Clinical review

Recent advances

Cardiac surgery

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Three heart operations in the past 18 months have been featured on British radio and television programmes and made headline news in the Sunday papers. Mr Stephen Westaby announced in the *Sunday Times* of 29 October 1995 that the implantation of a new artificial heart was a "first" for Oxford. The Bristol group, led by Professor Gianni Angelini, reported on BBC radio's *Today* programme on 15 February 1996 that they had performed the world's first combined angioplasty and "key hole" coronary operation. And then came the BBC 1 *QED* television programme "Brave Hearts" on 22 May, heralded by that morning's *Today* programme and articles in the *Sunday Times* (19 May) and *Independent* (May 20), announcing a series of left ventricular reduction operations performed in Bristol.

When medical advances are announced in the popular media even the best read doctors are put in a position where their patients seem more up to date than they, and specialists are upstaged by friends and colleagues who heard the latest advance on the radio before breakfast. How is the average medical practitioner, hearing these broadcasts or reading about them in the Sunday papers, to know where to place these self proclaimed advances in the context of cardiac surgery? I will attempt to do this, but I cannot tell you whether they will lead somewhere important or if they are among the many blind alleys we enter in our search for a way ahead. The research cul-de-sac usually becomes forgotten, but at the time it might have seemed as likely a route to take as any other.

As an illustration of this uncertainty, in September 1948 a visitor to the operating theatres of Guy's Hospital would have had the opportunity to witness two pioneering operations. In one theatre was Mr Russell Brock (later Lord Brock, President of the Royal College of Surgeons of England) performing one of the six or so operations in that year for the relief of mitral stenosis. In another theatre Mr Atkins (later Professor Sir Hedley Atkins, also President of the Royal College of Surgeons of England) was performing thoracolumbar sympathectomy for the relief of hypertension (Smithwick's operation).¹ Both these young surgeons went on to distinguished careers, but what happened to their operations? Which might a visitor have predicted to be important in the development of heart surgery?

Mr Atkins' thoracolumbar sympathectomy was a dramatic and effective operation (hypertension was relieved), but one that has vanished without trace.^{2,3}

Summary points

Advances in heart surgery make media headlines, and this article seeks to place three recent examples in context

Angelini's group is promoting combined "minimal access" coronary surgery and transluminal angioplasty as a way of maximising revascularisation while minimising invasiveness

Westaby is testing a new implantable flow generating device (as opposed to a pump) to aid the left ventricle of a failing heart

Batista is promoting left ventricular reduction to aid a failing heart

Only time will tell which of these operations is a way ahead and which is a cul-de-sac

From Mr Brock's valvotomy, however, heart surgery developed to modern practice, in which there is no structural or mechanical problem of the heart that we regard as inoperable. Yet, a reading of contemporary textbooks indicates that valvotomy to relieve mitral stenosis was regarded as reckless and, of the two operations, was the one without basis in science or logic.⁴⁻⁷

I will try to put in context the three heart operations that have recently made headlines, but we must allow time to tell which is a way ahead and which is a cul-de-sac.

Combined angioplasty and minimal access for coronary artery surgery

The techniques for restoring myocardial blood flow are well established—both with surgically fashioned coronary artery bypass grafts, with various combinations of veins and arteries, and by percutaneous transluminal angioplasty. There is now ample evidence that, for appropriate cases, the risks of death or infarction with the two operations are similar, but the prospect of primary success (that is, sustained relief of angina) is 90% with surgery but only about 60% with the less invasive angioplasty.⁸ Furthermore, patients who

receive angioplasty are denied the generally agreed benefits of an internal mammary artery graft to the left anterior descending coronary artery—an improved prospect of survival, freedom from infarction, and freedom from angina for over 10 years.⁹

In terms of morbidity, the price that has to be paid for an internal mammary artery graft is a major surgical incision (median sternotomy) and a period of artificial perfusion by cardiopulmonary bypass. This has encouraged cardiologists to use the much less invasive angioplasty whenever possible, a strategy welcomed by patients. Surgeons have tried to compete by performing internal mammary artery grafting through tiny incisions in the left chest.¹⁰⁻¹⁶ Such “minimal access” coronary surgery offers patients two theoretical advantages: they are spared the deleterious effects of cardiopulmonary bypass, and they can avoid having a large incision (fig 1). The advantages and disadvantages merit some further critical examination,¹⁷⁻¹⁹ but minimal access surgery seems to be gaining acceptance.²⁰⁻²¹ A practical limitation has been that minimal access internal mammary artery grafting may be applicable only to those patients with disease confined to the left anterior descending coronary artery.

Angelini and colleagues have taken this a stage further by combining minimally invasive surgery with angioplasty to the other vessels.²² The idea is that patients are offered the long term benefits and safer future that we associate with an arterial graft to the left anterior descending coronary artery, plus complete relief of angina by a percutaneous technique to other territories. This expands the group of patients from those with disease confined to the left anterior descending coronary artery to patients with multi-vessel disease. The two procedures—the surgical graft and the balloon dilatation—can be performed in close sequence, minimising, it is postulated, patients' hospital stay and discomfort. In the press release reported in the *Today* programme Angelini stated: “The procedure is set to transform heart surgery, and I believe it will lead to a reduction of as much as 20-40% in the number of conventional bypass. In a few years' time

everyone will be doing it. Obviously patients, particularly the elderly, will benefit from minimally invasive surgery—they could be in and out of hospital within a couple of days.”

Is he right? Will we look back on median sternotomy and cardiopulmonary bypass as unnecessarily radical adjuncts to coronary surgery? In truth, they are well tolerated by thousands of patients a year. When coronary bypass surgery was randomised against angioplasty in the RITA and BARI trials the measures of patients' quality of life (Nottingham health profile) were better in the surgical group²³⁻²⁴ because they correlated highly with relief of angina.²⁴ Claims for reduced morbidity with laparoscopic cholecystectomy compared with open surgery—similar to the claims made by Angelini et al—were not borne out in a randomised trial: postoperative pain, mobility, and time to discharge were no different in the open approach and the laparoscopic approach.²⁵

Where are we with the artificial heart?

Precedence can be a sensitive issue, but Westaby²⁶ gives Cooley and colleagues the credit for the first artificial heart nearly 30 years ago.²⁷ So in what sense was the Oxford experiment reported in the *Sunday Times* a “first,” and how should we understand it in the context of 30 years of attempts to achieve long term support of the circulation by a mechanical device?

First, we need to clarify some terms. The cardiopulmonary bypass equipment developed since the 1950s and now used in hundreds of thousands of cardiac operations each year is, in a sense, an artificial heart but, being temporary and external, is not regarded as such. In 1969 Cooley et al reported that they had removed a patient's heart and replaced it “orthotopically” with an artificial double ventricle heart.²⁷ This was, without doubt, a total artificial heart since it totally replaced the heart, which was removed. Thus, extracorporeal cardiopulmonary bypass and implantation of a total replacement heart can be seen as opposite ends of the spectrum of replacing cardiac function with a machine. The middle ground is occupied by a range of devices under the general heading of left ventricular assist devices, in which the heart is left in circuit but the function of the left side is augmented or replaced by a pump.

The distinction between an orthotopically sited total artificial heart and an implanted left ventricular assist device (such as the Jarvik 2000 used by Westaby and colleagues) has not been made in the lay press²⁸ nor, indeed, is it always made in more technical reports. These assist devices have generally been designed to imitate the mechanics of the heart in that there has been some means of displacing a stroke volume, usually a pusher plate working like a piston within a rigid chamber. The flow is directed by non-return valves at the inflow and outflow ends.²⁶ The Jarvik 2000 is an ingenious product of lateral thinking that relies on an alternative mechanism: instead of producing intermittent volume displacement, it drives a continuous stream of blood with an electromagnetically coupled impeller spinning in the blood stream within a conduit running between the apex of the left ventricle and the descending aorta (fig 2). There is no need for valves. This type of impeller pump has other valuable

Fig 1 Incision required for minimal access coronary surgery (adapted from Cooley 1996¹⁵)

Fig 2 The Jarvik 2000 left ventricular assist device (top), and how the device is positioned in a failing heart (bottom)

characteristics. The impeller, by its nature, is not occlusive and is less prone to creating back pressure, and there is a limit to the pressure it can create against an increased afterload. These advantages (inherent in the normal heart) are difficult to replicate in a mechanical pump with a fixed stroke volume, mechanical coupling, and inlet and outlet valves.

Future use of an artificial heart

Westaby's headline in the *Times* on 24 April 1997—"Tiny pump gives diseased hearts a chance to recover"—has subtly changed the emphasis away from replacing a heart towards supporting patients while their heart recovers, perhaps by combining the placement of the device with surgery on the coronary arteries, heart valves, or the ventricle.²⁶ This is logical and appealing. There has been ambiguity over the objective of an artificial heart programme. Was the

intent to create an implantable device as the definitive solution for a failing heart or as a holding manoeuvre, a "bridge," until a donor heart becomes available?

There is a strictly limited supply of donor hearts (about five per million of the population per year), and, in order to get the greatest benefit from each heart in terms of survival time and quality of life, they are reserved for patients with left ventricular failure severe enough to justify transplantation but who are fit in other respects. It has seemed wrong to many of us to expand the pool of potential recipients by holding a group of survivors made less suitable by the surgery and complications of the mechanical device itself. However, the mechanical heart lobby has countered that these devices will provide a period of improved end organ perfusion to make the sickest patients, who are the most deserving transplant recipients, more likely to recover after transplantation. It should not be overlooked that, for those developing artificial hearts, the prospect of a donor heart as the ultimate objective gave some credibility to the implantation of devices with such little prospect of long term success. It has been said that the Americans have spent as much money in the mechanical heart programme as in putting men on the moon but that there are fewer long term survivors, at least survivors with artificial hearts in place. "Bridging" has supplied patients with whom to try out devices but with an escape route to transplantation.

To date, no device has been developed that can be powered internally. In all implanted devices some form of cable or drive line has to pass through the skin from the device to some sort of external energy source. Other problems are noise and the generation of heat. A mechanical heart as a permanent solution to a failing heart still seems a long way off, but an acceptable temporary device to give weeks or months of convalescence, as envisaged by Westaby, may be the niche in the market place.

Partial left ventriculectomy (the Batista operation)

In early 1996 Batista et al briefly reported their operation in a single case, a 34 year old man with dilated cardiomyopathy.²⁹ They resected a strip of left ventricular muscle from the apex to the mitral annulus and repaired the defect by direct suture of the muscle edges. They reported that, two months later, the man was living a normal life. The objective of the procedure is to reduce the left ventricular diameter by 2 cm, which is achieved by removing 6 cm from the circumference of the left ventricular free wall: the concept is that, by thus reducing the ventricular circumference, the heart will generate pressure at lower wall tension, an application of the law of Laplace.³⁰

Batista et al point to the patient's increased ejection fraction as evidence of benefit.²⁹ However, unless the proportion ejected increases, there will be a smaller stroke volume and less cardiac output than in the preoperative state. We need better evidence of useful improvement in haemodynamics. The measurement most likely to accompany real benefit in terms of symptomatic improvement is an increased cardiac output without a pathological rise in filling pressure. Some objective evidence of improved symptoms and survival would be clinically important outcomes, but the

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available data are scant. Batista concluded the results section of his single case report with the words: "As of October 1995, we have performed the same operation on 154 patients."²⁹ By August 1996, this number had risen to over 300.³¹ This is an impressive denominator, but why no mention of the number of survivors?

In the *QED* programme Angelini said he thought that left ventricular reduction surgery "is the best thing to happen to cardiac surgery in 30 years." That would put it ahead of not only his own minimally invasive coronary surgery and Westaby's mechanical hearts but also the internal mammary artery graft, cardiac transplantation, the glutaraldehyde preserved xenograft, the arterial switch operation, and other contributions in heart surgery. The Bristol group had one survivor out of four at the time of the television broadcast.

Conclusion

To evaluate these three widely publicised innovations we must await further evidence and the passage of time. The fact that they are much vaunted by their originators is not a useful predictor, but we must not forget that even the best informed commentator in 1948 might not have made the right prediction about the future of surgical relief of mitral stenosis or thoracolumbar sympathectomy for hypertension.

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When I use a word ...

Difficult pronunciation

The incidence of diarrhoea associated with antibiotics has increased in the John Radcliffe Hospital in recent years, and in many cases we find *Clostridium difficile* toxin in the stools. The other day, after a long ward round, we went to the mess to take refreshments and wind down. "How do you pronounce 'C. diff.'?" our senior house officer asked, avoiding the problem. I knew what he meant.

If "difficile" were French it would be pronounced "dee-fee-seal" but it isn't. If it were Italian it would be pronounced "dee-fee-chi-li" but it isn't. "Difficile" is Latin, the neuter form of difficilis, difficult, and the organism is so called because it is difficult to grow in the laboratory. If you were taught to pronounce Cicero "Kikero" you would pronounce difficile "di-fi-ki-li" or "di-fi-ki-li," and if you were taught to say "Sissero" you would pronounce it "di-fi-si-li" or "di-fi-si-li." I was taught the former but I prefer to say "di-fi-si-li," which to me sounds the most euphonious of all the options.

Another Latin word that poses a similar problem with pronunciation is "rationale." Indeed, it is so commonly mispronounced that the mispronunciation has become standard. Since rationale is the neuter form of the Latin word rationalis, the final e should be pronounced. The first edition of the *Oxford English Dictionary* (the relevant fascicle of which was published in 1905)

gave the pronunciation as "rash-u-nai-li" and so did *Webster's New International* (1911). This pronunciation was still recommended in the 1959 edition of *Chambers 20th Century Dictionary*, although by then the alternative pronunciation "rash-u-nah-li" was also given. By the time that the next edition of the Chambers dictionary was published in 1972 "rash-u-nai-li" had disappeared, and the alternatives were "rash-i-o-nah-li" and "rash-u-nah-li."

However, at around this time, and presumably through the mistaken belief that the word is French, it was increasingly coming to be pronounced "rash-u-nahl." French has no such word, but this pronunciation has become so prevalent that it has been given first place in virtually all dictionaries since the early 'seventies. Some, such as *Collins English Dictionary* (1979) and *The Chambers Dictionary* (1993) give it as the sole pronunciation, although others, such as *Chambers English Dictionary* (1988) and the second edition of the *Oxford English Dictionary* (1989), give "rash-u-nah-li" or even "rash-u-nai-li" as alternatives.

In preferring the quasi-French pronunciation, the dictionary makers are not being prescriptive; they are merely following fashion. So, you can pronounce rationale almost any way you like. And that's finale.

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