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# The ESTECH Remote Access Perfusion Cannula in Minimally Invasive Cardiac Surgery

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## ABSTRACT

**Introduction:** Peripheral access cardiopulmonary bypass (CPB) and endoclamping of the aorta are prerequisites for performance of minimal access or totally endoscopic cardiac surgery on the arrested heart. We present our experience with the ESTECH remote access perfusion (RAP) cannula in arrested-heart totally endoscopic coronary bypass grafting (AHTECAB) and atrial-septal defect (ASD) repair via minithoracotomy and totally endoscopic ASD repair.

**Patients and Methods:** Remote access CPB was performed in 30 patients (17 male), with a median age of 56 years (range, 21-70 years) using the ESTECH RAP cannula. Preoperatively all patients received a thoracic and abdominal CT scan. Operations were 20 AHTECAB, 5 ASD repair via minithoracotomy, and 5 robotically assisted totally endoscopic ASD repairs. Intraoperatively the patients were monitored by transesophageal echocardiography and bilateral radial artery pressure lines for correct placement of the balloon in the ascending aorta.

**Results:** Neither vascular perforation nor dissection of the aorta occurred during these surgeries. Full CPB was achieved in all patients. Because of location in a supraaortic branch fluoroscopic visualization of the guide wire was necessary in 2 of 30 cases. Once the aortic occlusion balloon was placed, repositioning was required in none of our cases. In one AHTECAB case rupture of the balloon occurred before starting the anastomosis. The cannula was replaced and the AHTECAB could be finished without complications. In one patient inguinal wound infection occurred, which was successfully revised surgically. No perioperative myocardial ischemia, stroke, or critical leg ischemia occurred, and no hospital death occurred.

**Conclusions:** CPB and cardiac arrest can adequately be performed via a femoral access in minimally invasive cardiac surgery using the ESTECH RAP system. Intense preoperative patient evaluation and intraoperative monitoring are absolute prerequisites for safe application of the technique.

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## INTRODUCTION

Remote cardiopulmonary bypass (CPB) and balloon endoocclusion of the ascending aorta have enabled cardiac surgery through minithoracotomy or in an endoscopic fashion. So far 2 peripheral access CPB systems, the Heartport (Heartport, Redwood City, CA, USA) and the Estech system (ESTECH, Danville, CA, USA), have been applied clinically. Several authors have reported on application and results of the former device; little, however, has been published on experience with the latter system.

We report our experience with the ESTECH remote access perfusion (RAP) cannula in arrested-heart totally endoscopic coronary bypass grafting (AHTECAB) and atrial-septal defect (ASD) repair via minithoracotomy and totally endoscopic ASD repair.

## PATIENTS AND METHODS

Between November 2001 and August 2003 remote access CPB was performed in 30 patients using the ESTECH RAP cannula. Median age of this patient cohort was 56 years (range, 21-70 years) and 17 of 30 (57%) of the patients were male. The operations performed were AHTECAB in 20 cases, ASD repair via minithoracotomy in 5 cases, and totally endoscopic ASD repair in 5 cases. The AHTECABs and the totally endoscopic ASD repairs were carried out with the da Vinci telemanipulator system (Intuitive, Sunnyvale, CA, USA).

Preoperatively the patients were screened by clinical examination, echocardiography, and by computed tomographic (CT) scan to rule out contraindications for the remote access perfusion system, which are listed in the Table.

### *Surgical Technique*

Intraoperatively the patient was monitored by bilateral radial artery pressure lines and transesophageal echocardiography (TEE). A mobile C-arm was in standby for fluoroscopic placement of the guide wire if detection by TEE was impossible.

The femoral vessels were exposed 1 cm below the inguinal ligament, and an umbilical tape with a tourniquet was passed around the femoral artery and the femoral vein. In performing AHTECAB we cannulated the left femoral artery because the telemanipulator was placed on the right side of the patient; in ASD repair via minithoracotomy or in totally endoscopic ASD repair we cannulated the right femoral artery. After systemic heparinization a 4/0 prolene purse-string

Contraindications for the Use of the ESTECH Remote Access Perfusion System

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| Significant atherosclerosis of the aorta |
| Peripheral vascular disease |
| Dilatation of the ascending aorta (>35 mm) |
| Aortic valve regurgitation (≥II°) |
| Thoracic or abdominal aneurysmal disease |
| Aortic dissection |
| Aortic arch anomalies |
| Femoral artery diameter <6 mm |

suture was placed on the upper side of the femoral vein and passed through a tourniquet. A 23-, 25-, or 27-F venous cannula (Biomedicus; Medtronic, Minneapolis, MN, USA) was inserted into the femoral vein using the Seldinger technique under TEE control.

A 6-F arterial access sheath (Arrow, Reading, PA, USA) was placed into the proximal superficial femoral artery for distal perfusion of the leg.

The proximal and distal parts of the femoral artery were clamped with 120° vascular clamps. After performing a 1-cm longitudinal incision we advanced the ESTECH cannula into the common femoral artery until the furled balloon was entirely within the artery, whereas the first holes of the cannula remained outside. After the guide wire was advanced into the ascending aorta under TEE control the tip of the cannula was placed approximately 1 cm distally to the aortic valve (Figures 1 and 2). CPB was started. After sufficient CPB flows were achieved the aortic occlusion balloon was insufflated and a short period of cardiac arrest was induced by injecting 3 mg of adenosin (in 20 mL saline solution) through the cardioplegia line (Video online). The proper catheter balloon position 1 cm distally to the aortic valve was continuously monitored by TEE and bilateral radial artery pressure curves. The adequate amount of saline solution required to achieve full occlusion of the ascending aortic lumen in milliliters was the same as the diameter of the ascending aorta in millimeters when the 21-F cannula was used (eg, 25 mL in a patient with an ascending aorta of 25 mm diameter). In case of using the 17-F cannula, half amounts of saline solution were required for aortic endoclamping. Special attention was paid to the right radial artery monitoring line, which showed a decrease of the pulse wave (compared with the left side) if the balloon occluded the innominate artery. If this situation occurred the balloon was deflated and relocated to avoid cerebral ischemia. If the catheter balloon had reached a proper position cardioplegia was started.

After stopping the CPB and performing decannulation, we closed the femoral vein with purse-string sutures. The femoral artery was reconstructed with a Gore-Tex or pericardial patch.

### *Statistics*

Continuous variables are given as median (minimum-maximum); categorical variables are shown as absolute values and percentages.

## RESULTS

Full CPB flows (2.4 L/min per $m^2$) could be achieved in all 30 patients. Median CPB time was 132 (93-216) minutes in the ASD repair via minithoracotomy group, 181 (128-239) minutes in the totally endoscopic ASD repair group, and 128 (72-230) minutes in the TECAB group. The aortic endoclamp time was 58 (47-85) minutes in the ASD via minthoracotomy group, 104 (46-133) minutes in the totally endoscopic ASD repair group, and 83 (50-132) minutes in the TECAB group.

Fluoroscopic visualization of the guide wire was necessary in 2 (7%) of 30 cases, owing to location in one of the branches of the aortic arch. Once the aortic occlusion balloon was in place, repositioning was required in none of our cases.

In one TECAB case rupture of the balloon occurred before the left internal mammary artery–to–left anterior descending artery anastomosis was started. The perfusion cannula was replaced successfully by a new cannula, and the TECAB procedure could be finished without complications.

Delayed wound healing with lymphatic secretion of the groin occurred in 6 (20%) of 30 cases. The wound had to be punctured in 5 of 30 patients and drained spontaneously at the time of removal of the sutures in 1 patient. In all 6 patients no further surgical intervention had to be performed to stop the lymphatic secretion.

In 1 patient inguinal wound infection occurred and was successfully revised surgically.

No patients experienced vascular perforation or dissection of the aorta in our series.

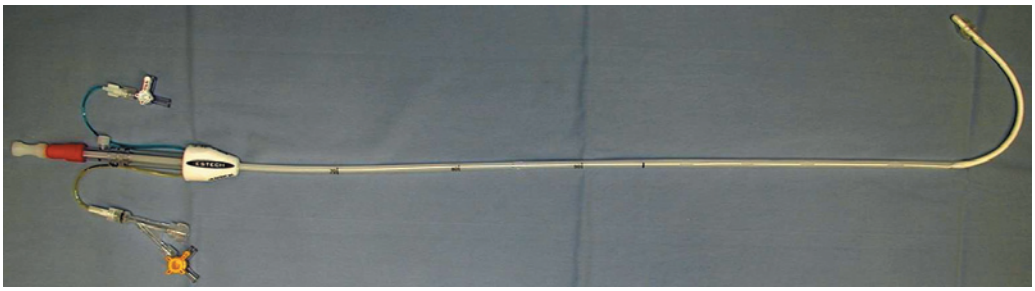

Figure 1. ESTECH remote access perfusion cannula

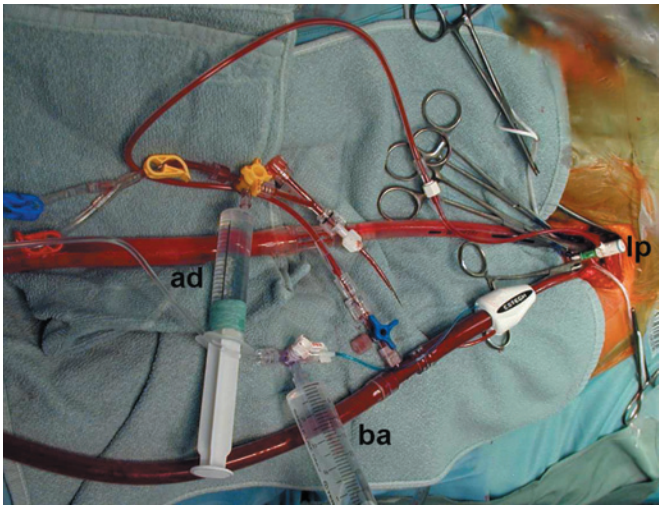


Figure 2. Perfusion with the use of the Estech remote access perfusion cannula via a left femoral access in arrested-heart totally endoscopic coronary bypass grafting. Note the distal leg perfusion (lp) via a 6-F arterial access sheath in the proximal superficial femoral artery. The syringe, which is marked by a green drape (ad), contains adenosin, which is applied via the cardioplegia line for induction of cardiac arrest during balloon endoocclusion of the ascending aorta. ba indicates syringe for balloon occlusion.

No perioperative myocardial ischemia, stroke, or critical leg ischemia occurred, and there were no deaths of hospitalized patients.

## DISCUSSION

Van Nooten and coworkers have successfully applied the ESTECH RAP system in conventional cardiac surgery [Van Nooten 2001a] and redo mitral valve surgery [Van Nooten 2001b]. Our current series demonstrates that the ESTECH RAP cannula can also be adequately applied in AHTECAB and minimally invasive ASD repair. Careful preoperative screening of the patient as well as intense intraoperative monitoring are in our opinion absolute prerequisites for the use of this technique. Preoperative evaluations by CT scans are especially helpful for exclusion of absolute contraindications such as significant aortoiliac atherosclerotic disease and ascending aortic dilatation.

Major complications of port-access cardiac surgery that have caused intense criticism of the technique are dissections of the aortic and iliac arteries. The rates of arterial dissections reported in the minimally invasive cardiac surgery literature range from 1.6% to 2.6% [Reichenspurner 1998a, 1998b, Schroeyers 2001]. The arterial perfusion jet of the femoral cannula can initiate the dissection, particularly in atherosclerotic iliofemoral vessels and in vessels that have been previously manipulated by guide wires. The perfusion system used in our series to provide antegrade perfusion at the descending thoracic aortic level was, at least in theory, one factor contributing to the avoidance of arterial dissection.

Another important issue is ischemia of the leg distal to the cannulation site during port-access CPB. Dogan and coworkers reported reperfusion injury to the leg in 2.2% of cases [Dogan 2002]. Argenziano and coworkers reported a 5.9% incidence of compartment syndrome of the leg requiring fasciotomy [Argenziano 2003]. In our series we observed no significant leg complications after femoral cannulation. This result is probably due to a consequent distal perfusion during CPB.

Wound healing problems in the groin have to be considered in port-access cardiac surgery. Reichenspurner and coworkers described delayed wound healing in the groin in 9.5% and lymphatic fistulas in 2.4% to 3.4% of cases after port-access CPB [Reichenspurner 1998b]. In our series we observed a relatively high percentage of cases with lymphatic wound secretion as well. The course of these cases, however, was benign and the lymphatic secretion was self-limited without necessity of surgical intervention.

Positioning of the occlusion balloon in the ascending aorta was straightforward in the majority of our patients, and use of a fluoroscopy C-arm enabled correct positioning in cases in which the guide wire did not spontaneously reach the aortic root. Adenosin injected into the cardioplegia line was especially helpful for avoidance of balloon migrations caused by ejections of the left ventricle during induction of cardioplegia. Despite this method several initial positioning maneuvers were necessary in some patients. It was highly satisfying, however, that after correct positioning no further migrations occurred.

Rupture of the catheter one is a possible complication that we experienced in 1 case in which marginally high balloon pressures were applied. If balloon rupture occurs before incision of the coronary artery in AHTECAB or the right atrium in ASD repair, as it did in our case, the catheter can be replaced easily, but it might be problematic at a later time point. It is recommended by the manufacturer of the device not to exceed a maximum balloon pressure of 500 mm Hg (in 21-F cannulas). In all of our cases there were slight balloon pressure drops in the range of 30 to 50 mm Hg, which were probably due to the elastic properties of the occlusion balloon. In order to assure proper endoclamping of the aorta we accepted initial balloon pressures higher than 500 mm Hg but we always avoided an injection of more saline solution than calculated by the formula described above.

Our initial experience with the ESTECH RAP cannula in minimally invasive cardiac surgery suggests that cardiopulmonary bypass and cardiac arrest can be adequately achieved using this system. Intense preoperative patient evaluation and intraoperative monitoring are absolute prerequisites for safe application of the technique. Difficulties include deviation of the guide wire into the supraaortic vessels, balloon migrations during initiation of cardioplegic arrest, balloon rupture during initial placement of the occlusion balloon, and wound healing problems in the groin including lymphatic secretion. Nevertheless insertion of the system, CPB flows, balloon stability after correct positioning, and application of intermittent cardioplegia are satisfying and can ensure proper remote access CPB and cardioplegia management.

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