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Case Report

Traumatic carotid artery injury caused by a metal sipping straw in a pediatric patient: Anesthetic management and considerations

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ABSTRACT

CNS injury following a traumatic intraoral injury is a rare but potentially catastrophic occurrence in pediatrics. For example, intraoral trauma resulting in acute ischemic stroke (AIS) secondary to carotid artery dissection has only been described by a limited number of case reports [1]. We report the case of a 4-year-old boy who suffered a penetrating right internal carotid injury after a fall resulting in a metal straw perforating the neck and oropharynx. The patient presented in hemorrhagic shock with altered consciousness. CT Angiography revealed a right internal carotid traumatic rupture with flow occlusion and right cerebral hemispheric hypoperfusion. The patient underwent emergent neuroradiologic intervention under general anesthesia with successful reconstruction of the right carotid artery through the use of five flow diverting pipeline stents. The patient was extubated one week later with the only neurologic sequala being slight left upper extremity weakness. Anesthetic management played a vital part in this outstanding outcome. Thoughtful management is required to ensure both survival and the best possible neurologic recovery. Despite the rarity of these events, there is sufficient evidence from similar interventions and neurophysiology to guide sound management. This case report highlights these principles and areas for further investigation. Our experience may be instructive in the support of safe care under similarly rare but challenging circumstances.

Introduction

Craniocervical arterial injury via oral trauma is very unusual in pediatric patients and can have devastating consequences. Intraoral injury accounted for only 7 cases of traumatic carotid dissection in a review of 34 case reports published between 1961 and 2007.

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Within this cohort all 7 patients were reported to have an intact neurological status immediately post injury [1]. Thoughtful surgical and anesthetic management is vital to achieve the best outcomes in these rare cases. For example, numerous studies in the recent decade have shown strong neuroprotective effects of certain anesthetics to prevent brain ischemia which can impact neurological outcomes and mortality [2]. Herein we report the first penetrating intraoral carotid injury with a compromised neurologic status on initial presentation. Care rooted in principles extrapolated from similar adult interventions and known neurophysiology resulted in an excellent outcome. Our experience may be instructive in the support of safe care under similarly rare but challenging circumstances.

Case report

A 4-year-old male weighing 18 kg with a past medical history of beta thalassemia trait was brought to the emergency department (ED) by ambulance after a fall from his porch. The patient was reportedly drinking from a metal straw when he fell forward from a porch swing and landed on the ground with the metal straw in his mouth. He immediately started crying and running to his parents when he collapsed midway. His parents noted that he was bleeding profusely from his mouth and called emergency medical services. En route to the hospital, he was noted to be hypotensive with systolic blood pressures in the 50–60s with waxing and waning consciousness. On arrival to the ED, the patient was found to be intermittently conscious with a GCS of 10, initial blood pressure of 62/38, and with continued pooling of blood in oropharynx. Immediate actions taken in the ED were to secure the airway by performing rapid sequence intubation, packing the oropharynx with gauze, and administering both intravenous fluids and packed red blood cells. Computed tomography angiography (CTA) of the head and neck showed complete tear and occlusion of the right cervical internal carotid artery with active extravasation into the right cervical soft tissues as well as the oropharynx, and global right hemisphere perfusion deficit (Figs. 1 and 2).

Given the active intraoral hemorrhage, the critical expanding hematoma and its associated risk on airway compromise and cerebral perfusion, an emergent interdisciplinary discussion between vascular surgery, neurosurgery, and interventional neuroradiology deemed that neuro-interventional repair would be the best option. Invasive arterial monitoring and central venous access was secured. The patient was started on a norepinephrine infusion to optimize cerebral perfusion and emergently taken to the cerebrovascular interventional suite. The patient underwent general anesthesia via propofol infusion that was selected based on reported neuroprotective properties [3], and he was paralyzed to provide akinesis during the delicate intervention. A targeted systolic blood

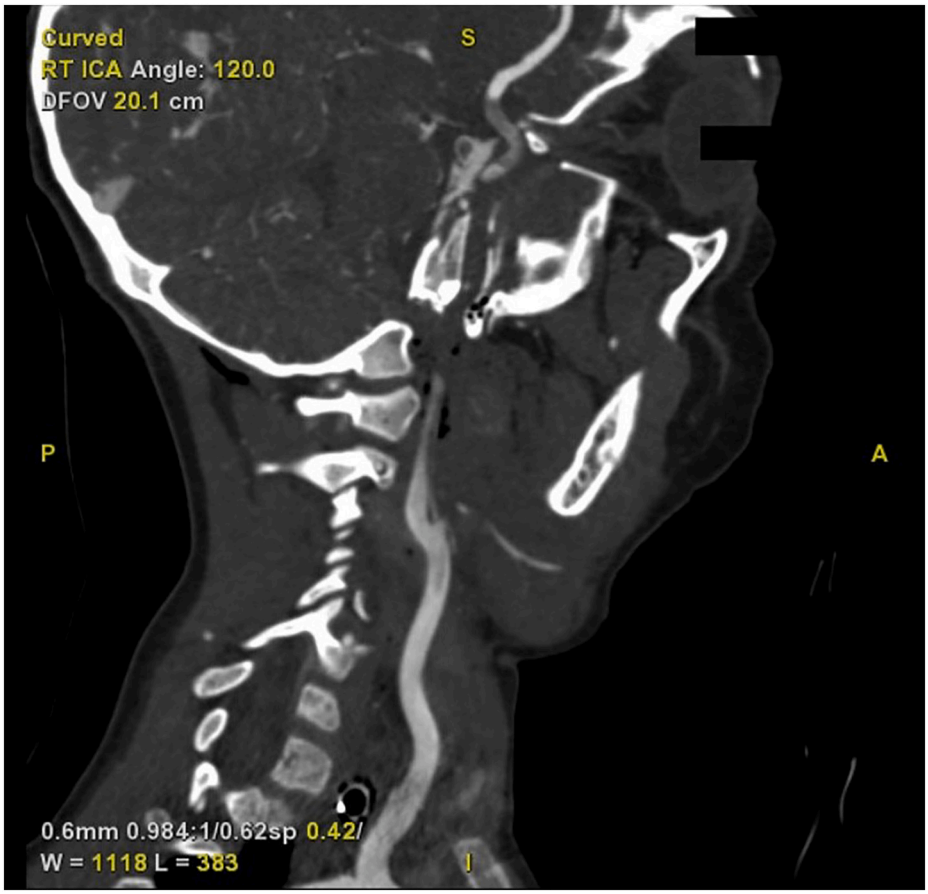

Fig. 1. Sagittal CT angiogram demonstrating a perfusion deficit of the right internal carotid artery.

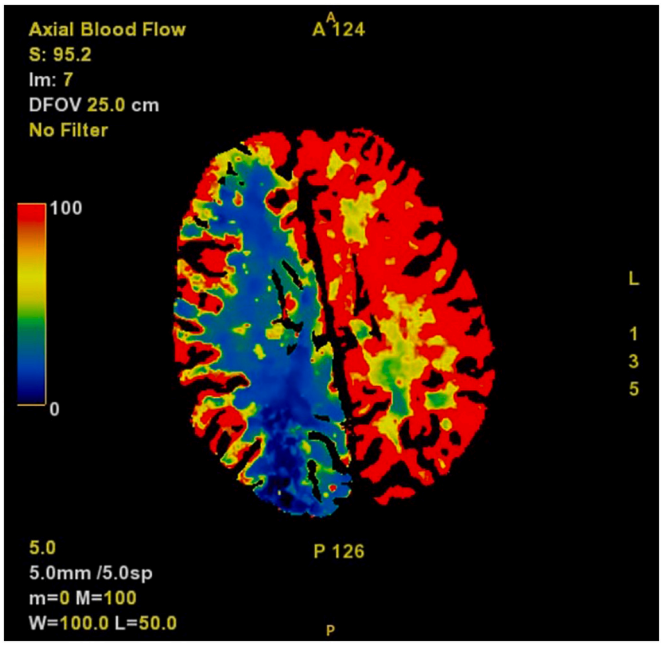

Fig. 2. CT perfusion study demonstrating hypoperfusion of the right cerebral hemisphere.

pressure (SBP) of >130 was agreed upon with primary service to optimize collateral perfusion both prior to and during arterial stenting. This was maintained through a combination of goal directed transfusion and vasopressor support. Ventilatory strategy focused on maintaining eucapnia to mild hypocapnia to minimize intracranial pressure without causing additional compromise to intracranial blood flow.

The patient was heparinized for the procedure, then the right carotid was reconstructed sequentially with five Pipeline Embolization Devices (PED). No intraoperative complications occurred. Following successful carotid artery reconstruction, efforts to minimize reperfusion injury and minimize hemorrhagic conversion included liberalizing SBP goal <90 with continued mild hyperventilation to attenuate the development of intracranial hypertension (Fig. 3).

Postoperatively, the patient was admitted to the pediatric intensive care unit (PICU) for further management. In the PICU, the patient was kept sedated with strict control of his serum sodium and blood pressure to limit further cerebral edema. The patient was maintained on aspirin and clopidogrel in the setting of the carotid stents and maintained on levetiracetam for seizure prophylaxis. Serial head CTs demonstrated initial cerebral edema with improvement over the next seven days. The patient experienced a dramatic neurologic recovery and was extubated one week post presentation, with the only sequela being slight left upper extremity weakness. He was discharged to a rehabilitation facility after a three-week hospital course. Five month follow-up revealed he is attending kindergarten and doing extremely well, only having minor trouble with the fine motor control of his left hand.

Discussion

Penetrating traumas of the head and neck can be dangerous and life-threatening due to the density of critical structures in this small space. Substantial damage can involve subcutaneous tissue, blood vessels, aerodigestive tracts, nerves, and the cervical spine [4]. We report a case of traumatic carotid injury in a pediatric patient successfully treated with neurointerventional endovascular therapy facilitated by thoughtful goal-directed anesthetic care aimed at preserving perfusion and providing neuroprotection from both edema and reperfusion injuries.

Penetrating neck traumas are relatively rare in children; consequently, there is a relative paucity of literature specifically addressing penetrating neck injury in the pediatric population. Unlike adults, there are no clear trends or guidelines for managing children with penetrating neck injury. Accordingly, the selection of interventions is based upon known injuries and best-evidence choices from similar pathologies. For example, there are no studies to specifically guide care following intra-oral injuries. However, there is retrospective data evaluating endovascular therapy for pediatric AIS. A sample of 3184 pediatric cases of AIS found that only 38 were treated with endovascular therapy and the patients were older, with an average age of 10.2 years versus 4.5 years in the group treated with other therapy [5]. A recent retrospective analysis of 12 children (median age of 14) with large-vessel occlusion undergoing thrombectomy demonstrated improved angiographic outcomes and improved neurologic function [6]. Given the small yet promising data, all pediatric AIS cases should be evaluated for possible neuro-interventional treatment, and our case report adds to the growing list of pediatric patients benefiting greatly from neuro-endovascular therapy.

Appropriate management of traumatic intracranial dissecting aneurysms remains challenging and controversial. Most published

Fig. 3. Left: Standard angiogram of the injured right internal carotid artery with the red circle showing contrast extravasation and the yellow arrow demonstrating the compromised flow leading to the perfusion deficit.
Right: Standard angiogram of the reconstructed right carotid artery

data come from sporadic case reports of spontaneous dissection and traumatic rupture of the internal carotid artery (ICA). In our case, we followed stent-in-stent technique utilizing flow diverting pipeline stents (FDS). Advantages to applying these pipeline embolization devices include restoring flow of blood through the ICA, while embolizing and occluding the traumatic pseudoaneurysm in the wall of the artery. Moreover, these stents can cover long segments of the artery, along with any curvatures in the course of the ICA [7].

Flow diverting pipeline stents (FDS) were first approved for the management of large unruptured intracranial aneurysms failing prior endovascular treatment in the United States in 2011 for improved clinical outcomes. While similar to conventional coil embolization techniques, FDS has a larger diameter guide catheter, intermediate support catheter, microwire and microcatheter that is used to aid with deployment and placement. Original indications for FDS were wide-necked, large, and giant aneurysms of the ICA, which have now been expanded. In recent years, the use of multiple overlapping pipeline devices has been adapted for reconstructing dissecting aneurysms. Zhao et al. described the treatment of 14 acute symptomatic dissecting aneurysms; immediate partial occlusion was observed in 12 patients (86 %) and follow-up angiographic results revealed recurrence in one patient (7 %) which ultimately resolved after implantation of an additional Solitaire stent [8].

Systematic reviews, meta-analyses, studies, and trials have shown effectiveness and complication rates similar to other traditional techniques in the treatment of aneurysms. DAPT (dual antiplatelet therapy) is considered the standard of care for FDS. It is recommended to start DAPT 5–7 days prior to procedure, and continue clopidogrel for 3–6 months, and aspirin for at least 6 months thereafter. Complication rates are comparable to other traditional techniques. A recurring major complication across studies is in-stent stenosis with discontinuation of antiplatelet agent, that can lead to symptomatic ipsilateral ischemic stroke and intraparenchymal hemorrhage [9].

Given the rarity of these injuries, the potential for significant long-term deficits, and the dynamic physiologic perturbations associated with care, anesthetic management is vital to risk mitigation. Anesthetic care was tailored to optimize perfusion in the context of ongoing and evolving challenges.

One area of paramount importance is hemodynamic management. The adult AIS experience can help guide hemodynamic management choices. Studies in adults with AIS have demonstrated that autoregulation in the ischemic hemisphere is impaired in the acute phase of stroke. The ischemic brain distal to the defect is dependent on collateral perfusion and is therefore highly blood pressure dependent [10]. This has been evidenced by two observational studies which showed that higher mean arterial pressures during thrombectomy led to better functional outcomes [11,12]. Thus, the Neuroscience in Anesthesia and Critical Care blood pressure guideline for pre-thrombectomy adult AIS is a systolic goal value of >140 mmHg [13]. Extrapolating from this adult literature, we decided for a slightly lower goal systolic blood pressure of at least 130 mmHg given that this was a pediatric patient, with the ultimate hemodynamic goal of providing adequate blood flow to the ischemic right cerebral hemisphere via collateral circulation.

Following successful carotid artery reconstruction, the blood pressure goal was liberalized <90 mmHg. Again, the target and goal was driven by the best-interpretation of adult literature for similar interventions. Reperfusion of the brain often lacks autoregulation capabilities leading to a higher risk of hyperperfusion and potential for hemorrhagic conversion [14]. Current 2019 adult AHA guidelines recommend maintaining a BP goal of ≤180/105 for the first 24 h after mechanical thrombectomy [15]. Optimal blood pressure targets remain unknown but there is growing evidence that more liberal (i.e., <140 mmHg) targets lead to better neurologic outcomes [14].

Regarding fluid management, there is no published data on this topic in patients undergoing endovascular treatment of either traumatic injury or stroke [13]. However, the Neuroscience in Anesthesia and Critical Care guideline recommends maintaining euvolemia during endovascular treatment of stroke [13]. This case presented a unique challenge where ongoing blood loss from the oropharynx required blood product replacement and blood loss may have been worsened by the need for permissive hypertension to improve cerebral perfusion and transient hypovolemia could have impaired cerebral perfusion. Accordingly, fluid management was tailored to optimize oxygen delivery in the setting of multiple possible disruptions to both perfusion and oxygenation. Hemoglobin values were monitored and a level >10 g/dL was maintained in the perioperative period ensuring adequate cerebral oxygen delivery.

In light of the known right sided cerebral ischemia and probable ensuing cerebral edema, the decision was made to hyperventilate the patient to a PaCO2 of 30 to decrease intracranial pressure and optimize cerebral perfusion. This was a clinical decision based on known physiology as there are no specific guidelines or evidence for these injuries or other similar endovascular interventions for AIS [13].

Anesthetic care was also based on optimizing perfusion in the context of likely evolving cerebral edema. A propofol total intravenous anesthetic was employed to optimize cerebral prefusion pressure, avoiding the intracranial pressure increase that may accompany volatile anesthetics. Many in vitro and in vivo studies demonstrate the neuroprotective effects of propofol, but a lack of available human data does not support the use of one anesthetic drug over the other based solely on its neuroprotective properties [13,16].

The child sustained an incredible neurologic recovery likely due to the expedient intervention, optimization of collateral flow from the contralateral hemisphere, and likely the abundant neuroplasticity of the pediatric population.

Conclusion

This case report demonstrated the successful carotid artery reconstruction after a traumatic puncture by a metal straw with an incredible neurologic recovery. The case report provides further evidence for the utility of neuroendovascular therapies following substantial traumatic injuries in the pediatric population, and it presents pipeline embolization device as potentially viable option when parent vessel preservation is necessary. Even in the face of a novel pediatric traumatic injury, basic neuro-anesthetic principles extrapolated from adult literature, translated to an optimal outcome in this pediatric patient. This case report also highlighted several

knowledge gaps in the evidence-based anesthetic care of patients undergoing endovascular treatment for acute ischemic stroke, necessitating further clinical investigation.

Statements

Informed consent was obtained from the patient guardian. All authors attest that they meet the current ICMJE criteria for Authorship.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] Kay Hon, et al., A case report of blunt intraoral cerebrovascular injury in a child following intraoral trauma: the pen is mightier than the sword, Trauma Case Rep. 37 (100567) (8 Dec. 2021), https://doi.org/10.1016/j.tcr.2021.100567.
[2] F. Bilotta, E. Stazi, A. Zlotnik, S.E. Gruenbaum, G. Rosa, Neuroprotective effects of intravenous anesthetics: a new critical perspective, Curr. Pharm. Des. 20 (34) (2014) 5469–5475, https://doi.org/10.2174/1381612820666140325110113.
[3] W. Fan, et al., Propofol: an anesthetic possessing neuroprotective effects, Eur. Rev. Med. Pharmacol. Sci. 19 (8) (2015) 1520–1529.
[4] T. Alao, M. Waseem, Neck trauma. [Updated 2023 Jul 3], in: StatPearls [Internet], StatPearls Publishing, Treasure Island (FL), 2023 Jan (Available from: https://www.ncbi.nlm.nih.gov/books/NBK470422/).
[5] Jenny L. Wilson, et al., Endovascular therapy in pediatric stroke: utilization, patient characteristics, and outcomes, Pediatr. Neurol. 69 (2017) 87–92.e2, https://doi.org/10.1016/j.pediatrneurol.2017.01.013.
[6] Peter B. Sporns, et al., Thrombectomy in childhood stroke, J. Am. Heart Assoc. 8 (5) (2019), e011335, https://doi.org/10.1161/JAHA.118.011335.
[7] V. Prasad, D. Gandhi, G. Jindal, Pipeline endovascular reconstruction of traumatic dissecting aneurysms of the intracranial internal carotid artery, BMJ Case Rep. (2013) (2013 Dec 12), bcr2013010899, https://doi.org/10.1136/bcr-2013-010899 (PMID: 24334465; PMCID: PMC3863097).
[8] K.J. Zhao, et al., Reconstruction of saccular and dissected intracranial aneurysms using SolitaireTM AB stents, PLoS One 8 (2) (2013), e57253, https://doi.org/10.1371/journal.pone.0057253 (Epub 2013 Feb 26. PMID: 23468947; PMCID: PMC3582555).
[9] Shin DS, Carroll CP, Elghareeb M, Hoh BL, Kim BT. The Evolution of Flow-Diverting Stents for Cerebral Aneurysms; Historical Review, Modern Application, Complications, and Future Direction. J Kore.
[10] Bradley J. Hindman, Anesthetic management of emergency endovascular thrombectomy for acute ischemic stroke, part 1: patient characteristics, determinants of effectiveness, and effect of blood pressure on outcome, Anesth. Analg. 128 (4) (April 2019) 695–705, https://doi.org/10.1213/ANE.0000000000004044.
[11] Kilian M. Treurniet, et al., A decrease in blood pressure is associated with unfavorable outcome in patients undergoing thrombectomy under general anesthesia, J. NeuroInterv. Surg. 10 (2) (February 2018) 107–111, https://doi.org/10.1136/neurintsurg-2017-012988.
[12] M.K. Whalin, et al., Even small decreases in blood pressure during conscious sedation affect clinical outcome after stroke thrombectomy: an analysis of hemodynamic thresholds, AJNR Am. J. Neuroradiol. 38 (2) (2017) 294–298, https://doi.org/10.3174/ajnr.A4992.
[13] Pekka O. Talke, et al., Society for neuroscience in anesthesiology and critical care expert consensus statement, J. Neurosurg. Anesthesiol. 26 (2) (2014) 95–108, https://doi.org/10.1097/ana.0000000000000042.
[14] Teng J. Peng, et al., Blood pressure management after endovascular thrombectomy, Front. Neurol. 12 (723461) (3 Sep. 2021), https://doi.org/10.3389/fneur.2021.723461.
[15] William J. Powers, et al., Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association, Stroke 50 (12) (2019) e344–e418, https://doi.org/10.1161/STR.0000000000000211.
[16] Daniela Schifilliti, et al., Anaesthetic-related neuroprotection, CNS Drugs (2010) 1, https://doi.org/10.2165/11584760-000000000-00000.