During abdominal aortic surgery, dynamic changes occur in the pelvic circulation. Near-infrared spectroscopy (NIRS) was used in this study to evaluate arterial flow in the buttocks as a monitor of arterial flow in the pelvic area during abdominal aortic surgery. Twenty-two patients who underwent abdominal aortic aneurysctomy comprised the study group. The NIRS probe was mounted on the left buttock during surgery, and the changes in oxy- and deoxy-hemoglobin (Hb) concentration were measured. In all cases Hb values reflected decreased arterial flow caused by aortic clamping and increased arterial flow after reconstruction of the distal arteries. The recovery pattern of the Hb values varied, but all recovered to the baseline value recorded before aortic clamping. None of the patients exhibited postoperative claudication of vessels supplying the gluteal muscles or colonic ischemia, and recovery time varied in accordance with the patient’s arterial condition. This method is simple and enables individual evaluation of blood flow recovery from reconstructed arteries. This method allows approximate evaluation of the pelvic arterial flow of individual arteries, helps to predict postoperative claudication of the gluteal muscles, and offers additional information for evaluating colonic ischemia. (Circ J 2002; 66: 1128–1131)

Key Words: Abdominal aortic surgery; Buttocks; Near-infrared spectroscopy; Pelvic arterial flow

Methods

We studied 22 patients who underwent aneurysctomy and prosthetic graft replacement for abdominal aortic aneurysm (AAA). The patients comprised 21 men and 1 woman, aged 73±6 years. Twenty-one of the patients underwent bifurcated graft replacement, and 1 underwent a straight graft replacement. The patients who received bifurcated grafts were divided into groups A and B. Group A comprised 17 patients who underwent reconstruction of the bilateral common iliac artery and ligation of the inferior mesenteric artery (IMA) in the usual manner. Patients who first underwent reconstruction of the left common iliac artery were classified as group A•I (6 cases) and those who first underwent reconstruction of the right common iliac artery were classified as group A•II (11 cases). Group B comprised 4 patients who underwent other patterns of arterial reconstruction for extended iliac aneurysms. The NIRS probe was mounted on the center of the left buttock (approximately 5cm cranial to the center of the large gluteal muscle) during the AAA repair operation. Measurements were taken using a NIRS oxygen electrode monitor (OMRON HEO-200). Changes in oxy- and deoxy-hemoglobin (Hb) concentration after clamping of the abdominal aorta were measured. We focused mainly on changes in oxy-Hb. Oxy- and deoxy-Hb concentrations changed proportionately in all cases. The recovery time (RT) was defined as the interval from aortic declamping (or declamping of the main artery feeding the left buttock) to the point where the oxy- and deoxy-Hb curves crossed over. The mean changes in Hb values and RTs were expressed as the mean±SD.

Results

Distinct types of circulatory changes in the gluteal muscles were detected by NIRS. In all cases the Hb values reflected decreased arterial flow because of aortic clamping.

Fig 1. Serial changes in hemoglobin (Hb) values for cases of straight graft replacement. (A) Maximum change in oxy-Hb value, (B) recovery time.
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and increased arterial flow after reconstruction of the distal arteries. The maximum change in the oxy-Hb value after aortic clamping was 0.15±0.04 g/dl (range, 0.05–0.29).

Data from the patient who underwent straight graft replacement are shown in Fig 1. Oxy-Hb values decreased rapidly upon aortic clamping, reached a plateau, and then recovered to the baseline (the value before aortic clamping) after declamping. Deoxy-Hb values changed proportionately with oxy-Hb values. The maximum variation in the oxy-Hb value was 0.16 g/dl, and RT was 50 min. The inferior mesenteric artery was ligated.

Cases in group A•I showed the same pattern of changes in Hb values; a typical pattern is shown in Fig 2. The oxy-Hb value decreased rapidly upon aortic clamping, with a mean maximum change of 0.11±0.08 g/dl. It then recovered rapidly on reperfusion of the left common iliac artery, which was performed first, and the mean RT was 3±2 min. The changes of arterial flow from the right common iliac artery, which was reconstructed second, were not recorded.

The patterns of change in the Hb value in group A•II were classified into 3 types (patterns I–III, as shown in Fig 3A–C). In pattern I (5 cases, Fig 3A), the oxy-Hb value decreased rapidly to a mean maximum of 0.08±0.04 g/dl upon aortic clamping, and did not change upon reconstruction of the right common iliac artery, which was performed first. The value recovered rapidly, however, upon reconstruction of the left common iliac artery, which was performed second, with a mean RT of 7±5 min. In pattern II (3 cases, Fig 3B) the oxy-Hb value decreased rapidly to a mean maximum of 0.07±0.03 g/dl upon aortic clamping, and recovered slowly upon reconstruction of the right common iliac artery, which was performed first; prompt recovery was observed upon reconstruction of the left common iliac artery. The mean RT was 9±5 min. In pattern III (2 cases, Fig 3C) the oxy-Hb value decreased to a mean maximum of 0.19 and 0.14 g/dl, respectively, upon aortic clamping. A degree of recovery was observed upon reconstruction of the right common iliac artery, performed first, and gradual recovery was observed upon reconstruction of the left common iliac artery, performed second.

The cases in Group B are shown individually in Fig 4 as cases I–IV. In case I, the abdominal aorta was clamped distal to the IMA orifice (preserving the blood flow in the...
IMA during aortic clamping). In this case the right internal iliac artery was preserved, and the left internal iliac artery was sacrificed for the aneurysm. Oxy- and deoxy-Hb values changed gradually after aortic clamping, and the maximum change in the oxy-Hb value was 0.16 g/dl. It recovered gradually to the baseline upon reconstruction of the right common iliac artery, and the RT was 80 min. In case II, the aorta was clamped proximal to the IMA orifice, and aortic anastomosis was performed distal to the IMA orifice, necessitating temporary clamping of the IMA, and the left and right internal iliac arteries were sacrificed for the aneurysm. Oxy- and deoxy-Hb values changed gradually upon aortic clamping, and the oxy-Hb value decreased to a maximum of 0.05 g/dl. The oxy-Hb value gradually recovered upon reperfusion of the IMA, independently of distal reperfusion of the left and right external iliac arteries, and the RT was 40 min. In case III, the left internal iliac artery was preserved and the IMA and right internal iliac artery were sacrificed. The oxy-Hb level decreased immediately upon aortic clamping, with a maximum change of 0.04 g/dl, and recovered rapidly after reconstruction of the left common iliac artery, and the RT was 55 min. In case IV the left internal iliac artery was preserved, and the IMA and right internal iliac artery were sacrificed. The maximum change in the oxy-Hb value was 0.08 g/dl, and the value improved gradually after reconstruction of the left common iliac artery, and the RT was 20 min.

In all cases, Hb values recovered to the baseline values. Postoperative colonic ischemia or claudication of vessels supplying the gluteal muscles was not identified in any of the cases, and RT varied in accordance with the patient’s arterial condition. Correlation of the quantity of bleeding, clamping time, maximum Hb variation and RT was statistically consistent (data not shown).

Discussion

In all the cases we examined, there was good producibility of NIRS measurements after aortic clamping. Most cases showed a rapid change in the Hb value upon aortic clamping, but some (Fig 3C, cases I and II) showed a gradual change. In the latter cases it was assumed that there was a relatively abundant collateral circulation independent of the infra-renal aortic clamping, and that the steeper slope of the change in oxy-Hb (or deoxy-Hb) indicated less collateral circulation. Of course, further comparisons with other examinations will be needed in future studies to confirm this. In the present study the range of maximum change in the Hb value after aortic clamping varied from case to case, and may have been influenced by local factors in the buttocks such as the thickness of fatty tissue, the thickness of gluteal muscles, or skin condition. However, Hb values recovered to the baseline after reperfusion of the distal arteries in all cases, and reflected restoration of the arterial flow after reconstruction of the IMA or iliac arteries. Although we were able to judge the blood flow of individual arteries approximately, the effect of direct blood flow to the left buttock from the left common iliac artery in group A+1 masked the blood flow from the right iliac artery, which was reconstructed second. It would have been possible to evaluate the pelvic blood flow from the left and right iliac arteries if both buttocks had been simultaneously used for measurement. In other cases we were able to evaluate approximately the collateral blood flow from the right common iliac artery (Fig 3B and case I: relatively good; 3C: mild; 3A: poor) and from IMA (case II: relatively good), and direct flow of the left iliac artery (Figs 2,3A,3B and case IV: good; 3C and case III: mild).

The individual RTs varied from case to case, but all were considered within the safe range of pelvic arterial flow in the absence of any complications because of ischemia. It was considered that the slope of Hb recovery might be important in addition to RT; for example, Fig 1 shows that RT was 50 min, but recovery was rapid just after reperfusion.

Because the patients in this study were of advanced age and postoperative activity was relatively low, that might explain the absence of subsequent claudication. Importantly, it has been reported that RT reflects the severity of intermittent claudication in arteriosclerosis obliterans. Therefore we expect that evaluation of Hb will prove useful for predicting claudication of the gluteal muscles after aortic surgery, because aortic clamping can be considered equivalent to a surrogate load test for the gluteal muscles, such as walking exercise as well as an occlusion test for evaluation of intermittent claudication in arteriosclerosis obliterans. However, further investigations of these complications will be necessary. Although none of the patients examined in this study developed postoperative colonic ischemia, our findings appear to offer information for improved prediction of colonic ischemia, in addition to the measurement of penile pressure or transanal Doppler. This would be particularly relevant in cases of stent grafting, cases where a retroperitoneal approach is chosen, and cases with stenosis of the IMA where it is impossible to measure the stump pressure of the IMA effectively.

Conclusion

Measurement of gluteal muscle oxygenation during aortic surgery using NIRS is simple and enables evaluation of blood flow from the aorta, IMA, iliac arteries and collateral arteries. With further investigation, we expect that this procedure will contribute to the prediction of postoperative claudication of the gluteal muscles and offer additional information for evaluating colonic ischemia.

References


