Swan-Ganz Catheter Use and Mortality of Myocardial Infarction Patients

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Using the 1989 Medicare provider analysis and review (MEDPAR) file, we calculated a 30-day indirectly standardized mortality ratio (SMR) for all "fresh" acute myocardial infarction (AMI) Medicare aged cases (i.e., fresh AMI patients are those who had not reported an AMI in the prior 8 weeks) at 2,900 hospitals, as well as an indirectly standardized procedure ratio (SPR) of Swan-Ganz catheter (SGC) use for these AMI cases at each hospital. Cases at hospitals with higher SGC SPRs also had higher SMRs. This positive association persisted when hospitals were further stratified by their annual volume of fresh AMI cases. We believe that our use of cases as the unit of observation, stratified by the SGC SPR of their hospital, avoids some case selection bias in observational studies directly comparing risk-adjusted mortality of cases with and without SGC.

INTRODUCTION

The use of the SGC (also known as the balloon-tip pulmonary artery catheter [PAC]) is a source of substantial controversy in the care of AMI patients. In AMI patients who develop hemodynamic instability manifested as congestive heart failure (CHF) or hypotension, cardiologists recommend that an SGC be placed inside the heart to monitor the filling pressures of the heart as a guide to appropriate care (Gunnar et al., 1990). Many have questioned whether there are any benefits to patients that can outweigh the known hazards of its use. Serious concerns about SGC use were published at least as early as 1983, and a 1987 article called for a moratorium on the use of SGCs (Robin, 1983, 1987). A recent review article on the indications for SGC use deplored the lack of factual evidence of patient benefit from their use and the absence of published guidelines based on "a formal group process and/or hierarchical review of evidence to demarcate proven from unproven indications" (Naylor et al., 1993).

A June 1993 literature review found more than 50 references on complications of SGC use published since January 1988, but no articles with data indicating improved outcomes for AMI patients following SGC procedure. Several published studies have sought to determine the influence of SGC use on the mortality of AMI cases. Gore et al. (1987) reported on all AMI cases hospitalized in the Worcester, Massachusetts metropolitan area in 1975, 1978, 1981, and 1984. The crude inhospital mortality rate for those with SGC was significantly higher than for those without SGC in patients with CHF or persistent hypotension, but not for patients with cardiogenic shock. The use of SGC remained a significantly high predictor of death in a logistic regression model which added peak creatine kinase, Q-wave presence, and age as covariates (risk ratio of 2.6 for all cases). Their conclusion that they "could not demonstrate a beneficial effect

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associated with the use of the PA catheter on selected patient outcomes. . . " was tempered by their statement that "A potentially confounding factor that could explain the higher short-term case fatality rates. . . in MI patients receiving PA catheters could be that PA catheters were more likely to be used in the sickest patients" (Gore et al., 1987).

A study based on 5,800 cases in the SPRINT (Secondary Prevention Reinfarction Israeli Nifedipine Trial) series used separate logistic regression models for males and females, with inhospital mortality from AMI as the dependent variable (Greenland et al., 1991). Their risk factors included age, CHF, prolonged hypotension, second- or third-degree atrioventricular block, diabetes mellitus, prior history of AMI, anterior AMI location, and high lactate dehydrogenase, in addition to SGC use. The odds ratio for SGC use was 1.66 for females and 3.88 for males, indicating that SGC use was associated with higher mortality.

In another study, also based on the SPRINT registry cases, the CHF/AMI cases with and without SGC were stratified into mild, moderate, and severe categories (Zion et al., 1990). In a set of CHF cases matched by age and gender and stratified by CHF severity, they found no significant difference in hospital mortality for those with or without an SGC. (Of those with no SGC, 59.5 percent had mild CHF, while this figure was only 15.2 percent for those with an SGC.) They concluded that the higher inhospital mortality in patients receiving an SGC "is likely related to difference in severity of CHF . . . It is unlikely that PAC increases mortality." In patients with severe CHF (pulmonary edema) the mortality was 1.31 times higher (but not statistically significant) in those with an SGC than in those without it. However, they acknowledged that "the possibility that even in patients with pulmonary edema, those receiving PAC were 'sicker,' or less responsive to treatment, cannot be excluded. We had no data on ejection fraction, pH, urine flow and other important variables that would have to be compared to assure comparability of the groups." Obviously the possibility of omitted covariates continued to trouble these authors. Based in part on this study, an editorial in the same journal stated "we must consider. . . the possibility that the use of pulmonary arterial catheterization does not benefit patients with acute myocardial infarction!" (Dalen, 1990).

The studies seeking to determine the influence of SGC use on AMI outcome found by a literature review have all used observational data rather than a random controlled trial. Although much can often be learned from non-experimental studies, estimating the effect of SGC as a treatment is particularly problematic. The cases selected for SGC by a given set of physicians typically have a much graver prognosis than those not selected for the SGC (i.e., there is confounding by indication [Greenland and Neutra, 1980]). Multivariate models with risk factors that fail to reflect nearly all of the criteria used by physicians to select cases for SGC can fail to adjust for a physician bias in selecting cases for SGC. In case-by-case comparisons of patients with and without SGC, it is essential to compare patients who are similar in risk for a given outcome, such as death. When all the cases being compared are from a hospital or set of hospitals with similar criteria for selecting patients for SGC, there may be few or no patients meeting these criteria who did not have an SGC. This could be a substantial problem in interpreting the results of many published studies. For these reasons, we sought a non-experimental data base and study method that could avoid or reduce such problems.

In order to minimize the problem of omitted covariates, we used a research approach that differs from those previously described by changing the study question from:

> "What is the association with 30-day mortality of hospitalized AMI patients who have had an SGC during their stay, as opposed to AMI patients who have not had the procedure?"

to:

> "What is the association with 30-day mortality of AMI patients admitted to hospitals with little or no use of SGC for AMI, compared with AMI patients admitted to hospitals with substantial use of SGC for AMI?"

This approach should circumvent most or all of the potential bias from confounding by indication in comparing those patients with an SGC to those without.

DATA SOURCE

This analysis was performed on the MEDPAR data file, which contains abstracts of the UNIBILL-82 records of all Medicare hospital admissions for calendar years (CYs) 1987 and 1988. The set of fresh AMI Medicare aged admissions in 1988 used in this study consisted of all cases either with a principal diagnosis of AMI (*International Classification of Diseases, 9th Revision, Clinical Modification* [ICD-9-CM] Code 410.x) or in diagnosis-related groups (DRGs) 121, 122, or 123. The inclusion of the cases in AMI DRGs added cases with a secondary diagnosis of AMI that did not fall within any surgical DRG. As a result of this refinement, about 10 percent of all study cases had a secondary diagnosis of AMI rather than a principal diagnosis. Prior inquiries revealed that, at many hospitals, cases admitted with an AMI were erroneously given a principal diagnosis of cardiac arrest when they had died in the hospital of a cardiac arrest as a complication of AMI (Hsia, 1990). Obviously this type of coding error at a hospital can seriously bias its reported AMI mortality.

The MEDPAR file has an encrypted health insurance claim (HIC) number for every hospital admission, which permits linking records from different episodes. Using this, we omitted any cases that had been in any hospital during an 8-week period prior to the index episode with any mention of an AMI diagnosis. This was done because the coding practice at the time permitted an AMI to be considered acute for up to 8 weeks.

This procedure resulted in a set of 290,707 fresh AMI cases. We then applied a set of seven criteria to determine the credibility of the coding at each hospital for diagnosis codes that we had previously found to be key risk predictors for AMI mortality or measures of coding diligence (see the Technical Note at the end of this article). Hospitals that failed one or more of these criteria by having either an extremely high or an extremely low percent of cases with a given attribute were designated as "extreme-data hospitals."

We used all deaths (in or out of hospital) within 30 days of admission for the index episode as our outcome measure. This information was in the MEDPAR data, having been obtained by the Health Care Financing Administration (HCFA) from Social Security records. Two publications describe in more detail the data sources and study method for a similar 1987 AMI study (Blumberg and Binns, 1989; Blumberg, 1991).

The physician fee for an SGC is substantial, and consequently we felt that there was some incentive to report it on the hospital discharge abstract, as well as on the physician bill, as a confirmation for Medicare. SGC is a procedure that is likely to be performed in the hospital to which the patient

Table 1

30-Day Mortality Ratios in Fresh Acute Myocardial Infarction (AMI) Medicare Aged Cases, by Hospital Data Type and Patient Swan-Ganz Catheter (SGC) Status: Calendar Year 1988

Hospital Data Type	Cases		Number of Deaths		Death Rate[1]		
and SGC Status	Number	Percent	Observed	Expected	Observed	Expected	SMR[2]
Non-Extreme Data:							
SGC	11,173	5.1	6,748	3,072.0	60.4	27.5	2.20
Other	207,862	94.9	45,933	49,609.0	22.1	23.9	0.93
Subtotal	219,035	100.0	52,681	52,681.0	24.1	24.1	1.00
Extreme Data:							
SGC	2,616	3.6	1,575	749.4	60.2	28.6	2.10
Other	69,056	96.4	16,414	17,883.7	23.7	25.9	0.92
Subtotal	71,672	100.0	17,989	18,633.1	25.1	26.0	0.97

[1]As a percentage of fresh AMI cases.
[2]Ratio of observed mortality rate to expected mortality rate.

NOTES: Fresh AMI cases are those patients who have not reported an AMI for 8 weeks prior to the study episode. SMR is standardized mortality ratio. Hospital data type criteria are defined in the Technical Note.

SOURCE: Blumberg, M.S., Kaiser Foundation Health Plan, Inc., and Binns, G.S., Dun & Bradstreet HealthCare Information, 1993.

was initially admitted for a heart attack, unlike other cardiovascular procedures such as coronary angiography, coronary artery bypass graft surgery (CABG), or percutaneous transluminal coronary angioplasty (PTCA), which often require that the patient be transferred to another hospital having suitable facilities for these procedures.

The distribution of the entire set of 290,707 fresh AMI cases by the hospital's data status and by the patient's SGC status is shown in Table 1. About 5 percent of the cases in the non-extreme-data hospitals had an SGC procedure, while about 3.6 percent of those in the extreme-data hospitals had an SGC. Overall, the extreme-data hospitals include a disproportionate number of low AMI-volume hospitals that are less likely to perform SGCs. Of all the fresh AMIs with an SGC procedure reported, fully 81 percent were in the non-extreme-data hospitals.

The number of observed and expected deaths in the non-extreme-data hospitals is equal because the cases in these hospitals served as the standards for the risk-adjustment models. (The derivation of the expected deaths is described later.) These standards were then applied to the cases in the extreme-data hospitals to obtain their expected deaths. The SMR of the SGC cases in both the non-extreme- and extreme-data hospitals was more than two, while it was less than one for all other cases. The expected death rates are a direct measure of severity, and they were a little higher on admission for cases receiving an SGC in both non-extreme- and extreme-data hospitals than they were for other cases. As noted previously, physicians selecting patients for SGCs have far more knowledge about the patient than we could possibly obtain from their computerized discharge abstracts. Thus, cases undergoing this procedure are subject to potentially serious selection bias when compared with cases not given this procedure.

STUDY METHOD

Many physicians who have observed the data presented in Table 1 have been tempted to conclude that the use of SGC in fresh AMI cases adversely increases 30-day mortality. This conclusion is made even more attractive by the number of papers that have been written on the hazards of using SGC. However, ascribing a causal relationship between use of an SGC and the observed high death rate of those who receive it is not warranted from the data in Table 1, because AMI patients who receive SGCs have much graver prognoses than those who do not.

One potential shortcoming of our research approach is that it can dilute the association of SGC and mortality. All the AMI cases at some hospitals are compared with all the AMI cases at other hospitals, and there are many factors other than SGC that are associated with greater or lesser risk-adjusted mortality at the hospital level. In this study, we have offset this loss of power in our design by using an extremely large data set (more than 200,000 cases in nearly 3,000 hospitals).

The units of observation in the study are fresh AMI cases, and the dependent variable is the SMR for sets of our study cases. We used two separate logistic regression models (Statistical Analysis System [SAS] PROC LOGIST) to estimate the probability of 30-day death for each case. One model was for all cases with one or more hospital episodes in the 6 months prior to their index hospitalization ("prior"). (Many of these cases were identified by use of the MEDPAR file for CY 1987.) The other logistic regression model was for the remaining cases that had not been in a hospital during the prior 6 months ("no prior"). The candidate risk predictor variables were limited to the following for those without prior episodes: those that represented chronic conditions; anatomical locations reported for the index heart attack; age; and gender. The data set of candidate predictor variables was much larger for those with prior episodes, because any diagnosis or procedure occurring on a prior episode clearly occurred before the index episode and therefore was admissible as a potential risk predictor. We used a forward stepwise procedure in ordinary least squares (SAS PROC STEPWISE) to select the most promising risk predictors in the two models on a 20-percent sample of our cases, using Mallows C as a guideline by comparing it with the degrees of freedom. We then used a bootstrap technique to compare the results of the learning set with four 20-percent test samples.

After eliminating non-significant variables, the final logistic regression models were run on the entire set of cases. These models provided an expected death probability for each of our study cases that could then be compared with the observed number of 30-day deaths for any set of cases. (Note that only cases in non-extreme-data hospitals were used as the standards for these models.) The models were tested for bias by the methods we developed, which are a modification of the Lemeshow-Hosmer test (Lemeshow and Hosmer, 1982; Blumberg and Binns, 1989; Blumberg, 1991).

Although we could have simply compared the crude SGC procedure rate at any given hospital with its SMR, we instead developed an SPR. An SGC procedure is an event that can be counted, just as deaths can be counted. Our approach to developing risk models for SGCs was the same as that used for mortality. Variables that were significant for mortality were candidate risk predictors for SGC, and thus we used only risk predictors that measured patient risk at admission, not desiring to use risk predictors that might have represented the patient's condition just prior to receiving the SGC. SGC procedures in AMI cases are primarily performed on patients who have developed CHF, persistent hypotension, or cardiogenic shock. Even if we had been able to determine this, it would have been inappropriate to use the information as a risk predictor for this study. Consider a patient who, because of problems in care, develops cardiogenic shock during the course of his stay. We would not want to give "credit" for a needed SGC under these circumstances. Remember that our study objective is not to determine the appropriateness of the utilization of SGC, but rather the association of hospitals' SGC SPR with the SMR of all their AMI patients. We believe that our use of an SPR incorporates the (treatment) "propensity score" advocated by Rosenbaum and Rubin (1983).

The variables that were significant in the logistic regression models used to predict 30-day deaths from AMI are listed separately in Table 2 for cases with no prior admissions and for those with prior admissions.

As previously noted, these same variables also served as the candidate variables for the logistic regression model to predict the probability of an SGC procedure. The beta weights for these two models are listed separately. For no prior admissions, all but three of the predictors entering the AMI mortality model also entered the SGC model. One would not expect the coefficients to be the same in the two models, because 30-day deaths were a much more common event than an SGC procedure. Nonetheless, the signs of the coefficients in the two models are the same with only a few exceptions. A positive sign indicates that the variable increases the probability of the event measured in the dependent variable, while a negative sign indicates that it decreases the probability. The signs for both respiratory malignancies and age are positive for the 30-day death model, but negative for the SGC model. This is logical, since respiratory malignancies and age both increase the probability of death from heart attacks, but both may reduce the likelihood of an SGC. The results of the prior admission model were very similar. The coefficient for age was also negative for SGC and positive for death. For prior admission diagnoses, both pneumonia and dementia coefficients were positive for death and negative for SGC.

The means listed are for all study cases at non-extreme-data hospitals. The SGC models excluded cases at hospitals that had no SGC procedures, and hence the means for them would differ somewhat from those shown. The number of cases and the percent with the dependent variable in each model are given at the bottom of Table 2.

RESULTS

Table 3 summarizes the relationship of the SMR of hospitals stratified by their SGC SPR. The top line pertains to the cases in the 936 hospitals that reported no SGC procedures in 1988 for their Medicare aged AMI cases. Hospitals on the other lines were sorted after placing them in rank order by their SGC SPR. The hospitals on the second line were all in the lower SGC SPR quartile of the 1,992 hospitals with one or more SGC procedures. The average observed SGC procedure rate in this set of hospitals was 1.9 percent, while the expected procedure rate was 6.27 percent. The ratio of 1.9 to 6.27 is 0.299. The top 5 percent of hospitals (in SGC percentile break 96-100) had an SGC SPR of 3.688, and a crude observed rate of 22.5 percent. There were only modest differences in the expected SGC rate for hospitals in the various strata. The highest expected SGC rate of 6.32 percent was found in hospitals that performed no SGC procedures. The expected rate declined generally as the hospitals' observed SGC rate increased. Very little hospital variation in the SPR was due to differences in the expected procedure rate; rather, most of it was due to differences in the observed procedure rate. It appears that most of the interhospital variation in the SGC procedure rate relates to the practice style within that hospital.

Table 2

Beta Weights of Logistic Regression Model Predictor Variables for 30-Day Acute Myocardial Infarction (AMI) Deaths and Swan-Ganz Catheter (SGC) Procedures, in Cases With No Prior and Prior Admissions: Calendar Year 1988

No Prior Admissions

Variables	Mean	Beta Weights: 30-Day Deaths	Beta Weights: SGC Procedure
Intercept	—	-5.020	-2.303
Fresh AMI Diagnoses			
Subendocardial Infarction	0.227	-1.108	-0.801
Iron Deficiency or Blood Loss Anemia	0.010	-0.756	-0.213
Hypothyroidism, Unspecified	0.014	-0.888	-0.709
Essential Hypertension	0.177	-0.760	-0.847
Aortocoronary Bypass Status or Cardiac Pacemaker in Situ	0.026	-0.523	-0.854
Hypertensive Heart Disease, Unspecified	0.017	-0.567	-1.120
Mitral/Aortic Valve Disorders	0.043	-0.363	—
Old Myocardial Infarction	0.030	-0.390	-0.586
Primary Diagnosis of AMI of Anterolateral Wall, Other Anterior Wall, Atrium, Papillary Muscle or Septum Alone	0.334	0.067	0.151
Diabetes Mellitus, Uncomplicated	0.130	-0.138	-0.261
Diabetes Mellitus, Complicated	0.049	0.160	0.149
Malignancies: Respiratory	0.005	0.398	-0.482
Chronic Obstructive Pulmonary Disease	0.086	-0.122	-0.071
Renal	0.019	0.565	0.553
Rheumatoid Arthritis	0.032	-0.997	—
Demographic			
Age	75.73	0.055	-0.002
Male	0.513	-0.094	—
Other			
Number of Cases	—	173,125	142,636
Number With Dependent Variable	—	39,225	8,762
(as Percent of Cases)	—	22.7	6.1

Prior Admissions

Variables	Mean	Beta Weights: 30-Day Deaths	Beta Weights: SGC Procedure
Intercept	—	-3.440	-1.055
Fresh AMI Diagnoses			
Pure Hypercholesterolemia	0.015	-0.542	-0.625
Subendocardial Infarction	0.270	-1.236	-0.723
Iron Deficiency or Blood Loss Anemia	0.037	-0.166	
Essential Hypertension	0.293	-0.304	-0.140
Old Myocardial Infarction	0.300	-0.144	-0.204
Diabetes Mellitus, Complicated	0.120	0.148	0.204
Malignancies: Respiratory	0.021	0.662	—
Malignancies: Secondary	0.030	0.285	—
Renal	0.067	0.390	—
Chronic Ulcer or Gangrene	0.034	0.363	—
Prior Admission Diagnoses			
Heart Failure	0.305	0.369	0.335
Pneumonia	0.050	0.243	-0.235
Cerebrovascular Accident	0.051	0.254	—
Dementia	0.027	0.396	-0.335
Fracture	0.022	0.199	0.317
Demographic			
Age	76.78	0.036	-0.020
Male	0.474	0.047	0.079
Other			
Days From Prior Admission	66.667	-0.002	—
Total Length of Stay	11.172	0.006	—
Prior Length of Stay of 2 or Fewer Days	0.115	-0.248	—
Number of Cases	—	45,910	37,690
Number With Dependent Variable	—	13,456	2,411
(as Percent of Cases)	—	24.3	6.4

SOURCE: Blumberg, M.S., Kaiser Foundation Health Plan, Inc., and Binns, G.S., Dun & Bradstreet HealthCare Information, 1993.

Table 3

30-Day Mortality Ratios in Fresh Acute Myocardial Infarction (AMI) Medicare Aged Cases, by Hospital Swan-Ganz Catheter (SGC) Procedure Rate: Calendar Year 1988

SGC	Number of		SGC Procedure			30-Day Mortality		
			Rate in Percent		Standardized[1]	Rate in Percent		Standardized[2]
Percentile Break	Hospitals	Cases	Observed	Expected	Ratio	Observed	Expected	Ratio
0	936	38,709	0.0	6.32	0	24.55	24.60	0.998
1-25	500	50,040	1.9	6.27	0.299	23.31	24.06	[3]0.969
26-50	496	47,416	4.2	6.18	0.681	23.82	23.94	0.995
51-75	498	45,952	7.1	6.18	1.153	23.53	23.89	0.985
76-90	299	23,841	10.8	6.16	1.757	24.98	23.90	[3]1.045
91-95	100	7,219	14.7	6.08	2.423	26.44	23.91	[3]1.106
96-100	99	5,858	22.5	6.11	3.688	26.39	23.42	[3]1.127
Subtotal in Hospitals With 1 or More SGC Procedures	1,992	180,326	6.2	6.20	1.000	23.95	23.93	1.000
All Hospitals	2,928	219,035	5.1	6.22	0.820	24.05	24.05	1.000

[1]Ratio of observed procedure rate to expected procedure rate.
[2]Ratio of observed mortality rate to expected mortality rate.
[3]Probability of standardized mortality ratio differing from 1.000 < .05.

NOTE: Fresh AMI cases are those patients who had not reported an AMI for 8 weeks prior to the study episode.

SOURCE: Blumberg, M.S., Kaiser Foundation Health Plan, Inc., and Binns, G.S., Dun & Bradstreet HealthCare Information, 1993.

Table 3 also gives the SMR for each of the hospital SGC strata. Hospitals with no SGC procedures were nearly identical in their SMR to that for all hospitals. However, there was a definite increase in the SMR as the hospital's SGC ratio increased. The lowest SMR (0.97) was in hospitals that did at least 1 SGC but averaged only 1.9 percent. The highest SMR (1.13) was for hospitals in the 96-100 percentile of SGC procedure ratios, in that the observed rate of SGCs averaged 22.5 percent.

Larger case volume hospitals are more likely to perform SGC procedures than lower case volume hospitals. For this reason, we sorted hospitals by their annual Medicare AMI case volume, as well as by their SGC percentile breaks. We divided hospitals into 4 AMI volume categories (fewer than 40, 40-79, 80-159, and 160 or more). Crossed with the 7 SGC procedure percentile breaks shown in Table 3, 28 hospital groups result. These are displayed in Table 4 along with subtotals for the four hospital AMI volume categories. Within each of the four volume groups, there is a fairly consistent trend for the SMR to increase as the SGC procedure rate increases. Stratification of hospitals by their AMI volume actually enhances the strong positive association between SGC procedure rate and SMR.

The subtotals of the 4 AMI volume categories show a progressive decline in SMR with increasing volume, from 1.056 for the fewer than 40 category to 0.971 for the 160 or more category. An association between hospital volume and outcomes has been noted for many conditions and procedures (Luft et al., 1990; Flood and Scott, 1987).

Figure 1 displays the information shown in Table 4 with the 95-percent confidence intervals of the SMR as error bars. The first panel shows the 7 different SGC percentile breaks for hospitals with the lowest volume of AMI cases (fewer than 40). The next panel is for hospitals with 40-79 cases, while the bottom 2 panels are for the 2 larger volume hospital sets. In each of the four panels, there is a strong tendency for the SMR ratio to increase as the percentile of the hospital's SGC ratio increases.

Table 4

30-Day Mortality Ratios in Fresh Acute Myocardial Infarction (AMI) Medicare Aged Cases, by Hospital AMI Volume and Swan-Ganz Catheter (SGC) Procedure Rate: Calendar Year 1988

AMI Case Volume and SGC Percentile Break	Percent Receiving SGC	Number of Hospitals	Number of Cases	SMR
Total	5.1	2,928	219,035	1.000
Fewer Than 40				
0	0.0	582	12,187	[1]1.041
1-25	2.9	35	1,209	1.051
26-50	4.1	94	2,635	1.001
51-75	7.0	105	2,786	1.031
76-90	11.2	81	2,163	[1]1.110
91-95	14.9	27	743	[1]1.145
96-100	23.6	38	894	[1]1.313
Subtotal	4.0	962	22,617	1.056
40-79				
0	0.0	232	12,492	1.001
1-25	2.1	195	11,370	1.024
26-50	4.3	155	9,045	1.021
51-75	7.3	159	9,781	0.994
76-90	11.0	91	5,335	[1]1.048
91-95	15.1	36	1,971	[1]1.148
96-100	23.4	38	2,119	[1]1.088
Subtotal	5.2	906	52,113	1.022
80-159				
0	0.0	112	11,969	[1]0.950
1-25	1.7	202	22,470	[1]0.957
26-50	4.2	173	19,460	0.994
51-75	7.1	160	17,809	0.989
76-90	10.8	105	11,658	[1]1.050
91-95	14.4	30	3,232	[1]1.093
96-100	22.0	18	1,867	1.074
Subtotal	5.2	800	88,465	0.990
160 or More				
0	0.0	10	2,061	0.984
1-25	1.8	68	14,991	[1]0.936
26-50	4.1	74	16,276	0.982
51-75	7.1	74	15,576	[1]0.966
76-90	10.5	22	4,685	0.997
91-95	14.8	7	1,273	1.051
96-100	20.8	5	978	[1]1.139
Subtotal	5.3	260	55,840	[1]0.971

[1]Probability of SMR differing from 1.000 < .05.

NOTE: SMR is standarized mortality ratio.

SOURCE: Blumberg, M.S., Kaiser Foundation Health Plan, Inc., and Binns, G.S., Dun & Bradstreet HealthCare Information, 1993.

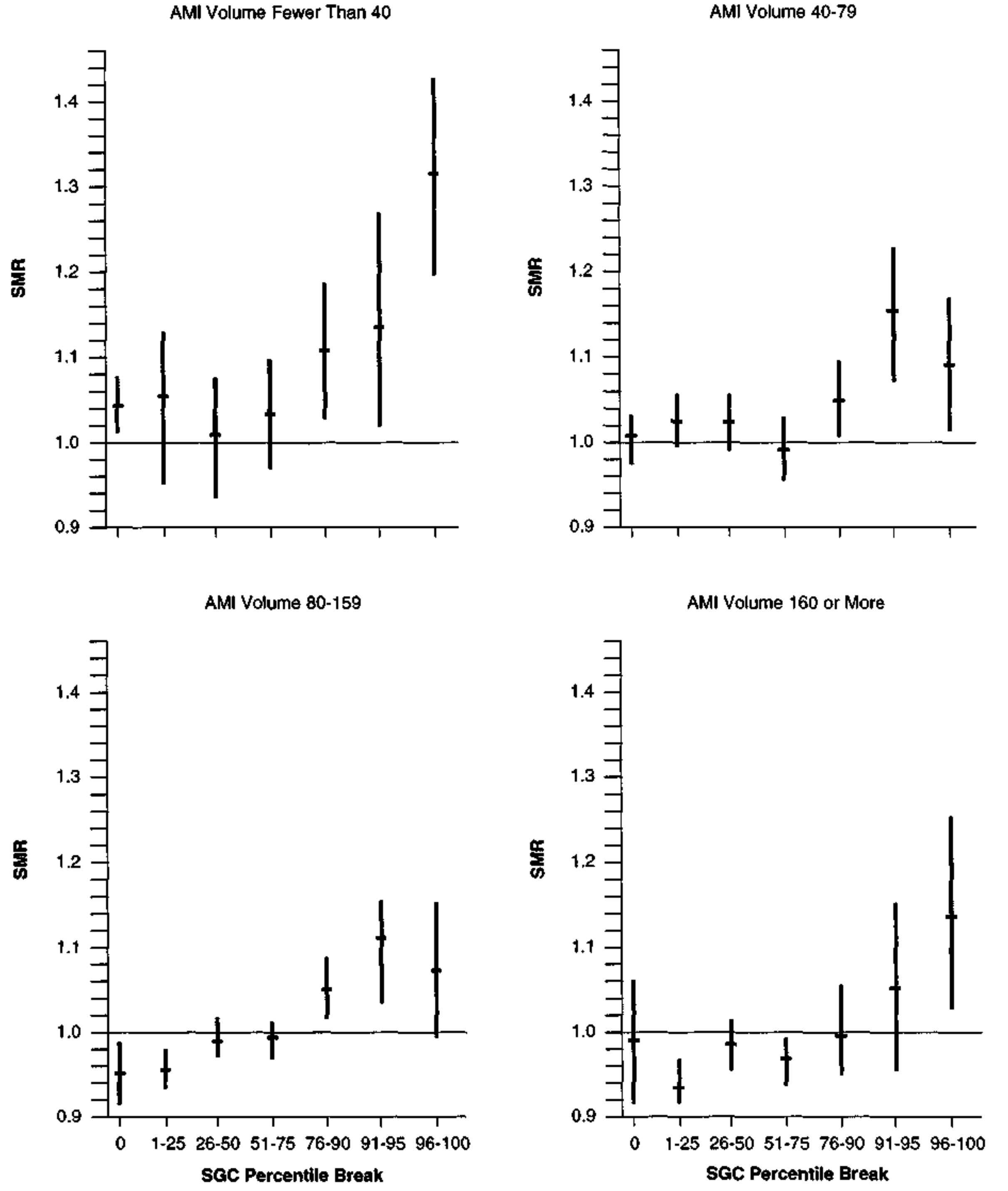
DISCUSSION

This analysis depends on data reported to Medicare on the UNIBILL-82 for these patients. We are not certain how uniform hospitals are in reporting the SGC procedure for heart attack patients, and we suspect that some of the high-volume hospitals that reported no SGC procedures may actually have performed some. However, we are less inclined to believe that hospitals that reported one or more SGCs would have systematically under-reported them, and we are very doubtful that any hospital systematically over-reported them.

At the very least, this article shows that hospitals vary greatly in their reported SGC rates on fresh AMI patients, with 100 out of the 2,900 study hospitals averaging more than 22 percent SGC rates on their patients. This variation is strong evidence that the propensity to do SGC procedures on this

Figure 1

Swan-Ganz Catheterization (SGC) After Acute Myocardial Infarction (AMI): Observed Values and 95-Percent Confidence Intervals for Standardized Mortality Ratios (SMRs), by Procedure Ratio by Volume: Calendar Year 1988



NOTE: Point estimates with 95-percent confidence interval error bars.

SOURCE: Blumberg, M.S., Kaiser Foundation Health Plan, Inc., and Binns, G.S., Dun & Bradstreet HealthCare Information, 1993.

set of AMI cases is highly dependent on the hospital to which the patient is admitted.

This article is one of an increasing number of studies concerned with identifying characteristics of health care providers that are associated with either better- or worse-than-expected outcomes. The study method focuses on the association of two measures characterizing a hospital and their association with a hospital's risk-adjusted 30-day post-admission mortality for fresh AMI in Medicare aged cases: (1) the volume of such AMI cases treated at the hospital during a year; and (2) the standardized ratio of AMI cases at the hospital with an SGC procedure. We use the SGC SPR as a descriptor of a hospital, in much the same way that others may use teaching status or hospital ownership. Although concerned with hospital characteristics, the unit of observation in this article is the case, not the hospital.

We found a strong positive association between a hospital's SGC SPR for AMI cases and the SMR for these cases. This positive association must be interpreted with care, since there are several alternative explanations. One is that SGC is overused in many hospitals and that complications of the procedure itself contribute directly to a higher-than-expected mortality ratio at such hospitals. Another possibility is that some hospitals provide initial care to AMI cases that somehow results in a far higher percent of serious post-admission complications resulting in CHF than found at other hospitals, and that this serious CHF results in both high SGC rates and high SMRs. A high SGC SPR may simply be a marker for a hospital where physicians use many invasive procedures in their care of AMI patients and where this style of practice results in a high mortality ratio, not necessarily caused directly by SGC use. A recent article has shown that many physicians who use SGC on their patients do not understand many aspects of its use, including interpretation of the information it provides (Iberti et al., 1990). Excessive use of SGC might also be associated with substandard care at some hospitals.

SGC is used frequently in CABG surgery. Some study cases with SGC were probably among the 2.7 percent of all study cases that had CABG performed during their index stay. However, as a group, the CABG cases had a very favorable SMR of only 0.56. Hence, SGC performed in CABG cases could not explain the high SMR of cases at hospitals with a high SGC ratio.

We reported the average SMR for 28 groups of hospitals (4 AMI volume groups crossed with 7 SGC ratio groups) considering all cases in each of these groups together, but we also studied the distribution of SMRs for each hospital within each group. These tended to follow a bell-shaped distribution in each group, so that there were considerable variations in these mortality ratios at the hospital level. There are certainly hospitals with very high SGC SPRs that also have favorable SMRs, just as there are hospitals with zero or a very low number of SGC procedures that have very high SMRs. This variation in SMR within hospital group might indicate that SGCs may be more appropriately and expertly used in some hospitals than in others, but more probably it simply reflects random variations. Our findings apply to the average use of SGCs in each of the 28 groups of hospitals, and our conclusions pertain to the average of all patients in each group of hospitals, not to the patients in each hospital within a group.

We believe that our study largely avoids the troubling issue of bias from confounding by indication noted in previous studies. Nor is it likely that we have introduced a selection bias at the hospital level. Some may ask whether the AMI patients who are most likely to warrant an SGC get preferentially admitted to hospitals that are more likely to perform SGC procedures on AMI cases. The possibility of this type of bias appears remote, because we found no evidence that those hospitals with the highest SGC SPR admitted sicker AMI patients more likely to need SGC procedures than hospitals that did zero or a very low number of SGC procedures on AMI cases.

Despite the large number of hospitals and cases in this study, it is exploratory in nature. A random controlled trial of SGC use would certainly add information not obtainable from observational studies. However, even such an experimental study could leave important issues unresolved if it were not done on cases in a very broad array of hospitals. For example, a random trial performed in a few medical centers would leave the results vulnerable to the question of external validity (i.e., how effective is SGC use in other settings?).

Although this study avoids some of the problems in prior studies comparing the outcomes of cases with and without SGC, it certainly does nothing to allay the persistent concerns of the many who believe that SGCs are frequently overused in AMI cases, to the detriment of the patient.

TECHNICAL NOTE

We chose the acceptable ranges of hospital-specific coding after examining the distribution of the frequency of the selected variables for all hospitals with 20 or more cases of AMI. Extreme-data hospitals were those that met one or more of the following seven criteria:

- 20 percent or more of fresh AMI cases, based on the principal diagnosis, with only a principal diagnosis and no secondary diagnoses.
- 30 percent or more of fresh AMI cases with only a principal diagnosis or a principal diagnosis accompanied by only one secondary diagnosis.
- 6 percent or fewer, or 50 percent or more, of fresh AMI cases with an accompanying diagnosis of diabetes.
- 4 percent or fewer, or 40 percent or more, of fresh AMI cases with an accompanying current diagnosis of hypertension.
- 30 percent or more of fresh AMI cases who stayed in the hospital more than 2 days diagnosed with ICD-9-CM code 410.9 (AMI not otherwise specified).
- 6 percent or fewer, or 50 percent or more, of all fresh AMI cases diagnosed with ICD-9-CM code 410.7 (sub-endocardial infarction) as first appearing AMI diagnosis.
- 25 percent or more of fresh AMI cases with no principal diagnosis of AMI.

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