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A New Technique for Intraoperative Graft Angiography Utilizing the Radial Artery Stump

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ABSTRACT

Background: Angiographic visualization is the gold standard in evaluating the patency of newly constructed bypass grafts. With the growth of beating heart bypass grafting procedures, there is a need to confirm patency and document the success of the operative techniques.

Methods: We have developed a new technique for performing intraoperative graft angiography following off-pump coronary artery bypass grafting (OPCABG) when utilizing the left radial artery as a free graft. Once the radial artery is removed, the proximal radial artery stump is cannulated using a standard femoral introducer sheath passed over an appropriately sized guide wire. The introducer is secured by simple ligature and the arm remains abducted during the construction of the grafts. Prior to heparin reversal, standard coronary angiographic catheters are introduced through the sheath and intraoperative images of the grafts obtained.

Results: Transsternal OPCAB was performed in 7 patients using the left radial artery as a free graft followed by transradial artery completion angiography. A total of 18 grafts (2.5 per patient) were examined with an immediate patency rate of 100% and TIMI grade 3 flow in all grafts. Mean fluoroscopy time was 8.21 minutes. No angiographic or surgical complications occurred in this group.

Conclusions: Beating heart coronary bypass grafting is evolving as a new standard which competes with the traditional technique of cardiopulmonary bypass and elective cardiac arrest. With newer digital portable fluoroscopy systems, excellent imaging of newly constructed grafts can be obtained prior to completion of the procedure using a transradial approach. Verification of graft patency is the essential element in protecting the quality of surgical coronary artery reconstruction in the new era of beating heart surgery.

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INTRODUCTION

Multi-vessel off-pump coronary artery bypass grafting (or OPCABG) is emerging as a new standard for the surgical management of coronary artery disease. As experience develops with beating heart surgery, there is a need to verify that the technical results are equal to the prior standard when all cases were performed with cardiopulmonary bypass and elective cardiac asystole. Our group, as well as other recent authors, have stressed the need to verify the quality of the surgical result prior to completion of the operation. Although less invasive methods have been proposed , we maintain that angiography is the one true "gold standard" for evaluating the quality of the graft and the anastomosis [Elberry 1997, Goldstein 1998, Lazzara 1999].

OPCAB techniques now include the use of multiple different conduits and configurations, including aorto-coronary saphenous vein grafts, free radial artery grafts, and/or in situ internal thoracic artery (ITA) grafts. To provide intraoperative verification of anastomotic quality, we have developed a new approach for imaging all of these various graft configurations utilizing the stump of the harvested left radial artery.

MATERIALS AND METHODS

After harvesting the radial artery as a free graft, the proximal stump is temporarily occluded with a bulldog clamp. An appropriate guide wire is selected (usually a 0.035 inch diameter). The bulldog clamp is released and the wire is passed retrograde through the stump into the proximal brachial artery. A standard femoral artery catheter introducer sheath (4 French or 6 French) is quickly threaded over the guidewire and passed into the brachial artery and then secured in place to the radial stump using a simple ligature. The forearm radial harvest incision is then is closed in two layers except for the very proximal end of the incision through which the introducer protrudes. The arm is left within the sterile field but positioned at 90° to the patient's torso during the remainder of the OPCAB procedure.

After completion of the bypass grafts and prior to heparin reversal, an intraoperative angiogram is performed

utilizing the introducer sheath which remains in the radial artery stump. This provides excellent access to the left internal thoracic artery (LITA) (Figure 1, ◎) and to the proximal anastomoses on the ascending aorta. Imaging is performed using hand injections through standard coronary diagnostic catheters and the OEC 9600 portable digital fluoroscopy unit. All catheter maneuvers and injections are performed by the attending surgeon.

RESULTS

We have performed transradial artery completion angiography in 7 OPCAB cases (4 men and 3 women) with a mean patient age of 72 years. A total of 18 grafts (2.5 per patient) were performed and all were studied prior to completion of the surgical procedure. Successful transradial angiographic imaging included the following graft configurations: 6 in situ LITAs to the left anterior descending (LAD), 1 in situ LITA to the first diagonal branch, 1 left radial artery free graft from the aorta to the LAD, 3 left radial free grafts to obtuse marginal branches, 2 left radial artery grafts to the right coronary artery, 1 left radial artery to the posterior descending artery, 3 saphenous vein grafts to the obtuse marginal, and 1 saphenous vein graft to the posterior descending artery.

Mean surgical time was 236 minutes. Mean fluoroscopy time was 8.21 minutes with a mean angiography time of 3.78 minutes. All grafts were patent with Thrombolysis in Myocardial Infarction (TIMI) grade III flow. Intensive care unit length of stay (LOS) averaged 18.4 hours with a mean hospital LOS of 5.42 days. No postoperative complications occurred in this group of patients and, at the 6-week follow-up, all were doing well.

DISCUSSION

Beating heart surgery is re-emerging as an important alternative technique for the surgical construction of coronary artery bypass grafts. The renaissance in beating heart surgery began in 1995 with the advent of Minimally Invasive Direct Coronary Artery Bypass (MIDCAB) [Benetti 1995, Robinson 1995, Diegler 1997] . This approach through a small anterior thoracotomy proved that excellent results could be obtained with a less invasive operative strategy. However, MIDCAB remained, for the most part, a single vessel operation due to the constraints of the anatomy and exposure. The stimulus provided by the introduction of MIDCAB included dissemination of beating heart techniques to surgeons practicing exclusively cardioplegic arrest techniques, and the introduction of facilitating instrumentation such as mechanical stabilizers. Within a few short years, MIDCAB has grown past single vessel disease into a spectrum of multivessel and multiconduit operations. The most common approach in the current era is a transsternal multivessel beating heart technique utilizing mechanical stabilizers (OPCAB).

Prior to 1995, the certainty of creating a suture line during cardioplegic arrest was an accepted dictum of the profession. Moving to beating heart surgery created a new concern that surgeons formerly trained in arrested heart techniques would not be able to maintain the standards of quality when migrating to beating heart techniques.

To circumvent the dangers of a long learning curve punctuated with graft failures, the authors have insisted on intraoperative angiographic proof of confirmation prior to completion of the procedure for all types of beating heart cases. We reported our initial experience with intraoperative angiography following MIDCAB in a prior publication [Lazzara 1999]. Several other authors have also championed the use of completion or pre-discharge angiography to verify the results of beating heart grafting procedures [Elbeery 1997, Gill 1997, Goldstein 1998, Mack 1999]. Despite original criticism that beating heart techniques would be inferior, the angiographic results have been rewarding with most studies reporting patency rates of 95% or higher.

The difficulty of obtaining intraoperative images has remained one hurdle to completion graft angiography. Surgeons are not typically trained in angiographic techniques or the use of various coronary diagnostic catheters. Now that the radial artery is being utilized more often as a free arterial conduit, we have developed a simplified method for accessing the proximal grafts, including the in situ LITA. Our method has capitalized on the availability of the radial artery stump which provides a direct, in line pathway to the ostium of the LITA as well as the ascending aorta. Our results indicate that completion angiography can be done simply and with a very short learning curve. Using a commercially available portable C-arm digital fluoroscope, excellent images can be obtained prior to closure of the patient. No complications in the radial or brachial artery have occurred with this initial experience and no grafts needed revision.

Since off-pump techniques are still evolving, it is incumbent on the surgeon to insure that OPCABG is a safe and efficacious operation with results equal to the traditional approach. We propose that intraoperative angiography provides the only "gold standard" assessment of coronary graft patency and can be performed by the operating surgeon with minimal difficulty and time commitment. Completion angiography in the operative suite is the initial step in the development of a "common cardiovascular suite" capable of deploying multiple surgical and endovascular techniques directed by a single cardiovascular medicine specialist.

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REVIEW AND COMMENTARY

1. Editorial Board Member EE455 writes:

The number of cases is very small. Any complication, even too statistically unlikely to be reported in a small cohort of patients, would be catastrophic and might lead to abandonment of the procedure (such as an acute ischemia of the upper limb). A larger series of patients would therefore be interesting.

It was not mentioned if all the grafts were studied or if some were inaccessible. Also, I think the authors should provide further technical details: 1) did they use a radiolucent operating table, 2) did this interfere with the OPCAB procedure which usally requires a lot of table motions, 3) what were the extremes quantities of contrast medium that were used and would they expect an effect on the renal function in high risk patients (often selected for OPCAB).

Authors' Response by Robert R. Lazzara, MD:

We use a standard operating table for all our OPCAB's and to perform our intraoperative angiography. We have tried a radiolucent table but found numerous technical drawbacks to its design, although it does enable you to perform a more complete study with more views. The standard OR table does limit the degree of angulation for angiography because of the metal side rails but we have found that we are able to get good AP views as well as both RAO and LAO to 20 degrees.

We are usually able to complete our studies with less than 80cc of contrast and so far we have seen no effect on renal function postoperatively.

2. Editorial Board Member NC124 writes:

Graft patency has been the major concern with off-pump procedures, so this is a simple way to assure it.

It is a good alternative. However, I would say that this technique can only be utilized if the radial artery is harvested. I do not mean that a conventional angiogram could not be done via the radial artery even if it has not been utilized. In that case the femoral access is always easier. I would also stress that there are other techniques that can help us assure graft patency like thermal imaging, surface doppler scan and flow verification with the Transonics device.

Authors' Response by Robert R. Lazzara, MD:

1) Femoral verses radial angiography. We have found that femoral angiography is not always easier. It is not uncommon for patients to have femoral/iliac disease, which can make the study more difficult. Conversely it is uncommon to find radial/brachial disease. Access to the LIMA and proximal ascending aorta is relatively easy from the left radial position but can be very difficult to access from the femoral approach. Access to the radial artery for purposes of angiography in the absence of its use is simple and straightforward.

2) Non invasive versus angiographic evaluation of grafts. Angiography remains the gold standard for documentation of graft patency. It is also the only technique which readily shows the cause of the problem if one is found. Both thermal and doppler studies can identify if a problem is present but neither can identify what the problem is. These problems can include: conduit spasm, anastomotic stenosis, native artery spasm, and inappropriate positioning of the conduit. Each problem requires a specific intervention that is best dictated by anatomy and hence angiography.

3. Editorial Board Member XA5 writes:

I'd suggest the article be updated to include more details on the techniques used: 1) which fluoro machine is used? 2) do the surgeons wear lead throughout the case or do they don aprons at the end?

Authors' Response by Robert R. Lazzara, MD:

We use an OEC 9600 flouro unit in the OR. It provides excellent images and multiple storage techniques (videotape/Jaz drive).

We do not wear lead throughout the case. When we have finished grafting and prior to any heparin reversal, we scrub-out and get our lead on. At the completion of the angiographic studies it is possible to remove the lead without ungowning, therefore only requiring you to wear it for a short time. Most of our angiographic studies are completed in 10 minutes or less.

4. Editorial Board Member KK138 writes:

This is an interesting new technique for intraoperative angiography that will help to establish a more widespread use of intraoperative quality control. It is important to emphasize that the angiograms were actually performed by the surgeon. This method cuts out a number of prob-

lems that may arise from limited availability of a cardiologist to perform an angiogram on request. The authors are encouraged to position themselves even more in the role of the interventionist.

1. A more precise description of the methodology would be helpful. When exactly was the angiogram performed, was the skin closed already and was the patient still draped sterile or not?
2. What planes were used to assess graft patency?
3. Where were the the C-arm and the operator positioned?
4. Which fluoroscopy unit was used and were any special programs run to enhance image quality?
5. Can the authors make any recommendation of the type of catheters they found most useful?
6. How did the surgeon train? Did he spent time in the cath-lab and was he trained by a cardiologist? If so, what is their recommendation for training?
7. What is the perspective of this? Will we all be stenting in the future?

Authors' Response by Robert R. Lazzara, MD:

1–5. Methodology. We perform our intraoperative angiography at the completion of the grafts prior to any closure and while still fully heparinized. As noted above, with the use of a standard operating room table our views are somewhat limited but we are able to get 20-degree RAO and LAO views as well as AP. To perform the study the surgeon stands on the patients left to allow access to the radial stump introducer, the sterile draped C-arm is brought in from the patient's right. This allows the surgeon to pass the diagnostic catheters into the sheath and manipulate the C-arm as he/she sees fit. We have been using the OEC 9600 which provides excellent images both in the flouro mode and in storage which is available in both video tape and Jazz drive. We have found that for the LIMA injections a standard LIMA catheter is the best. To access grafts off the proximal aorta we have found that a Judkins right or a multi purpose catheter works well.

6. Training. Training to perform intraoperative angiography consisted of finding a cardiologist with an interest in new procedures and willing to spend time in the OR, or willing to train in the cath lab. We felt that since we would be performing the studies in the OR, we should train in that venue. We were able to find a few cardiologists willing to help and first spent time observing in the cath lab and then performing the studies in the OR. We do not feel that there are a requisite number of cases to be performed prior to solo OR studies, rather a critical evaluation of your comfort level with these new skills.
7. The Future. The development of a common "cardiovascular disease suite" where diagnostic, interventional catheter procedures, and/or surgical procedures are performed is a coming reality. The development of this technology depends on input from multiple disciplines, cardiology, interventional radiology and cardiovascular surgery. We need to be proactive in growth of this new discipline in order to guide its development. Our goal is to provide the best care possible to our patients in the future. Completion angiography in the operative suite is the first step for the cardiac surgeon in becoming the complete cardiovascualr medicine specialist capable of deploying endovascular therapies, standard surgical therapies, less invasive surgical therapies, robotically assisted therapies, laser therapies and gene therapies. The bottom line is cost effective, efficacious care for patients with cardiovascular disease at a single sitting by a single specialist.