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Withdrawal of Life-supporting Treatment in Severe Traumatic Brain Injury

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Supplemental content

IMPORTANCE There are limited data on which factors affect the critical and complex decision to withdraw life-supporting treatment (LST) in patients with severe traumatic brain injury (sTBI).

OBJECTIVE To determine demographic and clinical factors associated with the decision to withdraw LST in patients with sTBI.

DESIGN, SETTING, AND PARTICIPANTS This retrospective analysis of inpatient data from more than 825 trauma centers across the US in the American College of Surgeons Trauma Quality Improvement Program database from January 2013 to December 2015 included adult patients with sTBI and documentation of a decision regarding withdrawal of LST (WLST). Data analysis was conducted in September 2019.

MAIN OUTCOMES AND MEASURES Factors associated with WLST in sTBI.

RESULTS A total of 37931 patients (9817 women [25.9%]) were included in the multivariable analysis; 7864 (20.7%) had WLST. Black patients (4806 [13.2%]; odds ratio [OR], 0.66; 95% CI, 0.59-0.72; *P* < .001) and patients of other race (4798 [13.2%]; OR, 0.83; 95% CI, 0.76-0.91; *P* < .001) were less likely than white patients (26 864 [73.7%]) to have WLST. Patients from hospitals in the Midwest (OR, 1.12; 95% CI, 1.04-1.20; *P* = .002) or Northeast (OR, 1.23; 95% CI, 1.13-1.34; *P* < .001) were more likely to have WLST than patients from hospitals in the South. Patients with Medicare (OR, 1.55; 95% CI, 1.43-1.69; *P* < .001) and self-pay patients (OR, 1.36; 95% CI, 1.25-1.47; *P* < .001) were more likely to have WLST than patients with private insurance. Older patients and those with lower Glasgow Coma Scale scores, higher Injury Severity Scores, or craniotomy were generally more likely to have WLST. Withdrawal of LST was more likely for patients with functionally dependent health status (OR, 1.30; 95% CI, 1.08-1.58; *P* = .01), hematoma (OR, 1.19; 95% CI, 1.12-1.27; *P* < .001), dementia (OR, 1.29; 95% CI, 1.08-1.53; *P* = .004), and disseminated cancer (OR, 2.82; 95% CI, 2.07-3.82; *P* < .001) than for patients without these conditions.

CONCLUSIONS AND RELEVANCE Withdrawal of LST is common in sTBI and socioeconomic factors are associated with the decision to withdraw LST. These results highlight the many factors that contribute to decision-making in sTBI and demonstrate that in a complex and variable disease process, variation based on race, payment, and region presents as a potential challenge.

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Severe traumatic brain injury (sTBI) presents a life-altering event for patients, and physicians must guide families through challenging decisions about which interventions are appropriate and when to discontinue interventions in favor of quality of life. Physicians offer families options for interventions, such as craniotomy, intracranial pressure monitoring, or mechanical ventilation, as lifesaving or life-improving measures. Some families and physicians will choose to remove or withhold further life-sustaining intervention. Physicians may recommend withdrawal of life-sustaining treatment (WLST) when they feel that the patient's prognosis is very poor and risk of experiencing adversity high. This decision in sTBI is uniquely difficult for several reasons. First, physicians may not agree on a prognosis.[1-3] Second, patients are typically incapacitated and unable to express their own wishes. Finally, the high acuity and severity of the situation may make it difficult for surrogate decision-makers to provide substituted judgment.[4]

Understanding when and how WLST occurs in sTBI is necessary to advance the field. Severe TBI is a leading cause of death nationally and internationally[5,6] and within-hospital death follows WLST in up to 40% to 70% of patients with critical illness.[3,7,8] Withdrawing LST prematurely could lead to lost opportunities for recovery or a self-fulfilling prophecy defined by a clinician's feeling that a patient's prognosis is poor because they observe poor outcomes in similar patients who have not had aggressive interventions.[9] Alternatively, uniformly sustaining life in sTBI could lead to prolonged adversity, which is deemed a worse outcome by some.[10]

There is limited evidence on which factors drive the decision to withdraw LST in the setting of sTBI. Medical futility cannot be easily addressed because of the uncertainty about outcomes.[11] Despite guidelines for sTBI management,[12] there is no clear threshold for WLST; therefore, a combination of factors likely contributes to this decision. In a multicenter study in Canada, Turgeon et al[3] found that factors, such as a receipt of a procedure to evacuate a hematoma, age, Glasgow Coma Scale (GCS) score, and computed tomography evidence of brain herniation, were associated with WLST followed by death. They also found in a prior study that the center where a patient presents is associated with the decision to withdraw LST.[8] The purpose of this study is to characterize factors associated with WLST in the US.

Key Points

Question Which factors are associated with the decision to withdraw life-supporting treatment (LST) in patients with severe traumatic brain injury in the US?

Findings In this large, multicenter cohort study, race, geographic region, and payment status were significantly associated with the decision to withdraw LST. Associated clinical factors included older age, lower Glasgow Coma Scale score, functionally dependent health status, hematoma, dementia, and disseminated cancer.

Meaning In addition to clinical factors, there is evidence for socioeconomic variation in the decision to withdraw LST in patients with severe traumatic brain injury.

Methods

Objectives

The primary objective was to identify demographic and clinical factors associated with the decision to withdraw LST in patients with sTBI. We hypothesized that clinical factors used in TBI prognostication, particularly GCS scores, would be most strongly associated with the decision to withdraw LST.

The secondary objective was to characterize differences in outcomes between patients with and without WLST. Main secondary outcome measures included within-hospital death, disposition, length of intensive care unit stay, and number of days on a ventilator.

Institutional Review Board

This study received approval from the Duke University Hospital institutional review board. As this study used deidentified data from a large database, it was determined exempt from informed consent of study participants.

Study Design

We retrospectively analyzed the American College of Surgeons-Trauma Quality Improvement Project (ACS-TQIP) database between 2013 and 2015. We selected this range because the primary outcome measure, WLST, was well documented for these years. The ACS-TQIP database represents more than 700 trauma centers in the US that have elected to participate in standardized trauma reporting.

Adult patients with TBI, including skull fracture and intracranial injury, were identified using *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes 800 to 804 and 850 to 854, respectively. Blunt and penetrating injury mechanisms were included. The GCS and the head section of the Abbreviated Injury Scale (AIS-Head) criteria were used to select patients with sTBI, which was defined by initial GCS score of 3 to 8 and AIS-Head score of 2 to 5. Patients with GCS score greater than 8 and patients missing the primary outcome field were excluded (**Figure 1**).

We then separated the patients into 2 groups: those with WLST and those without. The WLST decision needed to be documented in the medical record and included a limit to escalation of treatment for interventions, such as ventilator support, dialysis, medications for blood pressure or cardiac function support, and specific procedures. It was not considered the same as do not resuscitate status.

We analyzed multiple variables for associations with WLST. All pertinent demographic variables available in the database were included: sex, race, ethnicity, payment status, and region. Race was simplified into white, black, and other and ethnicity into Hispanic and non-Hispanic based on the limitations of the database and previously published methods.[13,14] Hospital teaching status, interhospital transfer, and number of neurosurgeons were included. Clinical variables were those commonly described in sTBI prognostic models and prior studies,[15-18] including GCS score, hematoma (*ICD-9* codes 852 and 853 denote subdural/subarachnoid/extradural and other/unspecified, respectively), craniotomy/craniectomy (*ICD-9* codes 01.24 and 01.25, respectively), Injury Severity Score (ISS), lowest systolic blood pressure, alcohol/drug use, time from dispatch of emergency medical services transporting unit to arrival at the emergency department (ED), volume of plasma or platelets transfused within 24 hours of arrival at the ED/hospital, mechanism of injury, palliative care consultation, and penetrating vs blunt injury. The ISS was derived by converting *ICD-9* codes to an AIS score using the ICDMAP-90 program (Tri-Analytics Corporation) and then calculating the ISS from the AIS score. Pupillary response and midline shift data were not available in the database during the study period. Variables representing chronic illnesses, such as disseminated cancer, functionally dependent health status, prior cerebrovascular accident, chronic kidney failure, and dementia, were included.

Data Analysis

Demographic information and clinical characteristics for the 2 groups (WLST and no WLST) were summarized with descriptive statistics. A multivariable logistic regression analysis was used to model the probability of the occurrence of WLST as a function of several variables (Figure 1). We tested all clinically relevant interaction terms and included only the interaction terms with significance ($P < .05$) in the final models. Variables with missing data for more than 1% of the data set (including race, region, payment, hematoma, ISS group, functionally dependent health status, dementia, cerebrovascular accident, chronic kidney failure, and disseminated cancer) were coded with a dummy variable to represent the missing data in regression analysis. Those with less than 1% missing were included.

To explore the validity of the model, we analyzed model fit. Based on available literature and clinical practice experience, we analyzed interactions between GCS score, ISS, age, and craniotomy, adding these to the model as appropriate. Additionally, we used backward selection modeling techniques. These exploratory analyses were performed to determine whether a better fit, as measured by area under the curve, was attainable. We did not observe a difference in the area under the curve with these techniques. Therefore, we chose a parsimonious version of the model to assess demographic and clinical associations with WLST.

Statistical significance was assessed at $P = .05$. Analyses were conducted using SAS, version 9.4 (SAS Institute).

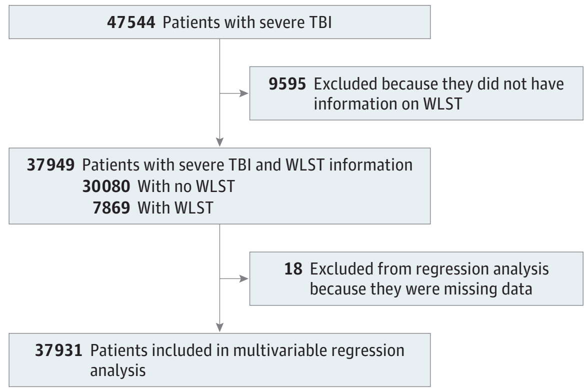
Results

Summary of the Patient Population: Demographic and Clinical Variables

A total of 47544 patients met criteria for sTBI. Of those, 9595 (20.2%) did not have data on the primary outcome (WLST) and were excluded, leaving 37949 patients for the descriptive analysis. In total, 37931 patients were included in the multivariable regression analysis based on availability of data elements.

Of the 37931 patients meeting criteria for inclusion in the study (having sTBI between January 2013 and December 2015 and an answer of yes or no to the primary outcome variable

Figure 1. Illustration of Study Design and Number of Individuals Meeting Criteria for Inclusion



Severe traumatic brain injury (TBI) was defined as an Abbreviated Injury Scale (AIS) score of 2 to 6 and a Glasgow Coma Scale (GCS) score of 3 to 8. The demographic predictors investigated included age group, sex, race, payment status, geographic region, teaching status of the hospital, number of neurosurgeons, and interhospital transfers. The clinical predictors included GCS group, Injury Severity Score (ISS) group, functionally dependent health status, penetrating vs blunt injury, presence or absence of hematoma, craniotomy vs no craniotomy, dementia, cerebrovascular accident (CVA) with residual neurological deficiency, chronic renal failure, and disseminated cancer. The interaction terms included GCS group and ISS group, GCS and age group, and GCS score and craniotomy. WLST indicates withdrawal of life-supporting treatment.

[WLST]), 7869 patients (20.7%) had WLST (Figure 1). Of these, 7026 patients with WLST (93.7%) died in the hospital. The median time to WLST was 2 days (quartile 1, 1, quartile 3, 6 days [range, 1-176 days]). **Table 1** summarizes the distribution of demographic data between the WLST and no WLST groups. The sex distribution of patients studied was 28 125 men (74.1%) and 9871 women (25.9%). The median age was considerably greater for patients who had WLST than for those who did not (60.0 years [quartile 1, 42.0 years; quartile 3, 76.0 years] vs 40.0 years [quartile 1, 26.0 years; quartile 3, 56.0 years]). The proportion of white (81.6% vs 71.6%) and non-Hispanic (91.6% vs 86.7%) patients was higher for the group with WLST. The percentage of patients with Medicare insurance as payment source was higher for those in the WLST group (37.9% vs 15.1%). However, the proportions of patients with commercial/private insurance (41.2% vs 30.8%) and Medicaid insurance (16.2% vs 9.2%) were higher in the no WLST group.

Clinical characteristics for patients with sTBI, subdivided by group, are summarized in **Table 2**. Patients with WLST had increased severity of injury as demonstrated by higher median AIS-Head scores (5 = critical vs 4 = severe) and the proportion of patients in the ISS of greater than 24 group (66.9% vs 50.7%), although the lowest total GCS score and median ISS were similar for both groups. The proportion of patients with hematoma was higher for those in the WLST group (78.8% vs 71.1%). The lowest median systolic blood pressure was similar between the WLST and no WLST groups (75.0 mm Hg vs 74.0 mm Hg). Patients in the WLST group had higher proportions of functionally dependent health status (3.1% vs 1.3%), dementia (4.2% vs 1.4%), chronic kidney failure (1.8% vs 0.7%), and other comorbidities than those who continued with LST.

Table 1. Demographic Information by Withdrawal of Life-Supporting Treatment

Characteristic	No. (%)		
	No withdrawal of LST	Withdrawal of LST	Total
No. of persons included	30 080	7869	37 949
Age, y			
Mean (SD)	42.9 (18.8)	57.6 (20.6)	45.9 (20.1)
Median (Q1-Q3)	40.0 (26.0-56.0)	60.0 (42.0-76.0)	44.0 (27.0-61.0)
Range	18.0-89.0	18.0-89.0	18.0-89.0
Age group, y			
<30	9841 (32.7)	1089 (13.8)	10 930 (28.8)
30-45	7640 (25.4)	1139 (14.5)	8779 (23.1)
46-60	6719 (22.3)	1809 (23.0)	8528 (22.5)
61-75	3834 (12.7)	1848 (23.5)	5682 (15.0)
>75	2046 (6.8)	1984 (25.2)	4030 (10.6)
Sex			
Women	7412 (24.6)	2405 (30.6)	9817 (25.9)
Men	22 662 (75.4)	5463 (69.4)	28 125 (74.1)
Race			
Black	4209 (14.6)	597 (7.9)	4806 (13.2)
White	20 695 (71.6)	6169 (81.6)	26 864 (73.7)
Other	4003 (13.8)	795 (10.5)	4798 (13.2)
Ethnicity			
Hispanic or Latino	3580 (13.3)	593 (8.4)	4173 (12.3)
Not Hispanic or Latino	23 384 (86.7)	6506 (91.6)	29 890 (87.7)
Payment[a]			
Medicaid	4611 (16.2)	698 (9.2)	5309 (14.7)
Medicare	4315 (15.1)	2857 (37.9)	7172 (19.9)
Private/commercial insurance	11 769 (41.2)	2326 (30.8)	14 095 (39.1)
Self-pay	5479 (19.2)	1201 (15.9)	6680 (18.5)
Other	2370 (8.3)	465 (6.2)	2835 (7.9)
Teaching status of hospital			
Community	9978 (33.2)	2777 (35.3)	12 755 (33.6)
Nonteaching	1921 (6.4)	608 (7.7)	2529 (6.7)
University	18 181 (60.4)	4484 (57.0)	22 665 (59.7)
No. of neurosurgeons			
0-2	2109 (7.0)	470 (6.0)	2579 (6.8)
3-5	13 576 (45.1)	3523 (44.8)	17 099 (45.1)
≥6	14 395 (47.9)	3876 (49.3)	18 271 (48.1)

Abbreviations: LST, life-supporting treatment; Q1, first quartile; Q3, third quartile.

[a] Payment: other government, not billed (for any reason), and other payments that are not specified are defined as other. No-fault automobile, workers compensation, and Blue Cross/Blue Shield are captured as private/commercial insurance.

The most frequent mechanism of injury for patients with WLST was a fall (46.5%), while the most frequent mechanism of injury for those who continued to have treatment was a transportation-associated injury (56.6%), and patients who did not have WLST had a higher proportion of penetrating injury (9.1% vs 4.9%).

Association of Race, Geography, Insurance, and Hospital Status With WLST

Of the demographic variables, race, geographic region, and payment were significantly associated with WLST after controlling for other covariates (**Figure 2**). Black patients were less likely than white patients to have WLST (OR, 0.66; 95% CI, 0.59-0.72; *P* < .001). Similarly, patients of other race were less likely than white patients to have WLST (OR, 0.83; 95% CI, 0.76-0.91; *P* < .001). Patients from hospitals in the Midwest (OR, 1.12; 95% CI, 1.04-1.20; *P* = .002) or Northeast (OR, 1.23; 95% CI, 1.13-1.34; *P* < .001) were more likely to have WLST than patients from hospitals in the South. Compared with patients with private insurance, the odds ratio of having WLST was 1.55 (95% CI, 1.43-1.69; *P* < .001) for patients with Medicare and 1.36 (95% CI, 1.25-1.47; *P* < .001) for self-pay patients.

The number of neurosurgeons at the institution was significantly associated with the decision to withdraw LST, particularly when a hospital had few neurosurgeons. The odds ratio of WLST in institutions with 0 to 2 neurosurgeons compared with 6 or more was 0.85 (95% CI, 0.75-0.95; *P* = .01). Hospital teaching status was also significantly associated after controlling for other factors. The odds ratio of having WLST for patients from a community hospital to those from a university hospital was 1.12 (95% CI, 1.05-1.19; *P* = .001) and the odds ratio for patients from a non-teaching hospital

Table 2. Clinical Characteristics by Withdrawal of Life-Supporting Treatment

Characteristic	No withdrawal of LST	Withdrawal of LST	Total
No. of persons included	30 080	7869	37 949
Highest AIS-Head score			
Mean (SD)	4.0 (0.7)	4.5 (0.6)	4.1 (0.7)
Median (Q1-Q3)	4.0 (4.0-4.0)	5.0 (4.0-5.0)	4.0 (4.0-5.0)
Range	2.0-5.0	2.0-5.0	2.0-5.0
ISS			
Mean (SD)	26.1 (12.1)	28.2 (12.3)	26.5 (12.1)
Median (Q1-Q3)	25.0 (17.0-30.0)	26.0 (17.0-34.0)	25.0 (17.0-33.0)
Range	4.0-75.0	4.0-75.0	4.0-75.0
ISS group, No. (%)			
<12	1264 (4.8)	79 (1.1)	1343 (4.1)
12-24	11 612 (44.5)	2238 (32.0)	13 850 (41.8)
>24	13 241 (50.7)	4678 (66.9)	17 919 (54.1)
Lowest total GCS score			
Mean (SD)	4.0 (1.7)	3.6 (1.3)	3.9 (1.6)
Median (Q1-Q3)	3.0 (3.0-5.0)	3.0 (3.0-3.0)	3.0 (3.0-4.0)
Range	3.0-8.0	3.0-8.0	3.0-8.0
GCS score group, No. (%)			
3-4	22 003 (73.1)	6649 (84.5)	28 652 (75.5)
5-6	3499 (11.6)	697 (8.9)	4196 (11.1)
7-8	4578 (15.2)	523 (6.6)	5101 (13.4)
Mechanism of injury, No. (%)			
Assault	364 (1.2)	80 (1.0)	444 (1.2)
Fall	8196 (27.4)	3632 (46.5)	11 828 (31.4)
Transportation	16 910 (56.6)	2894 (37.0)	19 804 (52.5)
Other	4402 (14.7)	1212 (15.5)	5614 (14.9)
Interhospital transfer, No. (%)	8322 (27.7)	2533 (32.2)	10 855 (28.6)
Functionally dependent health status, No. (%)	361 (1.3)	224 (3.1)	585 (1.7)
Hematoma, No. (%)	21 380 (71.1)	6197 (78.8)	27 577 (72.7)
Lowest systolic blood pressure, mm Hg[a]			
Mean (SD)	67.9 (45.5)	74.1 (44.6)	69.5 (45.3)
Median (Q1-Q3)	74.0 (40.0-98.0)	75.0 (51.0-101.0)	74.0 (45.0-98.0)
(Range)	(0.0-238.0)	(0.0-220.0)	(0.0-238.0)
Penetrating injury, No. (%)	2725 (9.1)	388 (4.9)	3113 (8.2)
Dementia, No. (%)	381 (1.4)	306 (4.2)	687 (1.9)
Cerebrovascular accident residual neurological deficiency, No. (%)	281 (1.0)	166 (2.3)	447 (1.3)
Chronic renal failure, No. (%)	209 (0.7)	130 (1.8)	339 (1.0)
Disseminated cancer, No. (%)	91 (0.3)	116 (1.6)	207 (0.6)

Abbreviations: AIS-Head, head section of the Abbreviated Injury Scale; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; LST, life-supporting treatment; Q1, first quartile; Q3, third quartile.

compared with those from a university was 1.30 (95% CI, 1.17-1.45; *P* < .001).

Association of Markers of Severity of Injury and Patients With Greater Illness Severity With WLST

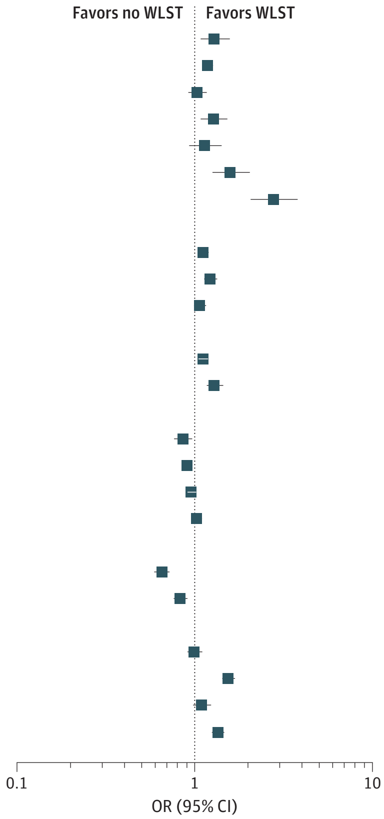
Several clinical variables were significantly associated with WLST after controlling for other factors. Patients classified as functionally dependent were more likely to have WLST than those who were functionally independent (OR, 1.30; 95% CI, 1.08-1.58; *P* = .01) when other covariates were held constant. Patients with hematoma were more likely to have WLST than those without (OR, 1.19; 95% CI, 1.12-1.27; *P* < .001). Patients who had dementia (OR, 1.29; 95% CI, 1.08-1.53; *P* = .004), chronic kidney failure (OR, 1.60; 95% CI, 1.26-2.05; *P* < .001), and disseminated cancer (OR, 2.82; 95% CI, 2.07-3.82; *P* < .001) were more likely to have WLST than patients without these conditions.

Probability of WLST by Key Interacting Variables

eTable 1 in the Supplement summarizes the significance of interactions between GCS score, ISS, craniotomy, and age. These interactions were significant and therefore included in the logistic regression model. Patients with lower ISS were generally more likely to have WLST. The odds of having WLST were generally higher for patients who had craniotomy than for those who did not. Older patients were more likely to have WLST,

Figure 2. Odds Ratio Estimates for Withdrawal of Life-supporting Treatment (WLST)

Effect	OR (95% CI)	*P* Value
Functionally dependent health status	1.30 (1.08-1.58)	.006
Hematoma	1.19 (1.12-1.27)	<.001
Penetrating injury	1.04 (0.92-1.17)	.546
Dementia	1.29 (1.08-1.53)	.004
CVA with residual neurological deficiency	1.14 (0.93-1.42)	.210
Chronic kidney failure	1.60 (1.26-2.05)	<.001
Disseminated cancer	2.82 (2.07-3.82)	<.001
Region		
Midwest vs south	1.12 (1.04-1.20)	.002
Northeast vs south	1.23 (1.13-1.34)	<.001
West vs south	1.07 (0.99-1.16)	.072
Hospital		
Community vs university	1.12 (1.05-1.19)	.001
Nonteaching vs university	1.30 (1.17-1.45)	<.001
No. of neurosurgeons		
0-2 vs ≥6	0.85 (0.75-0.95)	.005
3-5 vs ≥6	0.91 (0.86-0.97)	.003
Interhospital transfer	0.96 (0.91-1.02)	.220
Female vs male	1.03 (0.97-1.10)	.290
Race		
Black vs white	0.66 (0.59-0.72)	<.001
Other vs white	0.83 (0.76-0.91)	<.001
Payment		
Medicaid vs private	0.98 (0.89-1.08)	.634
Medicare vs private	1.55 (1.43-1.69)	<.001
Other vs private	1.15 (1.02-1.29)	.025
Self-pay vs private	1.36 (1.25-1.47)	<.001



Odds ratio estimates for the unknown levels vs the reference levels are omitted. Error bars indicate 95% CIs. CVA indicates cerebrovascular accident.

especially when GCS was higher. In general, the associations of ISS, craniotomy, and age with WLST were strengthened at higher GCS scores.

A second variable of interest was payment group. There was concern that age was a major contributor to the difference between the WLST and no WLST groups when considering payment status. This is because of specific, known criteria to obtain Medicare insurance. Of patients with Medicare (7172 [18.9%]), 5542 (77.3%) were 65 years or older. eTable 2 in the Supplement breaks down the proportion of patients with WLST by those younger than 65 years and 65 years or older for each payment type and shows a similar distribution in each age group, with WLST being higher in the older group across payment statuses.

Variation of Length of Stay and Discharge Disposition With Decision to Withdraw LST

Length of stay (LOS) and discharge disposition data are summarized in **Table 3**. Patients with WLST had considerably lower LOS (median, 3.0 days [quartile 1, 1.0 days; quartile 3, 7.0 days] vs 10.0 days [quartile 1, 3.5 days; quartile 3, 21.0 days]), total intensive care unit LOS (median, 3.0 [quartile 1, 1.0 days; quartile 3, 14.0 days] vs 6.0 days [quartile 1, 3.0 days; quartile 3, 7.0 days]), and total ventilator days (median: 2.0 [quartile 1, 1.0 days; quartile 3, 6.0 days] vs 4.0 days [quartile 1, 2.0 days; quartile 3, 11.0 days]) compared with patients with no WLST. Most patients who withdrew LST died in the hospital (7026 [93.7%]), while patients who continued with treatment had multiple dispositions: transferred to other hospitals (13 562 [47.1%]), discharged to home (8572 [29.8%]), and deceased (5961 [18.3%]). A total of 359 patients (4.8%) in the WLST group were discharged to hospice compared with 395 patients (1.4%) in the no WLST group.

Discussion

In this large, multisite cohort of patients with sTBI, one-third of patients died during their presenting admission. Most of these patients died after WLST. The decision to withdraw LST for patients with TBI is a challenging one; our findings highlight clinical and demographic factors that may be involved in these complex choices. Our study has 3 major findings. First, expected clinical markers of severity of injury and overall patient health status are associated with WLST. Second, demographic variables, such as race, payment status, and hospital type, have associations with WLST. Finally, LOS, within-hospital death, and discharge disposition differ between patients with and without WLST.

While clinicians and surrogate decision-makers likely value prognostic information as they make decisions about WLST,[19] existing data suggest that prognostication can be inaccurate.[3,20] Further, clinicians' and surrogates' predictions of outcome are often discordant because of differences in understanding and

Table 3. Length of Stay and Disposition by Withdrawal of Life-Supporting Treatment

Characteristic	No withdrawal of LST	Withdrawal of LST	Total
No. of persons included	30 080	7869	37 949
Total LOS			
No. with data	30 040	7868	37 908
Mean (SD), d	15.4 (17.4)	5.3 (7.3)	13.3 (16.4)
Median (Q1-Q3), d	10.0 (3.5-21.0)	3.0 (1.0-7.0)	8.0 (2.0-19.0)
(Range), d	(1.0-357.0)	(1.0-179.0)	(1.0-357.0)
Total ICU LOS			
No. with data	27 542	7909	34 751
Mean (SD), d	9.7 (10.0)	5.2 (6.3)	8.8 (9.5)
Median (Q1-Q3), d	6.0 (3.0-14.0)	3.0 (1.0-7.0)	5.0 (2.0-13.0)
(Range), d	(1.0-178.0)	(1.0-180.0)	(1.0-180.0)
Total ventilator days			
No. with data	25 960	7327	33 987
Mean (SD), d	7.5 (9.0)	4.8 (6.0)	6.9 (8.5)
Median (Q1-Q3), d	4.0 (2.0-11.0)	2.0 (1.0-6.0)	3.0 (2.0-10.0)
Range, d	1.0-207.0	1.0-180.0	1.0-207.0
Discharge disposition, No. (%)			
Deceased/expired	5961 (18.3)	7026 (93.7)	12 987 (33.9)
Discharged/transferred to home	8572 (29.8)	28 (0.4)	8600 (23.7)
Discharged/transferred to hospital	13 562 (47.1)	74 (1.0)	13 636 (37.6)
Discharged/transferred to hospice	395 (1.4)	359 (4.8)	754 (2.1)
Other	987 (3.4)	10 (0.1)	997 (2.7)

Abbreviations: ICU, intensive care unit; LOS, length of stay; LST, life-supporting treatment; Q1, first quartile; Q3, third quartile.

beliefs.[21] Our findings of multiple clinical factors associated with WLST point out the complexity of the decision.

Clinical practice and prior data suggest that increased severity of injury, advanced age, and comorbidities should have strong associations with WLST.[20] This study confirmed that factors, such as older age, lower GCS scores, and higher overall injury severity, are associated with increased likelihood of WLST. These findings highlight several additional clinical factors, such as the presence of hematoma, certain comorbidities, and functionally dependent health status, that may serve as proxies for poor prognosis. Having a craniotomy was additionally associated with an increased probability of having WLST. This opposes previously observed results[22] and challenges the commonly held view of therapeutic momentum.[23] We found this trend to be similar despite GCS scores.

The role of race, geography, and payment status on the decision to withdraw LST in sTBI is complex. As demonstrated in other disease processes,[22] black patients were less likely to have WLST than white patients, even when injury severity was similar. In other clinical contexts, such as cardiac disease, black patients are less likely to undergo intervention, but in this study, black patients were less likely to decline intervention and opt for WLST.[24] Taken together, these findings support a growing body of literature about different contexts of WLST conversations in black patients, including a lack of trust in health care clinicians and different rates of advance directives.[25] There were also regional differences in WLST. Southern patients were least likely to have WLST. While ACS-TQIP uses an opt-in process and is thus not nationally representative, this finding is consistent with other work suggesting that treatment center location can affect decisions in sTBI.[3]

Medicare and self-pay patients were more likely to have WLST than those with private insurance. In emergent settings, payment status is not intended to affect treatment decisions. The families of self-pay patients may be considering rising health care costs in their decision to pursue WLST or other unmeasured socioeconomic factors may be contributing. The reasons underlying this finding in Medicare patients are unclear, but possibilities include Medicare patients being more prepared for such events with prior discussions and advance directives, although these data were collected before the 2015 change in Medicare reimbursements for advance care planning.[26]

The LOS and discharge data associated with WLST demonstrate the importance of these decisions. Patients with WLST accounted for most within-hospital deaths. These results may reflect the overall sicker status of patients with WLST. The time to WLST was brief, as was the LOS in this group compared with those without LST. Withdrawal of LST often immediately preceded in-hospital death, consistent with previous studies.[3,7,8] Current recommendations suggest avoiding early decisions about WLST because of inaccurate prognostication.[8,27] This study shows a trend of early WLST that warrants further investigation to determine whether the new guidelines will affect this practice.

Limitations

Our study has several limitations. Inherent to the use of large databases is the inability to analyze subjective factors associated with outcomes. Other unmeasured covariates, including individual physician and certain demographic factors, were not considered in our model. Specifically, demographic variables, such as education, income, and zip code, were unavailable. Key prognostic indicators, such as pupillary response and midline shift,[15,16] were also unavailable during the study period. We only had access to inpatient data, so interpretations of results, especially regarding mortality, are confined to the present admission. Future investigations using different methods should be conducted to further elucidate the clinical, socioeconomic, and subjective factors associated with WLST in sTBI.

Conclusions

We have identified several variables associated with WLST in patients with sTBI. Patients with greater severity of injury and illness have more frequent WLST. Race, region, and insurance status are also associated with the decision to withdraw LST. These results highlight potential challenges in decision-making in sTBI.

ARTICLE INFORMATION

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Invited Commentary

Dying of Traumatic Brain Injury—Palliative Care too Soon, or too Late?

Anne C. Mosenthal, MD

Severe traumatic brain injury (TBI) carries high mortality and survivors experience high rates of disability and functional dependence. With such poor outcomes, these are patients with substantial palliative care needs. High-quality care should include palliative care for all those whose outcomes do not align with their goals, not just those for whom death is imminent. However, in practice, providing this consistently for patients with severe TBI remains a challenge. Despite rates of death and disability, surgeons still struggle with when and whether to recommend a transition to palliative care or withdrawal of life support. This manifests in various ways, including the low rate of palliative care use for patients with TBI[1] and variability in end-of-life care based on geography, socioeconomic, and trauma center status.[2,3] Williamson et al[4] describe the variability of withdrawal of life support at trauma centers participating in American College of Surgeons Trauma Quality Improvement Program based on geography, insurance status, and race.

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Why this disparity? First, we must understand why and when physicians recommend withdrawal of life support in the setting of severe TBI. This recommendation occurs if death is certain (impending brain death). But what if death is uncertain, or the expected cognitive and functional survival is not acceptable to the patient? Herein lies the challenge; while prognostic certainty is high for mortality from severe TBI, the ability to predict long-term functional outcomes is not. For many, especially elderly individuals, quality of life is more important than quantity[5] and living in a dependent state is a "fate worse than death."[6] Despite this preference, many surgeons do not feel comfortable withdrawing life support if there is even the smallest chance of survival because of fears that it might hasten death. Thus, it is easy to imagine that where one lives, what trauma center one goes to, and who one's physician is make stronger determinants of end-of-life care than severity of illness or patient preferences.

To address these disparities, the Trauma Quality Improvement Program released guidelines for palliative care in 2018 that recommend early palliative care and goals of care discussion for patients with severe injury. But we have yet to know its association with quality of care, much less what measures to use in assessment. Ideally, end-of- life-care should align with the patient's preferences in context of prognosis and not depend on surgeon or institutional practice norms. Delaying withdrawal of life support until certainty of death leads to prolonged use of nonbeneficial life support, patient and family distress, and poor end-of-life care. One such quality measure of care might be length of time receiving nonbeneficial life support for those who die. Changing practices across trauma centers by moving palliative care upstream is an important priority to improve the quality of care for severe TBI.

ARTICLE INFORMATION

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