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Cost-effectiveness of Minimally Invasive Cardiac Operations

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ABSTRACT

Background: Minimally invasive cardiac operations (MICOs) are reported to reduce procedural costs while at the same time decreasing operative morbidity and improving patient comfort. However, most of the cost data available for minimally invasive cardiac procedures is limited to short-term, peri-procedure, in-hospital costs. The scarcity of data to support claims for long-term cost-effectiveness prompted our interest in pursuing this research.

Methods: Cost-effectiveness analysis was used to estimate the monetary cost required to achieve a gain in health benefit. We reviewed the literature to accumulate all available relevant cost data regarding MICO in order to apply the principles of cost-effectiveness analysis to this relatively new procedure. For purposes of the analysis, two assumptions were made: (1) MICOs have a less favorable long-term survival outcome than does conventional coronary artery bypass grafting using cardiopulmonary bypass (CABG), and (2) the reintervention rates and long-term costs resulting from MICOs are similar to those of percutaneous transluminal coronary angioplasty with intracoronary stenting (PTCA/stenting).

Results: The average procedural costs from published literature were $13,782 for PTCA/stenting, $16,082 for MICO, and $23,938 for CABG. The cost-effectiveness of CABG and MICO were compared using PTCA/stenting as a standard of comparison. These estimations suggest that MICO is less cost-effective than CABG ($112,200 per year of life saved by MICO and $56,280 per year of life saved by CABG).

Conclusions: Usable data to provide accurate cost-effectiveness estimates for MICO is scarce. Preliminary estimates based on available data suggest two means of improving the cost-effectiveness of MICO. First, technical advances that improve the quality of MICO (e.g., improved patency rates for mammary anastomoses and complete revascularization strategies) will decrease the reintervention rates and out-of-hospital costs. Second, application of MICO to a high-risk subset of patients who will experience improved survival compared to other alternatives will improve cost-effectiveness by prolonging life for those patients. Therefore, in order to be cost-effective, MICOs must obtain high quality results, including complete revascularization, and must be used primarily in high-risk patients.

Address correspondence and reprint requests to: Victor A. Ferraris, MD, PhD, Tyler Gill Professor of Surgery and Chief, Division of Cardiovascular and Thoracic Surgery, University of Kentucky, Chandler Medical Center, Suite C-208, 800 Rose Street, Lexington, KY 40536-0084, Phone: (859) 323-6494, Fax: (859) 257-4682, Email: Ferraris@earthlink.net

INTRODUCTION

Minimally invasive approaches to cardiac operations have stirred a revolution in the field of heart surgery, including an explosion of information on the Web, as witnessed by the following websites devoted to discussion of this and related subjects: http://cvsurg.med.nyu.edu; http://www.vh.org/Patients/IHB/Surgery/Cardio/HeartSurgery/HeartSurgery.html; http://www.rapidcontent.com/realestate/chn/980521.x.0.heartdis.p.a.minsurgery.html; http://www.americanheart.org/Scientific/statements/1996/1115.html. Supporters of minimally invasive procedures claim significant improvements in patient comfort, lower procedural costs, and decreased operative morbidity [King 1997, Del Rizzo 1998, Magovern 1998, Arom 1999]. No controlled, randomized comparison of minimally invasive procedures with either percutaneous revascularization techniques or conventional operative revascularization using cardiopulmonary

Table 1. Possible outcomes from cost-effectiveness comparison of a new therapy to an established therapy.

Cost-effectiveness scenario	Cost	Efficacy	Desirability from Society Perspective
1	↑	↑	Uncertain – depends on amount of increased cost per QALY.
2	↓	↑	Good – new intervention is both more effective and cheaper.
3	↓	↓	Ethical dilemma – depending on resource availability, the less costly option may represent best therapy, particularly from managed care perspective.
4	↑	↓	Bad – more costly option is less effective therapy.

bypass exists. Because this controlled information is lacking, surgeons have either supported or shunned this new methodology largely based on intuition [Ullyot 1996]. Health care payors have embraced these minimally invasive cardiac procedures for reasons more related to short-term cost savings than to documented real, long-term patient benefit. Because of these factors, the number of minimally invasive cardiac procedures, especially off-pump coronary artery revascularization, has increased geometrically.

Available estimates indicate that direct medical care accounts for only about 10-15% of the declines in premature deaths that have occurred in this century. The remainder of decreased mortality is attributable to factors that prevent illness. This suggests that many technological advances may exceed their ability to deliver genuine health gains, at least on a population-wide basis. Unfortunately, advancements in technology consume resources. Because the cost-effectiveness of minimally invasive cardiac procedures is not known and because minimally invasive procedures are likely to account for an increasing portion of the health care dollar, a careful cost analysis of minimally invasive cardiac procedures is indicated. This article reviews available information on cost-effectiveness of minimally invasive cardiac procedures.

MATERIALS AND METHODS

In 1993, the Public Health Service convened a panel of experts to assess the current state of cost-effectiveness analysis (CEA) and to provide recommendations to improve the quality and increase comparability of cost-analysis studies [Gold 1996]. The publication and dissemination of these expert recommendations resulted in a more standardized approach to the assessment of cost-effectiveness of health care interventions. These recommendations also allow assessment of return on investment of health care dollars from spending on a new intervention or even a preventative intervention.

Principles of Cost-effectiveness

The goal of cost-effectiveness analysis is to estimate the monetary cost required to achieve a gain in health benefit. This involves calculating a ratio of cost associated with an intervention divided by the benefit provided by that intervention. In calculating the cost-effectiveness ratio, cost is usually measured in dollars. Health benefit may be expressed in either dollars saved or, more commonly, in disease specific terms such as prolonged years of life, strokes prevented, etc.

Very few health care institutions in the United States have true cost accounting systems that allow direct procedural costs to be computed. Hence, the direct cost of an intervention is difficult to determine. Hospital charges are often used as a surrogate of cost. A cost-to-charge ratio is used to estimate the direct cost of an intervention. Charges may not reflect true costs, and comparisons made solely on charge data must be viewed with caution [Finkler 1982, Cohen 1993]. Other costs that are difficult to measure and often overlooked include indirect costs (e.g., home health services, time off of work, travel and housing expenses for family, etc.) and intangible costs (physical and emotional pain and suffering). For all of these reasons, procedural costs are estimates of the true cost, not exact values.

In comparing the cost-effectiveness of a new procedure such as minimally invasive coronary revascularization to that of an established procedure such as conventional coronary artery bypass grafting (CABG) using cardiopulmonary bypass, there are four possible outcomes (Table 1). Any therapy that reduces costs without compromising efficacy is cost-effective (scenario 2 – Table 1). As long as all costs are considered, the new therapy is likely to be beneficial to society as a whole. Conversely, a new therapy that is both more costly and less efficacious is bad for society (scenario 4). The dilemma arises when the new therapy is more costly and more efficacious (scenario 1). Goldman and co-authors suggest that an incremental cost-effectiveness ratio of less than $20,000 per quality-adjusted life year (QALY) may be an acceptable price to pay for new therapy or technology from the public perspective [Goldman 1992]. On the other hand, a cost of more than $100,000 per QALY is higher than currently accepted standards and is not considered cost-effective for society as a whole. Incidentally, another ethical dilemma arises if the new therapy is both cheaper and less effective (scenario 3). Managed care organizations with limited resources may view the cheaper therapy as better for their patients although not as effective.

Costs of Minimally Invasive Cardiac Operations

A fundamental question exists when analyzing costs of minimally invasive cardiac procedures. To what should minimally invasive procedures be compared? Many minimally invasive coronary artery bypass operations are done in patients with one- and two-vessel disease who might just as easily have a catheter-based intervention. It therefore seems logical to compare minimally invasive operations to percutaneous transluminal coronary angioplasty

Table 2. Costs and/or charges of minimally invasive cardiac procedures compared to catheter-based procedures and to conventional CABG.

Researcher	Costs or Charges	Total patients	OPCAB / MIDCAB	PTCA/stent	Conventional CABG
Lemole, 1999	Charges	67	$14,676	$15,000	$22,817
Campos, 1999	Direct costs only	?	$8,232		$11,684
Arom, 1999	Direct & indirect costs	359	$17,438		$19,551
Hlatky, 1997	Cost to charge ratio (5 yr. cost)	934		$23,183 ($56,225)	$35,710 ($58,889)
King, 1997	Charges	28	$16,134	$10,178	$29,447
Weintraub, 1995	Cost to charge ratio – 3 yr. cost	384		$25,458	$31,033
Cohen, 1993	Cost to charge ratio	300		$13,370	$27,739

(PTCA) or PTCA with stenting. On the other hand, the technical components of minimally invasive cardiac operations are more closely related to conventional CABG. For the purposes of our analysis, we use both PTCA/stenting and CABG as comparison standards for minimally invasive cardiac procedures. By considering two standards of comparison, the complexity of the analysis is multiplied and any conclusions must be viewed as approximations that require confirmation. Nonetheless, analysis comparing minimally invasive cardiac procedures to PTCA and to conventional CABG more closely approaches the real-life clinical decision tree with which society as a whole, and individual clinicians in particular, must come to grips.

RESULTS

Several authors have pointed out that health care costs are initially higher with conventional CABG interventions than with PTCA/stenting but that costs tend to equalize with increasing time after the procedure [Weintraub 1995, Hlatky 1997]. This is related to the increased frequency of additional procedures required in PTCA/stent patients compared to CABG patients.

Other authors have questioned the quality and durability of arterial anastomoses done with minimally invasive techniques [Ullyot 1996, Wiklund 2000]. It is possible that minimally invasive procedures will require a 10-15% rate of reintervention as compared to lesser rates for conventional CABG and greater rates for PTCA/stenting. The greater reintervention rate for minimally invasive procedures increases the long-term costs of the procedure to a point close to PTCA/stenting. From a cost-effectiveness point of view, the post-procedure out-of-hospital costs associated with minimally invasive procedures may make this intervention less attractive than other alternatives. The reintervention rate and out-of-hospital costs for minimally invasive revascularizations will remain high if only one- and two-vessel bypass procedures are done exclusively. This strategy places the reintervention rate for minimally invasive cardiac operations close to that of PTCA/stenting.

Table 2 (◎) lists the cost data available in the literature for the various revascularization alternatives. Two studies, in particular, illustrate the incremental cost associated with out-of-hospital reinterventions for CABG and for PTCA/stenting [Weintraub 1995, Hlatky 1997]. In one of these studies, the procedural cost of PTCA/stenting was $23,183 compared to a cost of $35,710 for CABG [Hlatky 1997]. These costs were increased to $56,225 and $58,889 at five years for PTCA/stenting and CABG respectively. This suggests that procedural costs account for 41% of five-year health care costs related to the intervention while procedural costs for CABG account for 61% of this long-term cost. From a cost-effectiveness point of view, CABG becomes much more attractive as time passes, to the point that one author estimates the cost-effectiveness ratio for CABG at five years following operation to be $26,117 per year of life added [Hlatky 1997]. This estimate is comparable to the cost-effectiveness ratio for conventional CABG calculated in Table 3 (icon).

If one assumes that minimally invasive procedures are more likely to incur long-term costs like those of PTCA/stenting, it is possible to calculate the projected five-year costs associated with each of the three interventions. Table 3 (◎) summarizes the procedural and long-term costs of each of the three revascularization options. Additionally, if one assumes that minimally invasive procedures result in slightly better life expectancy projections than that of PTCA/stenting, it is possible to calculate the cost-effectiveness of these interventions. For the purposes of these cost-effectiveness estimates, it was assumed that minimally invasive procedures result in a 0.05-year longer survival than PTCA/stenting. There

Table 3. Estimated procedural and long-term costs of three revascularization options.

	PTCA/stenting	OPCAB/MIDCAB	CABG
Average procedural costs	$13,782	$16,082	$23,938
Projected five-year costs	$33,614	$39,224	$39,242
Cost-effectiveness ratio (cost per year of life saved compared to PTCA/stenting)	–	$112,200*	$56,280

*Assumes that OPCAB/MIDCAB has similar long-term costs to PTCA/stenting and results in 0.05-year life prolongation.

is no good published data to support this assumption, but it may be a generous presumption in favor of minimally invasive procedures based on the relative good health of patients undergoing these operations. It was assumed that CABG results in a 0.1-year longer survival compared to PTCA/stenting. This assumption is supported by the work of Hlatky and co-authors [Hlatky 1997]. Using these assumptions, it is possible to estimate, in cost-effectiveness terms, the cost per year of life saved for minimally invasive operations compared to CABG (Table 3).

DISCUSSION

Table 3 suggests that the cost-effectiveness of minimally invasive procedures is poor and unattractive to a society that is concerned about escalating health care costs. It must be emphasized that the estimates shown in Table 3 are likely to be imprecise. These estimates rest on two key assumptions: (1) minimally invasive operations result in less favorable long-term survival than do conventional CABG procedures, and (2) minimally invasive operations require similar reintervention rates and long-term costs to that of PTCA/stenting. We feel that these are reasonable assumptions given the scarcity of reliable data. A more definitive answer to these cost-effectiveness issues awaits more accurate data. Nonetheless, the analysis summarized in Table 3 is intriguing and raises important questions about minimally invasive operations.

One strategy of improving the cost-effectiveness of minimally invasive operations is to use these procedures in high-risk patients. If minimally invasive procedures can prolong life to the same or greater extent than conventional CABG, then the cost-effectiveness ratio is shifted in favor of minimally invasive operations. Del Rizzo and co-workers suggest that minimally invasive coronary artery revascularizations are safer in high-risk patients than are conventional CABG procedures [Del Rizzo 1998]. If this is true, and if minimally invasive procedures increase life expectancy compared to CABG or PTCA/stenting in these high-risk patients, then these minimal operations are more attractive from a cost-effectiveness standpoint.

One can speculate from the data in Table 3 that the most costly feature of minimally invasive operations is the out-of-hospital costs, including the reintervention rate. Much of the cost data for minimally invasive operations was generated using early-generation stabilization devices and other first-generation technology. With the advent of new intraoperative stabilization devices and other techniques to improve the quality of the coronary anastomoses, it is likely that the reintervention rate will decrease. This remains an unproven hypothesis and, in fact, a recent publication by Wiklund and co-workers suggests that an even higher need for reintervention may be necessary for minimally invasive coronary revascularization than was previously suspected [Wiklund 2000].

CONCLUSION

Any technological advances that result in better graft patency of minimally invasive coronary operations and decrease the reintervention rate will improve the cost-effectiveness of these procedures. Of course, the reintervention rate and out-of-hospital costs for minimally invasive revascularizations will remain high if only one- and two-vessel bypass procedures are done exclusively. The more complete and high-quality the revascularization that can to be done with minimally invasive techniques, the more cost-effective the procedure becomes.

Our analysis begs for more usable data upon which to draw conclusions. Until this data becomes available, a cautious approach to minimally invasive procedures seems justified.

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REFERENCES

1. Arom KV, Emery RW, Flavin TF, et al. Cost-effectiveness of minimally invasive coronary artery bypass surgery. Ann Thorac Surg 68:1562–6, 1999.
2. Campos CT, Levitsky S. Economic impact of minimally invasive surgery, in Cohen RG, Mack MJ, Fonger JD, et al. (eds.). Minimally Invasive Cardiac Surgery. St. Louis, Missouri: Quality Medical Publishing, Inc., 337–9, 1999.
3. Cohen DJ, Breall JA, Ho KK, et al. Economics of elective coronary revascularization. Comparison of costs and charges for conventional angioplasty, directional atherectomy, stenting and bypass surgery. J Am Coll Cardiol 22:1052–1059, 1993.
4. Del Rizzo DF, Boyd WD, Novick RJ, et al. Safety and cost-effectiveness of MIDCABG in high-risk CABG patients. Ann Thorac Surg 66:1002–7, 1998.
5. Finkler SA. The distinction between cost and charges. Ann Intern Med 96:102–9, 1982.
6. Gold MR, Siegel JE, Russell LB, et al. Appendix A: summary recommendations, in Gold MR, Siegel JE, Russell LB, et al. (eds.). Cost-effectiveness in Health and Medicine. New York: Oxford University Press, 304–11, 1996.
7. Goldman L, Gordon DJ, Rifkind BM, et al. Cost and health implications of cholesterol lowering [see comments]. Circulation 85:1960–8, 1992.
8. Hlatky MA, Rogers WJ, Johnstone I, et al. Medical care costs and quality of life after ran-domization to coronary angioplasty or coronary bypass surgery. Bypass Angioplasty Revascularization Investigation (BARI) Investigators [see comments]. N Eng J Med 336:92–9, 1997.
9. King RC, Reece TB, Hurst JL, et al. Minimally invasive coronary artery bypass grafting decreases hospital stay and cost. Ann Surg 225:805–11, 1997.
10. Lemole GM, Choudhri AF, Oz MC, et al. Economic impact of less invasive cardiac operations, in Oz MC, Goldstein DJ (eds.). Contemporary Cardiology: Minimally Invasive Car-

diac Surgery. Totowa, NJ: Humana Press Inc.:165–172, 1999.
11. Magovern JA, Benckart DH, Landreneau RJ, et al. Morbidity, cost, and six-month outcome of minimally invasive direct coronary artery bypass grafting. Ann Thorac Surg 66:1224–9, 1998.
12. Ullyot DJ. Look ma, no hands! [editorial] [see comments]. Ann Thorac Surg 61:10–1, 1996.
13. Weintraub WS, Mauldin PD, Becker E, et al. A comparison of the costs of and quality of life after coronary angioplasty or coronary surgery for multivessel coronary artery disease. Results from the Emory Angioplasty Versus Surgery Trial (EAST). Circulation 92:2831–40, 1995.
14. Wiklund L, Johansson M, Bugge M, et al. Early outcome and graft patency in mammary artery grafting of left anterior descending artery with sternotomy or anterior minithoracotomy. Ann Thorac Surg 70:79–83, 2000.