Perioperative use of the oesophageal Doppler probe (ODM II) on a patient scheduled for transmyocardial revascularization

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Summary
We describe the use of the continuous wave oesophageal Doppler monitor (ODM II) in the peri-operative management of a patient with chronic obstructive coronary artery disease undergoing transmyocardial revascularization (TMR). The use of ODM II allowed both quantitative and qualitative assessment of cardiac function relatively non-invasively. It detected the successful transmyocardial penetration of a laser beam during operation by visual and auditory phenomena in addition to reflecting improvement in cardiac performance after operation. (Br. J. Anaesth. 1997; 78: 760–761).

Key words

Transmyocardial revascularization (TMR) is a new surgical technique that is used in patients with chronic obstructive coronary artery disease that is refractory to conventional revascularization techniques and to maximal medical therapy. In this group of patients with end-stage coronary artery disease the chosen anaesthetic technique should minimize the haemodynamic changes imposed in the perioperative period and be tailored to meet the requirements of the procedure. Perioperative monitoring should provide early detection of haemodynamic changes and indicate the successful transmyocardial penetration of a laser beam during operation. We describe the successful and informative use of the continuous wave oesophageal Doppler (ODM II) in a patient undergoing TMR. The ODM II provides a visual display of the spectral analysis of the Doppler frequency shifts back-scattered from blood flow in the descending thoracic aorta allowing non-invasive assessment of cardiac output, which is provided by stroke distance, the product of waveform area (stroke distance) and heart rate.1 In addition, the device allows indirect assessment of left ventricular filling, contractility and resistance to ejection.2

Case report
A 60-yr-old, 75-kg male, ASA class IV, who had two consecutive coronary artery bypass grafting (CABG) operations but continued to suffer from limiting angina regardless of full medical therapy was offered TMR. After overnight sedation with lorazepam 4 mg he received morphine 10 mg and hyoscine 0.3 mg as premedication. The right radial artery and left forearm peripheral vein were cannulated with 20-gauge and 14-gauge cannulae, respectively, under local anaesthetic. Anaesthesia was induced with propofol 100 mg (as an infusion over 3 min) and alfentanil 1.5 mg. After neuromuscular block with atracurium 50 mg, an ODM II Doppler probe was placed in the oesophagus and a large left-sided Robertshaw double lumen tube was positioned and the lungs ventilated with an air-oxygen mixture. Baseline cardiac index was 2.5 litre m⁻² min⁻¹. A central vein was cannulated via the right internal jugular vein using a triple lumen catheter. An extradural catheter was then sited at the mid-thoracic level (T6–7) and pain relief was produced with an infusion of 0.125% bupivacaine and fentanyl 5 μg ml⁻¹ at a rate of 5 ml h⁻¹ via the extradural catheter after an initial bolus dose of 7 ml of the solution before surgery. Anaesthesia and neuromuscular block were maintained with propofol 3 mg kg⁻¹ h⁻¹ and atracurium 0.5 mg kg⁻¹ h⁻¹ infusions, respectively. Standard monitoring was used, including \( P_{O_2} \), ECG, pulse oximetry, direct arterial and central venous pressures, and ventilatory variables.

After a left anterior thoracotomy, one lung ventilation was commenced and the heart was exposed. Holes were drilled through the ischaemic myocardium by the laser beam and confirmed by the ODM II with visual (showers of ultrasound echoes) and auditory “whoosh” phenomena. A total of 22 holes were made. The patient tolerated the procedure well and his trachea was extubated immediately after surgery. He was then transferred to the intensive care unit. The patient was monitored closely in the postoperative period and remained haemodynamically stable with adequate gas exchange. The extradural infusion was continued for 24 h. He was pain free and felt subjectively improved. The Doppler probe was left in situ for 8 h after operation.

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and cardiac index was recorded continuously for that period. Cardiac index remained increased from baseline and varied from 3.9 to 4.5 litre m$^{-2}$ min$^{-1}$. The probe was removed after 8 h as the patient started taking fluids.

**Discussion**

It has been shown that producing small holes in the ischaemic myocardium by a laser beam improves functional status and offers a ray of hope for these sick patients. During operation, which is performed on the beating heart through a left thoracotomy, a high energy laser is used to bore transmural channels into the left ventricle so that blood flows directly from the left ventricle into the channels and then into the myocardial vascular plexus. Restoring perfusion should alleviate ischaemia in a potentially viable myocardium and improve ventricular function. Postoperative thallium stress tests and left ventriculography indicate that the channels remain patent and protect the ischaemic muscle. There has been anatomical evidence of patent endothelialized channels which contained red blood cells suggesting that the laser channels were functional.

A trans-oesophageal echocardiography (TOE) probe has been used in the past. It requires an additional medical person trained in TOE, it is not tolerated by an awake patient after operation and is costly. We suggest that the use of a continuous wave oesophageal Doppler probe can prove very useful in the intraoperative detection of flow turbulence during successful puncture and assessment of cardiac function in the immediate postoperative period. It is much smaller in size and tolerated better than a TOE probe by an awake patient after operation. The probe is positioned in the lower third of the oesophagus. An indication of which is the “best” signal can be assessed from the one with the highest peak velocity (PV). The ultrasound beam is reflected from the red blood cells travelling in the aorta and the resultant change in frequency is picked up by the probe and relayed to the monitor which calculates the velocity of blood in the descending aorta and from this calculates stroke volume, cardiac output and other associated variables in real time and for each heart beat. There is a signal quality bar which allows determination of whether the quality of the signal has changed as the probe was positioned. The correct signal has a very clear systolic pulse with a very low or totally absent diastolic flow. There is potential for movement artefact when the quality of the signal changes, for example if the patient’s position is changed it is possible to pick up a signal from venous and intracardiac sources, but these are easily recognized and corrected. The spectral waveform gives an indication of linear movement of blood in the aorta. To change these data from linear into volumetric, the computer uses a conversion table based on the age, sex and mean arterial pressure of the patient to produce a volume conversion factor (K) for that patient. This is multiplied by minute distance (MD) which is acquired from multiplying heart rate and stroke distance (distance moved by a column of blood for one cardiac cycle). This is used to produce continuous cardiac output (CO) data (CO = MD × K in litre min$^{-1}$). It was noted that cardiac index doubled and sometimes tripled immediately after successful penetration for approximately 1 min.

Animal data suggest that TMR is an alternative method of treating ischaemic heart disease in terms of both short- and long-term improvement in myocardial contractility and also for the diminished area at risk from necrosis. The optimum number of transmural channels per area, spacing and placement of channels, and contribution of the channel to overall perfusion still need to be quantified. Although it is too early to draw any conclusions it may be that the creation of transmyocardial channels increases cardiac index by improving the inotropic function of the myocardium in the immediate postoperative period. Previous studies have shown that estimation of cardiac output can be made to approximately 90% accuracy with a considerably lower coefficient of variation compared with a standard thermodilution method.

As TMR is taking its place in the treatment of patients with chronic obstructive coronary artery disease, we believe that the use of the ODM II in the perioperative period is a simple, reliable and useful guide for detection of successful penetration of an ischaemic myocardium. It is a good guide for measurement of cardiac output in the perioperative period and is minimally invasive providing flow-based rather than pressure-based monitoring.

**References**