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Body Mass Index and Risk of Non-Cardiac Post-Operative Medical Complications in Elderly Hip Fracture Patients: A Population-Based Study

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Abstract

Background—Obese patients are thought to be at higher risk of post-operative medical complications. We sought to determine whether body mass index (BMI) is associated with post-operative in-hospital non-cardiac complications following urgent hip fracture repair.

Methods—We conducted a population-based study of Olmsted County, Minnesota residents operated for hip fracture in 1988–2002. BMI was categorized as underweight (<18.5kg/m^2), normal (18.5–24.9kg/m^2), overweight (25.0–29.9kg/m^2) and obese (≥30kg/m^2). Post-operative inpatient non-cardiac medical complications were assessed. Complication rates were estimated for each BMI category and overall complication rates were assessed using logistic regression models adjusted for age, sex, calendar year, and American Society of Anesthesia (ASA) class.

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±7.5 years; 80% female). No significant difference was found among the BMI categories for baseline ASA status (ASA III–IV vs. I–II; p=0.14). After adjustment, the risk of developing an inpatient non-cardiac complication for each BMI category, compared to normal BMI, was: underweight (OR 1.33; 95%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 using stepwise selection 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 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), significantly contributed to an increased risk of

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developing a post-operative non-cardiac 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 post-operative non-cardiac medical complications in hip fracture patients. These results attenuate concerns that obese or frail underweight hip fracture patients may be at higher risk post-operatively for inpatient complications.

Keywords

Obesity; hip fractures; inpatient; medical complications; post-operative; elderly

INTRODUCTION

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 osteoporosis3 and its most devastating complication, hip fracture4. 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 population. In other surgical settings, there is disagreement as to whether underweight or obese patients are at higher risk of developing medical complications8–11, but for orthopedic patients, data have been limited to elective orthopedic populations12[–14]. We previously demonstrated that underweight hip fracture patients are at higher risk of postoperative cardiac complications at one year (Batsis *et al*, J Am Geriatric Soc, In Press), 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 post-operative non-cardiac medical complications and to assess predictors of such complications following urgent hip fracture repair.

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[15]. 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 County hip fracture surgeries are ultimately managed at St. Marys Hospital.

Following approval by the Institutional Review Board we used this unique data resource to identify all residents with an ICD-9 diagnosis code of 820–829 for hip fracture (n=1,310). Both sexes were included, and all patients included in the study provided research authorization for use of their medical records for research purposes[16]. We excluded patients who were managed conservatively (n=56), had a pathological fracture (n=20), had multiple injuries (n=19), were operated >72 hours after fracture (n=5), were aged <65 years (n=2) or 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 body mass index: underweight (BMI <18.5); normal (BMI 18.5–24.9); overweight (BMI 25.0–29.9); and obese (BMI≥30.0)17.

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 two months prior to surgery were recorded. Patients' pre-admission residence, functional status, baseline co-morbidities, 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, 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 which were previously reported[18]. Non-cardiac complications were classified broadly: respiratory (respiratory failure, respiratory depression, or pulmonary hypoxemia); neurologic (any cerebral event including hemorrhagic or ischemic stroke, transient ischemic attack, delirium); gastrointestinal (ileus, or gastrointestinal bleeding); vascular (pulmonary embolus, or deep vein thrombosis); infectious (pneumonia, sepsis, urinary tract, wound, cellulitis); renal/metabolic (acute renal failure, dehydration, or electrolyte abnormalities); or other (fractures, fall).

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. Bonferoni adjustments were performed where appropriate. The primary outcome was the risk of any non-cardiac medical complication during the post-operative 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 18.5–24.9kg/m^2 (normal) vs. all others, and above/below 25.0kg/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 American Society of Anesthesia (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 non-cardiac 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 two-sided, and p-values <0.05 were considered significant. All analyses were performed using SAS for UNIX (version 9.1.3, SAS Institute, Cary, NC).

RESULTS

Between 1988 and 2002, 1,195 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, 1,180 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 25.0–29.9kg/m^2, and 105

(8.9%) with a BMI≥30kg/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 normal BMI (p=0.03) or overweight patients (p=0.009), but not obese ones (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%) post-operative inpatient non-cardiac 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 sub-category 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 sub-categories. 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 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 non-cardiac complication included age (OR 1.04 [95%CI:1.02–1.06]; p<0.001), age≥75years (OR 2.25 [1.52–3.33];p<0.001), age≥85 years (1.49 [1.17–1.89]; p<0.001, male sex (OR 1.41 [1.05–1.90];p=0.02), admission from home (OR 0.77 [0.61–0.98];p=0.03), a history of cerebrovascular disease (OR 1.41 [1.08–1.83]; p=0.01), myocardial infarction (OR 1.41 [1.07–1.86]; p=0.02), angina (OR 1.32 [1.03–1.69]; p=0.03) or congestive heart failure (OR 1.45 [1.11–1.89]; p=0.006), dementia (OR 1.39 [1.08–1.78];p=0.01), peripheral vascular disease (OR 1.47 [1.06–2.03];p=0.02), COPD/asthma (OR 1.56 [1.18–2.08]; p=0.002), osteoarthritis (OR 1.29 [1.01–1.65];p=0.04), code status as Do Not Rescuscitate (OR 0.74 [0.58–0.94]; p=0.015), or an ASA Class III–V (OR 2.24 [1.53–3.29];p<0.001). Results were no different after using the Charlson co-morbidity index in place of ASA class (data not shown). No significant differences in overall non-cardiac complications were observed when examining BMI as a continuous variable, as a categorical variable, as ≥25kg/m^2 vs. <25kg/m^2, or as 18.5–24.9kg/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 non-cardiac 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 non-significant. Notably, after stepwise selection for other demographic and pre-morbid 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 non-cardiac 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 [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 post-operative 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 non-cardiac 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.* in their retrospective study of twenty facilities demonstrated an overall complication rate of 17%, even though they included post-operative cardiac complications as well. Although their study period overlapped our own (1982–1993), they additionally included patients aged 60–65, a population known to have fewer co-morbidities and fewer post-operative 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 had an ASA Class III–V (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 non-cardiac post-operative medical complications in any of the four methods we used to stratify BMI (continuous, categorical, normal vs. abnormal, $\geq 25 kg/m^2$). Evidence is contradictory as to what the effect of BMI has on post-operative complications. An elevated BMI ($\geq 30 kg/m^2$) 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 6,336 patients undergoing elective general surgery procedures, the incidence of complications were similar by body mass[30]. A matched study design which included urgent and emergent surgeries also did not find any appreciable increased peri-operative risk in non-cardiac 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 co-morbid conditions often are reflected in a higher ASA class, which increases the risk of significant peri-operative 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 co-morbidity index could alternatively been used, we elected to adjust for ASA class as it is more commonly used and 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 peri-operative 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 non-cardiac medical complication. However, our results do provide preliminary information regarding the impact of BMI on non-cardiac medical complications. Further studies would be needed, though, to fully determine the effect of BMI on the number of cases with each complication.

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 Pre-Operative algorithm function. The surgical literature often presents non-cardiac complications separately, allowing us to directly compare our own data to other published studies. We used two separate approaches focusing on the inpatient stay (ascertaining non-cardiac complications) and one-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 non-cardiac 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 % body fat and BMI in >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 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 United States white population.[15]. 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.* that long periods of time are necessary to accumulate data of this kind in an effort to describe complication rates epidemiologically[19].

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 body mass indices. This is contrary to our study focusing on cardiac complications, where underweight patients were at higher risk (Batsis et al, J Am Geriatric Soc, In Press). Conversely, obese patients, who have been demonstrated to be at higher risk of medical complications (particulary pulmonary), had no greater risk than patients with normal BMI. To the practicing geriatrician and hospitalist, this information provides important prognostication regarding additional peri-operative measures that need to be implemented in these different groups. Based on our results, body mass index does not play a particular role in non-cardiac 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 non-cardiac 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, body mass index does not appear to lead to an excess rate of inpatient non-cardiac 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 peri-operative prophylaxis. Whether BMI impacts specific complications or in-patient mortality in this population still requires investigation.

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ABBREVIATIONS

ASA	American Society of Anesthesia
BMI	Body mass index
CI	Confidence Interval
COPD	Chronic Obstructive Pulmonary Disease

OR	Odds Ratio
WHO	World Health Organization

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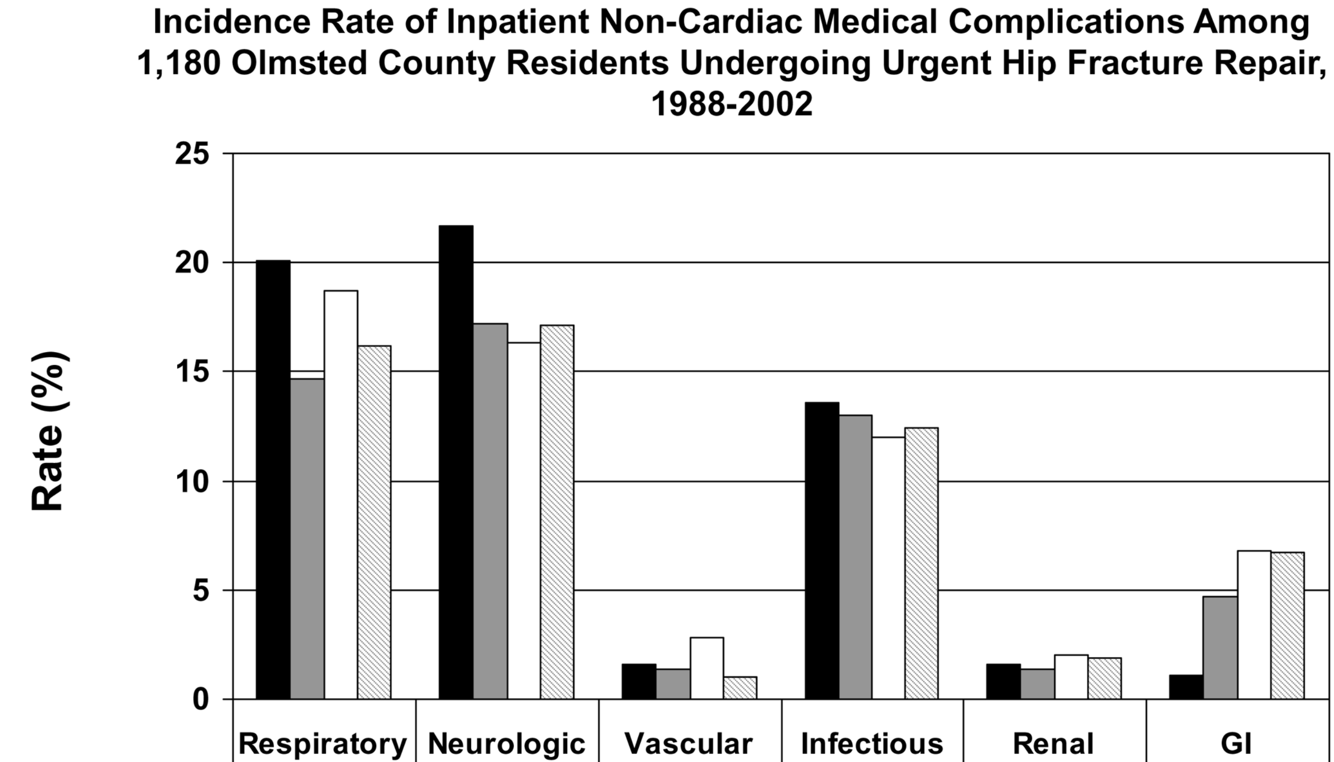

	Respiratory	Neurologic	Vascular	Infectious	Renal	GI
■ Underweight	20.1	21.7	1.6	13.6	1.6	1.1
Normal	14.7	17.2	1.4	13.0	1.4	4.7
□ Overweight	18.7	16.3	2.8	12.0	2.0	6.8
Obese	16.2	17.1	1.0	12.4	1.9	6.7

Figure 1. Rate of Inpatient Non-Cardiac Complications

Rate of non-cardiac complications by BMI category. Unadjusted proportions of the number of patients in each category having a given complication are represented in the data table accompanying the figure (as defined in the Methods section).

TABLE 1

Definitions of Post-Operative Non-Cardiac Complications

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 2g/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: T°>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 unconsciouness) post-operatively
	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 >3.0mg/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	Complications Respiratory Failure	Need for intubation and ventilation > 24hours post-operatively Need for re-intubation and ventilation after 1 hour post-operatively
	Respiratory Depression	Respiratory Arrest $PaCO_2$ >60mmHg that provider believed was associated
	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 Falls	Any in-hospital documented fracture of any bone Patients descending to the ground from any position unintentionally

TABLE 2

Baseline Characteristics of 1,180 Olmsted County, Minnestoa Residents Undergoing Urgent Hip Fracture Repair, 1988–2002, by Body Mass Index Classification

Variable	Underweight (< 18.5kg/m^2) n=184	Normal (18.5–24.9kg/m^2) n=640	Overweight (25–29.9kg/m^2) n=251	Obese ≥ 30kg/m^2 n=105	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
Pre-Admission 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

Variable	Underweight (< 18.5kg/m²) n=184	Normal (18.5–24.9kg/m²) n=640	Overweight (25–29.9kg/m²) n=251	Obese ≥ 30kg/m² n=105	P-value‡
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)	

Continuous variables are represented as mean±standard deviations. Discrete variables are represented as number (%)

* there were two (2) patients with missing data

there was one (1) patient with missing data

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

** there were five (5) patients with missing data

Abbreviations: ACE – Angiotensin Converting Enzyme Inhibitor; ALC – Assisted Living Center; ARB – Angiotensin Receptor Blocker; ASA - COPD – Chronic Obstructive Pulmonary Disease; SNF Skilled Nursing Facility

Table 3

Univariate Unadjusted Inpatient Non-Cardiac Complication Rates among 1,180 Olmsted County, Minnesota, Residents Undergoing Urgent Hip Fracture Repair, 1988–2002

	Overall Cohort	Underweight	Normal	Overweight	Obese	P-value
		< 18.5kg/m^2	18.5–24.9kg/m^2	25–29.9kg/m^2	≥30kg/m^2	
		‡n=184	‡n=640	‡n=251	‡n=105	
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

	Overall Cohort	Underweight	Normal	Overweight	Obese	P-value
		< 18.5kg/m^2	18.5–24.9kg/m^2	25–29.9kg/m^2	≥30kg/m^2	
		‡n=184	‡n=640	‡n=251	‡n=105	
Other						
Fractures	6 (0.5)	1 (0.5)	5 (0.8)	0 (0)	0 (0)	0.57
Falls	--	--	--	--	--	--

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-value represents a Fisher Exact or Cochran-Mantel-Haenszel

P<0.05 is significant

Table 4

Multivariable Analysis for Inpatient Medical Complications among 1,180 Olmsted County, Minnesota, Residents Undergoing Urgent Hip Fracture Repair, 1988–2002

	Underweight < 18.5kg/m² ‡ n=184	Normal 18.5–24.9kg/m² ‡ n=640	Overweight 25–29.9kg/m² ‡ n=251	Obese ≥30kg/m² ‡ n=105	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)*

Each row represents a separate multivariable logistic regression analysis. All values listed as Hazard Ratios (95% Confidence Intervals)

‡The number of observed number of fractures in this category

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

†Model 2 - Effect of BMI category (underweight, normal, overweight and obese) on overall non-cardiac inpatient complication rate, after adjusting for age, sex, surgical year, American Society of Anesthesia 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 body mass index as a categorical variable (underweight, normal, overweight and obese), adjusted for age, sex, surgical year, American Society of Anesthesia 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 body mass index in.

*P<0.05

Abbreviations: ASA–American Society of Anesthesia; COPD–Chronic Obstructive Pulmonary Disease