SURGERY FOR ACQUIRED HEART DISEASE

IS REFERRAL SOURCE A RISK FACTOR FOR CORONARY SURGERY? HEALTH MAINTENANCE ORGANIZATION VERSUS FEE-FOR-SERVICE SYSTEM

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We began performing coronary artery bypass grafting for a large health maintenance organization (HMO) in 1974, as the sole provider of their cardiac surgery. The outcomes of our HMO group of patients were compared with those of our patients treated on a fee-for-service (FFS) basis. The HMO system entails preintervention and multidisciplinary screening conferences and is devoid of self-referral and personal financial incentives. Since 1985, the operative mortality for HMO patients has been consistently lower than for FFS patients. There were 8483 operations during this study period: 3168 (37%) were in the HMO group, with an overall operative mortality of 2.7%, and 5315 (63%) were in the FFS group, with an operative mortality of 4.6% ($p = 0.00002$). This difference was investigated with univariate and multivariable analyses. Sixteen factors were found to univariately affect the risk of operative mortality; for five of these risk correlates there was a significant maldistribution between the HMO and FFS patients. Logistic regression was used to explore the influence of this imbalance in risk factors. The model found seven independent risk factors (left ventricular failure, emergency coronary bypass, redo bypass, nonuse of the internal thoracic artery, unstable angina, age, and diabetes) that significantly affected operative mortality. The FFS group variable closely approached independent risk significance at $p = 0.059$. This multivariable model explained only one third of the observed differences in actual mortality between the HMO and FFS groups. The system-wide angioplasty/coronary bypass ratio, which could not be used in a patient-specific model, was 0.6 in the HMO system and 1.5 in the FFS group. Other factors related to the operating structure of a mature, large HMO may account for the remainder of the difference. The HMO referral system, through a powerful selection process, resulted in fewer emergencies, redo bypass operations, and catheterization complications that, in turn, yielded lower operative mortality than a noncoordinated FFS system of cardiovascular management. (J THORAC CARDIOVASC SURG 1996;111:708-17)

Political and economic market forces of the past decade have powered major changes in the provision of health care in the United States. This

health care reform has been made evident by the constantly increasing market share of managed care and capitated delivery systems, with the pure private practice, fee-for-service (FFS) structure playing an ever diminishing role. Health maintenance organization (HMO) coverage grew from 8.3% of all hospital admissions to 17.0% between 1983 and 1988 in California.¹ This explosive growth of managed and capitated health care systems has since

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Read at the Seventy-fifth Annual Meeting of The American Association for Thoracic Surgery, Boston, Mass., April 23-26, 1995.

Received for publication April 27, 1995; revisions requested July 25, 1995; revisions received Dec. 12, 1995; accepted for publication Dec. 18, 1995.

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0022-5223/96 \$5.00 + 0 12/6/71254

spread to almost all other regions of the United States.

The restructuring of medical delivery into highly managed, clinically coordinated systems carries with it significant medical and socioeconomic questions concerning the benefits and risks of such a change in the process of disease treatment. Namely, does a coordinated process of disease management, with redirected financial incentives, provide an indirect method of rationing that may inherently alter the morbidity and mortality of the treatment of a particular disease?

Cardiovascular sector risk contracting growth, as exemplified by Medicare statistics, has mirrored the health care market changes with a fivefold growth to 6% over the past 10 years.² Even more striking is the progressive nature of cardiovascular health care delivery in the Pacific Northwest. This is exemplified by the Cardiology Preeminence Roundtable report,² which noted that 64% (10 times the national average) of all Medicare cardiovascular services in Portland, Oregon, in 1993 were capitated. Managed systems have gradually ascended to prominence in our geographic market over the past 15 years. Thus an unusual opportunity has presented itself during this transition—to test the hypothesis that a managed system of cardiovascular health care results in an altered risk to patients undergoing treatment for heart disease as compared with a pure FFS system.

Our cardiac surgical group has performed coronary artery bypass graft (CABG) operations at Providence St. Vincent Hospital and Medical Center in Portland, Oregon, since 1968. In 1974, we became the exclusive provider of cardiac surgical services to Kaiser Permanente Health Maintenance Organization in Oregon and Washington. These surgical services were provided at the same institution and with the same group of surgeons that concomitantly maintained an active tertiary referral, private FFS practice. By 1985, annual CABG volumes had increased to levels large enough to allow valid comparisons between the HMO and FFS groups. Annual review has shown that CABG operative mortality has been consistently lower in the Kaiser HMO group of patients over the past 10 years.

The purpose of this investigation was to test the hypothesis of HMO-altered CABG risk described earlier and elucidate the pertinent patient- and system-related variables contributing to this difference.

Fig. 1. Number of CABG operations per year since 1974, the first year of our HMO experience.

Patients and methods

Patients. A total of 14,416 CABGs were performed at Providence St. Vincent Hospital and Medical Center between January 1974 and March 1994. All patients were operated on by the same surgical group in a common hospital setting. In 1985, the number of HMO CABGs per annum rose above 200 for the first time and has grown gradually (Fig. 1). Thus we chose the decade between January 1985 and March 1994 as the study period for a comparative analysis between outcomes of patients having CABG in an HMO or FFS setting.

Demographic, catheterization, operative, perioperative, and follow-up data were extracted from our cardiac surgery outcomes database, which has been in active existence since 1972. This database is constantly updated with new patient and follow-up patient information. Non-surgical, myocardial infarction, admission, and death rates in 1992 and 1993 were obtained from the Kaiser Permanente and St. Vincent medical records centers.

Definitions

Catheterization complications. Catheterization complications were defined as problems in the catheterization laboratory that necessitated urgent or emergency CABG. These included (1) percutaneous transluminal coronary angioplasty (PTCA) or attempted PTCA resulting in a myocardial infarction or circulatory instability, chest pain, or hypotension or (2) direct intracoronary thrombolytic therapy resulting in a myocardial infarction or circulatory instability.

History of PTCA. Any patient who had had PTCA before the present admission was considered to have a history of angioplasty.

Elective CABG. An elective operation is one that is performed on a patient with cardiac ischemia that is stable in the days or weeks before the operation. Patients receiving an elective operation need not remain in the hospital in the interval between cardiac catheterization and the CABG operation.

Urgent CABG. Any patient who does not have to go to the operating room on an emergency basis but requires CABG on the basis of medical necessity before discharge is considered to need urgent CABG. The patient must have unstable symptoms or critical anatomy and may require intravenous intervention (e.g., nitroglycerin, hep-

Fig. 2. Operative mortality per year since 1985, the first year our HMO CABG procedures numbered greater than 200.

arin, or inotropic support) for stabilization before the operation. These patients do not fit into the elective or emergency categories.

Emergency CABG. An emergency operation is one in which there should be no delay in providing operative intervention. Patients requiring an emergency operation will have ongoing, refractory, unrelenting cardiac compromise, with or without hemodynamic instability, and are not responsive to any form of therapy except cardiac surgery.

Most other variable definitions are self-explanatory.

Data analysis. Statistical Package for Social Sciences (SPSS, Inc., Chicago, Ill.) statistical software was used to analyze all data. All results are expressed as mean $\pm$ standard error of measurement. Univariate comparisons were performed with two-tailed *t* tests for continuous variables and Pearson's χ^2 statistic for categorical variables. Bonferroni's correction for multiple analyses was applied to all univariate analyses by dividing the resultant *p* value by the total number of different comparisons between any two groups.

Multivariable analyses were performed by means of a forward stepwise logistic regression. To assess the fit of the resultant model, we used two methods of analysis, both of which can be portrayed graphically. These methods assess different properties of the model: one is called calibration³ or reliability^{4,5} and the second is called discrimination^{4,5} or resolution.⁶ The first measures the ability of the model to assign appropriate risk. It is usually evaluated by dividing the patients into groups according to expected risk and comparing the expected mortality to the mortality actually observed in those groups. The second measures the model's ability to discriminate among those who die or live and can be summarized by an ROC (receiver operating characteristic) curve.

Results

A total of 8483 CABGs were performed during the study period. Kaiser HMO patients accounted for 37% of the operations, with FFS patients making

up the remaining 63%. Annual operative mortality was consistently lower for the HMO patients throughout the study period (Fig. 2). Overall mortality was significantly lower in the HMO group (2.7%; 86/3168) than in the FFS group (4.6%; 242/5315; $p < 0.0005$).

A comparison of the demographic and medical characteristics of these two study groups (Table I) reveals that most patient-related variables such as age, gender, and the incidence of diabetes, hypertension, and previous infarction are strikingly similar. Likewise, most cardiac comorbidities are also closely matched, including the incidence of left ventricular failure, left main trunk disease, acute myocardial infarction, and the number and type of CABGs used. In addition, although a higher proportion of FFS patients were operated on early in the study period, the mean date of operation for the two groups was not different. However, some very important differences remain between the HMO and FFS populations. The HMO group had significantly lower rates of redo and emergency CABG operations and lower incidences of previous PTCA and catheterization laboratory complications. Note that the HMO group also had a lower mean ejection fraction.

Univariate analyses of these variables revealed several potential correlates of operative mortality (Table II). Many of these correlates of mortality concur with previously published independent CABG risk factors, including age greater than 70 years,⁷⁻⁹ female gender,^{7,8} diabetes,⁷ redo CABG,^{7,10} left main trunk disease,¹¹ left ventricular failure,⁷ acute myocardial infarction,^{8,12} emergency operation,^{10,13} preoperative use of an intraaortic balloon pump,^{7,12} and nonuse of the left internal thoracic artery.¹⁰ Interestingly, both a history of PTCA and hyperlipidemia were shown to be protective *against* CABG mortality.

Univariately significant variables were then used in a series of multivariable regression analyses to determine which factors were independent predictors of operative mortality. This series of tests began with many variables and few patients. The least significant variables at the end of each run were progressively excluded to gain a larger number of patients with complete sets of data available for inclusion in the model. The final regression model (Table III) included 3686 (43%) of the 8483 study patients. No significant demographic differences were observed between excluded patients (with one or more missing risk factors) and those patients included in the final model. As shown in Table III, this model revealed that left ventricular failure,

Table I. Patient characteristics: HMO versus FFS

Variable	HMO	FFS	p Values	
			Nominal	Significant
No. of Patients	3168	5315		
Demographics				
Mean age (yr)	64 ± 0.2	65 ± 0.1	0.0328	
Male gender (%)	73 ± 1	75 ± 1	0.0501	
History				
Cardiomegaly (%)	11 ± 1	10 ± 1	0.0937	
Diabetes (%)	23 ± 1	20 ± 1	0.0037	
Family history of CAD (%)	43 ± 1	48 ± 1	0.0008	Yes
Hypertension (%)	49 ± 1	50 ± 1	0.2588	
Hyperlipidemia (%)	26 ± 1	27 ± 1	0.4799	
Thrombolysis (%)	5.2 ± 0.4	4.3 ± 0.3	0.0422	
Digitalis plus diuretics (%)	3.1 ± 1	3.4 ± 1	0.5812	
Previous MI (%)	29 ± 1	30 ± 1	0.2406	
Previous CABG (%)	12 ± 1	18 ± 1	0.0000	Yes
Previous PTCA (%)	7.1 ± 0.4	9.3 ± 0.4	0.0004	Yes
Catheterization information				
Ejection fraction (%)	56 ± 0.6	60 ± 0.3	0.0000	Yes
Wall motion abnormality (%)	44 ± 4	53 ± 3	0.0000	Yes
Mean No. of diseased arteries	2.7 ± 1.7	2.6 ± 1.3	0.0001	Yes
Left main disease (%)	20 ± 1	20 ± 1	0.9911	
Indications				
LV failure (%)	1.8 ± 0.3	2.6 ± 0.3	0.0677	
Acute MI < 30 days (%)	14 ± 2	16 ± 2	0.1582	
Stable angina (%)	42 ± 3	45 ± 2	0.0206	
Elective (%)	86 ± 0.7	81 ± 0.6	0.0000	Yes
Emergency (%)	6.5 ± 0.5	10.4 ± 0.5	0.0000	Yes
Catheterization complication (%)	2.7 ± 0.4	6.8 ± 0.5	0.0000	Yes
Surgical factors				
Mean year of operation	1990.0 ± 0.05	1989.8 ± 0.04		
Preop IABP (%)	0.9 ± 0.4	2.7 ± 0.5	0.0071	
ITA used (%)	57 ± 0.9	56 ± 0.7	0.2074	
Mean No. of grafts	2.7 ± 0.02	2.7 ± 0.01	0.9983	

CAD, Coronary artery disease; MI, myocardial infarction; LV, left ventricular; IABP, intraaortic balloon pumping; ITA, internal thoracic artery.

*Univariate analyses with Bonferroni correction applied to determine significance. The *p* value required for significance = 0.05/25 = 0.0020.

emergency operation, redo CABG, nonuse of the internal thoracic artery, unstable angina, age, and diabetes were independent predictors of perioperative CABG mortality. In this multivariate analysis, FFS was not a significant independent predictor of risk but showed a strong trend toward significance, with a *p* value of 0.059 in the final model. Among the 3686 patients included in the final regression model, the operative mortalities of the HMO and FFS subgroups of patients were 2.6% (33/1279) and 4.1% (98/2407), respectively (*p* < 0.02).

The clinical outcome deviance (the negative of 2× the log likelihood) decreased from 1132 for the null model (step 0 of the multivariable regression) to 924 for the final regression model (step 7). This

difference of 208 was highly significant (*p* < 0.00001, with 7 degrees of freedom), indicating that the model did improve the ability to predict outcome. However, this particular model decreased the original deviance by only 18%. Thus other important variables not included in the model contribute to mortality. This result is not uncommon, in a pragmatic sense, for a predictive clinical outcomes model.

Indices of calibration and discrimination were used to assess the predictive accuracy of the logistic regression model. The patients were divided into ten groups of approximately equal numbers on the basis of the deciles of estimated operative mortality. Fig. 3 compares the average estimated mortality (*horizontal axis*) with the observed mortality (*vertical axis*)

Table II. Operative mortality by patient characteristics

Variable	Mortality		p Values	
	Present (%)	Absent (%)	Nominal	Significant
FFS patient	2.7	4.6	0.0000	Yes
Age >70 yr	6.2	2.7	0.0000	Yes
Female gender	5.3	3.4	0.0000	Yes
History				
Cardiomegaly	7.7	3.0	0.0000	Yes
Diabetes mellitus	5.1	3.5	0.0022	Yes
Family history of CAD	3.2	3.9	0.1539	
Hypertension	4.3	3.3	0.0135	
Hyperlipidemia	2.6	4.3	0.0003	Yes
Thrombolysis	5.1	3.8	0.1899	
Digitalis plus diuretic	6.9	3.8	0.0271	
MI	4.4	3.6	0.0879	
Previous CABG	7.5	3.2	0.0000	Yes
Previous PTCA	1.4	4.1	0.0004	Yes
Catheterization information				
Wall motion abnormality	4.8	2.3	0.0000	Yes
Left main trunk	6.0	3.5	0.0013	Yes
Indications				
Left heart failure	15.1	3.4	0.0000	Yes
Acute MI (<30 days)	8.5	3.3	0.0000	Yes
Unstable angina	5.4	1.7	0.0000	Yes
Emergency operation	12.0	2.8	0.0000	Yes
Catheterization complication	11.2	3.5	0.0000	Yes
Surgical factors				
Preop. IABP	44.4	3.6	0.0000	Yes
ITA used	1.8	6.6	0.0000	Yes

CAD, Coronary artery disease; MI, myocardial infarction; IABP, intra-aortic balloon pump; ITA, internal thoracic artery.

*Univariate analyses with Bonferroni correction applied to determine significance. The *p* value required for significance = $0.05/22 = 0.0023$.

within each group. The value of the Hosmer-Lemeshow test statistic¹⁴ was 0.77, indicating a good fit to the data. Fig. 4 contains the ROC curve derived from the model. The area under the curve (called the c-index) of 83% measures the probability that a randomly chosen death would have a higher expected mortality than a randomly chosen survival.

Long-term follow-up was completed between 1992 and 1994 on 6532 (77%) patients at a mean of 30 months after the operation. Kaplan-Meier survival analysis (Fig. 5) revealed no significant difference (*p* = 0.09) between the HMO and FFS patient populations through 9 years after the operation. Thus, despite a reduction in perioperative mortality, the HMO selec-

Table III. Multivariable risk factor analysis

Risk factor	p Value	Odds ratio		
		Point Est.	95% CI	β -coefficient
LV failure	0.0000	4.5	(2.2, 9.1)	1.5
Emergency operation	0.0000	4.3	(2.8, 6.9)	1.5
Previous CABG	0.0000	3.1	(2.0, 4.7)	1.1
ITA not used	0.0000	2.7	(1.7, 4.2)	0.98
Unstable angina	0.0001	2.5	(1.6, 4.0)	0.93
Age (per decade)	0.0000	1.9	(1.5, 2.3)	0.62
Diabetes	0.0190	1.6	(1.1, 2.5)	0.50
FFS	0.0599			None

CI, Confidence interval; LV, left ventricular; ITA, internal thoracic artery.

tion process had no significantly demonstrable effect on long-term CABG outcomes in operative survivors.

Discussion

The implication that the type of health care system in which cardiovascular services are provided may itself affect the short-term outcome of coronary revascularization is indeed provocative. To try to understand the mechanism of such an alteration in risk, one must dissect the respective paradigms of cardiovascular management in each system.

HMO system. The Kaiser HMO system uses an integrated approach to the delivery of cardiovascular services. The cardiac section is a high-volume service, experienced in the methods of coordinated care. Characteristics integral to this approach are as follows:

- A prospective interdisciplinary triage conference for *all* prospective cardiovascular interventions, both surgical and interventional, is mandatory.
- Retrospective case reviews are for emergencies only.
- A standard treatment protocol is in place for the selection of patients for surgery and PTCA (see appendix).
- Surgical referral is to a group of surgeons as a whole rather than to a specific individual surgeon.
- Cardiologic self-referral for PTCA is nonexistent. All PTCA cases are passed through the interdisciplinary triage conference to a third-party invasive cardiologist. This cardiologist is specifically employed to perform all catheterization laboratory interventions for the HMO group of patients.

FFS system. Providence St. Vincent Hospital and Medical Center is a high-volume tertiary cardiac referral center with one cardiothoracic surgical group and up to 10 individually practicing cardiolo-

Fig. 3. Calibration assessment of the logistic regression model: expected versus observed mortality for deciles of expected risk.

gist groups during this study period. Thus cardiovascular services are provided in a nonintegrated, disparate management system in which FFS reimbursement predominates. In contrast to the HMO, the FFS system characteristics include the following:

- There is no prospective interdisciplinary triage conference for surgical, interventional, or medical therapy.
- Retrospective and anecdotal case analysis is reserved for quality improvement only.
- Treatment protocols are cardiologist specific, not written down, and may dynamically vary over time.
- Referrals are surgeon specific and are subject to the cardiologist's discretion.
- Cardiologists may self-refer cases for PTCA without prior case review.

Coordination, redirected financial incentives, and mandatory triaging of HMO patients requiring CABG or PTCA drive a selection process that results in a CABG patient population that is significantly and clinically different from the FFS cohort. Two of these differences—emergency operation and redo CABG—directly contribute, as strong inde-

pendent factors, to a lower CABG mortality in the HMO group.

Although referral source, per se, was not found to be a strict independent predictor of mortality in this model, it is highly likely that it would come into the equation with more complete data by allowing a larger multivariable cohort for analysis. The FFS “risk factor” is the only univariate factor that “trends” toward significance, with a *p* value of 0.059. Thus more patients with similar characteristics would eventually bring the *p* value of FFS as an independent risk factor below the strict 0.05 cutoff.

Using the multivariate model described herein, one can compare the predicted and actual mortalities in the two cohorts. The predicted mortalities for the FFS and HMO groups are 3.7% and 3.2%, respectively, giving a *predicted* difference of 0.5%. The actual mortalities in the same cohorts were 4.1% and 2.6%, respectively, for an *actual* mortality difference of 1.5%. Thus the multivariate model fails to account for a full 1.0%, or two thirds of the total (1.0%/1.5%) mortality difference. This unaccounted mortality difference favors the HMO group and further suggests the eventual inclusion of FFS as a strict independent risk factor.

Fig. 4. Assessment of the discrimination of the logistic model (ROC curve).

Fig. 5. Kaplan-Meier survival curves for HMO and FFS CABG patient groups.

A possible contributor to this unaccounted mortality difference is the discrepancy in the use of PTCA between the FFS and HMO systems (Fig. 6). There is a profound difference in the ratio of PTCA/CABG use between the FFS and HMO systems (1.5 vs 0.6, $p < 0.00001$). This factor could not be directly entered into the analysis of risk for CABG because it pertains to each system's cardiac population as a whole and not to any individual patient. Nonetheless, possible overuse of PTCA in the FFS system, catalyzed by self-referral, direct financial incentives, and possible direct referral of

high-risk PTCA cases to this tertiary center, may indirectly affect CABG mortality. This is likely through an increased incidence of both catheterization complications and emergency operations in patients having PTCA.

The Kaiser HMO practice guidelines for selection of patients for CABG and PTCA are similar to those of the Coronary Artery Surgery Study randomized prospective study, which have the potential to delay surgery in *some* patients with ischemia. However, the highly honed HMO selection process for interventional cardiac procedures did *not* result

in a higher mortality from nonsurgical myocardial infarction in the Kaiser HMO group as a whole. The most recent data available from the Kaiser HMO and St. Vincent Hospital show similar mortality from myocardial infarction admissions in both 1993 (7.3%, 50/682 vs 7.1%, 54/758) and 1994 (7.2%, 52/724 vs 8.3%, 60/724), respectively. Therefore, the reduction in CABG mortality through the HMO selection process was not achieved at the expense of a higher mortality resulting from medically treated myocardial infarctions.

Limitations of this study include the comparison of a finite population (Kaiser HMO) with an indefinite population lacking a known denominator. Thus, although the mortality from myocardial infarction is similar, one cannot compare the incidence of myocardial infarction between the two population groups. Furthermore, St. Vincent Hospital and Medical Center has long been a tertiary cardiac referral center whose cardiologists and surgeons accept difficult cases from a four-state area. This referral group, which tends to be high risk, could easily skew the results against the FFS cohort. However, the independent risks associated with this referral group should be factored out by the multivariable regression analysis.

Despite these limitations, this analysis leads to the inescapable but provocative conclusion that referral source contributes to clinical and population differences that combine to produce a lower mortality in a coherently managed group of patients needing CABG. This suggests that the coordination that occurs between the primary care physician, internist, cardiologist, and surgical team provides a safer pathway for patient movement through a cardiovascular service that culminates in the application of coronary revascularization. This continuity of care is the hallmark of a coordinated system which, through a variety of factors, reduces the mortality of coronary revascularization. Coordination, redirected financial incentives, and mandatory triage are the cornerstones of this system.

The importance of this conclusion is that it argues against the concept that capitated delivery of health care is primarily focused on reducing use and thereby is not beneficial to the patient. On the contrary, we have shown that Kaiser HMO participation may have been protective against CABG mortality. Coordinated, coherent cardiac care may certainly be possible in an FFS system, outside of an HMO format, that may achieve similar benefits to those provided by a tightly managed HMO structure.

Fig. 6. Use of CABG and PTCA for HMO and FFS groups by year. Top two lines = FFS system; bottom two lines = HMO system.

Nevertheless, in this limited experience, a managed system of cardiovascular health provision results in a lowered risk to patients undergoing treatment for heart disease as compared with a pure FFS system.

We thank Skip McGinty and his staff for providing Kaiser Permanente patient data; Andrew Bennett, Avis Ostrem, and Carolyn Bingham for providing Providence St. Vincent Hospital patient data; and Natasha Pfeifer, Cindy Fessler, Deborah Gannon, and Jill Grunkemeier for assistance and preparation of the manuscript.

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Discussion

Dr. Thomas A. Pfeffer (*Los Angeles, Calif.*). You are probably in a unique position to perform a comparison such as this because you have a large number of patients in both the FFS and HMO settings.

At Southern California Kaiser Permanente, which is the largest HMO in Southern California, we have, I think, carried your coherent system one stage further in that there is no contract with an outside hospital for cardiac procedures. All adult cardiac operations are performed in house by four senior cardiac surgeons, excluding the San Diego region, and all pediatric cases from Southern California, including San Diego, as well as from Hawaii, are performed in house.

There is no financial incentive for the surgeons or the cardiologists to perform procedures; on the other hand, this is not a managed care system in which there is a potential for financial disincentive or for a potential gatekeeping system possibly restricting access to procedures.

Our 1994 caseload at Southern California Kaiser comprised 1639 procedures, of which 896 were CABG procedures. In comparing the cardiac characteristics of our series with those of yours, the incidence of redo CABGs was slightly lower, approximately 10% in our group, the incidence of recent myocardial infarction greater, approximately 20%, and the use of an internal thoracic artery as a conduit was more frequent.

Our 1994 mortality for CABG was 2.2%.

Dr. Starr, do you think there is a difference in rate of CABGs performed per population in the two groups of patients that you have? Second, inasmuch as there is no self-referral to cardiologists for PTCA, are these procedures performed on a contract basis with outside cardiologists or are they performed by the HMO cardiologists? Third, what accounts for the difference in the rate of emergency operations in these two groups?

Dr. Starr. The results of the large Kaiser group in California is very pertinent to this discussion. The PTCA is not farmed out by Kaiser but is done by an in-house cardiologist who is referred by other cardiologists to do the PTCA. Also, the number of PTCAs that are done by the Kaiser cardiologist, per cardiologist, is much higher than in the FFS system, these cardiologists are more experienced.

There are no financial incentives within our system. We have a capitated surgical portion of the Kaiser program.

Within a managed care system it is possible to achieve a significantly decreased overall mortality from CABG. The decrease in emergency surgery may be one of the important determinants of that difference. I believe that the decrease in emergencies is related to a more conservative management of acute infarction, which does not result in an increased incidence of death from infarction, and from a more judicious use of PTCA, which is markedly different in the two systems.

The use of CABG in the Kaiser system is about 100 cases per 100,000 population, which is about the same as the Oregon population in general. This is a high rate of use, but Oregon is also a high user of CABG in relation to other parts of the country, both being comparable.

In addition, as we examined the population of the Kaiser-insured population versus the population of Oregon matched for age and sex, it matched completely with the age and sex distribution of the Oregon population. So this is not a very unusual population within Kaiser.

Dr. Richard M. Engelman (*Springfield, Mass.*). Was there a difference in the age population of the two groups of patients that you investigated?

Dr. Starr. No, there was no difference in age, sex, hypertension, or diabetes. There were just a few elements that were different in each group, and they pertained mostly to cardiac emergencies.

Dr. Richard P. Anderson (*Seattle, Wash.*). The hypothesis of this study is that the so-called "coherent" system of prereferral HMO cardiology management results in a lower operative mortality than the so-called "chaotic" system of prereferral non-HMO cardiology management. The differences between the two systems are stated to be preintervention screening conferences, absence of self-referral, and personal financial incentives. I am a believer in managed care systems, but I do not understand how differences in these matters independently affect surgical results.

It is not clear whether HMO referral is an independent predictor of operative mortality. Multiple logistic regression analysis should answer this question. Has such an analysis or a comparable analysis been done? If the results show that HMO referral is an independent predictor of surgical mortality, then would you speculate on the physiologic basis for this conclusion? On the other hand, if such an analysis failed to show that HMO membership is an independent predictor of mortality, then one might reasonably conclude that the HMO merely refers patients in whom the risk is low. In that event, could you speculate on HMO enrollment practices that would result in referral of a low-risk group of patients who then have a lower operative mortality?

Dr. Starr. These are excellent questions that help clarify the issues. With regard to the triage preintervention conference, the FFS practice is a truly unstructured practice; there is no other mechanism than an individual phone call from an individual cardiologist to an individual surgeon. That surgeon is free to accept the patient on his own judgment according to the Hippocratic oath.

With regard to the reason for this HMO effect, there is no question that there is a difference in operative mortality, but how is this difference achieved? It is achieved in part by a selection process. This selection process avoids emergency

surgery to a greater extent than in the FFS practice, but it does not do so at the expense of a higher mortality from myocardial infarction. That is an important point.

Through this selection process, without encompassing any higher medical mortality, the results are achieved in part. But the logistic regression is not significant for just HMO alone as an independent predictor on a multivariate analysis. It comes close, immediately after diabetes. We think if we had a larger series it would be an independent predictor. If it were an independent predictor, then there may be some other mechanisms, that is, the appropriate timing of operation, the integration between the primary care physician and the cardiologist, and the integration between the cardiologist and the surgeon, all resulting in a smoother pathway for the patient that results in a lower overall operative risk.

Whether it is an independent predictor or not, there is no question that one system yields a group of patients for whom the operative mortality is distinctly lower without incurring a higher medical mortality.

Appendix: Cardiac surgery/PTCA criteria

Procedure to evaluate medical necessity for cardiac surgery/PTCA

A. Criteria used for CABG:

1. Coronary angiography shows left main disease with greater than 50% stenosis.

2. The patient is undergoing primary cardiac valvular surgery and angiogram shows left main or one-, two-, or three-vessel disease.
3. The patient has angina with two- or three-vessel disease and left ventricular dysfunction with an ejection fraction less than 50%.
4. The patient has had an episode of unstable angina within 3 months that responded to inpatient medical management and now has recurrent angina despite medical therapy consisting of nitrates, β -adrenergic blockers, and calcium channel blockers, *and* angiogram shows at least two-vessel disease.

B. Criteria used for PTCA:

1. Acute myocardial infarction with failed reperfusion with thrombolytic agents.
2. Acute myocardial infarction with severe residual stenosis in a single vessel after successful thrombolytic reperfusion.
3. Unstable angina with near complete occlusion or high-grade stenosis in one- or two-vessel disease.
4. Stable angina persisting despite antianginal therapy, *and*
 - a. high-grade single or double vessel stenosis, or
 - b. stenosis in one vessel and occlusion in another, or
 - c. high-grade stenosis in a CABG

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