital bed costs are relatively low, the cost of consumables may have a larger impact on the total cost of care. Furthermore, there is a lack of proper health insurance system in our part of the world. Analysis of our admitted patients showed that only 7% of them were medically insured. Lack of medical insurance puts a significant burden on patient and patient's family's financial resources. We believe that our institution results are true representation of this part of the world and should be considered relevant to other developing countries as well.

We also found that both groups were comparable with regard to clinical outcomes. In the past, the efficacy and safety of neurosurgical and endovascular techniques have been evaluated by comparing mortality and morbidity rates associated with the various techniques [10,17,22,24]. According to Fraser et al [9], the outcomes reported in ISAT have been misinterpreted by many to indicate the superiority of coiling to surgical clipping in all instances. He compared the ISAT results with the results of 19 other published studies regarding the treatment of ruptured intracranial aneurysms. Mean procedural complication rates were similar (surgical clipping, 11%; endovascular coiling, 9%); ISAT did not report procedural complications. However, ISAT rates were within the range of the other studies for overall mortality, total rebleeding, need for reoperation, and poor outcome. Fazer et al [8] found that there are minimal differences in the long-term cognitive outcome between the 2 groups. Mahmoud et al [19] performed a retrospective analysis of 133 patients and reported a more significantly favorable outcome with endovascular coiling than with microsurgical clipping after 3 months' follow-up. However, Hoh et al [11] in his study of 515 patients with aneurysmal SAH noted significantly better outcome in patients who underwent clipping as compared with the coiling group.

An important issue regarding endovascular treatment of aneurysms is the long-term outcome and durability of these procedures. In this study, we have one case of aneurysmal recurrence in the coiling group on follow-up angiography. These figures cannot be compared because follow-up angiography was not performed in the surgical group. However, David et al [6] have suggested, in a retrospective study of 102 patients with a mean angiographic follow-up period of 4.4 years, that surgical clipping has long-term durability and that rehemorrhage is uncommon when aneurysms are completely obliterated surgically. Edner and Almgvist [7] reports a 20-year follow-up of 40 patients whose SAH causing aneurysms were clipped microsurgically. They recommend that because none of the patients experienced a recurrent subarachnoid bleed from the treated aneurysm during a 20-year follow-up period, a routine long-term follow-up period is not necessary. However, de novo aneurysm formation and possible enlargements of aneurysm base remnants were observed in almost 2% of patients per person year and should, therefore, be the subject of a routine long-term follow-up. Campi et al [5] looked into follow-ups of the patients treated in ISAT to compare the frequency, timing, and consequences of aneurysm recurrences. The study showed that late treatment was 6.9 times more likely after endovascular therapy, which means that the short-term follow-up imaging is therefore insufficient to detect recurrences after endovascular treatment. This also adds cost issues.

Based on the significant higher cost of coiling according to this study and the relative better outcome of coiling according to ISAT trial, we have proposed a risk scoring system to give guidelines regarding the choice of treatment. Grading schemes, in general, allow for categorization and identification of patients at an increased risk of a poor outcome. These schemes also facilitate selection of patients suitable for surgery. The Hunt and Hess [12] and the Botterell et al [4] grading schemes for ruptured intracranial aneurysms and the Spetzler-Martin [23,24] grading scheme for intracranial Arteriovenous malformation (AVMs) are prime examples. Our proposed system is based on the age of the patient, location of the aneurysm, and the Hunt and Hess grade. Each of the risk factors is subdivided to allot a point (Table 6). This scoring of risk has been extrapolated and modified from a grading system postulated by Khanna et al [16] in his article. To identify the risk factors that predispose a patient to a higher morbidity after surgical intervention, they reviewed the surgical treatment of 172 patients with unruptured intracranial aneurysms managed at their institution.

Table 6
Risk scoring system

Risk factors		Point value
Patient age (y)	<40	1
	40-60	2
	>60	3
Aneurysm location	Simple anterior	1
	Complex anterior or Simple posterior	2
	Complex posterior	3
Hunt and Hess grade	Grade 1	1
	Grade 2 and 3	2
	Grade 4	3

Table 7
Decision making table

Size of aneurysm (mm)	Risk scores		
	1-3	4-6	7-9
<5	Clipping recommended	Coiling recommended	Coiling strongly recommended
>5	Clipping strongly recommended	Clipping recommended	Coiling recommended

The final decision whether to clip or to coil should depend upon the size of the aneurysm in the light of the risk score calculated according to the point scoring system mentioned above. The risk scores have been grouped as 1 to 3 and 4 to 6, and the final recommendations take into account the risks involved in clipping (based on risk scores) and the cost involved in coiling based on the size of the aneurysm. Thus, if the size of the aneurysm is less than 5 mm, the subcategories would be rated as "clipping suggested" for a point value ranging between 1 and 3, "coiling recommended" for a point value of 4 to 6, and "coiling strongly recommended" for 7 to 9.

However, should the size of the aneurysm exceed 5 mm, then clipping is "strongly recommended" provided the point value ranges between 1 and 3, only "recommended" for 4 to 6, and switching to the option of coiling for all point values exceeding 7 (Table 7).

5. Conclusion

In our study, there was no significant difference in the clinical outcome of coiling and clipping of ruptured intracranial aneurysms; however, clipping is more cost-effective in our setup than coiling. Because the results of this study reflect the practices of a single institution, a large multicenter study from different developing countries may be required to confirm our findings, and each new technique must be evaluated in careful well-designed studies before generalized use.

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Commentary

The authors present an article comparing the cost-effectiveness of treating intracranial aneurysms by clipping or by endovascular coiling in a developing country. Even