LITERATURE REVIEW AND A SERIES OF CASES

Traumatic intracranial aneurysms associated with traffic accidents and endovascular management options

Filip Vitošević, MD, PhD[1], Svetlana Milošević-Medenica, MD, PhD[1]

1. Interventional Neuroradiology Department, Center for Radiology and MRI, Clinic for Neurosurgery, Clinical Center of Serbia, Belgrade, Serbia

Abstract

Traumatic intracranial pseudoaneurysms are a rare form of aneurysm, comprising 1% of all aneurysms. Traumatic intracranial pseudoaneurysms are a complication of head injuries following traffic accidents, most often associated with skull fractures. Traumatic intracranial pseudoaneurysms are composed of a blood clot and small amount of fibrous tissue, occuring when the arterial wall breaks due to trauma and bleeding is confined only by the adventitia or surrounding tissues. Rupture of traumatic pseudoaneurysms, which occurs in up to 50% of all cases, is typically delayed following the initiating trauma. The delayed presentation, challenging diagnosis, and inadequate treatment options contribute to an overall poor prognosis for these lesions.

A review of the relevant literature and discussion of management options is presented with the cases of two patients who developed traumatic intracranial pseudoaneurysms following road traffic accidents who were treated with endovascular embolization in our institution.

The case studies confirm that conservative management is rarely appropriate. Instead, endovascular embolization represents an appropriate treatment option for these pseudoaneurysms due to their fragility and tendency to rupture. Most importantly, early, precise diagnosis with cerebral angiography and prompt treatment are essential to minimize mortality and morbidity.

Keywords: intracranial aneurysm; traffic accidents; polytrauma; intracranial pseudoaneurysm; endovascular treatment.

DOI: https://doi.org/10.55005/sjns.v1i1.5

Introduction

Almost one-third of all reported traumatic head and neck injuries are the result of road traffic accidents [1]. Significant vascular injuries occur in 1% to 3% of these patients [2]. Traumatic intracranial pseudoaneurysms (TIPA) are rare complications of traumatic brain injuries (TBI), most often associated with skull fractures [3]. TIPAs are rare among aneurysms, comprising 1% of all aneurysms [3]. The rupture of these pseudoaneurysms, which is typically delayed from days to weeks following the initiating trauma, 21 days on average, is associated with mortality as high as 50% and significant morbidity [4,5,6]. TIPAs are often described as a pulsating hematoma, which forms when the arterial wall is ruptured by trauma, and bleeding is confined only by the adventitia or surrounding tissues [7]. Unlike the structure of a true aneurysm, which contains all standard anatomical layers, the walls of TIPAs are com¬posed mainly of a blood clot and a small amount of fibrous tissue [3,5,7].

These pseudoaneurysms may be missed on initial investigation and may present as a delayed hemorrhage in a patient otherwise recovering well from a traumatic brain injury (TBI) 8. The most common presentation of these pseudoaneurysms is hemorrhage, with acute deterioration and new neurological deficit, although patients may present with ischemic events or remain asymptomatic until the pseudoaneurysm is diagnosed on follow-up imaging 8. Given their rarity and often indolent nature, TIPAs present both diagnostic and management challenges, especially in cases of polytrauma.

Although cerebral angiography represents the prefered modality for diagnosis and endovascular embolization represents the favored management strategy [8], the rarity of these aneurysms necessitates further examination. In this study, we investigate the outcomes of patients with TIPAs developed after traffic accidents who were treated with endovascular embolization in our institution and review the relevant literature.

Review

Formation

Histologically, traumatic aneurysms can be categorized as true, false, or mixed, with false aneurysms, also known as pseudoaneurysms, being the most common 4,9. In pseudoaneurysms, the wall of the aneurysm is formed only by the surrounding structures, particularly a hematoma [4]. The possible mechanisms for the development of TIPA involve either direct vascular injury secondary to skull fracture or stretching of the vessels by adjacent forces [3,6,9].

Location

In a closed head injury, the ICA is the most common location for the development of TIPAs [4,10]. However, although traumatic intracranial dissections at this level have been reported after road traffic accidents, TIPAs more often occur at the various levels of the vertebral arteries, followed by the extracranial parts of the ICA and common carotid artery [14,15].

The anatomical locations of TIPAs reflect the underlying mechanism of injury. Infraclinoid ICA aneurysms are commonly associated with skull base fractures [4,9,11]. At its supraclinoid segment, the ICA shifts from a relatively fixed structure in the skull base and cavernous sinus to a relatively mobile structure as it ascends into the cisternal spaces 6. It is possible that either movement of the supraclinoid segment against the anterior clinoid process or stretching of the ICA at this transition zone leads to the formation of these pseudoaneurysms [6,12,13]. This mechanism appears to apply to our first case.

Detection

The clinical course of a pseudoaneurysm is unpredictable since all three layers of the artery are disrupted, and bleeding and rebleeding easily occur [5]. Delayed growth and late detection of pseudoaneurysms are common [3]. TIPAs are commonly asymptomatic, but the most common symptomatic presentation is delayed intracranial hemorrhage with subsequent neurological deterioration. Imaging follow-up for patients with head trauma assists in diagnosis of asymptomatic cases. The primary goal in the management of these patients is early identification and intervention to prevent bleeding.

Although CTA has improved significantly over the past few years as a non-invasive screening method to detect intracranial aneurysms, it is not as sensitive as DSA [5]. DSA thus remains the gold standard in the diagnostic work-up of intracranial aneurysms and should be obtained in the setting of all severe head injuries, particularly in patients with penetrating head injuries or intracranial hemorrhage [3]. Angiographic features, including a poorly defined neck, irregular aneurysm wall, unusual location such as at a peripheral vessel rather than at a major proximal branching point, and delayed filling and emptying of the contrast from the aneurysm, differentiate TIPAs from congenital aneurysms [4,16,17].

The timing of angiography remains controversial. Angiography performed within hours of injury may be normal because these aneurysms develop over time [4]. Delaying angiography to optimize the visualization of an aneurysm after brain injury has been suggested [4]. However, when the du Trevou et al. [18] compared the outcomes of trauma patients undergoing early and delayed angiography, they concluded that postponing angiography in patients with a high risk of traumatic intracranial aneurysm was unsafe [4]. Therefore, early angiography should be considered in the setting of severe head injuries, and follow-up angiography should be obtained if the initial study is negative [4].

Management

Since TIPAs rarely regress and have a high incidence of rupture, early and effective treatment is an imperative. Improved survival rates have been reported in treated patients relative to untreated patients [4,9,19]. Techniques for the treatment of TIPAs, includ¬ing clipping, excision with or without arterial bypass, trapping, or neurointerventional ra¬diological approaches have been performed successfully [4,6,20]. The development of novel endovascular tools and techniques has shifted treatment to endovascular rather than open techniques. Surgery with direct neck clipping is difficult due to the fragility and broad neck of the pseudoaneurysm. However, directly embolizing the pseudoaneurysm is also risky because the false sac may result in bleeding during the intervention [6,20,21].

Case series

We retrospectively reviewed our institutional database at the Interventional Neuroradiology Department at the Clinic for Neurosurgery of the University Clinical Center of Serbia for cases in which a TIPA developed after traffic accidents and was treated with endovascular embolization between 2011 and 2021.

Overview

We found two cases of TIPA associated with traffic accidents and treated with endovascular embolization in our department within the last ten years. In both cases, traumatic pseudoaneurysms were formed after skull base fractures in young adults following traffic accidents. Skull base fractures were diagnosed on initial computed tomography (CT) imaging immediately after presentation to the Emergency Department, while pseudoaneurysms were diagnosed on follow-up CT angiography imaging (CTA) during the hospitalization. The patients did not experience new symptoms or neurological deficits that could be associated with the development of the pseudoaneurysms. CTA was performed solely according to the protocol in practice at our institution for treating patients with skull base fractures.

Case 1

In the first case, the pseudoaneurysm formed at the posterior wall of the clinoid segment of right internal carotid artery (ICA) (***Figure 1A***) We decided to treat this pseudoaneurysm with endovascular placement of platinum coils. The pseudoaneurysm was excluded from circulation with minor residual contrast filling (***Figure 1B***). Residual filling of the pseudoaneurysm fundus was increased on follow-up digital subtraction angiography imaging (DSA) three months after the procedure, so we decided to perform an additional intervention to enable complete occlusion of this pseudoaneurysm (***Figure 1C***). An intracranial braided stent (Leo+, Balt, Montmorency, France) was placed into the clinoid segment of the ICA over the aneurysm neck, and the pseudoaneurysm was filled with additional coils, completely excluding it from circulation (***Figure 1D***).

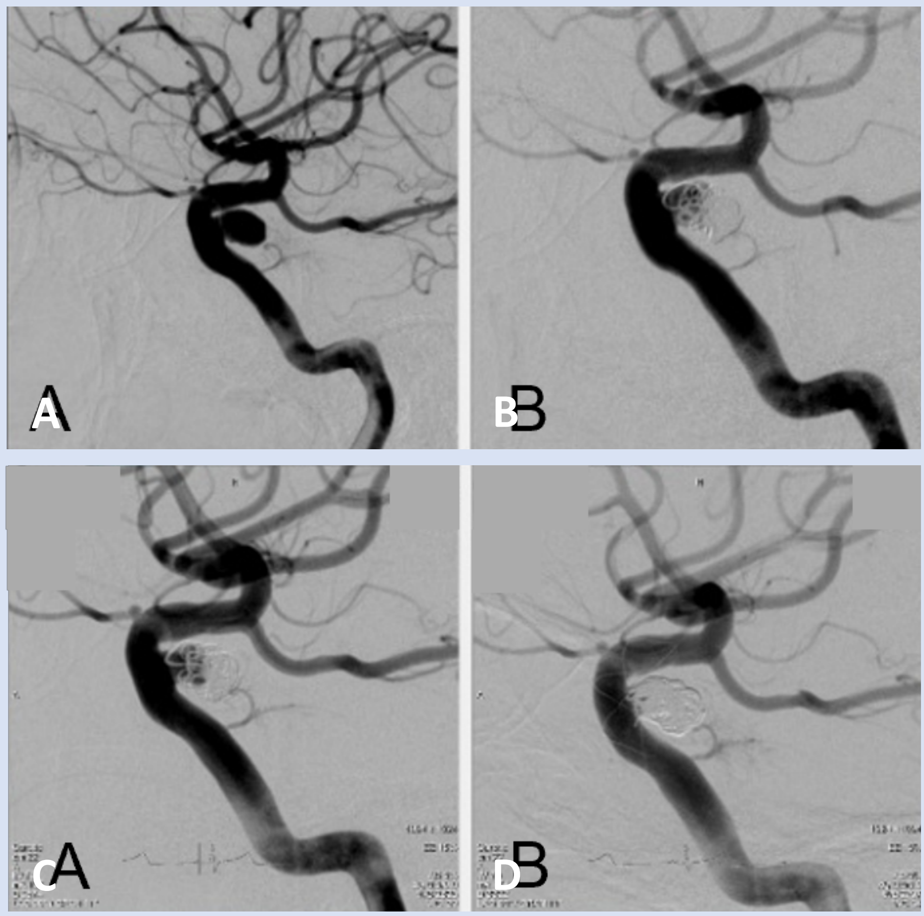

Figure 1. Traumatic pseudoaneurysm formed at the posterior wall of the clinoid segment of the right internal carotid artery. A. Initial DSA confirmation of aneurysm formation. B. Endovascular treatment of this pseudoaneurysm with the placement of platinum coils into the pseudoaneurysm fundus. C. Increased residual filling of the pseudoaneurysm fundus on follow-up DSA three months after the initial procedure. D. Reintervention with the placement of intracranial braided stent into the clinoid segment of the ICA over the pseudoaneurysm neck. The aneurysm filled with additional coils, such it was completely excluded from circulation.

This pseudoaneurysm remained completely occluded at follow-up DSA one-year later. The patient has not experienced any symptoms from this pseudoaneurysm before, in between, or after the treatments.

Case 2

In the second case, the pseudoaneurysm formed at the anterior wall of the cavernous segment of right ICA. (***Figure 2A***) After treatment with endovascular placement of platinum coils, the pseudoaneurysm was excluded from circulation with minor residual fundus filling. (***Figure 2B***) Residual filling was increased on follow-up DSA three months after the procedure, so we decided to perform additional intervention as described in the first case. (***Figure 2C***) A stent was placed over the aneurysm neck to stabilize the coil package, and the pseudoaneurysm was filled with additional coils, such that it was excluded from circulation. (***Figure 2D***) Follow-up DSA six months after the reintervention showed that this pseudoaneurysm has remained completely occluded**.**

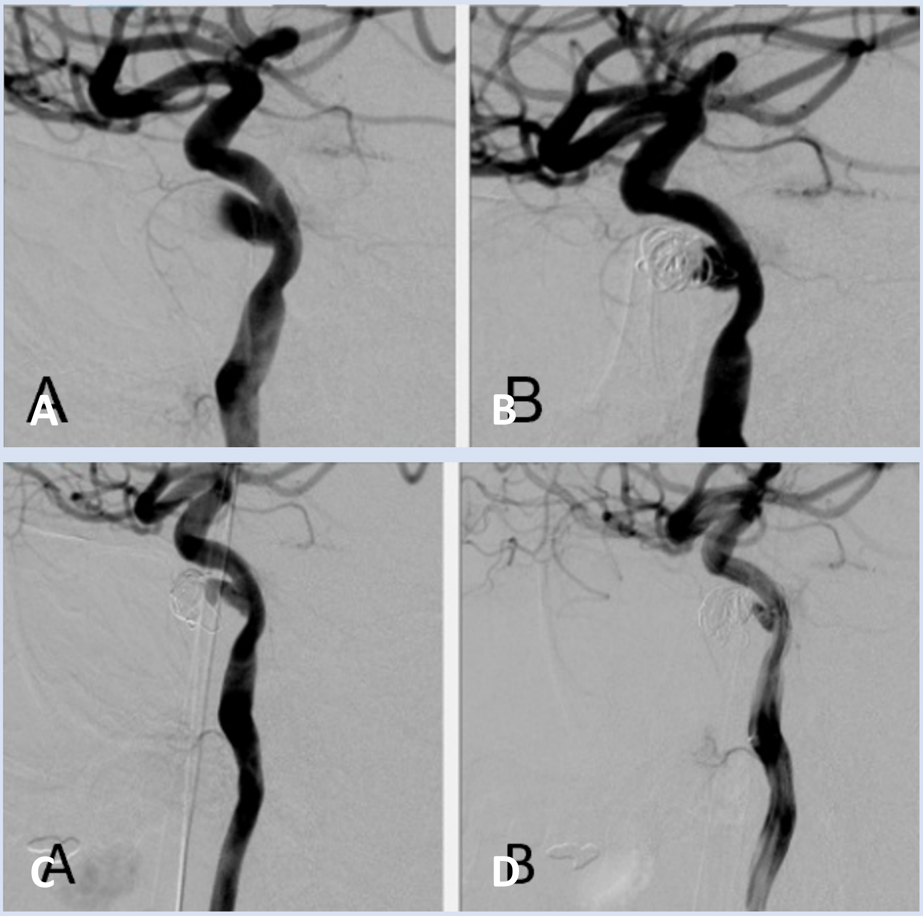

Figure 2. Traumatic pseudoaneurysm formed at the anterior wall of the cavernous segment of the right ICA. A. Initial DSA confirmation of aneurysm formation. B. Endovascular treatment of this pseudoaneurysm with the placement of platinum coils into the pseudoaneurysm fundus. C. Residual filling of the pseudoaneurysm fundus was increased on follow-up DSA three months after the initial procedure. D. A stent was placed over the pseudoaneurysm neck to stabilize the coil package, and more coils were added. The pseudoaneurysm was excluded from circulation.

Discussion

Our cases are remarkably similar. Both patients were young adults with multiple traumatic injuries after traffic accidents. Although both pseudoaneurysms had a wide neck, stent placement was avoided during the initial treatment encounter because stent placement requires antiplatelet therapy, which should often be avoided in patients with recent polytrauma. Complete aneurysm occlusion was attempted with coils alone. Unfortunately, on follow-up angiograms, the pseudoaneurysms were not completely excluded from circulation. Stents were placed in both cases to protect the vessels with thicker packing of coils to prevent migration into cerebral vessels. Stents were placed a few months following the initial trauma, thus avoiding the risk of side effects associated with antiplatelet therapy. Our cases demonstrated that the enlargement of the pseudoaneurysm fundus is common in TIPAs, likely due to the pseudoaneurysmal nature of these lesions.

Conclusion

Suspicion for TIPAs should be maintained for all patients with severe head injuries following road traffic accidents, especially if they present with delayed neurological deterioration. Given traumatic intracranial pseudoaneurysms may present both diagnostic and management challenges, especially after polytrauma cases, conservative management is rarely appropriate. Instead, endovascular embolization represents an appropriate treatment option for these pseudoaneurysms due to their fragility and tendency to rupture. Most importantly, early and precise diagnosis with cerebral angiography and prompt treatment are essential to minimize morbidity and mortality.

Disclosures

Conflict of Interest: The author certify that he have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the institutional ethical standards and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from the reported individuals.

Funding: No funding was received for this research.

Correspondence

Filip Vitošević

✉ Interventional Neuroradiology Department, Center for Radiology and MRI, Clinic for Neurosurgery, Clinical Center of Serbia
Višegradska 26, 11000, Belgrade, Serbia

☏ +381637203740

@ filipvitosevic@gmail.com

References

1. Vella M. A., Crandall M. L.Patel M. B. Acute Management of Traumatic Brain Injury. Surg Clin North Am, 2017. 97(5): p. 1015-1030. DOI: 10.1016/j.suc.2017.06.003.
2. Rathlev N. K., Medzon R.Bracken M. E. Evaluation and management of neck trauma. Emerg Med Clin North Am, 2007. 25(3): p. 679-94, viii. DOI: 10.1016/j.emc.2007.06.006.
3. Purgina B.Milroy C. M. Fatal traumatic aneurysm of the posterior inferior cerebellar artery with delayed rupture. Forensic Sci Int, 2015. 247: p. e1-5. DOI: 10.1016/j.forsciint.2014.11.003.
4. Dubey A., Sung W. S., Chen Y. Y., Amato D., Mujic A., Waites P., et al. Traumatic intracranial aneurysm: a brief review. J Clin Neurosci, 2008. 15(6): p. 609-12. DOI: 10.1016/j.jocn.2007.11.006.
5. Lee S. H., Moon J. U., Choi S. K., Choi M. K., Lee J.Sung J. Y. Pseudoaneurysm at the Distal Posterior Inferior Cerebellar Artery After Blunt Head Trauma: A Case Report and Review of the Literature. World Neurosurg, 2016. 92: p. 580 e11-580 e15. DOI: 10.1016/j.wneu.2016.06.054.
6. Han J. H., Koh E. J., Choi H. Y., Park J. S.Lee J. M. Visualization of a Traumatic Pseudoaneurysm at Internal Carotid Artery Bifurcation due to Blunt Head Injury: A Case Report. Korean J Neurotrauma, 2014. 10(2): p. 126-9. DOI: 10.13004/kjnt.2014.10.2.126.
7. Moon T. H., Kim S. H., Lee J. W.Huh S. K. Clinical Analysis of Traumatic Cerebral Pseudoaneurysms. Korean J Neurotrauma, 2015. 11(2): p. 124-30. DOI: 10.13004/kjnt.2015.11.2.124.
8. Kumar A., Jakubovic R., Yang V.Dacosta L. Traumatic anterior cerebral artery aneurysms and management options in the endovascular era. J Clin Neurosci, 2016. 25: p. 90-5. DOI: 10.1016/j.jocn.2015.05.063.
9. Larson P. S., Reisner A., Morassutti D. J., Abdulhadi B.Harpring J. E. Traumatic intracranial aneurysms. Neurosurg Focus, 2000. 8(1): p. e4. DOI: 10.3171/foc.2000.8.1.1829.
10. Tureyen K. Traumatic intracranial aneurysm after blunt trauma. Br J Neurosurg, 2001. 15(5): p. 429-31. DOI: 10.1080/02688690120082440.
11. Kumar M.Kitchen N. D. Infective and traumatic aneurysms. Neurosurg Clin N Am, 1998. 9(3): p. 577-86.
12. Kikkawa Y., Natori Y.Sasaki T. Delayed post-traumatic pseudoaneurysmal formation of the intracranial ophthalmic artery after closed head injury. Case report. Neurol Med Chir (Tokyo), 2012. 52(1): p. 41-3. DOI: 10.2176/nmc.52.41.
13. Pozzati E., Gaist G.Servadei F. Traumatic aneurysms of the supraclinoid internal carotid artery. J Neurosurg, 1982. 57(3): p. 418-22. DOI: 10.3171/jns.1982.57.3.0418.
14. Prasad V., Gandhi D., Jindal G. Pipeline endovascular reconstruction of traumatic dissecting aneurysms of the intracranial internal carotid artery. BMJ Case Rep, 2013. DOI: 10.1136/bcr-2013-010899.
15. Kray JE., Dombrovskiy V., Vogel TR. Carotid artery dissection and motor vehicle trauma: patient demographics, associated injuries and impact of treatment on cost and length of stay. BMC Emerg Med, 2016. 16(1): p. 23. DOI: 10.1186/s12873-016-0088-z.
16. Morard M.de Tribolet N. Traumatic aneurysm of the posterior inferior cerebellar artery: case report. Neurosurgery, 1991. 29(3): p. 438-41. DOI: 10.1097/00006123-199109000-00018.
17. Lath R., Vaniprasad A., Kat E.Brophy B. P. Traumatic aneurysm of the callosomarginal artery. J Clin Neurosci, 2002. 9(4): p. 466-8. DOI: 10.1054/jocn.2001.1050.

18. du Trevou M. D.van Dellen J. R. Penetrating stab wounds to the brain: the timing of angiography in patients presenting with the weapon already removed. Neurosurgery, 1992. 31(5): p. 905-11; discussion 911-2. DOI: 10.1227/00006123-199211000-00012.
19. Uzan M., Cantasdemir M., Seckin M. S., Hanci M., Kocer N., Sarioglu A. C., et al. Traumatic intracranial carotid tree aneurysms. Neurosurgery, 1998. 43(6): p. 1314-20; discussion 1320-2. DOI: 10.1097/00006123-199812000-00024.
20. Hopkins J. K., Shaibani A., Ali S., Khawar S., Parkinson R., Futterer S., et al. Coil embolization of posttraumatic pseudoaneurysm of the ophthalmic artery causing subarachnoid hemorrhage. Case report. J Neurosurg, 2007. 107(5): p. 1043-6. DOI: 10.3171/JNS-07/11/1043.
21. Wang X., Chen J. X., You C.He M. Surgical management of traumatic intracranial pseudoaneurysms: a report of 12 cases. Neurol India, 2008. 56(1): p. 47-51. DOI: 10.4103/0028-3886.39312.

_