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Near-Infrared Spectroscopy–Detected Cerebral Ischemia Resolved by Cannulation of an Axillo-Femoral Graft during Surgical Repair of Type A Aortic Dissection

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ABSTRACT

We report the case of a patient who experienced near-infrared spectroscopy (NIRS)-detected transient regional cerebral desaturation during cardiopulmonary bypass for an operation to replace the aortic arch. Prompt institution of additional flow through an axillo-femoral graft was associated with restoration of regional cerebral saturation. The aortic surgery had no neurologic complications. Promptness in detecting and restoring cerebral perfusion appeared crucial in avoiding prolonged cerebral ischemia and reducing the likelihood of adverse neurologic events.

INTRODUCTION

Malperfusion of vital organs during surgery for aortic dissection is a dangerous complication that demands both close evaluation when cardiopulmonary bypass (CPB) is started and monitoring throughout the procedure [Hagan 2000]. Integration of transesophageal echocardiography (TEE) and cerebral near-infrared spectroscopy (NIRS) has been advocated as a valid strategy for detecting the onset of ischemia in the cerebral district, because of its ability to provide a timely alarm and to prompt rapid institution of countermeasures [Murkin 2009]. We report the case of a patient with NIRS-detected transient regional cerebral desaturation who successfully underwent aortic arch replacement after reperfusion through an axillo-femoral graft.

CASE REPORT

A 57-year-old woman was referred to our hospital urgently after a computed tomography (CT) evaluation detected evidence of an acute type A aortic dissection. The disease involved the epiaortic vessels and extended to the abdomen, with complete occlusion of the aorta below the origin of the renal arteries. The patient was conscious, and no neurologic deficit could be noted in the preoperative evaluation. Normal pulsation was palpable in both radial arteries, but femoral pulses were absent bilaterally. After admission of the patient to the operating theater, we instituted bilateral monitoring of the radial arterial pressure, conducted TEE, and applied 2 spectroscopy probes (INVOS 5100B; Somanetics, Troy, MI, USA) to the forehead for site-specific NIRS monitoring of the frontal lobes. A left axillo-femoral bypass was performed with an 18F Dacron graft to restore (femoral) arterial flow beyond the aortic occlusion. CPB was then established with a right axillary side graft for arterial inflow and right atrial cannulation for venous drainage. After the start of CPB, an abrupt, profound decrease in the oxygen saturation of the right hemisphere occurred during core cooling, with values reaching approximately 15%. Left hemisphere saturation decreased at the same time, with values ranging between 40% and 50%. These events did not appear to be correlated with any evident TEE or visible anatomic change. An expansion of the false lumen along the right epiaortic vessels was presumed to be causing the cerebral malperfusion. A second side graft was then sewn onto the axillo-femoral bypass graft and was used as an additional arterial inflow for CPB to improve perfusion through to the true lumen (Figure 1). This procedure was completed 15 minutes after the start of CPB. After additional cerebral flow was established through the added side graft, cerebral saturation gradually increased bilaterally to values above the baseline. The patient was cooled to a rectal temperature of 19°C, CPB was discontinued, and the aorta was opened. An intimal tear extending from the ascending aorta to the entire arch was identified. Cerebral perfusion through the right subclavian artery cannula and the left Dacron graft for axillo-femoral bypass was started but was interrupted after 24 minutes because of epiaortic vessel disruption occurring after cross-clamping. Consequently, cerebral saturation decreased below 20% bilaterally (Figure 1). The arch was replaced with a tubular 18-mm Dacron graft, the left carotid and innominate arteries were reimplanted by interposition of 8-mm grafts, the aortic graft was clamped, and CPB was resumed after 49 minutes of circulatory arrest (Figure 1). After reinstitution of CPB during rewarming, the cerebral saturation gradually increased bilaterally. The saturation pattern of the right hemisphere presented a 55-minute plateau with the oxygen saturation

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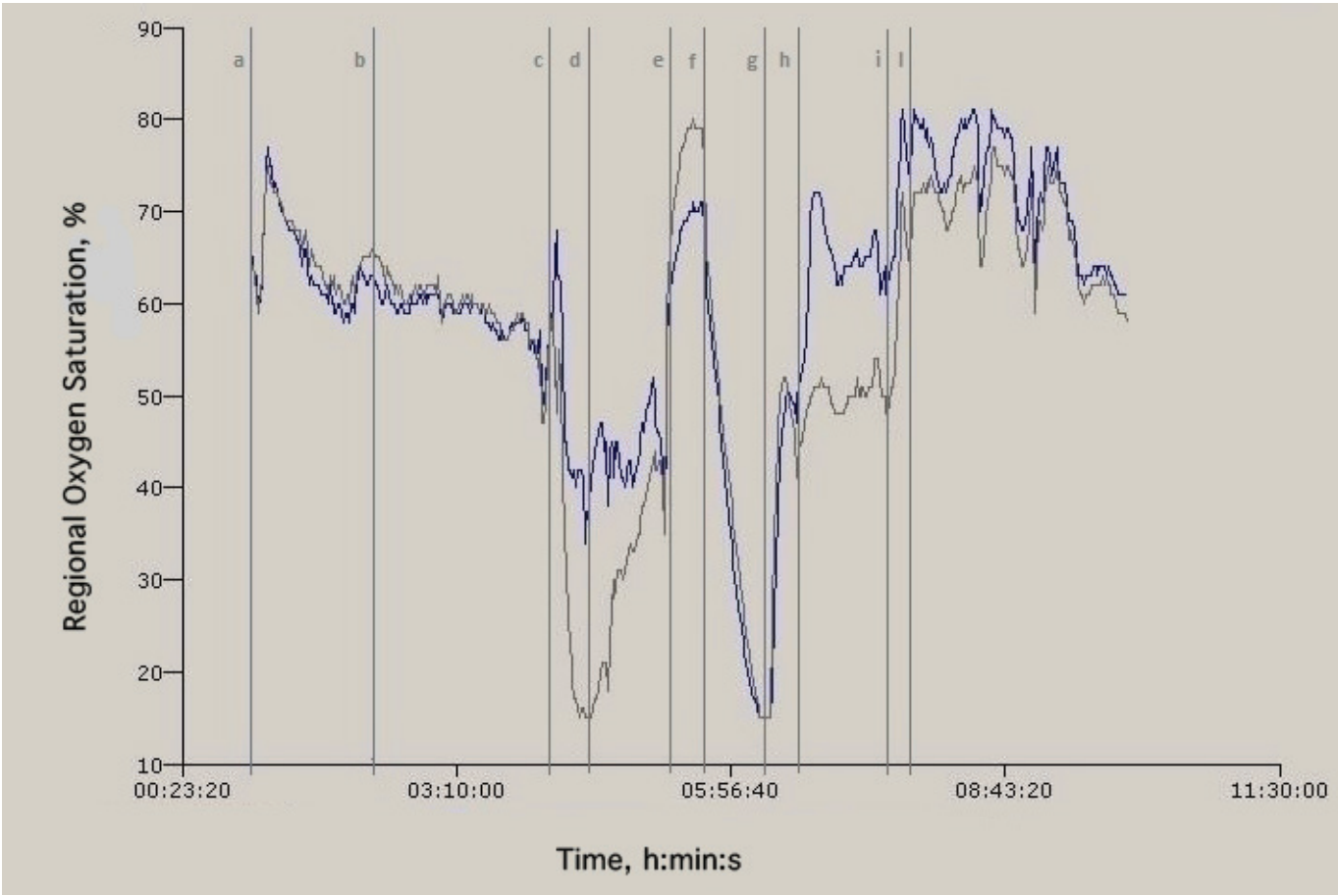

Figure 1. Tracing of near-infrared spectroscopy monitoring of the left and right frontal probes. Indicated are the times of anesthesia induction (a), start of the arterial axillo-femoral bypass operation (b), institution of cardiopulmonary bypass (CPB) (c), institution of additional flow through the left axillo-femoral graft (d), hypothermic circulatory arrest with cerebral perfusion (e), hypothermic circulatory arrest without cerebral perfusion (f), reinstitution of CPB (g), plateau of the right cerebral saturation curve (h, i), weaning off of CPB (i), and CPB off (l). Tracings for the left hemisphere (black line) and right hemisphere (gray line) are presented.

ranging between 40% and 55% (Figure 1, h-i interval). This flattening of the saturation curve of the right hemisphere was correlated with prolonged systemic hypotension, which began at an esophageal temperature >34°C. This situation required a norepinephrine infusion that was increased progressively to 0.08 µg/kg per minute.

Replacement of the ascending aorta with a 24-mm Dacron graft, aortic root repair, and aortic valve resuspension were performed in the meantime (Figure 2). When the patient was weaned progressively off of CPB, the saturation curve of the right hemisphere gradually increased and joined the saturation of the left hemisphere after 10 minutes and >70% saturation.

The patient was discharged on postoperative day 12 without any neurologic deficit. A postoperative CT scan showed no complications related to the vascular prostheses' interposition, patency of the axillo-femoral bypass, and an absence of cerebral lesions. The true lumen of the common right carotid artery had expanded, and its false lumen appeared thin and thrombosed.

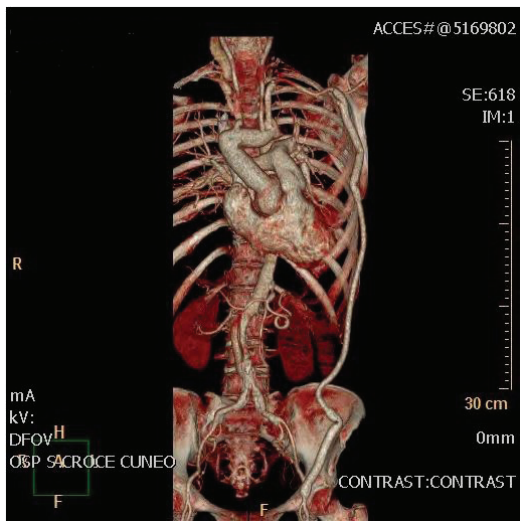

Figure 2. Postoperative 3-dimensional computed tomography imaging of thoraco-abdominal aorta and left axillo-femoral bypass graft.

DISCUSSION

Expansion of the false lumen along the epiaortic vessels during surgery for acute type A aortic dissection can cause intraoperative cerebral malperfusion and can have a profound effect on the surgical outcome [Olsson 2006]. The clinical availability of NIRS-based cerebral oximetry provides a potentially important tool for the detection of intraoperative cerebral ischemia. NIRS detects oxygen deficiency in the cerebral tissue in a timely manner. Combining this information with TEE visualization of events in the heart, in the aorta, and in the arch's branch arteries can have a significant impact on the quality of patient care by allowing real-time changes to be made during the course of the operation [Orihashi 2006]. Axillary arterial cannulation has been suggested as an ideal technique for reducing perfusion-related morbidity. Even in expert hands, however, problems related to the axillary cannulation site have been described in nearly 5% of cases [Strauc 2004]. Most of these problems consist of local dissection or inadequate backflow from the brachiocephalic artery. Continuous active monitoring for malperfusion is required even after a valid arterial inflow has been established, because progression of the primary disease is always possible during CPB. Any of these events may require a rapid change of the strategy for locating the arterial inflow. In the case we have described, the flow through the right axillary cannulation site appeared to be associated with malperfusion of the right hemisphere, the cause of which was assumed to be expansion of the false lumen along the right common carotid artery. An axillo-femoral bypass graft was easily accessible and could be used as an ideal alternative arterial access. By this strategy, right cerebral saturation was gradually improved during systemic cooling, suggesting an effective collateral flow to the right hemisphere through the circle of Willis. During patient rewarming, we encountered a transient period in which oxygen saturation of the right cerebrum became considerably lower than the left. This discrepancy was interpreted as a temporary moderate hypoperfusion of the right hemisphere due to insufficiency in the collateral flow through the Willis circle. Ischemic reperfusion of the lower body and systemic rewarming were considered causes for this hemodynamic impairment, which was characterized by systemic vasodilatation, acidosis, and poor responsiveness to drugs. During the progressive weaning off CPB, oxygen saturation of the right hemisphere increased when both hemodynamic stability and antegrade systolic flow in the ascending aorta were achieved. This event could be correlated with an improvement in the cerebral collateral flow or with restoration of the flow along the true lumen of the right carotid artery, as was shown in postoperative CT scans. In our experience, the use of NIRS-based cerebral oximetry facilitated prompt detection and restoration of cerebral perfusion and avoided a prolonged episode of cerebral ischemia, thereby reducing the likelihood of adverse neurologic consequences.

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