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# 2

## **Echocardiography in transmyocardial laser revascularisation**

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**Abstract**

We present two-dimensional echocardiographic images of laser-made channels in the myocardium in an experimental model and in a patient treated with TMLR.

## **Introduction**

Transmyocardial laser revascularisation (TMLR) is a new treatment of patients with severe angina for whom no other reperfusion therapy is possible. During TMLR, channels are made through the myocardium that are believed to persist as channels from intracavitary to intramyocardial, thus perfusing the myocardium [94,95]. The channels are made with either a CO<sub>2</sub> laser, which has an articulated arm to irradiate and vaporise the tissue directly, or a 1 mm fibre, coupled into an excimer or Ho:YAG laser that emits a small beam, which ablates the myocardium in the channel. Percutaneous myocardial revascularisation (PMR) with catheter-based laser techniques also is being developed. Transoesophageal echocardiographic guidance of the procedure is possible because of a strong intracavitary contrast effect from gas-bubble formation that is observed when the laser beam enters the cavity [96].

## **Case 1**

An experimental pig model was used to test the procedure. After induction of general anaesthesia, sternotomy and pericardiotomy were performed to expose the heart. An excimer laser (*MAX-20; Medolas, Munchen, Germany*) was used to make laser channels in the myocardium at 1 cm intervals to cover the anterior and lateral wall. The laser was operated at 40 mJ/pulse at a pulse frequency of 40 Hz to perforate the 1.6 to 1.8 cm thick myocardial wall in approximately one second. Echocardiography was performed with a 5 MHz monoplane transoesophageal probe (*Hewlett Packard, Andover, Mass, USA*) held to the epicardial surface. Figure 1 shows the intramyocardial laser channels observed during and after the procedure. Channels were visible up to 15 minutes after the procedure.

## **Case 2**

A 58-year-old man with a history of angina for several years had undergone PTCA and CABG. Neither re-PTCA nor re-CABG was considered an option to manage the recurrent angina. The existence of ischaemia was demonstrated with myocardial perfusion scintigraphy (MPS). The patient had a normal left ventricular function.

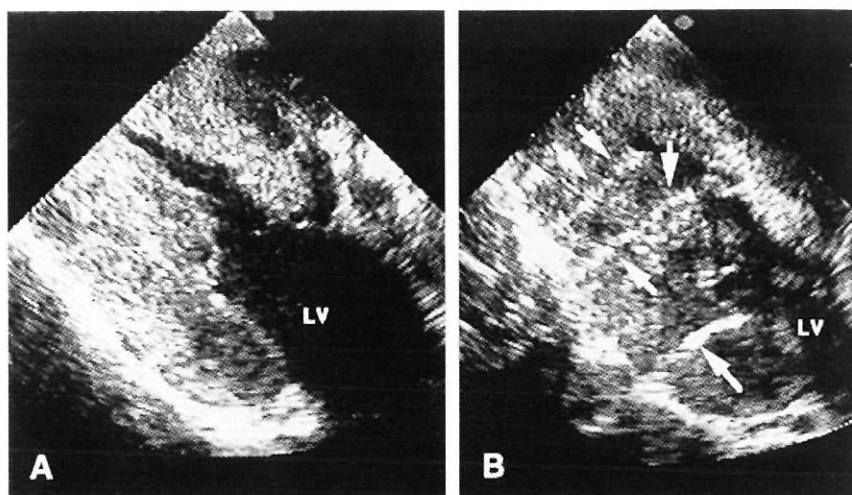


Figure 1. Epicardial echocardiogram of pig heart before (A) and after (B) transmyocardial laser channels were made. Arrows indicate multiple longitudinal channels through the myocardium.

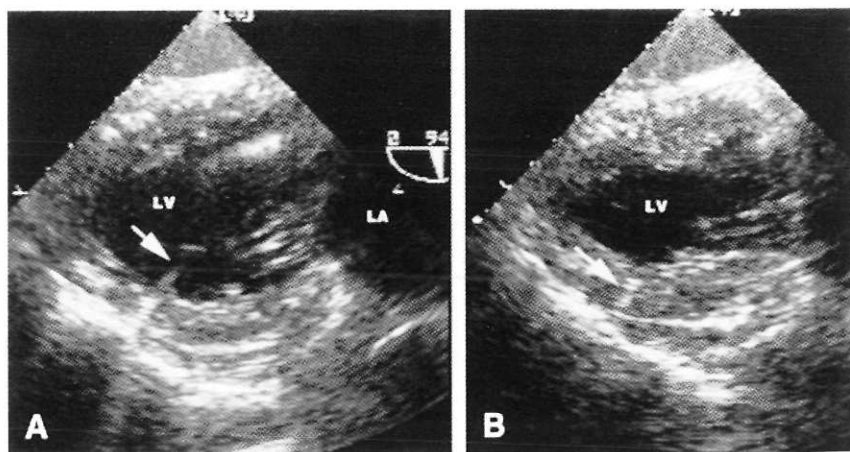


Figure 2. Transoesophageal echocardiogram of a patient during transmyocardial laser revascularisation. A: The laser fibre protrudes into the left ventricular cavity. B: The laser channel is still visible after removal of the laser fibre.

Fifty-five laser channels were made in the anterolateral wall through a lateral thoracotomy with the same excimer laser. The laser action was ECG-triggered by means of opening a shutter on the R-wave for 120 ms to allow 4-5 pulses per cardiac cycle. The 0.9 to 1.0 cm thick myocardium was perforated in 3 to 4 cardiac cycles. The procedure was guided with transoesophageal echocardiography. Figure 2A shows the laser fibre in the left ventricular cavity. In figure 2A no intracavitary contrast medium is visible because firing of the laser is stopped when the fibre has entered the cavity. In figure 2B the intramyocardial laser channel can be seen after the fibre is removed. The contrast in the channels disappeared gradually within 2-3 minutes. The patient recovered uneventfully and had improved exercise tolerance and a decreased extent of ischaemia on MPS 3 months after the procedure.

## **Discussion**

Transmyocardial laser revascularisation makes small laser channels by means of ablating tissue. This produces gas-filled microbubbles on entering the left ventricular cavity that have a strong contrast effect at echocardiography [97]. This enables the sonographer to guide the surgeon in making the channels in the correct ischaemic area and offers additional safeguards by preventing unnecessary microbubble generation with the potential for systemic embolisation and by preventing damage to the mitral valve apparatus. When the fibre enters the cavity without contrast effect if the laser beam is ECG-triggered and happens to shut off on entering the cavity, the laser needle can still be visualised with echocardiography. ECG-triggering is a safety measure to prevent ventricular arrhythmia during TMLR. The images herein demonstrate that it is possible to delineate the intramyocardial channels, enabling precise echocardiographic location of the laser channels. The disappearance rate of the intramyocardial contrast effect appears to be different in pig and human hearts, possibly because of the differences in thickness of the myocardium.

