

Cost economics of endovascular coiling versus surgical clipping of an intracranial aneurysm: Literature review and critical analysis

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ABSTRACT Background Cost-effectiveness of medical intervention is becoming increasingly important in healthcare delivery. Treatment in Neurosurgery is costly and there have been very few publications on neurosurgical health economics and comparative effectiveness analysis of neurosurgical procedures. Previous studies comparing the cost of clipping to coiling were from European centres with data accurately from the ISAT study conducted in Europe. They found no significant difference in the total cost of coiling when compared to clipping at one year. **Method** A literature search was conducted using electronic databases including MEDLINE and EMBASE. Inclusion Criteria are literature search limited to the last ten years (2006-2016), studies on adult human patients only, only papers published in English, editorials, comments and correspondences excluded. **Result** The systematic literature search yielded 5784 but after removal of duplicates and non-relevant studies finally had four studies that individually analysed cost economics of coiling and clipping of an intracranial aneurysm. Overall coiling more expensive than clipping in three studies. Wolstenholme et al. study showed no significant difference between the two procedures regarding cost economics. **Conclusion** Cost economics of an intracranial aneurysm showed that surgical clipping results to reduced re-operation rate when compared to endovascular coiling and also associated with increased complication, longer hospital stay and ultimately greater hospital cost.

KEYWORDS intracranial aneurysm; surgical clipping; endovascular coiling; cost economics

Introduction

The standard treatment of intracranial aneurysms has been neurosurgical clipping, however, with the introduction of the detachable coil to treat an aneurysm, endovascular coiling has currently emerged as a valid and reliable alternative to surgical clipping in the treatment of patients with aneurysmal subarachnoid haemorrhage (SAH) and unruptured intracranial aneurysms (IAs.)

The significant advantage of endovascular coiling is avoidance of craniotomy and early recovery following the procedure. The considerable disadvantage is in the event of coil impaction of failed endovascular coiling; the patient will have to undergo craniotomy[15]. Endovascular coiling of an intracranial aneurysm was introduced in 1991 as an alternative to microsurgical clipping. The proportion of patients experiencing endovascular coiling increased from 34% to 54% in the UK after the publication[7].

Cost-effectiveness of medical intervention is becoming increasingly important in healthcare delivery, treatment in Neurosurgery is costly, and there have been very few publications on neurosurgical health economics and comparative effectiveness analysis of neurosurgical procedures. Previous studies comparing the cost of clipping to coiling were from European centres with data accurately from the ISAT study conducted in Europe.

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They found no significant difference in the total cost of coiling when compared to clipping at one year.

This review aims to evaluate and analyse cost-effectiveness of endovascular coiling (in comparison to neurosurgical clipping) in the treatment of an intracranial aneurysm.

Methodology

A systematic literature search was conducted using electronic databases including, MEDLINE and EMBASE. Search keywords were used individually and in combination to identify relevant papers, keywords search included, intracranial aneurysm, Endovascular coiling, Efficacy, Cost/ cost-effectiveness. Inclusion Criteria are literature search limited to the last ten years (2006-2016). Studies on only adult human patients, only papers published in English, editorials, comments, correspondences excluded.

Results

The systematic literature search yielded 5784, but after removal of duplicates and non-relevant studies finally had four studies that individually analysed cost economics of coiling and clipping of an intracranial aneurysm. Overall coiling more expensive than excerpt in three studies. [9, 14, 6]. Wolstenholme study[17] showed that clipping more expensive than coiling 20,176 pounds against 18,436 pounds respectively. Treatment effectiveness was measured in QALY. Cost-effectiveness analysis includes all additional resources consumed and associated health intervention measured in ICER (a measure of the additional cost per unit health gain).

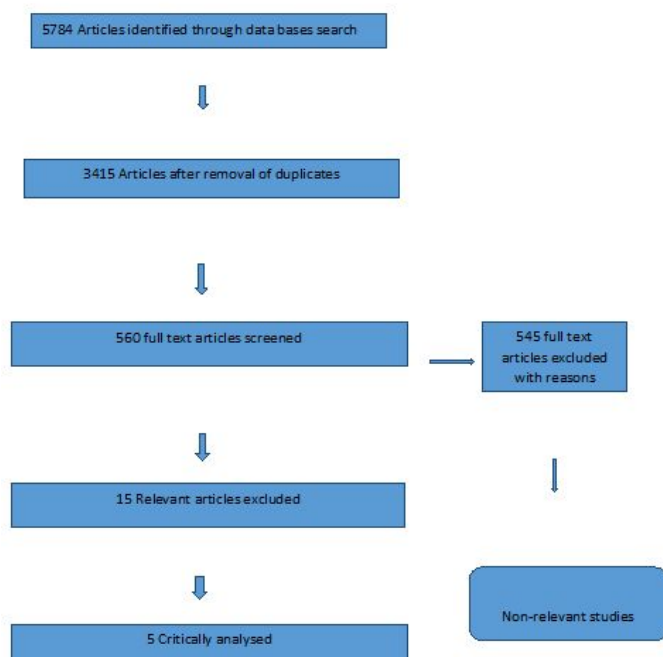


Figure 1: Search flow diagram

Discussion

Maud et al.[9] carried out Cost-effectiveness analysis of endovascular versus neurosurgical treatment for ruptured intracranial

aneurysms in the United States. Clinical data and values for quality of life were extracted from the ISAT trial[3] patients' eligibility is determined by the presence of a ruptured intracranial aneurysm judged by a neurosurgeon and interventional neuroradiologist to be suitable for either coiling or clipping based on its angiographic anatomy as agreed by both parties. The cost was derived from data on long-term care of stroke patients, relevant literature and the largest hospital-based comparative database. Cost analysis includes the total cost of hospitalisation, disability cerebral angiography, the frequency of retreatment and rebleeding for aneurysmal subarachnoid haemorrhage in the US in 2005-2006 using the prospective Comparative Database- Treatment effectiveness was measured in QALY. Cost-effectiveness analysis includes all additional resources consumed and associated health intervention measured in ICER (a measure of the additional cost per unit health gain). The average cost was estimated by multiplying each cost by the rate of clinical outcomes from ISAT findings.

This is a retrospective study based on the foremost database in the United States from 2005-2006 using the ISAT trial to extract data and for comparison. ISAT is the best evidence for the treatment of an intracranial aneurysm. About 1000 patients were randomised in each group with a majority in good clinical condition (WFNS Grades I-III) In the ISAT study. Initial hospitalisation of endovascular coiling of low severity case for subarachnoid haemorrhage cost \$35,143 while moderate to severe disability case cost \$21,645 with a median cost of \$3370. The median cost of cerebral angiogram was \$2800, and the retreatment and rebleeding cost were \$21,920 and \$61,622 respectively. The average 1-year total cost per patient with ruptured intracranial aneurysm treated by endovascular coiling over a period of one year was \$45,493. However, in the neurosurgical group, the initial hospitalisation of low severity SAH case was \$35,005, and the cost of retreatment and rebleeding were \$25,150 and \$58,426 respectively. The average 1-year total cost per patient with an intracranial aneurysm treated by clipping was \$41,769. The overall QALY for coiling was 0.69 and for clipping was 0.64. Mean ICER for coiling versus clipping was \$72,872 per QALY gained. Higher cost was recorded in the endovascular group at one year due to retreatment of originally treated intracranial aneurysm.

Cost analysis for endovascular coiling and surgical clipping may not reflect the exact cost for hospitalisation and services because these were collected retrospectively and may be influenced by ascertainment and documentation biases. Also, endovascular treatment is evolving at a rapid rate with significant and remarkable changes and adjustment hence this will go a long way to influence the cost-effectiveness unlike surgical clipping technique with little or no changes. This study reveals that in the United States endovascular coiling results in the higher cost at one year and also associated with better outcomes than surgical clipping among patients with ruptured intracranial aneurysm suitable for either endovascular or neurosurgical treatment pathways.

Wolstenholme et al.[17] carried out cost analysis on the treatment pathways, resources use and cost of endovascular coiling versus surgical clipping after aneurysmal subarachnoid haemorrhage. This is a post-randomisation analysis of ISAT, resource data collected prospectively for detailed cost analysis of endovascular coiling versus neurosurgical clipping. A total number of 2143 patients were recruited to the ISAT trial by 42 neurological centres, but this study focuses on the UK patients only compris-

Table 1 Search characteristics

Study/ Year	Design	Clipping (cost)	Coiling (cost)
Maud9 2009	Retrospective study	\$41769	\$45493
Wolstenholme17 2007	Post-randomisation analysis	£20176	£18436
Tahir14 2009	Retrospective	\$3127	\$5080
Hol18 2010	Retrospective	\$ 169 942 (Ruptured) \$ 80893 (Un-ruptured)	\$130,462 (Ruptured) \$68644 (Unruptured)
Lad6 2013	Retrospective	\$79577	\$82986

ing 1644 patients with a randomised endovascular group of 809 patients and a Neurosurgical group of 835 patients, they were followed up for two years.

Staff cost in the first episode of care associated with the intervention was remarkably lower in the endovascular group (£1450 per patient) than the neurosurgical group (£2108), a difference of £658. Though the consumable cost was higher in the endovascular group (£2627) than the neurosurgical group (£901), a difference of £1726, this significant difference due to the cost of coils. The cost of a postoperative length of stay in the first episode of care was much lower in the endovascular group (£11 547) than in the neurosurgical group (£15 311), a difference of £3764, showed that neurosurgical groups spent more days in inpatients ward, ITU and rehabilitation clinics compared to the endovascular. The mean and standard deviation of the overall total cost per patients after 12-months follow up was estimated to be £18 436 and £15 849 respectively for the endovascular group while mean value of £20 176 with a standard deviation of £21 984 for the neurosurgical group with an insignificant difference of £1740 in favour of endovascular patients. Furthermore, subsequent care cost from 12 to 24 months follows up showed mean cost of £613 in the endovascular group as against £131 in the neurosurgical group, a remarkable difference of £482 in favour of the neurosurgical group.

There is the non-significant difference in treatment cost for aneurysmal subarachnoid haemorrhage, though in favour of the endovascular group in the first 12 months, endovascular patients had a higher cost of treatment during the first intervention which was later minimised by the length of stay. Also, in the 12 to 24 months follow up period, costs were greater in the endovascular group due to subsequent procedures including angiograms, complications and adverse effects. There is no information regarding cost for long-term nursing and informal care hence this study is not a reflection of accurate and exact cost effectiveness. However, it does provide a significant glimpse into the cost economics of aneurysmal subarachnoid treatment pathway.

Tahir et al[14] performed a study on the cost-effectiveness of clipping versus coiling of an intracranial aneurysm after subarachnoid haemorrhage in a developing country. This is a prospective study with a population of 55 patients with

proven aneurysmal subarachnoid haemorrhage and were actively treated and followed up for a ruptured aneurysm at Aga Khan University Hospital (Pakistan) between January 2004 and June 2007.

All costs were in Pakistani Rupees (Rs) converted to US dollars, 60Rs = \$1). Cost enumerated included treatment cost (clipping or coiling), inpatient stay (initial stay, regular bed, ICU bed occupancy), and radiologic follow up (angiograms). Total costs were manually calculated. Clinical outcome was measured at the time of discharged and six months follow up visit using modified Rankin scale. Statistical analysis performed using SPSS 13.0 (SPSS, Chicago, and III). Average total cost for coiling was \$5080 (Rs.304 800), and clipping was \$3127 (Rs.187 620). The cost of coiling here was found to be 62% more expensive than the cost of clipping without providing the additional benefit of decrease morbidity. There was a decrease in the cost of hospital stay in the endovascular group because of short duration length of stay as against surgical group.

This study is from developing country, only 7% of them were medically insured which reflect significant lack of proper healthcare insurance and put massive pressure on patients and relatives finances. Regarding the clinical outcome, this study showed no significant difference between coiling and clipping. This prospective study is a single institution practice from a developing nation, small sample size, multicentre and multicountries studies may be required to confirm the finding.

Hol et al.[18] conducted a study on the length of stay and total hospital charges of clipping versus coiling for ruptured and un-ruptured Adult Cerebral Aneurysms in the Nationwide Inpatient Sample Database that is the most significant all-payer inpatient care database in the America. Hospitalizations for clipping or coiling of ruptured and unruptured cerebral aneurysms from 2002 to 2006. Length of hospital stay and total hospital charges for clipping and coiling were compared. There were 9635 hospitalisations for ruptured aneurysm treatments (6019 clipping, 3616 coiling) and 9399 hospitalisations for un-ruptured aneurysm treatments (4700 clipping, 4699 coiling). On average, clipping resulted in \$15325 more in a total charge for ruptured patients and resulted in \$11263 more in total charge for un-ruptured patients after considering all relevant hospital and patient characteristics. Clipping as compared to coiling, after

the adjustment for all-related factors, was associated with an average of 1.2 times more days in hospitalisation for ruptured patients and was associated with an average of 1.8-times more days in admission for un-ruptured patients. On average, clipping resulted in \$15325 more in a total charge for ruptured patients and resulted in \$11263 more in total charge for un-ruptured patients after considering all relevant hospital and patient characteristics. Nationwide analysis results differed from this single-institution study. Clipping compared to coiling was associated with significantly longer lengths of stay and significantly higher total hospital charges for both ruptured and un-ruptured aneurysm patients in America over these four over period in study

Lad et al[6] performed a retrospective study on the long-term economic impact of coiling versus clipping for unruptured intracranial aneurysms. Market-Scan database (which is a collection of six different databases) was utilised to identify and examined patients who had either endovascular coiling or surgical clipping procedures for unruptured intracranial aneurysm for a 9-year period (from 2000 to 2009) comparing health care resource use, angiogram, complications and reoperation rates. This is an evaluation of a nationally selected cohort of patients thereby minimising discrepancies and selection biases that may result from a selection from a particular institution. MarketScan is all comprehensive and all inclusive

A total of 4504 patients involved with 1878 underwent clipping while 2626 patients had coiling as their initial intervention. The healthcare resource used are the length of stay during initial procedure hospitalisation, accumulated days of subsequent admissions and postoperative outpatient services at one, two and five years, medications prescription and ED services with a primary diagnosis of an unruptured intracranial aneurysm. Total cost calculated as the sum of in-hospital costs, outpatients cost and medication costs.

Sum total cost for patients who underwent clipping was \$79 577 compared to \$82 986 for the endovascular group ($P = 0.69$), aneurysm-related (\$60 945 vs. \$63 835, $P = 0.53$) and haemorrhage related (\$1257 vs \$2632, $P = 0.27$). At 2yrs patients who underwent clipping and coiling have similar overall outcome (\$74 294 vs \$77 791, $P = 0.85$), aneurysm-related (\$58 039 vs. \$61 999, $P = 0.71$) and haemorrhage related (\$1731 vs \$1808, $P = 0.63$) health cost. There was no significant difference at a 5-year overall total healthcare cost of \$75 784 for surgical clipping compared to \$73 673 for endovascular coiling ($P = 0.51$). Patients who underwent surgical clipping accumulated more haemorrhage related costs at five years (\$3352 vs \$731, $P = 0.63$), the difference not statistically significant. Though clipping is associated with increased complications but results in fewer reoperation rates hence the cost of clipping and coiling are comparable at 5-years. However, those in the coiling group accumulates more cost due to longer follow up as a result of high reoperation rates and angiogram rate. Only Maud et al. study recorded QALY and ICER values.

Conclusion

Cost economics of an intracranial aneurysm showed that surgical clipping results to reduced re-operation rate when compared to endovascular coiling and also associated with increased complication, longer hospital stay and ultimately greater hospital cost. However, clipping is costlier than coiling for the initial procedure but regarding overall cost for one, two and five years post-procedure period did not reveal any statistically significant differences. Also, Wolstenholme study[17] found no significant

difference in cost between coiling and clipping 2-years post aneurysm treatment. However, an Australian study¹ did show that clipping was associated with higher total cost.

Authors' Statements

Competing Interests

The authors declare no conflict of interest.

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