Cerebral oxygenation monitoring for early detection of subarachnoid haemorrhage in infratentorial arteriovenous malformation undergoing embolisation: A case study

Dear Editor,

Arteriovenous malformation (AVM) is a rare condition with an incidence of 0.94 per 100,000 person-years,[1] and infratentorial AVMs account for only 6%–8% of all intracranial AVM cases.[2] Embolisation of AVMs for its management can cause cerebro-physiological changes and may result in haemorrhage in the surrounding vasculature.[3] Subarachnoid haemorrhage (SAH) following embolisation can be challenging to detect on digital subtraction angiography (DSA) imaging.

An 11-year-old male child was posted for embolisation of a Spetzler–Martin grade 3 AVM involving the inferior part of the right cerebellar hemisphere and the right middle cerebellar peduncle [Figure 1a]. In the radiology suite, anaesthesia was induced with intravenous (IV) fentanyl 60 μg, propofol 60 mg and atracurium 20 mg, and the trachea was intubated with an appropriate-sized endotracheal tube. Along with routine monitoring, an arterial line was secured. The O3 sensors™ (Masimo, Irvine, CA, USA) were placed bilaterally on the forehead and connected to the Masimo™ root monitor (Masimo Inc., San Diego, CA, USA) for continuous cerebral oximetry. Preinduction regional cerebral oxygenation values (rSO_2) were 67% on the right side and 69% on the left side of the forehead, which increased to 91% and 95% on the right and left sides, respectively, after anaesthesia induction. The feeding artery from the right anterior inferior cerebellar artery (AICA) was cannulated with the distal portion of the catheter within the nidus under adequate heparinisation, and 2.8 ml of liquid embolic agent (ethylene–vinyl alcohol–dimethyl sulfoxide copolymer) was injected through the microcatheter into the nidus under blank roadmap guidance. During this time, a decrease in rSO_2 values from 80% and 81% to 73% and 75% on the right and left sides, respectively, was

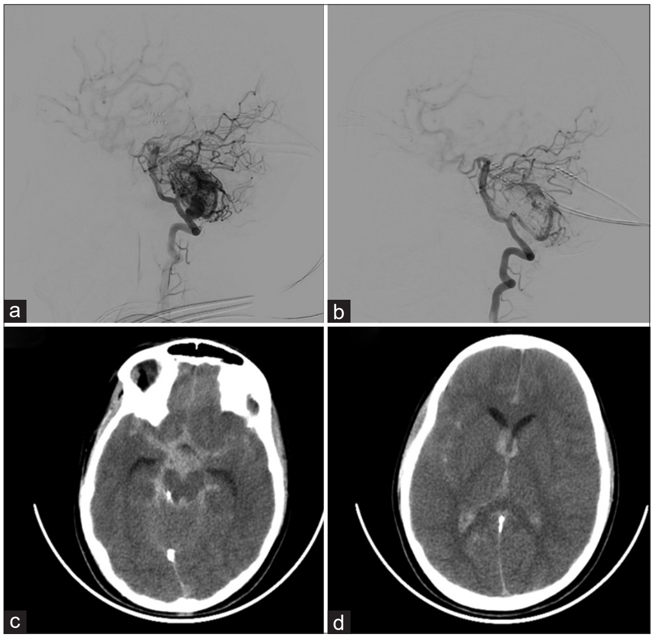

Figure 1: (a) DSA image (right vertebral artery run lateral view) showing a 3.3 cm × 1.6 cm × 2.6 cm AVM nidus in the inferior part of the right cerebellar hemisphere and the right middle cerebellar peduncle pre-embolisation. (b) AVM nidus post-embolisation. (c) Post-embolisation plain axial computed tomography scan showing diffuse subarachnoid haemorrhage in the basal cisterns, bilateral sylvian and interhemispheric cisterns, and (d) intraventricular haemorrhage in the lateral ventricle. AVM = arteriovenous malformation, DSA = digital subtraction angiography

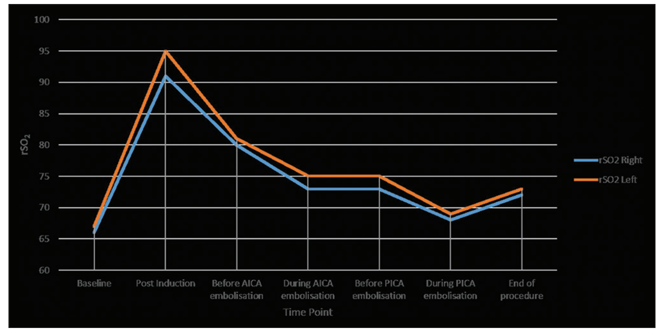

Figure 2: Trend of change of NIRS-derived rSO_2 values at time points of interest. AICA = anterior inferior cerebellar artery, NIRS = near-infrared spectroscopy, PICA = posterior inferior cerebellar artery, rSO_2 = regional cerebral oxygen saturation

observed over 3 minutes [Figure 2]. The radiologists were promptly alerted about this change. Although some residual (~15%–20%) components could not be embolised due to a reflux of embolic liquid along the microcatheter up to the detachable zone, an acceptable embolisation of AVM nidus was achieved. This was followed by right posterior inferior cerebellar artery (PICA) embolisation. All through this time, the rSO_2 values remained stable. After 1 ml of 33% *N*-butyl cyanoacrylate (NBCA) glue was injected into AVM nidus, the rSO_2 values fell to 68% and 69% on the right and left sides, respectively, while embolising the last feeding artery. This was not associated with significant changes in haemodynamics, saturation and airway pressures. The temporal alignment between the injections and the rSO_2 drops prompted the communication of these value changes to the neuroradiologists. With the radiologists expressing satisfaction with the extent of embolisation achieved [Figure 1b], a collective decision was reached to stop the procedure. Post-procedure, the patient underwent a smooth tracheal extubation with no delayed emergence, and the immediate postoperative Glasgow Coma Scale (GCS) was E4V5M6. A post-embolisation computed tomography (CT) scan revealed a diffuse SAH classified as Fischer grade IV [Figure 1c and d]. Despite SAH, the patient remained fully conscious and did not experience any deficit. Subsequent CT scans showed a gradual reduction in the volume of SAH. The patient was managed conservatively. The consciousness remained stable throughout his stay, and he was ultimately discharged from the hospital without any deficit.

The occurrence of SAH during AVM embolisation has been suggested to be associated with intranidal pseudoaneurysms, flow-related aneurysms or venous pouches.[4] In a study conducted by Brown *et al.*, involving 168 patients with unruptured intracranial AVM, they observed that 18% of the patients experienced intracranial haemorrhage due to AVM rupture, with a mean annual risk of 2.2% for haemorrhage.[5]

The O3™ sensor used in this study is a second-generation cerebral oximetry sensor.[6,7] In the case of infratentorial AVM, there was likely stagnant flow from the previous feeders, increasing the capillary blood volume. As a result, the sensors detected rSO_2 values around 70, indicating signals from shunted blood rich in oxyhaemoglobin. However, the backpressure changes in the pericapillary area surrounding the embolised nidus caused blood extravasation into the subarachnoid space, decreasing rSO_2 values [Figure 2]. Other possible causes of bilateral drop in rSO_2 could be intraprocedural hypotension, embolic material migration to the pulmonary circulation, or even air embolism during hand injection of the embolic agent. However, our patient showed no changes in the end-tidal carbon dioxide levels, saturation or airway pressures. It is important to note that SAH resulting from AVM embolisation can lead to global changes in cerebral blood flow, which was picked up in our report by an oximetry sensor placed on a child's forehead. But the lack of an absolute abnormal rSO_2 value with the use of cerebral oximetry remains a concern.[8] Thus, cerebral oxygenation monitoring can be valuable in the early detection of SAH during infratentorial AVM embolisation, aiding in patient management and safety.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the parents consented to images and other clinical information of the child to be reported in the journal. The parents understands that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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