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CLINICAL REPORT

# Cerebral regional oxygen saturation: a useful monitor during a surgical procedure involving the right-sided aortic arch in an infant

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## Abstract

A right aortic arch with an aberrant left subclavian artery and a Kommerell's diverticulum represents a rare anatomic variant carrying the risk of dissection or rupture. Resection of the diverticulum and re-implantation of the left subclavian artery during childhood have been recommended. Because of the risk of cerebral blood flow reduction during the aberrant subclavian artery re-implantation to the common carotid artery, monitoring and prompt measures to curb blood flow reduction are required. A 5-month-old boy was scheduled to undergo resection surgery. During the translocation of the aberrant subclavian artery to the common carotid artery, his regional oxygen saturation ($rSO_2$) in the left cerebrum began to decrease. We increased the end-tidal $CO_2$ ($EtCO_2$), mean arterial pressure, and a fraction of inspired oxygen, successfully restoring the $rSO_2$ to the initial level. No postoperative neurological complications were observed. Our experience with this patient suggests that $rSO_2$ monitoring is a useful, and intervention protocol including hypercapnia, elevated mean arterial pressure, and hyperoxia to counter the decreased cerebral blood flow is effective in infant patients undergoing right-sided aortic arch surgery.

**Keywords** Cerebral regional oxygen saturation · Kommerell's diverticulum · Anesthesia

## Introduction

Right-sided aortic arch is a relatively rare congenital abnormality that may be accompanied by an aberrant subclavian artery. A Kommerell's diverticulum may develop in the region of origin of the aberrant subclavian artery and carries the risk of rupture after dilatation; therefore, resection of the diverticulum and translocation of the aberrant subclavian artery to the common carotid artery during childhood have become the standard recommendation to avoid the risk of rupture [1].

Since translocation of the aberrant subclavian artery involves a transplant to the left common carotid artery, blood flow to the left common carotid artery is temporarily blocked during anastomosis. Left cerebral blood flow may decrease during such blockage in cases without sufficient blood flow support from the circle of Willis or other sources. The circle of Willis is incomplete in 50–85% of cases, making the monitoring of left and right cerebral blood flow changes highly important during decreased cerebral blood flow [2, 3].

Monitoring bilateral cerebral blood flow changes during decreased cerebral blood flow is important.

Use of regional oxygen saturation ($rSO_2$) monitoring for cerebral blood flow assessment has been demonstrated during surgeries such as coronary artery bypass surgery and carotid endarterectomy [4, 5]. There are several reports on the interventions to counter the decreased cerebral blood flow to improve outcomes in adult patients [6]; however, there are few reports on interventions for infant patients.

Here, we report the case of an infant patient who exhibited decreased cerebral oxygen saturation ($rSO_2$) during the surgical translocation of an aberrant subclavian artery and was successfully managed with $rSO_2$ monitoring and intervention protocol.

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## Case report

Our patient was a male infant aged 5 months and 22 days; he measured 63 cm in length and weighed 9.3 kg. He was diagnosed with a right-sided aortic arch during prenatal ultrasound. He presented no particular complications after his birth, but he suffered from persistent wheezing after being hospitalized for bronchitis at 2 months of age. Contrast-enhanced computed tomography revealed a right-sided aortic arch, an aberrant subclavian artery, and a Kommerell's diverticulum. His trachea was affected by the Kommerell's diverticulum that was directly in front of the bifurcation. He was placed under general anesthesia, and we performed an intubation that enabled the visualization of the tracheal stenosis site via bronchoscopy. Vertical pressure was present from a site just proximal to the bifurcations and, although we observed pulsation, we found no mechanical ventilation problems. To evaluate cerebral oxygen saturation, we used the FORE-SIGHT (FS2: CAS Medical system). Sensors were bilaterally applied to the forehead, and we set the alarm point at 20% from the reference value (i.e. surgical start point) [7]. Thus, we confirmed the absence of differences between the two sites. A lateral incision approach was taken to identify the aberrant subclavian artery; the area around the Kommerell's diverticulum was detached and the aortic arch was confirmed. After heparin administration, the subclavian artery was blocked and diverticulum was resected.

To confirm mean arterial pressure, hypercapnia, and cerebral oxygen saturation coordination, we administered 5 μg/kg/min dopamine (DOA) before blocking the common carotid artery. We then confirmed that the mean arterial pressure increased by 10 mmHg, with every 5% increase in cerebral oxygen saturation, or that in states of hypercapnia with $EtCO_2$ of ~ 50 mmHg, the cerebral oxygen saturation rose by 10%.

Next, during the test blockage of the left common carotid artery, the left forehead $rSO_2$ decreased from ~ 60 to ~ 40%, but it quickly recovered after releasing the blockage. During vascular anastomosis, the new blockage again resulted in $rSO_2$ dropping to ~ 40%. We then administered DOA and made into hypercapnia, the $rSO_2$ rose to ~ 50%. With the fraction of inspired oxygen increasing to 100%, we observed a 5% increase, and the $rSO_2$ returned to its initial levels (Fig. 1). The difference between the left and right $rSO_2$ improved quickly following the release of the blockade. The surgery was successfully concluded with a total blockage time of 26 min.

The patient was extubated 4 h postoperatively, and his oxygenation and hemodynamic states became stable. He was discharged 12 days later without any signs of neurological complications.

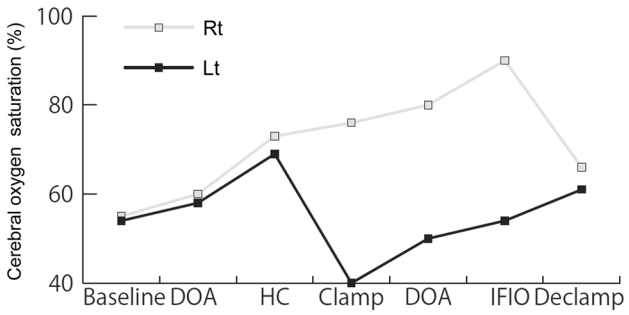


**Fig. 1** Cerebral oxygen saturation changes. *DOA* dopamine, *HC* hypercapnia, *IFIO* increased fraction of inspired oxygen

## Discussion

We report a case in which $rSO_2$ monitoring proved useful in comprehending cerebral blood flow, and we have shown that an intervention protocol including hypercapnia, elevated mean arterial pressure, and hyperoxia to counter decreased cerebral blood flow is effective in infant patients undergoing right-sided aortic arch surgery.

We used the $rSO_2$ to measure cerebral oxygenation because it can be noninvasively, continuously, and bilaterally measured. Recent reports have revealed that $rSO_2$ monitoring provides an opportunity for early recognition of imbalance between cerebral oxygen demand and supply and evaluation of subsequent performance of standardized interventions to prevent prolonged $rSO_2$ desaturation with the aim to avoid neurological complications in cardiac surgery and carotid endarterectomy [6, 8, 9].

Prolonged low-$rSO_2$ value is associated with cognitive dysfunction, prolonged length of hospital stay, and perioperative cerebrovascular accidents [10]. Murkin et al. reported that a similar protocol for the decreased $rSO_2$ in an adult patient improved patient prognosis. This protocol is based on optimizing factors that can affect cerebral oxygen demand and supply such as perfusion pressure, cardiac output, arterial oxygen content, $PaCO_2$, and cerebral metabolic rate [5].

The incidence of postoperative cognitive dysfunction in the cardiac surgery has been estimated to be more than 50%, thus, increasing the potential for hypoperfusion because of impaired autoregulation and requirement of elevated cerebral perfusion pressure (CPP) [4]. One of the most common interventions in the treatment of brain desaturation is maintaining CPP. We try to maintain mean arterial pressure using vasopressors. Normalization of $PaCO_2$ is also one of the most common interventions. $PaCO_2$ is a powerful determinant of brain circulation. Hyperoxia has been shown to increase cerebral blood flow, and normobaric hyperoxia has been clinically used as a therapy for ischemic stroke [11].

In this case, patient exhibited decreased left $rSO_2$ during the test clamp of the left common carotid artery. We expected a similar response during vascular anastomosis and thus decided to elevate the $EtCO_2$, and the mean arterial pressure to increase the cerebral blood flow and the perfusion to the circle of Willis, which both resulted in increase in the $rSO_2$. Although these measures were both effective for treating the decreased $rSO_2$ following blockage, the $rSO_2$ level remained low compared to the initial level prior to the start of the operation. Therefore, we also increased the fraction of inspired oxygen, due to which the $rSO_2$ rose to the initial normal level, and the patient was discharged without any signs of neurological complications.

In conclusion, because of the $rSO_2$ monitor, it was possible to compare the right and the left side $rSO_2$ level, and it was useful for high-risk infant surgeries, such as decreasing cerebral blood flow.

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