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ORIGINAL RESEARCH

Body Mass Index (BMI) and Risk of Noncardiac Postoperative Medical Complications in Elderly Hip Fracture Patients: A Population-Based Study

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BACKGROUND: Obese patients are thought to be at higher risk of postoperative medical complications. We determined whether body mass index (BMI) is associated with postoperative in-hospital noncardiac complications following urgent hip fracture repair.

METHODS: We conducted a population-based study of Olmsted County, Minnesota, residents operated on for hip fracture in 1988 to 2002. BMI was categorized as underweight (<18.5 kg/m^2), normal (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), and obese (≥ 30 kg/m^2). Postoperative inpatient noncardiac medical complications were assessed. Complication rates were estimated for each BMI category and overall rates were assessed using logistic regression modeling.

RESULTS: There were 184 (15.6%) underweight, 640 (54.2%) normal, 251 (21.3%) overweight, and 105 (8.9%) obese hip fracture repairs (mean age, 84.2 $\pm$ 7.5 years; 80% female). After adjustment, the risk of developing an inpatient noncardiac complication for each BMI category, compared to normal BMI, was: underweight (odds ratio [OR], 1.33; 95% confidence interval [CI], 0.95-1.88; $P = 0.10$), overweight (OR, 1.01; 95% CI, 0.74-1.38; $P = 0.95$), and obese (OR, 1.28; 95% CI, 0.82-1.98; $P = 0.27$). Multivariate analysis demonstrated that an ASA status of III-V vs. I-II (OR, 1.84; 95% CI, 1.25-2.71; $P = 0.002$), a history of chronic obstructive pulmonary disease (COPD) or asthma (OR, 1.58; 95% CI, 1.18-2.12; $P = 0.002$), male sex (OR, 1.49; 95% CI, 1.10-2.02; $P = 0.01$), and older age (OR, 1.05; 95% CI, 1.03-1.06; $P < 0.001$) contributed to an increased risk of developing a postoperative noncardiac inpatient complication. Underweight patients had higher in-hospital mortality rates than normal BMI patients (9.3 vs. 4.4%; $P = 0.01$).

CONCLUSIONS: BMI has no significant influence on postoperative noncardiac medical complications in hip-fracture patients. These results attenuate concerns that obese or frail, underweight hip-fracture patients may be at higher risk postoperatively for inpatient complications. ***Journal of Hospital Medicine* 2009;4:E1–E9**. *© 2009 Society of Hospital Medicine.*

KEYWORDS: elderly, hip fractures, inpatient, medical complications, obesity, postoperative.

Public health concerns such as the aging population[1] and the increasing prevalence of obesity[2] are also important issues to hospitals. However, little attention has been given to the interface of obesity and the elderly, largely due to the dearth of studies that include elderly patients. An aging population leads to an increase in geriatric syndromes, such as osteoporosis[3] and its most devastating complication, hip fracture.[4] These frail, hip-fracture patients pose management challenges to practicing geriatricians and hospitalists.[5,6] Furthermore, although fracture risk is inversely correlated to body mass index (BMI),[7] this relationship has yet to be fully examined in the postoperative hip-fracture

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population. In other surgical settings, there is disagreement as to whether underweight or obese patients are at higher risk of developing medical complications,[8-11] but for orthopedic patients, data have been limited to elective orthopedic populations.[12-14] We previously demonstrated that underweight hip-fracture patients are at higher risk of postoperative cardiac complications at 1 year,[15] consistent with studies of cardiac risk indices determining long-term events. Because of different pathophysiologic mechanisms, the purpose of this study was to ascertain the influence of BMI on inpatient postoperative noncardiac medical complications and to assess predictors of such complications following urgent hip fracture repair.

Patients and Methods

All Olmsted County, Minnesota, residents undergoing urgent hip repair due to fracture were identified using the Rochester Epidemiology Project, a medical-record linkage system funded by the Federal government since 1966 to support disease-related epidemiology studies.[16] All patient medical care is indexed, and both inpatient and outpatient visits are captured and available for review, allowing for complete case ascertainment. Medical care in Olmsted County is primarily provided by Mayo Clinic with its affiliated hospitals (St. Mary's and Rochester Methodist) and the Olmsted Medical Center, in addition to a few individual providers. Over 95% of all Olmsted County hip fracture surgeries are ultimately managed at St. Mary's Hospital.

Following approval by the Institutional Review Board we used this unique data resource to identify all residents with an International Classification of Diseases, 9th edition (ICD-9) diagnosis code of 820 to 829 for hip fracture (n = 1310). Both sexes were included, and all patients included in the study provided research authorization for use of their medical records for research purposes.[17] We excluded patients who were managed conservatively (n = 56), had a pathological fracture (n = 20), had multiple injuries (n = 19), were operated on >72 hours after fracture (n = 5), were aged <65 years (n = 2), or were admitted for reasons other than a fracture and experienced an in-hospital fracture (n = 3). We subsequently excluded patients with missing information (n = 10). World Health Organization (WHO) criteria were used for classifying BMI: underweight (BMI < 18.5); normal (BMI = 18.5-24.9); overweight (BMI = 25.0-29.9); and obese (BMI ≥ 30.0).[18]

All data were abstracted using standardized collection forms by trained nurse abstractors blinded to the study hypothesis. Patients' admission height and weight were documented; if unavailable, the nearest data within 2 months prior to surgery were recorded. Patients' preadmission residence, functional status, baseline comorbidities, admission medications, discharge destination, as well as whether patients had an intensive care unit stay or any major surgeries in the past 90 days were abstracted. In addition, American Society of Anesthesia (ASA) class, type of anesthesia, and length of stay were also obtained. Inpatient complications that had been identified by the treating physicians and documented in the medical record or identified on imaging studies were assessed from the time of hip fracture repair to the time of discharge using standardized clinical criteria (Table 1). For criteria that were based on either objective findings or clinical documentation/suspicion, the patient was considered to meet the criteria of having a complication if they fulfilled either one. We did not include any cardiac outcomes, including congestive heart failure, angina, myocardial infarction, or arrhythmias that had been previously reported.[15] Noncardiac complications were classified broadly: respiratory (respiratory failure, respiratory depression, or pulmonary hypoxemia); neurologic (any cerebral event including hemorrhagic or ischemic stroke, transient ischemic attack, or delirium); gastrointestinal (ileus or gastrointestinal bleeding); vascular (pulmonary embolus, or deep vein thrombosis); infectious (pneumonia, sepsis, urinary tract, wound, or cellulitis); renal/metabolic (acute renal failure, dehydration, or electrolyte abnormalities); or other (fractures or falls).

Continuous data are presented as means ± standard deviation and categorical data as counts and percentages. In testing for differences in patient demographics, past medical history, and baseline clinical data among BMI groups, Kruskal-Wallis tests were performed for continuous variables and Fisher's Exact or Cochran-Mantel-Haenszel tests were used for discrete variables. Bonferroni adjustments were performed where appropriate. The primary outcome was the risk of any noncardiac medical complication during the postoperative hospitalization, based on patients with complications. Incidence rates were calculated for the overall group as well as for each BMI category. BMI was evaluated categorically according to the WHO criteria, as a continuous variable dichotomized as a BMI 18.5 kg/m^2 to 24.9 kg/m^2 (normal) vs. all others, and above/below 25.0 kg/m^2. The effect of BMI and other potential risk factors on the complication rate was evaluated using logistic regression. The effect of BMI category on the overall complication rate was adjusted for the a priori risk factors of age, sex, surgical year, and ASA class both univariately (Model 1) and multivariately (Model 2). In addition to these variables, we also evaluated other potential risk factors, including baseline demographic and baseline clinical variables that were significant ($P < 0.05$) univariately using a stepwise selection; first forcing in BMI as a categorical variable (Model 3), then repeating the stepwise selection process without forcing in BMI (Model 4). Using data from Lawrence et al.,[19] we estimated that we would have 80% power to detect differences in rates of inpatient noncardiac complications equal to an odds ratio (OR) = 2.2 (normal vs. underweight), OR = 2.0 (normal vs. overweight), and OR = 2.4 (normal vs. obese). Finally, because of power considerations, as an exploratory analysis, we additionally identified predictors of inpatient complications within each BMI category using stepwise selection. All statistical tests were 2-sided, and *P* values

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TABLE 1. Definitions of Postoperative Noncardiac Complications

Definition	Symptom
Gastrointestinal	
Ileus	Dilated loops of bowel on X-ray; documented ileus with nausea, vomiting, no stool or inability to take oral intake
Gastrointestinal bleeding	Sudden appearance of frank blood on nasogastric lavage or by rectum AND a decrease in hemoglobin of 2 g/dL or greater with no other suspected source of ongoing blood loss
Infectious	
Pneumonia	New infiltrate on chest x-ray plus 2 of the following 3 findings: temperature >38°C, elevated white cell count, sputum pathogen that requires antibiotic treatment
Bacteremia/sepsis	Localized infection with positive blood culture for the same pathogen AND chills, rigors, fever, elevated white cell count AND intravenous antibiotic treatment
Urinary tract infection	Pyuria ± symptoms
	Positive gram stain ± symptoms
Wound	
Cellulitis	As documented in physician's note of a superficial skin infection
Neurologic	
Cerebral event—hypoxia, thrombosis or hemorrhage	New neurologic dysfunction (hemiplegia, hemianesthesia, hemianopia, aphasia, or unconsciousness) postoperatively
Transient ischemic attack	Any neurologic dysfunction resolving within a 24-hour period
Delirium	Positive Confusion Assessment Method[38]
Renal/metabolic	
Renal failure	A doubling of baseline value of creatinine; serum creatinine >3.0 mg/dL; acute need for dialysis
Dehydration	As documented in the physician's note
Electrolyte abnormalities	Any laboratory evidence of abnormal electrolytes compared to normal
Respiratory	
Respiratory failure	Need for intubation and ventilation >24 hours postoperatively; need for reintubation and ventilation after 1 hour postoperatively
Respiratory depression	Respiratory arrest; $PaCO_2$ >60 mmHg that provider believed was associated with narcotics
Pulmonary hypoxemia	SaO_2 <90% with or without supplemental oxygen; supplemental oxygen >24 hours
Vascular	
Deep vein thrombosis	Positive lower extremity venous Doppler
Pulmonary embolism	Acute onset dyspnea and tachycardia, increased central venous pressure AND (positive ventilation/perfusion scan OR positive computed tomography OR positive pulmonary angiogram)
Other	
Fractures	Any in-hospital documented fracture of any bone
Falls	Patients descending to the ground from any position unintentionally

Abbreviations: $PaCO_2$, pressure of carbon dioxide; SaO_2, oxygen saturation.

<0.05 were considered significant. All analyses were performed using SAS for UNIX (version 9.1.3; SAS Institute, Inc., Cary, NC).

Results

Between 1988 and 2002, 1195 urgent repairs for hip fracture met our inclusion/exclusion criteria. We subsequently excluded 15 repairs with missing BMI data, and, of the 7 patients with >1 repair, we included only their first fracture episode in our analysis. Two were subsequently excluded due to an administrative error. Ultimately, 1180 hip fracture repairs were included in the analysis cohort. There were 184 (15.6%) patients in the underweight group, 640 (54.2%) with normal BMI, 251 (21.3%) with a BMI 25.0 to 29.9 kg/m^2, and 105 (8.9%) with a BMI $\geq$ 30 kg/m^2. Baseline characteristics are otherwise shown in Table 2. Normal BMI patients were significantly older than the other groups, and underweight patients were less likely to be admitted from home. Past history of having a cardiovascular risk factor or a cardiovascular diagnosis appeared to increase with increasing BMI. Underweight patients were more likely to have chronic obstructive pulmonary disease (COPD) than patients with normal BMI ($P = 0.03$) or overweight patients ($P = 0.009$), but not more than obese patients ($P = 0.21$). There were no differences across BMI groups in ASA class, type of anesthesia, intensive care unit stay, or length of stay.

There were 77 (41.8%) postoperative inpatient noncardiac complications in the underweight group, 234 (36.6%) in the normal BMI group, 90 (35.9%) in the overweight group, and 42 (40.0%) in the obese group ($P = 0.49$). Figure 1 demonstrates the main subcategory complication rates by BMI group, and Table 3 outlines the univariate unadjusted complication rates. Other than gastrointestinal complications being more prevalent as BMI increases ($P = 0.005$), there were no significant differences in crude complication rates across BMI categories (all $P > 0.05$) for the other complication subcategories. A multiple comparisons analysis did not demonstrate any differences between normal and any of the other BMI categories for ileus. Normal BMI patients were more likely to be discharged to a nursing facility than

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TABLE 2. Baseline Characteristics of 1180 Olmsted County, Minnestoa, Residents Undergoing Urgent Hip Fracture Repair, 1988-2002, by Body Mass Index Classification

Variable	Underweight (<18.5 kg/m^2) n = 184 n (%)	Normal (18.5-24.9 kg/m^2) n = 640 n (%)	Overweight (25-29.9 kg/m^2) n = 251 n (%)	Obese (≥30 kg/m^2) n = 105 n (%)	*P* Value*
Age (years)	84.8 ± 8.0	85.0 ± 7.2	83.1 ± 7.3	80.7 ± 7.4	<0.001
Female sex	171 (92.9)	525 (82)	177 (70.5)	76 (72.4)	<0.001
Preadmission residence					
ALC/SNF	79 (42.9)	250 (39.1)	83 (33.1)	36 (34.3)	0.024
Home	105 (57.1)	390 (60.9)	168 (66.9)	69 (65.7)	
Functional status†					
Dependent	25 (13.6)	80 (12.5)	24 (9.6)	7 (6.7)	0.044
Walking independently	159 (86.4)	560 (87.5)	226 (90.4)	97 (93.3)	
History of					
Hypertension	84 (45.7)	374 (58.4)	159 (63.3)	70 (66.7)	<0.001
Diabetes	9 (4.9)	71 (11.1)	30 (12)	30 (28.6)	<0.001
Cerebrovascular disease	40 (21.7)	175 (27.3)	77 (30.7)	33 (31.4)	0.028
Myocardial infarction	44 (23.9)	140 (21.9)	61 (24.3)	36 (34.3)	0.106
Congestive heart failure	48 (26.1)	150 (23.4)	76 (30.3)	44 (41.9)	0.003
Atrial fibrillation/flutter	49 (26.6)	118 (18.4)	57 (22.7)	26 (24.8)	0.985
Chronic renal insufficiency	11 (6)	64 (10)	34 (13.5)	20 (19)	<0.001
Dementia	63 (34.2)	233 (36.4)	74 (29.5)	26 (24.8)	0.031
Obstructive sleep apnea	2 (1.1)	5 (0.8)	5 (2.0)	6 (5.7)	0.005
COPD	41 (22.3)	100 (15.6)	32 (12.7)	17 (16.2)	0.032
Asthma	13 (7.1)	47 (7.3)	18 (7.2)	12 (11.4)	0.395
COPD or asthma	49 (26.6)	133 (20.8)	45 (17.9)	23 (21.9)	0.093
Pulmonary embolism or deep vein thrombosis	9 (4.9)	21 (3.3)	21 (8.4)	17 (16.2)	<0.001
Osteoporosis	77 (41.8)	253 (39.5)	73 (29.1)	31 (29.5)	<0.001
Collagen vascular diseases	10 (5.4)	29 (4.5)	9 (3.6)	12 (11.4)	0.34
Cancer	61 (33.2)	169 (26.4)	75 (29.9)	32 (30.5)	0.88
Lymphoma	2 (1.1)	3 (0.5)	2 (0.8)	2 (1.9)	0.25
Leukemia	2 (1.1)	3 (0.5)	1 (0.4)	1 (1)	
Major surgery within 90 days	3 (1.6)	10 (1.6)	8 (3.2)	3 (2.9)	0.366
ASA class‡					
I or II	19 (10.4)	93 (14.5)	46 (18.3)	12 (11.4)	0.144
III, IV, or V	164 (89.6)	547 (85.5)	205 (81.7)	93 (88.6)	
Type of anesthesia					
General	134 (72.8)	477 (74.5)	192 (76.5)	84 (80)	
Other (spinal, epidural, local, combination)	50 (27.2)	163 (25.5)	59 (23.5)	21 (20)	0.16
Admission medications					
Insulin	2 (1.1)	18 (2.8)	11 (4.4)	17 (16.2)	<0.001
Aspirin	50 (27.2)	197 (30.8)	82 (32.7)	37 (35.2)	0.126
Beta-blockers	18 (9.8)	90 (14.1)	50 (19.9)	25 (23.8)	<0.001
ACE/ARB	32 (17.4)	95 (14.8)	55 (21.9)	28 (26.7)	0.009
Calcium-channel blocker	26 (14.1)	104 (16.3)	39 (15.5)	21 (20)	0.38
Intensive care unit stay	63 (34.2)	154 (24.1)	61 (24.3)	30 (28.6)	0.16
Length of stay, days	10.3 (9.7)	9.7 (6.8)	10.2 (7.6)	11.1 (8.6)	0.10
Discharge destination§					
Home	20 (10.9)	65 (10.2)	43 (17.1)	19 (18.1)	
ALC/nursing home	146 (79.8)	547 (85.5)	199 (79.3)	83 (79)	<0.001
In-hospital death	17 (9.3)	28 (4.4)	9 (3.6)	3 (2.9)	

NOTE: Continuous variables are represented as mean ± standard deviations. Discrete variables are represented as number (%). Table adapted with permission from Batsis et al.[15]

Abbreviations: ACE, angiotensin converting enzyme inhibitor; ALC, assisted living center; ARB, angiotensin receptor blocker; ASA, American Society of Anesthesia; COPD, chronic obstructive pulmonary disease; SNF, skilled nursing facility.

* *P* values are Kruskal-Wallis tests for continuous variables and either Fisher Exact or Cochran-Mantel-Haenszel values for discrete variables.

† There were 2 patients with missing data.

‡ There was 1 patient with missing data.

§ There were 5 patients with missing data.

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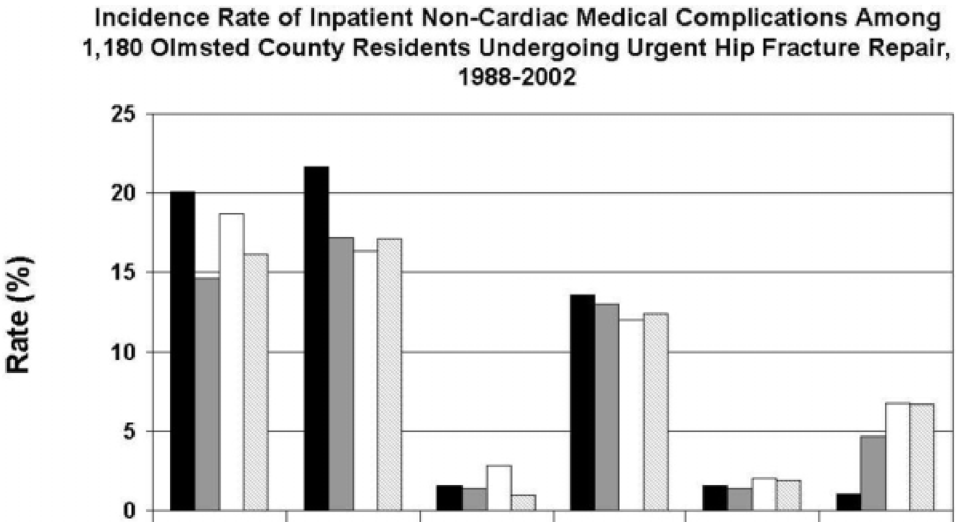

	Respiratory	Neurologic	Vascular	Infectious	Renal	GI
■ Underweight	20.1	21.7	1.6	13.6	1.6	1.1
■ Normal	14.7	17.2	1.4	13.0	1.4	4.7
□ Overweight	18.7	16.3	2.8	12.0	2.0	6.8
□ Obese	16.2	17.1	1.0	12.4	1.9	6.7

FIGURE 1. Rate of inpatient noncardiac complications. Rate of noncardiac complications by BMI category. Unadjusted proportions of the number of patients in each category having a given complication are represented in the data table below the figure (as defined in Patients and Methods).

overweight or obese patients (85.5% vs. 79.3%, $P = 0.03$; and 85.5% vs. 79.0%, $P = 0.03$, respectively). The proportion of in-hospital deaths among underweight patients was significantly higher than in any of the other groups (9.3% vs. 4.4%; $P = 0.01$), but mean length of stay was not significantly different.

Significant univariate predictors of the composite outcome of any noncardiac complication included: age (OR, 1.04 95% confidence interval [CI>], 1.02-1.06; $P < 0.001$), age ≥75 years (OR, 2.25; 95% CI, 1.52-3.33; $P < 0.001$), age ≥ 85 years (OR, 1.49; 95% CI, 1.17-1.89; $P < 0.001$), male sex (OR, 1.41; 95% CI, 1.05-1.90; $P = 0.02$), admission from home (OR, 0.77; 95% CI, 0.61-0.98; $P = 0.03$), a history of cerebrovascular disease (OR, 1.41; 95% CI, 1.08-1.83; $P = 0.01$), myocardial infarction (OR, 1.41; 95% CI, 1.07-1.86; $P = 0.02$), angina (OR, 1.32; 95% CI, 1.03-1.69; $P = 0.03$), congestive heart failure (OR, 1.45; 95% CI, 1.11-1.89; $P = 0.006$), dementia (OR, 1.39; 95% CI, 1.08-1.78; $P = 0.01$), peripheral vascular disease (OR, 1.47; 95% CI, 1.06-2.03; $P = 0.02$), COPD/asthma (OR, 1.56; 95% CI, 1.18-2.08; $P = 0.002$), osteoarthritis (OR, 1.29; 95% CI, 1.01-1.65; $P = 0.04$), code status as Do Not Resuscitate (OR, 0.74; 95% CI, 0.58-0.94; $P = 0.015$), or ASA class III-V (OR, 2.24; 95% CI, 1.53-3.29; $P < 0.001$). Results were no different after using the Charlson comorbidity index in place of ASA class (data not shown). No significant differences in overall noncardiac complications were observed when examining BMI as a continuous variable, as a categorical variable, as ≥25 kg/m^2 vs. <25 kg/m^2, or as 18.5 kg/m^2 to 24.9 kg/m^2 vs. all others. Examining renal, respiratory, peripheral vascular, or neurologic complications univariately within these aforementioned strata also did not demonstrate any significant differences among BMI categories (data not shown).

Multivariable analyses (Models 1-4) are shown for any overall noncardiac inpatient medical complication in Table 4. BMI was not a significant predictor in any of our models, specifically in our main model that examined the effect of BMI adjusting for a priori variables (Model 2). However, older age, male sex, and ASA class were highly significant predictors of complications in all four models; however, surgical year was nonsignificant. Notably, after stepwise selection for other demographic and premorbid variables, a history of COPD or asthma was found to be an additional significant factor both in Model 3 (forcing BMI in the model) and Model 4 (without BMI in the model). Exploratory analysis of individual predictors of inpatient noncardiac complications within each BMI category demonstrated that, in underweight patients, admission use of β-blockers was a significant predictor of having any medical complication (OR, 3.1; 95% CI, 1.1-8.60; $P = 0.03$). In normal BMI patients, age ≥75 years (OR, 2.6; 95% CI, 1.4-4.9; $P = 0.003$), ASA class III-V (OR, 2.3; 95% CI, 1.3-3.9; $P = 0.003$), and a history of cerebrovascular disease (OR, 1.5; 95%CI, 1.04-2.1; $P = 0.03$) were predictors; and, in obese patients, only age

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TABLE 3. Univariate Unadjusted Inpatient Noncardiac Complication Rates Among 1,180 Olmsted County, Minnesota, Residents Undergoing Urgent Hip Fracture Repair, 1988-2002

	Overall Cohort n (%)	Underweight (<18.5 kg/m²) n = 184 n (%)	Normal (18.5-24.9 kg/m²) n = 640 n (%)	Overweight (25-29.9 kg/m²) n = 251 n (%)	Obese (≥30 kg/m²) n = 105 n (%)	*P* Value
Gastrointestinal						
Ileus	38 (3.2)	1 (0.5)	21 (3.3)	12 (4.8)	4 (3.8)	0.03
Gastrointestinal bleeding	21 (1.8)	1 (0.5)	11 (1.7)	6 (2.4)	3 (2.9)	0.35
Infectious						
Pneumonia	69 (5.8)	12 (6.5)	39 (6.1)	14 (5.6)	4 (3.8)	0.51
Bacteremia/sepsis	8 (0.7)	1 (0.5)	2 (0.3)	5 (2.0)	0 (0)	0.06
Urinary tract infection	84 (7.1)	12 (6.5)	47 (7.3)	15 (6)	10 (9.5)	0.78
Wound	—	—	—	—	—	—
Cellulitis	—	—	—	—	—	—
Neurological						
Cerebral event-hypoxia, thrombosis or hemorrhage	15 (1.3)	1 (0.5)	6 (0.9)	6 (2.4)	2 (1.9)	0.21
Transient ischemic attack						
Delirium	199 (16.9)	40 (21.7)	106 (16.6)	36 (14.3)	17 (16.2)	0.08
Renal/metabolic						
Renal failure	19 (1.6)	3 (1.6)	9 (1.4)	5 (2.0)	2 (1.9)	0.82
Dehydration	—	—	—	—	—	—
Electrolyte abnormalities	—	—	—	—	—	—
Respiratory						
Respiratory failure	53 (4.5)	10 (5.4)	23 (3.6)	15 (6.0)	5 (4.8)	0.61
Respiratory depression	23 (1.9)	3 (1.6)	11 (1.7)	8 (3.2)	1 (1.0)	0.50
Pulmonary hypoxemia	157 (13.3)	33 (17.9)	78 (12.2)	34 (13.5)	12 (11.4)	0.22
Vascular						
Deep vein thrombosis	5 (0.4)	0 (0)	2 (0.3)	3 (1.2)	0 (0)	0.24
Pulmonary embolism	16 (1.4)	3 (1.6)	7 (1.1)	5 (2.0)	1 (1.0)	0.65
Other						
Fractures	6 (0.5)	1 (0.5)	5 (0.8)	0 (0)	0 (0)	0.57
Falls	—	—	—	—	—	—

NOTE: All values are represented as count (proportion) for categorical variables; counts are the number of cases that fulfilled the criteria for a given inpatient complication. *P* values represent a Fisher Exact or Cochran-Mantel-Haenszel; $P < 0.05$ is significant.

(OR, 1.1; 95% CI, 1.00-1.12; $P = 0.05$) was significant. There were no significant predictors of having a medical complication in the overweight group.

Discussion

Most research describing the association of BMI with postoperative outcomes has concentrated on cardiac surgery, general surgical procedures, and intensive care unit utilization.[8-11,20] In the orthopedic literature, an elevated BMI has been associated with a higher number of short-term complications, but this was limited to elective knee arthroplasty and spine surgery populations.[12,13,21] Conversely, no differences were observed in obese patients undergoing hip arthroplasties.[14,22] To the best of our knowledge, this study may be the first to examine the impact of BMI on inpatient hospital outcomes following urgent hip fracture repair. Our results suggest the risk of developing a noncardiac medical complication is the same regardless of BMI.

Our overall complication rate was higher (38%) than previous reports by others.[19,23-26] Thus, Lawrence et al.,[19] in their retrospective study of 20 facilities, demonstrated an overall complication rate of 17%, even though they also included postoperative cardiac complications. Although their study period overlapped our own (1982-1993), they additionally included patients aged 60 to 65 years, a population known to have fewer comorbidities and fewer postoperative complications than the elderly hip-fracture patients studied here. In addition, their population may have been healthier at baseline, in that a higher proportion lived at home (73%) and a lower percentage were ASA class III-V

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TABLE 4. Multivariable Analysis for Inpatient Medical Complications Among 1,180 Olmsted County, Minnesota, Residents Undergoing Urgent Hip Fracture Repair, 1988-2002

	Underweight <18.5 kg/m² n = 184* n (%)	Normal 18.5-24.9 kg/m² n = 640* n (%)	Overweight 25-29.9 kg/m² n = 251* n (%)	Obese ≥30 kg/m² n = 105* n (%)	Age†	Male Sex†	Surgical Year†	ASA Score, III-V vs. I/II	COPD/ Asthma
Model 1a†	1.25 (0.89-1.74)	Referent	0.97 (0.72-1.31)	1.16 (0.76-1.76)	—	—	—	—	—
Model 1b	1.26 (0.90-1.77)	Referent	1.05 (0.77-1.43)	1.38 (0.90-2.13)	1.04 (1.02-1.06)‡		—	—	—
Model 1c	1.30 (0.93-1.83)	Referent	0.93 (0.68-1.26)	1.12 (0.73-1.71)	—	1.47 (1.09-1.98)‡	—	—	—
Model 1d	1.28 (0.91-1.79)	Referent	0.97 (0.71-1.31)	1.13 (0.74-1.73)	—	—	1.03 (1.00-1.06)	—	—
Model 1e	1.23 (0.88-1.72)	Referent	1.00 (0.73-1.36)	1.13 (0.74-1.73)	—	—	—	2.22 (1.52-3.24)‡	—
Model 2§	1.33 (0.95-1.88)	Referent	1.01 (0.74-1.38)	1.28 (0.82-1.98)	1.04 (1.02-1.06)‡	1.59 (1.17-2.17)‡	1.02 (0.99-1.05)	1.89 (1.28-2.79)‡	—
Model 3‖	1.30 (0.92-1.84)	Referent	1.04 (0.76-1.42)	1.30 (0.84-2.02)	1.05 (1.03-1.06)‡	1.52 (1.11-2.07)‡	1.02 (0.99-1.05)	1.77 (1.20-2.62)‡	1.58 (1.17-2.12)‡
Model 4¶	—	—	—	—	1.05 (1.03-1.06)‡	1.49 (1.10-2.02)‡	—	1.84 (1.25-2.71)‡	1.58 (1.18-2.12)‡

NOTE: Each row represents a separate multivariable logistic regression analysis. All values are listed as hazard ratios (95% confidence intervals).

Abbreviations: ASA, American Society of Anesthesia; BMI, body mass index; COPD, chronic obstructive pulmonary disease.

*The number of observed number of fractures in this category.

† Model 1: Effect of BMI category (underweight, normal, overweight, and obese) on overall noncardiac inpatient complication rate adjusted, a priori individually, for age, sex, surgical year, and ASA score univariately.

‡ $P < 0.05$.

§ Model 2: Effect of BMI category (underweight, normal, overweight, and obese) on overall noncardiac inpatient complication rate, after adjusting for age, sex, surgical year, and ASA class.

‖ Model 3: Model evaluating other potential risk factors, including baseline demographic and baseline clinical variables that were significant ($P < 0.05$) univariately using stepwise selection. Model includes BMI as a categorical variable (underweight, normal, overweight, and obese), adjusted for age, sex, surgical year, and ASA class.

¶ Model 4: Model evaluating other potential risk factors, including baseline demographic and baseline clinical variables that were significant ($P < 0.05$) univariately using stepwise selection. Model 3 is similar to this, but does not force BMI in.

(71%) than our cohort. These differences in baseline characteristics may explain the higher complication rates observed in our study.

Our findings did not suggest any relationship of BMI with noncardiac postoperative medical complications in any of the 4 methods we used to stratify BMI (continuous, categorical, normal vs. abnormal, and ≥ 25 kg/m^2). Evidence is contradictory as to what the effect of BMI has on postoperative complications. An elevated BMI (≥ 30 kg/m^2) has been shown to lead to increased sternal wound infection and saphenous vein harvest infection in a cardiac surgery population,[27] but other studies[10,28,29] have demonstrated the opposite effect. Among 6336 patients undergoing elective general surgery procedures, the incidence of complications were similar by body mass.[30] A matched study design that included urgent and emergent surgeries also did not find any appreciable increased perioperative risk in noncardiac surgery.[28] Whether this may be due to the elective nature of the surgeries in these studies, hence leading to selection bias, is unknown.

In geriatric patients, multiple baseline comorbid conditions often are reflected in a higher ASA class, which increases the risk of significant perioperative complications. Our multivariate modeling showed that a high ASA class strongly predicts morbidity and mortality following hip fracture repair, in line with other studies.[19,31,32] Although the Charlson comorbidity index could alternatively been used, we elected to adjust for ASA class as it is more commonly used and is simple to use. Interestingly, surgical year did not significantly predict any complication, which can suggest that practice changes play a minimal impact on patient outcomes. However, we caution that because the individual event rates, particularly vascular, were low, we were unable to fully determine whether changes in practice management, such as improved thromboprophylaxis, would impact event rates over time. Finally, other predictors such as older age[33] and a concomitant history of either COPD or asthma,[34] are well-accepted predictors of inpatient complications. Our attempt to examine specific predictors of complications in each BMI category revealed differing results, making interpretations difficult. Because of power considerations, this was meant solely as an exploratory analysis, and larger cohorts are needed to further ascertain whether predictors are different in these groups. Such a study may in fact identify perioperative issues that allow practitioners caring for this population to modify these factors.

One of the major limitations in our study was our inability to adjust for individual complications using multivariable models, such as deep vein thrombosis or delirium, within each BMI stratum, because of statistical power issues. Such a study would require large numbers of individual complications or events to allow for appropriate adjustments. The authors acknowledge that such individual complication rates may vary dramatically. We were aware of this potential problem, and therefore a priori ascertained a composite outcome of any noncardiac medical complication. However, our results do provide preliminary information regarding the impact of BMI on noncardiac medical complications. Further studies would be needed, though, to fully determine the effect of BMI on the number of cases with each complication.

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Obesity (or BMI) is a known cardiovascular risk factor, and our previous study's aim was to determine cardiovascular events in a comparable manner to the way risk indices, such as the Goldman, Lee, or the AHA preoperative algorithm function. The surgical literature often presents noncardiac complications separately, allowing us to directly compare our own data to other published studies. We used 2 separate approaches, focusing on the inpatient stay (ascertaining noncardiac complications) and 1-year cardiac outcomes (cardiac complications), as these are mediated by different mechanisms and factors. Furthermore, the intent of both studies was to dispel any concerns that an elevated BMI would in fact lead to an increased number of complications. Whether cardiac complications, though, would impact noncardiac complications, or vice-versa, is unknown, and would require further investigation.

Although we relied on well-established definitions for body mass, they have often been challenged, as they may underestimate adiposity in the elderly population due to age-related reductions in lean mass.[35,36] Studies have demonstrated a poor correlation between percent body fat and BMI in the >65 year age group,[37] which could impact our results and outcomes by misclassifying patients. Yet, as an anthropometric measurement, BMI is easily obtainable and its variables are routinely documented in patients' medical records, as compared to other anthropometric measurements. Other means of estimating adiposity, such as densitometry or computed tomography (CT) scanning, are impractical, expensive, and not used clinically but routinely in research settings. The lack of standardization in obtaining height and weight, despite nurse-initiated protocols for bed calibration, may have introduced a degree of measurement bias. Furthermore, the extent of lean mass lost and volume status changes lead to further challenges of using BMI in hospital settings. Whether other anthropometric measurements, including hip circumference, waist circumference, or waist-hip ratio, should be used in this group of patients requires further examination. However, despite its shortcomings in elderly patients, BMI is still deemed an appropriate surrogate for obesity.

Our main strength was the use of the Rochester Epidemiology Project medical record linkage system to ascertain all patient data. This focuses on patients from a single geographically-defined community minimizing referral biases often observed in studies originating from a tertiary care referral center. Previous disease-related epidemiology studies using the Olmsted County population have demonstrated excellent external validity to the U.S. white population.[16] We relied on the medical documentation of the treating clinician for many diagnoses in our data abstraction. Although we attempted to use standardized definitions, clinicians may have inadvertently forgotten to document subjective signs or symptoms that would assist in the categorization of these complications. Hence, added inpatient complications may have been overlooked, suggesting that our results may slightly underestimate the true incidence in this population. Additionally, certain complications may overlap categories, such as pneumonia and infections. We agree with Lawrence et al.[19] that long periods of time are necessary to accumulate data of this kind in an effort to describe complication rates epidemiologically.

Despite no difference in outcomes among BMI categories, our results have striking implications for the hospitalized patient. Thus, underweight elderly patients, often considered frail with minimal functional reserve, are at no higher risk for developing inpatient medical complications than patients with higher BMIs. This is contrary to our study focusing on cardiac complications, where underweight patients were at higher risk.[15] Conversely, obese patients, who have been demonstrated to be at higher risk of medical complications (particularly pulmonary), had no greater risk than patients with normal BMI. To the practicing geriatrician and hospitalist, this information provides important prognostication regarding additional perioperative measures that need to be implemented in these different groups. Based on our results, BMI does not play a particular role in noncardiac medical complications, dispelling any myths of the added burden of excess weight on surgical outcomes in this population. From a hospital perspective, this may be important since additional testing or preventative management in these patients may lead to additional resource use. However, in-hospital deaths were higher in underweight patients than in patients with a normal BMI. Although we were underpowered to detect any differences in mortality between groups and could therefore not adjust for additional variables, it is unknown whether cardiac or noncardiac complications may be a stronger predictor of death in the underweight patient population. Further studies would be needed to better ascertain this relationship.

Conclusions

In elderly patients undergoing urgent hip fracture repair, BMI does not appear to lead to an excess rate of inpatient noncardiac complications. Our results are the first to demonstrate that BMI has no impact on morbidity in this patient population. Further research on the influence of body composition on inpatient complications in this population is needed to accurately allow for appropriate perioperative prophylaxis. Whether BMI impacts specific complications or in-patient mortality in this population still requires investigation.

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