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Transbrachial Intra-Aortic Balloon Pumping for High-Risk Percutaneous Coronary Intervention

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Abstract

The beneficial effect of placement of intra-aortic balloon (IAB) pump before revascularization in patients with high-risk coronary anatomy and impaired left ventricular systolic function is documented. However, the conventional insertion of IAB pump via the common femoral artery may be contraindicated or may be even impossible in patients with severe vascular disease. Recently, the percutaneous insertion of IAB via the brachial artery has been shown to be effective and safe in small series of patients with vascular disease undergoing coronary artery bypass surgery. The authors report their experience with a patient with aortobifemoral bypass grafts who underwent successful stenting of a trifurcating distal left main stenosis after placement of a 7.5-Fr IAB pump via the left brachial artery.

Keywords

Brachial artery; High-risk angioplasty; Intra-aortic balloon pump; Left main coronary artery

There is general agreement regarding the beneficial effects of placement of intra-aortic balloon (IAB) pump before revascularization in patients with high-risk coronary anatomy and impaired left ventricular (LV) systolic function.^{1,2} However, the conventional insertion of IAB pump via the common femoral artery may be contraindicated or impossible in patients with vascular comorbid conditions, including severe atherosclerotic disease of the iliac arteries or abdominal aorta.

The development of smaller IAB pump catheter sizes allows the use of alternative arterial approaches for IAB placement. Recently, the percutaneous insertion of IAB pump via the brachial approach has been proposed as an effective and safe alternative in patients with peripheral vascular disease undergoing coronary artery bypass surgery.^{3–6} Herein, we report our experience of IAB pump insertion via the left brachial artery in a patient with severe unprotected trifurcating distal left main coronary artery stenosis, severely impaired LV function and bilateral aortofemoral bypass grafts, who underwent successful percutaneous coronary intervention.

CASE REPORTS

A 64-year-old man with hypertension, dyslipidemia, type-2 diabetes, active tobacco use, obesity, chronic obstructive pulmonary disease and peripheral arterial disease was referred to our hospital for cardiac catheterization and selective coronary angiography. He had initially presented to another hospital with an episode of chest pain, hypotension and decompensated heart failure. He had a history of bilateral aortofemoral bypass graft surgery and nonobstructive coronary artery disease by angiography 10 years ago.

Laboratory results showed an increased troponin-I (7.3 ng/mL), creatine kinase isoenzyme MB (72 ng/mL) and B-type natriuretic peptide (1070 pg/mL). The electrocardiogram (ECG) demonstrated left axis deviation, right bundle branch block and low voltage. Transthoracic echocardiography showed LV ejection fraction of 15% to 20% with anterior wall and apical akinesis and moderate to severe hypokinesis of the other wall segments, LV and right ventricular dilatation and moderate to severe tricuspid regurgitation. The patient received intravenous inotropic agents, diuresis and heparin and was brought to the catheterization laboratory.

Right heart catheterization revealed a high pulmonary wedge pressure (45 mm Hg). Coronary angiography was performed through a 5-Fr sheath placed into the right aortofemoral graft. The trifurcating left main had a 95% diameter stenosis distally, involving the ostium and the proximal segment of the left anterior descending (LAD) coronary artery. Competitive flow was noted in the LAD. The left circumflex (LCX) and the large ramus intermedius coronary arteries had mild luminal irregularities (Figure 1A). The dominant right coronary artery had luminal irregularities and was providing collaterals to the distal LAD (Figure 1B). The LV end-diastolic pressure was 44 mm Hg.

Given the high-risk nature of the patient's coronary anatomy, the severely impaired LV function and the borderline hemodynamic condition (brachial blood pressure of 85–95/55–65 mm Hg), an IAB pump was placed. Because the patient had bilateral aortofemoral bypass grafts, percutaneous insertion of an IAB via the brachial artery was pursued. To screen for subclavian stenosis, blood pressure was measured in both arms. Interarm systolic pressure difference was <5 mm Hg.

The left brachial artery was used for access. After conscious sedation with midazolam and fentanyl and local anesthesia with lidocaine, a 7.5-Fr sheath was placed into the left brachial artery. Advancement of a 0.025-in × 175-cm Teflon-coated 3-mm “J” stiff guide wire (Arrow International, Reading, PA) to the descending aorta was facilitated with a 4-Fr internal mammary artery diagnostic catheter (Infiniti; Cordis, Bridgewater, NJ). Then, a 40-mL 7.5-Fr UltraFlex Flexible IAB catheter (Arrow International) was advanced under fluoroscopy over the wire and placed into the descending thoracic aorta, with the proximal marker of the balloon positioned at the level of the third intercostal space. The IAB pump (Arrow AutoCAT2 Wave; Arrow International) was set on a 1:1 mode and was synchronized with the ECG (Figure 2). Intravenous heparin 4000 IU was given as a bolus, followed by infusion of 1000 IU per hour. Heparin was titrated to maintain an activated clotting time of at least 300 seconds. Cefazolin was given intravenously for prophylaxis. An arterial catheter was placed in the left radial artery, and a pulse oximeter was applied to the left middle finger. Radial pressure waveforms, pulse oximetry waveforms and saturation and hand temperature were continuously monitored. The brachial insertion site was also checked for bleeding or hematoma at regular intervals.

Cardiothoracic surgery was consulted. Given the borderline hemodynamics, the severely impaired LV function and decompensated heart failure, right ventricular dilatation, chronic obstructive pulmonary disease and obesity, the patient was considered a poor candidate for

urgent coronary artery bypass surgery. The calculated Society of Thoracic Surgeons risk⁷ of operative mortality was 10.6%, and the calculated risk for major perioperative outcomes was 69.1%. The patient was stabilized overnight on the IAB pump, and high-risk stenting of the left main coronary artery was pursued the next morning, using the right aortofemoral graft. After engaging the left main coronary artery with a 7-Fr EBU 3.5 guide catheter with side holes (Launcher; Medtronic, Santa Rosa, CA), we advanced 3 Choice PT Extra Support wires (Boston Scientific, Natick, MA) to the LAD, ramus and LCX. Balloon angioplasty of the distal left main and LCX was first performed with a balloon Maverick 2.5 × 15 mm (Boston Scientific, Natick, MA), followed by deployment of a drug-eluting stent, Xience V, 3.0 × 23 mm (Abbott Laboratories, Abbott Park, IL), across the left main and LCX arteries. The proximal stent segment was postdilated with a 3.5 × 15 mm Maverick balloon. The final angiographic result was excellent, with TIMI 3 flow in the LCX and the ramus intermedius (Figure 3). The ostium of the ramus was free of disease poststenting. The ostium and proximal segment of the LAD remained severely stenotic, but considering the collateralization from the right coronary artery, the akinesis of the anterior wall and the apex and the borderline hemodynamic condition of the patient, we decided to end the procedure. The whole procedure was performed with the IAB pumping at 1:1; the patient tolerated the entire procedure with mild hypotension during balloon inflations only.

He remained hemodynamically stable postprocedure, and this was confirmed by switching the pump to the 2:1 mode and by temporarily discontinuing the pumping. The 7-Fr arterial sheath was removed from the right aortofemoral graft 3 hours after the end of the procedure, when the active clotting time fell below 180 seconds. Hemostasis was obtained with manual compression for 15 minutes. The patient denied pain, numbness or paresthesias in his left hand and the pressure waveform of the left radial artery, as well as pulse oximetry waveforms and saturation and hand temperature, were normal. Pumping was discontinued, and the IAB catheter was removed 4 hours after the end of the procedure.

The duration of IAB pumping was 20 hours. The patient was discharged 6 days later, being hemodynamically stable, euvoletic, and without chest pain or shortness of breath. No symptoms or signs of limb ischemia or infection were recorded until his discharge. At a follow-up visit 3 months later, the patient was ambulating without assistance, free of cardiovascular symptoms.

DISCUSSION

The protective effect of elective placement of IAB pump before revascularization for short-term circulatory support in patients with high-risk coronary anatomy and impaired LV function is well established.^{1,2} Currently, an increased number of elderly patients with several comorbidities, including severe peripheral vascular disease, are referred for coronary revascularization. The traditional placement of IAB via the common femoral artery may be contraindicated or impossible in patients with severe atherosclerotic disease of the iliac arteries or abdominal aorta or in patients with suprainguinal vascular bypass grafts. Several alternatives to the femoral approach have been developed, including surgical insertion into the axillary artery⁸ or grafts to the ascending aorta,⁹ but these techniques require anesthesia and are time consuming and, thus, unsuitable in most patients who are hemodynamically unstable. Some reports underscore the feasibility of surgical or percutaneous placement of IAB in patients with vascular bypass grafts to the lower extremity arteries.^{10,11} In contrast to the safety of coronary procedures via aortofemoral synthetic vascular grafts,¹² IAB placement through vascular grafts may be associated with a high rate of limb ischemia and a potentially increased incidence of graft infection.¹⁰ In the report of LaMuraglia et al,¹¹ 3 of 9 patients who had percutaneous IAB placement through mature bypass grafts developed limb ischemia and 2 of them required thrombectomy of the occluded grafts.

The development of smaller IAB catheter sizes allows the use of alternative arterial approaches for IAB placement. Recently, the percutaneous insertion of IAB via the brachial approach has been proposed as an effective and safe alternative in patients with peripheral vascular disease undergoing coronary artery bypass surgery.³⁻⁶ Noël et al¹³ were the first to report the insertion of an IAB catheter into the brachial artery for ventricular support during a high-risk left main percutaneous coronary intervention. They had used an 8-Fr IAB, which had been removed early because of hand ischemia. Herein, we report our experience of IAB insertion via the left brachial artery in a patient with critical coronary anatomy, severely impaired LV function and bilateral aortofemoral bypass grafts. To the best of our knowledge, this is the first report of a successful percutaneous coronary intervention of an unprotected trifurcating distal left main stenosis, assisted by a 7.5-Fr IAB inserted percutaneously through the brachial artery without causing upper limb ischemia.

From a technical standpoint, access to the brachial artery is readily attainable, and adequate hemostasis can be achieved after the removal of the IAB catheter, because manual compression of the brachial artery is easy. In our case, we used a 7.5-Fr sheath to insert the IAB, and we did not witness any hand ischemia. The principal limitation of the transbrachial approach is the small caliber of the brachial artery and the potential risk of ischemic complications of the upper extremity. We believe this limitation can be overcome by the recent availability of 7 Fr IAB catheters, by inserting the catheter with the sheathless technique and by careful anticoagulation. The importance of close monitoring for hand ischemia cannot be overemphasized. It seems that pulse oximetry is a reliable way to monitor hand perfusion.^{3-6,13} In addition to pulse oximetry, we placed a catheter into the left radial artery for continuous recording of the radial pressure waveform.

The timing of IAB catheter removal is crucial, because prolonged pumping via the brachial artery may theoretically increase the risk of arm ischemia due to thromboembolism. We withdrew the IAB 4 hour-postprocedure, after hemodynamic stability had been confirmed. However, reports from patients who underwent bypass surgery indicate that the IAB catheter can remain in the brachial artery for as long as 90 hours without complications.⁶

Although brachial artery atherosclerosis is rare, the prevalence of subclavian artery stenosis is up to 6% in patients with coronary artery disease.^{14,15} English et al¹⁵ reported that an interarm systolic pressure difference of >10 to 20 mm Hg has a low sensitivity and positive predictive value but a high specificity and negative predictive value for identification of subclavian stenosis. If a transbrachial IAB insertion is planned, blood pressure in both arms must be measured. Ideally, in patients with an interarm pressure difference >10 mm Hg or with known peripheral vascular disease, the subclavian anatomy has to be defined with an angiogram of the aortic arch or a selective subclavian angiogram, before IAB insertion. If contrast nephropathy is a concern, pressure recording during a simple pull back from the aorta to the subclavian artery of a brachially inserted catheter can rule out significant subclavian disease.

We inserted the IAB via the left brachial artery, because this avoids all the cerebral arteries except the left vertebral artery and may theoretically decrease the risk of cerebrovascular complications. However, the right brachial artery can be also considered, because there are no reports of neurological complications in patients who had an IAB placed via the right arm.^{3,4,6} In patients undergoing bypass graft surgery, the right brachial may be preferable, because it allows harvesting of the left radial artery, if needed.

In our patient and in previous reports using a transbrachial IAB, pumping was synchronized with the ECG,^{4,6} because of concerns that the pressure waveform would not be a reliable trigger. The pressure sensor at the tip of the catheter points away from the direction of

propagation of the aortic pressure waveform, theoretically, may interfere with correct triggering. However, the correctness of this hypothesis needs to be determined.

In conclusion, our case demonstrates that in patients with critical coronary anatomy and impaired LV function who are at high risk for complications if an IAB catheter is inserted via the conventional transfemoral route, placement of the IAB via the brachial artery before coronary revascularization may offer an effective and safe alternative for ventricular support. However, larger prospective studies are needed to evaluate this alternative approach and to further define the technical challenges that may influence its efficacy and safety.

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FIGURE 1.

(A) Injection of the left coronary artery at the right anterior oblique view with caudal angulation showing a diffusely diseased trifurcating left main coronary artery with a critical stenosis distally, involving the ostium and proximal segment of the left anterior descending coronary artery. The left circumflex and ramus intermedius coronary arteries are free of significant disease. (B) Injection of the right coronary artery at the right anterior oblique view showing collaterals to the distal left anterior descending coronary artery (arrows).

FIGURE 2.

The inflated intraaortic balloon (IAB) (highlighted with arrows) is positioned in the descending thoracic aorta. (A) IAB catheter in the left subclavian artery and descending aorta. (B) The tip of the IAB catheter points caudally.

FIGURE 3. Postcoronary intervention injection of the left coronary artery at the right anterior oblique view with caudal angulation (A) and at the left anterior oblique view with caudal angulation (B) showing the final angiographic result. The arrows highlight the inflated intra-aortic balloon.