Role of transcutaneous ultrasound in evaluation of graft patency following minimally invasive coronary surgery

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Abstract

Objective: Recent development in minimally invasive coronary surgery prompted us to carry out prospective evaluation of patients undergoing coronary artery bypass grafting through left anterior small thoracotomy.

Methods: Between April 1996 and February 1997, 15 patients (age 32–70, 12 male) were operated on. The left internal thoracic artery (LITA) basal flow was assessed by means of transcutaneous Duplex ultrasound scanning with pulsed waved Doppler. Eight patients were studied in the immediate postoperative period (2–4 days) and seven patients (1–7 months) following revascularisation. In addition to that, nine patients underwent coronary angiography.

Results: LITA graft flows were quantifiable in all 15 patients. In two patients there was a significant reduction in both time-averaged velocity and total flow. The subsequent coronary angiogram revealed severe (>50%) stenosis of LITA graft in both patients. One of these patients had a reversible obstruction documented by Duplex scanning and coronary angiography. Systolic measures did not differ between normal (13) and stenosed grafts (2), but diastolic time-averaged velocity (indicating coronary run-off) and total flow appeared lower in the latter.

Conclusions: LITA flow following left anterior small thoracotomy surgery can be evaluated non-invasively. Measurement of diastolic flow (i.e. coronary perfusion rather than internal thoracic branch run-off) and total flow is useful in estimating graft function.

Keywords: Coronary artery flow; Doppler ultrasound; Internal mammary graft; Minimally invasive heart surgery

1. Introduction

Coronary artery bypass grafting remains one of the most frequently used myocardial revascularisation techniques. There has been increasing use of ‘left internal mammary artery (LIMA)’ for coronary artery bypass grafts (CABG) because of long-term patency. The major disadvantage of the conventional procedure is the use of temporary cardiopulmonary bypass, median sternotomy and wide exposure of the heart [6]. This has lead to recent development in minimally invasive coronary surgery.

Post operative LIMA flow assessment is normally done by angiography and some centres, including our own, have used transcutaneous Doppler ultrasound for evaluation of flows in conventional internal mammary artery bypass grafts. [1,2,5,7–13].

Doppler ultrasound has now been used in evaluation of left anterior small thoracotomy (LAST) patients by a few authors. [3,4,15]. Herein we report the value of transtheoretical Doppler ultrasound in evaluation of graft patency following minimally invasive coronary surgery.

2. Patients and method

From April 1996 to February 1997, 15 patients had undergone the LAST procedure. There were 12 male and three female patients (32–70 years). Informed consent was obtained from all patients and the study was approved by the District Ethics of Medical Research Committee. All patients had severe exertional angina despite optimal medical management. Preoperative angiograms showed severe proximal left anterior descending artery stenosis in five patients and total occlusion of the left anterior descending artery in ten patients.

Eight patients were studied in the immediate postoperative period (2–4 days) and seven patients (1–7 months) following revascularisation. In addition to that, nine patients underwent coronary angiography from 12 days to 9 months postoperatively.

We have previously described the technique used [1]. A
Diasomics (Bedford UK) Spectra Duplex ultrasound scanner was used with a 5-MHz linear array probe and colour Doppler facility. The most frequently used transducer position was 2 cm lateral to the left sternal border in the first or second intercostal space with the patient in supine position. The B scan mode was used to image the proximal part of the internal mammary artery and to measure the vessel at this point. Thereafter a transducer-position as near coaxial with the vessel as possible was chosen to record the Doppler sonogram. An angle of less than 60° was possible from a parasternal approach. Ultrasound measurement was made using internal software, with appropriate correction for angle of insonation.

The following protocol was used: time-averaged velocity- systolic and diastolic (TAVs and TAVd) which is the integral of all the components of the velocity spectrum over the whole cardiac cycle or during systole and diastole as defined by the electrocardiogram.

Peak systolic velocity (VPs), peak diastolic velocity (VPd), systolic time (ST) diastolic time (DT), vessel diameter and graft flow (estimated by multiplying the TAVd by the cross-sectional area of the graft, assuming the graft has a circular cross-section).

Results are given as mean ± standard deviation and a $P < 0.05$ was taken as significant.

3. Results

A typical Doppler sonogram from a grafted internal thoracic artery is shown in Fig. 1. LIMA graft flows were quantifiable in all 15 patients. As Table 1 shows, the systolic measures i.e. time-averaged velocity (systolic) and peak velocity (systolic) did not differ between normal (13) and stenosed (two) grafts, but diastolic time-averaged velocity (indicating coronary runoff) and total flow appeared lower in the latter. This difference is also shown in Figs. 2 and 3.

In two patients, Doppler showed reduced time-averaged velocity (diastolic) and total flow and the subsequent angiogram revealed severe (>50%) stenosis of the distal LIMA graft (Fig. 4). One of these patients had a reversible obstruction documented by duplex scanning and later confirmed by angiography. All of the other patients had increased diastolic flows on Doppler and angiograms showed patent grafts. (Fig. 5)

4. Discussion

In the present study, we revealed that a high parasternal approach using Duplex ultrasound can be easily performed...
in LAST patients because the LIMA is not displaced from its normal position as the technique involves limited mobilisation of LIMA about 5–6 cm at its distal end.

A grafted IMA has a biphasic (systolic and diastolic) pattern of forward flow in the proximal IMA as opposed to a predominant systolic flow pattern in an ungrafted IMA [1,14,16–18]. In other words, during systole, forward flow in the proximal part of the graft represents flow into an elastic but closed-end tube and a part runoff into the intercostal arteries. During diastole, myocardial blood flow is made up of this volume of blood plus the proximal flow detected during diastole [1,2].

The use of transcutaneous Doppler for assessment of conventional bypass grafts have been used by Fusejima et al. [10], Takaji et al. [17] and Kyo et al. [13]. Our own centre has developed [1] and used this technique for measuring...
Fig. 4. Angiogram of a grafted internal mammary artery in a patient with distal graft stenosis. Arrow indicates the area of stenosis.

Fig. 5. Angiogram of a grafted internal mammary artery in a patient with a patent anastomosis.
Transcutaneous Duplex ultrasound can be easily performed in LAST patients from a high parasternal approach as opposed to a supraclavicular approach. Measurement of diastolic flow (i.e., coronary perfusion) and total flow is useful in estimating graft function. A reduction in diastolic flow parameters most probably indicates graft dysfunction.

5. Conclusion

Transcutaneous Duplex ultrasound can be performed in LAST patients from a high parasternal approach as opposed to a supraclavicular approach. Measurement of diastolic flow (i.e., coronary perfusion) and total flow is useful in estimating graft function. A reduction in diastolic flow parameters most probably indicates graft dysfunction.

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References