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HOW I DO IT
High-Quality Intraoperative Fluorescence Imaging in Off-Pump Coronary Artery Bypass Grafting

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ABSTRACT

We have developed a simple technique for establishing high-quality intraoperative fluorescence imaging in off-pump coronary artery bypass grafting. The technique of transaortic injection of indocyanine green is an effective method of achieving clear fluorescence imaging and for evaluating the quality of graft anastomoses. We consider the images obtained with this technique to be equivalent to those obtained by conventional coronary angiography with selective enhancement of the graft.

INTRODUCTION

The use of off-pump coronary artery bypass grafting (CABG) has become increasingly widespread in recent years. We have performed off-pump CABG as part of a less invasive surgery that we have been developing since the 1990s [Watanabe 1999]; however, the quality of the anastomoses achieved in off-pump CABG have been of particular concern [Racz 2004]. Among the currently available graft-assessment techniques, conventional coronary angiography remains the gold standard, but it is generally not available in the operating room because of the bulky nature of the equipment and concerns regarding contrast-induced renal insufficiency and bleeding complications.

Recently, Taggart and colleagues [2003] reported that intraoperative imaging of coronary grafts with indocyanine green (ICG) offers the advantages of safety, simplicity, reproducibility, speed of assessment, and the capability for immediate surgical revision if necessary. Although intraoperative fluorescence imaging can confirm graft patency intraoperatively, it does not permit precise angiographic assessment of the quality of the anastomosis if the native coronary artery has not been appreciably narrowed. In such cases, the native coronary artery is enhanced first, followed by the graft, because the dye is injected into the central venous system. The transaortic-injection technique decreases the competitive enhancement of the native coronary artery and produces superior fluorescence images of the in situ graft, especially grafts of the left internal thoracic artery (ITA) [Yasuda 2005]. In this study, we modified the transaortic-injection technique by applying it to the free graft proximally connected on the ascending aorta in order to achieve high-quality intraoperative fluorescence imaging of all grafts.

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TECHNIQUE

Between January 2007 and June 2007, we performed intraoperative fluorescence imaging using the Novadaq SPY imaging system (Novadaq Technologies, Mississagua, Ontario, Canada) in 8 patients who underwent total arterial revascularization with at least one proximal radial artery (RA) graft anastomosis to the aorta. First, we used an ultrasonic scalpel to harvest the RA graft in a totally skeletonized fashion and simultaneously harvested bilateral ITAs in a partially skeletonized fashion. Then, we performed the proximal anastomosis of the RA graft with a hand-sewn technique or via a mechanically anastomotic technique using the PAS-Port system (Cardica, Redwood City, CA, USA). Finally, all distal anastomoses were performed off pump.

Graft patency was then evaluated by intraoperative fluorescence imaging with a modified transaortic-injection technique. We used a 23-gauge butterfly needle to inject 2 mL of ICG within a few seconds directly into the ascending aorta adjacent to the proximal anastomotic site. The entire RA graft was immediately enhanced after dye injection. Then, the revascularized coronary artery was enhanced, followed by enhancement of the native coronary arteries in an antegrade fashion (Figure 1). The image clearly indicates that the anastomosis between the RA graft and the diagonal branch was widely patent. The in situ grafts were subsequently evaluated in the same manner. Intraoperative fluorescence images obtained with this technique were equivalent to those

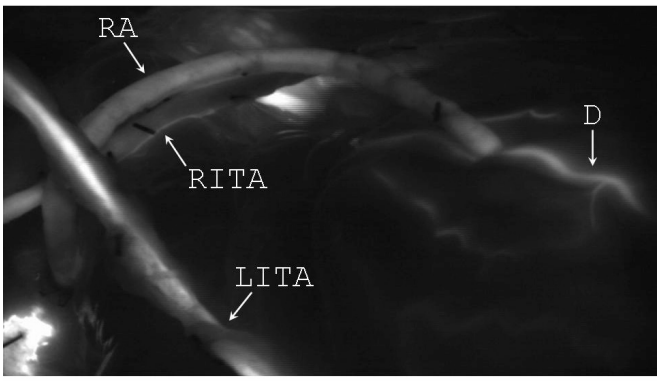

Figure 1. Intraoperative fluorescence image obtained with the transaortic-injection technique. The entire radial artery (RA) graft was immediately enhanced, and the revascularized diagonal branch (D) was subsequently enhanced before enhancement of the native coronary artery. The left internal thoracic artery (LITA) graft and the right internal thoracic artery (RITA) graft were enhanced simultaneously.

obtained with a conventional coronary angiogram selectively enhanced with a catheter.

DISCUSSION

In recent years, several reports have described the usefulness of a fluorescence imaging system, but these techniques have involved injecting the ICG dye through a central venous line [Taggart 2003; Desai 2006]. The transit time of the ICG dye depends on various factors, including the diameter of the graft, the competing flow of the native coronary artery (ie, the severity of the stenosis in the native artery), and the size of the distal coronary vascular bed. We found it difficult to assess the quality of the anastomosis in some cases, because the native coronary arteries became enhanced first when they were not severely stenosed. We previously described the use of the transaortic-injection technique to evaluate the quality of the anastomosis between the left ITA graft and the left anterior descending coronary artery [Yasuda 2005]. In that study, we injected the dye directly into the ascending aorta just below the brachiocephalic artery to avoid infusing the dye directly into the native coronary ostia. We extended this technique to the free graft and injected the dye into the ascending aorta adjacent to the graft. The entire free graft was enhanced immediately after dye injection, followed by enhancement of the revascularized coronary artery and then by enhancement of the native coronary arteries in an antegrade manner. Eliminating enhancement of the native coronary artery and almost selectively infusing a high dye concentration into the graft allowed us to clearly evaluate the quality of both the proximal and distal anastomoses, particularly in the setting of a short free graft.

In conclusion, the transaortic ICG dye–injection technique is an effective method for achieving high-quality intraoperative fluorescence imaging and for evaluating the quality of graft anastomoses, including both the free graft and the in situ graft. We consider the images obtained with the SPY system using this technique to be equivalent to those obtained via conventional coronary angiography with selective enhancement of the graft.

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