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HOW TO DO IT

Intermittent distal perfusion shortens hypothermic circulatory arrest time in aortic arch replacement surgery

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Abstract The procedure and efficacy of the intermittent distal perfusion during hypothermic circulatory arrest in total arch replacement was described. During hypothermic circulatory arrest, elephant trunk was fixed inside the descending aorta. Then, the AP Grid Catheter was inserted through the elephant trunk, and blood perfusion at a flow rate of 500 ml/min for 5 min was installed. After the perfusion, distal anastomosis was completed. Clinical results of 23 patients (Group I) with this technique were compared with these of 21 patients without the procedure (Group II). Continuous hypothermic circulatory arrest time was significantly shorter (32.7 vs. 72.7 min; $p < 0.05$) and postoperative serum creatinine level was significantly lower (1.29 vs. 1.68; $p < 0.05$) in Group I than Group II. The incidence of abdominal complication was also fewer in Group I. Intermittent distal perfusion shortens hypothermic circulatory arrest time and is protective for the lower body including kidneys.

Keywords Aortic arch replacement · Spinal cord · Kidney · Hypothermic circulatory arrest

Introduction

According to the annual report from Japan, clinical results of total arch replacement (TAR) is quite satisfactory, and the operative mortality was very low as 2.2 % in un-ruptured aneurysm, 6.8 % in dissection and 4.9 % in ruptured aneurysm in 2013 [1]. Selective cerebral perfusion (SCP) associated with hypothermic circulatory arrest (HCA) in lower body is most popular surgical procedure during TAR in Japan. Despite systemic hypothermia reduces the metabolic rate, the safe limitation of HCA time of lower body is still unclear. We describe the intermittent distal perfusion (IDP) technique to shorten HCA time to prevent damage of the lower body in TAR.

Patients and methods

We have adopted IDP in 2011, and have performed TAR with IDP in subsequent 23 patients (Group I; 17 males; mean age of 68.6 years). Clinical data on these patients were analyzed and were compared with 21 patients (Group II; 18 males; mean age of 65 years) who underwent TAR without IDP before 2011. Informed consent was obtained from all patients and the study protocol was approved by the local ethics committee.

All statistical analyses were performed with IBM SPSS statics 20. Continuous variables are expressed as mean ± standard deviation, with ranges when appropriate. Differences in baseline characteristics were analyzed with Student's *t* test. Categorical variables are expressed as frequencies and percentages and were compared with the use of the Chi square test. *P* values of less than 0.05 were considered to indicate statistical significance.

Surgical procedures

After an extracorporeal circulation (ECC) was established, systemic hypothermia was introduced. Ascending aorta was clamped and blood cardioplegia was given

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intermittently in an antegrade and/or a retrograde fashion at 20-min intervals. At 26 °C of rectal temperature, systemic circulation was discontinued and ascending and transverse aorta was opened. SCP was established associated with regional cerebral oxygen saturation monitor by the INVOS® oximeter (Somanetics, Boulder, CO). Then, proximal descending aorta was transected and an elephant trunk (ET) of 5 cm was inserted and the proximal end was anastomosed with a continuous suture. After the completion of anastomosis, AP GRID Catheter (AGC; Fuji medical systems corp. Tokyo) was inserted into the descending aorta through ET and the perfusion was gradually started (Fig. 1). For de-airing of the descending aorta, the balloon of AGC was kept still deflated before air babbles disappeared. Distal perfusion was performed at a flow rate of 500 ml/min for 5 min through AGC after inflating the balloon. After IDP, the AGC was removed and an end-to-end anastomosis to a 4-branched graft was completed. Then, the proximal end of the graft was clamped and lower body perfusion was resumed through the side branch of the graft. During the rewarming phase, a proximal anastomosis was completed. After de-airing, the cross-clamp on the graft was removed and coronary perfusion was re-started. The cervical arteries were anastomosed to each corresponding branch of the graft. ECC was weaned after rectal temperature had reached to 35 °C.

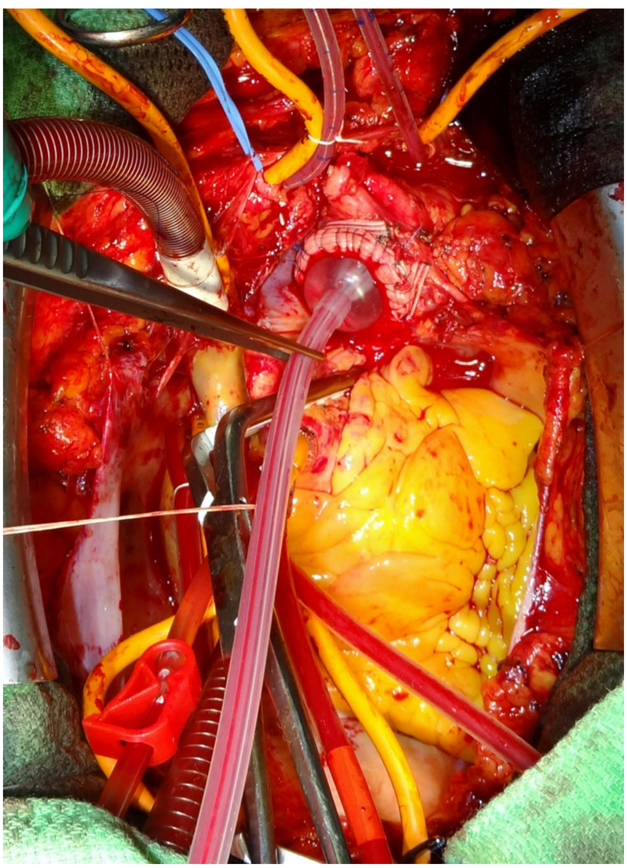

Fig. 1 AP grid catheter was inserted into the proximal descending aorta and delivered blood flow rate of 500 ml/min as the intermittent distal perfusion

Results

There were no significant differences in preoperative patients' characteristics including age, gender distribution, preoperative comorbidities, and aortic pathologies between groups. As to operative data, operation time, ECC time, and cross-clamp time were similar between groups, however, continuous HCA time was significantly shorter in Group I than that in Group II (32.7 ± 21.9 vs. 79.7 ± 20.5 min, $p < 0.05$). There were no significant differences in duration of intensive care unit stay or hospitalization. One of the patients with IDP died during hospitalization due to cerebral infarction, however, none of those without IDP died. No spinal cord ischemia was reported. Postoperative serum creatinine level was significantly lower in Group I when compared with that of Group II (1.29 ± 0.5 vs. 1.68 ± 0.81 mg/dl, $p < 0.05$) while there was no significant difference in preoperative serum creatinine level between groups (0.99 ± 0.36 vs. 1.17 ± 0.56 mg/dl, $p > 0.05$). Three patients suffered from abdominal complications in early postoperative phase (cholecystitis in 1 and pancreatitis in 2) in Group II, while there was no abdominal complication in Group I.

Discussion

One of the most important points during aortic surgery is to protect all organs from ischemic damages. The protection strategies should be based on each organ specific metabolism. During ECC, arrested heart is mainly protected by cardioplegia. Brain is also protected by hypothermia associated with selective antegrade, or retrograde cerebral perfusion. However, there is no general consensus of strategies to protect the lower body. HCA is the most common strategy, but it is only to decrease the temperature of the lower body and its safe limit of time has not yet been clearly defined [2].

The intermittent distal perfusion with our technique is easy and may be an additional protection strategy of the lower body. During IDP, we can save the time by giving a selective cardioplegia to the heart.

There are two published papers from the Italian institution to perform "continuous" thoracoabdominal perfusion during SCP with a low incidence of end-organ complications [3, 4]. They inserted an endotracheal cannula of 8 mm internal diameter and dilated a balloon directly in the descending aorta. The blood was delivered at a flow rate of 1–1.5 l/min during the distal anastomosis. Because the balloon of AGC may disturb distal anastomosis, we prefer IDP to the continuous perfusion. Meticulous care has to be taken when balloon is inflated inside the ET to prevent distal embolism by atheroma or plaque.

Although HCA alone can protect kidneys for a while [5–7], postoperative renal dysfunction has been still common complication and strongly influences the outcome in patients with aortic dissection [8]. In our series, postoperative maximum serum creatinine level kept lower in Group I when compared with that in Group II. In case of acute dissection, it is important to perfuse blood into true lumen. From this point of view, our IDP strategy could bestow a certain benefit on lower body.

Conclusion

The intermittent distal perfusion during hypothermic circulatory arrest of the lower body could shorten continuous hypothermic circulatory arrest time, and may be an additional protection for the lower body including kidneys.

Compliance with ethical standards

Conflict of interest The authors have no conflict of interest to declare.

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