A new technique facilitating intraoperative, high-frequency echocardiography of coronary bypass graft anastomoses

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The technical quality of anastomoses during coronary artery bypass grafting is often evaluated by measuring flow rate in grafts using transit time flowmetry. Unfortunately, flow rate and flow waveform are poor indicators of the anatomy of anastomoses.¹ Up to 9% of the anastomoses may have a stenosis of more than 50% not detected by flow measuring techniques.²

A better way to evaluate the anatomy of an anastomosis is 3-dimensional imaging. High-frequency epicardial echocardiography has the spatial and temporal resolution to produce a clear image of the anastomoses, detect intramural vessels, and ensure the optimal place for grafting. (phantom resolution of 6.5–15 MHz transducers is reported in the range of 0.1 to 0.25 mm, with approximately 4-cm penetration depth).³ On the basis of *ex vivo* porcine and human hearts, epicardial high-frequency echocardiography has a high sensitivity (0.98) and specificity (1.0) for detection of anastomotic construction errors.⁴

Three problems must be overcome in performing epicardial echocardiography on the beating heart:

1. The transducer must be kept in a steady position relative to the anastomosis for 5 to 10 cardiac cycles to minimize frame-rate variability.
2. Ultrasound gel must be kept in contact with the transducer and the region studied.
3. The transducer must not cause any deformation of the vessels.

METHODS

We designed an ultrasound transducer positioning device, the Echoclip device (Aalborg Hospital, Aalborg, Denmark), which can stabilize the involved part of the myocardium on the beating heart, keep the gel at place, and position the ultrasound transducer correctly for imaging in the anteroposterior (AP) and left–right (LR) planes without deforming the anastomosis studied.

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Disclosures: Niels-Henrik Staalsen, Jan Jesper Andreasen, and Aalborg Hospital have obtained US Provisional Patent No. 61/171,557 and a Danish patent DK PA200900527 on the Echoclip device.

Received for publication Oct 12, 2009; revisions received Nov 16, 2009; accepted for publication Nov 18, 2009.

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J Thorac Cardiovasc Surg 2011;141:295-6

0022-5223/\$36.00

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doi:10.1016/j.jtcvs.2009.11.074

FIGURE 1. Three-dimensional image of the second-generation prototype of the Echoclip device for visualization of the AP (left) and LR planes (right). The Echoclip device consists of 2 skin supports, 2 and 3, which stabilize the imaging area. Between the skin supports, a cavity, 4, is provided. The cavity may accommodate a bypass graft, an anastomosis, or a coronary vessel. Inasmuch as bypass grafts may vary in size, the distance between the skin supports may vary. Also, the height of bypass grafts may vary. To obtain a good imaging contact between the graft and the transducer, the height of the inner sides of the skin supports may vary. In addition, the cavity allows the transducer to obtain imaging. The device also comprises an aperture for receiving the transducer used together with the device. The device comprises fixing elements to ensure that the transducer is properly secured in the aperture, 1. For obtaining longitudinal and transversal sectional images, the cavity is positioned longitudinally and transversely to the aperture, respectively. Size of the Echoclip device: length = 37.5 mm, width = 17 mm, and height = 15 mm.

Figure 1 shows the Echoclip device for visualization of the AP and LR planes. In Figure 2, a 13-MHz, i13L GE ultrasound transducer (General Electric, Schenectady, NY) (contact area of 27.3 mm by 9.6 mm) especially designed for epicardial imaging is mounted on the Echoclip device for visualization of the AP plane. The transducer is operated by a GE Vivid 4 echo machine (General Electric). Figure 3 shows the transducer mounted on the Echoclip device for visualization of the LR plane. It takes 10 seconds to visualize the anastomosis in the AP plane and 15 seconds to obtain the image of the LR plane for untrained personnel.

DISCUSSION

Ultrasound images are operator dependent, but intraoperative echocardiography of coronary anastomoses using a new ultrasound transducer positioning device has the potential to be reproducible and is relatively easy to use in all coronary territories. The Echoclip device will be further developed and adjusted to various types of transducers.

This communications was intended to describe the principles of stabilizing an ultrasound transducer with optimal

FIGURE 2. Left, The ultrasound transducer mounted on the Echoclip device on a left internal thoracic artery–left anterior descending coronary artery anastomosis. Right, Anteroposterior plane.

FIGURE 3. Left, The ultrasound transducer mounted on the Echoclip device on a left internal thoracic artery–left anterior descending coronary artery anastomosis. Right, Left–right plane. The left–right plane, shown here, is through the middle of the anastomosis.

acoustical contact without deforming the anastomosis on beating heart.

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