



Endovascular Treatment of Intracranial Aneurysms: What Does Bibliographic Analysis Tell Us About Treatment Paradigms and Predictions for the Future?

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Aneurysmal subarachnoid hemorrhage is associated with significant morbidity and mortality.¹ Rebleeding is the most common cause of death after the initial insult and is more common when no intervention is implemented.² The 2001 International Subarachnoid Aneurysm Trial (ISAT) demonstrated that endovascular treatment can be used safely and effectively in the treatment of ruptured intracranial aneurysms, dramatically shifting the focus away from craniotomy and clipping and directing it toward minimally invasive procedures. While the cumulative risk of rebleeding was slightly higher in the endovascular group (0.022, 95% confidence interval [CI] 0.012–0.038 vs. 0.0064, 95% CI 0.0024–0.017), the risk was small and outweighed by a significantly greater disability-free survival at 10 years (odds ratio 1.34, 95% CI 1.07–1.67) with an absolute risk reduction of 7.4% (95% CI 3.6–11.2, $P = 0.0001$).³ It has been 16 years since the publication of the ISAT, which commenced randomization in 1994, at which time endovascular aneurysm treatment was only just emerging. Notably, proceduralists only had to have previously done a minimum of 30 procedures using the Guglielmi platinum coil (Stryker Neurovascular, Kalamazoo, Michigan, USA) to be eligible for the trial.

Our recent bibliographic analysis in the *Journal of Interventional Neuroradiology* demonstrated that even 15 years on from publication, the ISAT remained the most cited article over the past 27 years. In addition, it also received 114.5 citations per year, demonstrating the relevance it maintains in contemporary medicine.⁴ A bibliographic analysis by Kim et al⁵ in 2016 revealed that it had been cited 1640 times during their study period, further emphasizing its influence. This had increased to 1832 during our bibliographic analysis between July and August 2017.⁴ Furthermore, this study has now been cited 1943 times (89 citations in 2018 and increased to 3398 from 2988 citations using Google Scholar), reinforcing its standing regarding endovascular aneurysm management.

Since ISAT, several novel devices and endovascular techniques have emerged. These have become particularly popular in Europe and the United States, where balloon-assisted⁶ and stent-assisted approaches,^{7,8} scaffolding devices, and flow diverters⁹ have changed the landscape of complex aneurysm management. Although no studies of its kind have been published, it is fathomable that occlusion and/or rebleeding rates have reduced with the emergence of these newer devices.^{10,11} Bibliographic analysis demonstrates that an increasing interest in the utility of such devices is developing. The SURPASS Streamline flow diverter, recently approved by the U.S. Food and Drug Administration, has shown early efficacy for the treatment of wide-necked aneurysms. Published outcomes are comparable with that of

stent-assisted coil embolization, having been successfully deployed in 98% of cases with low morbidity, mortality, and procedural complications.¹² This paper, published in 2015, has already been cited 43 times (71 Google Scholar) with an average of 10.75 citations per year—a rate higher than many of those in our original top 100 list.

The Woven Endobridge (WEB) device is another example of a novel device that is gaining popularity. It allows for the endovascular treatment of wide-necked aneurysms using flow diversion, expanding the armamentarium for endovascular treatment of intracranial aneurysms. *Intrasaccular Flow-Disruption Treatment of Intracranial Aneurysms: Preliminary Results of a Multicenter Clinical Study*, by Pierot et al¹³ in 2012, has been cited 66 times (84 Google Scholar) with an average citation rate of 9.43 per year—again, a rate higher than many of those in our original top 100 list. Their subsequent study in 2018 reported clinical and anatomic results of the WEB treatment in the cumulative population of 3 Good Clinical Practice (GCP) studies: WEBCAST (WEB Clinical Assessment of Intrasaccular Aneurysm), French Observatory, and WEBCAST-2.¹⁴ To date, this has been cited 4 times (7 Google Scholar).

The original ISAT included smaller aneurysms (≤ 10 mm), predominantly of the anterior cerebral circulation. This has led many to question the safety and efficacy of endovascular intervention in patients who do not fulfill the ISAT criteria, resulting in craniotomy and clipping of many ruptured aneurysms despite these results. The International Subarachnoid Aneurysm Trial II (ISAT II, [ClinicalTrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT01668563) identifier: NCT01668563) is currently recruiting patients with no specific restrictions on aneurysm size to receive endovascular treatment using coils and related adjuncts such as balloon remodeling, stents, and flow diverters. The results of this study will be of great importance in the guidance of aneurysm treatment. The trial protocol has already been cited 23 times (40 Google Scholar) with an average of 3.83 citations per year. It is likely these citations metrics will continue to increase, particularly after publication of preliminary results regardless of the outcome.

A bibliometric analysis is a quantitative method used to analyze the knowledge structure and development of a research field based on related publications. The use of citation analysis as a method of evaluating and understanding the literature has been debated; however, it is useful in measuring and assessing the quality and impact of research. Although we acknowledge its limitations, citation analysis regarding the role of endovascular approaches in the treatment of aneurysms highlights the changing landscape of this field and allows us to hypothesize the trajectory of endovascular neurosurgery and interventional neuroradiology going forward.

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