Monitoring the Diffusion of a Technology: Coronary Artery Bypass Surgery in Ontario

GEOFFREY M. ANDERSON, MD, AND JONATHAN LOMAS, MA

Abstract: Technology assessment involves not only examining technologies before they are released but also their diffusion into practice once they have been released. In this study we show how basic analysis of a large administrative data set, combined with a review of evidence on effectiveness, can be used as the first step in technology assessment. We analyze the use of coronary artery bypass surgery (CABS) in the province of Ontario, Canada. The annual number of procedures increased 52 per cent over a seven-year period between 1979 and 1985. Large increases in CABS rates in the over-65 population accounted for more than half of this increase in procedures. Increased rates of surgery in the over-65 population are unlikely to be caused by increased prevalence of coronary artery disease and may be the result of a change in clinical attitude toward the use of CABS. This change is discussed in the context of the evidence on the effectiveness and cost-effectiveness of CABS. We conclude that there is a need to carefully monitor and evaluate the use of technologies especially in the elderly. (*Am J Public Health* 1988; 78:251–254.)

Introduction

In recent years there has been increasing interest in assessing the use of medical technologies.[1–3] The purpose of technology assessment is to bring the use of these technologies in line with the available evidence on their efficacy and cost-effectiveness.[4,5] This should involve both careful examination of technologies before their release and monitoring of their diffusion after their release. Monitoring diffusion of a technology involves comparing patterns of use to evidence-based criteria for their appropriate application.

The importance of monitoring the diffusion of new technologies was demonstrated in the recent analysis of the patterns of use of cimetidine. While this drug was shown to be safe and efficacious for the treatment of specific conditions before it was released for use, analysis of the patterns of use after its release indicated that it was administered for additional indications for which there was little or no evidence of benefit.[6,7]

In this article we examine the diffusion of one costly and risky procedure—coronary artery bypass surgery (CABS). The analysis covers a recent seven-year period in the province of Ontario, Canada.

Methods

Ontario had a population of approximately 8.5 million during the study period. Its residents are insured under the Ontario Health Insurance Plan (OHIP) for the cost of the health care service they receive. The physician-to-population ratio in Ontario is similar to that in the United States; physicians are reimbursed through fee-for-service. Neither the method of reimbursement nor the populaton per cardiac surgeon (approximately 95,000) changed significantly during the period under study. The centralized insurance system in the province makes it possible to identify all procedures performed on Ontario residents in the province's hospitals and to estimate the number of procedures received by residents outside the province.

The population figures used in the analysis were supplied to the authors by the Ontario Ministry of Health. The data on procedures were obtained from the Hospital Medical Records Institutes (HMRI). The Institute receives an abstract for each discharge from an acute care hospital in Ontario. The abstract contains information on the patient (age, sex, place of residence) as well as detailed procedural data. The data from HMRI are the source for federal and provincial utilization statistics, and have previously been used to study the patterns of use of other surgical procedures.[8]

Cases were included in the study if a CABS procedure had been performed on an individual who was 20 years of age or older and resided in Ontario. Cases were collected for the years 1979, 1981, 1983, and 1985.

All Ontario residents are covered under OHIP. The plan will reimburse residents for care received outside the province. Analysis by OHIP indicates that less than 2 per cent of CABS procedures received by Ontario residents were performed outside the province.

Results

Patterns of Use of CABS

Table 1 shows that the number of procedures performed increased by 52 per cent between 1979 and 1985; and the rate per 100,000 individuals 20 years of age or older increased by 39 per cent between 1979 and 1983 but appeared to have stabilized by 1985.

The age-specific rates for CABS over the study period are shown in Figure 1. The most notable feature of these age-use curves is the rapid and steady increase in rates in the older populations, particularly the age 65 and over population. The rate in the 65-to-69-year-old age group doubled and the rate in the 70 and older population increased more than five-fold over the study period.

The stabilization of overall rates in the 1983 to 1985 period was the result of decreasing rates in some of the

TABLE 1—Trends in CABS Utilization in Ontario 1979–1985

Year	Number of Procedures	Rate* (Procedures/100,000)
1979	2,434	42.5
1981	2,961	49.9
1983	3,659	59.1
1985	3,711	57.4

*The denominator for these rates is the population 20 years of age or older.

Address reprint requests to Geoffrey M. Anderson, MD, Department of Epidemiology and Community Medicine, University of Ottawa, 451 Smith Road, Ottawa, Ontario Canada, K1H 8M5. Mr. Lomas is with the Department of Clinical Epidemiology and Biostatistics, McMaster University, Hamilton, Ontario. This paper, submitted to the Journal February 4, 1987, was revised and accepted for publication September 10, 1987.

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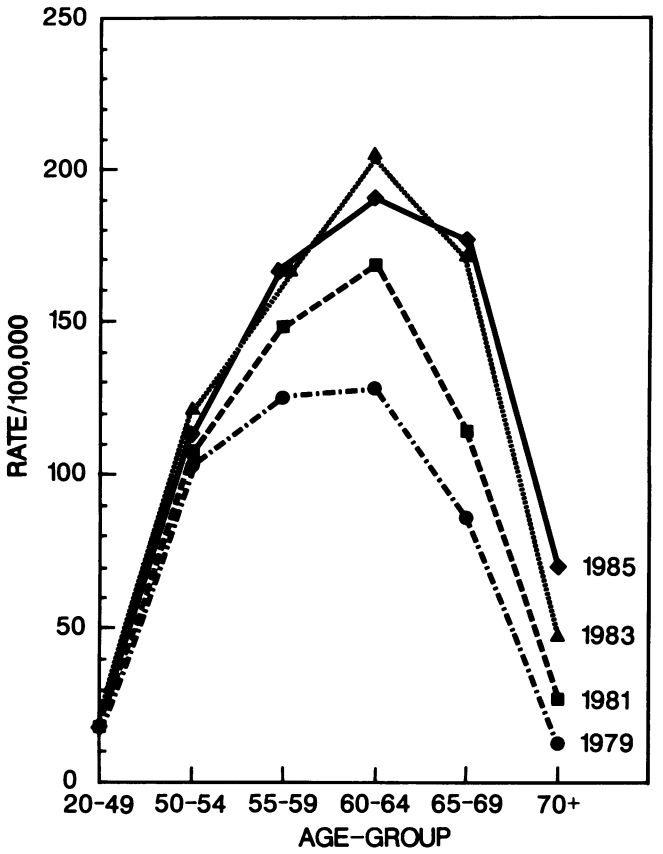

FIGURE 1—Age-specific Rates of CABS, 1979–85

younger age groups compensating for continuing increases in the rates for the very elderly.

The aggregate effects of the increased rates in the age 65 and older population are shown in Table 2. The percentage of procedures performed in the elderly (the term elderly is used to describe the 65 and older population in this paper) more than doubled from 12.8 per cent in 1979 to 27.4 per cent in 1985 and the operations in the elderly accounted for over half of the increase in CABS procedures.

In Ontario, as a result of budgetary and planning policies of the provincial government, CABS has been regionalized to nine hospitals in six metropolitan centers. Table 3 shows the number of procedures performed at each center and the percentage of procedures in each hospital performed on patients who were age 65 or over in the years 1979 and 1985.

TABLE 3—Percentage of Procedures in Persons age 65 and Older by Institution: 1979 and 1985

	Year				
	1979		1985		
Institution	Total Procedures	% in 65+	Total Procedures	% in 65+	Difference (1985–1979)
1	207	11.6	218	19.7	+8.1
2	149	15.4	146	33.6	+18.2
3	145	20.7	199	23.2	+2.5
4	210	13.8	371	27.8	+14.0
5	444	11.5	798	30.2	+18.7
6	180	8.9	262	18.3	+9.4
7	352	11.1	634	27.1	+16.0
8	327	13.8	591	29.6	+15.8
9	420	12.9	492	25.2	+12.3
Total	2,434	12.8	3,711	27.4	

There is a difference in the volume of surgery performed in the institutions but each had an increase in the percentage of procedures performed for the elderly. Therefore, the increased rate of procedures in the elderly cannot be attributed to only one or two hospitals in the province. However, both the size of the increase and the percentage of procedures performed on the elderly varied across the institutions. This may suggest some difference in attitude toward the use of CABS in the elderly among these institutions.

Discussion

Epidemiology of Coronary Artery Disease

An increase in the prevalence of coronary artery disease (CAD) could explain these increased rates of CABS. However, a number of reviews [9–13] indicate that the overall prevalence of CAD has been decreasing steadily in recent years. This trend also appears to be present in the elderly population. Canadian data show that mortality from ischemic heart disease and admissions for myocardial infarction have decreased in the elderly.[12,14] While data on mortality and myocardial infarction rates do not provide definitive evidence regarding the prevalence of CAD, it is unlikely that changes in the prevalence of CAD could explain the rapid increase in CABS rates, particularly given the size of the rate increases noted in this study. In the next section of this paper we briefly review current evidence on the efficacy and cost-effectiveness of CABS—evidence which should guide the appropriate use of this procedure.

Efficacy and Cost-effectiveness of CABS

Coronary artery bypass surgery has been studied in three large randomized trials.[15–17] The results of these trials have

TABLE 2—Trends and Impact of CABS Utilization in Persons age 65 and Over

Year	Number of Procedures in 65+	65+ Procedures as % of Total	% of Total Increase in Procedures Due to Increased Rate in 65+*
1979	311	12.8	—
1981	504	17.0	33
1983	830	22.7	48
1985	1,018	27.4	52

*This percentage is calculated by applying the 1979 age-specific rates to the elderly populations of subsequent years yielding the expected number of procedures if the rates had remained at 1979 levels. This expected number of procedures was subtracted from the observed number to isolate the effect of increased rates in the elderly. The number of such procedures in each year divided by the increase in the number of procedures from 1979 is the proportion of the increase attributable to increased rates in the elderly.

been reviewed extensively and they indicate that CABS can increase the survival of patients in specific sub-groups and can improve the quality of life for many patients in which angina is refractory to medical therapy. Although these randomized trials have been used to define the appropriate indications for CABS, none have included patients who were age 65 or over.

Whatever direct evidence there is for the definition of appropriate indications for CABS in elderly patients has been drawn from non-experimental studies. Until mid-1985 the only direct evidence of the benefit of CABS in the elderly was taken from case series studies of CABS in elderly patients.[18–29] In general, case series designs are subject to several inherent biases.[4] In particular, the failure of any of these studies to include a comparable group of patients treated with medical therapy means that they provide little evidence regarding the relative benefit of alternate therapies.

In 1985, the results of a non-randomized controlled trial of CABS in the elderly were published.[30] This trial concluded that CABS was effective in "specific higher risk subsets of . . . . [patients] 65 years of age or older." The inclusion of a medically treated group in this study does provide some evidence for the relative benefit of CABS. However, the analysis of the evaluation of other technologies has shown that trials which use non-randomized control groups tend to show more favorable effects of new interventions than true randomized controlled trials.[31] Thus, while this study provides some evidence that CABS may be effective in subgroups of the elderly, it does not provide definitive evidence of such benefit. With respect to our analysis of CABS utilization in Ontario, the fact that the results of this trial were not published until the last year of our observation period suggests that this trial would have had little impact on the observed use of the procedure.

Given the lack of direct experimental evidence of the effectiveness of CABS in the elderly, the increased procedure rates observed in this study might be based on the assumption that the effectiveness demonstrated in the non-elderly could be generalized to the elderly. This assumption may or may not be supportable.

The net beneficial effect of CABS over medical therapy involves a trade-off between the higher immediate risk associated with surgery compared to medical therapy, and the longer term benefit of surgery over medical therapy. In order to generalize the results of effectiveness studies in the non-elderly to the elderly, it is necessary to assume that the trade-off is the same in both age groups.

There is clear evidence that surgical mortality is higher in the elderly than the non-elderly.[32] Thus, unless there are equivalent increases in immediate mortality for medical therapies, there is increased risk associated with CABS in the elderly. Further, elderly patients have a shorter life span in which to accrue the long-term benefits of surgery over medical therapy. Thus, the elderly may receive less of a long-term benefit from surgery than the non-elderly. Therefore, the trade-off of short term risk to long-term benefit may well be different in the elderly compared to the non-elderly.

The relationship of net benefit to age is not unique to CABS. Neuhauser and Gilbert demonstrated in a more formal fashion for hernia that, while herniorrhaphy may be the preferred form of treatment in the non-elderly, because of increasing surgical risk and decreasing life span, truss may be the therapy of choice in the elderly.[33,34]

Appropriate use of CABS is determined not only by effectiveness criteria but also in terms of cost-effectiveness. Analysis of the cost-effectiveness of CABS has shown that there are wide variations across indications for surgery in the cost per quality adjusted life year gained. For some indications, the cost-effectiveness ratios may be consistent with overall resource allocation goals, while for other indications they may be inconsistent with these goals.[35] The relationship of age to net benefits indicates that the cost-effectiveness of CABS is likely lower in the elderly than the non-elderly.

Implications

In this paper we have shown that in Ontario the use of CABS has diffused over time from a population of non-elderly patients, in which there is clear evidence of benefit in selected patients, to an elderly population, in which the evidence of benefit is less clear.

The pattern of diffusion of CABS noted in this study is reflected in the experience in the United States. Over roughly the same time period as this study, there was even a larger percentage increase in the number of CABS performed in the United States.[36] In Ontario in 1983, 23 per cent of CABS procedures were performed on patients who were over age 65; in the same year in the United States, 37 per cent of the procedures were performed for this age group.[37]

The observation of an apparent change in clinical policies toward the use of CABS in the elderly without solid evidence of efficacy and cost-effectiveness to support such a change is grounds for concern. This observation does not mean that CABS may not benefit certain subgroups of elderly patients. It simply suggests that there is a need to carefully consider what the appropriate indications might be for the use of this costly procedure in patients who are 65 years of age or older.

The finding that limiting access to the technology through regionalization and centralized cost control, as found in Ontario,[38] may modify but cannot control the diffusion process, might indicate that successful interventions into health care system organization have to be more focused.

The central issue with CABS, as with many other surgical procedures, is that there are very few data available on the benefits of these procedures in the elderly. If we are to develop specific indications for the use of surgical procedures in the elderly, we must either generalize results from non-elderly populations or gather evidence in randomized controlled trials in the elderly. As discussed above, the generalization of evidence of the benefits of surgical procedures from non-elderly to elderly populations may not be justifiable. The large number of CABS performed on the elderly indicates that, if the medical profession would support it, a randomized controlled trial could enroll the requisite number of patients in short order. The results of such a trial could be used to define the appropriate indications for CABS in the elderly.

Monitoring of the diffusion of technologies can be accomplished through the use of large population-based data sets such as used in this and other studies.[39] Analysis of large administrative data sets may well be an effective way to identify targets for more clinically detailed but more expensive chart-based assessment.[40] Alternatively, if the medical profession is unwilling to support the type of randomized trials suggested above for CABS, then administrative data sets could be improved in order to permit more detailed, outcome-based, analysis.[41,42] The results of such "observational trials" might then persuade the profession of the advisability of a full randomized controlled trial for the area in question. Monitoring involves not only collecting data but

also identifying factors related to utilization and comparing utilization patterns to evidence of effectiveness.[43] Monitoring can be used to determine if utilization is in line with evidence on effectiveness and cost-effectiveness, and can lead to reassessment of the use of the technology by the medical profession.[44]

Diffusion of technologies is a dynamic process which is worthy of careful monitoring, particularly in high-use groups such as the elderly. Monitoring can help focus future research efforts and can provide a useful guide to the development of rational health care policies at both the aggregate and clinical levels.

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