Review Article

Global Trends in Cardiology and Cardiothoracic Surgery – An Opportunity or a Threat?

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Abstract

Coronary heart disease is currently the leading cause of death globally, and is expected to account for 14.2% of all deaths by 2030. The emergence of novel technologies from cardiothoracic surgery and interventional cardiology are welcome developments in the light of an overwhelming chronic disease burden. However, as these complementary yet often competing disciplines rely on expensive technologies, hastily prepared resource plans threaten to consume a substantial proportion of limited healthcare resources. By describing procedural and professional trends as well as current and emerging technologies, this review aims to provide useful knowledge to help managers make informed decisions for the planning of cardiovascular disease management. Since their inception, developments in both specialties have been very rapid. Owing to differences in patient characteristics, interventions and outcomes, results of studies comparing cardiothoracic surgery and interventional cardiology have been conflicting. Outcomes for both specialties continue to improve through the years. Despite the persistent demand for coronary artery bypass surgery (CABG) as a rescue procedure following percutaneous coronary intervention (PCI), there is a widening gap between the numbers of PCI and CABG. Procedural volumes seem to have affected career choices of physicians. Emerging technologies from both disciplines are eagerly awaited by the medical community. For long-term planning of both disciplines, conventional health technology assessment methods are of limited use due to their rapid developments. In the absence of established prediction tools, planners should tap alternative sources of evidence such as changes in disease epidemiology, procedural volumes, horizon scan reports as well as trends in disease outcomes.

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Introduction

Until the end of the first half of the 20th century, the management of coronary heart disease (CHD) lay largely in the hands of general cardiologists. Subsequently, treatment of CHD was influenced by breakthroughs from two complementary yet often competing subspecialties. Coronary artery bypass graft surgery (CABG) was the first definitive intervention introduced in the 1960s by cardiothoracic surgeons. More than a decade later, a group of physicians who were eventually called interventional cardiologists performed the first human coronary angioplasty. To this day, both technologies continue to evolve, at times with one discipline announcing the impending arrival of a breakthrough before the other could finish celebrating its most recent success.

The value of rapid technological advances becomes clearer in light of the growing pandemic of cardiovascular diseases, and this free enterprise "competition" can only be beneficial to the patient. However, investing heavily in two divergent technologies intended for the same disease and the same subset of patients is an inefficient way of allocating finite resources. Infrastructure planning for catheter-based interventions and cardiothoracic surgery is much like trying to hit a constantly moving target. The challenge lies in arriving at a resource allocation plan that optimises both technologies that is cost-effective.

This paper reviews the secular trends in procedural statistics for cardiothoracic surgery and interventional cardiology, and the current and emerging technologies envisioned to assume major roles in the future management

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of heart diseases. It is hoped that this review will provide useful knowledge to help managers make informed decisions on planning for management of cardiovascular diseases.

Impetus for Technological Advances in CHD Management

Population ageing will drive the rising prevalence of chronic diseases including CHD. In Singapore, the population of residents aged 65 years and older grew by 21.8% between 2002 and 2007.[1] Between 2005 and 2007, the number of deaths from cardiovascular diseases in Singapore increased by 5.7%.[2] The proportion of all deaths attributed to CHD also increased from 18.2% in 2005 to 19.8% in 2007.[2] Globally, the proportion of deaths attributed to CHD is expected to grow by 2% between 2004 and 2030.[3] However, the current status of CHD as the leading cause of death globally[3] seems to indicate that interventions are unable to cope with the overwhelming disease burden.

The Past: Evolution of CHD Management

The histories of cardiac surgery and interventional cardiology are marked by inspiring stories of remarkable individuals. Dr. John Gibbons' pioneering work on the heart-lung machine[4] paved the way for open heart surgery. Since the first successful and clearly documented CABG in a human being by Dr Robert H Goetz in 1960,[4] the procedure has undergone a series of modifications, including variation in the graft vessel used.

In the field of catheter-based interventions, much of what has been achieved is credited to Dr Werner Forssmann's adventures with his self-catheterisation experiment of the right atrium.[5] Since Andreas Grüntzig's first percutaneous transluminal coronary angioplasty (PTCA) in 1977, numerous developments in percutaneous coronary interventions (PCI) have unfolded. After the first coronary stent was implanted in France in 1986,[6] newer stents used with safer and more effective antithrombotics expanded the range of indication for PCI.[7]

The Present: Current Trends in Cardiac Surgery and Interventional Cardiology

Despite having been established as standard treatments for CHD, the question of which technology is superior in the long term remains largely unanswered. Developments are so rapid that before long term outcomes could be assessed, a new technology would have likely replaced the most recent one. Thus, meaningful head to head comparisons can only be made for short to medium-term outcomes.

Results of cost-effectiveness studies are often conflicting and seem to result from differences in study characteristics such as indications for revascularisation, the specific interventions used (type of stent), outcome of interest, patient characteristics and year the study was conducted. A randomised controlled trial at the U.S. Veterans Affairs Medical Center involving patients with medically refractory myocardial ischemia found that PCI was generally less costly and more effective at 3 and 5 years.[8] On the other hand, results of the SYNTAX trial, a randomised controlled trial involving 1800 patients with 3-vessel or left main coronary artery disease (or both) showed that CABG, as compared with PCI, had lower rates of major adverse cardiac or cerebrovascular events at 1 year, and the conclusion was that it should therefore remain the standard of care for such patients.[9] A systematic review of 68 studies concluded that CABG is initially more expensive and may have higher immediate risks compared to bare metal stents, but that over time, the difference in cost is reduced and long-term outcomes favour CABG.[10] The same conclusions hold true for drug-eluting stents versus CABG in multiple-vessel disease, as reduced cost from fewer repeat revascularisations is more than offset by the higher cost of drug-eluting stents.[10]

Given the dynamic nature of these technologies, it may be useful to compare secular trends in outcomes. An Australian study showed reductions in death rates from PCI as well as rates of emergency CABG post-PCI between 1992-1990, 1999-2002, and 2003-2004.[11] Similarly, at the Mayo Clinic in the U.S., PCI for chronic total occlusions has become safer with a reduction in rates of major adverse cardiac events from 8.0% in 1979-1989 to 3.8% in 2003-2005.[12] Improved outcomes have been observed in spite of increasing disease complexity, prevalence of comorbidities and risk factors over time.[12] Better outcomes have likewise been observed in patients undergoing CABG. After peaking at 8.5% in 1985, CABG mortality has declined to 2.5% in 2000 despite the same rise in patient age, disease severity and comorbidities noted in patients undergoing PCI.[13]

As technology advanced and operator experience increased, the application of PTCA expanded from dilatation of simple, concentric single-vessel stenotic lesions to more complex lesions in multivessel disease.[14] Contraindications to PTCA in its early years, particularly acute coronary syndromes have become its main indication by 2007.[7] Performing the procedure in the absence of surgical standby was deemed inappropriate up to the 1990s. However, due to improved technical success rates over the years, PCI in facilities without cardiac operating theatres has gained acceptance in many countries. These developments may have contributed to the surge in the volume of PCI procedures performed over the past two decades. Globally, statistics consistently demonstrate a progressive increase in PCI procedure rates and a corresponding decline in the number of CABG surgeries (Table 1).

Technological developments in CHD management have affected the career choices of physicians as well as the

Table 1. International Procedure Statistics for PCI and CABG

Setting	Data Source	Findings
United Kingdom		
East Midlands	East Midlands Public Health Observatory[15]	• Ratio of PCI:CABG increased from 0.8:1 (1988/1989) to 2.6:1 (2006/2007) • PCI projected to increase from <1000 procedures (2006/2007) to 1280 (2010/2011); CABG to remain stable at <400 per year
UK (National)	Data collected by European Society of Cardiology from national registries and reports from national cardiology societies[16]	• PCI increased from 147/million (1990) to 758/million (2002)
United States		
US (National)	Medicare data[17]	• No. of hospitals performing CABG increased by 15% between 1996 to 2002 while total no. of CABG performed decreased by 20%
US (National)	Healthcare Cost and Utilization Project database, and US population estimates[18]	• Widening difference in PCI vs. CABG utilisation through the years for age groups 45-64, 65-84, & 85+ • Widening difference in PCI vs. CABG utilisation with increasing age (45-64 vs. 65-84 vs. 85+)
Montana	Illinois Hospital Association[19]	• No. of CABG performed decreased by 12% while PCI increased by 8.7% between 2002 to 2005
Washington State	Washington State Dept of Health Comprehensive Hospital Abstract Reporting System database[20]	• Between 1987 and 2001, no. of CABG performed decreased by 16% while PCI increased by 128% • Between 1997 and 2001, no. of CABG performed decreased by 19% while PCI increased by 18%
Denmark	National Institutes of Public Health, Denmark[21,22]	• Between 2000 and 2008, total CABG procedures decreased from 3155 to 1425 while PCI increased from 4971 to 5916
France	Data collected by European Society of Cardiology from national registries and reports from national cardiology societies[16]	• PCI procedure rate increased from 924/million (1990) to 2439/million (2002)
Germany		• PCI procedure rate increased from 426/million (1990) to 2439/million (2002)
Italy		• PCI procedure rate increased from 89/million (1990) to 1319/million (2002)
Netherlands		• PCI procedure rate increased from 537/million (1990) to 1295/million
Spain		• PCI procedure rate increased from 92/million (1990) to 654/million (2001)
Sweden		• PCI procedure rate increased from 128/million (1990) to 1102/million

demand for surgeons. In the US, while the annual number of positions available for cardiothoracic surgery training programs remained stable from 1993 to 2005, the number of applicants has steadily declined. The year 2004 marked the first year that the number of applications for training positions in cardiothoracic surgery fell below the number of positions available.[23] After peaking at 1.2% in 1992, the proportion of U.S. graduating medical students planning a career in cardiothoracic surgery dropped to 0.3% during 1996 to 2004.[23] In recent years, scarcity of employment opportunities rather than personal choice, has driven fully trained thoracic surgeons to pursue additional fellowship training.[23,24]

The Future: Emerging Technologies

After introducing drug-eluting stents into the market, manufacturers are developing newer models with superior stent composition, design, geometry, configuration and surface refinement.[25] Among the new stents being tested are absorbable metal stents,[26] stents which inhibit the proliferation of a gene known to induce restenosis,[27] and regenerative stents which reduce the risk of thrombosis.[28] Various stent coatings which provide a biologically inert barrier between the stent surface, circulating blood and endothelial wall have been tested. Among these are carbon, silicon carbide, phosphorylcholine, and endothelial progenitor cells antibody-coating.[25,29]

In the field of cardiothoracic surgery, the low rates of emergency CABG after PCI reflect the low but persistent demand for CABG after PCI, and its continuing role particularly in the treatment of postinfarction patients.[30] Aside from off-pump bypass surgery (OPCAB) which allows the heart to continue pumping blood into the circulation during the procedure, other less invasive techniques such as minimally invasive CABG (MIDCAB) and totally endoscopic CABG (TECAB) are emerging.[31] Investigators have demonstrated closed-chest multi-vessel OPCAB using left internal mammary artery grafts involving robots.[32] Distal anastomotic devices, better closed-chest stabilizers and thoracoscopic ports with tremor reduction technology are some of the devices envisioned to facilitate closed-chest procedures.[32]

Years from now, nano-surgery with microscopic robots, and neoangiogenesis or the technology to grow new blood vessels, are envisioned to be the future of CHD management.[6] Neoangiogenesis using heparin-binding growth factors has undergone clinical testing intramyocardially alongside coronary bypass with satisfying results.[33]

Discussion

While a health technology assessment is suitable for evaluating the short to medium term applicability of new technologies, it has limited use for long-term infrastructure planning of disciplines that are rapidly changing. In the absence of accurate prediction tools, decision makers should use other readily available evidences such as secular changes in disease epidemiology, procedural volumes, professional patterns, horizon scan reports, as well as trends in disease outcomes.

In Canada, an attempt was made to estimate future resource needs for revascularisation. A needs-based model using data on historical trends in utilisation, incidence of potential indications for coronary procedures and comparisons with procedure rates in similar settings was developed.[34] This technique can provide precise estimates of future demand for specific diseases or procedures such as PCI and CABG. However, they are of limited use for projecting resource requirements of entire specialties or departments such as cardiothoracic surgery and interventional cardiology. This is because specialties manage not just a single condition such as CHD, but a wide range of diseases.

The role of CABG as a rescue procedure for failed PCI and for post-infarction patients may change with further improvements in catheter-based interventions. While this paper has focused on the role of PCI and CABG in CHD management, catheter-based interventions are foreseen to encroach on the management of other heart conditions such as congenital and valvular diseases, which like CHD have traditionally been managed by the surgeons. Catheter-based interventions will become increasingly useful for the replacement of diseased aortic valves, repair of mitral valve and cardiac septa, and treatment of plaques in the coronaries.[26]

Angioplasty was introduced as a procedure for treating only proximal single vessel disease, but has evolved into a highly successful "disruptive technology" rivaling the gold standard for revascularisation. The impact that catheter-based interventions has had on CABG procedural volumes has been significant enough to stimulate much discussion on the future of cardiothoracic surgery from the surgeons themselves.[32,33,35-38] In an effort to institute measures which will ensure the viability of cardiothoracic surgery as a specialty it has been suggested that while surgeons should embrace new catheter-based interventions, they should not feel that it is beneath them to perform lesser procedures other than cardiac surgery.[32,33] Organisational issues including structures and practices were claimed to have prevented cardiothoracic surgeons from recognising and investing in catheter-based interventions as a disruptive technology, thus losing the "first mover advantage."[38] To ensure a robust future for cardiothoracic surgery, one suggestion is for the specialty to re-emphasise broad based learning in cardiac, vascular, pulmonary and general surgery, thus allowing the flexibility of venturing into other complementary fields.[38] Another is to reorganise the care of patients with heart diseases such that specialty training will incorporate all aspects of cardiac disease management including diagnosis, interventional radiology, interventional cardiology, electrophysiology, and cardiac surgery.[38] Analogies have been made to ophthalmology, orthopaedics and otolaryngology which provide multidimensional, comprehensive organ-system based care.

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