The snake heart affair

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Cardiac surgery is quivering with new excitement and the name of the game is transmyocardial laser revascularization (TLR). Surgical lasers are here to drill channels through the heart muscle while the heart continues to beat. The channels in turn establish connections with a vast network of sinusoids in the heart muscle and promote blood flow from the ventricle when all else including coronary artery bypass (Figure 1) and angioplasty are inadvisable. The advent of the new technique has been, as usual, marked by much fanfare. Surgeons have jumped on the bandwagon; workshops are held in posh hotels; glossy pamphlets rain on the medical fraternity; carbon dioxide laser machines roll out of the production line and sugar plums dance in the heads of investors. In fact, TLR is the latest in the long list of procedures which sought to relieve patients with coronary artery disease. The list opened long ago with sympathectomy, wrapping of the heart with omentum, implantation of the internal mammary artery in the heart muscle, coronary artery bypass, balloon angioplasty and various allied procedures. Some had their day and champions, others reign supreme. But behind the latest in the series, TLR, hangs a tale.

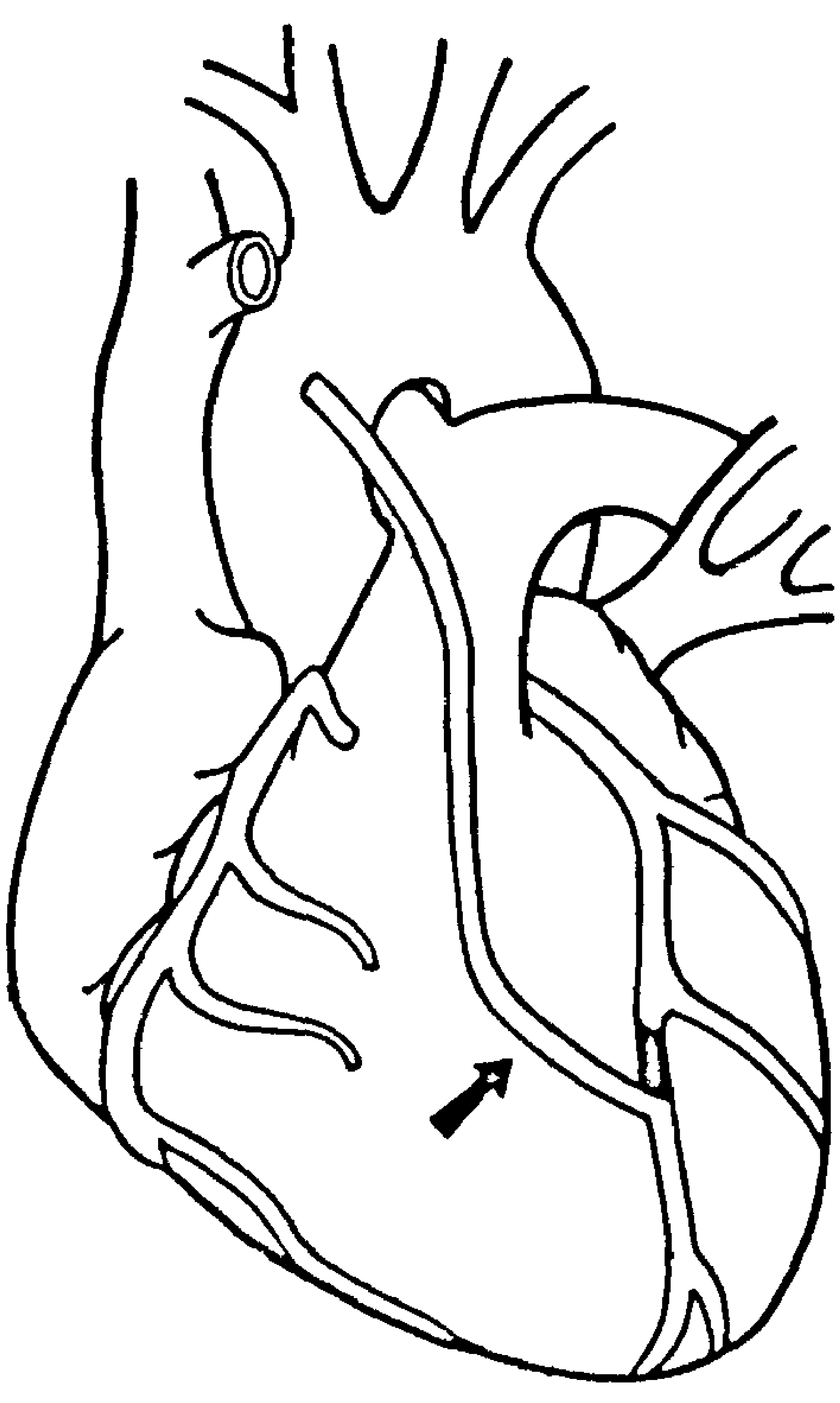

Figure 1. Coronary artery bypass graft. Arrow points to the graft.

The snake heart operation

Before the era of coronary artery bypass began, P. K. Sen of Bombay startled the surgical world by a classic paper on transmyocardial acupuncture or what he nicknamed as the snake-heart operation[1]. Gifted with a sharp intellect and creative imagination, Sen always saw symptoms in terms of their pathophysiological correlates and therapeutic interventions in terms of what they did to the form and function of the body. Not surprisingly, the concept and outcome of the Vineberg operation[2] which was advocated in the nineteen sixties for coronary artery disease drew his attention. In this operation which had many detractors, the internal mammary artery was divided at the lower end, dissected off the anterior chest wall and implanted in the wall of the beating left ventricle with its tiny branches and divided end still bleeding. While Vineberg claimed extraordinary results, others questioned the very basis, if not the physiological legitimacy, of the operation. There was however clear evidence, confirmed in later years by Sones, that the Vineberg implant did remain patent and perfuse the heart muscle in a diffuse manner in many patients. Sen noted that this kind of perfusion of the heart muscle occurred through its microvasculature, which was reminiscent of the snake heart. In the snake heart, the perfusion of the heart muscle had less to do with the diminutive coronary artery flow than with the direct ingress of blood into the muscle from the left ventricular chamber. Like a reticulated plastic foam, the snake myocardium sucks blood from the chamber, thanks to the network of sinusoids which exists between the arterial and venous phases of the coronary circulation. Sen argued that mechanisms for vital processes like myocardial perfusion would seldom disappear despite millions of years of evolution even though they may get superceded by more efficient mechanisms at successive stages. He went a step further and claimed that the dormant mechanisms from the distant past could be reactivated by a stimulus provided it was powerful enough. His attempt to recreate the snake heart model in the mammalian heart consisted of producing myocardial ischaemia by blocking a major branch of the coronary artery in dogs and making a number of needle punctures from the outer surface of the ischemic ventricle into the chamber. The puncture sites stopped bleeding with finger pressure, the muscle regained its healthy colour and the heart, if fibrillating, responded more readily to a DC shock. In some studies the needle tracks were observed to remain patent after many weeks, suggesting thereby that they had established connections with the microcirculation of the heart. The procedure was also employed in a few patients. Sen's report created a surgical sensation and one vividly recalls the interest of several laboratories in the US for investigating the reptilian heart and reproducing Sen's acupuncture model. However the euphoria was short-lived. Pifarre placed a saphenous vein graft in the canine myocardium[3] like a Vineberg implant and noted that the pressure in the venous channel remained higher than the pressure in the chamber throughout the cardiac cycle. This observation was taken to mean that the direct perfusion of the myocardium from the chamber was a physiological impossibility. Thanks to Pifarre's paper, the snake heart operation soon passed into oblivion and caused a professional setback to Sen. It was another instance of the quick transition from standing ovation to overnight dismissal, both equally unwarranted.

It occurred to no-one in those unhappy far-off days that Sen's hypothesis on the perfusion of the myocardial sinusoids from the ventricular chamber could not be disproved by the pressure changes in a large vein which was placed in the heart muscle. Microcirculation is a far cry from the flow and pressure changes in large circulatory conduits which are designed

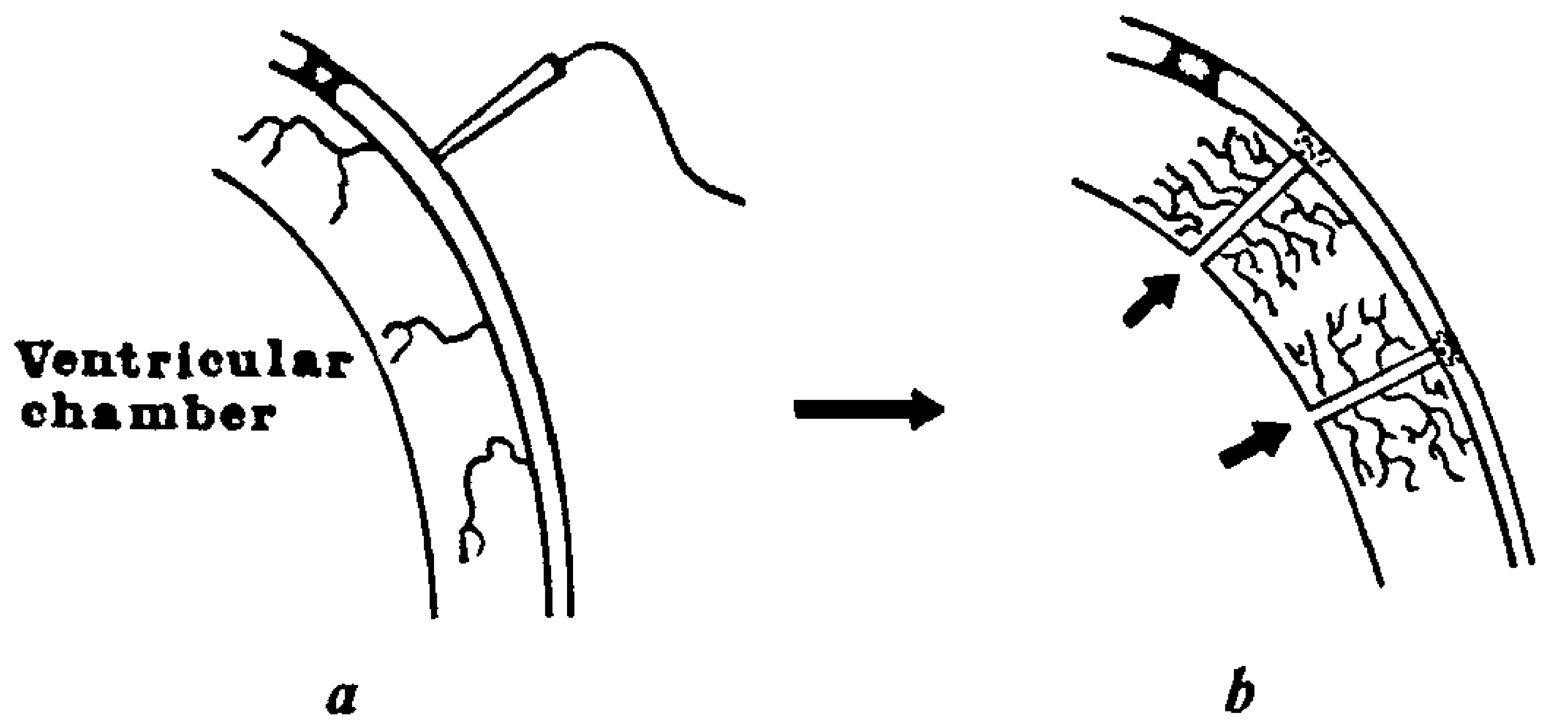

Figure 2. Transmyocardial laser revascularization. *a*, Before lasing; *b*, after lasing.

to perform a different function. Nevertheless Pifarre's report sounded the requiem for the snake heart operation.

Transmyocardial laser revascularization

Quarter of a century later, a resurrection is at hand. This merely supports the view that biomedical ideas often take a generation to fructify. The long gestation intervenes because the ideas are far in advance of available technology and even more in advance of the understanding of contemporary scientists. The development of heart–lung bypass, application of potassium cardioplegia, covalent bonding of heparin to surfaces and a host of other examples bear testimony to the long gestational interval between concepts and practice in medicine. In TLR we are witnessing no more than a repeat performance of Sen's snake heart operation, the sole difference being the substitution of a stainless steel needle by a carbon dioxide laser probe. Mirhoseini[4,5] developed a 100 W carbon dioxide laser for myocardial revascularization and began its clinical use in 1985. Initially employed as an adjunct to areas which were not amenable to grafting during coronary artery bypass surgery, his early experience established the clinical protocol and the basis for using TLR as the sole interventional therapy. In current practice, the heart is approached through the left chest without heart–lung bypass and a 100 W carbon dioxide laser source coupled to a disposable delivery kit employed to drill 15–30 channels, approximately 1 mm in diameter, through the vulnerable part of the heart muscle. The channels are made from the outer surface to the ventricular chamber while the heart continues to beat (Figure 2*a*, *b*). The laser is computer-synchronized with the patient's heart beat and programmed to fire during the relaxation phase of the cardiac cycle when the chamber is filled with blood. The procedure is straightforward and the TLR takes no more than 20 minutes: opening and closing the chest takes much longer. Early results from several centres in Europe and the US suggest that over 90% patients get relief in angina and improvement in the contractile function of the heart. Perfusion studies confirm improved wall motion and increased perfusion in the previously ischaemic areas of the heart muscle. Despite the data being preliminary and being limited to less than 100 patients, Christian Barnard has gone on record that TLR would become a straightforward alternative to coronary artery bypass in countries which lack the resources for open heart surgery. In any event, TLR recommends itself for the paradoxical set of patients who have coronary artery disease with ungraftable vessels but good pumping function of the ventricle.

Like its surgical predecessors, TLR will advance with growing experience, become popular if not fashionable and eventually find its appropriate level in the therapeutic armamentarium for coronary artery disease. However, what is shocking in this unfolding drama is the fact that the latter-day pioneers have failed to acknowledge their debt to Sen who fathered the concept and technique of transmyocardial revascularization. So much for intellectual property rights and ethics in medical research.

Conclusion

Among medical advances, one continually runs into the most modern as it steps out from the most ancient. Who would imagine that an external counter pulsator for cardiac assist resembles in concept and design the auxiliary heart of a hagfish? Or the skeletal muscle which rhythmically compresses the heart in cardiomyoplasty takes after the musculi cordis caudalis of our piscine ancestor? Transmyocardial laser revascularization shares a lineage which is no less ancient. The Preacher uttered more than the literal truth when he said:

'The thing that hath been, it is that which shall be; and that which is done. is that which shall be done, and there is no new thing under the Sun.'

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