Adverse Hospital Events for Mentally Ill Patients Undergoing Coronary Artery Bypass Surgery

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Context. Patients with mental disorders show higher burden of coronary heart disease, and may face special safety issues during in-hospital cardiac care.

Objectives. To compare the postoperative complication rate between patients with and without mental disorders undergoing isolated coronary artery bypass graft (CABG) surgery.

Design, Setting, and Patients. Retrospective analyses of New York state hospital claims between 1997 and 2004 ($N = 135,701$). Complications were defined using the Agency for Healthcare Research and Quality Patient Safety Indicators (AHRQ PSI).

Principal Findings. Mental disorders were significantly associated with higher anesthesia complications (adjusted odds ratio [AOR] = 6.44, $p < .001$), decubitus ulcer (AOR = 1.42, $p = .006$), postoperative hip fracture (AOR = 3.29, $p < .001$), and overall complication rate representing nine PSIs (AOR = 1.27, $p < .001$).

Conclusions. Mentally ill patients undergoing CABG surgery are more likely to experience potentially preventable complications and injuries. The mechanism underlying this observation warrants further study.

Key Words. Preventable adverse event, complication, CABG, mental disorder

An estimated 5.4 percent of American adults have severe mental illness including psychiatric and substance-abuse disorders (Kessler et al. 2002). Mental disorders are associated with an increased risk of coronary heart disease (CHD) (Kawachi et al. 1994; Lett et al. 2004; Shah et al. 2004; Hennekens et al. 2005), and strongly predict worse cardiac outcomes after medical or surgical interventions of CHD (Connerney et al. 2001; Druss et al. 2001; Blumenthal et al. 2003; Pignay-Demaria et al. 2003; Lett et al. 2004; Shemesh et al. 2004). For example, patients with coexisting major depression show more frequent readmissions after coronary artery bypass graft (CABG) surgery (Connerney et al. 2001; Pignay-Demaria et al. 2003; Lett et al. 2004), and higher mortality (Blumenthal et al. 2003) up to 12 years postoperatively.

Despite the heightened burden of CHD among mentally ill patients, less is known about the quality of cardiac service that they receive and how their mental illness can complicate the quality, safety, and outcomes of cardiac interventions during nonpsychiatric hospitalizations. Druss et al. reported that after hospitalizations for myocardial infarction, patients with mental disorders were less likely to receive indicated medical prescriptions (Druss et al. 2001) or revascularization procedures (Druss et al. 2000), suggesting suboptimal quality of care in these medically vulnerable patients. Moreover, one recent study found that mentally ill patients undergoing CABG surgery in New York State tended to be treated by lower-quality cardiac surgeons (Li et al. 2007).

The issue of quality and safety of hospital care was highlighted by the Institute of Medicine (IOM)'s report *To Err Is Human: Building a Safer Health System* (Institute of Medicine Committee on the Quality of Health Care 2000), which estimated that up to 98,000 hospital deaths each year were due to preventable medical errors. Preventable hospital adverse events, such as major complications after the CABG procedure, may be caused by mistake or delay in diagnosis and treatment, inadequate monitoring or follow-up of treatment, and failure in communication (Leape et al. 1993). It is conceivable that compared with CABG patients without mental illness, those who are mentally ill may experience higher rate of postoperative complications because of their concomitant pathology associated with mental disorders (Pignay-Demaria et al. 2003); the adverse effects of antipsychotic medications (Buckley and Sanders 2000); their cognitive, affective, and behavioral abnormalities that cause miscommunications or noncompliance with treatment regimens (Kronish et al. 2006); and the likelihood of receiving care from lower-quality surgeons (Li et al. 2007).

The objective of this study was to compare the occurrence of postoperative complications in patients with and without mental disorders who underwent isolated CABG surgery in New York State. We hypothesized that coexisting mental disorders were associated with higher rate of post-CABG complications and injuries during hospital stay. We measured these adverse

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outcomes using the patient safety indicators (PSIs) that were developed by the Agency for Healthcare Research and Quality (AHRQ) (Miller et al. 2001; Romano et al. 2003; Agency for Healthcare Research and Quality 2006a).

METHODS

Data Source and Sample

We used the New York's Statewide Planning and Research Cooperative System (SPARCS) hospital discharge data to retrospectively identify all adult patients undergoing isolated CABG surgery in an acute care hospital in the state between 1997 and 2004. The SPARCS data contain uniform inpatient discharge records for all patients, including age, gender, race/ethnicity, principal, and up to 14 secondary diagnoses, as classified by the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes; principal and up to 14 secondary ICD-9-CM procedure codes; admission type; diagnosis-related groups (DRGs); and encrypted hospital identifiers. We selected CABG patients using ICD-9-CM procedure codes 36.10–36.19. Patients with concomitant open-heart procedure such as valve replacement, and patients who were younger than 18 years were excluded. The final sample included 135,701 CABG cases.

Identifying Adverse Events

We used the *AHRQ PSI* software (Agency for Healthcare Research and Quality 2006b) to identify adverse hospital events that can be captured by the diagnostic ICD-9-CM codes and other information in hospital claims (Miller et al. 2001; Romano et al. 2003; Agency for Healthcare Research and Quality 2006a). To target events that most likely represent preventable complications and injuries, the selection of each indicator and its ICD-9-CM definition in the PSI algorithm were subject to a rigorous process of systematic literature review, reliability and validity evaluation, clinical and coding expert consensus review, and empirical analyses and validation using New York hospital discharge data (Daumit et al. 2006). Detailed information about the definition of each event and risk pool of patients (denominator), and about the inclusion and exclusion criteria is documented elsewhere (Agency for Healthcare Research and Quality 2006b). These indicators provide a valuable case-finding tool to flag potential process-of-care failures that warrant institutional review, but are not intended to definitively measure medical errors (Miller et al. 2001; Daumit et al. 2006). It is also likely that these indicators do not capture all

safety-related events because they were defined primarily using ICD-9-CM codes, which in general are very specific but not highly sensitive in recording diagnoses, and because these indicators were designed in a way to minimize false positives in screening for instances of compromised patient safety (Romano et al. 2003). Despite these potential limitations, the AHRQ PSIs have been widely used for safety research (Miller et al. 2001; Romano et al. 2003; Zhan and Miller 2003; Encinosa and Bernard 2005; Daumit et al. 2006), and there is no evidence that the case identification issue selectively affects patients with comorbid mental disorders.

In this study, we analyzed the safety indicators that were clinically relevant to patients undergoing CABG surgery and that had adequate number of events for statistical comparisons. These included nine separate indicators for the occurrence of anesthesia complications, decubitus ulcer, infections of medical care, postoperative hip fracture, postoperative hemorrhage or hematoma, postoperative physiologic and metabolic derangement, postoperative pulmonary embolism (PE) or deep vein thrombosis (DVT), postoperative sepsis, and accidental puncture or laceration. In addition, we created an overall summary variable for each CABG patient indicating the presence of any of the nine complications.

Mental Disorders

We defined coexisting mental disorders using all secondary diagnoses with ICD-9-CM codes 290–319, excluding 305.1 for tobacco use. CABG patients with mental disorders were further categorized into one of three mutually exclusive subgroups: psychiatric disorder only (ICD-9-CM codes 290–302 and 306–319), substance-abuse disorder only (ICD-9-CM codes 303–305, excluding 305.1 for tobacco use), and dual diagnosis (both psychiatric and substance-abuse disorders). In our sample, psychiatric disorders included schizophrenia, major depression, bipolar, dementia, and other psychiatric diagnoses. Several earlier studies (Lurie et al. 1992; Kashner 1998; Walkup, Boyer, and Kellermann 2000) have shown the validity of identifying mental diagnoses based on ICD-9-CM codes in hospital claims data.

Patient Covariates

We adjusted for the following patient risk factors in multivariate analyses that may be associated with patient safety outcomes: age; gender; race/ethnicity categorized as non-Hispanic white, black, other race/ethnicity (Hispanic, Asian/Pacific Islander, Native American), and unknown; admission type

(scheduled or not); individual medical comorbidities and disease severity defined by the algorithm developed by Elixhauser et al. (1998); an indicator variable for tobacco use (ICD-9-CM code 305.1); and an indicator variable for admission year (≥ 2001 or not). The comorbidities according to Elixhauser et al. (1998) were defined using ICD-9-CM diagnostic codes (see Table 1 for the list of conditions), and have been shown to be associated with higher hospital resource use and mortality for patients of varied disease groups. For the present study, several defined conditions, such as congestive heart failure, valvular disease, and pulmonary circulation disorders, capture the severity of CHD. We used a set of dummy variables (one for each listed condition in Table 1) in multivariate analyses to control for the effects of these conditions.

Statistical Analysis

We performed bivariate analyses to assess differences in adverse event rates and patient characteristics by mental diagnosis. Difference in mean age was examined with t -test, and differences in other categorical variables were examined with χ^2 -tests.

We estimated multivariate logistic regression models to determine the independent impact of mental disorder on the likelihood of each complication and the overall complication separately. The effect of “any mental disorder” was estimated in each analysis. In the analyses of overall complication where statistical power was adequate for subgroup analyses, one additional regression model was estimated to compare the effects of psychiatric disorder alone, substance-abuse disorder alone, and dual diagnosis relative to patients without mental disorders.

Each regression model controlled for the patient covariates described above, and was estimated as mixed model that incorporated fixed effects of patient covariates and random hospital effects (Littell et al. 2006). The mixed logistic regression was estimated using *SAS* (SAS Corp., Cary, NC) *Proc Glimmix* (Littell et al. 2006) where random intercepts of hospitals were specified to account for hospital variations in safety outcome. We calculated intraclass correlation coefficient (ICC) in each model to quantify the extent to which outcome variations are due to hospital performance. The ICC was calculated as

$$\text{ICC} = \frac{\tau_0}{\tau_0 + \pi^2/3},$$

where τ_0 is the estimated variance of the random effects and $\pi = 3.014159$ (Snijders and Bosker 2000). In order to test whether the association between

Table 1: Description of Patients Undergoing Coronary Artery Bypass Graft Surgery by Mental Status (*N* = 135,701)

<i>Characteristic</i>	<i>Mental Disorder (N = 9,737)</i>	<i>No Mental Disorder (N = 125,964)</i>	<i>p- Value</i>
Age in years, mean ± SD	64.8 ± 11.51	66.1 ± 10.67	<.001
Female (%)	30.4	28.5	<.001
Race/ethnicity (%)			.026
Non-Hispanic white	67.9	67.1	
Black	4.5	4.2	
Other	10.3	11.8	
Unknown	17.3	16.9	
Scheduled admission	38.8	44.5	<.001
Medical conditions (%)			
Congestive heart failure	20.8	16.9	<.001
Valvular disease	7.6	6.6	<.001
Pulmonary circulation disorders	1.8	1.4	.004
Peripheral vascular disorders	11.1	9.2	<.001
Hypertension	66.1	64.2	<.001
Paralysis	0.7	0.5	.001
Other neurological disorders	4.2	2.0	<.001
Chronic pulmonary disease	21.4	13.9	<.001
Uncomplicated diabetes	29.6	30.7	.024
Complicated diabetes	5.2	4.2	<.001
Hypothyroidism	7.6	5.3	<.001
Renal failure	3.5	3.3	.244
Liver disease	1.4	0.4	<.001
Peptic ulcer disease	2.2	1.5	<.001
excluding			
bleeding			
AIDS	0.3	<0.1	<.001
Lymphoma	0.4	0.5	.798
Metastatic cancer	0.1	0.2	.697
Solid tumor without metastasis	7.0	7.1	.680
Rheumatoid arthritis	1.3	1.0	.008
Obesity	7.4	4.7	<.001
Weight loss	0.7	0.6	.049
Blood loss anemia	0.6	0.5	.029
Deficiency anemia	10.1	6.6	<.001
Tobacco use (%)	14.2	6.4	<.001
Admission year ≥ 2001 (%)	54.7	44.4	<.001

mental disorders and safety outcomes varies across hospitals, we finally estimated random-coefficient models where the effect of mental disorder on patient safety outcome was specified as a random coefficient and allowed to vary across hospitals.

RESULTS

Compared with CABG patients without mental disorders ($N = 125,964$), patients with mental disorders ($N = 9,737$) were slightly younger, and more likely to be female and to be admitted as unscheduled cases (Table 1). They also had more comorbidities such as congestive heart failure, neurological disorders, chronic pulmonary disease, hypothyroidism, liver disease, AIDS, obesity and deficiency anemia, and tended to be tobacco users.

Compared with patients without mental disorders, patients with mental disorders had a higher rate of overall complications after CABG procedure (42.1/1,000 versus 32.0/1,000), particularly anesthesia complications (2.4/1,000 versus 0.3/1,000), decubitus ulcer (10.8/1,000 versus 7.3/1,000), and postoperative hip fracture (0.8/1,000 versus 0.3/1,000) (Table 2, $p < .001$ in all cases). Multivariate random-intercept regression confirmed these observed differences after adjusting for patient characteristics listed in Table 1 and hospital random effects (Table 2). The ICC in each model indicated that hospital effects accounted for between 5 percent (accidental puncture or laceration) and 20 percent (anesthesia complications) variations of individual safety events. In addition, the effect of mental disorders on some safety outcomes varied across hospitals (i.e., the variance of the estimated random coefficients equaled 0.16 [SE = 0.07], 0.79 [SE = 0.35], and 0.34 [SE = 0.17] for overall complication, decubitus ulcer, and postoperative PE/DVT, respectively), suggesting that hospitals may perform differently in caring for mentally ill patients.

Table 3 shows that in the subgroup analysis, patients with psychiatric disorder alone had higher overall complication rate than patients without mental disorders (adjusted odds ratio [AOR] = 1.32, $p < .001$); patients with only substance-abuse disorder and patients who were dually diagnosed did not show significantly higher complication rates, due in part to their small samples and the rarity of adverse events.

DISCUSSION

This study found that compared with patients without mental disorders, patients with mental disorders experienced higher rate of several potentially preventable complications and injuries during hospitalization for CABG surgery. The higher rate of postoperative adverse events for mentally ill patients persisted after adjusting for patient characteristics and hospital effects. Complication rates after CABG surgery may vary across hospitals for all patients and for patients with mental disorders.

Table 2: Mental Disorder and Complication following Coronary Artery Bypass Graft Surgery

	Mental Disorder			No Mental Disorder			Adjusted Odds Ratio (95% CI)*		p-Value of Adjusted Odds Ratio	Intraclass Correlation Coefficient (ICC)*
	Unadjusted Rate per 1,000 Patients	Patients at Risk		Unadjusted Rate per 1,000 Patients	Patients at Risk					
Overall complication	42.1	9,737		32.0	125,964		1.27 (1.14–1.41)	<.001		0.03
Anesthesia complications	2.4	9,737		0.3	125,963		6.44 (4.08–10.17)	<.001		0.21
Decubitus ulcer	10.8	6,128		7.3	79,185		1.42 (1.10–1.82)	.006		0.11
Infections due to medical care	7.4	8,638		5.2	112,107		1.24 (0.95–1.62)	.107		0.09
Postoperative hip fracture	0.8	9,665		0.3	124,997		3.29 (1.79–6.05)	<.001		0.15
Postoperative hemorrhage or hematoma	4.1	9,735		4.0	125,940		1.10 (0.80–1.50)	.562		0.14
Postoperative physiologic and metabolic/derangement	5.4	3,123		3.9	47,255		1.19 (0.75–1.89)	.461		0.07
Postoperative PE/DVT	10.7	9,731		9.2	125,906		1.04 (0.85–1.28)	.671		0.10
Postoperative sepsis	11.6	2,672		8.2	40,471		1.34 (0.92–1.94)	.128		0.06
Accidental puncture or laceration	9.4	9,736		7.7	125,950		1.22 (0.98–1.51)	.073		0.05

*Adjusted odds ratios, 95% confidence intervals (95% CI), and intraclass correlation coefficients (ICCs) were computed from random-intercept random-intercept logistic regression that controlled for age, gender, race/ethnicity, admission type, medical co-morbidities and disease severity, tobacco use, admission year, and hospital random effects.
PE, pulmonary embolism; DVT, deep vein thrombosis.

Table 3: Mental Disorder and Complication for Patients Undergoing Coronary Artery Bypass Surgery

	<i>Overall Complication (N= 135,701)</i>			
	<i>Unadjusted Rate per 1,000 Patients</i>	<i>Patients at Risk</i>	<i>Adjusted Odds Ratio (95% CI)*</i>	<i>p-Value</i>
Any mental disorder	42.1	9,737	1.27 (1.14–1.41)	<.001
Psychiatric disorder only	45.6	7,789	1.32 (1.18–1.47)	<.001
Substance abuse disorder only	26.1	1,534	0.97 (0.70–1.34)	.863
Dual diagnosis	36.2	414	1.24 (0.74–2.10)	.414
No mental disorder	32.0	125,964	Reference	–

*Adjusted odds ratios and 95% confidence intervals (95% CI) were computed from random-intercept logistic regression, controlling for age, gender, race/ethnicity, admission type, medical comorbidities and disease severity, tobacco use, admission year, and hospital random effects.

Our data showed that CABG patients with concurrent mental disorders had a higher prevalence of medical comorbidities than other CABG patients, and were more likely to be admitted for unscheduled surgery, which would suggest that they were sicker and presented later in the course of their cardiac disease. Their higher disease burden may be caused by adverse effects of antipsychotic drugs, potential direct effects of mental abnormalities on medical vulnerability, and poor health behaviors such as increased smoking and alcohol consumption, unhealthy diet, and sedentary lifestyle (Shah et al. 2004). In addition, earlier studies report that mentally ill patients may have delayed hospital admission for myocardial infarction (Bunde and Martin 2006).

In this study, although we cannot totally rule out the possibility that unobserved clinical and health care factors lead to their increased postoperative injuries, the increased odds of overall and several individual adverse outcomes associated with mental disorders remained significant after adjusting for available patient diagnoses and hospital effects. This suggests that mentally ill patients undergoing CABG surgery may have received lower quality of care than other CABG patients. The likelihood of deficiency in care and its manifestation in safety outcomes among these patients are supported by the existing literature showing that mentally ill patients tend to receive suboptimal quality of medical care (Druss et al. 2001) and surgical care (Li et al. 2007) during hospitalizations for CHD.

Multiple plausible factors may explain the association between mental disorders and the increased risk of postoperative complications. Surgical

patients with mental disorders may present a variety of problems during anesthesia including difficulty in provider–patient communication, interactions between antipsychotics and anesthetic drugs, hazardous behaviors such as agitation, and lack of patient cooperation (Kudoh 2005). In addition, physicians and other health professionals may have less experience treating these “difficult” patients, who are more likely to have adverse reactions to anesthetic and analgesic drugs, including arrhythmias, hypotension, torsade de pointes, and postoperative confusion (Buckley and Sanders 2000; Shah et al. 2004; Kudoh 2005). If this is the reason behind the safety issues faced by patients with mental disorders, specific interventions to sensitize medical providers to their complex care needs are necessary so as to bridge the gap in safety outcomes and improve the quality of cardiac services that they receive.

Patients with mental disorders also tend to have reduced sensation and pain responsiveness, poor compliance with recommended postoperative health behaviors such as ambulating and self-hygiene, and more frequent restraint use, all of which can contribute to their increased risk of developing decubitus ulcer during hospital stay. The threefold increase in postoperative hip fractures in these patients may be partially related to the undesirable sedative and autonomic effects of psychotropic drugs such as confusion, drowsiness, and ataxia (Ray et al. 1987). In addition, some of these patients may exhibit abusive, aggressive, or other disruptive behaviors, which may lead to physical injuries and falls due to nurse aides’ reluctance to provide necessary supportive care.

Our study has several strengths. It is based on the innovative AHRQ PSIs that have been shown to be associated with longer length of stay, higher hospital charges, and increased mortality (Zhan and Miller 2003). The AHRQ PSI, with its rigorous measurement design, allowed this study to identify patient safety events that likely reflect consequences of hospital care failures. Although not all flagged cases may reflect problematic care and the PSI algorithm may miss a portion of cases with compromised safety, the AHRQ PSI provides an important tool for population-based comparisons of hospital care safety. In addition, our access to multiple years of New York hospital claims databases makes it feasible to conduct the analysis with a large sample of a well-defined patient population (i.e., patients undergoing CABG surgery). To the extent that most complications occur in rare circumstances, our large sample allowed for meaningful statistical comparisons between patients with and without mental disorders.

The use of hospital claims data, however, is also associated with several limitations. First, the validity of the PSI outcomes depends on the completeness

and precision of recorded administrative and clinical information. Because ICD-9-CM diagnoses can be undercoded or miscoded, and are relatively insensitive in capturing medical conditions, the prevalence of safety events is likely to be underestimated in our data. However, the overall underestimation of outcomes would bias our result towards the null hypothesis or lack of associations between mental disorder and postoperative complications. Second, we used ICD-9-CM codes to identify mental disorders, which is a widely used approach in mental disparity studies (Druss et al. 2000, 2001; Daumit et al. 2006; Li et al. 2007). Several validation studies, including one conducted over 10 years ago, have shown that hospital administrative data can be a reliable source of mental diagnoses for Veteran Affairs patients and Medicaid patients (Lurie et al. 1992; Kashner 1998; Walkup, Boyer, and Kellermann 2000), but similar studies do not exist that examine the validity of mental diagnoses in the general population. Therefore, mental disorder could be underdetected in our sample due to undercoding or underdocumentation by medical providers. The underdocumentation of mental disorder may be more likely to occur when its symptom is less severe. However, the misclassification of mentally ill patients would also bias the estimated result toward the null hypothesis and thus make it a conservative estimate of the true effect of mental disorder.

Third, the administrative data do not contain as detailed clinical information as in chart review data for risk adjustment. Although we statistically adjusted for over 20 medical comorbidities defined by a validated ICD-9-CM algorithm (Elixhauser et al. 1998), it is possible that uncontrolled clinical confounders mediate a part of the effect of mental disorders, and thus lead to an overestimation of the effect.

Finally, our analyses included only New York patients undergoing CABG surgery and therefore may not be generalized to patients in other states. New York State might be unique in open heart surgery because of its long-standing, highly reputed quality report cards for CABG outcomes, which likely have affected patient access and physician and hospital practice (Li et al. 2007). Therefore, although we do not believe the effect of mental disorder on post-CABG complications is unique to this state, similar studies in other states are needed to confirm our findings.

CONCLUSION

In summary, this study finds that mentally ill patients are more likely than other patients to experience potentially preventable complications and injuries after CABG surgery. These adverse hospital events have been shown to be

associated with longer hospital stay and greater resource utilization (Zhan and Miller 2003), and may contribute to the worse postdischarge outcomes that are frequently documented among CABG patients with mental disorders (Pignay-Demaria et al. 2003). Therefore, findings in this study have both clinical practice and policy implications in terms of promoting the safety of care for patients with mental disorders. Because this is one of the few studies to report patient safety problems during CABG surgery in this vulnerable population, additional work is necessary to better understand the mechanism underlying these findings in order to inform and guide the development of strategies to address this issue, and to explore the safety problems faced by patients with mental disorders during other types of cardiac interventions.

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SUPPLEMENTARY MATERIAL

The following supplementary material for this article is available online:
Appendix SA1. Author Matrix.

This material is available as part of the online article from <http://www.blackwell-synergy.com/doi/abs/10.1111/j.1475-6773.2008.00875.x> (this link will take you to the article abstract).

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