

## Coronary Artery Exposure in Off-Pump CABG: A Word of Caution

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### ABSTRACT

Coronary exposure and stabilization have focal importance in off-pump coronary surgery. Off-pump complete myocardial revascularization can be performed safely in the majority of the patients whenever strict surgical protocols are followed. Although new devices may be used to facilitate the performance of this demanding operation, technical pitfalls should be recognized to ensure the success of the procedure. We herein report our timely experience with the Xpose™ device (Guidant Corp., Cupertino, CA).

### INTRODUCTION

The increasing popularity of off-pump coronary artery bypass grafting (OPCAB) has stimulated interest and concerns about different techniques of coronary exposure and stabilization. In our experience, complete myocardial revascularization may be performed safely without cardiopulmonary bypass (CPB) and via median sternotomy if strict surgical protocols for coronary exposure and stabilization are followed in order to maintain adequate hemodynamics during the entire procedure. Since March 1998, the introduction of the "single suture" technique [Bergsland 1999] has drastically changed the applicability of beating heart coronary surgery. A single heavy suture is placed in the oblique sinus of the pericardium after having elevated the heart from the pericardial cradle. The suture is then passed through a double-armed vaginal tape and is snared down to the posterior pericardium [Bergsland 1999]. Different degrees of traction on the suture and different positioning of the vaginal tape allow adequate exposure of the different coronary branches including the topographically more difficult circumflex coronary artery. Our experience has shown that normal hemodynamic values can be maintained during lateral revascularization in the majority of the patients with the "single suture" technique [D'Ancona 2000].

Recently a new device (Xpose™, Guidant Corp., Cupertino, CA.) has been developed to enrich the surgical armamentarium for complete myocardial revascularization off-CPB.

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The Xpose™ device consists of a suction cup system that is placed at the apex of the left ventricle. The cup is connected to an articulated arm that is fixed to the sternal retractor. Once suction is applied, the tip of the heart can be gently elevated and different positions of the arm allow for exposure of different coronary artery branches. The clinical applicability of this device has been recently demonstrated in an elegant study [Dullum 2000]. Although the Xpose™ is a unique and user friendly system, some associated technical pitfalls should be recognized. We herein summarize a timely case report.

### CASE REPORT

TA is a 67-year-old male, with three-vessel coronary artery disease, class I angina pectoris, and preserved ejection fraction. OPCAB was scheduled electively. After induction of general anesthesia and endo-tracheal intubation, a median sternotomy was performed. The left internal mammary artery (LIMA) was harvested together with saphenous vein conduits. After systemic heparinization, the pericardium was opened using an inverted T incision. The heart was normal in size with preserved global contractility. The coronary targets were adequate for OPCAB [Bergsland 2000]. The Xpose™ cup-suction was placed on the apex of the left ventricle to expose the left anterior descending coronary artery (LAD). The LAD was a 2-mm vessel with 80% proximal stenosis. The vessel extended to the apex of the ventricle. After mechanical stabilization, placement of a 4-0 polypropylene pledgetted suture, the coronary was opened and a 2-mm intracoronary shunt was placed to maintain adequate distal perfusion. The proximal snare was released and 7-0 continuous polypropylene running suture was used to anastomose the LIMA to the LAD.

During the procedure, multiple premature ventricular contractions with ST segment elevation in the anterior leads were noted. At the end of the anastomosis, intraoperative graft patency verification was performed using transit time flow measurement (TTFM) (Medi-Stim, Oslo, Norway). A 2-cm segment of the LIMA was skeletonized and a 3-mm flow probe was placed around the LIMA, with the Xpose™ in place. The TTFM curve showed an adequate diastolic pattern with a relatively low absolute flow value (Figure 1, ©). Initial TTFM analysis suggested LIMA to LAD anastomosis.

While measuring flow, ST segment elevation was accompanied with sudden hemodynamic impairment. At closer

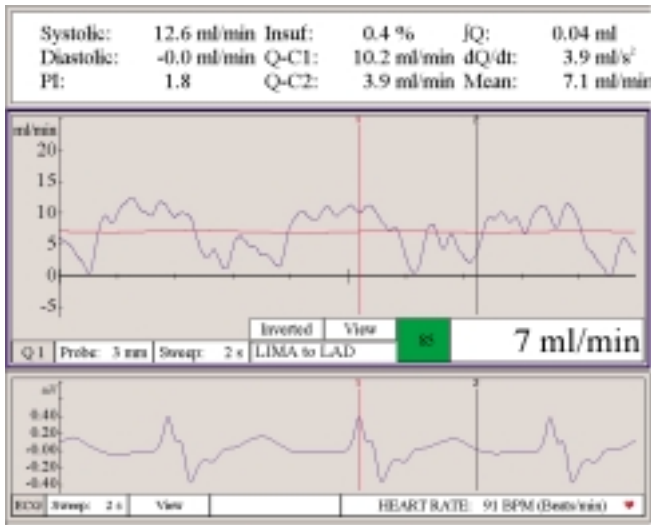


Figure 1. TTFM findings in LIMA to LAD graft with Xpose™ cup in position

inspection, the Xpose™ suction cup seemed to compress the distal segment of the native LAD. We immediately released the tip of the heart from the suction cup and reassessed flow within the LIMA graft. Transit time flow measurements were repeated and a significant increase in the absolute flow value was noted (Figure 2, ●). The EKG tracing reverted to normal and the systemic hypotension resolved. After that, we used the “single suture technique” to achieve adequate exposure of the remaining coronary targets. The operation was successful, without perioperative morbidity or mortality.

## DISCUSSION

OPCAB is performed successfully using different techniques of coronary exposure and stabilization. In our experience, simple, standardized, and reproducible protocols have been used to ensure satisfactory technical results and postoperative outcomes. Minimal changes in the surgical routine can drastically compromise the success of the operation and, for this reason, should always be adopted cautiously. The “single suture” technique enables coronary exposure while different degrees of traction are placed on the pericardium. In theory, no compression on the heart and the epicardial vessels is utilized with this technique.

Although the Xpose™ can achieve adequate coronary exposure, direct snaring of the apical vessels with the suction cup should be avoided. As documented in this case report, compression on the coronary artery branches not only reduces native flow causing regional ischemia, but also limits actual flow through newly constructed anastomoses. As a consequence, erroneous revisions of patent grafts can be avoided if the pitfall is recognized. This case report also documents the wide applicability of intraoperative flowmetry [Canver 1994, Louagie 1994, Walpoth 1996, Canver 1997, Jaber 1998a, Jaber 1998b, Louagie 1998, Walpoth 1998, Cerrito 1999, D’Ancona 1999, Di Giammarco 1999, Walpoth 1999]. This technology may be useful in detecting anastomotic imperfections [Canver 1994, Louagie 1994, Walpoth 1996, Canver 1997, Jaber 1998a, Jaber 1998b, Louagie 1998, Walpoth 1998, Cerrito 1999, D’Ancona 1999, Di Giammarco 1999, Walpoth 1999] and in identifying modifications in graft flow during the different phases of the operation. Proper function of coronary grafts should always be ensured at any time to maintain adequate hemodynamics

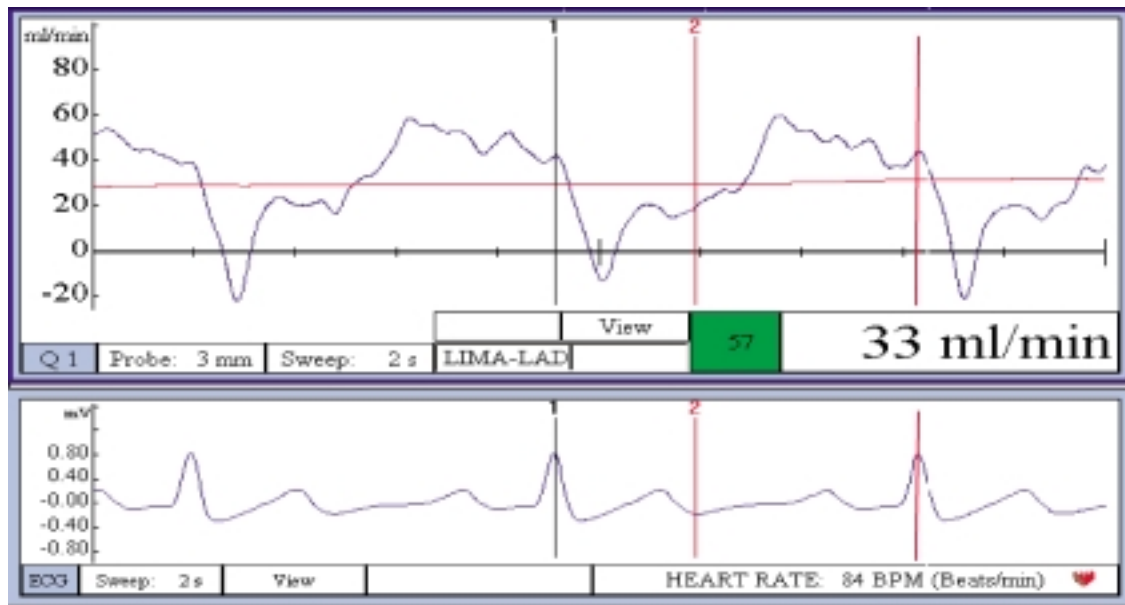


Figure 2. TTFM findings in LIMA to LAD graft after removal of the Xpose™ device

during off-pump coronary surgery and to prevent emergent conversions to CPB.

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## REVIEW AND COMMENTARY

### 1. Editorial Board Member SC389 writes:

There are no values such as PI shown with Figure 1. There should be a picture or diagram of placement of the Xpose™ device on the heart so that the location of the device and also the placement of the heart can be visualized so as to assess incorrect displacement, such as RV or LV compression.

I am concerned about the conclusion from this case report. I do not have the familiarity and experience with the TTFM that the authors obviously have, but just looking at the absolute numbers of flow in Figures 1 and 2 — Figure 1 is 33 ml/min and Figure 2 is 7 ml/min. I have significant experience with off pump cases with and without the Xpose™ and have seen these changes occur from many other reasons with spontaneous resolution and feel very strongly that this conclusion can not be drawn from this case.

I would be interested in knowing if the authors have ever had these changes occur in any of their prior cases without the Xpose™. I am also interested in exactly where the Xpose™ was placed to be able to compress the distal LAD and how much of the LAD was compressed. In the early Octopus experience, it was shown that a suction device could be placed directly over a coronary vessel without damage to the vessel.

### Authors' Response by Giuseppe D'Ancona, MD:

PI values were adequate in both measurements. The suction cup was placed on the apex of the heart and was compressing the terminal portion of the LAD (last 3 cm). The right pleura was fully opened to prevent compression on the right ventricle. Measurements were done after removing the coronary stabilizer to prevent compression on the left ventricle.

We usually test graft flow many times (an average of 20 times/case) during the same operation to detect any possible kinking, compression, or excessive tension on the newly constructed grafts, especially when the heart is elevated and rotated to expose the lateral coronary targets. If the heart stays in a fixed position and there are no sudden changes in blood pressure, we very seldom see drastic changes in the flow curves and values.

As already proven in the Octopus experience, direct suction does not cause any sort of endothelial lesion on the coronary vessels. On the contrary, no one has ever shown any data about how coronary flow may change during the use of these suction devices. It is logical to believe that, although the suction cup will not cause any sort of permanent damage of the vessel, its compressing effect may temporarily deform the coronary artery and consequently reduce the blood flow.

### 2. Editorial Board Member MN393 writes:

The original work on suction stabilization (Grundeman, Borst, et al.) showed no ill effect of 400 mmHg suction applied directly to the epicardium over a coronary artery. The present case report strongly suggests coronary compression. Could this be related to the design of the Xpose™ device? I have observed

that this draws the whole apex of the heart into the cup (i.e., curving around the outer lip). Clearly this increases the amount of traction one can obtain. However, I can see how a relatively unsupported epicardial coronary artery (lying in epicardial fat) could be kinked around this edge.

***Authors' Response by Giuseppe D'Ancona, MD:***

Yes, we believe that a direct compression of the LAD and the surrounding tissue may be the explanation for our findings. A suctioning cup with a smaller design may be an option.

***3. Editorial Board Member EE455 writes:***

To me ischemia to the distal LAD, though likely, has not definitely proven to be the origin of the problem. In this case report, the fact that removing the Xpose™ system improved the situation is of course convincing in its role as a trigger of hemodynamic instability, but other factors may have been involved. Further details should be provided, if available (e.g., TEE findings, hemodynamic measurements, etc.).

ECG changes are not interpretable and some ESV when the heart is tilted are frequent; there are no definitive proofs of severe ischemia. Authors should provide further data about the acute hemodynamic intolerance that happened after completion of the anastomosis. In my experience, compression of the LAD with the Xpose™ system, if any, is very distal and would be unlikely to provoke major ischemia. Could any other factor have been an issue, such as inappropriate twisting of the great vessels, or compromise of the RV function?

***Authors' Response by Giuseppe D'Ancona, MD:***

Grafting of the LAD requires only minimal displacement

and manipulation of the heart and, for this reason, hemodynamic impairment due to compression of the ventricles and twisting of the great vessels is very seldom. On the contrary, we have often noted sudden instability for ischemic reasons, for example, when the LAD is not properly shunted or the vessel is excessively compressed by the stabilizer foot. In this case report, signs of ischemia were noted after some minutes from the placement of the Xpose™, during construction of the LAD anastomosis. The coronary was shunted and there were no evident causes of ischemia. At the end of the anastomosis, the coronary stabilizer was removed, the mammary was opened to reperfuse the distal LAD, and the heart was almost back to its initial position. In spite of this, EKG changes persisted and were accompanied by low-graft flow and then by sudden hypotension. Because there were no other explanations, we suspected the Xpose™ to be the cause of our findings. Immediately after removal of the suction cup, the situation reverted to normality. This should be enough to justify our reasonable doubts.

***4. Editorial Board Member PB44 writes:***

Was the distal LAD visible epicardially and could this have been anticipated from the angiogram? The LAD usually needs minimal displacement to perform an anastomosis, thus a stitch usually is more than adequate. Should one not reserve devices like this to when they are best needed?

***Authors' Response by Giuseppe D'Ancona, MD:***

The LAD was visible epicardially.

We agree that exposure of the LAD and other coronary artery branches can be easily achieved using different strategies.