

Original Article

Dual diagnostic catheter technique in the endovascular management of anterior communicating artery complex aneurysms

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Abstract

Background: The configuration of the anterior communicating artery (AcomA) complex is important in the endovascular treatment of AcomA complex aneurysms. In cases of codominant anterior cerebral arteries (ACA), coil embolization may result in inadvertent occlusion of the contralateral ACA due to poor visualization. A second diagnostic catheter in the contralateral carotid artery may help with visualization of this angiographic blind spot. To our knowledge, the safety and efficacy of this dual diagnostic catheter technique have never been assessed.

Methods: A cohort of consecutive patients that underwent coil embolization of an AcomA complex aneurysm at a major academic institution in the United States between 2007 and 2014 were retrospectively reviewed.

Results: Eighty-two patients who had an AcomA complex aneurysm treated with coil embolization were identified. The dual diagnostic catheter technique was used in 17 (20.7%) patients. Aneurysms treated with the dual diagnostic catheter technique were less frequently ruptured and had less favorable dome-to-neck ratios as well as neck width for primary coil embolization. The rate of codominant ACAs was significantly higher and stent-assisted coil embolization was performed more frequently. The rate of thromboembolic complications, angiographic outcome, and retreatment did not differ between both the groups.

Conclusions: The dual diagnostic catheter technique is a safe and effective method during coil embolization of AcomA complex aneurysms and preferred for aneurysms with codominant ACAs, incorporation of either A1 or A2 segments into the aneurysm, and aneurysms with a wide neck and low dome-to-neck ratios.

Key Words: Aneurysm coiling, anterior communicating artery complex, stent-assisted coiling, subarachnoid hemorrhage

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INTRODUCTION

Asymmetry of the circle of Willis is an important factor in the development of intracranial aneurysms and ischemic stroke, and patients with aneurysms are more likely to have asymmetry of the circle.^[3,4] The anterior communicating artery (AcomA) complex is a complicated neurovascular structure that harbors one-third of all intracranial aneurysms.^[2] The incidence of absence or hypoplasia of an A1 segment of the anterior cerebral artery (ACA) has been reported to be 1–2%^[8] and 10%^[4], respectively. Variations of the AcomA are common and include AcomAs with plexiform (multiple vascular channels), dimple (incomplete fenestration), fenestration, duplication, string, and fusion patterns. Median artery of the corpus callosum and azygos ACA are other well-characterized variations.^[12] The configuration of the AcomA complex is of important consideration in the endovascular treatment of such aneurysms. In cases where one of the two A1 segments is dominant and contributes to both A2 segments, angiographic evaluation of both A2 segments during coil embolization from the dominant A1 segment is feasible. When ACAs are codominant, angiographic evaluation may only visualize the ipsilateral A2 segment and inadvertent occlusion of the contralateral A1/A2 junction may occur during coil embolization. To circumnavigate this potential blind spot, a second diagnostic catheter in the contralateral, non-interventional common carotid may help with visualization. The technique is not to be confused with the dual microcatheter technique that has been described and evaluated.^[5,6,13] Safety and efficacy of the dual diagnostic catheter technique, however, have never been assessed.

PATIENTS AND METHODS

After approval from the Institutional Review Board (IRB) was obtained, a retrospective review of a prospectively maintained database of patients who underwent coil embolization of an AcomA complex aneurysm at a major academic institution in the United States from 2007 to 2014 was performed. The following information was collected: Patient characteristics (patient age, gender, history of subarachnoid hemorrhage), aneurysm characteristics (dome-to-neck ratio, neck width, Aspects ratio, aneurysm direction), ACA characteristics (dominance), treatment characteristics, including degree of obliteration according to the updated Raymond Roy classification,^[7,11] complications, and follow up. The dual diagnostic catheter technique was preferred for AcomA complex aneurysms with codominant ACAs, incorporation of either A1 or A2 segments into the aneurysm, and aneurysms with a wide neck and low dome-to-neck ratios. Cases where the dual diagnostic catheter technique was used were compared to cases without it.

Technique

Initial access was obtained through the right common femoral artery and a 6 French (F) sheath was placed. Diagnostic angiography of both common carotid arteries were obtained. When the AcomA complex was codominant, either A1 or A2 segments incorporated into the aneurysm, and the aneurysms had wide neck and low dome-to-neck ratio, the dual diagnostic catheter technique was used. The side for intervention was based on which A1 segment appeared more robust. The contralateral femoral artery was accessed and a 4 F sheath was placed. A diagnostic catheter was placed into the contralateral, non-interventional common carotid artery and was connected to a heparinized-saline flush. Standard guide catheter access, three-dimensional rotational angiography, and aneurysm catheterization were obtained from the side of intervention. Anticoagulation was achieved using intravenous heparin given at the time of guide catheter access with a goal activated clotting time (ACT) of 250. During coil embolization, angiograms were periodically obtained from both the sides to assess the status of the A1 and A2 segment bilaterally. Following the intervention, the catheters were removed and the arteriotomy sites were closed with the vascular closure device.

Statistical analysis

Statistical analysis was performed using R version 3.1.1 (<http://www.r-project.org>). In univariate analysis, variables were compared between groups by the Wilcoxon Rank-Sum test for numerical variables and Chi-square test for categorical variables. Statistical significance was defined as $P < 0.05$.

RESULTS

Eighty-two patients who had an AcomA complex aneurysm treated with coil embolization between 2007 and 2014 were identified. The dual diagnostic catheter technique was used in 17 (20.7%) patients [Table 1].

Patient characteristics

Age ($P = 0.151$) and gender ($P = 0.783$) did not differ significantly both the groups. Aneurysms treated with the dual diagnostic catheter technique were less frequently ruptured (35.3% vs. 60%; $P = 0.1$) [Table 2].

Aneurysm characteristics

Aneurysms treated with the dual diagnostic catheter technique were more complex and less favorable for primary coiling as indicated by lower dome to neck

Table 1: Indications for dual diagnostic catheter technique in the endovascular management of anterior communicating artery complex aneurysms

| |
|---|
| Codominant anterior cerebral arteries |
| Incorporation of either A1 or A2 segments into the aneurysm |
| Aneurysms with a wide neck and low dome-to-neck ratios |

ratios (dome-to-neck >2 ; 5.9% vs. 24.6%; $P = 0.107$) and wider necks (neck >4 mm; 52.9% vs. 43.1%; $P = 0.586$). Aspects ratio ($P = 0.316$) and aneurysm direction ($P = 0.508$) were similar in both the groups [Table 2].

Anterior cerebral artery characteristics

The dual diagnostic catheter group had a significantly higher rate of codominant ACAs (70.6% vs. 20%; $P < 0.001$) [Figure 1]. In cases without codominant ACAs, the dual diagnostic catheter technique was used when the A1/A2 junction was obscured during coil embolization. In cases where one A1 was dominant, right and left-sided dominance were equally distributed ($P = 1$) [Table 2]. No other AcomA complex variants were encountered frequently enough to allow for statistical analysis.

Treatment characteristics, complications, and follow up

Stent-assisted coil embolization was performed more frequently in the dual diagnostic catheter group (41.2 vs. 15.4%; $P = 0.039$). Loss of contralateral filling across

the AcomA was noted in 6.2% of cases where the dual diagnostic catheter technique was not used. The rate of thromboembolic complications was comparable for both groups (4.6% vs. 0%, $P = 1$) and the dual diagnostic catheter technique was not associated with more frequent femoral artery access site complications. Angiographic outcome at the end of the procedure ($P = 0.844$), upon follow up ($P = 0.592$), and retreatment ($P = 0.171$) were comparable between both groups [Table 3].

DISCUSSION

The use of a contralateral diagnostic catheter to visualize the angiographic blind spot during coil embolization of aneurysms of certain AcomA complex configurations is not to be confused with the dual microcatheter technique used to treat wide-necked aneurysms.^[5,6,13] While the dual microcatheter technique has been scientifically evaluated,^[5,6,13] there have been no prior studies on the safety and efficacy of the dual diagnostic catheter technique despite its popularity among neurointerventionalists. The purpose of this study was to provide a long-overdue scientific evaluation of this technique.

The dual diagnostic catheter technique was used in approximately 20% of AcomA complex aneurysms treated in this series. In the majority of cases where the technique was used, the AcomA complex was codominant and the aneurysm had a less favorable dome-to-neck ratio for coil embolization, a wider neck, and a higher rate of stent-assisted coiling. While only the rate of codominant A1s and the use of stent-assisted coiling were statistically different compared to the AcomA complex aneurysm treated without a contralateral diagnostic catheter, the small sample size may have increased the potential for type II error or the inability to detect differences in the other variables. In a minority of cases without codominant ACAs, the dual diagnostic catheter technique was used when the A1/A2 junction was obscured during coil embolization.

Challenges of anterior communicating artery complex aneurysm treatment

AcomA complex aneurysms represent a unique challenge to both microsurgical clipping and

Table 2: Patient and aneurysm characteristics

| Characteristic | Dual catheter N=17 | No Dual catheter N=65 | P value |
|--------------------|-----------------------|--------------------------|----------|
| Age (years) | 61.7±9.0 | 56.9±14.0 | 0.151 |
| Female | 11 (64.7%) | 38 (58.5%) | 0.783 |
| Male | 6 (35.3%) | 27 (41.5%) | |
| SAH | 6 (35.3%) | 39 (60.0%) | 0.1 |
| Dome-to-neck >2 | 1 (5.9%) | 16 (24.6%) | 0.107 |
| Neck >4 mm | 9 (52.9%) | 28 (43.1%) | 0.586 |
| Aspects ratio | 2.1±0.9 | 1.9±0.8 | 0.316 |
| Aneurysm direction | | | |
| Superior | 10 (58.8%) | 32 (49.3%) | 0.508 |
| Inferior | 3 (17.7%) | 16 (24.6%) | |
| Anterior | 3 (17.7%) | 16 (24.6%) | |
| Posterior | 1 (5.8%) | 1 (1.5%) | |
| Dominance | | | |
| Codominance | 12 (70.6%) | 13 (20.0%) | <0.001 |
| No codominance | 5 (29.4%) | 52 (80.0%) | 1 |
| Dominant right | 2 (40.0%) | 22 (42.3%) | |
| Dominant left | 3 (60.0%) | 30 (57.7%) | |

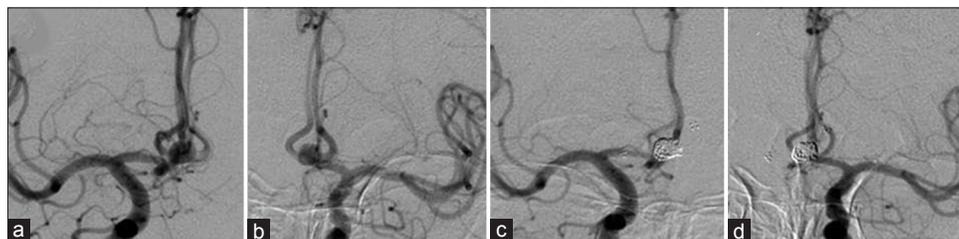


Figure 1: Angiographic evidence of codominant anterior cerebral arteries. Anteroposterior angiograms of right (Panel a) and left-sided (Panel b) injections demonstrate balanced filling of the AcomA complex and aneurysm. The dual diagnostic catheter technique was used. Injections from the side of intervention (right; Panel c) and contralateral side (left; Panel d) during coil embolization show the patency of the AcomA complex

Table 3: Treatment characteristics, complications, and follow up

| Characteristic | Dual catheter N=17 | No Dual catheter N=65 | P value |
|------------------------------------|-----------------------|--------------------------|---------|
| Side of intervention | | | |
| Left | 11 (64.7%) | 29 (44.6%) | 0.177 |
| Right | 6 (35.3%) | 36 (55.4%) | |
| Stent-assisted coiling | 7 (41.2%) | 10 (15.4%) | 0.039 |
| Loss of contralateral filling | 0 (0%) | 4 (6.2%) | 0.576 |
| Thromboembolic complications | 0 (0%) | 3 (4.6%) | 1 |
| Any endovascular complications | 0 (0%) | 6 (9.2%) | 0.336 |
| End treatment angiographic outcome | | | |
| RR1 | 15 (88.2%) | 48 (73.9%) | 0.844 |
| RR2 | 1 (5.9%) | 8 (12.3%) | |
| RR3A | 1 (5.9%) | 6 (9.2%) | |
| RR3B | 0 | 3 (4.6%) | |
| Time of follow up [#] | 18.5 (8.0, 24.8) | 17.0 (6.0, 40.0) | 0.993 |
| Follow up angiographic outcome* | | | |
| RR1 | 9 (90%) | 49 (92.4%) | 0.592 |
| RR2 | 1 (10%) | 3 (5.7%) | |
| RR3A | 0 | 1 (1.9%) | |
| RR3B | 0 | 0 | |
| Time to retreatment [#] | 12 (12, 12) | 5.5 (1.0, 8.0) | 0.295 |
| Retreatment | 1 (5.8%) | 15 (23.1%) | 0.171 |
| Type of retreatment | | | |
| Recoiling | 0 | 11 (73.3%) | 0.313 |
| Stent-assisted coiling | 1 (100%) | 3 (20%) | |
| Surgical clipping | 0 | 1 (6.7%) | |

[#]Time of follow up and retreatment are reported as first quartile, median, third quartile due to significant skew in the data; *Angiographic follow up data was not available for 7 patients with dual catheter and 12 patients without dual catheter; RR: Raymond-Roy Score

endovascular coil embolization due to their complex and highly variable anatomy. Microsurgical clipping can be complicated by perforator injuries, particularly with superiorly or posteriorly projecting aneurysms. In addition, large aneurysms often obscure the visualization of bilateral A1 and A2 segments during clipping.^[1] Due to these challenges, coil embolization has been increasingly utilized for AcomA complex aneurysms. However, coil embolization also has its challenges. It can be particularly difficult to select adequate working views that show all the relevant anatomy. Adjunctive methods such as the use of stents or balloons allow for treatment of complex wide-necked aneurysms, however, they may increase treatment-related complication rates.^[9] Stent or balloon-assisted coiling of AcomA complex aneurysms is often utilized not only because of the wide neck of the aneurysms but also due to difficulties in completely

visualizing the entire AcomA complex by deploying a stent or balloon into one A1/A2 complex, those arteries become protected.^[10]

Dual diagnostic catheter technique

Unless the A1 of the side of intervention is dominant and provides flow to both A2s, guide catheter angiography may only visualize the ipsilateral A2. To address this angiographic blind spot, a diagnostic catheter in the contralateral, non-interventional common carotid may help with visualization, particularly with codominant A1s, incorporation of the A2 origin in the aneurysm, or working views where the aneurysm overlaps with the contralateral A1/A2 junction. If the contralateral A1/A2 junction is demonstrated reliably using the dual diagnostic catheter technique, and minimal coil prolapse into the AComA complex occurs, one can proceed safely and confidently knowing both A2s are preserved [Figure 2]. Without the dual diagnostic catheter technique, one may be unsure whether minimal coil prolapse is causing occlusion of the contralateral A1/A2 junction and results in decreased coil packing density and lower rates of complete aneurysm occlusion. In 6.2% of the cases without the dual diagnostic catheter technique, there was loss of contralateral filling, which resulted in ACA territory infarctions in 2 patients in the present series. This complication occurred in cases where the AcomA complex was codominant but dual diagnostic catheter technique was not used. Using the dual diagnostic catheter technique in these cases may have prevented this complication. Approximately 40% of the cases required stent-assistance despite a high rate of less favorable dome-to-neck ratios and wide neck aneurysms. Without the use of the dual diagnostic catheter technique, a higher rate of stent-assistance may have been necessary raising the likelihood for complications.

There was no added risk with the use of the dual diagnostic catheter technique. No complications occurred in cases where the second catheter was used. With respect to end treatment result, need for retreatment, and long-term outcome, the results with the dual diagnostic catheter technique were comparable to cases where the technique was not used.

Limitations

The main limitation is the inability to perform a genuine head-to-head comparison of both techniques as the dual diagnostic catheter technique is inherently preferred for more complex AcomA complex aneurysms. Aneurysms treated with the dual diagnostic catheter technique in the present study had less favorable dome-to-neck ratio and neck width for primary coil embolization resulting in a higher rate of stent-assisted coiling. Another limitation is the small number of patients because it limits the power of the study.

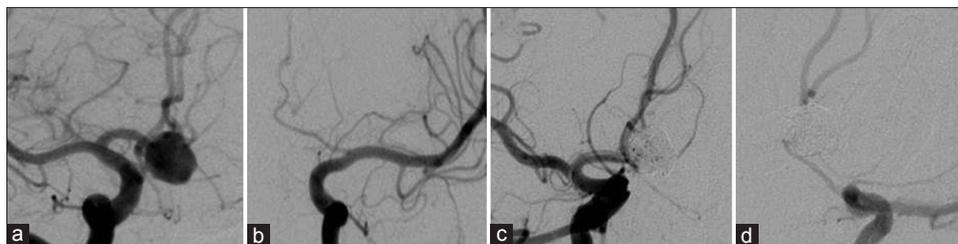


Figure 2: A 76-year-old man presenting with subarachnoid hemorrhage from an Acoma complex aneurysm. The dual diagnostic catheter technique was used during balloon-assisted coil embolization. Anteroposterior angiograms of right (Panel a) and left-sided (Panel b) injections demonstrate right dominant filling of the Acoma complex and aneurysm. While the right-sided injection demonstrates filling of the left A2 segment, the A1/A2 junction is invariably obscured by the coil mass. Right-sided injection after conclusion of the aneurysm obscures the Acoma complex and no definitive filling of the left A2 is seen (Panel c). Left-sided injection demonstrates patency of the left A1/A2 junction (Panel d)

CONCLUSION

To our knowledge, the safety and efficacy of the dual diagnostic catheter technique have not been previously assessed. We conclude that the technique is safe and effective and preferred for aneurysms with codominant ACAs, incorporation of either A1 or A2 segments into the aneurysm, and aneurysms with a wide neck and low dome-to-neck ratios.

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Conflicts of interest

There are no conflicts of interest.

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