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Psychosocial Factors in Heart Surgery: Presurgical Vulnerability and Postsurgical Recovery

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Objective: Distress and low perceived social support were examined as indicators of psychosocial vulnerability in patients about to undergo heart surgery. ***Design:*** A total of 550 study patients underwent heart surgeries, including bypass grafting and valve procedures. Psychosocial interviews were conducted about five days before surgery, and biomedical data were obtained from hospital records. ***Main Outcome Measures:*** Sociodemographic, personality, religious, and biomedical factors were evaluated as predictors of psychosocial vulnerability, and all five sets of variables were evaluated as contributors to hospital length of stay (LOS). ***Results:*** Patients scoring higher on one or more indicator of presurgical psychosocial vulnerability were younger, more likely to be female, less likely to be married, less well educated, lower in dispositional optimism, higher in trait anger, and lower in religiousness. Older age, depression, low support, and low trait anger each showed an independent, prospective association with greater LOS, and several other predictors had prospective relationships with LOS that were statistically mediated by depression or perceived support. ***Conclusion:*** Evidence that multiple psychosocial factors may influence adaptation to heart surgery has implications for understanding and ameliorating presurgical distress and for improving postsurgical recovery.

Keywords: coronary artery bypass surgery, distress, hospital length of stay, psychosocial factors, valve surgery

About 427,000 coronary artery bypass graft surgeries (CABG) and 99,000 heart valve surgeries were performed in the United States in 2004 (Rosamond et al., 2007). Despite technical advances, heart surgery remains a major adaptive challenge (Contrada, Leventhal, & Anderson, 1994), especially for the increasing number of older and otherwise more vulnerable heart surgery patients. Anticipation of heart surgery is distressing for patients and families (Bengtson, Karlsson, Wahrborg, Hjalmarson, & Herlitz, 1996; Mahler & Kulik, 2002), and surgical recovery is physically and psychologically demanding. Few studies have sought to identify determinants of adaptation at both of these time-points. The purpose of this study was to test a preliminary conceptual framework describing psychosocial factors that affect patients prior to surgery and during the ensuing recovery period.

Depressive symptoms are commonly elevated prior to heart surgery (Blumenthal et al., 2003; Goyal, Idler, Krause, & Contrada, 2005; Khatri et al., 1999; Pirraglia, Peterson, Williams-Russo, Gorkin, & Charlson, 1999) and are associated with female gender (Czajkowski et al., 1997), neuroticism (Duits et al., 1999), lower education level, life stress, and lower social support (Pirraglia et al., 1999). Anxiety is also common (Khatri et al., 1999; Phillips-Bute et al., 2003), with predictors that include female gender and neuroticism (Czajkowski et al., 1997; Phillips-Bute et al., 2003). Presurgical interventions reduce distress, but this is not always accompanied by improvements in objective measures of surgical recovery (M. Johnston & Vogele, 1993). Although levels of social support experienced prior to heart surgery can be high, they vary significantly between patients (Pirraglia et al., 1999).

Adaptation to major surgery affects length of hospital stay (LOS). Data on LOS are collected routinely and have been described in large, multisite samples (Peterson et al., 2002). Within-hospital variation in LOS reflects presurgical factors, surgical

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procedures, complications, physical recovery, behavior, and medical utilization. Although average LOS has been shortened over the past few decades, LOS can be extended by major complications and other causes. Lengthy stays have an economic cost (Peterson et al., 2002) and are associated with long-term outcomes including readmission (Deaton et al., 1998), poor functional status, and mortality (Bashour et al., 2000).

A preliminary framework to guide the present study was adapted from models of psychosocial factors in other health outcomes. In particular, we drew upon the notion of psychosocial vulnerability, a key component of a transactional model of the health-damaging effects of personality hostility (Smith & MacKenzie, 2006). In that model, psychosocial vulnerability refers to a high level of life stress and a low level of social support. This construct is similar to elements of the reserve capacity model of the health effects of socioeconomic status (Gallo & Matthews, 2003). Reserve capacity refers to tangible, interpersonal, and intrapersonal resources for coping with stressors and is thought to exert effects partially through its emotional and cognitive impact.

Anxiety, symptoms of depression, and low perceived social support may reflect forms of psychosocial vulnerability during the period preceding surgery (see Figure 1). Psychosocial vulnerability, in turn, reflects antecedent factors such as sociodemographics, personality, religious involvement, and biomedical variables. In the present context, psychosocial vulnerability is both an indication of poor adjustment to anticipation of a major stressor and a condition that later undermines postsurgical recovery. Anticipation and recovery periods are therefore addressed within the same framework, rather than as separate outcomes. As suggested by Figure 1, one set of hypotheses associated with this model is that distress and low social support at least partially mediate the effects of other psychosocial factors, as well as those of demographic and biomedical variables, on LOS.

Religious involvement has received considerable attention for its possible effects on health outcomes. It refers to subjective attributes, such as belief in religious doctrine, and behaviors, such as praying and attending services. Meta-analysis suggests that religious involvement is associated with lower risk of all-cause mortality in population studies (McCullough, Hoyt, Larson, Koenig, & Thoresen, 2000). Religious beliefs and activities may be especially important for patients confronting life-and-death issues raised by major surgery. However, effects of different aspects of religious involvement in heart surgery patients have not been uniform (Contrada et al., 2004).

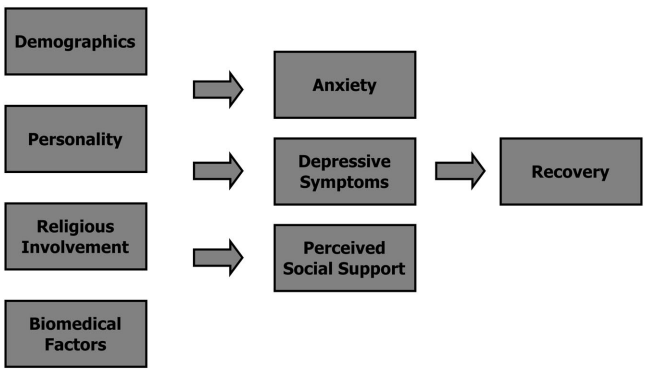

Figure 1. Conceptual framework for determinants of preoperative psychosocial vulnerability and postoperative recovery in heart surgery patients. Higher levels of anxiety and depressive symptoms and lower levels of perceived social support are both indicators of vulnerability during the presurgical period and potential mediators of the effects of more distal psychosocial factors on surgical recovery.

Adaptation to surgery also may reflect personality. Anger-related traits have been linked to CAD, and identify individuals who are vulnerable to stressors and report low social support (Smith & MacKenzie, 2006), which may mediate negative outcomes. On the other hand, anger has adaptive value as a stimulus to action and in communicating aversive conditions to others (Panskepp, 1998). Anger also has been linked to a behavioral approach system associated with left frontal cortical activity (Harmon-Jones, Lueck, Fearn, & Harmon-Jones, 2006), and cancer research has suggested that "fighting spirit" may promote adjustment to illness and its treatment (Cordova et al., 2003). Thus, anger may be associated with anticipatory distress and at the same time promote later recovery, irrespective of its negative long-term effects on cardiovascular health. Dispositional optimism is another relevant personality attribute. Trait optimism has been found to facilitate adjustment to various medical conditions and treatments, including heart surgery (e.g., Scheier et al., 1989). Optimistic expectations are thought to promote confidence and active engagement in the process of adaptation (Scheier, Carver, & Bridges, 1994).

Demographic indicators are markers for multiple psychological and biomedical variables, a factor that can complicate predictions. For example, older age is associated with cumulative illness burden and functional decline, which undermine surgery recovery (Eagle et al., 2004). But younger age has been linked to greater distress in cardiac patients (e.g., Brummett et al., 2004), possibly because negative events have more impact when they occur unexpectedly early in life (Neugarten, 1979). Women with heart disease often show greater depression than men, and depression has prognostic value for cardiac outcomes (Wulsin et al., 2005). However, female heart patients also have reported higher levels of social support (e.g., Krohne & Slangen, 2005), which might counteract effects of depression (Frasure-Smith et al., 2000). Marriage can be a source of support, but its effects vary as a function of gender and relationship quality (Kiecolt-Glaser & Newton, 2001).

With regard to surgical recovery, over two dozen preoperative demographic and biomedical variables collectively account for about 14% of the variance in LOS following CABG (Peterson et al., 2002). Intrasurgical factors and complications have added impact (Contrada et al., 2004). Limited work on psychosocial factors points to possible effects of depression, religion (Contrada et al., 2004), subjective health indicators (Halpin & Barnett, 2005; G. Johnston, Goss, Malmgren, & Spertus, 2004), and social isolation (G. Johnston et al., 2004). Thus, several psychosocial factors may affect LOS. However, most studies focused on one or two predictors, rather than examining multiple constructs within a single framework to distinguish between their unique and overlapping contributions. In addition, few studies have approached comprehensive coverage of relevant biomedical variables.

In the present study, psychosocial and demographic factors were assessed by interviewing patients about five days prior to heart surgery. Biomedical data were drawn from hospital charts. As suggested by the model depicted in Figure 1, we expected religious

involvement, trait anger, dispositional optimism, and demographic characteristics to be significant predictors of presurgical psychosocial vulnerability as reflected by levels of anxiety, depressive symptoms, and perceived social support, controlling for presurgical biomedical variables. Anxiety, depressive symptoms, and perceived support were expected to statistically mediate effects of the first set of predictors on LOS. Other research questions concerned similarities and differences between predictors of psychosocial vulnerability and of LOS, and comparison of direct and indirect (mediated) effects of LOS predictors.

Method

Participants

Participants underwent coronary artery bypass graft surgery (CABG), valve surgery, and other forms of heart surgery at the Robert Wood Johnson University Hospital (RWJUH) in New Brunswick, NJ, between October 11, 2000 and October 8, 2003. Patients who had different forms of heart surgery were included in view of similarities in procedure (e.g., cross-clamp, anesthesia protocol) and course of recovery (Jenkins, Jono, & Stanton, 1996). Patients were approached when staff and space were available, time periods that were well distributed throughout the day and week such that there is unlikely to have been a systematic bias in the kinds of patients that were invited to participate. The only exclusion criteria were inability to speak English and conditions that would interfere with interviewing. Elective surgery patients were approached at an outpatient consultation visit. Urgent and emergent surgery patients were approached in hospital. Of 1,078 eligible patients approached, 677 (63%) agreed to participate. For 101 who agreed, an interview could not be arranged because of staff scheduling constraints, resulting in an initial sample of 576 patients (53% of those approached). Of those patients, 6 were excluded because they never underwent heart surgery, 15 because they died during the hospital stay, and 5 because essential medical data could not be obtained. This yielded a final sample of 550 patients. As can be seen in Table 1, there were 405 (73.6%) men, 482 (87.6%) were White, and 398 (72.4%) were married. The mean age was 65.1.

Procedures

Elective surgery patients were interviewed during preadmission testing. Urgent and emergent surgery patients were interviewed bedside. Research assistants described the study, obtained informed consent, and conducted interviews an average of 5.0 days prior to surgery. Biomedical data were obtained through the hospital's electronic database and from manual chart review. Two research assistants reviewed charts to extract data, and a third resolved discrepancies. All were blind with respect to psychosocial data.

Measures

Descriptive data for key measures are presented in Table 1.

Interview. Demographic data included age, gender, ethnicity, marital status, and education. Depressive symptoms experienced during the past week were assessed with the Center of Epidemiologic Studies–Depression scale (CES-D), a commonly used, 20-item instrument (Radloff & Teri, 1986). Perceived social support was measured with the Multidimensional Scale of Perceived Social Support (MSPSS: Zimet, Dahlem, Zimet, & Farley, 1988). The 12-item total score reflects the amount of support the respondent perceives to be available from friends, family, and a confidante. Dispositional optimism was assessed using the Life Orientation Test–Revised (LOT-R) (Scheier et al., 1994), a 6-item measure of generalized expectancies for positive outcomes. Anxiety experienced over the past month was measured using a 4-item subscale of the Medical Outcomes Study Questionnaire (Stewart & Ware, 1992). Trait anger was assessed using a 7-item subscale of the Buss-Perry Aggression Questionnaire (Buss & Perry, 1992). Subscales of the Rutgers Multidimensional Religion Inventory (Idler et al., 2007) were used to measure three aspects of religious involvement: daily devotional activities (6 items), including behaviors such as private prayer, bible reading, and saying grace before meals; beliefs (7 items) in the existence of a divine being, an afterlife, and in the role of faith in everyday activities; sense of purpose (3 items), or the belief that life has a purpose, that personal beliefs give meaning to life, and that one has a clear philosophy of life.

Hospital chart data. Hospital records were used to assess preoperative medical variables, surgical treatment, postoperative complications, and hospital LOS. This assessment was guided by research examining presurgical predictors of complications (Shroyer et al., 2003) and LOS (Peterson et al., 2002) following CABG. Both studies examined sociodemographics, CHD risk factors, illness severity, and comorbidities, using data for nearly identical multisite samples of about 500,000 CABG patients. Data for these variables are recorded routinely following standardized definitions specified by the Society for Thoracic Surgery (STS).

To reduce the number of predictors, a presurgical biomedical index was created as a count of the following 20 conditions and treatments (the number of patients with each risk factor is given in parentheses): history of smoking (372), hypertension (426), hypercholesterolemia (420), history of congestive heart failure (93), history of atrial fibrillation (23), diabetes (189), left main disease (83), aortic stenosis (94), previous myocardial infarction (81), New York Heart Association Class IV (54), renal failure (25), chronic lung disease (71), cerebrovascular accident (25), cerebral or peripheral vascular disease (142), prior/multiple open heart surgeries (42/4), urgent or emergent operative status (226), cardiogenic shock (2), immunosuppressive therapy (30), preoperative intraarterial balloon (7). Continuous indicators of mitral valve insufficiency, number of diseased vessels, ejection fraction, and body surface area were included separately. Additional, non-STS presurgical predictors available from charts were preadmission use of beta-blockers and ace-inhibitors. In addition, year of surgery was coded to reflect technical improvements over the recruitment period (2000 = 0, 2001 = 1, 2002 = 2, 2003 = 3).

We also examined specific aspects of surgical procedure. Dummy variables coded the type of surgery (CABG, valve, other heart surgery), the responsible surgeon, whether an intraoperative balloon pump was used, and whether a heart-lung machine was used (on/off pump). Continuous variables were derived from charts to represent the number of grafts and duration of surgery (in minutes).

Table 1
Descriptive Statistics

Demographics	*n*	Number	Percent	Mean	*SD*	Min	Max	α
Age	550			65.06	11.52	28.00	89.00	
Gender	550							
Female		145	26.4					
Male		405	73.6					
Marital status	550							
Married		398	72.4					
Unmarried		152	27.6					
Education	545			13.51	3.01	0.00	22.00	
Ethnicity	550							
White		482	87.6					
Black		25	4.6					
Hispanic		12	2.2					
Other		31	5.6					
Personality								
Trait anger	547			2.34	0.90	1.00	5.00	0.86
Dispositional optimism	547			3.67	0.69	1.00	5.00	0.76
Religious involvement								
Daily devotional activities	542			2.04	0.64	1.00	4.43	0.72
Religious beliefs	533			3.82	0.79	1.00	5.00	0.81
Sense of purpose	544			4.20	0.62	1.00	5.00	0.79
Psychosocial vulnerability								
Anxiety	545			2.53	1.03	1.00	5.50	0.85
Depressive symptoms	550			11.21	9.05	0.00	48.00	0.89
Perceived social support	546			6.00	0.89	1.00	7.00	0.86
Presurgical biomedical variables								
Biomedical index[a]	550			4.34	1.98	0.00	11.00	
Admission beta blockers	550	293	53.3					
Admission ace inhibitors	550	219	39.8					
Ejection fraction	530			48.79	12.67	15.00	93.00	
Mitral valve insufficiency	544			0.82	1.26	0.00	4.00	
Number of diseased vessels	549			2.01	1.13	0.00	3.00	
Body surface area	550			1.96	0.22	1.36	2.79	
Recruitment year	550			1.83	0.82	0.00	3.00	
Intrasurgical biomedical variables								
CABG surgery[b]	550	443	80.6					
Valve surgery	550	149	27.1					
Other surgery	550	49	8.9					
Number of grafts	550	1186	215.6					
On pump	550	528	96.0					
Balloon pump	550	10	1.8					
Surgeons	550							
Surgeon 1		47	8.6					
Surgeon 2		82	14.9					
Surgeon 3		401	72.9					
Other surgeons		20	3.6					
Duration of surgery	550			2.59	1.04	0.80	8.80	
Complications								
Atrial fibrillation	549	164	29.9					
Complications index[c]	549			0.35	0.99	0.00	8.00	
Length of hospital stay	550			7.97	6.94	3.00	71.00	

Note. CABG = coronary artery bypass graft. All continuous variables are keyed such that higher values indicate more of the characteristic. Mean scores are reported for psychosocial factors, except for depressive symptoms, for which Center of Epidemiologic Studies–Depression (CES-D) total scores are reported.
[a] Sum of all dichotomous biomedical predictors (see text for details).
[b] Some patients underwent multiple surgical procedures.
[c] Count of all complications other than atrial fibrillation (see text for details).

Postoperative atrial fibrillation was analyzed separately as a predictor of LOS because as in most studies it was the most frequent complication, occurring in 164 (29.9%) of the patients. Other complications were assessed using an index created by coding (*absent* = 0, *present* = 1) and summing 23 specific postsurgical events (the number of patients experiencing each complication is given in parentheses): reoperation for bleeding (11), reoperation for valve repair (1), other cardiac reoperation (2), noncardiac reoperation (9), renal failure/dialysis (25/4), pneumonia (9), permanent stroke (10), transient stroke (3), deep sternal wound infection (3), peri-operative myocardial infarction (2), prolonged ventilation (40), complication of anticoagulation therapy

(18), urinary tract infection (8), cardiac arrest (6), gastrointestinal complication (10), septicemia (10), tamponade (7), heart block (7), multiple system failure (2), ischemic limb (1), pulmonary embolism (1), thoratomy (1).

Results

Descriptive Data

Most patients underwent elective surgery ($n = 324$, 58.9%) and received coronary artery bypass grafting (CABG) ($n = 443$, 80.6%). Total LOS ranged from 3 to 71 days ($M = 7.97$). Scores on the complications index ranged from 0 to 8, with a mean of 0.35. Because distributions for LOS and the complications index were positively skewed, both were logarithmically transformed for statistical analysis.

To evaluate sample representativeness, we compared our data with those of Shroyer et al. (2003), which, as mentioned earlier, were derived from the STS database comprising standardized measures of biomedical variables collected routinely on heart surgery patients from participating centers around the United States. Mean age for the multisite sample was 64.9 years ($SD = 10.7$), the majority were male (70.9%), and White (86.8%), and mean postoperative LOS in the multisite sample was 6.9 days ($SD = 7.0$), values that agree reasonably well with corresponding figures for the present sample given in Table 1. The incidence of complications reported by Shroyer et al. was 1.63% for permanent stroke, 3.53% for renal failure requiring dialysis, 5.96% for prolonged ventilation, 0.63% for deep sternal wound infection, and 5.17% for cardiac surgery reoperation, also values similar to those for the present sample, which were 1.8%, 0.7%, 7.3%, 0.6%, and 3.8%, respectively. In another large study, 32.3% of 1,503 CABG patients developed atrial fibrillation (Mathew et al., 2004), compared with 29.9% in the present sample. Thus, our sample was demographically and biomedically similar to larger study populations described in the literature.

Bivariate Associations

Intercorrelations of major variables ranged from negligible to moderately large (see Table 2). There were small but significant relationships indicating longer hospital stays in patients who were older, female, unmarried, less well educated, lower in trait anger, higher in depressive symptoms, and lower in perceived social support.

Multivariate Associations With Anxiety, Depressive Symptoms, and Perceived Social Support

Preoperative anxiety, depressive symptoms, and perceived social support were analyzed first, each in a separate multiple regression analysis, to test hypotheses regarding the determinants of these forms of psychosocial vulnerability. Demographic, personality, religious involvement, and presurgical biomedical factors were entered simultaneously into each regression model to estimate their unique predictive effects, that is, the effect of each predictor was estimated with statistical control of all other predictors in the model (see Table 3). Each predictor was represented as indicated in Table 1, except that ethnicity was coded *non-White* = 1 and *White* = 0 to simplify presentation after preliminary analysis revealed no significant differences between specific ethnic groups.

The analysis for anxiety yielded five significant effects (see Table 3). Anxiety was higher among patients who were younger, among women, and in patients who were less well educated, higher in trait anger, and lower in dispositional optimism. There were no other significant effects on anxiety.

It can be seen in Table 3 that results for depression were similar, but not identical. As with anxiety, depression was higher in younger patients, women, those higher in trait anger, and those lower in dispositional optimism. Unlike anxiety, there was no effect for education level, but there was an effect indicating higher depressive symptom levels among patients scoring lower in sense of purpose and meaning, a variable that was not predictive of anxiety. Also unlike anxiety, the biomedical index predicted level of depressive symptomatology.

Results for perceived social support are also presented in Table 3. Women reported greater support than men, and married patients reported greater support than those who were unmarried. In addition, dispositional optimism was associated with higher levels of support, as were scores on the religious beliefs scale. The only biomedical variable that was related to perceived support was body surface area.

Prospective Associations With Postoperative Length of Stay

Analysis of LOS included all predictors used in the analyses of anxiety, depression, and perceived social support. In addition, anxiety, depression, and social support were themselves added to the model, as were intrasurgical variables, postoperative atrial fibrillation, and the complications index. All predictors again were entered simultaneously, so that the effect of each was estimated with statistical control of all the others.

Results, presented in Table 4, indicated greater LOS among older patients ($p < .05$). With regard to psychosocial predictors, higher trait anger was associated with shorter LOS ($p < .05$) and, conversely, higher levels of depressive symptoms ($p < .05$) and lower perceived social support ($p < .01$) were associated with longer LOS. Optimism, religion, and anxiety were not independently associated with LOS. Among biomedical predictors, history of atrial fibrillation, duration of surgery, postoperative atrial fibrillation, and the complications index were associated with greater LOS at $p < .05$ or better. The model accounted for 62% of the variance (adjusted $R^2 = 0.59$).

Mediation Analysis

Results of the regression analyses described above provide evidence of indirect (mediated) effects of demographic and psychosocial factors on LOS. This is based on the intervening variable approach to mediation analysis described by MacKinnon, Lockwood, Hoffman, West, and Sheets (2002), which requires joint significance of the relationship between predictor and mediator and of the relationship between mediator and outcome. It does not require a significant total effect of the predictor on the outcome (cf. Baron & Kenny, 1986). In the present case, significant associations between predictors and two mediators—depressive symptoms and perceived social support—are summarized in Table 3, and signif-

Table 2
Correlations Among Selected Predictor and Outcome Variables

Measure	2	3	4	5	6	7	8	9	10	11	12	13	14
Demographics													
1. Age	0.16	−0.10	−0.21	−0.25	−0.14	0.03	0.06	−0.01	0.00	−0.14	−0.05	−0.04	0.22
2. Gender		−0.25	−0.20	−0.09	−0.04	−0.04	0.17	0.13	0.03	0.22	0.26	0.08	0.14
3. Marital status			0.17	0.06	0.01	0.12	0.01	0.03	0.11	−0.06	−0.15	0.24	−0.14
4. Education				0.15	−0.09	0.12	−0.03	−0.13	0.12	−0.19	−0.17	0.03	−0.10
5. Ethnicity, non-White					0.05	−0.01	0.20	0.03	0.07	−0.04	−0.02	−0.03	−0.04
Personality													
6. Trait anger						−0.31	−0.10	−0.02	−0.22	0.34	0.27	−0.09	−0.09
7. Dispositional optimism							0.16	0.20	0.43	−0.30	−0.46	0.22	−0.05
Religious involvement													
8. Daily devotional activities								0.46	0.29	−0.02	−0.05	0.15	0.01
9. Religious beliefs									0.38	0.01	−0.04	0.22	−0.03
10. Sense of purpose										−0.17	−0.27	0.24	−0.08
Psychosocial vulnerability													
11. Anxiety											0.66	−0.04	0.03
12. Depressive symptoms												−0.16	0.12
13. Perceived social support													−0.09
Postsurgical adaptation													
14. Length of stay													

Note. Correlations with an absolute value ≥0.09 are statistically significant at $p < .05$.

icant effects of those two mediators on the outcome—LOS—are summarized in Table 4. A direct test of mediation was conducted for each individual pathway, which involved calculation of the 95% confidence intervals for the product of each pair of statistically significant constituent regression coefficients (i.e., that linking predictor to mediator, and that linking mediator to LOS), using the PRODCLIN software program (MacKinnon, Fritz, Williams, & Lockwood, in press). All mediational pathways were significant

Table 3
Regression Analyses for Anxiety, Depressive Symptoms, and Perceived Social Support

	Anxiety		Depression		Social support	
Predictors	β	sr^2	β	sr^2	β	sr^2
Demographics						
Age	-0.188^{***}	.0267	-0.108^{**}	.0089	−0.035	.0009
Gender	0.223^{***}	.0333	0.262^{***}	.0460	0.138^{**}	.0127
Marital status	0.030	.0008	−0.037	.0012	0.236^{***}	.0497
Education	-0.130^{**}	.0140	−0.051	.0022	0.001	.0000
Ethnicity, non-White	−0.060	.0029	−0.009	.0001	−0.032	.0008
Personality						
Trait anger	0.250^{***}	.0532	0.126^{**}	.0135	−0.041	.0014
Dispositional optimism	-0.197^{***}	.0277	-0.341^{***}	.0827	0.097^{*}	.0067
Religious involvement						
Daily devotional activities	0.011	.0001	0.003	.0000	0.038	.0010
Religious beliefs	0.021	.0003	0.028	.0005	0.131^{**}	.0115
Sense of purpose	−0.028	.0005	-0.103^{*}	.0071	0.091	.0056
Presurgical Biomedical Status						
Index of dichotomous variables	0.033	.0008	0.119^{**}	.0110	0.005	.0000
History of atrial fibrillation	0.011	.0001	−0.001	.0000	0.057	.0031
Admission medications, beta blockers	−0.014	.0002	0.028	.0007	0.029	.0008
Admission medications, ace inhibitors	0.024	.0005	−0.026	.0007	−0.049	.0022
Ejection fraction	0.058	.0029	−0.040	.0014	$0.080^{\dagger}$	.0056
Severity of mitral valve insufficiency	0.067	.0037	0.021	.0004	0.011	.0001
Number of diseased vessels	0.028	.0006	0.031	.0007	−0.027	.0006
Body surface area	0.018	.0002	0.014	.0001	0.106^{*}	.0078
Recruitment year	0.007	.0000	0.010	.0001	−0.049	.0023
R^2	0.25		0.33		0.18	
Adjusted R^2	0.23		0.31		0.15	

Note. Values of β are standardized regression coefficients; squared semipartial correlation coefficients (sr^2) reflect the proportion of variance accounted for independently by a given predictor.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. $^{\dagger}p < .10$.

Table 4
Regression Analysis for Postoperative Length of Stay

Predictors	*B*	*SE B*	β	sr^2
Demographics				
Age	0.039	0.017	0.076*	.0040
Gender	0.030	0.041	0.026	.0004
Marital status	−0.037	0.035	−0.032	.0008
Education	−0.026	0.016	−0.051	.0020
Ethnicity, non-White	−0.028	0.048	−0.018	.0003
Personality				
Trait anger	−0.035	0.016	−0.069*	.0037
Dispositional optimism	0.019	0.018	0.037	.0008
Religious involvement				
Daily devotional activities	0.019	0.017	0.038	.0010
Religious beliefs	−0.021	0.017	−0.042	.0011
Sense of purpose	−0.006	0.017	−0.011	.0001
Psychosocial vulnerability				
Anxiety	0.000	0.020	0.000	.0000
Depressive symptoms	0.042	0.021	0.083*	.0030
Perceived social support	−0.043	0.016	−0.084**	.0055
Biomedical status				
Index of dichotomous variables	0.007	0.009	0.026	.0005
History of atrial fibrillation	0.222	0.073	0.087**	.0069
Admission medications, beta blockers	0.043	0.030	0.043	.0016
Admission medications, ace inhibitors	−0.018	0.030	−0.017	.0003
Ejection fraction	0.000	0.001	0.006	.0000
Severity of mitral valve insufficiency	0.021	0.013	0.051	.0018
Number of diseased vessels	0.008	0.025	0.017	.0001
Body surface area	−0.017	0.078	−0.007	.0000
Recruitment year	0.000	0.018	0.000	.0000
CABG surgery	−0.089	0.069	−0.069	.0012
Valve surgery	0.017	0.058	0.015	.0001
Other surgery	0.005	0.055	0.003	.0000
Number of grafts	0.009	0.023	0.023	.0001
On pump	0.048	0.076	0.018	.0003
Balloon pump	0.086	0.119	0.023	.0004
Surgeon 1	−0.056	0.091	−0.031	.0003
Surgeon 2	0.086	0.088	0.060	.0007
Surgeon 3	0.128	0.082	0.112	.0018
Duration of surgery	0.051	0.023	0.103*	.0038
Complications				
Atrial fibrillation	0.199	0.033	0.179***	0.0277
Index of other complications	0.743	0.038	0.603***	0.2804

Note. CABG = coronary artery bypass graft surgeries Values of *B* and β are raw and standardized regression coefficients, respectively; squared semi-partial correlation coefficients (sr^2) reflect the proportion of variance accounted for independently by a given predictor; Model $R^2 = 0.62$ (adjusted $R^2 = 0.59$).
* $p < .05$. ** $p < .01$. *** $p < .001$.

at $p < .05$. The overall model, depicted in Figure 2, also contains two direct effects, linking older age and lower trait anger to greater LOS, which were not mediated by anxiety, depression, or social support.

Description of Psychosocial Effects on LOS

The regression equation represented in Table 4 was used to estimate differences in LOS for patients high and low (mean ± 1 *SD*) on depressive symptoms, trait anger, and social support. Values for other predictors were set at the sample means. Results indicated a difference of 0.56 days between patients with high and low levels of depressive symptoms. Corresponding values for support and anger were 0.60 and 0.49. The combined independent contribution of these three psychosocial factors to total postoperative LOS was 1.65 days.

Interaction Effects

Further analyses indicated there were no interactions involving gender or age, between psychosocial factors, or between psychosocial variables and type of surgery ($ps > .12$).

Discussion

Findings of this study were consistent with a multivariate model in which two aspects of psychosocial vulnerability, namely, depressive symptoms and social support, statistically mediate effects of sociodemographic, religious, and personality factors on recovery from heart surgery as reflected in LOS. There also were prospective associations not mediated by anxiety, depression, or support, indicating that older age and lower trait anger directly predicted greater LOS. All psychosocial effects on LOS were

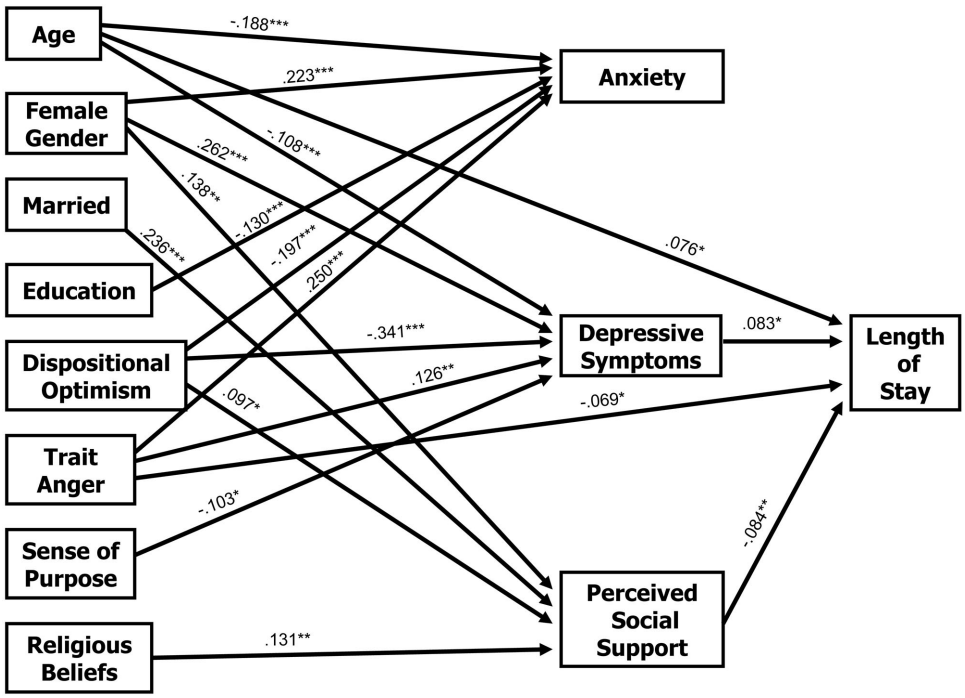

Figure 2. Direct (unmediated) and indirect (mediated) predictive effects of psychosocial factors on postoperative hospital length of stay; values are standardized regression coefficients. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$; not shown are significant effects of biomedical predictors (see Tables 3 and 4).

independent of one another and of a large set of biomedical variables. These results have useful implications for both theory and practice.

Psychosocially vulnerable heart surgery patients, as defined in this study, tended to be younger, more likely female than male, less likely to be married, less well educated, lower in dispositional optimism, higher in trait anger, lower in sense of purpose, and lower in the strength of their religious beliefs (see Figure 2). The inverse relationship between age and distress is consistent with findings obtained in other heart patient populations (e.g., Brummett et al., 2004), perhaps reflecting greater emotional impact of a health-related stressor not expected by younger individuals (Neugarten, 1979). As in previous studies, women reported greater anxiety and depression than men (Czajkowski et al., 1997), despite greater perceived support (Krohne & Slangen, 2005). Effects of marital status and education on social support and anxiety, respectively, also agree with previous work (Gallo & Matthews, 2003; Kiecolt-Glaser & Newton, 2001). Associations linking dispositional optimism (Scheier et al., 1994), trait anger (Smith & MacKenzie, 2006), sense of purpose (Mascaro & Rosen, 2005), and religious beliefs (Idler et al., 2007) to measures indicating greater distress and/or lower social support are also consistent with previous work involving those constructs. For patients exhibiting features of this profile, impending surgery may have a particularly severe psychological impact, possibly warranting preparation beyond that provided by routine care.

Two of three aspects of psychosocial vulnerability, in turn, appeared to influence postoperative adaptation as reflected in LOS. The relationship between depressive symptoms and greater LOS accords with previous findings (Contrada et al., 2004), and adds to the literature implicating depression as a pervasive factor in cardiac outcomes (Wulsin et al., 2005). Depressive symptoms in CABG patients also predict mortality (Blumenthal et al., 2003), poorer cardiac symptom relief (Jenkins et al., 1996), cardiac hospitalization, reduced activity levels (Burg, Benedetto, Rosenberg, & Soufer, 2003), and worsening quality of life (Goyal et al., 2005). The relationship between perceived support and shorter LOS extends previous research on LOS (Krohne & Slangen, 2005) and on other postsurgical outcomes such as emotional adjustment (Kulik & Mahler, 1993). Despite their statistically significant (inverse) intercorrelation, presurgical depression and support had separable relationships with LOS. This suggests that previous observations involving either social support or distress also may represent independent effects. It also suggests that, whereas enhancing social support may be a useful intervention component for heart surgery patients, it may not always be a sufficient means of alleviating the effects of presurgical distress on LOS.

Unlike higher depressive symptoms and lower perceived social support, higher presurgical anxiety was not associated with greater LOS. Although this may reflect methodological factors, it does agree with other evidence that presurgical self-reports indicating high anxiety levels do not always correlate with objective measures of poor surgical adjustment (de Bruin, Schaefer, Krohne, & Dreyer, 2001). A motivational interpretation may account for differential effects of depression and anxiety. More than anxiety, depression involves a lack of behavioral activation that may slow postoperative recovery. Consistent with this view, depressive symptoms were related to low levels of purpose and meaning,

constructs with motivational implications (Idler et al., 2007). However, depressive symptoms also were associated with poor presurgical biomedical status, which, while not inconsistent with a motivational interpretation, also might reflect biological processes that more directly influenced LOS.

Not all relationships with LOS were statistically mediated by measures of psychosocial vulnerability. Higher trait anger independently predicted shorter LOS. This effect appears inconsistent with findings linking greater hostility to negative health outcomes (Smith & MacKenzie, 2006). One possible explanation is that different facets of the anger, hostility, and aggressiveness domain have different health consequences. Trait anger, a disposition to experience angry affect, is not necessarily accompanied by cynicism and mistrust, attitudinal attributes that play a prominent role in research on hostility and CHD (Smith & MacKenzie, 2006). On the other hand, anger might promote earlier hospital discharge despite a relationship with CHD, since these outcomes likely reflect quite different underlying processes. In either case, behavioral correlates, such as assertiveness and active coping efforts, may account for the effect on LOS. Trait anger scores are correlated with measures of assertiveness (Buss & Perry, 1992). Consistent with an assertiveness interpretation, the mean score was 2.34, below the (neutral) midpoint of 3.0, suggesting that the observed effect mainly distinguished patients with low and intermediate scores, rather than involving many patients very high in trait anger. Also, as noted earlier, trait anger is related to a behavioral approach system associated with left frontal cortical activity (Harmon-Jones et al., 2006) that might underlie assertiveness or "fighting spirit." Thus, it is possible that trait anger, like depressive symptoms, served as a marker for motivation level. If so, more direct measurement of assertiveness and motivation to influence recovery might allow more complete assessment of psychosocial vulnerability than was obtained in the present study.

Age also was related to LOS independently of psychosocial vulnerability. The direct relationship between older age and greater LOS, like that involving low trait anger, may reflect aspects of psychosocial vulnerability, or biological factors, that were not measured in the present study. Findings for age also resembled those for trait anger in that both had direct effects on LOS that were in the direction opposite to effects mediated by depression. These data patterns underscore the importance of modeling the psychosocial determinants of presurgical distress and postoperative recovery simultaneously, and support a framework in which these two outcomes are viewed as reflecting the product of qualitatively distinct adaptive challenges (Contrada et al., 1994). Despite some similarity, there may be important differences between patients who are at greatest risk for presurgical distress and social isolation, and those most likely to show a suboptimal course of postsurgical recovery.

Regarding predictors whose relationships with LOS were entirely indirect, female gender showed associations with indicators of both high and low psychosocial vulnerability (depression and perceived support, respectively), which had substantially offsetting effects on LOS. By contrast, as in previous research (Brissette, Scheier, & Carver, 2002), dispositional optimism was associated with lower depression and greater support, variables whose additive effects promoted shorter LOS, thereby extending previous findings that involved behavioral indicators of recovery and incidence of rehospitalization following CABG (Scheier et al., 1989, 1999). Results indicating that perceived support mediated LOS effects of marital status agree with research on mediators of marriage's beneficial effects (Kiecolt-Glaser & Newton, 2001). The association between sense of purpose and lower levels of depressive symptoms is consistent with published findings (Mascaro & Rosen, 2005), as is that linking religious beliefs to greater perceived support (Bradley, 1995). Although mediation analysis suggested that both relationships represent pathways whereby religious involvement influenced LOS, our earlier study on a different sample reported a somewhat more complex pattern of results (Contrada et al., 2004). This might be attributed to differences between the studies in the instruments used to assess religious involvement. Alternatively, findings of the present study may be more reliable as a result of larger sample and more comprehensive coverage of biomedical predictors. Recent work has failed to support an experimental approach in which religious variables involve the behaviors (i.e., prayer) of others, rather than of surgery patients themselves (Benson et al., 2006). The present findings encourage further work on self-initiated religious practices and beliefs, which would be more consistent with the epidemiologic literature (McCullough et al., 2000).

Predictors showing either direct or indirect prospective associations with LOS may have influenced cognitive appraisal and coping processes associated with biological activity that slows wound healing and recovery (Kiecolt-Glaser, Page, Marucha, MacCallum, & Glaser, 1998). Effects on behaviors such as postoperative coughing, breathing, and movement exercises also may have played a role. Whatever the mechanism, it should be noted that variation in LOS is not determined solely by patients' physical condition, psychological state, and behavior. These factors interact with and are constrained by perceptions and behaviors of staff and visitors, treatment protocols, and hospital administration.

Limitations and Strengths

The study sample in some ways resembled a very large, multisite sample. But, as in most clinical research, it clearly was not nationally representative and may not have been representative of the cardiac surgery population at RWJUH. Bias in recruitment might have reduced the proportions of psychosocially and biomedically vulnerable patients in the sample, thereby reducing the magnitude of associations through attenuation of range. But other forms of bias may have been operating, and representativeness is an empirical question that cannot be addressed fully with the available data. Another issue is the role of unmeasured variables, which, despite a large set of covariates, may have spuriously influenced the findings, as in any correlational study. With regard to statistical mediation, MacKinnon et al. (2002) demonstrated that the intervening variable approach provides a better balance of Type I and 2 error rates than alternatives, and showed that the Baron and Kenny (1986) approach can be too conservative. However, consensus on the issue of how best to conduct mediation analysis is not complete. In addition, although prospective with regard to LOS, the present study was cross-sectional with regard to assessment of predictors and mediators. Causal priority of certain predictors is clear (e.g., age, gender), but for others it is likely but not necessarily the case (e.g., marital status, personality, religious involvement). Thus, while statistical mediation is often examined even in data sets that are entirely cross-sectional, fully prospective

designs and experimental tests of interventions are needed to probe causal hypotheses more confidently.

Notwithstanding its limitations, this study also had significant strengths: (1) sample size was moderately large; (2) we recruited urgent/emergent patients and had few exclusion criteria, whereas much of the literature is based on samples that excluded nonelective and other kinds of patients (e.g., women, particular age groups); (3) most prior studies had much less comprehensive coverage of relevant biomedical predictors; (4) the majority of previous studies focused on one or two psychosocial factors whereas our multivariate approach reduces the possibility of spurious findings reflecting unmeasured psychosocial factors; (5) by contrast with most previous work, we modeled the effects of psychosocial factors on both presurgical vulnerability and postsurgical recovery.

Conclusions and Implications

The effects observed in this study were not large, but they might underestimate the predictive value of a more complete assessment of psychosocial risk that may be made possible by further research. Whereas presurgical medical conditions, surgical procedures, and postsurgical complications are the major determinants of LOS, even modest psychosocial effects are significant in view of the annual volume of cardiac surgeries and associated economic and psychological costs. It would be of both theoretical and practical interest to determine which facets of psychosocial vulnerability have effects on diverse physical health outcomes, which are outcome-specific, and how psychosocial vulnerability combines or interacts with biomedical risk factors.

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