

SPECIAL ARTICLE

Cardiac Revascularization in Specialty and General Hospitals

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ABSTRACT

BACKGROUND

The emergence of specialty hospitals focusing on narrow procedural areas has generated controversy, although little is known about their quality.

METHODS

We conducted a retrospective cohort study of 42,737 Medicare beneficiaries who underwent percutaneous coronary intervention (PCI) and 26,274 who underwent coronary-artery bypass grafting (CABG) during 2000 and 2001 in specialty cardiac hospitals (15 for PCI and 15 for CABG) and general hospitals (82 for PCI and 75 for CABG) in the same markets. Administrative data were used to compare patients' characteristics, hospital procedural volumes, and patient outcomes.

RESULTS

Patients undergoing PCI or CABG in specialty hospitals were less likely to have coexisting conditions than those being treated at general hospitals and were less likely to have had an acute myocardial infarction ($P < 0.001$). The better health of the patients at specialty hospitals than of those at general hospitals was reflected by the lower mean predicted risk of death (2.1 percent vs. 3.1 percent for PCI and 5.0 percent vs. 5.8 percent for CABG; $P < 0.001$ for each comparison). Mean volumes of PCI and CABG procedures in 2000 and 2001 were higher in specialty hospitals than in general hospitals (799 vs. 375 PCI procedures, $P < 0.001$; and 571 vs. 236 CABG procedures, $P < 0.001$). The unadjusted rate of death during the index hospitalization or within 30 days after admission was lower in specialty hospitals than in general hospitals (2.1 percent vs. 3.2 percent for PCI and 4.7 percent vs. 6.0 percent for CABG; $P < 0.001$ for both comparisons). In multivariate analyses adjusted for patients' characteristics, the odds ratio for death after PCI in specialty hospitals and general hospitals was similar (0.89; 95 percent confidence interval, 0.69 to 1.15; $P = 0.39$), but the odds ratio for death after CABG was lower in specialty hospitals than in general hospitals (0.84; 95 percent confidence interval, 0.72 to 0.99; $P = 0.05$). In stratified analyses comparing specialty and general hospitals with similar volumes, differences in mortality were not significant.

CONCLUSIONS

The lower unadjusted mortality rate after cardiac revascularization in specialty cardiac hospitals is accounted for by their healthier patients and higher procedural volumes.

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SPECIALTY HOSPITALS PROVIDE CARE TO specific populations of patients.¹ Although women's and children's hospitals have existed for decades, the development of specialty hospitals with a focus on narrow procedural areas has recently accelerated.²⁻⁴ Proponents of specialty hospitals cite specialization as an opportunity to improve care and reduce costs.⁵ However, opponents argue that such hospitals focus on lucrative procedures and seek low-risk patients. On the basis of these concerns, the 2003 Medicare Act was passed, which placed an 18-month moratorium on further development of specialty hospitals.⁶

Despite these concerns, there are limited data comparing specialty and general hospitals. Moreover, available analyses have led to conflicting conclusions^{1,7,8} and no study has comprehensively compared patients' characteristics (e.g., demographic characteristics and presence or absence of coexisting illnesses), overall health, and outcomes between specialty and general hospitals.

We conducted a retrospective cohort study of Medicare beneficiaries to compare demographic and socioeconomic characteristics, the number of coexisting illnesses, the length of hospitalization, and risk-adjusted mortality among patients who underwent percutaneous coronary intervention (PCI) or coronary-artery bypass grafting (CABG) in specialty cardiac and general hospitals in the same geographic regions. We hypothesized that as compared with general hospitals, specialty hospitals would care for patients who resided in more affluent areas and had fewer coexisting illnesses and would have greater procedural volumes, shorter hospital stays, and lower mortality rates.

METHODS

DATA COLLECTION

Consecutive Medicare beneficiaries 65 years of age or older who underwent PCI (552,638 patients) or CABG (335,255 patients) during 2000 and 2001 were identified from the Medicare Provider and Analysis Review (MedPAR) Part A public-use files on the basis of the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) procedure codes (36.01, 36.02, 36.05, and 36.06 for PCI and 36.10 through 36.19 for CABG). The Part A files contain abstracted discharge data for Medicare patients discharged from acute care hos-

pitals with the exception of Medicare managed-care enrollees.⁹ Data include demographic information; ZIP Code and state of residence; primary and secondary diagnoses and procedures, as reflected by the ICD-9-CM codes; admission source (e.g., emergency department); admission and discharge dates; discharge disposition; date of death up to three years after discharge; and a six-digit unique hospital identifier. Socioeconomic measures, including median home values and per capita income, were determined at the ZIP Code level for each patient by linking the ZIP Code of residence with ZIP Code-specific data from the 2000 U.S. Census.¹⁰

Each hospital performing PCI or CABG was assigned to 1 of 307 unique hospital-referral regions (HRRs) with the use of algorithms available from the *Dartmouth Atlas of Health Care*.¹¹ HRRs represent distinct regional markets for cardiac care. The HRR algorithms map each ZIP Code in the United States to the specific HRR in which the highest proportion of patients residing in the ZIP Code receive cardiovascular care. We excluded patients treated at hospitals that could not be matched to an HRR (4953 patients [0.9 percent of eligible patients] in 25 hospitals performing PCI and 2914 patients [0.9 percent] in 19 hospitals performing CABG). Additional hospital-level information was obtained from the 2000 survey of the American Hospital Association, including whether a hospital was a member of the Council of Teaching Hospitals, the type of ownership (for profit vs. not for profit), and total admissions.¹²

DEFINITION OF SPECIALTY CARDIAC HOSPITALS AND GENERAL HOSPITALS

Although no standard approach exists to define specialty cardiac hospitals, a study by the General Accounting Office identified 17 specialty cardiac hospitals by selecting hospitals with the highest ratio of cardiac admissions to total admissions.¹ We modified this approach by developing an index of cardiac specialization, defined as the proportion of total Medicare admissions categorized in Medical Diagnostic Category (MDC) 5 (diseases of the circulatory system). The specialty index was used to identify the 50 hospitals performing PCI and CABG with the greatest degree of cardiac specialization (i.e., the highest specialty-index ratio). We then excluded from this group all 29 hospitals that provided obstetrical care, general pediatric services, or

both because obstetrical and pediatric patients are typically not included in the Medicare data on which the specialty hospital index was based. Of the remaining 21 hospitals, we excluded all 6 hospitals that offered a comprehensive array of services (e.g., orthopedic surgery, oncology, and psychiatry) to adults. The provision of such services was determined from a review of hospital Web sites, a review of the data from the 2000 survey of the American Hospital Association, and telephone calls (by two of us) to hospital admissions departments for additional clarification when necessary. Finally, the status of each of the 15 cardiac specialty hospitals that were identified (see the Supplementary Appendix, available with the full text of this article at www.nejm.org) was verified by means of a review of hospital Web sites, confirmatory telephone calls, or both.

We identified a primary comparison group of general hospitals by selecting all hospitals performing PCI or CABG in the same HRRs as the 15 specialty hospitals. This group was limited to hospitals within the same HRRs to account for regional variations in care.^{13,14} In addition, a secondary comparison group of general hospitals that specialize in cardiac procedures was identified by selecting the 35 hospitals with high values for the cardiac specialty index that did not meet the criteria for a specialty cardiac hospital.

RISK ADJUSTMENT

We developed multivariate models that included patients' characteristics in the MedPAR database that are risk factors for death after PCI and CABG.¹⁵⁻¹⁸ Candidate variables (39 for PCI and 42 for CABG) for the models included demographic factors, socioeconomic measures, admission source (emergency room, transfer from another acute care hospital, or other), surgical priority (emergency, urgent, or elective), prevalence of coexisting conditions, and additional clinical factors reflecting the urgency of PCI or CABG (e.g., primary diagnosis of acute myocardial infarction or PCI or CABG performed on the same day as cardiac catheterization).

We used the entire national MedPAR database to develop risk-adjustment models for PCI and CABG. Candidate variables associated with mortality in bivariate analyses with a P value of less than 0.05 were entered into stepwise logistic-regression models; variables were retained in the model if they were independently associated with a risk of death

at a P value of less than 0.01. The discriminatory ability of the model was evaluated by means of the *c* statistic, and the accuracy of calibration was assessed with the use of the Hosmer–Lemeshow statistic.^{19,20} Risk-adjusted models for PCI (*c* statistic = 0.83) and CABG (*c* statistic = 0.74) contained 21 and 22 variables, respectively, of which 18 were common to both models (see the Supplementary Appendix). These models were used to provide estimates of the predicted risk of death for each patient in the study.

STATISTICAL ANALYSIS

Differences in demographic characteristics, socioeconomic status, prevalence of coexisting conditions, unadjusted mortality rates, the predicted risk of death, and the length of hospitalization between patients in specialty hospitals and those in general hospitals in the same HRRs were compared with the use of the chi-square statistic or Wilcoxon's signed-rank test. Characteristics of specialty and general hospitals (e.g., volume of PCI and CABG procedures and teaching status) were assessed with the use of similar tests. The length of each patient's hospitalization was log-transformed and compared between specialty and general hospitals with the use of linear regression to adjust for differences in patients' characteristics.

Mortality was defined as death during the index hospitalization or within 30 days after admission. Generalized estimating equations were used to compare mortality rates in specialty and general hospitals to account for clustering of patients within hospitals.^{21,22} Sequential analyses were adjusted first for the patients' characteristics identified above and then for procedural volume.

Additional analyses compared mortality in specialty and general hospitals with similar procedural volumes. For these analyses, hospitals performing 200 or fewer procedures were excluded (2 specialty and 30 general hospitals for PCI and 2 specialty and 43 general hospitals for CABG). The remaining hospitals were then classified as either low volume (201 to 650 procedures performed in 2000 and 2001) or high volume (more than 650 procedures). Lastly, we conducted secondary analyses that compared patients' characteristics, hospitals' characteristics, and mortality in the 15 specialty cardiac hospitals and the 35 specialized general hospitals.

All reported P values are two-tailed, with P values of less than 0.05 considered to indicate statistical

significance. All analyses were performed separately for PCI and CABG with the use of Stata SE software (version 8.0).

RESULTS

PCI

The 15 specialty hospitals performed 11,983 PCI procedures, and the 82 general hospitals performed 30,754 procedures. There were clinically small but statistically significant differences in age, sex, and race or ethnic group between patients who under-

went PCI in specialty hospitals and those who did so in general hospitals (Table 1). Patients who were treated at specialty hospitals resided in ZIP Code areas with higher per capita incomes and housing values than did patients who were treated at general hospitals.

Patients who underwent PCI in specialty hospitals were less likely than those who underwent PCI in general hospitals to have chronic renal failure, diabetes with complications, or congestive heart failure but were more likely to have peripheral vascular disease or cerebrovascular disease (Table 1).

Table 1. Characteristics of Patients Who Underwent PCI or CABG in Specialty Cardiac Hospitals or General Hospitals.*

Characteristic	PCI			CABG		
	Patients in Specialty Hospitals (N=11,983)	Patients in General Hospitals (N=30,754)	P Value	Patients in Specialty Hospitals (N=8563)	Patients in General Hospitals (N=17,711)	P Value
Demographic						
Age — yr	74.7±6.2	74.9±6.4	0.002	74.6±5.8	74.4±5.8	0.002
Female sex — no. (%)	4,704 (39.3)	12,907 (42.0)	<0.001	2963 (34.6)	6,195 (35.0)	0.35
Race or ethnic group — no. (%)†						
Non-Hispanic white	11,091 (92.6)	27,448 (89.3)	<0.001	7930 (92.6)	16,057 (90.7)	<0.001
Black	252 (2.1)	1,273 (4.1)	<0.001	183 (2.1)	584 (3.3)	<0.001
Other or unknown	640 (5.3)	2,033 (6.6)	<0.001	450 (5.3)	1,070 (6.0)	<0.001
Socioeconomic						
Home value — \$	143,430±100,700	135,600±90,530	<0.001	141,360±107,920	127,660±84,880	<0.001
Per capita income — \$	22,290±9,720	22,066±9,360	0.03	22,060±10,080	21,580±8,930	<0.001
Coexisting conditions						
Chronic renal failure — no. (%)	192 (1.6)	869 (2.8)	<0.001	236 (2.8)	546 (3.1)	0.008
Diabetes — no. (%)	2,896 (24.2)	7,714 (25.1)	0.05	2233 (26.1)	4,743 (26.8)	0.23
With complications	180 (1.5)	685 (2.2)	<0.001	197 (2.3)	516 (2.9)	0.004
Congestive heart failure — no. (%)	1,492 (12.5)	4,986 (16.2)	<0.001	1845 (21.5)	4,209 (23.8)	<0.001
Coagulopathy — no. (%)	120 (1.0)	492 (1.6)	<0.001	374 (4.4)	1,141 (6.4)	<0.001
Peripheral vascular disease — no. (%)	968 (8.1)	2,304 (7.5)	0.04	797 (9.3)	1,503 (8.5)	0.03
Cerebrovascular disease — no. (%)	532 (4.4)	1,120 (3.6)	<0.001	1043 (12.2)	1,785 (10.1)	<0.001
Admission						
Emergency department — no. (%)	1,945 (16.2)	8,592 (27.9)	<0.001	965 (11.3)	3,470 (19.6)	<0.001
Acute myocardial infarction — no. (%)	2,342 (19.5)	8,589 (27.9)	<0.001	1367 (16.0)	3,709 (20.9)	<0.001
Surgical priority — no. (%)						
Emergency	3,550 (29.6)	9,217 (30.0)	0.42	2377 (27.8)	3,721 (21.0)	<0.001
Urgent	2,821 (23.5)	10,840 (35.2)	<0.001	1695 (19.8)	5,994 (33.8)	<0.001
Elective	5,612 (46.8)	10,697 (34.8)	<0.001	4491 (52.4)	7,996 (45.1)	<0.001
Predicted risk of death — %‡	2.1±3.4	3.1±5.1	<0.001	5.0±4.8	5.8±6.0	<0.001

* Plus-minus values are means ±SD.

† Race or ethnic group was self-assigned.

‡ Prognostic models were used to estimate the risk of death (see the Supplementary Appendix).

In addition, patients who underwent PCI in specialty hospitals were less likely to be admitted from the emergency department or with an acute myocardial infarction but were more likely to have procedures classified as elective ($P<0.001$ for both comparisons). The mean predicted risk of death was lower among patients who underwent PCI in specialty hospitals than among those who underwent PCI in general hospitals (2.1 percent vs. 3.1 percent, $P<0.001$).

CABG

The 15 specialty hospitals performed 8563 CABG procedures, and the 75 general hospitals performed 17,711 procedures. As with PCI, there were clinically small but statistically significant differences between groups in age and race or ethnic group, and patients who underwent CABG in specialty hospitals resided in ZIP Code areas with higher per capita incomes and housing values than those who underwent CABG in general hospitals (Table 1).

Patients who underwent CABG in specialty hospitals also had lower rates of coexisting conditions, but not of vascular disease, and were less likely than those who underwent CABG in general hospitals to be admitted from the emergency department or with an acute myocardial infarction ($P<0.001$ for both comparisons). Patients treated at specialty hospitals were significantly more likely than those treated at general hospitals to undergo emergency or elective surgery ($P<0.001$ for all comparisons). The mean predicted risk of death was also lower among patients who underwent CABG

in specialty hospitals than among those who did so in general hospitals (5.0 percent vs. 5.8 percent, $P<0.001$).

CHARACTERISTICS OF THE HOSPITALS

Of the 15 specialty hospitals, 7 were located in three states: 3 in Arizona, 2 in California, and 2 in Texas. The mean procedural volume in 2000 and 2001 was higher in specialty hospitals than in general hospitals for both PCI (799 vs. 375 procedures, $P<0.001$) and CABG (571 vs. 236 procedures, $P<0.001$) (Table 2). In addition, specialty hospitals performing PCI and CABG were more likely to be for-profit hospitals.

OUTCOMES OF PCI AND CABG

The unadjusted rate of death after PCI was lower in specialty hospitals than in general hospitals (2.1 percent vs. 3.2 percent, $P<0.001$; unadjusted odds ratio for death, 0.66) (Table 3). However, the odds ratio for death after PCI among patients in specialty hospitals, as compared with patients in general hospitals, was not significant after adjustment for patients' characteristics (0.89; 95 percent confidence interval, 0.69 to 1.15; $P=0.39$) and for patients' characteristics and procedural volume (1.05; 95 percent confidence interval, 0.83 to 1.32; $P=0.68$). The odds ratios for death were also similar between specialty and general hospitals within the low-volume and high-volume strata, after adjustment for patients' characteristics.

The percentages of patients who underwent CABG on the same day as PCI (a potential marker

Table 2. Characteristics of Specialty Cardiac Hospitals and General Hospitals Performing PCI and CABG.*

Characteristic	PCI			CABG		
	Specialty Hospitals (N=15)	General Hospitals (N=82)	P Value	Specialty Hospitals (N=15)	General Hospitals (N=75)	P Value
No. of procedures in 2000–2001	799±700	375±339	<0.001	571±532	236±217	<0.001
No. of Medicare admissions in 2000–2001	4771±4532	9561±5217	0.001	4771±4532	9748±5326	0.001
No. of hospital admissions in 2000	7146±5668	17,543±9638	0.004	7146±5668	17,938±9756	0.003
Length of stay — days	3.2±4.0	3.9±5.0	<0.001	10.5±9.2	11.1±10.4	<0.001
Proportion of total Medicare admissions in MDC 5 2000–2001	0.71±0.12	0.28±0.06	<0.001	0.71±0.12	0.28±0.06	<0.001
Major teaching hospitals — no. (%)	0	15 (18)	0.07	0	14 (19)	0.07
For-profit ownership — no. (%)	12 (80)	14 (17)	<0.001	12 (80)	14 (19)	<0.001

* Plus-minus values are means ±SD. MDC 5 denotes Medical Diagnostic Category 5.

of PCI complications) were similar in specialty and general hospitals (0.4 percent and 0.5 percent, respectively; $P=0.48$), as were the percentages of patients in specialty hospitals who underwent CABG after PCI but before discharge (1.0 percent and 1.2 percent, respectively; $P=0.25$).

The unadjusted rate of death from CABG was lower in specialty than in general hospitals (4.7 percent vs. 6.0 percent, $P<0.001$), with an unadjusted odds ratio for death of 0.77 (Table 3); after adjustment for patients' characteristics, the odds ratio was 0.84 (95 percent confidence interval, 0.72 to 0.99; $P=0.05$). This difference was no longer significant after adjustment for procedural volume. The odds ratios for death were also similar in specialty and general hospitals within the low-volume and high-volume strata, after adjustment for patients' characteristics.

The mean length of hospitalization was shorter among patients in specialty hospitals than among those in general hospitals after either PCI (3.2 vs. 3.9 days, $P<0.001$) or CABG (10.5 vs. 11.1 days, $P<0.001$). However, after adjustment for patients' characteristics, differences in the length of stay between patients in specialty hospitals and those in general hospitals were no longer significant for PCI (4 percent shorter in specialty hospitals; 95 percent confidence interval, -15 to 7; $P=0.45$) or CABG (3 percent shorter; 95 percent confidence interval, -14 to 7; $P=0.50$).

Secondary analyses comparing the 15 specialty cardiac hospitals and the 35 general hospitals that specialized in cardiac procedures yielded results that were similar to those of the primary analyses. For example, as compared with general hospitals, specialty hospitals admitted a smaller percentage of patients with acute myocardial infarction for PCI (19.5 percent vs. 22.2 percent, $P<0.001$) or CABG (16.0 percent vs. 19.3 percent, $P<0.001$). The predicted risk of death after PCI was lower among patients in specialty hospitals than among those in general hospitals that specialized in cardiac procedures (2.1 percent vs. 2.3 percent, $P=0.01$), but the predicted risk of death after CABG was similar in the two types of hospitals (5.0 percent and 5.2 percent, respectively; $P=0.24$).

The proportion of Medicare admissions categorized as MDC 5, a measure of cardiac specialization, was greater for the 15 specialty cardiac hospitals than for the 35 specialized general hospitals (0.71 vs. 0.46, $P<0.001$). The mean volume of PCI procedures was lower in specialty hospitals than in

general hospitals that specialized in cardiac procedures (799 vs. 1366, $P=0.02$), but the volume of CABG procedures was similar in the two types of hospitals (571 and 795, respectively; $P=0.15$). The specialty hospitals were less likely than specialized general hospitals to be major teaching hospitals (0 percent vs. 29 percent, $P=0.02$) and were more likely to be for-profit hospitals (80 percent vs. 20 percent, $P<0.001$). Finally, the odds ratio for death after PCI or CABG was similar in specialty hospitals and specialized general hospitals, after adjustment for patients' characteristics (PCI, 1.07; 95 percent confidence interval, 0.81 to 1.43; $P=0.62$; CABG, 0.89; 95 percent confidence interval, 0.71 to 1.23; $P=0.34$) and after adjustment for both patients' characteristics and procedural volume (PCI, 1.07; 95 percent confidence interval, 0.78 to 1.46; $P=0.68$; CABG, 0.87; 95 percent confidence interval, 0.72 to 1.06; $P=0.29$).

DISCUSSION

Our findings confirm several of our a priori hypotheses. First, patients who underwent PCI or CABG in specialty hospitals were less likely than those who underwent such procedures in general hospitals to be admitted on an emergency basis or with an acute myocardial infarction, had a lower predicted risk of death, and tended to have fewer coexisting conditions, as reflected by hospital claims data. These findings support the assertion that specialty hospitals attract healthier patients.^{23,24} Patients in specialty hospitals also resided in ZIP Code areas with somewhat higher socioeconomic status, as evidenced by higher mean home values and higher per capita income.

Second, specialty hospitals had greater procedural volumes for both PCI and CABG and had lower unadjusted mortality rates. Third, differences in mortality were no longer statistically significant after adjustment for procedural volume and patients' characteristics. Although the subgroup analyses may have lacked the statistical power to exclude a clinically meaningful difference (e.g., 15 to 20 percent) in mortality, especially among low-volume CABG hospitals, our findings suggest that outcomes may be similar in specialty and general hospitals that have similar volumes. Moreover, the finding of similar adjusted mortality rates in analyses comparing specialty hospitals and general hospitals specializing in cardiac procedures provides further support for this conclusion.

Table 3. Unadjusted and Adjusted Odds Ratios for Death after PCI or CABG among Patients in Specialty Hospitals, as Compared with Patients in General Hospitals.*

Variable	PCI		CABG	
	Value	P Value	Value	P Value
All hospitals				
Specialty				
No. of patients	11,983		8,563	
No. of hospitals	15		15	
General				
No. of patients	30,754		17,711	
No. of hospitals	82		75	
Odds ratio for death (95% CI)				
Unadjusted	0.66 (0.48–0.92)	0.01	0.77 (0.65–0.92)	0.003
Adjusted for patients' characteristics†	0.89 (0.69–1.15)	0.39	0.84 (0.72–0.99)	0.05
Adjusted for patients' characteristics and procedural volume†	1.05 (0.83–1.32)	0.68	0.91 (0.74–1.11)	0.35
Low-volume hospitals				
Specialty				
No. of patients	3,400		3,024	
No. of hospitals	7		8	
General				
No. of patients	13,632		9,531	
No. of hospitals	37		27	
Odds ratio for death (95% CI)				
Unadjusted	0.78 (0.58–1.04)	0.09	0.76 (0.58–1.00)	0.05
Adjusted for patients' characteristics†	1.03 (0.78–1.39)	0.81	0.82 (0.66–1.02)	0.08
Adjusted for patients' characteristics and procedural volume†	1.02 (0.76–1.35)	0.91	0.83 (0.67–1.02)	0.08
High-volume hospitals				
Specialty				
No. of patients	8,351		5,400	
No. of hospitals	6		5	
General				
No. of patients	14,357		4,039	
No. of hospitals	15		5	
Odds ratio for death (95% CI)				
Unadjusted	0.77 (0.47–1.23)	0.28	0.79 (0.58–1.08)	0.14
Adjusted for patients' characteristics†	0.98 (0.70–1.37)	0.91	0.95 (0.70–1.29)	0.74
Adjusted for patients' characteristics and procedural volume†	1.12 (0.82–1.53)	0.46	0.94 (0.65–1.34)	0.71

* Generalized estimating equations were used. Death was defined as death in the hospital or within 30 days after admission. Low volume was defined as 201 to 650 procedures. High volume was defined as more than 650 procedures. CI denotes confidence interval.

† Patients' characteristics included age, sex, race or ethnic group, median income, coexisting conditions (congestive heart failure, neurologic disease, chronic renal failure, chronic obstructive pulmonary disease, peripheral vascular disease [CABG only], cerebrovascular disease, coagulopathy, metastatic disease, weight loss [PCI only], valvular heart disease, and liver disease), surgical priority, primary diagnosis of acute myocardial infarction, use of aortic balloon pump (PCI only), concurrent valve replacement (CABG only), PCI on the same day as CABG (CABG only), cardiac catheterization on the same day as CABG (CABG only), previous CABG (PCI only), year of discharge, and admission source. Hospitals performing 200 or fewer procedures were excluded (2 specialty and 30 general hospitals for PCI and 2 specialty and 43 general hospitals for CABG).

The finding that patients in specialty cardiac hospitals were generally less severely ill than those in general hospitals may indicate that such patients preferentially seek care from specialty hospitals or, conversely, that specialty hospitals preferentially seek healthier patients. In the context of prospective reimbursement (e.g., reimbursement based on diagnosis-related groups), this difference may result in higher profit margins for specialty hospitals and inequities in the economic burden of caring for patients with more complex conditions.

The greater procedural volume of specialty hospitals raises other important policy issues. If specialty hospitals achieve higher volumes by attracting patients who would otherwise seek care in local general hospitals, their higher volumes may represent a market-based evolution of health care regionalization and may lead to better outcomes.²⁵⁻²⁷ However, because specialty hospitals often provide services with higher profit margins, the number of candidates for such services who could be treated at general hospitals may decrease after the opening of a new specialty hospital, which may make it more difficult for general hospitals to cross-subsidize lower-margin, yet essential, services (e.g., emergency care and primary care) or to provide care to indigent patients.^{28,29} Alternatively, if specialty hospitals generate higher volumes by increasing the number of procedures performed in a fixed population of patients, health care costs may increase, without a concomitant improvement in population-level outcomes.³⁰⁻³²

The interpretation of our findings related to mortality and hospital volume is complex. If the specialty-hospital model leads to higher-volume programs, it might be argued that the model has inherent advantages. Conversely, given that we found no significant differences in outcomes between specialty and general hospitals with similar volumes or between specialty cardiac hospitals and specialized general hospitals, it could be argued that the specialty-hospital model itself does not yield better outcomes.³³ It is also possible that relationships between specialty hospitals and outcomes are confounded by other, unmeasured differences in the organization of care that are important determinants of outcomes (e.g., nursing care or physicians' experience).

Our findings have potential methodologic limitations. First, our analysis was limited to fee-for-service Medicare beneficiaries. The generalizability of our results to patients with other forms of insurance is uncertain. Second, systematic differences between specialty and general hospitals in the coding of diagnoses and procedures could have biased our results. Third, we examined a limited number of outcomes and did not consider such outcomes as functional status or patients' satisfaction. Fourth, our analysis relied on claims data, which may not reflect important aspects of the severity of illness and may underestimate differences in the severity of illness between specialty and general hospitals. Fifth, our use of relatively large samples may have led to statistically significant differences that were not necessarily clinically significant, particularly with respect to comparisons of demographic and clinical variables. Sixth, our comparison of the specialty cardiac hospitals and specialized general hospitals may have been confounded by regional variations in care, because these hospitals were not in the same HRRs. Finally, we used a relatively novel method to identify specialty cardiac hospitals.¹

Nonetheless, we believe our findings have important implications for health policy. Although federal legislation in 2003 temporarily halted the development of specialty hospitals, pressures fostering their emergence remain, including physicians' desire for greater autonomy of practice, the progressive specialization of medicine, inequities in compensation for procedural and nonprocedural medical services, and the repeal of certificate-of-need regulations in many states. Although the concept of physician-owned specialty hospitals may raise ethical issues regarding referral, future policies and regulations should also be driven by careful assessments of the cost and quality of specialty hospitals, in relation to those of competing general hospitals, and their effect on access to and the use of health care services. In this respect, our study provides no definitive evidence that cardiac specialty hospitals provide better or more efficient care than general hospitals with similar procedural volumes.

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REFERENCES

1. Specialty hospitals: information on national market share, physician ownership, and patients served. Washington, D.C.: General Accounting Office, 2003:1-20. (GAO-03-683R.) (Accessed March 14, 2005, at <http://www.gao.gov/new.items/d03683r.pdf>.)
2. Voelker R. Specialty hospitals generate revenue and controversy. *JAMA* 2003;289:409-10.
3. Casalino LP, Devers KJ, Brewster LR. Focused factories? Physician-owned specialty facilities. *Health Aff (Millwood)* 2003;22(6):56-67.
4. Devers KJ, Brewster LR, Ginsburg PB. Specialty hospitals: focused factories or cream skimmers? Issue Brief Cent Stud Health Syst Change 2003;62:1-4.
5. Swartzmeyer S, Killoran CN. Specialty hospital ban was premature: studies would have shown whether those facilities help or harm healthcare. *Mod Healthc* 2004;34(2):21.
6. Medicare prescription drug improvement and modernization act of 2003. 2003. (Accessed March 14, 2005, at http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=108_cong_bills&docid=f:h1enr.txt.pdf.)
7. Dobson A. A comparative study of patient severity, quality of care and community impact at MedCath heart hospitals: executive summary — May 2003. (Accessed March 14, 2005, at http://www.medcath.com/index.aspx?CORE_ElementID=corp_Study.)
8. Specialty hospitals: geographic location, services provided, and financial performance. Washington, D.C.: General Accounting Office, October 2003:1-41. (GAO-04-167.) (Accessed March 14, 2005, at <http://www.gao.gov/new.items/d04167.pdf>.)
9. Mitchell JB, Bubolz T, Paul JE, et al. Using Medicare claims for outcomes research. *Med Care* 1994;32:Suppl:JS38-JS51.
10. 2000 U.S. Census data. (Accessed March 14, 2005, at <http://www.census.gov/main/www/cen2000.html>.)
11. Dartmouth atlas of health care. Hanover, N.H.: Dartmouth Medical School Center for the Evaluative Clinical Sciences, 2003. (Accessed March 14, 2005, at <http://www.dartmouthatlas.org/>.)
12. Rosenthal GE, Harper DL, Quinn LM, Cooper GS. Severity-adjusted mortality and length of stay in teaching and nonteaching hospitals: results of a regional study. *JAMA* 1997;278:485-90.
13. Welch WP, Miller ME, Welch HG, Fisher ES, Wennberg JE. Geographic variation in expenditures for physicians' services in the United States. *N Engl J Med* 1993;328:621-7.
14. Birkmeyer JD, Sharp SM, Finlayson SR, Fisher ES, Wennberg JE. Variation profiles of common surgical procedures. *Surgery* 1998;124:917-23.
15. Hannan EL, Kilburn H Jr, Lindsey ML, Lewis R. Clinical versus administrative data bases for CABG surgery: does it matter? *Med Care* 1992;30:892-907.
16. Hannan EL, Racz MJ, Jollis JG, Peterson ED. Using Medicare claims data to assess provider quality for CABG surgery: does it work well enough? *Health Serv Res* 1997;31:659-78.
17. Vaughan-Sarrazin MS, Hannan EL, Gormley CJ, Rosenthal GE. Mortality in Medicare beneficiaries following coronary artery bypass graft surgery in states with and without certificate of need regulation. *JAMA* 2002;288:1859-66.
18. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care* 1998;36:8-27.
19. Lemeshow S, Hosmer DW Jr. A review of goodness of fit statistics for use in the development of logistic regression models. *Am J Epidemiol* 1982;115:92-106.
20. Ash AS, Shwartz M. Evaluating the performance of risk-adjustment methods: dichotomous outcomes. In: Iezzoni LI, ed. Risk adjustment for measuring healthcare outcomes. 2nd ed. Chicago: Health Administration Press, 1997:427-70.
21. Liang K-Y, Zeger SL. Longitudinal data analysis using generalized linear models. *Biometrika* 1986;73:13-22.
22. White H. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* 1980;48:817-38.
23. Reilly P. Picking patients: GAO: specialty hospitals serve fewer uninsured. *Mod Healthc* 2003;33(43):6-7.
24. Fong T. Not so special: doc ownership in specialty hospitals scrutinized by health-care panel. *Mod Healthc* 2003;33(16):20-1.
25. Birkmeyer JD, Siewers AE, Marth NJ, Goodman DC. Regionalization of high-risk surgery and implications for patient travel times. *JAMA* 2003;290:2703-8.
26. Milstein A, Galvin RS, Delbanco SF, Salber P, Buck CR Jr. Improving the safety of health care: the Leapfrog initiative. *Eff Clin Pract* 2000;3:313-6. [Erratum, *Eff Clin Pract* 2001;4:94.]
27. Luft HS, Bunker JP, Enthoven AC. Should operations be regionalized? The empirical relation between surgical volume and mortality. *N Engl J Med* 1979;301:1364-9.
28. Gaskin DJ, Hadley J, Freeman VG. Are urban safety-net hospitals losing low-risk Medicaid maternity patients? *Health Serv Res* 2001;36:25-51.
29. Sloan FA. Organ procurement: expenditures and financial incentives. *JAMA* 1993;269:3155-6.
30. Fisher ES, Wennberg DE, Stukel TA, Gottlieb DJ, Lucas FL, Pinder EL. The implications of regional variations in Medicare spending. 1. The content, quality, and accessibility of care. *Ann Intern Med* 2003;138:273-87.
31. Robinson JL, Nash DB, Moxey E, O'Connor JP. Certificate of need and the quality of cardiac surgery. *Am J Med Qual* 2001;16:155-60.
32. Guadagnoli E, Hauptman PJ, Ayanian JZ, Pashos CL, McNeil BJ, Cleary PD. Variation in the use of cardiac procedures after acute myocardial infarction. *N Engl J Med* 1995;333:573-8.
33. Piotrowski J. If at first you do succeed...: Puckett launches specialty hospital company based on MedCath operating model. *Mod Healthc* 2003;33(11):42, 44.

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