A Multicenter Analysis of Computed Tomography Angiography Alone Versus Digital Subtraction Angiography for the Surgical Treatment of Poor-Grade Aneurysmal Subarachnoid Hemorrhage

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BACKGROUND: **Poor-grade aneurysmal subarachnoid hemorrhage (aSAH) is associated with increased intracranial pressure, and these patients are unstable with a high risk of rebleeding. Computed tomography angiography (CTA) has been proposed as an examination tool for the rapid detection of ruptured aneurysms. We aimed to determine the safety and efficacy of CTA alone for surgical treatment of poor-grade aSAH compared with digital subtraction angiography (DSA).**

METHODS: **We conducted a multicenter retrospective analysis of 144 patients with poor-grade aSAH who underwent surgical treatment for 2 different cohorts. Patients were grouped into CTA alone and DSA groups. Baseline characteristics, postoperative complications, and clinical outcomes at discharge and at last follow-up were compared between the 2 groups. Multivariate logistic regression models were used to assess the association between CTA alone and clinical outcomes after we adjusted for potential confounders.**

RESULTS: **Of the 116 patients included, 42 (36.2%) patents received CTA alone and 74 patients (63.7%), including 12 patients with CTA and DSA and 62 patients with DSA alone, received DSA before surgical treatment. Patients with larger ruptured aneurysms ($P = 0.006$), aneurysm sizes of larger than 5 mm ($P = 0.025$), presence of single aneurysms ($P = 0.018$), and presence of intraventricular hemorrhage ($P = 0.019$) more often received CTA alone. All ruptured aneurysms were clipped successfully during surgery. There were no statistically significant differences in postoperative complications and clinical outcomes between the 2 groups.**

CONCLUSIONS: **Although CTA alone can be safely and effectively used in most patients requiring surgical treatment, additional DSA may be considered in patients with smaller ruptured aneurysms or in those with multiple aneurysms.**

INTRODUCTION

Poor-grade aneurysmal subarachnoid hemorrhage (aSAH) is associated with high rates of morbidity and mortality. Traditionally, digital subtraction angiography (DSA) has been the gold standard technique for detecting ruptured aneurysms in the setting of poor-grade aSAH.[1-5] In the past 2 decades, numerous studies have assessed the sensitivity and specificity of computed tomography angiography (CTA) to detect intracranial aneurysms.[6] CTA is less invasive, cheaper, and less time-consuming to provide adequate information on ruptured aneurysms and has been proposed as a primary examination tool in the workup of patients with aSAH.[6,7] Several studies have suggested that CTA alone can be used in patients with aSAH[8-14]; however, a very small number of patients with poor-grade aSAH were included in these studies.[8,10,13,14]

Key words
- Complications
- CT angiography
- Intracranial aneurysms
- Outcomes
- Poor-grade
- Subarachnoid hemorrhage
- Surgery

Abbreviations and Acronyms
aSAH: Aneurysmal subarachnoid hemorrhage
CT: Computed tomography
CTA: Computed tomography angiography
DSA: Digital subtraction angiography
mRS: Modified Rankin Scale
WFNS: World Federation of Neurosurgical Societies

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Poor-grade aSAH is a more severe subtype of aSAH and is associated with increased intracranial pressure, which often requires early surgical intervention.[1,15-18] A large multihospital database has shown that the percentage of patients with subarachnoid hemorrhage who received CTA significantly increased from 2006 and 2011 and the trend was observed in clipping patients but not coiling patients.[7] Therefore, we hypothesized that CTA alone could be safely and effectively used in patients with poor-grade aSAH who require surgical treatment. We conducted a multicenter, retrospective analysis to compare surgical results, postoperative complications, and clinical outcomes at discharge and at last follow-up between CTA-alone and DSA groups in patients with poor-grade aSAH who underwent surgical treatment.

METHODS

Study Design

The study was approved by the Institutional Review Board. From October 2010 to March 2012, 109 patients treated with surgical treatment were enrolled in selected 9 centers because all patients in 2 centers were excluded at the first analysis, and from March 2012 and April 2014, 35 consecutive patients with poor-grade aSAH undergoing surgical treatment were identified in a high-volume neurosurgical center.[18] A total of 144 patients were included from 10 centers (**Appendix**). Details of patient population have been described previously.[18,19] During the study, patients were assessed by a multidisciplinary team, and aggressive treatment was considered according to the patient's clinical condition and aneurysm characteristics. Patients with a large intracerebral hematoma associated with ruptured aneurysms preferably were considered for surgical treatment, whereas patients with posterior circulation aneurysms often were considered for endovascular coiling. In this report, 16 patients receiving emergency surgery without CTA or DSA, 9 patients showing clinical improvement from a poor grade to a good grade before surgery, and 3 patients with follow-up less than 6 months were excluded. Finally, 116 patients presenting with a World Federation Neurosurgical Societies (WFNS) grade of IV or V at time of surgery were included in the analysis.

CTA Image Acquisition

During the study period, a 16-channel multidetector computed tomography (CT) scanner or a 64-channel multidetector CT scanner was used to acquire the CTA images. CTA image acquisitions were performed according to individual institutional standards of practice. A 16-channel CT scanner with a section thickness of 1.25 mm and a reconstruction interval of 0.625 mm and a 64-channel CT scanner with a section thickness of 0.625 mm and a reconstruction interval of 0.625 mm were often used in most centers. A workstation for postprocessing of images was used to reconstruct 3-dimensional images of the aneurysms.

Outcome Measures

The primary outcome measures were postoperative major complications. The definitions of major complications (aneurysm rebleeding, cerebral infarction, symptomatic vasospasm, hydrocephalus, and meningitis) have been described previously.[17,18] Symptomatic vasospasm was defined by clinical criteria because not all patients who developed neurological deterioration had angiographic or transcranial Doppler results. The secondary outcome measures were clinical outcomes at discharge and at last follow-up. Clinical outcome was assessed with the modified Rankin Scale (mRS). A poor outcome was defined as a mRS of 4, 5, or 6, and mortality was defined as a mRS of 6 because there is a high risk of morbidity and mortality in patients with poor-grade aSAH. The mean time to follow-up was 12.5 ± 3.3 months (range, 6–26 months).

Statistical Analysis

Statistical analysis was performed with IBM SPSS, version 22.0 (SPSS; IBM, Armonk, New York, USA). An independent samples *t*-test or Mantel-Haenszel test was used for continuous variables and a χ^2 test or Fisher exact test for categorical variables. Baseline characteristics, postoperative complications, and clinical outcomes were compared between CTA-alone and DSA groups. Aneurysm characteristics between CTA-alone and both CTA and DSA groups also were compared. Multivariate logistic regression models were used to determine the associations between the use of CTA alone and postoperative symptomatic vasospasm and poor clinical outcomes and mortality at discharge and at last follow-up by the use of the enter variable selection method after we adjusted for intraventricular hemorrhage, aneurysm size, and multiple aneurysms. The multivariate analysis of the effect on clinical outcomes also was performed by use of the same method after adjusting for age, sex, WFNS grade, intraventricular hemorrhage, aneurysm size, and multiple aneurysms. Adjusted odds ratios and 95% confidence intervals were calculated. A P value <0.05 was defined statistically significant.

RESULTS

Baseline Characteristics

Of the 116 patients, 67 (57.8%) patients were female. The mean age was 55.7 ± 11.4 years (range, 22–75 years); 65 (56.0%) patients presented with a WFNS grade of IV at the time of surgery, and 51 (44.0%) patients presented with a WFNS grade of V. The mean size of ruptured aneurysms was 6.1 ± 3.7 mm (range, 1.3–20.0 mm). A total of 42 (36.2%) patients underwent CTA alone before surgery; 74 (63.8%) patients, including 12 patients receiving both CTA and DSA and 62 patients receiving DSA alone, underwent DSA before surgery (**Figure 1**). All ruptured aneurysms were confirmed during surgery and were treated successfully with surgical clipping.

Characteristics of the CTA-Alone Group Compared with DSA

Patient and aneurysm characteristics between CTA-alone and DSA groups are presented in **Table 1**. There were no statistically significant differences in patient age, sex, medical history, Glasgow Coma Scale score, and WFNS grade after resuscitation and before surgery, Fisher grade, ruptured aneurysm site, intracerebral hematoma, and timing of surgery between the 2 groups. Patients with a larger ruptured aneurysm ($P = 0.006$), aneurysm size larger than 5 mm ($P = 0.025$), presence of