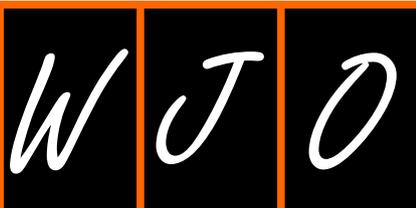


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*WJO* covers topics concerning arthroscopy, evidence-based medicine, epidemiology, nursing, sports medicine, therapy of bone and spinal diseases, bone trauma, osteoarthropathy, bone tumors and osteoporosis, minimally invasive therapy, diagnostic imaging. Priority publication will be given to articles concerning diagnosis and treatment of orthopedic diseases. The following aspects are covered: Clinical diagnosis, laboratory diagnosis, differential diagnosis, imaging tests, pathological diagnosis, molecular biological diagnosis, immunological diagnosis, genetic diagnosis, functional diagnostics, and physical diagnosis; and comprehensive therapy, drug therapy, surgical therapy, interventional treatment, minimally invasive therapy, and robot-assisted therapy.

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## Retrospective Cohort Study

**Do-Not-Resuscitate status is an independent risk factor for patients undergoing surgery for hip fracture**

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**Data sharing statement:** The original anonymous dataset is available on request from the corresponding author at [urman@bwh.harvard.edu](mailto:urman@bwh.harvard.edu).

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**Abstract****AIM**

To determine morbidity and mortality in hip fracture patients and also to assess for any independent associations between Do-Not-Resuscitate (DNR) status and increased post-operative morbidity and mortality in patients undergoing surgical repair of hip fractures.

**METHODS**

We conducted a propensity score matched retrospective analysis using de-identified data from the American College of Surgeons' National Surgical Quality Improvement Project (ACS NSQIP) for all patients undergoing hip fracture surgery over a 7 year period in hospitals across the United States enrolled in the ACS NSQIP with and without DNR status. We measured patient demographics

including DNR status, co-morbidities, frailty and functional baseline, surgical and anaesthetic procedure data, post-operative morbidity/complications, length of stay, discharge destination and mortality.

### RESULTS

Of 9218 patients meeting the inclusion criteria, 13.6% had a DNR status, 86.4% did not. Mortality was higher in the DNR compared to the non-DNR group, at 15.3% *vs* 8.1% and propensity score matched multivariable analysis demonstrated that DNR status was independently associated with mortality (OR = 2.04, 95%CI: 1.46-2.86,  $P < 0.001$ ). Additionally, analysis of the propensity score matched cohort demonstrated that DNR status was associated with a significant, but very small increased likelihood of post-operative complications (0.53 *vs* 0.43 complications per episode; OR = 1.21; 95%CI: 1.04-1.41,  $P = 0.004$ ). Cardiopulmonary resuscitation and unplanned reintubation were significantly less likely in patients with DNR status.

### CONCLUSION

While DNR status patients had higher rates of post-operative complications and mortality, DNR status itself was not otherwise associated with increased morbidity. DNR status appears to increase 30-d mortality *via* ceilings of care in keeping with a DNR status, including withholding reintubation and cardiopulmonary resuscitation.

**Key words:** Do-Not-Resuscitate; Consent; Perioperative; Outcomes; Mortality; Hip fracture

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**Core tip:** We present a large, multi-institution retrospective cohort study which examines the independent association of Do-Not-Resuscitate (DNR) status with perioperative outcomes during hip fracture surgery. We find that DNR status independently predicts overall rates of complications and mortality at 30 d without other clear sources of morbidity. Our conclusions place this work in the context of other literature on the outcomes for patients with DNR status during the perioperative period, exploring the data among other surgical populations and hypotheses for this effect.

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## INTRODUCTION

Do-Not-Resuscitate (DNR) status documents that a

decision has been made to withhold certain resuscitative measures in the event of cardiorespiratory arrest. This typically includes withholding chest compressions and endotracheal intubation. DNR status documents a patient's advance refusal of resuscitative procedures, due to expressed wishes or beliefs, or where cardiopulmonary resuscitation would fail to restore a quality of life compatible with the patient's goals of care<sup>[1-3]</sup>. DNR status is most common when patients have multiple, severe co-morbidities, extreme frailty, or end-stage diseases<sup>[4-6]</sup>.

DNR status does not prevent surgery, despite the potential need for endotracheal intubation or inotropic support during anesthesia. The American Society of Anaesthesiologists' Ethics Committee guidance of 2013 states: "an essential element of preoperative preparation and perioperative care for patients with DNR orders ... is communication among involved parties. ...The status of these directives should be clarified or modified based on the preferences of the patient"<sup>[7]</sup>. Patients with DNR status can undergo a range of emergency, urgent or elective surgical procedures to prolong life or improve quality of life. However, as DNR status frequently coincides with narrowed goals of care, procedures tend to be life sustaining or palliative, rather than elective.

The true incidence and composition of surgery in patients with DNR status is unknown. One recent analysis identified 22% of all surgeries in patients with DNR status were lower limb orthopedic procedures<sup>[8]</sup>. Hip fracture fixation is the most common indication for hip surgery at the older extreme of age, and orthogeriatric patient outcomes have been the focus of recent national quality improvement initiatives<sup>[9-12]</sup>. However, outcomes after hip fracture surgery specifically in the DNR status population are unknown.

It is also unclear whether DNR status itself independently and negatively impacts major outcomes such as morbidity and length of stay<sup>[13-16]</sup>. DNR status only directs actions in the event of cardiopulmonary arrest. The "failure to treat" hypothesis, describing inadequate (non-resuscitative) treatment of patients because of DNR status, has been suggested but with inconclusive evidence<sup>[17]</sup>. The aim of this study is to describe the incidence and distribution of DNR status in patients undergoing hip fracture surgery and to determine whether DNR status is an independent risk factor for worse outcomes on 30 d follow up.

## MATERIALS AND METHODS

### Data source

The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) is a data registry of cases reported from approximately 400 participating sites. ACS-NSQIP is a well-validated database and incorporates data from patients' medical charts, with data entry overseen by a designated Surgical Clinical Reviewer (SCR) at each site. Institutional Review Board (Brigham and Women's Hospital,

Boston, MA, United States) approval was obtained for analysis of the data and was exempted from the consent requirement due to the de-identified nature of the data.

### Study sample

The 2007-2013 NSQIP was compiled into a single data file containing 306 variables across 2.8 million surgical cases. All cases recording patients under age 18, trauma cases, transplant surgeries, cases where the patient is American Society of Anesthesiologists (ASA) physical status class 6, representing a brain-dead organ donor are excluded from NSQIP (Table 1). We isolated all admissions for hip fracture surgery using all listed ICD codes (Appendix 1) and Current Procedural Terminology (CPT) codes (included in Table 2 with case mix data). All cases failing to report the "do not resuscitate" variable or CPT code were excluded from the analysis. Patient demographic data were collected for age, ASA physical status (PS) class, sex, race, ethnicity, height, weight, and body mass index. Preoperative comorbidity data were collected for functional status prior to surgery, defined as ability to perform activities of daily living (ADL), baseline dyspnea, diabetes mellitus (insulin and non-insulin dependent); smoking status within one year prior to admission; presence of chronic obstructive pulmonary disease, congestive heart failure, coronary artery disease (defined as a composite of a history of angina, myocardial infarction, percutaneous coronary interventions or previous cardiac surgery), hypertension, chronic kidney disease, cerebrovascular accidents, pre-operative weight loss of greater than 10% in the 6 mo prior to surgery, sepsis physiology and a previous operation within the past 30 d. Additional pre-operative laboratories, including the creatinine, albumin, hematocrit, platelet count and international normalized ratio (INR) were collected.

We calculated a frailty score for each patient undergoing hip fracture surgery to assess for presence of any baseline differences in pre-morbid status between the DNR and non-DNR status groups. We used a variation of the well-known Charlson Comorbidity Index<sup>[18-21]</sup>. The Canadian Study of Health and Ageing (CSHA)<sup>[22]</sup> Clinical Frailty Scale is a 7 point index, modified from the Charlson Comorbidity Index. It has been validated previously using NSQIP data, and has been modified for use with data collected within the NSQIP dataset<sup>[23]</sup>.

Data collection for the surgical procedure included the primary surgical CPT code, surgical wound classification, total anesthesia and surgical time and anesthesia type. To assess for independent association between preoperative patient demographic, comorbidity and frailty variables and DNR status, we conducted univariable and multivariable regression analysis. For the logistic regression, odds ratios (OR) were reported with their associated 95% CI. OR not including 1.00 in their 95%CI were considered statistically significant and were included in the multi-

variable regression analysis.

We collected binary outcomes data for the following postoperative events up to 30 d after surgery: Death, return to the operating room, superficial and deep space surgical site infections, post-operative pneumonia, unplanned intubation, failure to wean from the ventilator, progressive renal insufficiency and acute renal failure requiring dialysis, urinary tract infections, cerebrovascular accidents, myocardial infarction, post-operative bleeding requiring transfusion of packed red blood cells, deep venous thrombosis requiring therapy, pulmonary embolism and post-operative sepsis. Additional data on discharge destination (Home, Skilled Care, or Rehabilitation facility) and total length of stay were also collected. All outcomes were reported as percentages, with the numerator defined as the absolute count reporting a given outcome and the denominator defined as the total number of cases reporting any outcome for that variable. To assess for the associations between DNR status and post-operative outcomes, we developed a propensity score matched cohort in which patients were matched by propensity for DNR status. We performed univariable and multivariable regression analysis on the matched cohort and OR not including 1.00 in their 95%CI were considered statistically significant.

### Statistical analysis

R Project for Statistical Computing (R version 3.2.3) was used to perform all statistical analysis. Differences between cohorts were assessed using the Pearson chi squared test for categorical variables and using the Student's *t*-test for continuous variables due to assessment of normality. However, for the variable length of stay, assessment of the distribution of data was non-normal; thus a Wilcoxon rank sum test was performed on this variable. For all demographic, comorbidity, and operative characteristics, a univariable logistic regression model was fitted to assess the association of each variable with DNR status. Of note, the database does not report any postoperative outcomes (including death) occurring more than 30 d after surgery. Additionally, for variables with a large continuous range, the following assumptions were made; platelet count assumes a change of 100000, while the morbidity and mortality risk scores assume a change of 10%. For anesthesia and surgical operating time, the regression model assumes a time interval change of 10 min.

### Multivariable logistic regression propensity score matched model

For our primary analysis, we applied a propensity score matched logistic regression model accounting for propensity for DNR status. The matched cohort was developed using a propensity scoring method in which we incorporated statistically significant variables from the unmatched model into a propensity score model. A 1:1 greedy, nearest neighbor matching strategy was employed utilizing the MatchIt library, producing successful matching of 725 patients who were DNR

**Table 1 Demographics, co-morbidities and functional baseline of Do-Not-Resuscitate and non-Do-Not-Resuscitate status patients undergoing hip fracture surgery**

Category	DNR			Not DNR			OR (95%CI)	P values
	Num	Denom	%	Num	Denom	%		
Age, mean (SD)	85.1		6.7	77.55		12.3	1.098 (1.088-1.109)	< 0.001
< 65	26	1256	2.1	1188	7962	14.9	Reference	< 0.001
65-80	169	1256	13.5	2384	7962	29.9	3.239 (2.131-4.923)	
> 80	1061	1256	84.5	4390	7962	55.1	11.043 (7.445-16.381)	
Sex								
Male	313	1254	25.0	2395	7950	30.1	Reference	< 0.001
Female	941	1254	75.0	5555	7950	69.9	1.296 (1.131-1.486)	
Demographics								
White	781	1215	64.3	6008	7544	79.6	Reference	< 0.001
Black	11	1215	0.9	371	7544	4.9	0.228 (0.125-0.417)	
Asian	3	1215	0.2	94	7544	1.2	0.246 (0.078-0.777)	
Other	4	1215	0.3	31	7544	0.4	0.993 (0.349-2.819)	
Not reported	416	1215	34.2	1040	7544	13.8	3.077 (2.686-3.525)	
Hispanic	18	824	2.2	314	6677	4.7	0.453 (0.28-0.732)	0.001
BMI								
Mean (SD)	24.1		5.5	25.3		6.5	0.966 (0.953-0.978)	< 0.001
< 18.5	110	913	12.0	630	7076	8.9	1.261 (1.007-1.579)	< 0.001
18.5-25	454	913	49.7	3279	7076	46.3	Reference	
25-30	244	913	26.7	1976	7076	27.9	0.892 (0.756-1.052)	
> 30	105	913	11.5	1191	7076	16.8	0.637 (0.51-0.795)	
Functional status								
No dyspnea	1098	1256	87.4	7136	7961	89.6	Reference	0.015
Dyspnea with moderate exertion	116	1256	9.2	652	7961	8.2	1.156 (0.94-1.423)	
Dyspnea at rest	42	1256	3.3	173	7961	2.2	1.578 (1.12-2.224)	
Independent	491	1251	39.2	4726	7917	59.7	Reference	< 0.001
Partially dependent	579	1251	46.3	2583	7917	32.6	2.158 (1.896-2.456)	
Totally dependent	181	1251	14.5	608	7917	7.7	2.865 (2.369-3.466)	
ASA class								
1 or 2	108	1256	8.6	1739	7951	21.9	0.388 (0.315-0.478)	< 0.001
3	779	1256	62.0	4866	7951	61.2	Reference	
4 or 5	369	1256	29.4	1346	7951	16.9	1.712 (1.492-1.965)	
Comorbidities								
Hypertension	908	1256	72.3	5413	7962	68.0	1.229 (1.076-1.402)	0.002
Diabetes	184	1256	14.7	1468	7962	18.4	0.759 (0.643-0.897)	0.001
COPD	181	1256	14.4	899	7962	11.3	1.323 (1.114-1.571)	0.001
CHF	55	1256	4.4	234	7962	2.9	1.512 (1.12-2.041)	0.006
CAD	212	1256	16.9	1340	7962	16.8	1.004 (0.856-1.176)	0.966
PVD	25	1256	2.0	235	7962	3.0	0.668 (0.44-1.013)	0.056
CKD	29	1256	2.3	214	7962	2.7	0.856 (0.578-1.267)	0.436
Stroke	229	1256	18.2	1023	7962	12.8	1.512 (1.292-1.771)	< 0.001
Weight loss	31	1256	2.5	119	7962	1.5	1.668 (1.118-2.488)	0.011
Sepsis	204	1249	16.3	931	7892	11.8	1.46 (1.238-1.721)	< 0.001
Recent surgery	12	1256	1.0	114	7962	1.4	0.664 (0.365-1.207)	0.177
Labs								
Creatinine	1.09		0.8	1.08		0.9	1.015 (0.946-1.088)	0.664
Hematocrit	30.7			30.1			1.01 (0.986-1.034)	0.394
Platelets	212			208			1.04 (0.977-1.107)	0.196
Surgical urgency								
Emergent	428	1256	34.1	2194	7962	27.6	1.359 (1.197-1.542)	< 0.001
Surgical complexity								
Work RVU	17.45		2.0	17.46		2.7	0.998 (0.975-1.021)	0.841
Anesthesia								
General	796	1255	63.4	6028	7959	75.7	NA	< 0.001
Neuraxial/regional	446	1255	35.5	1876	7959	23.6	1.8 (1.586-2.044)	
Other	13	1255	1.0	55	7959	0.7	1.79 (0.974-3.291)	
Anesthesia time	117.9		48.1	128.8		58.5	0.996 (0.995-0.997)	< 0.001
Operation time	61.4		43.8	70.2		43.5	0.994 (0.992-0.996)	< 0.001
Modified Charlson score	2.44		1.4	2.03		1.5	1.207 (1.16-1.255)	< 0.001

DNR: Do-Not-Resuscitate; BMI: Body mass index; SD: Standard deviation; ASA: American Society of Anesthesiologists; COPD: Chronic obstructive pulmonary disease; CHF: Congestive heart failure; CAD: Coronary artery disease; PVD: Peripheral vascular disease; CKD: Chronic kidney disease; RVU: Relative value unit.

to 725 patients who were not DNR. Success of the matching process was evaluated using Student's *t*-test for

**Table 2 Surgical case mix of hip fracture surgery performed on Do-Not-Resuscitate and non Do-Not-Resuscitate status patients after propensity matching**

CPT code	Translation	DNR			Not DNR			P value
		num	denom	%	num	denom	%	
27236	Open treatment of femoral fracture, proximal end, neck, internal fixation or prosthetic replacement	210	725	28.966	223	725	30.759	0.994
27245	Treatment of intertrochanteric, per-trochanteric, or sub-trochanteric femoral fracture; with intramedullary implant	173	725	23.862	171	725	23.586	
27125	Hemiarthroplasty, hip, partial (e.g., femoral stem prosthesis, bipolar arthroplasty)	111	725	15.31	104	725	14.345	
27244	Treatment of intertrochanteric, per-trochanteric, or sub-trochanteric femoral fracture; with plate/screw type implant, with or without cerclage	91	725	12.552	99	725	13.655	
27235	Percutaneous skeletal fixation of femoral fracture, proximal end, neck	48	725	6.621	44	725	6.069	
27130	Arthroplasty, acetabular and proximal femoral prosthetic replacement (total hip arthroplasty)	20	725	2.759	19	725	2.621	
27248	Open treatment of greater trochanteric fracture, with or without internal or external fixation	9	725	1.241	5	725	0.69	
27506	Open treatment of femoral shaft fracture, with or without external fixation, with insertion of intramedullary implant, with or without cerclage and/or locking screws	8	725	1.103	12	725	1.655	
27187	Prophylactic treatment (nailing, pinning, plating or wiring) with or without methylmethacrylate, femoral neck and proximal femur	6	725	0.828	4	725	0.552	
27454	Osteotomy, multiple, with realignment on intramedullary rod, femoral shaft (e.g., Sofield type procedure)	5	725	0.69	4	725	0.552	
27507	Open treatment of femoral shaft fracture with plate/screws, with or without cerclage	5	725	0.69	8	725	1.103	
27511	Open treatment of femoral supracondylar or trans-condylar fracture without intercondylar extension, with or without internal or external fixation	5	725	0.69	6	725	0.828	
27228	Open treatment of acetabular fracture(s) involving anterior and posterior (two) columns, includes T-fracture and both column fracture with complete articular detachment, or single column or transverse fracture with associated acetabular wall fracture, with internal fixation	3	725	0.414	4	725	0.552	
27513	Open treatment of femoral supracondylar or trans-condylar fracture with intercondylar extension, with or without internal or external fixation	3	725	0.414	1	725	0.138	
27122	Acetabuloplasty; resection, femoral head (e.g., Girdlestone procedure)	2	725	0.276	2	725	0.276	
27138	Revision of total hip arthroplasty	2	725	0.276	2	725	0.276	
27165	Osteotomy, intertrochanteric or sub-trochanteric, including internal or external fixation and/or cast	2	725	0.276	0	725	0	
27509	Percutaneous skeletal fixation of femoral fracture, distal end, medial or lateral condyle, or supracondylar or trans-condylar, with or without intercondylar extension, or distal femoral epiphyseal	2	725	0.276	1	725	0.138	
27132	Conversion of previous hip surgery to total hip arthroplasty	1	725	0.138	1	725	0.138	
27134	Revision of total hip arthroplasty	1	725	0.138	0	725	0	
27254	Open treatment of hip dislocation, traumatic, with acetabular wall and femoral head fracture, with or without internal or external fixation	1	725	0.138	1	725	0.138	
27450	Osteotomy, femur, shaft or supracondylar; with fixation	1	725	0.138	3	725	0.414	
27514	Open treatment of femoral fracture, distal end, medial or lateral condyle, with or without internal or external fixation	1	725	0.138	1	725	0.138	

DNR: Do-Not-Resuscitate.

continuous variables and Pearson’s  $\chi^2$  test for categorical variables. We found only one statistically significant difference between the cohorts after matching, which suggested that the matched groups may have hematocrit values that differed by approximately 1.3% (OR = 0.87;  $P = 0.017$ ; see Table 3).

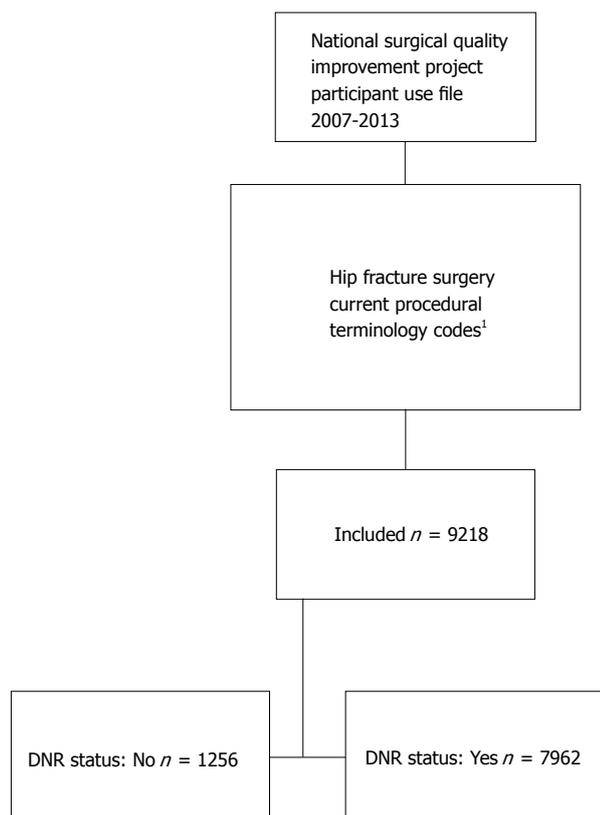
For the logistic regression on the matched cohorts, odds ratios (ORs) were reported with associated 95%CI. ORs not including 1.00 in the 95%CI were considered statistically significant. To assess the association specifically between length of stay and DNR status, a Cox proportional hazard model was fitted, incorporating the demographic and comorbidity co-variables as described above to generate a hazard ratio (HR). The model was right censored with death as a completing

event.

## RESULTS

### Study population

The ICD codes included in the analysis are shown in Appendix 1. A total of 9218 cases met inclusion criteria (Figure 1). Of these, 1256 (13.6%) were patients with DNR status, and 7962 (86.4%) were patients without DNR status. Unmatched univariable analysis demonstrated that patients undergoing hip fracture surgery with DNR status were more likely to be female, aged over > 80 years, unreported race/ethnicity, BMI < 18.5, dyspneic with moderate exertion or rest, ASA class III or IV, partially or totally dependent for activities



**Figure 1 Study population.** <sup>1</sup>See Appendix 1. DNR: Do-Not-Resuscitate.

of daily living or diagnosed with hypertension, diabetes, COPD, CHF, PVD, prior stroke, weight loss, or sepsis (Table 1). Comparison between the groups in the unmatched cohort also suggested that patients with DNR status were more likely to have surgery booked as emergent, to receive a neuraxial or regional anesthetic, have a shorter anesthetic and operative time, and a higher modified Charlson score. These factors were used to construct the propensity score matched cohort as described above.

### **Risk prediction**

Using the ACS-NSQIP calculator, the average pre-operative risk prediction within the DNR status group was a mortality of 10% [Standard deviation (S.D) 10%] and morbidity of 15% (S.D 7%). In the non-DNR status group, using the ACS-NSQIP risk prediction calculator the average predicted mortality was 4% (S.D 6%) and morbidity was 11% (S.D 6%).

### **Surgical case mix for hip fracture surgery in DNR and non-DNR populations**

Table 2 shows the most common 23 CPT codes encountered for hip fracture surgery in the matched cohorts. Ninety-seven point six percent of all DNR patients and 95% of all non-DNR patients had hip fracture surgery classed by one of these CPT codes. The remaining minority (2.4% of DNR and 5% of non-DNR) had other hip fracture surgery CPT codes not listed. These patients were included in the analysis. Table 3 demonstrates the propensity score matched case mix

of procedures and the distribution within DNR and non-DNR status groups. The numbers of patients per CPT code were too small to conduct regression analysis. However, ranking CPT codes by frequency demonstrated very similar surgical case mixes in terms of CPT codes between the DNR and non-DNR groups, with the same 10 CPT codes accounting for over 95% of cases and occurring in the same order of frequency, with several low volume exceptions. This suggests there were minimal differences and a high correlation between the surgical case mixes encountered across the two groups, however the degree or significance of differences beyond this were not analysed further. CPT codes were not included in multivariable regression modelling.

### **Operative and anesthetic comparisons in DNR and non-DNR populations undergoing hip fracture surgery**

Table 3 demonstrates various surgical and anaesthetic factors between the matched groups. Post propensity matching univariable regression demonstrated no increased likelihood for patients with DNR status to have a hip fracture surgery as an emergency procedure. DNR status was not independently associated with shorter surgical time (OR = 0.99, CI 0.99-1.00) or anesthetic time (OR = 0.99, 95%CI: 0.99-1.00). DNR status also did not appear to impact anesthesia modality: Compared to general anaesthesia, spinal anesthesia was not more likely in the DNR patient group compared to the non-DNR patient group in the propensity score matched analysis (OR = 0.96, 95%CI: 0.75-1.22).

### **Post-operative 30 d outcomes: Mortality**

Table 4 presents outcomes up to 30 d postoperatively between the propensity matched cohorts. Mortality was higher in DNR status patients than in non-DNR status patients undergoing hip fracture surgery, at 15.3% vs 8.1% of patients. Multivariable regression demonstrated DNR status was independently associated with mortality (OR = 2.04, 95%CI: 1.46-2.85,  $P < 0.001$ ). DNR status was not associated with return to the operating room on multivariable regression.

### **Post-operative 30 d outcomes: Morbidity**

Our analysis of the propensity score matched cohort found one difference with respect to post operative morbidity. Patients with DNR status had a slightly higher average number of complications per hospitalization (0.53 vs 0.43; OR = 1.213, 95%CI: 1.04-1.41). Although DNR patients appeared more likely to experience superficial surgical site infections (OR = 21.3; 95%CI: 1.25-364), this was likely an artifact of no events for the non-DNR patients and was no difference was seen with deep surgical site infections or dehiscence rates. DNR patients were less likely to experience reintubation (OR = 0.253; 95%CI: 0.09-0.69), or cardiac arrest with CPR (OR = 0.115; 95%CI: 0.03-0.52). Mean length of stay in the DNR group was no different between the propensity score matched groups.

**Table 3 Propensity score matched case mix of procedures and the distribution within Do-Not-Resuscitate and non-Do-Not-Resuscitate status groups**

Category	Do-Not-Resuscitate			Not Do-Not-Resuscitate			OR (95%CI)	P-values
	Num	Denom	%	Num	Denom	%		
Age, mean (SD)	85.1	NA	6.7	85.0	NA	6.5	1.001 (0.985-1.016)	0.946
< 65	17	725	2.3	18	725	2.5	Reference	0.982
65-80	92	725	12.7	93	725	12.8	1.047 (0.508-2.158)	
> 80	616	725	85.0	614	725	84.7	1.062 (0.542-2.081)	
Sex								
Male	177	725	24.4	165	725	22.8	Reference	0.458
Female	548	725	75.6	560	725	77.2	0.912 (0.716-1.163)	
Demographics								
White	692	725	95.4	689	725	95.0	Reference	0.462
Black	6	725	0.8	4	725	0.6	1.493 (0.42-5.316)	
Asian	3	725	0.4	9	725	1.2	0.332 (0.089-1.231)	
Other	3	725	0.4	2	725	0.3	1.493 (0.249-8.966)	
Not Reported	21	725	2.9	21	725	2.9	0.996 (0.539-1.84)	
Hispanic	17	725	2.3	17	725	2.3	1 (0.506-1.974)	1
BMI								
Mean (SD)	24.1	NA	5.6	24.3	NA	5.4	0.996 (0.977-1.015)	0.646
< 18.5	90	725	12.4	88	725	12.1	0.999 (0.719-1.389)	0.901
18.5-25	350	725	48.3	342	725	47.2	Reference	
25-30	198	725	27.3	211	725	29.1	0.917 (0.718-1.171)	
> 30	87	725	12.0	84	725	11.6	1.012 (0.724-1.415)	
Functional status								
No Dyspnea	614	725	84.7	608	725	83.9	Reference	0.899
Dyspnea with moderate exertion	77	725	10.6	80	725	11.0	0.953 (0.684-1.329)	
Dyspnea at rest	34	725	4.7	37	725	5.1	0.91 (0.564-1.469)	
Independent	267	725	36.8	269	725	37.1	Reference	0.938
Partially Dependent	342	725	47.2	336	725	46.3	1.025 (0.818-1.286)	
Totally Dependent	116	725	16.0	120	725	16.6	0.974 (0.717-1.323)	
ASA class								
1 or 2	47	725	6.5	49	725	6.8	0.955 (0.627-1.455)	0.977
3	444	725	61.2	442	725	61.0	Reference	
4 or 5	234	725	32.3	234	725	32.3	0.995 (0.796-1.245)	
Comorbidities								
Hypertension	547	725	75.4	555	725	76.6	0.941 (0.74-1.198)	0.623
Diabetes	120	725	16.6	113	725	15.6	1.074 (0.812-1.422)	0.617
COPD	112	725	15.4	117	725	16.1	0.949 (0.716-1.259)	0.719
CHF	36	725	5.0	40	725	5.5	0.895 (0.563-1.421)	0.637
CAD	147	725	20.3	159	725	21.9	0.905 (0.703-1.165)	0.44
PVD	17	725	2.3	23	725	3.2	0.733 (0.388-1.384)	0.336
CKD	16	725	2.2	12	725	1.7	1.341 (0.63-2.855)	0.445
Stroke	137	725	18.9	139	725	19.2	0.982 (0.756-1.277)	0.894
Weight loss	21	725	2.9	20	725	2.8	1.051 (0.565-1.957)	0.874
Sepsis	148	725	20.4	152	725	21.0	0.967 (0.75-1.247)	0.795
Recent surgery	5	725	0.7	6	725	0.8	0.832 (0.253-2.739)	0.762
Labs								
Creatinine	1.13		0.8	1.11		0.7	1.034 (0.897-1.192)	0.646
Hematocrit	33.3			34.6			0.868 (0.765-0.985)	0.017
Platelet count	210			206			1.067 (0.94-1.211)	0.313
Surgical urgency								
Emergent	181	725	25.0	175	725	24.1	1.046 (0.823-1.328)	0.714
Surgical complexity								
Work RVU	17.4		2.2	17.5		2.1	0.988 (0.942-1.036)	0.622
Anesthesia								
General	562	725	77.5	557	725	76.8	Reference	0.568
Neuraxial/Regional	162	725	22.3	168	725	23.2	0.956 (0.748-1.222)	
Other	1	725	0.1	0	725	0.0	1 (-∞-∞)	
Anesthesia Time	122.0	NA	49.4	123.6	NA	49.7	0.999 (0.997-1.001)	0.55
Operation Time	63.9	NA	34.0	64.7	NA	36.1	0.999 (0.996-1.002)	0.645
Modified Charlson Score	2.6	NA	1.4	2.59	NA	1.4	1.007 (0.936-1.084)	0.852

DNR: Do-Not-Resuscitate; BMI: Body mass index; SD: Standard deviation; ASA: American Society of Anesthesiologists; COPD: Chronic obstructive pulmonary disease; CHF: Congestive heart failure; CAD: Coronary artery disease; PVD: Peripheral vascular disease; CKD: Chronic kidney disease; RVU: Relative value unit.

**Table 4** Thirty-days outcomes after hip fracture surgery in DNR and non-DNR status patients

Outcomes	DNR			Not DNR			OR (95%CI)	P values
	Num	Denom	%	Num	Denom	%		
Death	111	725	15.3	59	725	8.1	2.04 (1.459-2.851)	< 0.001
Reoperation/return to OR	22	725	3.0	17	725	2.3	1.309 (0.689-2.487)	0.417
Failure to wean from ventilator	4	725	0.6	7	725	1.0	0.558 (0.161-1.934)	0.364
Reintubation	5	725	0.7	19	725	2.6	0.253 (0.093-0.688)	0.004
Superficial SSI	10	725	1.4	0	725	0.0	21.294 (1.245-364.078)	0.002
Deep incisional SSI	3	725	0.4	2	725	0.3	1.466 (0.242-8.901)	0.654
Organ/space SSI	2	725	0.3	2	725	0.3	1.011 (0.142-7.196)	1
Wound Dehiscence	1	725	0.1	0	725	0.0	3.00 (0.122-73.870)	0.317
Pneumonia	25	725	3.4	34	725	4.7	0.725 (0.428-1.23)	0.232
Acute kidney injury	3	725	0.4	4	725	0.6	0.754 (0.168-3.383)	0.705
Renal failure requiring dialysis	3	725	0.4	2	725	0.3	1.5 (0.249-9.034)	0.654
CVA	4	725	0.6	5	725	0.7	0.798 (0.213-2.994)	0.738
Cardiac arrest with CPR	2	725	0.3	16	725	2.2	0.115 (0.025-0.523)	0.001
Acute MI	16	725	2.2	13	725	1.8	1.245 (0.594-2.608)	0.574
Transfusion	169	725	23.3	139	725	19.2	1.243 (0.964-1.603)	0.054
Venous thromboembolism	9	725	1.2	14	725	1.9	0.621 (0.265-1.457)	0.293
UTI	45	725	6.2	41	725	5.7	1.061 (0.683-1.649)	0.657
Sepsis	14	725	1.9	23	725	3.2	0.595 (0.303-1.17)	0.134
Number of complications	Mean		SD	Mean		SD	OR (95%CI)	P-values
	0.53		0.65	0.43		0.61	1.213 (1.043-1.409)	0.004
Length of hospital stay	Mean		SD	Mean		SD	HR (95%CI)	P-values
	6.4		5.0	6.74		5.3	2.133 (0.469-0.871)	0.219

DNR: Do-Not-Resuscitate; OR: Operating room; SSI: Surgical site infection; CVA: Cerebrovascular accident; CPR: Cardiopulmonary resuscitation; MI: Myocardial infarction; UTI: Urinary tract infection.

## DISCUSSION

Our study aimed to examine post-operative mortality and morbidity in patients with DNR status undergoing hip fracture surgery. We also aimed to determine whether DNR status was independently associated with increased morbidity or whether DNR status purely decreased utilisation of CPR and reintubation, without affecting other postoperative outcomes. We found that mortality was over two times greater in the DNR status group, with DNR status independently predicting mortality after patient groups were matched for other underlying comorbidities using propensity scoring methods. However, relatively few sources of morbidity were independently associated with DNR status. Although overall complication rates were slightly higher, rates of reintubation and cardiac arrest with CPR were much lower among patients with a DNR order in place. This raises the question of how we reconcile the increased rate of mortality observed among the DNR cohort in the setting of an isolated, modest overall rate of complications but no clear source of morbidity.

Historically, some surgeons and anesthesiologists have considered perioperative DNR status controversial, given the interventional procedures and unique physiologic changes that occur during anesthesia and the way clinicians manage these events. In light of this, both the American College of Surgeons<sup>[24]</sup> and American Society of Anesthesiologists<sup>[7]</sup> have produced consensus statements to guide perioperative management of DNR status. These emphasize communication and individualized management plans, including suspending, then reinstating DNR status post-operatively, if in

accordance with a patient's wishes.

The impact of DNR status on surgical outcomes has been examined previously in the wider surgical cohort and in specific specialty groups such as patients undergoing vascular surgery<sup>[25,26]</sup>. Kazaure *et al.*<sup>[25]</sup> demonstrated similar patient associations with having DNR status (white, female, > 85) and also demonstrated high mortality (nearly 1 in 4) in surgical patients with DNR status. However, in contrast to our findings, they demonstrated significantly higher morbidity rates in DNR vs non DNR patients. These higher rates of morbidity were not replicated in our hip fracture specific study, and therefore may imply that in our orthopedic cohort a DNR status did not negatively impact outcomes or morbidity to the degree described in the predominantly general surgery (63%) cohort which they analysed. Aziz *et al.*<sup>[26]</sup> investigated outcomes of patients undergoing vascular surgery with DNR status and also demonstrated higher mortality in DNR patients, but found similarity in rates of complications between the two groups, except for graft failure, a procedure specific complication. This demonstrates the importance of procedure specific information in discussing risk with patients.

Other emerging literature supports our findings of relatively high mortality among patients with DNR orders who undergo surgery. A recent study by our group<sup>[8]</sup> examined outcomes among DNR patients undergoing a variety of the most common procedures done for this patient population using NSQIP data. The most common procedures among DNR patients focused on symptom relief but were also associated with higher rates of 30 d mortality (but not morbidity)

when compared to non-DNR matched controls<sup>[8]</sup>. In another analysis focused on DNR patients undergoing hip surgery, the urgency of the procedure (emergent vs non-emergent) was found to cause no independent increase in 30-d morbidity, while DNR status itself again demonstrated high 30-d mortality rates in excess of those predicted by the NSQIP risk calculator<sup>[27]</sup>.

Patients undergoing hip fracture surgery comprise a diverse patient group, making risk stratification important<sup>[28,29]</sup>. High quality perioperative care and subsequent recovery particularly in the most elderly and medically complex patients presents a growing challenge for an ageing population<sup>[10-12]</sup>. Ours is among the emerging literature to measure hip fracture surgery outcomes in the presence of a DNR status and quantify the impact of this important risk factor in this common condition. Our analysis demonstrates that at present, 13.6% of all patients undergoing hip fracture surgery have DNR status. This incidence was previously unknown, despite the growing awareness of the higher risk orthogeriatric population. The burden of mortality and morbidity in this population therefore may present a sizeable and specific opportunity for quality improvement<sup>[30]</sup>. It may also identify a skills gap or systems gap in broaching discussions about end of life wishes in a pre-emptive, comprehensive, acceptable and sensitive fashion. Shared surgical decision making is an emerging topic in the literature, and there have been research and policy agendas proposed for improved perioperative code status discussion between providers involved in perioperative care and patients as well as their families<sup>[31]</sup>.

We report that patients with DNR status undergoing hip fracture surgery were more likely to be female, aged over > 80 years, dyspneic with moderate exertion or rest, ASA class III or IV, partially or totally dependent for activities of daily living or diagnosed with hypertension, diabetes, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), peripheral vascular disease (PVD), prior stroke, weight loss, or sepsis and this is in keeping with patterns described elsewhere<sup>[4,25,32,33]</sup>. Similar to previous reports on DNR status, we also found patients with DNR status were less likely to report their race/ethnicity and more likely to be underweight (BMI < 18.5)<sup>[33-35]</sup>. This could also reflect physician inconsistency in discussing end of life and resuscitation status as well as ethnic variations in fragility fractures or even of life expectancy<sup>[36,37]</sup>.

Concern has been expressed previously that DNR status may carry inadvertent care provider bias, or the so-called "failure to rescue" hypothesis. This could lead to inadequate or insufficient care, extending beyond withholding CPR or intubation and ventilation<sup>[14]</sup>. Our study was not designed to evaluate this specifically, however propensity score matching and regression analysis created a model to compare outcomes in patients with and without DNR status, controlling for age, gender, race, ethnicity, ASA class, functional status, albumin levels and presence of multiple independently significant comorbidities. Additionally, our model ma-

tched patients using a frailty index, which may have further eliminated differences between the matched groups based on physical status alone.

Our study found that patients with DNR status had slightly shorter mean anesthesia and surgery times in the unmatched analyses. This may reflect an effort to reduce operative or anesthetic time for higher risk patients, by selecting more senior or experienced staff, or less complex operative procedures<sup>[38]</sup>. We found the rates of spinal anesthesia were higher for patients who were DNR. This may reflect ongoing debate as to whether spinal anesthesia out-performs general anesthesia in specific patient groups<sup>[39,40]</sup>. Potential benefits from regional anesthesia, such as reduced respiratory and neurological complications, and reduced opiate consumption and side effects may be more pronounced in high risk patients. This finding was despite the fact that some contraindications to spinal anesthesia, such as anticoagulation, may be more prevalent<sup>[39]</sup>.

#### **Limits of the study and summary**

The primary limit to this study is fundamental to the retrospective data review design that we were obligated to by the dataset. We were not able to control selection of patients for the surgeries as a result, and therefore sought to address these limitations by our statistical methods, as described above.

The surgical case mix was similar for both groups, though due to a relatively small sample size this could not be analysed in detail. The 10 most common procedures appeared in approximately the same order for both groups, and no gross discrepancies were apparent to visual inspection of the relative proportions. Although our data was able to describe the case mix of procedures undertaken in this population, we were not able to discern sufficient level of detail to describe all aspects of the procedures performed. For instance, although we describe an approximately 15% incidence of total hip arthroplasty, the data set does not provide specific details on the techniques used to accomplish the surgery (*e.g.*, use of cementing agent type, specific screw or prosthesis hardware type). This must be recognized as one of the specific limitations of the study in addition to the general limitations of retrospective administrative and clinical datasets.

Although the emerging literature in this area suggests that shared decision making is a crucial aspect of care for patients with DNR status, our data sources did not allow us to investigate the surgical decision making that preceded the operations among DNR patients in this cohort. Thus, we cannot comment on the specific decision making process that was used in deciding to undergo surgery for hip fracture among these patients. However, this would be a valuable area of future investigation.

However, the mortality and morbidity demonstrated in this study provides a useful reference point for specific discussions about risks of hip fracture sur-

gery, for informed consent, end of life discussions, and for planning perioperative care in this high risk demographic. Importantly, while mortality was higher in DNR status patients, morbidity, defined by post-operative complications, either individually or overall, was generally not higher in the DNR status patients. Indeed, the reduced rate of CPR and unplanned intubation is both expected and consistent with findings in general and other surgical specialties<sup>[8]</sup>. It is unclear why a small number of patients with DNR status did undergo such resuscitative procedures, or what the events leading to this were. Taken together, it does not seem that an excess burden of post-operative adverse events cannot adequately explain the increased mortality and suggests the need for further research to understand what unmeasured variables account for these consistent differences in outcome. Our findings support the need for routine, systematic, perioperative discussion with hip fracture patients regarding their goals of care in the event of post-operative morbidity leading to cardiopulmonary arrest. Hip fracture surgery has high perioperative mortality, however this data suggests DNR status is effective in reducing specific interventions such as CPR and reintubation, without appearing to increase overall morbidity in the first 30 d after surgery.

## ARTICLE HIGHLIGHTS

### Research background

Relatively little is known about the exact mechanism through which Do Not Resuscitate (DNR) status affects patient outcomes during the perioperative period. The approach of surgical and anesthesia societies has been to treat DNR status as a component of the decision to undergo surgery or as a means of framing surgical goals and expectations with patients and their families. Depending on patients' goals, DNR status may even be reversed during the perioperative period. However, little is known about how preoperative DNR status affects morbidity and mortality during the perioperative period, if at all.

### Research motivation

Patients in the orthogeriatric population who are undergoing hip fracture fixation surgery may be at increased risk for morbidity and/or mortality. Given that these patients have already made a premeditated decision to limit cardiopulmonary resuscitative aspects of their medical care, they may also benefit from additional counselling with regard to any additional risks that may apply to their surgical population.

### Research objectives

This study seeks to describe the incidence and distribution of DNR status in patients undergoing hip fracture surgery and to determine whether DNR status is an independent risk factor for worse outcomes on 30-d follow up. The study's objective was realized by analysis of propensity matched groups of patients in a large retrospective cohort. The study seeks to support an emerging field of literature which describes the unique perioperative outcomes among patients with preoperative DNR/DNI status.

### Research methods

A large, national, US-based retrospective cohort database was used to identify patients undergoing surgical fixation for hip fracture across a variety of geographic and hospital settings. Characteristics of this cohort were examined for unmatched groups of patients with and without DNR/DNI orders, as well as for groups of matched on their propensity for having a DNR/DNI order.

### Research results

This study demonstrates that when comparing groups of patients that have

been matched on propensity for DNR/DNI status, having a DNR/DNI order was independently associated with mortality (OR = 2.04, 95%CI: 1.46-2.86,  $P < 0.001$ ). Additionally, DNR/DNI status was associated with a very slight increased risk of perioperative complications without otherwise showing significantly different incidences of morbidity between the matched groups.

### Research conclusion

New findings contributed by this study include insight in the role of DNR/DNI status as an independent predictor of perioperative mortality among patients undergoing hip fracture fixation surgeries. Notably, these matched groups did not demonstrate associations between DNR/DNI status and perioperative morbidity. Given that rates of CPR and reintubation were markedly lower in the DNR/DNI group, we demonstrate that there may be a "ceilings of care" effect in this context. The findings also raises a question as to whether a "failure to rescue" mechanism may be active among these patients in the perioperative period. Regardless, the results of this study raise questions for future research which will hopefully yield additional insight into the mechanisms driving increased mortality among patients with DNR/DNI status who are undergoing surgery for hip fracture. In the immediate term, these findings will assist clinicians in appropriately counselling patients who may have a DNR/DNI order and are undergoing surgery for hip fracture.

### Research perspectives

Future research will hopefully yield additional insight into the mechanisms driving increased mortality among patients with DNR/DNI status who are undergoing surgery for hip fracture.

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