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Cerebral Oxygenation Monitoring Using Near Infrared Spectroscopy for Posttraumatic Innominate Pseudoaneurysmal Surgery

Yong Cheol Lee, M.D., Seung Ho Kwon, M.D., Young Ho Jang, M.D.

Department of Anesthesiology and Pain Medicine, Keimyung University School of Medicine, Daegu, Korea

Abstract : Posttraumatic pseudoaneurysm of innominate artery (IA) is uncommon vascular injury. The conventional surgical repair of the IA injury needs profound hypothermia with circulatory arrest, cardiopulmonary bypass with selective perfusion of the right common carotid artery (CCA), or external or internal shunts. However, in case of the presence of contralateral cerebral perfusion to right CCA, it is possible without selective perfusion of the right CCA.

We experienced anesthetic management of repairing traumatic pseudoaneurysm of the IA using near infrared spectroscopy (NIRS) without bypass or shunting. Regional cerebral oxygen saturation (rSO_2) was continuously measured with NIRS. The back flow test with NIRS to ensure cerebral collateral circulation to the right CCA was performed before IA repair. Right/Left rSO_2 were 73/69% and 72/72% at immediately and 3 min after clamp, respectively. The rSO_2 were well maintained as baseline level after test-clamping of the IA.

Surgical repair was performed without arterial bypass and postoperative course was uneventful. He was discharged without any neurologic complication.

Key Words : Brain , Cerebral oxygen saturation , Innominate artery

Introduction

Injury of the innominate artery (IA) is uncommon and may be caused by blunt chest traumas following vehicle collisions. In surgical repair of the IA injury, cerebral protection is an important consideration[1], and achieved by cardiopulmonary bypass, retrograde perfusion, hypothermia, and external or internal shunts[2]. However, repair of the IA injury is also possible without selective perfusion of the right common carotid artery (CCA) in case of the presence of contralateral cerebral perfusion to right

CCA[3]. In general, the collateral circulation via contralateral carotid or vertebral artery can be confirmed by electroencephalogram, vigorous back bleeding, or stump pressure measurement[4,5].

However, near-infrared spectroscopy (NIRS) is a noninvasive optical technology that measures real time regional cerebral oxygen saturation (rSO_2). We experienced a successful management of repairing the IA injury through the NIRS monitoring for cerebral protection without shunting or arterial bypass. We used rSO_2 as an index of cerebral collateral circulation.

Fig. 1. Arteriogram showing a rupture of distal segment of the innominate artery and pseudoaneurysm at the site of rupture (arrow).

Case

A 25-year-old male was brought into the emergency room following a motor vehicle accident. Chest X-ray and computed tomographic examinations showed mediastinal widening, multiple rib fractures, bilateral hemopneumothoracies, and bilateral pulmonary contusions. Chest tubes were inserted in both sides. The patient underwent emergent angiography, which revealed a rupture of the splenic artery and a formation of pseudoaneurysm of the distal IA (Fig. 1). His vital signs were recovered after emergent splenic arterial embolization using coiling and transfusion (hematocrit 35%). Mean arterial pressure (MAP) was controlled between 60-70 mmHg.

The patient was taken to the operating room for the IA repairment without premedications. Electrocardiogram, pulse oximetry, and central venous pressure were continuously monitored. There was no pulsation on the right radial artery, therefore arterial catheterization was performed via the left radial artery. Sensors for cerebral oximetry were placed bilaterally on the right and left sides of the forehead before induction of anesthesia. The rSO_2 were continuously monitored using NIRS (INVOS® 5100B Cerebral Oximeter, Somanetics Corporation, Troy, USA). The baseline values of rSO_2 were 70%/73% (right/left).

Anesthesia was induced with 200 mg thiopental sodium and 50 mg rocuronium bromide, and maintained with 0.4-1.2 vol% isoflurane in pure oxygen. His vital signs were stable except slight tachycardia (118 bpm). The value of arterial blood gas analysis revealed within normal range. MAP was kept to 60 mmHg in average to reduce blood loss and to secure operative fields. The rSO_2 revealed 72%/72% during this period.

Operation was performed with median

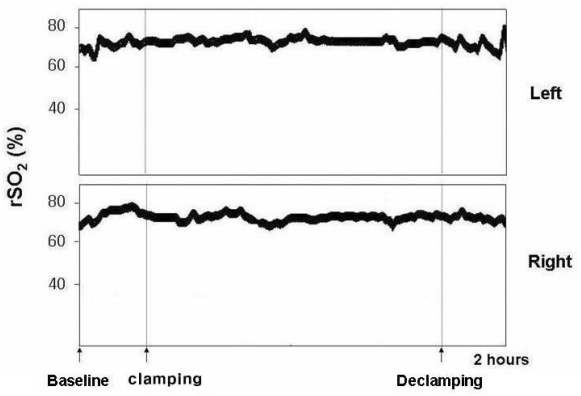

Fig. 2. Changes in regional cerebral oxygen saturation (rSO_2) measured by near infrared spectroscopy during the repair of the innominate artery (IA). The rSO_2 were measured at immediately, 1 and 3 min after the clamp of the right common carotid and subclavian arteries. The rSO_2 in both sides were well maintained following 3 min of clamping test of the IA. Total clamping time was 80 min.

sternotomy. Immediately before the surgical repair, we performed back flow test with NIRS to ensure cerebral collateral circulation with preparing of arterial bypass. The right common carotid artery (CCA) and subclavian artery were clamped for 3 min. Right and left rSO_2 were 73%/69%, 72%/70%, 72%/72% immediately, and at 1 and 3 min after the clamp, respectively (Fig. 2). The rSO_2 were maintained between 71−75% in both sides throughout the operation. Surgical repair was performed as patch closure with the femoral vein without arterial bypass.

Total clamping time was 80 min. Immediately after unclamping, rSO_2 in both sides were 70%/71%. MAP decreased to 50 mmHg and heart rate was 121 bpm. Heart rate and MAP were transiently recovered after the administration of fluid and blood components and intravenous ephedrine. The rSO_2 and vital signs were well maintained until the end of anesthesia. He was discharged at 26th day of hospitalization without any neurologic complication.

Discussion

Posttraumatic pseudoaneurysm of the IA is an uncommon vascular injury. The conventional techniques employed for the surgical repair of injured IA include profound hypothermia with circulatory arrest, cardiopulmonary bypass with selective perfusion of the right CCA, and external or internal shunts[6,7]. However, repair of the IA is also possible without selective perfusion of the right CCA in case of the presence of contralateral cerebral perfusion to the right CCA[3].

In human, the majority of total cerebral blood flow is supplied by the internal carotid arteries (approximately 90%) and the remaining by the vertebral arteries[7]. Therefore, if the left CCA and Circle of Willis are intact the shunt may not be necessary to protect the brain during the repair of the injured IA. In some cases, preoperative angiogram may also demonstrate adequate collateral supply to the right CCA via the Circle of Willis.

Various modalities to confirm the collateral cerebral circulation for the surgical repair of the injured IA include electroencephalogram, vigorous back bleeding, and measuring stump pressure[4,5]. Symbas *et al.*[5] assessed right CCA stump pressure and demonstrated that less than 50 mmHg of back pressure called for right CCA shunting.

Electroencephalogram may also be useful for test-clamping of the IA[8]. In this case, we used rSO_2 as an index of cerebral collateral circulation for test-clamping of the IA. NIRS allows non-invasive continuous rSO_2 measurement and readily monitors intraoperative neurological status. NIRS relies on the relative transparency of biological tissues to near-infrared light where oxygenated and deoxygenated hemoglobins have distinct absorption spectra. NIRS determines a value for rSO_2 by measuring the attenuation of light at several wavelengths and distances between emitter and detector[9]. This assessment is clinically useful in open heart surgery, in patients with head trauma, and carotid endarterectomy[10].

The usefulness of rSO_2 in the surgical repair for the injured IA for clamp test may still be controversial. Acute and persistent decreases in rSO_2 were associated with cerebral vascular complications and detected before the development of clinical neurologic symptoms. However, the absolute values of rSO_2 cannot be comparable because of the wide interindividual variations of baseline values, indicating that it is more appropriate to view as trend values[11]. Cerebral desaturation is defined as the reduction of rSO_2 less than 75% of baseline for 15 seconds[10]. And rSO_2 less than 80% of baseline is considered as cerebral desaturation when if the baseline value is less than 50%. Otherwise, Cho *et al.*[12] demonstrated that the decrease of rSO_2 more than 10% of baseline value or a decrease below of 50% indicates cerebral ischemia sufficiently severe to decrease the amplitude of somatosensory evoked potentials. Samra *et al.*[13] demonstrated 20% decrease of rSO_2 reading from the preclamp baseline as a predictor of neurologic compromise, in patients undergoing carotid endarterectomy with sensitivity of 80%. The rSO_2 of both side were well maintained in our IA injury patient and there was no neurological complications relating the occlusion of the right CCA.

We report a traumatic pseudoaneurysm of the IA in a 25-year-old man. The back flow test was performed using NIRS. The rSO_2 was well maintained as baseline level after test-clamping of the IA. Surgical repair was performed without arterial bypass and postoperative course was uneventful. He was discharged without any neurologic complication.

Summary

NIRS is a noninvasive optical technology that measures real time rSO_2. We experienced a successful case of the IA injury repairment via NIRS monitoring for cerebral protection without shunting or arterial bypass.

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