Technical Note

Comprehensive Coronary Bypass Graft Assessment: Transit-Time Ultrasound Augmented by Ultrasound Imaging — a Marriage of Function and Structure

Introduction
Routine intraoperative assessment of coronary artery bypass grafts (CABG) is the standard of practice in cardiac units throughout the world. Although intraoperative angiography still is considered optimal for intraoperative graft assessment, the infrastructure that it requires, the time it takes and its operator dependency render it unobtainable for routine use. Currently, transit-time ultrasound is the most feasible and economical technology for intraoperative assessment of bypass grafts. It provides quantitative data that assesses the actual performance of a bypass graft. By measuring flow and adhering to the Transonic Graft Patency Protocol, bypass grafts at risk for premature closure can be identified and corrected before the patient leaves the operating room.

Why Epicardial Imaging?
It has been reported that up to 22% of patients undergoing CABG surgery have more than 50% stenosis of at least one carotid artery and, therefore, are at risk for stroke. Consequently, epiaortic ultrasound is used during cardiac surgery to diagnose and evaluate the presence and degree for ascending aortic atherosclerosis and to determine the optimal location for cross-clamping and aortic cannulation.

In a 2009 review, “High-frequency epicardial ultrasound: review of a multipurpose intraoperative tool for coronary surgery,” Budde et al (University of Utrecht, the Netherlands) identified three surgical challenges in open-chest coronary artery bypass grafting (CABG).

1) to locate the target coronary artery;
2) to select the optimal anastomotic site;
3) to assess the quality of the graft and distal anastomosis.

After using epicardial ultrasound in 628 patients to visualize and assess 912 coronary arteries, as well as 418 grafts and distal anastomoses, the clinicians concluded that CABG surgery may be facilitated and improved in several ways by intraoperative high-frequency epicardial ultrasound scanning.

In her 2014 article in the European Journal of Cardiothoracic Surgery, Di Giammarco et al investigated the increase in diagnostic accuracy when high-resolution epicardial ultrasonography to transit-time flow measurement is added to transit-time ultrasound and concluded that imaging should be considered complimentary to flow measurement for assessment of bypass graft patency. She states, “Simultaneous use of the two methods during CABG provides morphological and functional information improving considerably diagnostic accuracy of intraoperative graft verification procedure close to 100%.”

Is Knowing Flow/Function Sufficient?
In their clinical update “Coronary Artery Bypass Grafting: Part 2-Optimizing Outcomes and Future Prospects,” Stuart J. Head et al state, “Two parameters, graft function and anatomy, are required for the complete assessment of bypass grafts.” They suggest that transit time ultrasound, combined with epicardial ultrasonic scanning, may provide both a functional as well as an anatomic assessment of the bypass graft and its anastomosis.

The 2010 Guidelines of the European Society of Cardiology (ESC) and European Association for Cardio-Thoracic Surgery (EACTS) recommend verifying anastomotic patency with transit-time ultrasound technology. However, unlike velocity which spikes as a vessel narrows, flow drops off precipitously only when an occlusion exceeds 70%. Before that there is very little effect on flow. Therefore, measuring flow alone will not catch a 50% stenosis.

Graph adapted from Spencer and Reid shows that peak systolic blood flow begins a gradual decrease when vessel is occluded 60% and drops precipitously at a 70% vessel occlusion.
Comprehensive Coronary Bypass Graft Assessment: Transit-Time Ultrasound with Ultrasound Imaging — a Marriage of Function with Structure cont.

The Solution

Transonic recommends verification of the function of all coronary artery bypass grafts by following its time-tested Flow-based Graft Assessment Protocol. Moreover, to visualize the anatomy/structure of a bypass anastomosis, any of the myriad ultrasound imaging devices which support intraoperative transducers can be used. These include:

- Philips EPIQ 5, EPIQ 7, Affiniti 50, Affiniti 70, IE33, IU22, CX30, CX50 CompactXtreme, HD11 XE, and HD15 ultrasound systems. All of these systems support the Philips L15-7i0 Broadband Compact Linear Array Transducer, for intraoperative use. [http://www.usa.philips.com/healthcare/solutions/ultrasound](http://www.usa.philips.com/healthcare/solutions/ultrasound)
- Vivid E9 ultrasound system, which supports the GE i13L Linear IO Transducer for intraoperative use. GE LOGIQ E9, LOGIQ S8, and LOGIQ S7 ultrasound systems. All of these support the GE L8-18i-D Broad-Spectrum Linear Transducer for intraoperative use. [http://www3.gehealthcare.com/en/products/categories/ultrasound](http://www3.gehealthcare.com/en/products/categories/ultrasound)

Conclusion

Assessment of the function (physiology) of a bypass graft requires a quantitative-measurement. Transonic’s highly accurate transit-time ultrasound technology offers such unparalleled flow measurements. By measuring flow and following Transonic’s time-tested Flow-based Graft Assessment Protocol, confident assessment of bypass graft patency can be achieved. However, for those that wish to support their quantitative measurement conclusions with a qualitative visualization of a bypass graft’s anastomosis, any one of the intraoperative epicardial transducers on the market can be used to show structure (anatomy) for a comprehensive graft patency assessment.

References


Transonic Systems Inc. is a global manufacturer of innovative biomedical measurement equipment. Founded in 1983, Transonic sells “gold standard” transit-time ultrasound flowmeters and monitors for surgical, hemodialysis, pediatric critical care, perfusion, interventional radiology and research applications. In addition, Transonic provides pressure and pressure volume systems, laser Doppler flowmeters and telemetry systems.