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Obesity delays functional recovery in trauma patients

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ABSTRACT

Background: Obesity is known to complicate trauma hospital stays. We hypothesize that obesity delays functional recovery in trauma patients.
Materials and methods: Between 2005 and 2007, adult patients with a hospital length of stay >24 h were prospectively recruited for the study. Functional Independence Measurement (FIM) scores were calculated at the time of admission, discharge, and 6 mo after discharge. Patients were classified as nonobese (body mass index [BMI] <25), overweight (BMI ≥25 and <30), obese (BMI ≥30 and <35), and morbidly obese (BMI ≥35). Multivariate analyses were performed to determine the impact of obesity on FIM scores.
Results: Two hundred thirty-five patients met the study inclusion criteria. Average injury severity scores was >18. We recorded no mortality at the time of discharge and follow-up. During acute hospital stay stage, nonobese patients had an average of 24 points increase on FIM scores compared with morbidly obese patients with 16 points improvement ($P = 0.023$). Compared with nonobese patients, the rate of recovery was reduced by 30% in overweight ($P = 0.034$), 37% in obese ($P = 0.025$), and 48% in morbidly obese patients ($P = 0.003$). Alternatively, we found that for every unit increase in BMI, the functional recovery rate was reduced by 4% ($P < 0.001$). Changes in FIM scores during the postdischarge period were not significantly different by obesity classification, and all groups achieve similar functional outcome at follow-up ($P = 0.482$).
Conclusions: Most trauma patients achieve full functional recovery some time after hospital discharge, but the recovery is delayed in obese patients and the delay is directly correlated with the severity of obesity.

1. Introduction

Both obesity and trauma are major causes of morbidity and mortality in the United States. Obesity is increasing in the United States; with more than two-thirds of the adult population with a body mass index [BMI] ≥25 and at least one-third of the adults classified as obese [1]. The proportion of obese individuals has increased >55% in the last two decades. Given

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the current trend, it has been predicted that three of four US adults will be overweight or obese by 2020 [2]. Obesity in trauma patients is associated with increased complications, worse outcomes and caring for these patients have become a clinical challenge [3–8].

The added risk of obesity on trauma mortality has been intensely studied and still controversial [5,9]. Given medical advances and increasing experience of physicians, the ultimate mortality outcome may be narrowing such that the increased risk from obesity becomes less detectable. However, it is consistent in the literature that obesity complicates trauma recovery and demands greater resource utilization [5]. Much has been published on short-term health care outcomes such as higher rates of complications and increased utilization of intensive care that could be linked to slower recovery. However, studies directly measuring trauma patient functional recovery are few and they only focused on certain injury patterns [10,11]. In this study, we hypothesize that obesity delays trauma patient functional recovery. We directly measured functional independence status during hospitalization and at follow-up in obese and nonobese trauma patients.

2. Materials and methods

This is a prospective observational study of blunt trauma patients admitted to the University of Iowa Level I Trauma Center between 2005 and 2007. This study is partially funded by the Iowa Injury Prevention Research Center and proper institutional review board permission was obtained. All patients were aged >18 y and were admitted for at least 24 h. Patients transferred from other medical centers were also included. We excluded patients not evaluated by the trauma service, patients aged <18 y, pregnant patients, and those who refused or were unable to give consent and hospital length of stay (LOS) <24 h. The subjects were recruited and consented within 24 h of admission by research staff during regular working hours and were given initial functional assessment immediately on enrollment.

Demographic data, injury severity scores (ISS), Glasgow Coma Scale [GCS], pre-existing medical comorbidities, hospital course information, and patient disposition statuses were collected. All consented subjects were administered the functional assessment tool at admission, discharge, and at approximately 6 mo post discharge. We used the Functional Independence Measure (FIM) for patients' functional recovery assessment. A proper licensure to use FIM tool was acquired from Uniform Data System for Medical Rehabilitation (UDSMR), Amherst, NY.

The FIM was developed by the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation for uniform measurement and data collection on disability and rehabilitation outcomes [12]. This tool has been shown to be valid for evaluating functional independence in trauma patients [10,11,13,14]. In the United States, FIM use is mandated by Medicare for patients hospitalized for rehabilitation [15]. The complete FIM score incorporates 18 daily activities in multiple domains including self-care, sphincter control, mobility, locomotion, communication, and social cognition.

The standard FIM score uses a scale of 7 for each activity with 1 being completely dependent and 7 being completely independent. We used the modified scale of 4 with 1 being complete dependence, 2 being dependent on human assistance for supervision and moderate or minimal assistance, 3 being dependent on nonhuman devices, and 4 being completely independent [14]. The modified scale is more objective and much easier to administer at follow-up where dedicated providers are not available to accurately rate patients' functional status. The total score is treated as a numeric value of overall functional status with 18 as the minimum score and 72 as the functional maximum.

Subjects were divided into different comparison groups based on BMI: normal weight as BMI <25, overweight as BMI ≥25 and <30, obese as BMI ≥30 and <35, and morbidly obese as BMI ≥35. Because our groups were constructed on a continuous dimension (BMI), we chose not to perform pairwise comparisons. All *P* values for univariate analyses are for four group comparisons. We also treated BMI as a continuous variable for measuring obesity in alternative analyses. Multivariate regression analysis was performed to determine the independent effect of obesity on functional recovery. All tests are two tailed and $P < 0.05$ was considered statistically significant. All statistical analyses were carried out using Stata 11.2 (StataCorp LP, College Station, TX).

3. Results

Two hundred fifty-three patients were initially enrolled and 18 patients were excluded for failing to meet inclusion criteria. Our final sample contains 235 patients, and all of them survived to hospital discharge. Compared with the rest of potentially eligible patients during our study period, our sample does not differ in demographics, BMI, and ISS. The potentially eligible patients had overall mortality of 3.4%. We also notice that our sample had longer hospital stay than those who did not participate in the study (12.24 ± 16.07 *versus* 9.35 ± 10.54, $P < 0.001$).

Patients were classified as nonobese, overweight, obese, and morbidly obese. Demographic and baseline clinical data are shown in Table 1. ISS, GCS, and trauma injury severity survival probability scores were not statistically different among the groups. The majority of patients in the study were males and patients were much younger in the nonobese normal weight group. Rates of heart disease, diabetes, chronic obstructive pulmonary disease, liver disease, and kidney disease were similar between BMI groups. Significantly, more patients in the abnormal BMI groups had hypertension.

Outcome and follow-up data are presented in Table 2. Follow-up surveys on functional recovery were completed on 186 (79%). Length of hospital stay, days in the intensive care unit (ICU), and days on mechanical ventilation were not statistically different among the different BMI groups. From the time of admission to the time of hospital discharge, FIM scores of nonobese patients increased an average of 24.1 points; whereas morbidly obese patients had an average increase of 16.4 points. This difference was statistically significant ($P = 0.023$). The mean gain in FIM scores per day during hospitalization was 5.0 ± 5.8 for the nonobese group; compared with 3.3 ± 3.4 in the overweight group, 3.1 ± 4.4 in the obese group, and 1.7 ± 1.4 in the morbidly obese group ($P = 0.002$).

Table 1 – Demographic and clinical characteristics of patients by obesity status.

Characteristics	Nonobese (n = 61)	Overweight (n = 95)	Obese (n = 42)	Morbidly obese (n = 37)	P value
Age	38.7 ± 18.1	46.0 ± 16.2	47.6 ± 15.7	46.5 ± 15.4	0.018
Female (%)	17 (28)	24 (25)	8 (19)	13 (35)	0.431
White (%)	54 (90)	90 (98)	39 (98)	35 (97)	0.105
ISS	18.7 ± 14.2	17.7 ± 9.5	20.2 ± 12.1	18.8 ± 9.3	0.704
GCS	13.0 ± 4.3	13.6 ± 3.6	13.5 ± 3.8	13.4 ± 3.9	0.801
TRISS probability	0.9 ± 0.2	0.9 ± 0.2	0.9 ± 0.2	0.9 ± 0.2	0.645
DM (%)	2 (3)	7 (7)	3 (7)	6 (16)	0.166
CHF (%)	0 (0)	0 (0)	0 (0)	1 (1)	0.157
CAD (%)	1 (2)	8 (8)	5 (12)	2 (5)	0.158
COPD (%)	2 (3)	2 (2)	1 (2)	0 (0)	0.864
HTN (%)	5 (8)	22 (23)	12 (29)	8 (22)	0.048
Liver disease (%)	0 (0)	2 (2)	0 (0)	0 (0)	0.148
CRI (%)	0 (0)	1 (1)	0 (0)	1 (1)	0.482
Alcohol (%)	31 (53)	53 (56)	19 (45)	17 (46)	0.606
Drug abuse (%)	12 (21)	8 (9)	3 (7)	4 (12)	0.135
Current smoker (%)	13 (22)	21 (23)	11 (27)	10 (29)	0.840

CAD = coronary artery disease; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CRI = chronic renal insufficiency; DM = diabetes mellitus; HTN = hypertension; TRISS = trauma injury severity survival probability.

The rate of recovery was reduced by 30% in overweight group (P = 0.034), 37% in obese group (P = 0.0025), and 48% in morbidly obese group (P = 0.003).

Gains in FIM scores from the time of discharge to 6-mo follow-up were not significantly different between the obesity groups. At follow-up, most patients reached similar functional status. On average, FIM scores at follow-up ranged from 71.1 in the nonobese group to 69.8 in the morbidly obese group. The nonobese patients were more likely to be discharged to home without any home health nursing services (56%) compared with overweight group (33%), obese group (40%), and morbidly obese patients (16%) (P = 0.001). At follow-up, 76% of the patients achieved full functional recovery, and there was no statistical difference between the obesity groups.

When examining obesity as a continuous variable, we found that for every unit increase in BMI, the FIM recovery during hospital stay was reduced by 0.31 (P = 0.010) in univariate analysis and by 0.17 (P = 0.0037) when adjusted for confounding variables (see Fig. 1). After hospital discharge, FIM recovery shows a tendency of increase with BMI but such a trend is statistically insignificant regardless of whether confounding variables are adjusted. When analyzing the rate of FIM recovery, the observed trends become more apparent (Fig. 2). During hospital stay, the rate of FIM score improvement per day was reduced by 4% per each unit of BMI increased (P < 0.001) with confounding variables controlled. After hospital discharge, there is a trend for slower FIM recovery rates associated with higher BMI but the changes remain statistically insignificant.

Consistent through all models, age is negatively related to FIM recovery. Older patients tend to recover slower and achieve worse overall recovery during and after hospital stay. With each year increase of age, the patient FIM recovery rate slows down by 1% (P = 0.013) during hospital stay and 0.01 after hospital stay (P = 0.025). Injury severity measures are independently associated with FIM recovery. During hospital stay, the severely injured patients have slower recovery. With each unit increase of ISS, there is 3% reduction in FIM recovery per day (P < 0.001) and each unit decrease of GCS score, there is 6% reduction in FIM recovery per day (P = 0.004). After hospital stay, injury severity is no longer related to FIM recovery rate in controlled analysis. Compared with patients going home without additional care, patients discharged to home with outpatient rehabilitation experienced additional 0.87 FIM improvement per month (P = 0.014) and those going to skilled nursing facility experienced less improvement at −1.79 FIM per month (P = 0.004).

4. Discussion

By design, our nonselected sampling does not include the entire patient population. There is no mortality among patients because of the selection process. We happened to recruit patients who had significant longer hospital LOS. We did not detect any other differences as a result of potential bias related to subject selection. Our sample does represent the entire eligible study patient population in terms of injury severity and obesity profile. The sample also represents the national trend in obesity where 74% of the patients are overweight or obese, and 34% are clinically classified as obese. The normal weight group was about 7–9 y younger than the overweight or obese patients, which is expected because of the age-dependent obesity in the population [1]. Younger patients recover faster, and age is one of the most potent confounders for trauma outcome studies, especially related to obesity [14], as also evidenced in our current analysis.

The most researched outcome related to obesity in trauma patients is mortality, which is of course the most serious in the outcome spectrum. The initial reports with data from the late 1980s described a huge impact of obesity on trauma mortality where obese patients may suffer mortality up to 21%–42% [16,17]. By the beginning of the 21st century, the effect of obesity on trauma mortality became less defined with repeated reports both supporting and refusing the higher

Table 2 – Clinical outcome and functional recovery by obesity status.

Outcomes	Nonobese ($n = 61$)	Overweight ($n = 95$)	Obese ($n = 42$)	Morbidly obese ($n = 37$)	P value
LOS	10.3 ± 12.8	12.3 ± 18.0	11.6 ± 12.9	15.6 ± 18.0	0.451
Days in ICU	4.0 ± 9.1	3.3 ± 7.5	3.6 ± 6.8	4.2 ± 7.3	0.925
Days ventilation	3.4 ± 9.3	2.2 ± 5.6	2.4 ± 5.7	3.3 ± 5.9	0.698
Operations	1.1 ± 1.4	1.3 ± 1.5	1.0 ± 1.3	1.3 ± 1.2	0.797
Discharged home no assistance (%)	34 (56)	31 (33)	17 (40)	6 (16)	0.001
FIM at admission	38.2 ± 13.9	40.0 ± 11.1	38.3 ± 15.1	41.6 ± 13.9	0.550
FIM at discharge	62.4 ± 7.9	60.0 ± 8.4	56.7 ± 13.0	58.7 ± 9.3	0.027
FIM at follow-up	71.1 ± 2.1	70.6 ± 3.4	70.3 ± 3.8	69.8 ± 5.4	0.482
Independent (FIM = 72)					
At admission (%)	2 (3)	2 (2)	0 (0)	1 (3)	0.750
At discharge (%)	15 (25)	15 (16)	3 (8)	6 (17)	0.155
At follow-up (%)	33 (79)	60 (77)	25 (76)	24 (73)	0.934
Acute recovery					
Total FIM gain	24.1 ± 13.7	20.0 ± 11.5	18.8 ± 13.1	16.4 ± 11.3	0.023
FIM gain/d	5.0 ± 5.8	3.3 ± 3.4	3.1 ± 4.4	1.7 ± 1.4	0.002
After acute recovery					
Total FIM gain	9.3 ± 7.1	10.2 ± 7.1	12.0 ± 8.4	10.0 ± 6.4	0.468
FIM gain/mo	1.7 ± 1.3	1.8 ± 1.0	1.8 ± 1.1	2.0 ± 2.3	0.918
Follow-up rate (%)	42 (69)	78 (82)	33 (79)	33 (89)	0.093
Follow-up days (since discharge)	198 ± 26	202 ± 28	199 ± 23	189 ± 43	0.293

mortality hypothesis [18]. Some authors even suggested that there might be a protective effect of obesity [19,20]. Meta-analyses that pool multiple studies support the hypothesis of obesity resulting in higher mortality in trauma, but with much less dramatic effects [9,20].

In our sample, obesity not only bares no impact on mortality but also has no effect on patients' hospital LOS, ICU LOS, or the duration of mechanical ventilation. Those outcomes measures are almost as controversial as trauma mortality. Even if obesity increases these durations, the clinical effect is likely to be insignificant [9]. The effects of obesity on trauma patient care complications are much better established in other areas. Obesity has been shown to increase the risk of acute respiratory distress syndrome, renal failure, and multiple organ failure [9]. Obesity complicates patient recovery course; therefore, they are much less likely to be discharged home without need for additional assistance, as evidenced in our study.

Obesity significantly reduces the functional recovery of trauma patients at hospital discharge and the effect is dose-dependent; the higher the BMI, the larger the effect. Our findings are consistent with earlier studies that focus on various injury patterns [10,11,15]. In the present study, patients were followed 6 mo after discharge. We found that the discrepancy in functional recovery rate between nonobese and obese patients gradually disappears after discharge. We believed that if the data had been collected every 3 d after discharge; we would have been able to demonstrate the same delayed functional recovery among the obese patients. Our results showed all trauma patients eventually recovered fully at follow-up. Therefore, we may conclude that obesity tends to delay, not prevent full recovery of trauma patients and the effect of obesity tends not to be long term. In spinal cord injuries, the functional status of patients at discharge is linked to long-term consequences [15]. Our sample size does not

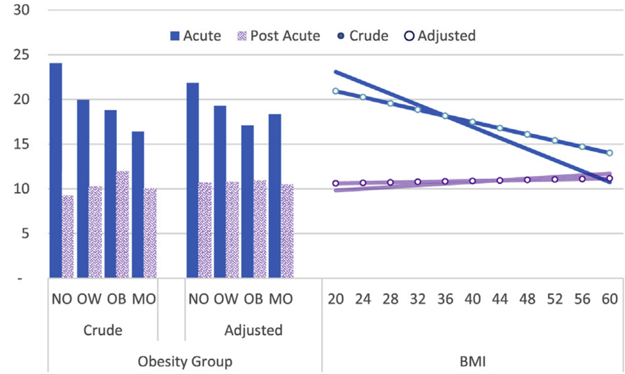

Fig. 1 – Adjusted and unadjusted total FIM recovery for trauma patients. NO = nonobese; OW = overweight; OB, obese; MO, morbidly obese; adjusted value controls for age, gender, ISS, GCS, comorbidities, and period starting FIM. (Color version of the figure is available online.)

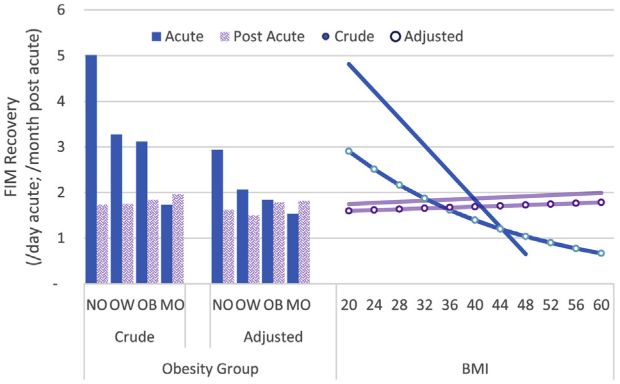

Fig. 2 – Adjusted and unadjusted FIM recovery rate for trauma patients. Adjusted value controls for age, gender, ISS, GCS, comorbidities, and period starting FIM. (Color version of the figure is available online.)

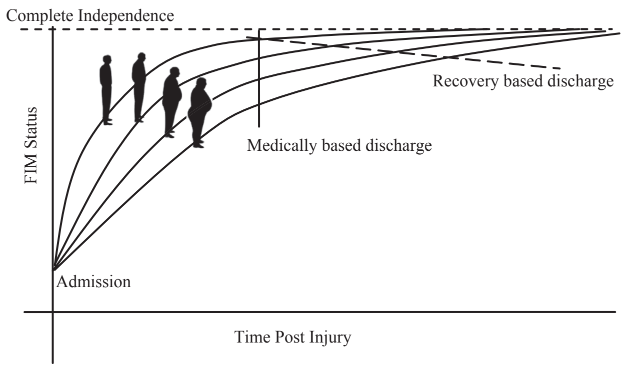

Fig. 3 – Projected recovery trajectory of trauma patient by obesity.

allow us to identify patient subgroups that suffer long-term effect of obesity, but we did notice that GCS instead of ISS is linked to final functional status of the patients. Patients with injuries of the nervous system may suffer longer functional recovery delays.

Although we did not track the functional status of our patients continually, our results do offer us a glimpse into the trajectory of functional recovery in trauma patients. The effect of obesity in delaying functional recovery can be best illustrated with a theoretical diagram (see Fig. 3). Starting from similar injury status, the patients experience different recovery rates after injury. The functional recovery among obese patients is delayed and it is directly correlated with the degree of obesity.

In a traditional recovery-based discharge model, the patients are discharged with similar functional status; we would expect longer hospital stay for more obese patients. Pressured by prospective payment system, the US hospitals shifted from recovery-based discharge model to medically based one where discharge decision is mainly driven by medical necessity and safety, and as a result, the average LOS was reduced 35% from 1980–2000 and stabilized thereafter [21]. We could predict that the duration outcomes such as hospital LOS or ICU stays for trauma patients would differ significantly by obesity status in countries such as Japan and South Korea where national average LOS is three to four times that of the United States [22], and the discharge basis is likely to be recovery based. In either model, obesity is still linked with increased health care resource consumption by requiring additional postdischarge assistance.

During the follow-up period, patients in the higher BMI category had higher gains in FIM scores compared with the nonobese patients. Although these gains were not significantly different, they were consistent among all the BMI groups. It is likely that the nonobese group takes less time to achieve plateau status, whereas the obese group still is able to reach a higher gain over a period of time because of obvious gaps in functional status. This thinking is supported by the fact that there are significant different FIM scores at discharge for the various groups. One may also be tempted to associate faster FIM recovery during the follow-up period with additional institutional and home care received by obese patients. Our analysis offers limited support for this hypothesis in that patients tend to benefit from outpatient rehabilitation but recovery is impeded among patients going to a skilled nursing facility. The latter effect may be an intrinsic characteristic of the population instead of true impact by institutional care provided by skilled nursing facilities.

Our model is limited in examining the appropriateness of care rendered during follow-up period but assumed that various levels of post discharge care may be necessary to maintain the projected recovery trajectory. Another potential explanation for not being able to detect the statistical significance for the rate of functional recovery in the postdischarge phase may be because of too few data points collected during the follow-up period or insufficient power. Given the observed positive trend, reevaluation with more frequent assessment of FIM score after discharge or a larger sample size may provide a more definitive answer to this question.

It was not the aim of this clinical investigation to assess the impact of comorbidity on functional recovery. Furthermore, there were some variations in the prevalence of comorbidities in our sample compared with those of the general population. For example, 8% of our sample was diabetic compared with 13% of the general population [23]. In the normal weight group, we only had two patients with diabetes. Our limited sample size did not provide enough statistical power to examine the true effect of diabetes on functional recovery.

We have a significantly high percentage of patients who smoke (24%) and tested positive for alcohol or drugs (52% and 12%, respectively). Such variables are linked to the risk behavior of the underlying population [24,25]. Those variables may negatively impact on detectability of functional recovery.

In the present study, we successfully followed up 79% of our study sample. Comparison between the patient with follow-up data and those without, we did not show systematic differences in demography, clinical characteristic at admission and at discharge. We have no mortality at discharge among the study group; however, we do know that our institutional annual trauma service mortality is approximately 4%. As a result, our findings may not be representative of all trauma patients, but rather those who may ultimately achieve full recovery after hospital discharge.

Our study is unique because it is one of the initial studies to prospectively follow trauma patients and collect data on functional recovery scores at predetermined time intervals. We observed a severity-dependent relationship between obesity and delayed functional recovery. After discharge, all groups across obesity classification were able to reach a similar level of recovery. Our findings could be used for building recovery expectations among patients and planning for health care resource allocation for trauma patient care.

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Disclosure

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