The Pterional and Suprabrow Approaches for Aneurysm Surgery: A Systematic Review of Intraoperative Rupture Rates in 9488 Aneurysms

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Key words
- Aneurysm
- Clipping
- Intraoperative rupture
- Pterional
- Suprabrow
- Systematic review

Abbreviations and Acronyms
ACom: Anterior communicating artery
CI: Confidence interval
ICA: Internal carotid artery
IOR: Intraoperative rupture
MCA: Middle cerebral artery
OR: Odds ratio
PtCA: Pterional craniotomy approach
QS: Quality score
SBCA: Suprabrow craniotomy approach

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OBJECTIVE: **To assess the safety of the suprabrow approach (SBCA) for aneurysm surgery by comparing intraoperative rupture rates with those for the standard pterional approach.**

METHODS: **A systematic review of all literature published in or after 1997 was performed using specified search words. All articles described aneurysm surgery by one of two approaches—pterional or suprabrow—and mentioned the rate of intraoperative rupture. A total of 41 articles were found fit for inclusion for the final analysis. Articles that focused on giant, bilateral, posterior fossa, or previously coiled aneurysms were not included. The χ^2 test was used to compare the two cohorts and various subgroup analyses were carried out. A *P* value of <0.05 was considered significant.**

RESULTS: **The search of literature yielded 9488 aneurysm reports (41 articles), 7535 operated by the pterional approach and 1953 aneurysms by the SBCA. The overall intraoperative rupture (IOR) rate for the entire group was 9.20%. In the pterional craniotomy approach (PtCA) group, the rate of IOR was 10.09% and in the SBCA group, IOR occurred in 5.78%. The IOR rate in the PtCA group was almost double that in the SBCA group and the odds ratio (OR) for this difference was 1.8 (95% confidence interval [CI] 1.49–2.26; *P*< 0.001). A total of 3039 ruptured aneurysms were analyzed—2848 aneurysms in the PtCA group and 191 in the SBCA group. The rate of IOR was 14.15% for the overall group, 13.8% in the PtCA group, and 19.37% in the SBCA group. The difference in IOR between the PtCA group and the SBCA group for ruptured aneurysms was found to be significant (OR 1.5, 95% CI 1.003–2.119; *P*< 0.05). The number of unruptured aneurysms in the PtCA group was 862 (39.4%) and in the SBCA group, it was 232 (49.1%). The difference in the number of unruptured aneurysms between the groups was significant (*P*< 0.001). The rate of IOR was significantly less with the SBCA than with the pterional approach.**

CONCLUSIONS: **The rate of intraoperative rupture is significantly higher when ruptured aneurysms are operated with the SBCA (in comparison to the pterional approach). However, the SBCA may be safer for unruptured and middle cerebral artery aneurysms with a lower rate of IOR.**

INTRODUCTION

Microsurgery retains a fundamentally important role in the management of aneurysms although endovascular techniques have replaced open surgery to a considerable extent. The cost of endovascular therapy means that surgical clipping remains the standard of care in many parts of the world (4, 7). The problems that have been noted when patients whose lesions have been treated by the endovascular route are followed-up (coil compaction and regrowth of the aneurysm fundus) (22) emphasize the need for continued evolution of microsurgical techniques (49).

The standard surgical approach for most anterior circulation and many posterior circulation aneurysms is the pterional frontotemporal craniotomy approach (PtCA) described by Yaşargil and Fox in 1975 (56). No major modifications were made to this approach for almost 15 years after it was described. In 1991, Guglielmi et al. (20) published their landmark article on the electrothrombosis of aneurysms using platinum coils. This technique was revolutionary and represented the first major alternative to surgical clipping of aneurysms. Parallel to the development of endovascular surgery, "minimally invasive" microsurgical techniques gained in popularity. Jho (28) in 1997 and van Lindert et al. (52) in 1998 introduced the concept of keyhole approaches for clipping aneurysms. Since then, keyholes and minicraniotomies at various locations on the skull have been

described for specific aneurysms; the most popular of these is the suprabrow craniotomy approach (SBCA) (17).

Neurosurgeons are now divided about the choice of approach for aneurysm surgery (41). The keyhole craniotomies are smaller and have fewer craniotomy-related complications, but the need for significant brain retraction exists. Aneurysm-related factors (size, location, rupture status) should logically influence the choice of approach, but with increasing experience, these factors probably become less relevant (41). In this systematic review, we analyze the safety of the SBCA for aneurysm surgery and compare it with the PtCA, which is the "gold standard." The safety of an approach depends on the access and degrees of freedom it provides to manipulate the aneurysm. However, these are surgeon reported (and surgeon dependant) and there is no objective way to assess this. Alternatively, the number of complications that occur during surgery can be used as an indicator of the safety of a surgical approach.

The most important intraoperative complications during aneurysm surgery are parent/distal/branch artery occlusion by the clip, incomplete clipping of the aneurysm, and intraoperative premature rupture (IOR) of the aneurysm (5, 18). Each of these complications has the potential to adversely affect the outcome of treatment. However, after a review of literature, we elected to assess only one of these factors (viz, IOR) as most large series reported their rates of IOR. The reporting of other adverse events (and even of the outcome) was not uniform. We performed a systematic review of literature and compared IOR rates for aneurysms operated by PtCA with those operated by SBCA. We included as many aneurysms as possible (e.g., ruptured and unruptured, all sizes) so as to eliminate bias. We focused exclusively on IOR rates as a marker of the safety of the approach and did not assess other intraoperative complications or eventual patient outcome.

METHODS

Selection Criteria

All articles that dealt with aneurysm clipping by PtCA or SBCA (with or without the addition of orbitotomy) were considered for inclusion. Those articles that included the addition of an orbitotomy and/or zygomatic osteotomy to the PtCA were also included. All articles that detailed the SBCA were chosen, irrespective of the nomenclature used by the authors (e.g., supraciliary incision, supratransorbital approach, mini-brow craniotomy). The SBCA for aneurysm clipping gained popularity only after 1997 (52). Hence, only those articles published in the past 15 years (in or after 1997) were considered for this study, so as to have a comparable time frame of reference for both groups. All articles that mentioned exact rates of IOR were included in the study. Articles dealing with ruptured, unruptured, and mixed groups of aneurysms were included so as to include a larger number of lesions. Demographic features and outcome measures were not taken into consideration. If a subset of the data presented in an article met the requirements of this study, then only that subset of patients was included (1, 3, 13, 14, 16, 31, 46, 54).

Articles that described other keyhole approaches were excluded. Although anterior and posterior circulation aneurysms were included, articles that dealt exclusively with posterior circulation aneurysms, giant aneurysms, and bilateral aneurysms were excluded. Non-English language articles were included only if the English language abstract mentioned the rate of IOR (29, 43, 44, 57). Articles that dealt with the management of previously coiled aneurysms or those detailing combined microsurgical and endovascular management of aneurysms were not included.

Search Strategy

A search of PubMed using standard strings as well as MeSH terms was carried out. Once the primary set of articles had been selected, the second level of search was carried out by examining the references cited by these articles and cross-referencing them on PubMed (Figure 1). The strings used on the PubMed search builder for selecting articles for this study and the number of papers generated by each are mentioned in Table 1. Some combinations of search terms (e.g., "supraciliary + aneurysm") did not generate any results. A total of 3954 articles were identified using these search words. In the first screening-out step, 3538 articles were rejected on the basis of the title. The remaining 416 articles were screened further for possible inclusion in the final analysis. One hundred thirty articles were rejected after perusing the abstracts and 286 were selected for a reading of the full text of the manuscripts (Figure 1). After reading the full text of the selected articles and eliminating duplications, 41 articles (26 in the PtCA group and 15 in the SBCA group) were found suitable for inclusion in the analysis (1-3, 6, 9-13, 15-19, 21, 23-27, 29, 30, 32-37, 39, 40, 43, 45-48, 51-55, 57) (Tables 2 and 3).

Review

Data were collated across all articles. The focus of this study was to identify the rates of IOR in each artuicle selected and categorize it as belonging to the PtCA or SBCA group. Some articles had data that belonged in both groups and data from such articles was split accordingly. Data were entered on SPSS v20 (IBM, Inc., Armonk, New York, USA) as well as Microsoft Excel (Microsoft Corp. Redmond, Washington, USA). Statistical analysis was carried out using SPSS, Microsoft Excel, and the OpenEpi online calculators (provided by the Centers of Disease Control, Atlanta, Georgia, USA). Data were first summarized across all articles using frequency tabulation. Comparisons were made between the PtCA and SBCA groups, as well as subsets of the same using the Fisher's exact test to generate an odds ratio and a P value for the odds ratio. Pairwise comparisons were considered significant only if the P value was <0.05. Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were adhered to for defining the research problem, searching and collecting data, and reporting the results of the analysis (38).

Quality Grading

Because the focus of this study was a single point (i.e., assessment of IOR), each article included for the analysis was graded as to the quality of information it provided. A 5-point scale was devised, with a minimum score of 0 and a maximum of 5. For each reporting point mentioned in the article, it received one point. The points considered were: 1, exact proportion/number of ruptured and unruptured aneurysms in the cohort was mentioned; 2, the locations of the aneurysms were mentioned (percentage or numbers); 3, the size distribution of the