Journal of Clinical Monitoring and Computing (2019) 33:403–405
https://doi.org/10.1007/s10877-018-0184-6

CASE REPORT

Patent ductus arteriosus closure and somatic regional oxyhemoglobin saturation

Junichi Saito[1] · Kishiko Nakai[1] · Jun Kawaguchi[1] · Daiki Takekawa[1] · Kazuyoshi Hirota[1]

Received: 24 March 2018 / Accepted: 17 July 2018 / Published online: 3 August 2018
© Springer Nature B.V. 2018

Abstract

The authors report a case of a 14-day-old infant patient with patent ductus arteriosus (PDA) with pulmonary hypertension. Accidental clipping of the left pulmonary artery (LPA) during intended PDA closure was revealed, and subsequent urgent PDA closure and releasing a clip of the LPA were conducted. During surgeries we measured somatic regional oxyhemoglobin saturation (rSO_2) values and change in those might be a key for early diagnosis of accidental clipping of the LPA. These findings suggest that we should understand the risk of accidental closure of the LPA during PDA surgery and somatic rSO_2 values will provide information for early diagnosis of critical complication.

Keywords Regional oxyhemoglobin saturation · Patent ductus arteriosus closure · Surgical complication

Accidental ligation of the left pulmonary artery (LPA) has been reported as a rare complication of intended patent ductus arteriosus (PDA) closure [1]. A delay in the diagnosis of an accidental ligation of the LPA could be associated with poor outcomes including death. A patient's regional oxyhemoglobin saturation (rSO_2) can be measured noninvasively in the tissue bed. Low rSO_2 values after cardiac surgery reflect poor perfusion and are associated with morbidity and mortality [2, 3]. Here we report a case of accidental clipping of the LPA during an intended PDA closure, and we describe the subsequent urgent PDA closure and release of a clip of the LPA. During the patient's two surgeries, the somatic rSO_2 values were measured. We discuss the possibility that changes in the somatic rSO_2 values might be a key to the early diagnosis of accidental clipping of the LPA.

1 Case presentation

A 14-day-old female infant with PDA and pulmonary hypertension was transferred to our hospital to undergo PDA clipping. At 35 weeks/3 days' gestation, she was delivered by vacuum extraction. She was diagnosed with PDA based on echocardiography findings and was treated with diuretics. At 5 days old, she exhibited tachypnea and tachycardia due to congestive heart failure. Echocardiography revealed that the patient's PDA was 3.5 mm in dia. with a left to right shunt; it also showed 50 mmHg as the peak pressure gradient of tricuspid regurgitation, moderate mitral regurgitation, and left atrial dilatation. Spontaneous closure of the PDA could not be expected, at 14 days after the patient's birth, she was transferred to our hospital and we performed an urgent direct ligation of the PDA through a left thoracotomy.

Immediately prior to the PDA ligation, the patient was 44 cm long and her weight was 1900 g. The preoperative laboratory examination revealed brain natriuretic peptide at 4620 pg/mL and the hemoglobin concentration 8.3 g/dL. Her trachea had already been intubated with a 3.0-mm cuffed tube. Anesthesia was induced and maintained with

J. Saito is the archival author.

✉ Junichi Saito
fix-you@hotmail.co.jp

Kishiko Nakai
kishiko_sk1064@yahoo.co.jp

Jun Kawaguchi
jkawaguchi3@gmail.com

Daiki Takekawa
takekawa.daiki50@gmail.com

Kazuyoshi Hirota
hirotak@hirosaki-u.ac.jp

[1] Department of Anesthesiology, Hirosaki University Graduate School of Medicine, Zaifu-cho 5, Hirosaki 036-8562, Japan

midazolam, fentanyl, and ketamine. To avoid body movement, rocuronium was administered.

Throughout the PDA ligation procedure, the following variables were continuously monitored: invasive blood pressure (BP) at the right radial artery, central venous pressure, electrocardiogram, peripheral oxygen saturation (SpO_2) at the right hand and right foot, the end-tidal concentration of carbon dioxide (CO_2), body temperatures (forehead deep-tissue, palm of right hand deep-tissue, esophagus and rectum), and somatic rSO_2. For the measurement of the rSO_2 value, we placed a pediatric-sized oximetry sensor on the patient's back below the costovertebral angle. An INVOS 5100B oximeter™ (Somanetics, Troy, MI) was used to monitor her somatic rSO_2 values.

The PDA closure was achieved with the use of a single clip. The difference in the patient's BP between pre- and post-clipping was minor: 58/28 and 61/30 mmHg, respectively. Just before the clipping of the LPA, the patient's somatic rSO_2 value was 65%, and the value gradually decreased to 55% after the clipping (Fig. 1). At 5 min after the LPA was clipped, the arterial blood gas analysis with F_IO_2 (at 0.4) revealed a 7.35 pH, 95 mmHg PaO_2, 55 mmHg $PaCO_2$, and a base excess of 4.3 mmol/L. Around the same time, the patient's end-tidal CO_2 decreased from 40 to 32 mmHg. The SpO_2 values at her right hand and right foot were maintained at 99–100% (F_IO_2, 0.4) until the end of the surgery, and her hemoglobin concentration increased from 8.2 to 9.8 g/dL.

At 30 min after surgery in the neonatal intensive care unit (NICU), an arterial blood gas analysis showed 65 mmHg PaO_2 (F_IO_2, 0.21) and 55 mmHg $PaCO_2$, and transthoracic echocardiography revealed remaining PDA flow. The subsequent computed tomography revealed that clipping of the upper LPA had taken place but a large PDA had remained.

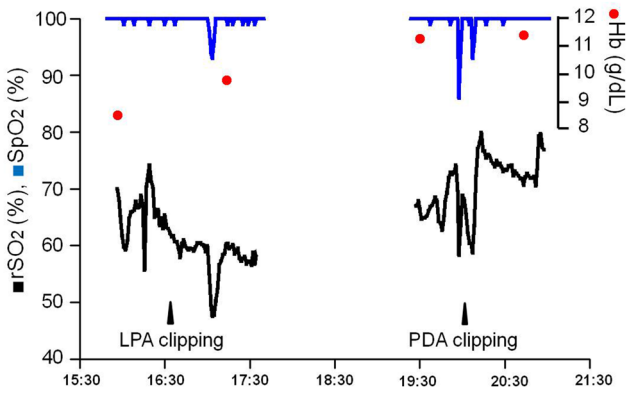

Fig. 1 Change in the patient's regional oxyhemoglobin saturation during repeated patent ductal arteriosus closure. *LPA* left pulmonary artery, *PDA* patent ductal arteriosus, rSO_2 regional oxyhemoglobin saturation, SpO_2 peripheral oxygen saturation, *Hb* hemoglobin concentration

At 2 h after the first surgery, we performed an urgent thoracotomy. After the induction of anesthesia, the arterial blood gas analysis with F_IO_2 0.6 revealed a pH of 7.41, 115 mmHg PaO_2, 45 mmHg $PaCO_2$, and a base excess of 3.9 mmol/L. The patient's hemoglobin concentration had increased to 11.1 g/dL due to RBC transfusion in the NICU. Due to this increased hemoglobin concentration, the baseline value of rSO_2 (67%) was higher than that at the end of the first surgery.

Because the patient's left recurrent laryngeal nerve ran around the upper LPA, the surgeons identified the LPA as PDA. After the clip was released from the LPA, the true PDA was clipped. A change in the patient's BP between pre- and post-clipping was evident: 64/37–73/45 mmHg, respectively. Her somatic rSO_2 value increased after the PDA clipping from 67 to 75 to 83% (Fig. 1). The second surgery was uneventful. No organ necrosis was present.

2 Discussion

The clinically important issue to highlight in this patient's case is that a change in rSO_2 values might be a key to the early diagnosis of accidental clipping of the LPA. In our patient's case, the somatic rSO_2 value decreased after accidental closure of the LPA and increased after the PDA closure. Because the rSO_2 represents a regional venous-weight value, monitoring of a patient's rSO_2 provides an immediate indication of changes in the balance of oxygen delivery and oxygen consumption. A PDA closure increases the blood flow and oxygen supply to the lower body, and thus an increase in the somatic rSO_2 value after PDA closure is expected. An absolute rSO_2 value < 40–50% or a change in the baseline rSO_2 value of > 20% is associated with poor outcomes [4]. However, even a minor but unexpected change in the rSO_2 value provides information for the early diagnosis of a critical complication.

In general, an immediate increase in the patient's blood pressure (especially of the diastolic blood pressure) should be observed after clipping of the PDA. In addition to minor changes in blood pressure after a vessel is clipped, a decrease or no change in the rSO_2 indicates the accidental clipping of the wrong vessel. It is essential to confirm changes in the patient's blood pressure and those in the somatic rSO_2 in order to prevent or diagnose early clipping of the wrong vessel. In addition, somatic rSO_2 monitoring can detect the accidental ligation of the descending aorta, which is a major complication. Thus, the somatic rSO_2 should be monitored routinely in PDA patients.

In our patient, even after the clipping of the LPA, the PaO_2 and SpO_2 did not decrease drastically; this was because the pulmonary shunt did not increase even though the dead space increased. PaO_2 and SpO_2 might not be suitable

indicators. The gradient between our patient's end-tidal CO_2 and $PaCO_2$ increased after the LPA clipping. This phenomenon might provide telling clues about accidental clipping of the LPA. As there are as yet no specific indicators for accidental clipping of the LPA, it is important to not miss the subtle changes in monitored values. Surgeons should be acutely aware of the possibility of clipping the LPA.

Accidental clipping of the LPA during intended PDA closure is a rare but critical complication that should be avoided. A review of PDA surgical closure cases noted that the incidence of accidental LPA closure was one of 936 surgeries [1], but few case reports of this complication have been published [5]. To prevent morbidity and mortality caused by this complication, transthoracic echocardiography immediately after PDA surgery is important, especially for low-body-weight patients for whom transesophageal echocardiography is not indicated during surgery and patients with a low somatic rSO_2 value after PDA closure. Knowledge of an accidental closure of the LPA will prevent misdiagnosis and enable early intervention.

In conclusion, surgeons should understand the risk of accidental closure of the LPA during PDA surgery. Monitoring the patient's somatic rSO_2 values will provide information for the early diagnosis of a critical complication.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Panagopoulos PG, Tatooles CJ, Aberdeen E, Waterston DJ, Carter RE. Patent ductus arteriosus in infants and children: a review of 936 operations (1946-69). Thorax. 1971;26:137–44.
2. Murkin JM, Adams SJ, Novick RJ, Quantz M, Bainbridge D, Iglesias I, Cleland A, Schaefer B, Irwin B, Fox S. Monitoring brain oxygen saturation during coronary bypass surgery: a randomized, prospective study. Anesth Analg. 2007;104:51–8.
3. Ruf B, Bonelli V, Balling G, Hörer J, Nagdyman N, Braun SL, Ewert P, Reiter K. Intraoperative renal near-infrared spectroscopy indicates developing acute kidney injury in infants undergoing cardiac surgery with cardiopulmonary bypass: a case-control study. Crit Care. 2015;19:27.
4. Hoffman GM, Ghanayem NS, Tweddell JS. Noninvasive assessment of cardiac output. Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu. 2005;8:12–21.
5. Tefera E, Bermudez-Cañete R, van Doorn C. Inadvertent ligation of the left pulmonary artery during intended ductal ligation. BMC Res Notes. 2015;8:511.