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Variability in Early Do Not Attempt Resuscitation Orders Among Patients With Serious Traumatic Brain Injury

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Abstract

Objectives—The objective was describe the use of early do not attempt resuscitation (DNAR) orders in patients with serious traumatic brain injury (TBI) and its association with outcomes.

Methods—This was a retrospective cohort study of all serious TBI patients admitted through the emergency department (ED) to acute care hospitals in California between 2002 and 2010 using ED International Classification of Diseases, 9th revision (ICD-9), admitting diagnosis codes specifying intracranial hemorrhage. DNAR placement within 24 hours of admission was the primary variable of interest. Outcomes included neurosurgical procedures and in-hospital mortality. Hospital and patient characteristics were analyzed using descriptive statistics and multivariable generalized estimation equation regression models to account for hospital-level clustering.

Results—Of all 76,962 patients with serious TBI, 71,275 were admitted at 141 hospitals that each cared for at least 10 serious TBI patients annually and formed the primary sample. Early DNAR orders were placed in 7.5% of patients (range = 0 to 36.1% by hospital). Early DNAR use varied by trauma designation: Level I, 4.0% (95% confidence interval [CI] = 3.8% to 4.4%); Level II, 6.7% (95% CI = 6.5% to 7.1%); Level III, 9.7% (95% CI = 8.4% to 11.3%); and nontrauma hospitals, 10.8% (95% CI = 10.6% to 11.3%). Early DNAR was also less likely in teaching hospitals (9.3% vs. 4.3%). These results persisted after accounting for age, year, and hospital-level clustering. In-hospital mortality (39.4% vs. 8.7%) and neurosurgical interventions (14.5% vs. 19.7%) also differed for patients with versus without early DNAR orders. Patients 65 years of age and older constituted 87.7% of those with early DNAR orders; our findings remained qualitatively unchanged when restricted to older adults.

Conclusions—Use of early DNAR orders among patients with serious TBI is highly variable by individual hospital and hospital type, suggesting substantial practice variation. Associations with fewer surgical intervention and higher mortality suggest that such practice variation may be contributing to differences in TBI outcomes, particularly among older adults.

Traumatic brain injury (TBI) causes over 53,000 annual deaths in the United States and more than 30% of injury-related deaths.¹ Survivors suffer from significant long-term disability, decreased self-perceived health value, and depression.² Both mortality and morbidity are of particular concern among elderly patients for whom the incidence of TBI has doubled over the past two decades³ and in whom outcomes are markedly worse than in younger patients.⁴⁻⁶ The overall annual financial burden of TBI in the United States has been estimated at over \$75 billion annually.⁷

Early care following TBI is critical in minimizing negative outcomes.⁸ Therefore, efforts are ongoing to improve early identification and prognostication of TBI patients to guide intervention and early management.⁹ Despite advancements in specialized care involving trauma teams and neurosurgical interventions, up to one-third of TBI patients die during hospitalization, and nearly one in 10 die within 1 year of injury. Further, care and intervention for these patients can vary substantially, as has been shown in lower intensity care of elderly TBI victims.¹⁰ A common early issue following serious TBI is prognostication, determining the appropriate aggressiveness of care and when withdrawal of care or limited interventions is appropriate. This last aspect is poorly understood in TBI. Placement of a do not attempt resuscitation (DNAR) order is often a surrogate marker for the decision to limit interventions following TBI or to minimize aggressive care. However, the frequency, variability, and potential effect of early DNAR orders in TBI remains unknown. Previous studies involving trauma and nontrauma patients have revealed that early DNAR placement is associated with increased early mortality^{10,11} and fewer procedures and varies significantly by race, ethnicity, and hospital facility type.^{10,12-15}

In this study, we evaluated the frequency and hospital-level variability of early DNAR placement among patients with serious TBI using a large sample of hospitals in California. We also studied the association of early DNAR use with neurosurgical interventions and in-hospital mortality.

METHODS

Study Design

This was a retrospective cohort study using the public patient discharge database of the California Office of Statewide Health Planning and Development (OSHPD). We merged the OSHPD Facility Database file into the patient-level data file to provide hospital-level information. Our institutional review board approved this study and waived the requirement for informed consent.

Study Setting and Population

This study setting included 350 acute-care hospitals in California. Acute care hospitals included trauma centers (Level I–III) and nontrauma centers; teaching and nonteaching hospitals; and a wide variety of different types of hospital ownership, funding, size, and volume categorizations. To assure an adequate number of TBI patients within individual hospitals and stable quantitative estimates, we limited the sample to hospitals admitting on average at least 10 patients with serious TBI per year across the study period.

The study population consisted of all patients with serious TBI admitted to the hospital through the emergency department (ED) to in California between January 1, 2002, and September 30, 2010. We defined serious TBI by primary hospital ICD-9 diagnosis specifying intracranial hemorrhage (International Classification of Diseases, 9th Revision, Clinical Modification [ICD-9] diagnostic codes 851, 852, 853, and 854). Our goal in selecting this population was to specify a sample of patients with similar injury severity. We excluded concussion and nontraumatic intracranial bleeding (hemorrhagic cerebrovascular accident, etc.). Patients with serious TBI who died in the ED were also excluded. The study dates (and resulting sample size) were based on the time period during which there was a consistent definition and capture of the “early DNAR” variable (described in the next paragraph) in the OSHPD data file. We excluded patients admitted in the fourth quarter of 2010, as the OSHPD database changed its definition of DNAR in this period such that the timing of DNAR placement was indecipherable.

Study Protocol

Variables—The primary exposure variable in the study was placement of a DNAR order within 24 hours of hospital admission, which we term “early DNAR.” Orders for DNAR placed after 24 hours were not included in this variable. Early DNAR orders included, but were not limited to, withholding of resuscitative measures such as assisted ventilation, intubation, defibrillation, cardiopulmonary resuscitation, and use of cardioactive drugs. The early DNAR variable was collected from each patient’s medical record by trained data abstractors using standardized data collection procedures at each hospital.

Patient variables included age, sex, race (Asian, white, black, Hispanic, native, “other”), insurance type (Medicare, MediCal, private, self-pay, employer, other), length of stay, and hospital procedures (see below). Primary hospital variables included trauma-level designation and teaching status.

Outcomes—Primary outcomes were in-hospital mortality and neurosurgical procedures. In-hospital mortality was characterized as in-hospital death at any point following admission. We defined neurosurgical procedures based on ICD-9 procedure codes for invasive intracranial interventions relevant to the TBI population. We used the following categories and associated ICD-9 codes: intracranial pressure monitoring (01.10); ventriculostomy (02.2); extracranial ventricular shunt (02.31–02.35 and 02.39); revision; removal and irrigation of ventricular shunt (02.41–02.43); percutaneous insertion of intracranial vascular stents (00.65); angiography/arthrectomy of intracranial vessels (00.62); cranial puncture (01.01, 01.09); craniotomy/craniectomy (01.21–01.28); incision or excision/destruction of brain and cerebral meninges (01.31–01.32, 01.39, 01.52–01.53); cranioplasty (02.01–02.07); repair of cerebral meninges (02.11–02.14); and other operations on skull, brain, and cerebral meninges (02.92, 02.94–02.95).

Data Analysis

We used descriptive statistics to characterize patients, procedures, outcomes, and hospitals. We compared the proportions of early DNAR use by hospital, hospital type, and stratified by age group (≥ 65 years vs. <65 years). The primary analysis was descriptive.

We used multivariable regression as a supplemental analysis to further evaluate the association between different types of hospitals and early DNAR use. For the multivariable models, we used generalized estimating equations (logistic regression) to account for hospital-level clustering and the following covariates: patient age, time (year), and hospital type. We considered the multivariable models as a supplemental analysis because many important patient-level confounders (e.g., physiologic measures, injury severity, comorbidities, preinjury medication use, and individual providers) were not available in these data. The model covariates and model type were chosen based on known (a priori) association with DNAR use (age), the potential for changes in DNAR use over time (year), and the potential for clustering at the hospital level. We evaluated model fit based on model convergence and the quasi-likelihood under the independence model criterion to compare models. We also used these models to test for change in the overall rate of early DNAR use over time during the study period. We considered $\alpha = 0.05$ the predetermined level of significance.

We used several strategies to reduce bias and evaluate outliers in the data. First, we restricted the primary sample to hospitals that admitted at least 10 patients with serious TBI per year (averaged across the 9-year study period). This process removed several hospitals with apparently very high early DNAR rates that were based on small sample sizes and large variance. We also excluded patients treated in rural hospitals, as they represented a very small portion of the sample ($n = 159$, 0.2%) that was insufficient to draw conclusions from these hospitals. To evaluate outliers, we reviewed data from all hospitals with rates of early DNAR use greater than 20%. Finally, to account for hospitals preferentially admitting older patient populations, we repeated all analyses using a sample restricted to patients 65 years of age and older. All database management and quantitative analyses were conducted using SAS (version 9. 2).

RESULTS

Between 2002 and 2010, there were 76,962 patients with serious TBI, 71,275 of whom were admitted to the 141 hospitals that each cared for at least 10 serious TBI patients annually and which formed the primary sample for analysis. Of the 71,275 patients, 5,358 (7.5%) were assigned DNAR status within 24 hours of hospital admission. Characteristics of the sample are presented in Table 1. Compared to serious TBI patients without early DNAR orders, patients with early DNAR orders tended to be elderly (87.7% vs. 42.7%), white (88.6% vs. 77.9%), female (54.5% vs. 36.8%), insured by Medicare (81.0% vs. 38.3%), and admitted to nontrauma facilities (48.9% vs. 33.0%). In the full sample of TBI patients, early DNAR order use steadily increased during the 9-year study period (6.1% to 9.2%, $p = 0.04$ adjusted for patient age and hospital clustering).

At the hospital level, early DNAR use ranged from 0.0% to 36.1% among the 141 hospitals (Figure 1). When stratified by age, there were substantive differences in the proportions of early DNAR use. For patients older than 65 years, the 90th percentile of early DNAR placement at the hospital level was 28.5% versus 5.8% in patients younger than 65 years. Early DNAR use also varied by hospital facility type, with major trauma centers and teaching hospitals having the lowest rates of early DNAR use (Figure 2). In the 65-year

subgroup, the proportions of patients with early DNAR orders were notable higher in all types of hospitals, although the pattern by hospital type was similar (Figure 2).

Multivariable model results of hospital type (trauma level and teaching status) and early DNAR use are demonstrated in Table 2. After accounting for age, year, and correlated data (clustering within hospitals), the association between trauma center level, teaching status, and early DNAR use persisted (models 1 and 2). However, when trauma center level and teaching status were included in the same model (model 3), only teaching status retained its statistical association with early DNAR use. These results remained consistent when restricted to patients ≥ 65 years, with both trauma center level and teaching status retaining statistical significance in model 3 (results not shown). Early DNAR placement by individual Level I trauma center facilities also demonstrated variability, but showed no clear correlation over time (Figure 3).

Early DNAR placement was associated with hospital outcome and use of neurosurgical interventions (Figure 4). Patients with early DNAR assignment were more likely to die in the hospital (39.4% vs. 8.7%) and have less neurosurgical intervention (14.5% vs. 19.7%). Results were consistent when the sample was restricted to patients ≥ 65 years and older (Figure 4).

DISCUSSION

This study demonstrates significant variability in the practice of early DNAR order use for patients with serious TBI across a variety of California hospitals spanning nearly a decade. This variability persisted across trauma and nontrauma hospitals, with early DNAR use predominating among elderly patients. Hospitals with the lowest rates of early DNAR use for patients with serious TBI were Level I trauma centers and teaching hospitals. Patients with early DNAR assignments were more likely to die during their hospital stay and have less neurosurgical procedures performed. While we were unable to account for certain key confounders, our findings suggest that early decision-making regarding the aggressiveness of care among patients with serious TBI is not applied evenly between hospitals and may influence patient outcomes, particularly among elder patients.

Variability in early DNAR use has been demonstrated among out-of-hospital cardiac arrest patients surviving to hospital admission, with associated decreased intensity of care and increased mortality.¹³ Our current study demonstrates similar findings among patients with TBI. Hospitals with the highest rates of early DNAR use were nontrauma centers and nonteaching hospitals; however, there was variability even among Level I trauma centers. Reasons for these findings are unclear. It is possible that higher-volume TBI hospitals, greater levels of expertise, more familiarity with TBI, greater availability of resources, and provider or patient/family preference could have all influenced these findings. Because major trauma centers and teaching hospitals tend to care for the most complicated and severely injured patients, severity of injury does not seem a plausible explanation for these findings. The timing and selection of patients for DNAR orders (and presumed less aggressive TBI care) may be key factors in evaluating hospital-level differences in outcomes following TBI. DNAR orders have been shown to affect mortality comparisons among

patients with hemorrhagic shock.¹⁴ Further study is needed to determine the appropriate timing for prognosticating outcomes following TBI, as the first 24 hours have been shown to be too early to accurately determine neurologic outcome following cardiac arrest.¹³ Our findings also provide an opportunity for subsequent studies to improve on the limitations of the current study by accounting for detailed patient-level confounders, clustering at the provider level, patient/family preferences, and investigating more detailed contextual information regarding the decision-making involved with placing DNAR orders on TBI patients.

Finding higher mortality among patients with early DNAR placement is not surprising. DNAR order placement likely indicates worse prognosis, higher comorbidity burden (including chronic and terminal diseases), less aggressive clinical management (or withdrawal of care), and fewer interventions. Our findings regarding less procedural intervention in early DNAR TBI patients support this hypothesis, although the difference in neurosurgical intervention was less than that of mortality. This is consistent with prior studies, some of which have correlated early DNAR use to worsened longer-term outcomes and decreased overall care intensity.^{10-12,16-18} However, it is plausible that the variability in early DNAR use between hospitals reflects true differences in the application of DNAR orders and resulting clinical outcomes. In fact, the implementation of early DNAR orders itself has been shown to confound our prognostic abilities and modeling in the setting of intracranial hemorrhage.¹⁹ These issues are important regarding differences in clinical outcomes among elderly patients with TBI, who represented the overwhelming majority of early DNAR use in our sample. However, we were unable to examine the appropriateness of DNAR placement or clinical and situational details regarding these patients. Additionally, we were unable to determine the timing of early DNAR with respect to that of procedural interventions, so it is possible that increased mortality in the early DNAR group instead reflects early DNAR placement postprocedure in patients anticipated to have negative outcomes.

LIMITATIONS

We used a retrospective cohort study design and administrative data, which are subject to unmeasured bias and confounding. The primary sample included patients diagnosed with serious TBI by ICD-9 codes, although ICD-9 diagnoses may underestimate the actual number of such cases.²⁰ It is also possible that ICD-9 coding differed between hospitals. However, even among Level I trauma centers with presumably similar resources and quality of trauma coding, there was variability in early DNAR use. Also, while the early DNAR term was collected using a standardized definition, it was not possible to ascertain from these data whether a patient had a preexisting DNAR order prior to hospital admission. If certain hospitals had high rates of patients with serious TBI and preexisting DNAR orders that were not placed as new orders, this scenario could have biased our results.

Exclusion of certain patients with TBI could have also biased our findings. We attempted to reduce the potential for bias by only including hospitals admitting a minimum number of patients with serious TBI each year; inclusion of lower-volume hospitals may demonstrate even wider variability in early DNAR use. Furthermore, these data came from a single state;

whether the practices in California regarding DNAR placement, neurosurgical intervention, and TBI mortality reflect those in other states is unclear.

We were unable to account for certain patient-level confounders, including physiologic status (e.g., Glasgow Coma Scale score, blood pressure, oxygen level), medication use (e.g., anticoagulant and antiplatelet agents), comorbidities (e.g., dementia, cancer, and other chronic conditions), and injury severity. However, because the most medically complicated and seriously injured patients tend to be cared for in major trauma centers, which had the lowest rates of early DNAR use, these factors do not appear to explain our findings. Furthermore, models accounting for clustering within hospitals yielded consistent results. A similar study evaluating intensity of care on mortality in TBI patients also found that comorbidities were not primary risk factors for in-hospital death.¹⁰ Finally, we were unable to account for provider-level variability, which may be another important factor affecting early DNAR placement (even within the same hospital). Our study does not demonstrate causal inferences, as our findings were primarily descriptive.

CONCLUSIONS

Use of early do not attempt resuscitation orders among patients with serious traumatic brain injury appears highly variable by individual hospital and by type of hospital in this California sample. Early do not attempt resuscitation placement is associated with higher in-hospital mortality and fewer neurosurgical interventions. These findings may help explain some of the variation in outcomes following traumatic brain injury, particularly among older adults, and suggest that further consideration of the timing of do not attempt resuscitation in traumatic brain injury patients is needed to optimize patient outcomes.

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Figure 1.

Hospital-level variability in DNAR use among admitted patients with serious traumatic brain injury ($N = 71,275$). DNAR = do not attempt resuscitation.

Figure 2.

Variability by hospital type in use of early DNAR placement among admitted patients with serious traumatic brain injury ($N = 71,275$, 141 hospitals). *When restricted to patients 65 years ($n = 29,364$), the proportion of early DNAR orders placed on patients with serious TBI were as follows: Level I–10.0%, Level II–14.9%, Level III - 19.3%, non-trauma centers–16.7%, teaching hospitals–10.7%, and non-teaching hospitals - 16.5%. DNAR = do not attempt resuscitation.

Percentage of Patients with Early DNAR by Level I Trauma Center 2002 and 2010

Figure 3.

Change in DNAR use (%) by individual Level I trauma center over time. Trauma centers are anonymized as letters A–M ($N = 17,023$). DNAR = do not attempt resuscitation; OSHPD = Office of Statewide Health Planning and Development.

Figure 4.

In-hospital mortality and neurosurgical interventions among patients with and without early DNAR orders ($N = 71,725$, 141 hospitals). *When restricted to patients ≥ 65 years ($n = 29,364$), the comparison of patients with versus without early DNAR orders demonstrated: in-hospital mortality 35.6% versus 9.7% and use of neurosurgical procedures was 12.8% versus 23.0%. DNAR = do not attempt resuscitation.

Table 1

Characteristics of Traumatic Brain Injury Patients Admitted Through the ED, Separated by Timing of DNAR Order

Characteristics	DNAR <24hours <i>n</i> = 5,358	No DNAR <i>n</i> = 65,917	All TBI Patients <i>N</i> = 71,275
Demographics			
Age, yr			
<1	2 (0.0)	514 (0.9)	516 (0.8)
1 to 17	33 (0.7)	4,062 (7.0)	4,095 (6.5)
18 to 34	120 (2.4)	10,071 (17.3)	10,191 (16.1)
35 to 65	466 (9.2)	18,805 (32.2)	19,271 (30.4)
>65	4,423 (87.7)	24,941 (42.7)	29,364 (46.3)
Sex			
Male	2,003 (45.5)	29,645 (63.2)	31,657 (61.7)
Race			
White	3,561 (88.6)	31,191 (77.9)	34,752 (78.9)
Hispanic	299 (7.8)	8,368 (22.7)	8,667 (21.3)
Black	66 (1.6)	2,185 (5.5)	2,251 (5.1)
Native American	3 (0.1)	39 (0.1)	42 (0.1)
Asian	246 (6.1)	2,617 (6.6)	2,863 (6.5)
“Other” race	144 (3.6)	4,021 (10.0)	4,165 (9.5)
Insurance type			
Medicare	4,338 (81.0)	25,249 (38.3)	29,587 (41.5)
MediCal	250 (4.7)	10,027 (15.2)	10,277 (14.4)
Through employer	22 (0.4)	1,194 (1.8)	1,216 (1.7)
Self	114 (2.1)	6,594 (10.0)	6,708 (9.4)
Private	552 (10.3)	17,093 (25.9)	17,645 (24.8)
Other	82 (1.5)	5,742 (8.7)	5,284 (8.2)
Hospital type			
Trauma level designation			
I	684 (12.8)	16,339 (24.8)	17,023 (23.9)
II	1,899 (35.4)	26,402 (40.1)	28,301 (39.7)

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Characteristics	DNAR <24hours <i>n</i> = 5,358	No DNAR <i>n</i> = 65,917	All TBI Patients <i>N</i> = 71,275
III	155 (2.9)	1,446 (2.2)	1,601 (2.3)
Non-trauma center	2,620 (48.9)	21,730 (33.0)	24,350 (34.2)
Teaching hospital	1,019 (19.2)	22,738 (35.1)	23,757 (33.9)

Values reported as *n* (%).

DNAR = do not attempt resuscitation.

Table 2Multivariable Models Evaluating Hospital Type and Early DNAR use ($N = 71,275,141$ Hospitals)

Variable	Model 1			Model 2			Model 3		
	Estimate	95% CI		Estimate	95% CI		Estimate	95% CI	
Level I trauma center	Reference	—	—	—	—	—	Reference	—	—
Level II trauma center	0.37	0.09 to 0.66	—	—	—	—	0.10	-0.17 to 0.38	—
Level III trauma center	0.61	0.24 to 0.97	—	—	—	—	0.31	-0.09 to 0.72	—
Nontrauma center	0.53	0.32 to 0.74	—	—	—	—	0.23	-0.06 to 0.52	—
Teaching hospital	—	—	—	-0.48	-0.69 to -0.27	—	-0.36	-0.64 to -0.07	—
Year	0.02	0 to 0.04	—	0.02	-0.005 to 0.04	—	0.02	-0.004 to 0.04	—
Age (yr)									
<1	-3.68	-5.64 to -1.72	-3.63	-3.63	-5.62 to -1.65	-3.63	-3.63	-5.61 to -1.65	—
1-17	-2.94	-3.33 to -2.55	-2.91	-2.91	-3.30 to -2.52	-2.89	-2.89	-3.28 to -2.50	—
18-34	-2.60	-2.85 to -2.35	-2.62	-2.62	-2.90 to -2.34	-2.58	-2.58	-2.84 to -2.33	—
35-64	-1.89	-2.08 to -1.70	-1.89	-1.89	-2.10 to -1.68	-1.87	-1.87	-2.06 to -1.68	—
Age missing	-1.37	-1.52 to -1.23	-1.39	-1.39	-1.55 to -1.23	-1.36	-1.36	-1.50 to -1.22	—
65	Reference	—	Reference	Reference	—	Reference	Reference	—	—

* Generalized estimating equations models (logistic regression) were used to account for clustering at the hospital level. Estimates greater than 0 indicate a positive association with early DNAR use (greater DNAR use), while estimates below 0 indicate a negative association (lower DNAR use). 95% CIs that cross 0 (the null value) correspond to p-values > 0.05.

DNAR = do not attempt resuscitation.