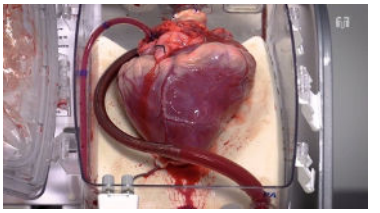

Technologies of Heart Transplantation
Medical Device Technology
Material Matters, 2008

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It is now 40 years since the world's first heart transplant was performed at the Groote Schuur Hospital in Cape Town, South Africa. It is interesting to assess just how far heart transplantation has come since then.

The rise and fall of heart transplantation

I am writing this column just after taking a tour around the new Heart of Cape Town Museum in Groote Schuur Hospital. This is where, just over 40 years ago, Professor Christiaan Barnard performed the world's first successful human heart transplant. He took the heart from 25 year old Denise Darvall and implanted it into Louis Washkansky. A massive hurdle was overcome that day and, even though Washkansky survived for only a couple of weeks, the door was technically open for heart transplantation to make its mark worldwide for the treatment of heart failure. On the basis of the experience of Barnard in South Africa and of his competitors in the United States (US) such as Adrian Kantrowitz and Norman Shumway, who made their transplantation debuts within a few days of Barnard, it could have been expected that heart transplantation would have a major impact globally on cardiothoracic surgery.

In the United Kingdom (UK), transplantation centers opened up and successes reported, but, as in many other countries, the story has not been a totally happy one. The numbers of heart transplants peaked in the mid 1990s with more than 350 procedures annually. Now the number is less than half this number. There are only six centers in the UK authorized to perform transplants. Two of these, the centers in Papworth, Cambridgeshire, and in Glasgow, Scotland, had that authority suspended whilst investigations into high percentages of early deaths (7 out of 20 and 4 out of 11 within thirty days, respectively) took place during the past year. The normally quoted success rates for heart transplant patients are 85–90% survival at one year, 75% at five years and 45% at 10 years. This reminds me of one or two other phenomenal scientific, technological and medical advances that have been made in the last half century, where the impact has not been sustained or has even been lost. The world's only successful commercial supersonic airliner, Concorde, made its maiden flight just two years after the first Cape Town transplant and, for a variety of political, sociological and economic reasons had to close operations decades later. Is there a similar history developing here?

The origins of transplantation

The Cape Town Museum is remarkable. The main wing of the old Groote Schuur Hospital has been replaced by a modern building and part of it converted into this museum. The operating theatres, which had been modernized, have been restored to their original form with original high ceilings and tiled floors and walls, and re-fitted as far as possible with the equipment that Barnard and his team used in 1967. It is a fascinating sight, with the original heart–lung machine, the bulky heat exchanger and oxygenator and excellently reproduced mannequins replicating the clinical staff. Many of the letters Barnard received at that time, both in praise and in damnation of him (for example, one is addressed "To the Butcher of Groote Schuur") are displayed, together with the preserved hearts of Darvall and Washkansky. The

history of medicine is an interesting and worthwhile subject, but let us move forward to today. Where has the technology moved to and what are the problems?

Factors that control success

Cost is one factor, although it is not decisive in terms of the progress of heart transplantation. Average actual hospital costs for the procedure are in the region of US$150 000, although this depends on the general health of the patient and the variable requirements for intensive care and length of hospital stay. Health economics have to be considered in the context of alternative therapies. It is interesting to note that the equivalent hospital costs for treatment by left ventricular assist devices (LVADs) are nearer to US $20 000.[1] The availability of these competing technologies is also a factor in determining the need for transplantation. Although treatment with LVADs is now more readily available, so far this is not diminishing the need for heart transplants. LVADs are successful in many patients, offering as much as a 50% reduction in mortality compared with the best pharmaceutical therapies. However, they are usually considered to be a bridge to heart transplantation and this potentially creates an even larger demand for transplants. In addition, LVADs can of course only benefit those patients where it is the left ventricle alone that is seriously diseased; they are relatively ineffective in those patients where both ventricles are affected. The emergence of the total artificial heart provides for a potentially different outcome, but long term success and a reduction in the clinical need for transplants, have not been realized as yet.

One of the most significant issues is of course the availability of quality donor hearts. In the USA, nearly 100 000 people are on the waiting list and less than one third will receive a transplant. Of these, 10% die each year before a heart becomes available and a further 10% become too ill to undergo the procedure. In spite of many campaigns in many countries to increase the number of organ donors, and to introduce legally based opt-out rather than opt-in schemes, the actual number is still small and not significantly increasing. Equally important is the fact that the average age of donors appears to be increasing and, as a consequence, the quality of the donor hearts that are avail-able is decreasing. The ideal donor would be an otherwise healthy individual in their early twenties who dies of a traumatic event. It is now more likely that the person is in middle age, probably with some existing disease, even their own heart disease, with high blood pressure and high cholesterol. In some places there is a serious shortage of young donors so that heart transplantation for children with congenital heart conditions is problematic.

New technologies

The news is not all bad, however, and there are considerable prospects for much better outcomes from heart transplantation. The traditional procedure for transplantation has been to wait for confirmation of brain death before removal of the heart and then storing it in a cold ischemic state until transplantation. The maximum time for storage is four to six hours and the one year survival figures for transplant patients is significantly related to the length of time the heart is without blood between donor and recipient procedures.

In February 2007, in the General Hospital in Vienna, Austria, a new procedure was used for the first time involving the Organ Care System of TransMedics Inc. (Andover, Massachusetts, USA), which allows for beating hearts to be transplanted without the need for cold ischemic storage.[2] Six other European centers are involved in the study. A little later in 2007, the US Food and Drugs Administration gave approval for a pilot phase of a trial of this technique in the US. The first procedure was performed in Pittsburgh, Pennsylvania, in April 2007. With this technique, immediately after removal from the donor, the heart is transferred to the System, where it is revived to a beating state and perfused with oxygen and nutrient rich blood. In the European study, all the first 20 patients survived beyond the first 30 days.

Heart transplantation has come far, but as yet it is not delivering the widespread benefits of which it is capable. At the moment there is no better treatment for end stage heart failure, but logistics, costs and other issues limit its effectiveness. It is supplemented by other heart assist technologies and may well be challenged by stem cell therapy and tissue engineering in the near future. It is to be

hoped that the Concorde analogy does not come to pass.

References

1. P.L. Digiori et al., “Heart Transplant and Left Ventricular Assist Device Costs," J. Heart Lung Transplant, 24, 200–204 (2005).
2. www.transmedics.com