Journal of Clinical Neuroscience 22 (2015) 775–778

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Review

Cerebrovascular neurosurgery 2014

Mohamed Salem [b], Bradley A. Gross [a,*], Rose Du [a], Ajith J. Thomas [b]

[a] Department of Neurological Surgery, Brigham and Women's Hospital, Harvard Medical School, 75 Francis Street, Boston, MA 02115, USA
[b] Department of Neurological Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

ARTICLE INFO

Article history:
Received 4 December 2014
Accepted 10 January 2015

Keywords:
Aneurysm
Arteriovenous malformation
Moyamoya
Stroke

ABSTRACT

Continued advances in our understanding of the management of cerebrovascular disease were made in 2014. A randomized trial for management of unruptured brain arteriovenous malformation (ARUBA) (Mohr et al. Lancet 2014;383:614–21.) and the Scottish intracranial vascular malformation study (Al-Shahi Salman et al. JAMA 2014;311:1661–9) were published and contrasted with reports based on extensive surgical experience. We highlight the results from the simvastatin in aneurysmal subarachnoid hemorrhage study (STASH) (Kirkpatrick et al. Lancet Neurol 2014;13:666–75) which unfortunately did not demonstrate a benefit of simvastatin on outcome in patients with aneurysmal subarachnoid hemorrhage. The 10 year follow-up of the international subarachnoid aneurysm trial (ISAT) (Molyneux et al. Lancet 2014 [E-pub]) and the 3 year follow-up results from the stenting and aggressive medical management for preventing recurrent stroke in intracranial stenosis (SAMMPRIS) (Derdeyn et al. Lancet 2014;383:333–41) were also reported. Results from the Japan adult Moyamoya trial (JAM) (Miyamoto et al. Stroke 2014;45:1415–21) are also briefly reviewed. Furthermore, benefits of familial screening for relatives of intracranial aneurysm and arteriovenous malformation patients, a promising angioscopic experience for endovascular procedures, as well as a modified bypass technique for management of complex aneurysms are outlined. The largest literature series to date for coiling large and giant aneurysms together with the midterm results of the Solitaire stent (ev3, Irvine, CA, USA) aneurysm remodeling study in coiling wide-necked aneurysms (SOLARE) are also presented (Gory et al. Neurosurgery 2014;75:215–9).

1. Introduction

Several landmark papers in cerebrovascular neurosurgery were published in 2014 including three randomized control trials: simvastatin in aneurysmal subarachnoid hemorrhage (STASH) [1], a randomized trial for management of unruptured brain arteriovenous malformation (ARUBA) [2] and the Japan adult Moyamoya trial (JAM) [3] (Table 1). The 3 year follow-up results of the stenting and aggressive medical management for preventing recurrent stroke in intracranial stenosis (SAMMPRIS) [4] trial originally published in 2011, along with the 10 year follow-up of the international subarachnoid aneurysm trial (ISAT) [5] were also reported. We also highlight several other noteworthy studies published this year [6–13].

2. Aneurysms

2.1. Familial screening

A long term follow-up study of screening people with a positive family history of aneurysmal subarachnoid hemorrhage (aSAH) was conducted in the Netherlands [8]. A positive family history was defined as two or more first degree relatives (FDR) with aSAH or unruptured intracranial aneurysms. An initial screen of 458 people was 11% positive, and second, third, and fourth screens were 5% positive (261, 128 and 63 individuals were available for these screens, respectively). The interval between screens was approximately 5 years. Significant risk factors for a positive first screen were smoking (odds ratio [OR] 2.7; 95% confidence interval [CI] 1.2–5.9), previous history of aneurysms (OR 3.9; 95% CI 1.2–12.7) and family history of aneurysms (OR 3.5; 95% CI 1.6–8.1). A prior history of aneurysms was the only significant risk factor at follow-up screening. One patient developed a *de novo* aneurysm which ruptured during the screening interval illustrating that even screening cannot eliminate the risk of aSAH.

2.2. Coiling versus clipping

The 10 year follow-up [5] of ISAT [14] was reported. In contrast to the statistically significant difference in death or dependence (modified Rankin Scale [mRS] 3–6) at 1 year after ruptured aneurysm coiling as compared to clipping (23.5% *versus* 30.9%, respectively; $p = 0.0001$), at 5 year follow-up no statistically

* Corresponding author. Tel.: +1 617 732 5500.
E-mail address: bgross1@partners.org (B.A. Gross).

http://dx.doi.org/10.1016/j.jocn.2015.01.002
0967-5868/

significant difference in independence was seen (mRS 0–2; 83% after coiling *versus* 82% after clipping) [15]. However, the risk of death remained significantly lower in the endovascular cohort at 5 year follow-up (relative risk [RR] 0.77; 95% CI 0.61–0.98) [15]. At 10 year follow-up, rates of independence still did not differ between the two groups (OR 1.25; 95% CI 0.92–1.71), however, the probability of being alive and independent was more likely in the endovascular cohort (OR 1.34; 95% CI 1.07–1.67). Consistent with a recent meta-analysis [16], the risk of rebleeding was higher in the endovascular group than the neurosurgical group (1.56 bleeds per 1000 patient years *versus* 0.49 bleeds per 1000 patient years, respectively). This underscores the importance of lifelong follow-up and we hope that continued study of the impact of treatment modality on outcome shifts beyond independence/dependence/death and toward broader and more meaningful cognitive outcome parameters [17].

2.3. Bypass in the surgical treatment of complex aneurysms

A modified internal maxillary artery (IMAX) to middle cerebral artery (MCA) bypass technique was recently presented by Langer et al. [12], employed in the treatment of three giant MCA aneurysms and in a fourth patient for flow augmentation to a hypoperfused hemisphere. In all patients, a zygomatic osteotomy was used followed by a standard frontotemporal craniotomy. To expose the IMAX donor a temporal fossa craniectomy was performed defined medially by a virtual line connecting the foramen rotundum and foramen ovale. The deep temporal arteries were then followed proximally to the IMAX with identification augmented by the use of computed tomography angiography-based neuronavigation and a micro Doppler probe. An end to end proximal anastomosis to a harvested brachiocephalic vein was employed in most patients deemed the optimal match by the authors. All of the patients tolerated the procedure well and all bypasses were reported as angiographically patent.

2.4. Endovascular treatment

The largest series to date of large and giant aneurysm coiling was recently published by Chalouhi et al. [9] With a total of 334 patients, 67.4% were treated by unassisted coiling, 26.4% with stent-assisted coiling, 2.1% with balloon-assisted coiling and 4.2% with parent vessel occlusion. Favorable outcome (Glasgow Outcome Score IV–V) was obtained in 92% of patients. The authors reported a 10.5% complication rate, 33% recurrence rate and 39% retreatment rate. As expected, stent-assisted coiling was associated with a lower recurrence rate than conventional coiling. Interestingly, however, morbidity rates between the unassisted coiling and stent-assisted coiling group did not significantly differ in this study. Aneurysm size, location and increased follow-up time were significant predictors of recurrence while presenting clinical grade, new or recurrent hemorrhage and aneurysm size were significant predictors of poor outcome.

Though frequently used in the endovascular treatment of ischemic stroke, the Solitaire stent (ev3, Irvine, CA, USA) is also an excellent device for stent-assisted coiling given its high radial force, wide gaps between stent struts and decreased thrombogenicity [18,19]. Six month follow-up results from the prospective Solitaire aneurysm remodeling study (SOLARE) were recently published evaluating the safety and efficacy of the stent employed adjunctively for coiling wide-necked aneurysms [10]. Complete occlusion was achieved in 60% of patients, a neck remnant was seen in 29.1% and an aneurysm remnant in 10.9% as compared to 42.2%, 39.1%, and 18.2% in the initial report, respectively [20]. No permanent morbidity or mortality was reported, comparing favorably to a previous retrospective study with rates of 3.9% and 2.9%, respectively [21].

2.5. Pharmacology in aSAH

The use of statins in patients with aSAH has been a topic of considerable controversy. Despite initial promising results in experimental studies [22], subsequent single center trials did not confirm a beneficial effect of statins [23]. A recently published meta-analysis [24] of six randomized controlled trials did not support the role of statins for vasospasm prophylaxis but asserted their significance in decreasing delayed ischemic neurologic deficits (DIND) along with mortality. In the STASH trial [1], within 96 hours of ictus 803 patients were randomized in a 1:1 fashion to a 21 day course of either 40 mg simvastatin or placebo. The analysis of mRS at 6 months follow-up (primary outcome) showed favorable outcome (mRS 0–2) in 271 patients (71.5%) in the simvastatin group versus 289 patients (71.7%) in the placebo group ($p = 0.809$). Similarly, favorable outcome at discharge was not significantly different between the two groups ($p = 0.608$). Although fewer patients receiving simvastatin required extended hypervolemic therapy (21% *versus* 29%, respectively; $p = 0.009$), there was no significant difference in the rates of DIND or mortality between the two groups. Another ongoing trial is currently comparing the difference between 40 mg and 80 mg simvastatin [25].

2.6. Angioscopy

The first *in vivo* angioscopic experience in porcine models was published by Krings et al. [11], using a scanning fiber endoscope (SFE) to obtain high resolution video imaging during endovascular procedures. The SFE was used within a 6F guide catheter with a clear field of view maintained by continuous heparinized saline flush along with conventional fluoroscopic angiography. This technique was used to record aneurysm coiling, stent implantation and mechanical thrombectomy. Potential advantages of combining this technology with standard angiography include lower rates of intraprocedural rupture, easier assessment of side branch patency, better estimation of aneurysm base coverage by a stent and the ability to monitor the interaction between thrombus and a stent retriever. Additionally, endoluminal visualization by SFE may allow for an early diagnosis of dissection before manifesting on fluoroscopy and may reduce the risk of iatrogenic dissection, at least in part as a result of direct visualization of atherosclerotic plaque components, as well as their relation to the perforators. One limitation of this approach is the need for near total occlusion of the parent vessel. Nevertheless, this may mark the beginning of an exciting technical era in endovascular neurosurgery.

3. Arteriovenous Malformations

3.1. Familial screening

The authors of the aforementioned study analyzing familial intracranial aneurysms also sent questionnaires to 460 patients with known brain arteriovenous malformations (AVM) to evaluate the prevalence of AVMs in 2992 first degree relatives [13]. Three patients had a first degree relative with an AVM. Comparing results to the general prevalence of AVMs from a Scottish population-based study, the authors considered a prevalence ratio of at least nine to be indicative of a shared familial risk factor. However, the prevalence ratio was 6.8 in this study (95% CI 2.2–21). Based on these findings, the authors advised against the regular screening of first degree relatives of patients with AVMs.

3.2. Treatment versus no treatment

The ARUBA trial [2], comparing no treatment and any treatment modality (embolization, radiosurgery, microsurgery, alone or in