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Review

Meta-analysis of stent-assisted coiling versus coiling-only for the treatment of intracranial aneurysms

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ABSTRACT

Endovascular coil embolization is a widely accepted and useful treatment modality for intracranial aneurysms. However, the principal limitation of this technique is the high aneurysm recurrence. The adjunct use of stents for coil embolization procedures has revolutionized the field of endovascular aneurysm management, however its safety and efficacy remains unclear. Two independent reviewers searched six databases from inception to July 2015 for trials that reported outcomes according to those who received stent-assisted coiling versus coiling-only (no stent-assistance). There were 14 observational studies involving 2698 stent-assisted coiling and 29,388 coiling-only patients. The pooled immediate occlusion rate for stent-assisted coiling was 57.7% (range: 20.2%–89.2%) and 48.7% (range: 31.7%–89.2%) for coiling-only, with no significant difference between the two (odds ratio [OR} = 1.01; 95% confidence intervals [CI}: 0.68–1.49). However, progressive thrombosis was significantly more likely in stent-assisted coiling (29.9%) compared to coiling-only (17.5%) (OR = 2.71; 95% CI: 1.95–3.75). Aneurysm recurrence was significantly lower in stent-assisted coiling (12.7%) compared to coiling-only (27.9%) (OR = 0.43; 95% CI: 0.28–0.66). In terms of complications, there was no significant difference between the two techniques for all-complications, permanent complications or thrombotic complications. Mortality was significantly higher in the stent-assisted group 1.4% (range: 0%–27.5%) compared to the coiling-only group 0.2% (range: 0%–19.7%) (OR = 2.16; 95% CI: 1.33–3.52). Based on limited evidence, stent-assisted coiling shows similar immediate occlusion rates, improved progressive thrombosis and decreased aneurysm recurrence compared to coiling-only, but is associated with a higher mortality rate. Future randomized controlled trials are warranted to clarify the safety of stent-associated coiling.

1. Introduction

Endovascular therapy is a well-established treatment approach for intracranial aneurysms. Large, complex, wide-necked, and fusiform aneurysms were initially considered unamenable to endovascular coil embolization. With the advent of stents designed specifically for the intracranial circulation, such aneurysms can now be safely and efficiently managed endovascularly [1]. However, recent studies have found a benefit of stent-assisted coiling in reducing aneurysm recurrence for both complex, as well as normal, smaller aneurysms [2,3]. This is likely to reflect the benefit of the stent in promoting endothelialization of the parent vessel-aneurysm interface and flow-diverting properties [4,5].

The results of stent-assisted coiling have varied widely across different studies. A French series of 217 aneurysms [6], had a permanent neurological deficit rate of 7.4% in the stent-assisted group compared to 3.8% in the coiling-only group, and mortality rates of 4.6% vs. 1.2% respectively. This higher complication profile is concerning for stent-assisted coiling, and suggested this technique be reserved only for aneurysms with complex morphologies. However, other studies have demonstrated similar, and even improved morbidity and mortality rates compared to coiling-only [7,8].

This systematic review and meta-analysis aims to compare stent–assisted coiling with coiling-only for intracranial aneurysms in terms of immediate occlusion, progressive thrombosis, recurrence, and complication profile based on the current literature.

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2. Methods

2.1. Literature search

The present systematic review and meta-analysis was performed according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [9] and recommendations [10]. Electronic searches were performed using Ovid Medline, PubMed, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, ACP Journal Club and Database of Abstracts of Reviews of Effects (DARE) from their dates of inception to July 2015. To achieve maximum sensitivity of the search strategy and identify all studies, we combined the terms: "intracranial", "cerebral", "carotid", "basilar", "aneurysms", "stent", or "coil" as either keywords or MeSH terms. The reference lists of all retrieved articles were reviewed for further identification of potentially relevant studies. All identified articles were systematically assessed using the inclusion and exclusion criteria.

2.2. Selection criteria

Eligible comparative studies for the present systematic review and meta-analysis included those in which patient cohorts underwent either stent-assisted or coiling-only endovascular therapy for intracranial aneurysms. Inclusion criteria were: (1) Studies which compared stent-assisted coiling versus coiling-only approaches, (2) reported patients who had definite intracranial aneurysms, whether ruptured or not, verified by CT scan, MRI or angiography, (3) reported occlusion rate, complications or clinical outcomes, (4) included at least five patients in each group. Exclusion criteria included: (1) Reported patients who had dissecting aneurysms, (2) reported patients who received treatment other than stent-assisted coiling or coiling-only, (3) had insufficient outcome data for comparison between the two cohorts. When institutions published duplicate studies with accumulating numbers of patients or increased lengths of follow-up, only the most complete reports were included for quantitative assessment at each time interval. All publications were limited to those involving human subjects and in the English language. Abstracts, case reports, conference presentations, editorials and expert opinions were excluded. Review articles were omitted because of potential publication bias and duplication of results.

2.3. Data extraction and appraisal

The primary outcomes were immediate occlusion and progressive thrombosis rate, all-complication rate and angiographic recurrence. Progressive thrombosis was defined as increases of packing density on follow-up angiography. While recurrence was defined as a decreasing extent of occlusion on follow-up angiography. The secondary outcomes included mortality, permanent complication and thromboembolic complication. All data were extracted from article texts, tables and figures. Two investigators independently reviewed each retrieved article (K.P. and F.J.). Assessment of risk of bias for each selected study was performed according to the most updated Cochrane statement. Discrepancies between the two reviewers were resolved by discussion and consensus. The final results were reviewed by the senior investigator (A.M.M.).

2.4. Statistical analysis

The odds ratio (OR) was used as a summary statistic. In the present study, both fixed- and random-effect models were tested. In the fixed-effects model, it was assumed that treatment effect in each study was the same, whereas in a random-effects model, it was assumed that there were variations between studies. Chi squared tests were used to study heterogeneity between trials. I^2 statistic was used to estimate the percentage of total variation across studies, owing to heterogeneity rather than chance, with values greater than 50% considered as substantial heterogeneity. I^2 can be calculated as: $I^2 = 100\% \times (Q - df)/Q$, with Q defined as Cochrane's heterogeneity statistics and df defined as degree of freedom. If there was substantial heterogeneity, the possible clinical and methodological reasons for this were explored qualitatively. In the present meta-analysis, the results using the random-effects model were presented to take into account the possible clinical diversity and methodological variation between studies. Specific analyses considering confounding factors were not possible because raw data were not available. All p values were 2-sided. All statistical analysis was conducted with Review Manager Version 5.3.2 (Cochrane Collaboration, Software Update, Oxford, United Kingdom).

3. Results

A total of 697 references were identified through the electronic database searches (Fig. 1). After exclusion of duplicate or irrelevant references, 688 potentially relevant articles were retrieved. After detailed evaluation of these articles, 52 studies remained for detailed assessment. After applying inclusion and exclusion criteria, 14 comparative studies [2,3,6–8,11–19] were included for the present systematic review and meta-analysis. In these studies, 2698 patients undergoing stent-assisted coiling were compared with 29,388 patients undergoing coiling-only for intracranial aneurysms. The study characteristics are summarized in Table 1.

3.1. Baseline characteristics

All the included studies were observational studies. The mean follow-up ranged from 9.7 months to greater than 36 months. The mean age range ranged from 51.1 to 61.3 years for stent-assisted coiling, and 49.7 to 64.3 years. The mean size of the aneurysm ranged from 5.41 to 11.5 mm for the stent-assisted coiling group, and 5.64 to 9.7 mm for the coiling only group. Patient baseline characteristics are summarized in Table 2. Risk of bias assessment of included studies is summarized in Supplementary Table 1.

3.2. Endovascular therapy technical details

Two studies [13,15] used only one stent brand, whilst the other 12 studies [2,3,6–8,11,12,14,16–19] used a combination of two or more stent brands. The most commonly used stent brand was Neuroform (Boston Scientific Neurovascular, Fremont, CA, USA) (12/14 studies), followed by Enterprise (EP; Codman & Shurtleff, Miami, USA) (8/14 studies) and Solitaire AB (ST; ev3 Neurovascular, Irvine, CA, USA) (2/14 studies).

3.3. Immediate occlusion, progressive thrombosis and recurrence rate

Twelve studies reported immediate occlusion rates in stent-assisted versus coiling-only cohorts for intracranial aneurysms. The pooled immediate occlusion rate for stent-assisted coiling was 57.7% (1228/2133; range: 20.2%–89.2%) and 48.7% (777/1597; range: 31.7%–89.2%) for coiling only. There was no significant difference between the two groups (OR = 1.01; 95% confidence intervals [CI]: 0.68–1.49; $I^2 = 80\%$; p = 0.96) (Fig. 2a).

For progressive thrombosis (increases in packing density on follow-up), six studies reported outcomes. The pooled progressive thrombosis for stent-assisted coiling was 29.9% (131/438; range: 2.8%–56.8%) and 17.5% (90/514; range: 0%–27%) for coiling only.