Case Report

Sequential aneurysms with incidental persistent primitive trigeminal artery: Is this association purely coincidental? A case study and review of the literature in search for a pathobiological mechanism

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INTRODUCTION

The appearance of sequential bilateral aneurysms in patients with persistent primitive trigeminal artery (PTA) is not described in the literature. There is disputing evidence in favor of long-term screening strategies for patients with incidental PTAs and cerebral aneurysms. We conducted a review with the aim to find out whether the associations of PTA with aneurysms are incidental
or does it have a pathobiological mechanism? Does specific embryological or genetic mechanism predispose to aneurysms in patient with PTA? Does it have any clinical implications on long-term follow-up? A Google Scholar and PubMed search revealed 3270 articles where 34 studies had 50 aneurysms with incidental PTAs [Table 1]. A separate search among 223 studies to find histology or genetic analysis of PTA was conducted, but did not reveal any positive outcome. We also describe a rare case to highlight the association of incidental PTA.

CASE DETAILS

A 55-year-old lady presented to the clinic with occasional headaches. She did not have family history of cerebral aneurysms. An outside computerized tomography scan showed hyperdensity in the right supraclinoid region. As further evaluation, she underwent diagnostic digital subtraction angiography (DSA).

A persistent trigeminal artery communicating between cavernous portion of the left internal carotid artery (ICA) and basilar artery was noticed [Figure 1]. The presence of PTA was confirmed on injection of ICA [Figure 1] and vertebral artery injection [Figures 2a-c]. A three-dimensional reconstruction showed the aneurysm of size 11.2 × 5.5 mm along with presence of PTA filling the upper extent of basilar artery and posterior cerebral artery bifurcation [Figures 3a and b]. The aneurysm was saccular in morphology [Figure 3b].

On performing aortic arch injection, the origin of innominate and left common carotid arteries appeared extremely close. This represented a bovine arch configuration. A direct origin of the vertebral artery from the left aortic arch was also noticed (type III aortic arch). A fetal posterior communicating artery (Pcom) was also present. After appropriate counseling and consent, she underwent therapeutic angiography. A 5 mm × 16 mm size pipeline flex flow diverter device was deployed across the aneurysmal ophthalmic ICA segment [Figure 4a] and coils of microsphere 4 mm × 7.5 cm, two target −360 coils: 4 mm × 15 cm and one target helical ultra 3 mm × 8 cm were gradually placed into the aneurysm sac [Figure 4b]. During coil placement, no contrast extravasation or distal thromboembolism was noticed. Contrast stasis within the aneurysm was noticed subsequently.

Figure 1: (a) Early filling of PTA (red arrow) from ICA injection (b) filling of the ophthalmic segment ICA aneurysm (black arrow), PTA (red arrow), and upper extent of basilar artery (c) ICA injection image showing filling of posterior circulation (yellow arrow) through the PTA (d) ICA injection image showing filling of PTA with upper extent of basilar artery (blue arrow) and bifurcation into posterior cerebral arteries (postoperative image with coiled aneurysm seen).

Figure 2: (a) Subtracted angiography image showing vertebral artery injection filling the PTA (black arrow) and cavernous segment of ICA, (b) sequential angiography image showing filling of ICA ophthalmic segment of ICA and faint filling of aneurysm (red arrow) via the PTA (black arrow), and (c) sequential angiography image showing filling of anterior circulation (black arrow) via PTA, after a vertebral injection.
A follow-up angiogram at 6 months demonstrated complete occlusion of the left ICA aneurysm [Figure 5] and no residual filling or intrastent stenosis was noticed. This angiogram revealed a new second aneurysm arising from the right supraclinoid ICA [Figure 6a]. It measured 3.5 mm × 1.5 mm [Figures 6a and b]. It was decided to follow the patient with serial angiograms. Angiography at 6 months showed good reconstruction of the left ICA with the pipeline flex device. Progression of the right supraclinoid ICA aneurysm in size and morphology was noticed [Figures 7a and b]. Two blebs measuring 3.1 mm and 2.2 mm were noticed on the aneurysm dome and the base of aneurysm measured 5.4 mm. Contralateral persistent trigeminal artery and fetal Pcom artery were noticed intact with good flow.

Table 1: A list of studies with cerebral aneurysms and incidental persistent primitive trigeminal artery.

| Study Number | Author            | Year | Side       | Aneurysm location                                           | Comments                                      |
|--------------|-------------------|------|------------|------------------------------------------------------------|-----------------------------------------------|
| 1            | Kosnik et al.     | 1977 | Bilateral  | ICA                                                       |                                               |
| 2            | Yamanaka et al.   | 1979 | Right      | Posterior communicating artery aneurysm                   | With subarachnoid hemorrhage                  |
| 3            | Tran-Dinh et al.  | 1984 | Right      | ICA and anterior communicating artery aneurysm            |                                               |
| 4            | Matsumura et al.  | 1985 | Left       | ICA                                                       | Polycystic kidney disease, cavum septum pellucidi Surgical clipping |
| 5            | Sugiyama et al.   | 1987 | Right      | Anterior communicating artery aneurysm                    |                                               |
| 6            | Yamanaka et al.   | 1987 | Right      | ICA                                                       |                                               |
| 7            | Abe et al.        | 1994 | Left       | Cavernous ICA                                             |                                               |
| 8            | Nakayama et al.   | 1994 | Right      | Middle cerebral artery                                     |                                               |
| 9            | Ishigura et al.   | 1995 | Right      | Anterior communicating artery aneurysm                    |                                               |
| 10           | De Oliviera et al.| 1997 | Right      | Middle cerebral artery                                     |                                               |
| 11           | Maeshima et al.   | 1999 | Right      | Anterior cerebral Artery aneurysms                         |                                               |
| 12           | Baskaya et al.    | 2000 | Left       | Posterior communicating artery                              |                                               |
| 13           | Schlamann         | 2006 | Right      | Basilar artery                                            | Subarachnoid hemorrhage                       |
| 14           | Memis et al.      | 2007 | Right      | Cavernous ICA left side                                    |                                               |
| 15           | Sherkat et al.    | 2008 | Left       | Middle cerebral artery                                     |                                               |
| 16           | Aronson et al.    | 2008 | Right      | Posterior meningeal artery pseudoaneurysm                  | With subarachnoid hemorrhage                  |
| 17           | Zhang et al.      | 2009 | Right      | Cavernous ICA                                             |                                               |
| 18           | Yamamoto et al.   | 2011 | Bilateral  | Middle cerebral artery                                     | With subarachnoid hemorrhage                  |
| 19           | Schlamann         | 2011 | Right      | Basilar artery                                            | With subarachnoid hemorrhage                  |
| 20           | Lei Yan et al.    | 2013 | Right      | (3) Anterior communicating artery aneurysms                |                                               |
| 21           | Alonso-Vanegas et al.| 2016 | Right      | Posterior communicating artery                            |                                               |
| 22           | Lam et al.        | 2018 | Right      | Cavernous ICA aneurysms distal to PTA                      | Hypoplastic vertebal artery                   |
| 23           | Zenteno et al.    | 2018 | Right      | Anterior communicating artery aneurysm                    |                                               |
| 24           | Bahar et al.      | 2018 | Right      | Posterior communicating artery                            |                                               |
| 25           | Zhang et al.      | 2019 | Right      | Basilar artery                                            |                                               |
| 26           | Watan et al.      | 2019 | Right      | (3) Multiple anterior circulation aneurysms               |                                               |
| 27           | Kun hou et al.    | 2019 | Right      | (2) Multiple aneurysms with moyamoya disease              |                                               |
| 28           | Soylu et al.      | 2019 | Left       | BA-superior cerebellar artery junction                     | Endovascular treatment through PTA           |
| 29           | Bechri et al.     | 2020 | Right      | Posterior meningeal artery aneurysm                        | With subarachnoid hemorrhage                  |
| 30           | Ito et al.        | 2022 | Left       | Superior cerebellar artery dissecting aneurysm            |                                               |
A single SURPASS flow diverter device measuring 5 mm × 20 mm was placed across the right suprachiasma ICA aneurysm origin [Figure 8 – black arrows]. All the tines of the device were not approximated to the endothelium. Balloon angioplasty was, hence, performed with a 4 mm × 10 mm balloon.

A 6-month follow-up angiography showed that majority of this new aneurysm was thrombosed, with an extremely small residual 0.9 mm aneurysm on the right side ICA [Figures 9a and b]. It was decided to conservatively manage this residual aneurysm with subsequent angiography. Our total follow-up duration for this patient was 18 months with DSA performed after every 6 months.

DISCUSSION

The most common fetal intracranial anastomosis to survive unto adulthood is the persistent PTA.[1] The otic, hypoglossal, and intersegmental arteries rarely persist beyond embryonic stage. In Saltzman type I circulation, the PTA joins distal to anterior inferior cerebellar artery (AICA) and proximal to superior cerebellar artery (SCA). Here, dominant supply to SCA comes from the PTA. In type II, the distal basilar tip is hypoplastic. A giant thrombosed ICA aneurysm causing hypopituitarism and associated with a PTA has been reported.[15] Maeshima et al. reported eight aneurysms of bilateral ACA and MCA.[11] A basilar artery aneurysm associated with PTA was treated with coil embolization with a microcatheter through PTA.[7] Multiple aneurysms in fenestrated MCA and ICA-PTA junction were reported with PTA.[16] A PTA with fetal Pcom
and hypoplastic vertebral artery was known. This patient had a ruptured Pcom aneurysm which was clip repaired.\textsuperscript{[6]}
We believe that the presence of PTA might alter the flow dynamics of circle of Willis, predisposing to aneurysm formation. Other pathogenic mechanisms of aneurysm formation include hypertension and hemodynamic stress. A PTA represents a developmental structural abnormality. The presence of PTA creates additional hemodynamic stress on ICA and BA. The PTA is a vessel situated in lateral parasellar region usually. Rarely, a medial sphenoidal variant (Salas) may be seen. The latter one may be associated with hypopituitarism. The abnormal origin of PTA from ICA and basilar artery predisposes to two regions of hemodynamic stress – one at the ICA posteromedial wall and one at the anterolateral wall of basilar artery. As per Rhoton’s theory, the presence of additional branch points in a vessel predisposes to aneurysm formation. The standard anatomy of basilar artery consists of two branch points of PCAs, two for superior cerebellar arteries within 5–8 mm of each other. The presence of another branch point within few millimeters of these will definitely cause added hemodynamic stress. The relative frequency of aneurysms near ICA-PTA junction and anterior circle of Willis were more common than near PTA-BA junction and the posterior circle. Of the 50 aneurysms seen in our literature review, majority were localized to ACA/Acom region, while ICA and PCom aneurysms were equal (eight each), and fewer MCA (6), BA (3), PCA (1), and SCA (2) aneurysms were noticed. This indicates an increased hemodynamic stress in the anterior circulation due to the presence of PTA.

The presence of PTA provides additional anatomic weak spots/pressure points: anatomical branch points act as weak pressure points. There are few cadaveric studies which highlight presence on PTA with associated aneurysms. We searched PubMed for 223 articles with key words – PTA, histology, and genetic basis; but none revealed a histological analysis from cadaveric studies. The anatomical composition of a PTA will suggest the fundamental basis of pathologies associated with it. It would be worthwhile to study the histology of PTA vessel wall – the tunica intima, media, and externa. A genetic analysis of the vessel wall would highlight the basic difference between a normal intracranial vessel and persistent carotid basilar anastomotic remnant.[14]

The location of aneurysm in relation to PTA is a decisive factor for therapy. An aneurysm which involves the ostium of PTA will need careful handling. Risk of occlusion of PTA with coils during endovascular treatment cannot be negated. Prolapse of coils into the parent artery with occlusion of PTA is another risk of treatment. Retrograde filling of aneurysm through a PTA needs to be considered. Simple ligation of aneurysm (while clipping) may not be sufficient when the PTA supplies blood to the aneurysm too.

The physiological significance of PTA depends on the type of circulation. In a fetal type, basilar system and PCAs are supplied by PTA. Occlusion of PTA can be hazardous here. In adult-type circulation, the PTA plays a rudimentary role. Risk of significant clinical consequences is low in this type. In our patient, the flow diverter stent encompassed the origin of PTA. While deploying the stent, it was essential to ensure complete apposition of the stent with endothelium. Precarious density between the endothelium and stent would predispose to thromboembolism of PTA and, hence, ischemia of brainstem perforators. Symptoms of posterior circulation stroke such as distal vertebrobasilar insufficiency will be seen in case of a fetal-type PTA thrombosis.

**Association of PTA with stroke**

In patients with carotid stenosis and incidental PTAs, posterior circulation ischemic stroke has been reported. PTA may also act as a conduit for superselective catheterization in angiography for stroke.

**Association of PTA with trigeminal neuralgia**

Symptoms of trigeminal neuralgia have been attributed to a PTA in some patients. Surgical manipulation does provide relief from neuralgic symptoms.

**Other associations**

Several case reports documenting association of PTA with moyamoya disease, aneurysms, hemangiomas, and brain tumors such as medulloblastoma and hemangioblastomas, and other pathologies like arteriovenous malformations have been published.[12,9] PTA has been used a conduit for passing endovascular catheter for therapy of aneurysms in nearby circulation.[7,17]

**Need of surveillance**

An important component of the management of patients with incidentally detected PTA is regular periodic follow-up angiography imaging. Appearance of new aneurysms on the PTA trunk, ICA-PTA junction, or BA-PTA junction or anywhere else in the circulation needs to be identified. In our patient with treatment history for two unruptured aneurysms, certain important features were traced on the follow-up angiography. This included detection of new aneurysms, patency of parent vessel with stent in situ, development of in-stent stenosis, thromboembolic occlusion of the PTA/ophthalmic artery/Pcom artery, or other perforator vessels.

**CONCLUSION**

Persistence of carotid vertebral anastomosis has been associated with aneurysms in various locations. Histological basis of aneurysm formations remains to be seen. Although papers documenting equivocal presence of aneurysms in
the patients with incidental PTA have been published, we report a case where patient develops progression of a newly diagnosed aneurysm. This highlights the heterogeneous nature of aneurysms with PTA as an associated factor. The role of active angiographic surveillance in patients with PTA cannot be undermined. Large-scale studies are needed to clarify the role of screening angiography in this subset of patients.

Consent to participate and publish material
Obtained in written from patient and relatives.

Availability of data and material
Available.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest
There are no conflicts of interest.

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