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Analysis of relationship between superior hypophyseal artery visualization and preservation and postoperative visual field deficit in paraclinoid aneurysm

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ABSTRACT

Direct surgery for paraclinoid aneurysms can result in visual field deficit owing to compromised blood flow to the superior hypophyseal artery (SHA). However, it is rarely visualized in angiography, and discussions regarding its preservation in the field of neuro-endovascular treatment are limited. Biplane angiographic suite with high spatial resolution has been used at our institution since 2014. Since then, there were a few cases where SHAs could be visualized via digital subtraction angiography. We retrospectively analyzed the relationship between the presences and abscence of SHAs in paraclinoid aneurysms and post-procedural visual field deficit. Sixty-three paraclinoid aneuryms treated by neuro-endovascular procedure in 2014–2018 at our neurosurgery department were analyzed. Pre- and post-procedural multiplanar reconstruction imagings of three-dimensional rotation angiography were analyzed to retrospectively investigate the SHAs. SHAs were visualized in 26 patients (41%) and the median number of pre-procedurally visualized SHAs was 0 (interquartile range 0–1). Their origins were the aneurysmal necks in 11 patients (42%). In two of the 11 cases, they were noticed before coil embolization and were able to be preserved after the procedure. In the remaining nine cases, they were not pre-procedurally detected, and coiling was normally conducted. Visual field deficit occurred in one of these nine cases, but symptoms were transient, and the patient fully recovered. Because SHAs could be visualized in >40% cases and no visual field defects occurred in cases that SHAs could be identified and preserved preoperatively, we recommend their preservation during coil embolization for paraclinoid aneurysms.

Keywords: superior hypophyseal artery, paraclinoid aneurysm, visual field deficit, coil embolization

Abbreviations:
ICA: internal carotid artery
SHA: superior hypophyseal artery
MPR: multiplanar reconstruction
3D-RA: three-dimensional rotation angiography
ICAG: internal carotid angiography

INTRODUCTION

Surgical treatment of paraclinoid aneurysms of the internal carotid artery (ICA) can lead to visual field loss owing to compromised blood flow to the superior hypophyseal artery (SHA).[1] Direct visualisation of SHA is possible during open surgery, but it is rarely noted during angiography and discussions about preserving SHA in neuro-endovascular procedures are limited.[1] In 2014, our neurosurgery department initiated the use of the biplane angiographic suite (ArtisQ; Siemens) with high spatial resolution, which gave promising results with respect to visualization of SHA. We experienced a case (case 1) in which visual field deficit might have been caused by the compromised SHA blood flow in paraclinoid aneurysm coil embolization. In this case, in internal carotid angiography, SHA originated in the aneurysmal neck.

In this study, we retrospectively analyzed the relationship between the presence and absence of SHA in paraclinoid aneurysms and post-procedural visual field deficit.

MATERIALS AND METHODS

In total, 63 cases of paraclinoid aneurysms treated between 2014 and 2018 at our neurosurgery department were investigated. Five cases with visual field deficit and four cases with follow-up treatments were excluded. The reasons for exclusion were not being possible to ascertain whether the visual field deficit was newly caused in the cases of symptomatic aneurysms and difficulty in accurately visualising the SHA owing to coil artefact in the cases of follow-up treatment.

SHA is defined as the blood vessel originating from the medial wall of the internal carotid artery from the vicinity of the dural ring to the bifurcation of the posterior communicating artery and supplying blood to the inferior surface of the optic nerve and chiasm and pituitary stalk.[2] In this study, we defined SHA as the blood vessel originating from the same site toward the pituitary stalk.

Pre- and post-procedural multiplanar reconstruction (MPR) images of three-dimensional rotation angiography (3D-RA) were carefully reviewed and retrospectively analyzed for presence and absence of SHA.

Additionally, SHA origin, number and diameter and clinical course of new visual field deficit cases were also investigated. Cases were categorised as (1) all cases, (2) overall visualized SHA cases and (3) visualized SHA cases arising from aneurysmal neck.

The presence or absence of preoperative visual field impairment was evaluated by recording the presence or absence of subjective symptoms in the patients. In case the patient complained of visual field symptoms, their existence was evaluated by ophthalmologists.

RESULTS

Patient and aneurysmal characteristics

In total, 63 patients with paraclinoid aneurysms, including 51 (80%) female patients, with a mean age of 53.8 years were investigated in this study. Mean (range) aneurysmal diameter was 7.05 (4–15.8) mm. SHAs were visualized in 26 of 63 cases (41%), and the median (interquartile range) number of pre-procedurally visualized SHAs was 0 (0–1). Post-procedural visual field deficit was observed in one case, but symptoms were transient and the patient fully recovered within one hour (Table 1).

Table 1 Patient and aneurysmal characteristics

All cases	N=63
Mean age	53.8 (37–78)
Female	51 (80%)
Mean aneurysmal diameter	7.05 mm (4–15.8)
Visualized SHA cases	26 (41%)
Mean SHA diameter	0.47 mm
Postprocedual visual deterioration	1 (1.5%)
Permanent morbidity	0 (0%)
Visualized SHA cases	N=26
The origin of SHA	
Aneurysmal neck	11 (42%)
ICA medial wall other than the neck	15 (58%)

SHA arising from aneurysmal neck cases N=11		
	Not noticing SHA before procedure 9 cases	Noticing SHA before procedure 2cases
Procedural visual deterioration	1/9 (11%)	0/2 (0%)

SHA: superior hypophyseal artery

Total 63 cases were analysed. SHA was visualised in 26 cases (41%) and the median (interquartile range) number of pre-procedurally visualized SHAs was 0 (0–1). Postprocedural visual field deficit was observed in one case, but symptoms were transient, and the patient fully recovered within one hour. In 26 cases, in which SHA could be visualized, cases of SHA originated in the aneurysmal neck were 11 (42%) and in the medial C2 and C3 wall were 15 (58%).

In the two of the 11 visualised SHA cases arising from the aneurysmal neck, SHA was noticed before coil embolisation and could be preserved after a neuro-endovascular procedure. In the remaining nine cases, SHA was not preprocedurally identified, and coiling was normally conducted. Visual field deficit occurred in one of the nine cases, but symptoms were transient, and the patient fully recovered with no (0%) permanent complication.

Analysis of the 26 visualized SHA cases

The 26 cases, in which SHA could be visualized, were investigated. SHA originated in the aneurysmal neck in 11 cases (42%) and ICA medial wall other than the neck in 15 cases (58%).

Analysis of the 11 visualized SHA cases arising from the aneurysmal neck

The 11 visualized SHA cases arising from the aneurysmal neck were investigated. In two of the 11 aneurysmal neck cases, SHA was noticed before coil embolization, and could be preserved after neuro-endovascular procedure. Visual field deficit did not occur in the two cases. In the remaining nine cases, SHAs were not pre-procedurally identified, and coiling was normally conducted. In the postoperative image, SHA was not clearly visualized in one case because of coil artifacts; however, in other cases, SHA was visualized as before the operation. Visual field deficit occurred in one of the nine cases (11%), but symptoms were transient and the patient fully recovered with no (0%) permanent complications. As a result, transient visual field deficit occurred in one of the 11 cases in which the SHA arose from the neck (9%).

CASE PRESENTATION

Case 1

(Fig. 1-1) The present case refers to a left paraclinoid aneurysm located far from the ophthalmic artery origin, with an approximate 5-mm aneurysmal size. In internal carotid angiography (ICAG) before coil embolization, arteries arising from the aneurysmal neck were not visualized. However, the retrospective analysis of the 3D-RA MPR image showed that arteries were visible and running inwards, appearing like SHAs. Because arteries were not detected before the procedure, coiling was normally conducted. Analyzing post-procedural 3D-RA MPR image, arteries were visualized similarly to pre-procedural, but their origin was not identified due to coil artefact. In an hour's time after the intervention, the patient complained about medial and upper quadrantanopia of the left eye, but symptoms were transient and the patient fully recovered within an hour. The post-procedural diffusion weighted image and fluid-attenuated inversion recovery image of MRI showed no apparent cortical, optic chiasm, optic tract infarction and no aneurysmal mass effect (Fig. 1-2). The left choroidal brush was revealed as before the operation, and the aneurysm was located far from the origin of the ophthalmic artery. During an ophthalmologist's examination 3 days after the procedure, visual field and funduscopy examinations were performed; however, no anomalies, including ischemic changes, were detected. However, the appearance of ipsilateral medial upper one-fourth blindness suggested that the lateral inferior surface of the ipsilateral optic nerve was damaged and that SHA was supplying blood to the underside of optic nerve. Because cerebral infarction, mass effect of the aneurysm to the optic nerve, and blood flow disorder of the ophthalmic artery and lacrimal artery were denied, we suspected that the symptoms had manifested due to compromising blood flow to the SHA.

Case 2

The second case refers to a right paraclinoid aneurysm, with an aneurysmal size of approximately 6 mm. In ICAG before coil embolization, arteries were visualized arising from the aneurysmal neck (Fig. 2). Analysis of 3D-RA MPR image showed that arteries were also evident in this examination. Because they were running inwards and upwards, they might be SHAs. As arteries were identified, coil embolization was carefully performed not to occlude them. Analysis of post-procedural MPR image and ICAG showed that arteries were similarly visualized as pre-procedurally. The patient did not complain of visual field deficit.

DISCUSSION

Anatomy of the SHA

SHA is reported to arise from the medial wall of the ICA between the dural ring and the posterior communicating artery bifurcation.[2] Gibo et al reported that there was more than one SHA in the unilateral ICA and that the mean (range) number of vessels and mean (range) diameter of the SHA were 2.2 (1–5) and 0.25 (0.1–0.5) mm, respectively.[3,4] The present series revealed a median (interquartile range) SHA vessel number was 0 (0–1) and a mean (range) diameter of visualized SHA was 0.47 (0.38–0.61) mm in angiography. Therefore, we conclude that only the thick SHA could have been angiographically detected.

It was reported that SHA anastomosis was formed between the contralateral SHA and the ipsilateral inferior hypophyseal artery around the infundibulum[2] and that they also fed the optic nerve and optic chiasm in addition to the infundibulum.[2] Additionally, SHA was also reported to be distributed on the undersurface on the optic nerve and chiasm. Roger et al reported the

Superior hypophyseal artery visualization and post procedual visual field deficit
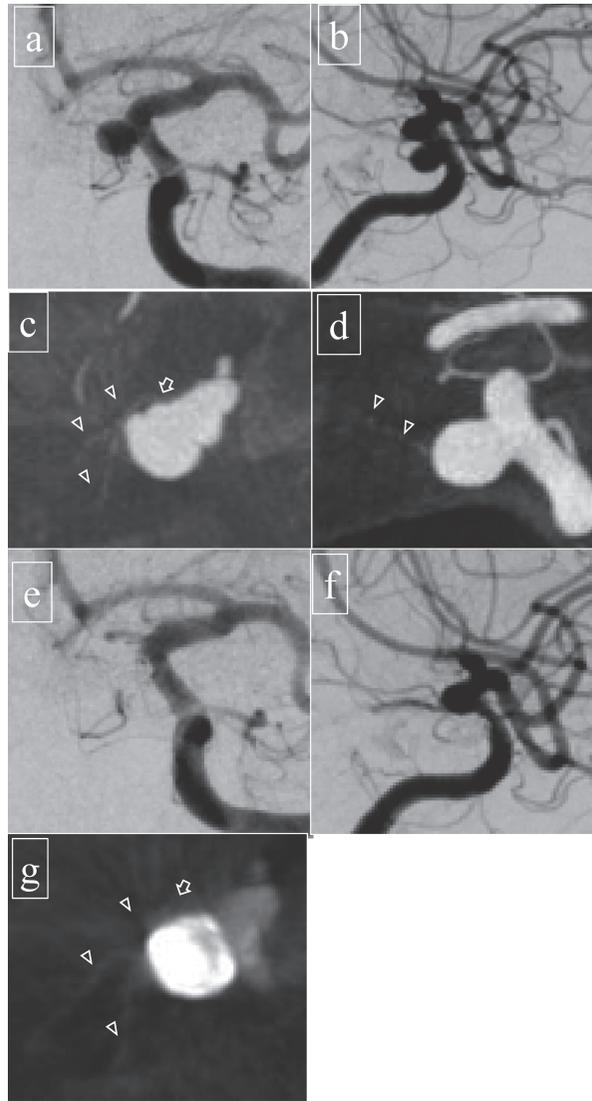
Fig. 1-1 A left paraclinoid aneurysm 5 mm in size. Pre- and post-procedural ICAG
and MPR image of 3D-RA

Fig. 1-1a-b: Left ICAG AP) (a) and lateral (b) views.
　　　　SHA was not visualized.

Fig. 1-1c-d: Pre-procedural left ICAG MPR image of 3D-RA: axial (c) and coronal (d) views.

Fig. 1-1e-f: Post-procedural left ICAG: AP (e) and lateral (f) views.
　　　　Complete embolization, including the neck, was performed.

Fig. 1-1g: Post-procedural ICAG and MPR image of 3D-RA: axial view (g). SHA was visualized but the origin
　　　　was unclear.

arrow head: SHA
arrow: SHA origin
ICAG: internal carotid angiography
AP: anterio-posterior
SHA: superior hypophyseal artery
MPR: multiplanar reconstruction
3D-RA: three-dimensional rotation angiography

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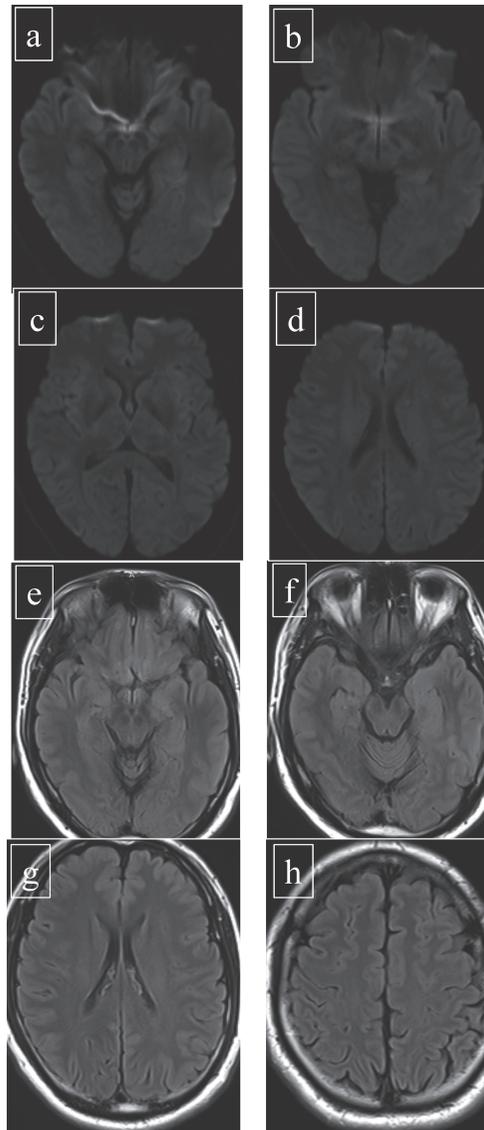
Fig. 1-2 In case 1, post-procedual DWI and FLAIR of MRI

Fig. 1-2a-d: Post-procedual DWI of MRI revealed no cortical or optic chiasm or tract infarction

Fig. 1-2e-h: Post-procedual FLAIR of MRI revealed no subarachnoid haemorrhage, intracerebral haemorrhage and aneurysmal mass effect.

MRI: magnetic resonance imaging

DWI: diffusion weighted image

FLAIR: fluid-attenuated inversion recovery image
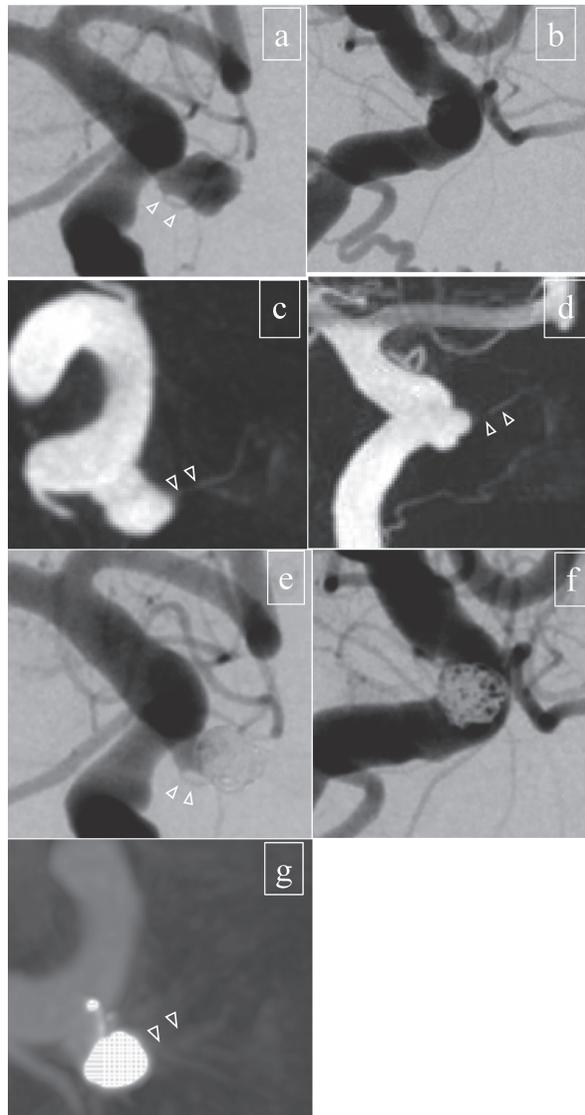
Fig. 2 A right paraclinoid aneurysm approximately 6 mm in size.
Pre-and post-procedual ICAG and MPR image of 3D-RA

Fig. 2a-b: Right ICAG: frontal (a) and lateral (b) views of the working angle. SHA arising from the neck was visualized and detected before coil embolization.

Fig. 2c-d: Pre-procedural right ICAG MPR image of 3D-RA: axial (c) and coronal (d) view.Perforators were visualized. Because they were running inside and upwards, they were considered SHA.

Fig. 2e-f: Post-procedural ICAG: frontal (e) and lateral (f) views of the working angle. Coil embolization was carefully performed not to occlude the arteries.

Fig. 2g: Post-procedural ICAG MPR image of 3D-RA: axial view(g).Arteries were visualized similarly to that visualized during pre-procedural visualization.

arrow: SHA

ICAG: internal carotid angiography

SHA: superior hypophyseal artery

MPR: multiplanar reconstruction

3D-RA: three-dimensional rotation angiography

representation of the visual field at the level of the optic nerve and chiasm and that compromising blood flow to the lower lateral surface of the optic nerve and chiasm can cause one-fourth blindness of the medial and upper side of the ipsilateral eye.[5-6]

When we considered the branch pattern, it was reported to arise as a common trunk and become 'candelabra-like' branched, occurring in 42% of cases.[2] In the present series, case report 1 SHA was considered to originate from the common trunk and the branched was considered to be have 'candelabra-like' pattern.

Visual field deficit associated with compromised SHA blood flow in neuro-endovascular procedures

In the field of neuro-endovascular procedures, the presence of SHA is rarely discussed because it is seldom visualized by angiography and SHA occlusion symptoms have been rarely reported.

To our knowledge, only Johnson et al reported visual deterioration associated with SHA occlusion.[7] The authors reported that they performed coil and Onyx embolization for a paraclinoid aneurysm and that the patient experienced a right incongruous homonymous hemianopia after the procedure. Large endovascular coiling series of ophthalmic region aneurysms have also reported visual deterioration rates of 0%–5%.[8,9] It was reported that the etiologies of visual disturbance attributed to be aneurysm coiling were divided into cortical embolic stroke, ophthalmic artery occlusion, lacrimal artery embolus, aneurysm mass effect and SHA occlusion.[7] In case 1, diffusion weighted image and fluid-attenuated inversion recovery image revealed no apparent cortical infarction, optic chiasm, optic tract infarction and no aneurysmal mass effect. The left choroidal brash was revealed before the operation, and the aneurysm was located far from the origin of the ophthalmic artery. The remaining etiology was only SHA occlusion. However, the ophthalmologist did not find any evidence of fundus ischemia or visual field impairment. Therefore, although it could not be concluded that impaired blood flow to SHA was the mechanism of the symptoms, we hypothesised that thrombosis due to coil mass occurred, it compromised SHA blood flow and caused medial and upper quadrantanopia. We assumed that the mechanism resembled that of arterio-arterial embolism. Due to the above-mentioned abundant anastomosis, it was transient and the patient fully recovered. In addition, when the pattern of visual field defects reported by Roger et al[5] and the range of SHA distribution[2] were considered, we speculated that the pattern of visual field defects caused in case 1 may be SHA blood flow disorder.

Visual field deficit associated with compromised SHA blood flow in direct surgery field

Surgical treatment for paraclinoid aneurysm can lead to visual field loss due to compromised blood flow to the SHA. However, a direct SHA visualization is possible during open surgery. Horiuchi et al reported visual deterioration after direct surgery for paraclinoid aneurysms in 13% of cases.[10] Although this series did not find a statistically significant correlation between visual deterioration and compromised SHA blood flow in direct surgery, it reported that the SHA impairment group tended to have more visual field deficit. In addition to compromised SHA blood flow, manipulation of the optic nerve, thermogenic effects from high-speed drilling of the clinoid process and other unknown causes have been reported in previous series of direct surgery.[10-15] Although compromised blood flow to the SHA does not always lead to visual field deficit, the authors recommend preserving SHA when it is visually identified.

Study limitations

First, this study was a retrospective and single-centre analysis. Therefore, these limitations should be considered when interpreting its results.

Second, in the present study, among the 11 cases in which SHA arising from the aneurysmal neck could be visualized, coil embolization was performed without noticing SHA in 9 cases.

However, only one patient developed symptoms that were transient and did not cause permanent morbidity. Although coil embolization for paraclinoid aneurysms has been performed in many cases, to the best of our knowledge, only Johnson et al have reported the occurrence of visual field defects. It has not been proven whether thin SHAs, which can be visualized only on 3D-RA MPR images, should be preserved in coil embolization. Therefore, more cases should be accumulated.

Third, only paraclinoid aneurysmal cases were included in the present study; normal cases were not analyzed. The number and origin of SHA may be affected by the presence of paraclinoid aneurysms.

Forth, postoperative visual field examination was not performed in all cases. Therefore, cases of asymptomatic visual field deficit were not be detected.

CONCLUSION

With thorough imaging review, SHA could be visualized in more than 40% of cases, with one case exhibiting post-procedural transient visual field loss. Because SHA could be visualized in >40% cases and no visual field defects occurred in cases that SHA could be identified and preserved preoperatively, we recommend its preservation during coil embolization for paraclinoid aneurysm.

ACKNOWLEDGEMENT

CONFLICT OF INTEREST STATEMENT

We declare that we have no conflict of interest.

ETHICAL APPROVAL

All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

INFORMED CONSENT

Informed consent was obtained from all individual participants included in the study.

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