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Predisposing Factors for Post-Operative Delirium After Hip Fracture Repair Among Patients With and Without Dementia

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Abstract

OBJECTIVES—Based on a multi-factorial model of delirium, we compared the types and magnitude of pre- and intra-operative predisposing factors for incident delirium in a stratified sample of acute hip fracture repair patients with and without pre-operative dementia.

DESIGN and SETTING—A prospective cohort study based in an academic medical center.

PARTICIPANTS—425 non-delirious, acute hip fracture patients (mean age: 80.2 +/− 6.8; female: 73.2%; “probable dementia”: 33.1%) admitted to the multi-disciplinary hip fracture repair service.

MEASUREMENTS—Each participant was assessed for delirium by a research nurse based on the Confusion Assessment Method (CAM) before study enrollment and from the second postoperative day until hospital discharge.

RESULTS—The incidence of delirium was higher in the Probable Dementia Group than in the No Dementia Group (54% vs. 26%; $p \leq 0.001$). In the No Dementia group (n = 284), age (OR: 1.07; 95% CI: 1.02-1.13), male gender (OR: 2.81; 95% CI: 1.40-5.64), BMI (OR: 0.92; 95% CI: 0.86-0.99), number of medical comorbidities (OR: 1.15; 95% CI: 1.01-1.32), and duration of surgery longer than two hours (OR: 2.53; 95% CI: 1.20-4.88) were independently associated with

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a post-operative delirium. In the Probable Dementia group, only the lag time from emergency room to operation room was significantly associated (OR: 2.83; 95% CI: 1.24-2.25) with delirium.

CONCLUSION—Pre-operative determination of dementia status is important for risk stratification for incident delirium after acute hip fracture repair surgery because types and magnitude of predisposing risk factors for post-operative delirium substantially differ based on their pre-operative dementia status.

Keywords

dementia; delirium; hip fracture; surgery; risk factor

INTRODUCTION

With more than 320,000 hip fracture-related hospital admissions per year in the US, hip fracture surgery is a common surgical procedure among the elderly (1). One of the most common post-operative complications after hip fracture repair is delirium with incidence of up to 53.3%, a substantially higher rate than other elective surgeries according to a recent meta-analytic review (2). Since post-operative delirium is associated with greater morbidity and mortality, longer length of hospital stay, and greater institutionalization (3-7), identification of patients at high risk for delirium and development of targeted prevention and intervention strategies after hip fracture repair are of great public health significance.

Previously, Inouye et al (8, 9) proposed a multi-factorial model for delirium, which involves examination of the complex interrelationship between predisposing patient factors (e.g. dementia, severe illness), and precipitating events (e.g. major surgery, anesthesia, multiple psychoactive medications, etc.) occurring during hospitalization. Based on this model, a highly vulnerable patient with a severe *predisposing factor* (e.g. dementia) may develop delirium after a relatively benign *precipitating event* (e.g. receiving single dose of sleeping medication) while a healthy, young patient would be spared of delirium despite going through a severely noxious *precipitating event* (i.e. major surgery). In hip fracture repair all patients are uniformly exposed to severe *precipitating event*s for delirium such as major trauma, surgery and prolonged anesthesia. Therefore, identifying reliable predisposing factors to guide pre- or intra-operative risk assessment for post-operative delirium becomes even more imperative in guiding early detection, treatment, and development of preventive strategies for post-operative delirium.

Among the various putative predisposing factors, pre-operative diagnosis of dementia is the most consistently reported risk factor for incident delirium among hospitalized patients (8, 10). Other risk factors, including age, gender, co-morbidity, and various peri-operative factors are inconsistently reported, likely due to heterogeneity in assessment methods and inclusion criteria, small sample size, and limited availability of potential risk factors in the studies (2). Despite the apparent impact of pre-operative cognitive status on incidence of post-operative delirium, most delirium studies either exclude patients with dementia or neglect to distinguish subjects based on dementia status in their analysis (2, 10). Potentially, those patients with dementia versus those without dementia may have different precipitating risk factors for post-operative delirium. Additionally, dementia is associated with other predisposing factors (e.g. age, gender, and medical comorbidities) for post-surgical delirium, and could be a “confounder” that leads to false conclusions about the longitudinal association between the candidate precipitating factor (e.g. age) and the incident delirium.

The primary aim of this study was to determine the impact and utility of pre-operative assessment of dementia in risk stratification for post-operative delirium among patients uniformly exposed to an acute precipitating event (i.e. hip fracture repair surgery).

Therefore, we stratified a large, relatively homogenous sample of hip fracture repair patients based on the presence of pre-operative dementia status and compared pre- and intra-operative predisposing factors for incident delirium between patients with and without pre-operative dementia. We hypothesized that types and magnitude of risk factors for incident delirium between the two groups would be different.

METHODS

Study Sample and Group Assignment

The study protocol was approved by the Committee on Human Research, the Institutional Review Board for Johns Hopkins Bayview Medical Center. Between 1999 and 2008, 726 consecutive hip fracture repair patients above age 65 were approached for consent for collection of their peri-operative clinical data for research purpose. During the consent process, those with pre-operative delirium (n= 131; 18%) ascertained by a trained research nurse based on the Confusion Assessment Method (CAM; 11) were ineligible for our study. Of the remaining 595 eligible patients, 428 or 72% consented to participate in this study. Excluding three participants with incomplete post-operative delirium assessment data, the remaining 425 patients age: 80.2 +/− 6.8; female: 73.2%) were pre-operatively categorized into two groups: No Dementia (n = 284) and Probable Dementia (n = 141). Preoperative "probable dementia" was diagnosed if the patient had: 1) no delirium by Confusion Assessment Method (CAM) and either 2) Mini Mental State Examination (MMSE; 12) cut-off score <24 or 3) clinical diagnosis of dementia by a geriatrician during the pre-hip fracture repair evaluation.

Assessment of Incident Delirium

Each participant was assessed for delirium based on CAM and MMSE from the second postoperative day until hospital discharge about 10:00 AM by the same research nurse who had consented and assessed the participant before the surgery. Assessment on first postoperative day was not attempted because of the residual effects of anesthesia that makes it difficult to distinguish between true delirium and transient confusion. The research nurse was blind to the group assignment based on pre-operative dementia status, but was aware of the preoperative MMSE score. The primary outcome was incident delirium, determined based on the CAM diagnostic algorithm at any time during hospitalization from the second post-operative day onward. CAM has a high sensitivity (94%-100%) and specificity (90%-95%) for detection of delirium (12).

Assessment of Candidate Predisposing Factors

Based on a review of the literature and variables available in our database, the following candidate pre-and intra-operative predisposing factors were selected (10). The sociodemographic variables investigated were: 1) age (continuous in years); 2) race (dichotomous: white =1, non-white = 0); 3) and gender (dichotomous: male =1, female = 0). The smoking and alcohol use variables were dichotomous (current =1; former/never = 0) and based on self-report. Body-mass index (BMI) was calculated from a person's weight and height measured by the nursing staff at the time of admission.

For each participant, past medical history was obtained from the pre-operative assessment by an experienced geriatrician according to the multi-disciplinary hip fracture service protocol. The number of chronic medical conditions (continuous) and prescribed medications (continuous) were recorded as well as presence or absence of individual medical diagnoses including depression (dichotomous) that were based on self report.

Each patient was rated preoperatively by the anesthesiologist based on the American Society of Anesthesiologists (ASA) physical status (PS) classification rating system (13; ordinal scale: 1 to 5 scale; where 1 = normal healthy patient, and 5 = moribund patient who is not expected to survive without operation). Complete blood count, metabolic panel (e.g. sodium, blood urea nitrogen, creatinine, albumin, etc.) and other pertinent serological laboratory results were available. Lag time to surgery (continuous) was measured in hours from the patient's arrival time in emergency department (ED) to the start time of the surgery.

Intra-operative variables were obtained based on the anesthesiology record and post-operative note recorded by the attending orthopedic surgeon. Types of hip fracture and surgery (categorical), types of anesthesia (dichotomous: spinal or general anesthesia), duration of surgery (continuous: in hours), and amount of red blood cell (RBC) transfusion (continuous: in units of transfusion; dichotomous: less than 2 units of RBC transfusion = 0 or more than 2 units = 1) during the surgery were obtained.

Statistical Analysis

First, we conducted a series of comparisons of sociodemographic, medical history, and pre and intra-operative variables between participants with or without "probable dementia" using student t- test for continuous variables and Chi-square for categorical variables. Then, we stratified (as planned) the sample into two groups (No Dementia and Probable Dementia) based on the pre-operative "probable dementia" status, and we conducted a case-control analysis, comparing the incident delirium cases with non delirium controls to estimate delirium risk by putative predisposing factors in each group. Crude odds ratios (ORs) with 95% confidence intervals were calculated for comparison of types and magnitude of predisposing factor for delirium between the No Dementia and Probable Dementia groups.

For multivariate models, if a candidate predisposing factor was significant at $P<.10$ or if its removal altered the multivariate model by more than 10% of the variance based on the pseudo – R^2, we retained the variable in the final model for both groups and the combined sample. We checked for significant colinearity between putative predisposing factors (e.g. the number of medical comorbidities and ASA PA rating). If colinearity was found between variables, we chose the variable that provided a higher Nagelkerke R^2 in the final model.

RESULTS

Table 1 compares the No Dementia (n= 284) and Probable Dementia (n = 141) groups in terms of putative predisposing factors. The Probable Dementia group was significantly older in age, higher in number of medical comorbidities, and had higher proportion of ASA PS scale rating of 4 ("severe systemic disease that is constant threat to life") or above and history of cerebrovascular accident (CVA) or Transient ischemic attack (TIA).

Table 2 summarizes the incidence of postoperative complications in the two groups. There was no difference in non-cognitive, medical complications between the groups. However, incidence of delirium was substantially higher in the Probable Dementia group than in the No Dementia group (54% versus 26%, $p < 0.001$; OR: 3.38; 95% Confidence Interval [CI]: 2.21-5.17). Overall incidence of delirium was 35% for the total sample.

Table 3 compares the crude ORs between pre- and intra-operative predisposing factors and incident delirium in both groups. In the No Dementia group, age, male gender, number of medical comorbidities, pre-operative MMSE score, and an ASA PS rating of 4 or above were associated with incident delirium. Individual medical comorbidities including history of CVA and TIA were not associated with incident delirium in either group. Lower BMI was also associated with higher odds of incident delirium, but no specific BMI category was associated with incident delirium.

Among intra-operative variables, longer duration of surgery was significantly associated with higher incidence of delirium in the No Dementia group. More specifically, those with hip fracture repair lasting more than two hours had significantly higher incidence of delirium than those without (31.8% versus 19%; p = 0.015). Among the surgery types, the Intramedullary hip screw procedure was substantially shorter in duration than other procedures (mean duration: 1.22 ± 0.54 hours versus 2.35 ± 0.90 hours; p<0.001) and was associated with lower incidence of delirium.

In the Probable Dementia group, however, the crude ORs for the aforementioned predisposing factors trended toward 1.0., but were not statistically significant. For example, duration of hip fracture surgery in Probable Dementia group was nearly identical in those who developed delirium versus those who did not (mean duration ± SD: 2.12 ±0.92 hours versus 2.12 ± 0.90 hours; p = 0.996; OR: 0.98 [0.69, 1.42]). In fact, the only significant predisposing factor for delirium in Probable Dementia Group was the lag time between the patients' presentation in the ED to the surgery. Compared to those who had surgery within 36 hours of presentation to the ER, those who waited more than 36 hours had significantly higher incidence of postoperative delirium (41.1% versus 65.9%; p <0.014; OR: 2.84 [1.24, 6.48]).

Table 4 compares the predisposing factors for incident delirium across the final multivariate models for the No Dementia group, Probable Dementia group, and the total sample respectively. In developing the final multivariate models, significant colinearities were observed among the number of the medical comorbidities, number of prescribed medications and the ASA PA rating, and among types of surgery, length of surgery, and units of RBC transfusion. Number of medical comorbidities (continuous) and duration of surgery lasting longer than two hours (dichotomous) were retained in the final models while other variables were removed based on the goodness of fit of the multivariate models. The resulting multivariate model for the No Dementia group in Table 4 revealed that age, male gender, lower BMI, higher number of medical comorbidities, and duration of surgery longer than two hours were significantly associated with incident delirium in the No Dementia group. However, for the Probable Dementia group, no multivariate model could be developed as the lag time between ED to surgery was the only predictive predisposing factor. Without stratifying the sample by pre-operative dementia status, the final multivariate model for the total sample consisted of age, gender, number of medical comorbidities, duration of surgery longer than two hours, and pre-operative dementia status only. Neither lag time between ER to surgery nor BMI were independently associated with incident delirium for the total sample.

DISCUSSION

Pre-operative determination of dementia status appears to be critical in risk stratification for post-operative delirium among hip fracture surgery patients for two major reasons. First, the incidence of post-operative delirium was substantially higher among those with pre-operative dementia than without (54% vs. 26%; p≤ 0.001; OR: 3.35 [2.19, 5.12]) and pre-operative dementia was the most predictive predisposing factor for delirium, as was reported previously (14). Higher morbidity and mortality have been associated with patients with delirium superimposed on dementia than with delirium or dementia alone (15-18). Therefore, the clinical staff should implement close and frequent post-operative monitoring of mental status among all dementia patients after hip fracture repair so that delirium can be diagnosed and intervened as early as possible.

Secondly, types and magnitude of predisposing factors for post-operative delirium differ based on the pre-operative dementia status. In fact, without stratification by pre-operative dementia status, we would not have identified the important predisposing factors such as low BMI in the No Dementia group and the lag time between ED to surgery in the Probable Dementia group.

In the No Dementia group age and higher number of medical comorbidities (or ASA PA rating of 4 or higher) were significant risk factors for incident delirium. In addition, we found that male gender was a significant predisposing factor for post operative delirium. Recently, a systematic review of preoperative risk factors for delirium after non-cardiac surgery concluded that there is insufficient evidence to support an association between male gender and delirium based on pooled analysis of ten non-cardiac elective surgery studies (10). In their analysis, however, significant heterogeneity ($p<0.03$) across the study samples were observed. Based on a more homogenous group of elective orthopedic surgery patients, Williams-Russo P, et al and Fisher et al. (19, 20) reported male gender as a significant predisposing factor for delirium, but only among those without pre-operative dementia. It is also important to note that male gender has comparable point estimates in the No Dementia group (OR: 2.06 [1.16, 3.63] and in the Probable Dementia group (OR: 1.85 [0.85, 4.02]), and that the differences in statistical significance may be due to a smaller sample size and lower power to detect associations in the Probable Dementia group than in the No Dementia group. Further study is needed to examine the mechanisms underlying the longitudinal relationship between male gender and incident delirium after hip fracture repair.

Another predisposing factor specific to the No Dementia Group was lower BMI. This is consistent with a recent report of BMI less than 20 as an independent risk factor after hip fracture repair (22). Interestingly, however, in our study, BMI was in fact somewhat higher in patients with delirium superimposed on dementia than patients with dementia alone. Our findings suggest that the relationship between BMI and post-operative delirium may vary based on pre-operative cognitive status.

Consistent with findings from the previous systematic reviews, no difference in delirium incidence was found between those who had general anesthesia versus spinal anesthesia, regardless of their pre-operative dementia status (23, 24). However, the duration of hip fracture repair surgery appeared to be strongly associated with postoperative delirium in patients without pre-operative dementia. One possible explanation is the colinearity between the perioperative blood loss and the duration of surgery in our study. However, no association was found between pre-operative hematocrit level and incidence of post-operative delirium in our study. Also, the negative results from the recently completed, randomized clinical trial of blood transfusion thresholds on delirium severity after a hip fracture repair (25) suggest that blood loss is unlikely to explain the link between the duration of surgery and post-operative delirium in our study.

A more likely explanation between duration of surgery and postoperative delirium in the No Dementia Group is the anesthesia effect. We have recently reported that depth of sedation in general anesthesia is often similar to spinal anesthesia during hip fracture repair (26) and that minimizing sedation during spinal anesthesia reduces incident delirium (27). The current study suggests that duration of anesthesia, regardless of type of anesthesia, might be just as important as depth of anesthesia and prolonged exposure to anesthesia may predispose a non-demented hip fracture repair patient to postoperative delirium.

Interestingly, the duration of surgery was not a significant predisposing factor for delirium in the Probable Dementia group. In fact, the only predisposing factor associated with postoperative delirium among patients with pre-operative dementia was the lag time between the ER to OR. In the Probable Dementia group the ER to OR lag time for those who developed delirium was nearly 15 hours longer than those who didn't (50.93 + 38.7 hours versus 35.69 + 31.8 hours; $p = 0.033$). Reasons for the prolonged delay to surgery could be due to lack of surgical clearance due to anti-coagulation status and medical stability or limited availability of OR staff._Our study confirms the recent finding by Juliebo et al (22) on the association between presurgical delay and postoperative delirium, focusing on the relationship in patients with preoperative dementia. Delay to acute hip fracture surgery has been implicated in longer length of stay and increased morbidity and mortality after hip fracture repair surgery (28, 29). However, why the ER to OR lag time impacts the incidence of delirium only in the Probable Dementia Group is unclear and further study is needed.

These differences in magnitude and types of predisposing factors for post-operative delirium potentially suggest different underlying mechanism in development of post-operative delirium among the patients with pre-operative dementia and these without. Alternatively, in the setting of severe precipitating events (e.g. surgery), the highly vulnerable state of demented brain itself renders other putative risk factors insignificant. Despite the well-established primacy of dementia as a delirium risk factor, the unifying biological and/or psychological mechanism to link delirium and dementia remains elusive (30). Previous studies have postulated that neuropathophysiological changes - reduced "brain reserve" - accompanying dementia process, such as decreased cerebral metabolism, cholinergic deficiency, and inflammation, leads to increased vulnerability for POD (31, 32). In parallel, others have suggested that cognitive decline and accompanying reduction of "cognitive reserve" – resiliency of mind to cope with brain insults – due to dementia lead to vulnerability for POD (33). Elucidation of linking mechanism between delirium and dementia could lead to development of specific strategies for early detection, prevention, intervention strategies among surgical patients with pre-operative dementia.

There are several important limitations to our study. First, detailed pre-operative cognitive and functional data were not available to ascertain preoperative dementia status with greater certainty. In order to avoid interference of preoperative clinical care for acute hip fracture repair, we chose to avoid prolonged cognitive and functional evaluation and relied on the pre-operative MMSE score and the geriatrician's diagnosis of dementia for our stratification. Invariably, some misclassifications must have occurred and may have influenced our analysis. Second major limitation is the lack of availability of other important putative risk factors for delirium. Visual impairment has been reported to be a risk factor for hospitalized elderly patients (9) and was not assessed in our study. Also, other the total number of medications and the amount of opioid medications, our clinical database lacked detailed information on specific medications that our participants were taking prior to surgery. We have recently reported the lack of association between narcotics and post-operative delirium (34). However, besides narcotics, previous studies have reported association between delirium and several other classes of medications such as benzodiazepines, anticholinergics, and antihistamines (35, 36). Our study is limited by the absence of data on these classes of medications. Furthermore, our clinical database was initiated in 1999, before several putative, intra-operative risk factors (e.g. hypotension, 0_2 saturation, etc.) became known. Therefore, intraoperative details in our study are limited to surgical indication, types, duration, and amount of perioperative blood transfusion. Preoperative depression is a putative risk factor for postoperative delirium (37), and we relied on self-report only to ascertain history of depression. Third, the long period of recruitment is vulnerable to changes in clinical practice that could influence the incidence of postoperative delirium. During this period, our hip fracture service has instituted a multidisciplinary team approach that involves perioperative co-management of hip fracture patients by geriatricians and orthopedic surgeons in 2003 (38). Over the years, due to these changes in clinical practice, the incidence of post-operative complications among our hip fracture repair patients has decreased. Therefore, our findings based on a multidisciplinary hip fracture service may have limited generalizability to other services that do not employ similar multidisciplinary team approach. Fourth, our daily late morning delirium assessment that began on postoperative day two may have under-detected mild, transient delirium that only occurred on post-operative day one and at other times of the day.

Overall, our findings underscore the importance of pre-operative dementia assessment for risk stratification. For hip fracture repair patients at high risk for postoperative delirium, several prevention strategies are already available. For example, Marcantonio et al (39) have reported that proactive consultation by a geriatrician before, or within, 24 hours of operation may reduce the incidence and severity of delirium in patients undergoing surgery for hip fracture. Identification of high risk patients for post-operative delirium based on our findings could lead to more efficient referral to geriatricians or more targeted development of delirium prevention strategies in the future.

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Table 1

Characteristics of the Sample by Pre-Operative Dementia Status

Variables	No Dementia (N = 284)	Probable Dementia (N= 141)	P-value
age, years (sd)	**79.4 (6.9)**	**83.1 (6.2)**	**<0.001**
male (%)	77 (27)	37 (26)	0.849
White (%)	131 (94)	275 (97)	0.082
current smoking (%)	46 (16)	21 (15)	0.774
current alcohol use (%)	34 (12)	116 (12)	0.921
Katz ADL Index (sd)	**5.4 (1.1)**	**4.4 (1.8)**	**<0.001**
Lawton IADL Scale (sd)	**6.2 (2.7)**	**3.7 (3.1)**	**<0.001**
pre-operative MMSE, (sd)	**27.6 (1.9)**	**18.9 (4.3)**	**<0.001**
Body-Mass Index-bmi,(sd)	*24.5 (4.9)*	*23.5 (5)*	*0.105*
Underweight: bmi <18.50 (%)	31(12)	17 (17)	0.275
Normal: bmi =18.50 – 24.99(%)	112 (45)	53 (52)	
Pre-obese: bmi = 25.00 – 29.00(%)	78 (31)	24 (23)	
Obese: bmi ≥30.00)	30 (12)	9 (9)	
Medical History			
# of medical comorbidities, (sd)	**4.4 (2.4)**	**5.6 (2.5)**	**<0.001**
Cardiovascular disease (%)	84 (30)	38 (27)	0.558
CVA/TIA (%)	**46 (16)**	**37 (26)**	**0.015**
Diabetes (%)	66 (23)	34 (24)	0.826
Kidney disease (%)	33 (10)	23 (16)	0.223
COPD (%)	61 (22)	31 (22)	0.919
Cancer (%)	39 (14)	25 (18)	0.284
Depression (%)	40 (14)	28 (20)	0.134
# of prescription meds, (sd)	4.1 (2.5)	3.8 (2.7)	0.528
Pre-operative variables			
Type of fracture (%)			
femoral neck	130 (46)	71 (50)	0.141
Intertroch	127 (45)	62 (44)	
Others	7 (3)	25 (9)	
ASA rating 4 or above (%)	**31 (11)**	**25 (18)**	**<0.001**
Laboratory abnormality (%)			
hematocrit <30 (%)	27 (10)	13 (9)	0.924
bun/creatinine >20 (%)	158 (57)	93 (68)	**0.034**
WBC>12,000 (%)	88 (36)	50 (37)	0.806
Sodium <130 (%)	19 (7)	7 (5)	0.472
albumin <3.5 or >4.5 (%)	46 (19)	24 (21)	0.651
ED to Surgery –hours (sd)	39.7 (25.7)	43.6 (36.2)	0.336
Intraoperative Variables			

Variables	No Dementia (N = 284)	Probable Dementia (N= 141)	P-value
Type of surgery (%)			
Hemiarthroplasty	114 (41)	59 (44)	0.913
Screw and side plate	55 (20)	23 (17)	
Intramedullary hip screw	58 (21)	29 (22)	
Cannulated screw	34 (12)	16 (12)	
others	17 (6)	8 (6)	
Type of anesthesia –general (%)	106 (39)	61 (44)	0.322
Length of surgery – minutes(sd)	121.1 (54.5)	127.4 (57.7)	0.287
Transfusion >2 units of RBC (%)	44 (16)	23 (17)	0.754

Table 2

Summary of Post-Operative Complications by Pre-Operative Dementia Status

Complications	No Dementia (N = 284)	Probable Dementia (N= 141)	P-value
UTI (%)	49 (17.3)	28 (20.3)	0.449
Acute renal failure (%)	25 (8.8)	14 (10.1)	0.655
Pneumonia (%)	27 (9.5)	21 (10.1)	0.836
Myocardial infarction (%)	14 (4.9)	116 (7.2)	0.335
Congestive heart failure (%)	37 (13.0)	11 (8.0)	0.125
Arrhythmia (%)	25 (8.8)	12 (8.7)	0.971
Incident Delirium (%)	**73 (26)**	**76 (54)**	**<0.001**

Table 3

Comparison of Predisposing Factors for Delirium after Hip Fracture Repair by Pre-Operative Dementia Status

	No Dementia (N = 284)		Probable Dementia (N =141)	
Variables	**Crude OR (95% CI)**	**p-value**	**Crude OR (95% CI)**	**p-value**
age –in years	**1.07 (1.05, 1.08)**	**0.020**	1.00 (0.93, 1.07)	0.843
gender - male	**2.06 (1.16, 3.63)**	**0.012**	1.85 (0.85, 4.02)	0.119
race - white	0.89 (0.23, 3.44)	0.708	0.54 (0.39, 5.93)	0.413
current smoking	0.55 (0.25, 1.25)	0.198	1.39 (0.54, 3.61)	0.486
current alcohol use	0.59 (0.23, 1.48)	0.399	1.86 (0.61, 5, 69)	0.293
body-mass index-bmi (kg/m^2)	**0.93 (0.88, 0.99)**	**0.025**	1.06 (0.98, 1.14)	0.151
underweight: bmi <18.50	1.23 (0.52, 2.90)	0.638	0.86 (0.29, 2.56)	0.781
normal: 18.50≤ bmi < 25.00	REF	N/A	REF	N/A
overweight: bmi ≥ 25.00	0.63 (0.34, 1.19)	0.152	1.48 (0.61, 3.58)	0.382
pre-operative MMSE	**0.77 (0.60, 0.99)**	**0.039**	0.93 (0.83, 1.05)	0.274
Katz ADL index	0.74 (0.52, 1.06)	0.098	0.90 (0.69, 1.17)	0.422
Lawton IADL scale	0.89 (0.76, 1.03)	0.123	0.99 (0.84, 1.17)	0.916
Medical History				
# of medical comorbidities	**1.14 (1.03, 1.27)**	**0.023**	1.09(0.95, 1.25)	0.201
CVA or TIA	1.15 (0.77, 3.03)	0.225	1.22 (0.57, 2.59)	0.613
# of prescription meds	**1.32 (1.02, 1.70)**	**0.034**	0.95 (0.74, 1.20)	0.651
ASA rating 4 or above	**2.45 (1.12, 5.25)**	**0.022**	1.30 (0.54, 3.14)	0.555
history of depression	1.13 (0.53, 2.39)	0.758	0.98 (0.43, 2.26)	0.919
Pre-operative variables				
Type of fracture				
femoral neck	REF	N/A	REF	N/A
Intertrochanteric	0.87 (0.51.1.49)	0.621	0.99 (0.51.1.94)	0.994
Pre-op serological abnormality				
hematocrit <30	1.52 (0.65, 3.56)	0.328	0.72 (0.23, 2.26)	0.573
bun/creatinine >20	0.71 (0.41, 1.22)	0.211	0.97 (0.47, 1.99)	0.932
WBC>12,000	0.74 (0.39, 1.40)	0.200	1.03 (0.51, 2.08)	0.936
sodium <130	2.25 (0.87, 5.83)	0.088	1.16 (0.25, 5.41)	0.846
albumin <3.5 or >4.5	1.30 (0.71, 3.72)	0.246	1.48 (0.60, 3.65)	0.396
ER to surgery – in hours	1.00 (0.99, 1.02)	0.417	**1.01 (1.00, 1.03)**	**0.042**
ER to surgery > 36 hours	0.81 (0.42, 1.58)	0.536	**2.83 (1.24, 6.48)**	**0.017**
Intraoperative Variables				
Type of surgery				
Hemiarthroplasty	REF	N/A	REF	N/A
Screw and side plate	0.84 (0.35, 2.05)	0.710	0.84 (0.35, 2.06)	0.710
Intramedullary hip screw	**0.39 (0.18, 0.94)**	**0.034**	0.72 (0.28, 1.90)	0.509

	No Dementia (N = 284)		Probable Dementia (N =141)	
Variables	**Crude OR (95% CI)**	**p-value**	**Crude OR (95% CI)**	**p-value**
Cannulated screw	0.56 (0.14, 1.09)	0.072	1.72 (0.54, 5,56)	0.359
Others	0.70 (0.21, 2.28)	0.548	0.47 (0.10, 2.16)	0.334
Type of anesthesia –general	1.40 (0.79, 2.48)	0.254	1.15 (0.58, 2.25)	0.692
Length of surgery – hours, (sd)	**1.36 (1.03, 1.79)**	**0.030**	0.98 (0.69, 1.42)	0.919
Length of surgery >2 hours	**1.99 (1.14, 3.47)**	**0.017**	1.02 (0.52, 1.98)	0.960
Transfusion >2 units of RBC	**2.60 (1.33, 5.08)**	**0.004**	0.98 (0.40, 2.41)	0.965

Table 4

Multivariate Models of Predisposing Factors for Incident Delirium after Hip Fracture Repair

Risk Factors	No Dementia Group (N = 284)		Probable Dementia Group (N = 141)		Total Sample (N = 425)	
	Adj. OR (95% CI)	p-value	Adj. OR (95%CI)	p-value	Adj. OR (95%CI)	p-value
age in years	1.07 (1.02, 1.13)	0.005	----	----	1.05 (1.02, 1.09)	0.004
gender - male	2.81 (1.40, 5.64)	0.004	----	----	2.10 (1.28, 3.44)	0.003
body-mass index	0.92 (0.86, 0.99)	0.025	----	----	----	----
# of medical comorbidities	1.15 (1.01, 1.32)	0.040	----	----	1.14 (1.04, 1.25)	0.005
duration of surgery ≥ two hours	2.53 (1.20, 4.88)	0.006	----	----	1.75 (1.12, 2.74)	0.014
ED to Surgery > 36 hrs	---	---	2.83 (1.24, 6.38)	0.014	---	---
“probable dementia”	N/A		N/A		2.74 (1.72, 4.34)	<0.001