Incidence of the initiation of comfort care immediately following emergent neurosurgical and endovascular procedures

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OBJECTIVE It is unknown what proportion of patients who undergo emergent neurosurgical procedures initiate comfort care (CC) measures shortly after the operation. The purpose of the present study was to analyze the proportion and predictive factors of patients who initiated CC measures within the same hospital admission after undergoing emergent neurosurgery.

METHODS This retrospective cohort study included all adult patients who underwent emergent neurosurgical and endovascular procedures at a single center between 2009 and 2014. Primary and secondary outcomes were initiation of CC measures during the initial hospitalization and determination of predictive factors, respectively.

RESULTS Of the 1295 operations, comfort care was initiated in 111 (8.6%) during the initial admission. On average, CC was initiated 9.3 ± 10.0 days postoperatively. One-third of the patients switched to CC within 3 days. In multivariate analysis, patients > 70 years of age were significantly more likely to undergo CC than those < 50 years (70–79 years, $p = 0.004$; > 80 years, $p = 0.0001$). Two-thirds of CC patients had been admitted with a cerebrovascular pathology ($p < 0.001$). Admission diagnosis of cerebrovascular pathology was a significant predictor of initiating CC ($p < 0.0001$). A high Hunt and Hess grade of IV or V in patients with subarachnoid hemorrhage was significantly associated with initiation of CC compared to a low grade (27.1% vs 2.9%, $p < 0.001$). Surgery starting between 15:01 and 06:59 hours had a 1.70 times greater odds of initiating CC compared to surgery between 07:00 and 15:00.

CONCLUSIONS Initiation of CC after emergent neurosurgical and endovascular procedures is relatively common, particularly when an elderly patient presents with a cerebrovascular pathology after typical operating hours.

<https://thejns.org/doi/abs/10.3171/2018.7.JNS181226>

KEYWORDS cerebrovascular pathology; comfort care; complications; emergent neurosurgery; end-of-life care; outcomes; surgical start time; vascular disorders

NEUROSURGICAL pathologies can cause rapid changes in a patient's neurological state, thereby requiring emergent medical and surgical intervention. Surgeon decision-makers face a challenging task—to make the best decision for their loved ones in a time-pressured, emotionally fraught environment with an inevitably incomplete understanding of prognosis and treatment options.^{7,14,28–30} As a consequence, consenting family members and friends often default to a do-all mentality until they are better able to absorb the full context of the patient's condition and prognosis. This, combined with the

challenges of accurate prognostication during neurosurgical emergencies,^{6,7,11,21,25,38} often leads to decisions that favor early intervention as opposed to conservative management.

In the neurosurgical context, emergent surgery is required for a variety of conditions. Most commonly, patients undergo emergent procedures for cranial or spinal trauma, craniocerebral infections, and cerebrovascular diseases, such as subarachnoid hemorrhage (SAH), ischemic stroke, and intraparenchymal hemorrhage. Urgent reoperation for postoperative complications is also common.³ However,

ABBREVIATIONS CC = comfort care; EMERSE = Electronic Medical Record Search Engine; PGY = postgraduate year; SAH = subarachnoid hemorrhage; SST = surgical start time.

SUBMITTED May 3, 2018. **ACCEPTED** July 31, 2018.

INCLUDE WHEN CITING Published online December 14, 2018; DOI: 10.3171/2018.7.JNS181226.

despite the best efforts of the surgical team, a proportion of patients undergoing emergent neurosurgical procedures will be transitioned to comfort care (CC) postoperatively.^{11,21,26,31} The reasons for initiating CC after emergency intervention are diverse: poor postoperative neurological condition, better understanding of a patient's wishes after reflection, diminishing chances of a meaningful recovery, or increasing clarity in the understanding of the chances of clinical recovery.

Much of the neurosurgical literature pertaining to CC, end-of-life care, and hospice focuses on neurooncology.^{16,19,20,27,32–36} While this represents an important area of attention, it is essential to develop an overall understanding of how frequently patients initiate CC soon after emergent operations. Identification of such patients may prevent unnecessary emergent neurosurgical interventions and thus lead to a reduction in healthcare expenditures, as well as to alleviate preventable suffering for the patient and their loved ones.^{4,7,8,23} This retrospective cohort study is the first study to attempt to delineate the proportion and pattern of adult patients who underwent emergency neurosurgery to identify factors related to the initiation of CC.

Methods

Study Design

This retrospective cohort study included all adult patients who underwent emergent neurosurgical and endovascular procedures between 2009 and 2014 at our institution. The study is limited to a single institution due to the difficulty of reliably measuring CC using existing multicenter data sources. Patient medical record numbers were collected through the Data Office of Clinical & Translational Research. Approval for this study was obtained from our local institutional review board, with a waiver of patient consent for retrospective data collection.

Patient Selection

All included patients were coded as having undergone either an “urgent” or “emergent” operation. Urgent operations were operations that occurred within 6 hours of the decision to proceed with surgery, whereas emergent operations were those that were performed within 1 hour of admission. For the purpose of this study, both urgent and emergent operations were considered as a single group because they all occurred independently of elective cases. Adult patients (≥ 18 years of age) were included. All patients either presented to the emergency department or were on the inpatient service when it was determined that they required an emergent intervention.

Clinical Data

Demographic data were all obtained through the University of Michigan's Data Office of Clinical & Translational Research. Variables included age, sex, Charlson coded comorbidities, date of procedure, day of the week (weekday vs weekend), surgical start time (SST), and CC order sets. Age was measured as an ordinal variable: < 50 , 50–59, 60–69, 70–79, ≥ 80 years. SST was analyzed as a binary variable defined as 07:00–15:00 and 15:01–06:59.

CC was defined as cessation of life-sustaining measures and a shift in focus to maintaining the comfort and dignity of the patient. CC status was considered and assessed during the initial hospital admission. Patients who died in the hospital before CC was initiated were not designated as having achieved CC status. We determined CC status through a two-step verification process. At our institution, CC is initiated by entering a CC order set into the electronic medical record. We flagged patients for whom the CC order set was issued by attending physicians. To validate the order set entry as a reasonable metric for the initiation of CC, a free-text search of electronic medical records was performed, using the Electronic Medical Record Search Engine (EMERSE).⁹ The search terms “comfort care,” “comfort,” “care,” “death,” and “die” were applied across all electronic medical records to verify the initial list.

We also used EMERSE to gather patient-specific data, including presenting pathology, Hunt and Hess grade, and presence of midline shift. We coded Hunt and Hess grade as an ordinal variable and as a binary variable (low grade being I, II, or III and high grade being IV or V). We categorized the presenting pathologies into the following: 1) cerebrovascular, 2) spine, 3) neurooncology, 4) cranial trauma, 5) peripheral nerve, 6) wound care, 7) infection, and 8) other.

In most cases, neurosurgical residents were responsible for the initial discussion regarding the need for emergent surgical intervention. In order to determine which residents had this discussion, we matched the date of emergent admission with the resident call schedule. Our electronic call records were started in 2011. Thus, identification of the resident was applied only to patients admitted between 2011 and 2014 in the analysis. Residents were grouped into junior residents (postgraduate years [PGYs] 2–4) and senior residents (PGYs 5–7). Interns (PGY 1) are not on 24-hour call at our institution.

Statistical Analysis

Chi-square tests, Fisher exact tests, and t-tests were utilized to analyze the data, as appropriate. In order to evaluate the relative contributions of our measured clinical variables, a univariate logistic regression was performed for each variable against the initiation of CC measures. All variables with a p value < 0.20 were included in a multivariate logistic regression. Subgroup analysis was then performed by isolating the patients presenting with a cerebrovascular pathology. Univariate and multivariate logistic regression analyses were then performed on the remaining cerebrovascular data in the same manner described above to determine specific predictors of CC within the cerebrovascular population. We considered a two-sided p value ≤ 0.05 to be statistically significant. All data were analyzed using SAS software (SAS Institute Inc.).

Results

Descriptive Analysis

This study included 1116 patients undergoing 1295 emergent operations. The average age of the patients undergoing emergent neurosurgery was 52.4 ± 16.1 years, and 50.7% of the population were female. Of the 1295

FIG. 1. Presenting pathologies compared to pathologies initiating CC. Figure is available in color online only.

operations, comfort care was initiated in 111 (8.6%) during the initial admission. The majority of presenting pathologies were cerebrovascular (35.8%), spine (23.9%), hydrocephalus-related disorders (14.8%), or cranial trauma (12.2%; Fig. 1). All measured patient factors are summarized in Table 1.

Patients over the age of 70 years were significantly more likely to initiate CC compared to younger patients ($p < 0.0001$). Additionally, they tended to have more Charlson coded comorbidities when they presented to the hospital (1.7 ± 1.3 vs 0.9 ± 1.4 ; $p < 0.0001$). Nearly 36% (463/1295) of the operations performed were for a cerebrovascular pathology; however, patients with a cerebrovascular pathology made up nearly two-thirds of patients who initiated CC ($p < 0.001$; Fig. 1).

An SST between 15:01 and 06:59 was significantly associated with an increased initiation of CC compared to an SST between 07:00 and 15:00 ($p = 0.004$); however, there was no difference between patients initiating CC when they presented during the weekend compared to weekdays ($p = 0.75$) (Table 1). On average, CC measures were initiated 9.3 ± 10.0 days postoperatively. A full third of the patients switched to CC measures within 3 days of the operation. There was no significant difference between the likelihood of junior (PGY 2, 3, or 4) versus senior (PGY 5, 6, or 7) residents involved in the care of patients undergoing initiation of CC ($p = 0.3$).

Multivariate Analysis

After accounting for other variables, patients aged 70–79 years had 2.57 times the odds of initiating CC compared to patients < 50 years old ($p = 0.0006$). The effect of old age was further demonstrated in those older than 80 years (OR 3.69, 95% CI 1.56–8.73, $p = 0.003$; Table 2). Additionally, compared to patients with a spinal pathology, patients presenting with a cerebrovascular pathology (OR 14.18, 95% CI 5.76–34.88, $p < 0.0001$), infection (OR 6.04, 95% CI 1.53–23.88, $p = 0.01$), or cranial trauma (OR 5.02, 95% CI, 1.93–13.08, $p = 0.001$) had significantly higher odds of initiating CC during the hospital admission (Table 2).

Patients with an SST between 15:01 and 06:59 were 70% more likely to initiate CC than patients with an SST between 07:00 and 15:00. Additionally, patients with more severe Charlson coded comorbidities, including congestive heart failure, hemiplegia, moderate/severe renal disease, and cancer with or without metastases, were also more likely to initiate CC (Table 2).

Cerebrovascular Subanalysis

Subanalysis of cerebrovascular pathologies demonstrated that 15.8% of all cerebrovascular patients initiated CC during their initial hospitalization. Multivariate logistic regression demonstrated that patients 70–79 years old had 4.08 times greater odds (95% CI 1.59–10.51, p

TABLE 1. Demographic information

Variable	Began CC During Admission (n = 111)	Did Not Begin CC During Admission (n = 1184)	p Value
Age (yrs)			<0.0001
<50	27 (24.3%)	479 (40.5%)	
50–59	32 (28.8%)	317 (26.8%)	
60–69	20 (18.0%)	241 (20.4%)	
70–79	21 (18.9%)	103 (8.7%)	
≥80	11 (9.9%)	44 (3.7%)	
Sex			0.04
Female	46 (41.4%)	611 (51.6%)	
Charlson coded comorbidities			
Chronic obstructive pulmonary disease	12 (10.8%)	80 (6.8%)	0.11
Peripheral vascular disease	19 (17.2%)	166 (14.0%)	0.37
Congestive heart failure	14 (12.6%)	50 (4.2%)	<0.0001
Myocardial infarction	8 (7.2%)	25 (2.1%)	0.001
Cerebrovascular disease	54 (48.7%)	336 (28.4%)	<0.0001
Hemiplegia	20 (18.0%)	137 (11.6%)	0.05
Dementia	2 (1.8%)	6 (0.5%)	0.10
Peptic ulcer disease	0 (0.0%)	3 (0.3%)	>0.99
Rheumatology	0 (0.0%)	19 (1.6%)	0.40
Mild liver disease	3 (2.7%)	35 (3.0%)	>0.99
Moderate/severe liver disease	1 (0.9%)	5 (0.4%)	0.48
Moderate/severe renal disease	13 (11.7%)	27 (2.3%)	<0.0001
Uncomplicated diabetes mellitus	16 (14.4%)	64 (5.4%)	0.0007
Complicated diabetes mellitus	0 (0.0%)	11 (0.9%)	0.61
Cancer w/o metastases	13 (11.7%)	76 (6.4%)	0.04
Cancer w/ metastases	9 (8.1%)	46 (3.9%)	0.03
Total no. of comorbidities	1.7 (1.3)	0.9 (1.4)	<0.0001
Diagnosis category			<0.0001
Cerebrovascular	73 (65.8%)	390 (32.9%)	
Spine	7 (6.3%)	303 (25.6%)	
Hydrocephalus & related disorders	5 (4.5%)	186 (15.7%)	
Cranial trauma	18 (16.2%)	140 (11.8%)	
Neurooncology	3 (1.8%)	61 (5.2%)	
Peripheral nerve	0 (0.0%)	12 (1.0%)	
Wound care	0 (0.0%)	34 (2.9%)	
Infection	4 (3.6%)	31 (2.6%)	
Other	2 (1.8%)	27 (2.3%)	
Day of week of procedure			0.75
Weekday	76 (68.5%)	828 (69.9%)	
Weekend	35 (31.5%)	356 (30.1%)	

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TABLE 1. Demographic information

Variable	Began CC During Admission (n = 111)	Did Not Begin CC During Admission (n = 1184)	p Value
SST			0.004
07:00–15:00	35 (31.5%)	540 (45.6%)	
15:01–06:59	76 (68.5%)	644 (54.4%)	
Resident level			0.3
Junior resident	68 (77.3%)	663 (72.1%)	
Senior resident	20 (22.7%)	256 (27.9%)	

= 0.004) of initiating CC than patients younger than 50 years, while those older than 80 years had 12.06 times the odds of initiating CC than patients younger than 50 years (95% CI 3.42–42.59, $p = 0.0001$; Table 3). Patients with an SST between 15:01 and 06:59 had 2.02 times the odds of initiating CC than those with an SST between 07:00 and 15:00 (95% CI 1.10–3.74, $p = 0.02$).

About 3% of patients with a low Hunt and Hess grade (I, II, or III) SAH initiated CC, whereas 27.1% of those patients with a high Hunt and Hess grade (IV or V) initiated CC ($p < 0.001$; Fig. 2). No patients with a Hunt and Hess grade of I or II initiated CC.

Discussion

Emergent neurosurgical procedures are common and not infrequently followed by the initiation of CC measures during the same hospital admission. As the cost of health care in the United States continues to increase, physicians and surgeons recognize the importance of efficient utilization of healthcare resources.⁵ It is estimated that healthcare costs will consume nearly 20% of the gross domestic product by 2020.^{2,12} The amount of money spent at the end of a patient's life for procedures and critical care services is exorbitant and represents an opportunity to reduce healthcare expenditures.^{5,10,13,24} Patients and families who choose to proceed with neurosurgical procedures and then initiate CC measures during the same hospital admission represent a group for whom a better understanding of this situation could lead to the avoidance of the procedure and thus avoidance of the emotional suffering of patients and families and the financial burdens associated with costly neurosurgical procedures. Wright et al.³⁷ demonstrated that early end-of-life discussions were associated with less aggressive medical care and that aggressive care was associated with worse patient quality of life and worse bereavement adjustment. However, the number of patients undergoing emergent neurosurgeries and initiation of CC measures during the same admission is unknown. We aimed to answer this question by utilizing a single-center retrospective analysis covering a 5-year period at a single large quaternary medical center. This is the first study to demonstrate that almost 9% of emergent neurosurgeries are associated with the initiation of CC within the same hospital admission.

TABLE 2. Univariate and multivariate analyses for all patients

Variable	Univariate Analysis			Multivariate Analysis		
	OR	95% CI	p Value	OR	95% CI	p Value
Age (yrs)						
<50*						
50–59	1.79	1.05–3.05	0.03	1.44	0.82–2.55	0.21
60–69	1.47	0.81–2.68	0.21	1.03	0.54–1.97	0.93
70–79	3.62	1.97–6.65	<0.0001	2.57	1.31–5.06	0.006
≥80	4.44	2.06–9.54	0.0001	3.69	1.56–8.73	0.003
Sex						
Female	0.66	0.45–0.99	0.04	0.64	0.41–1.00	0.05
Charlson coded comorbidities						
Chronic obstructive pulmonary disease	1.67	0.88–3.17	0.12	1.77	0.67–4.68	0.25
Peripheral vascular disease	1.27	0.75–2.13	0.37			
Congestive heart failure	3.27	1.75–6.13	<0.0001	2.88	1.03–8.06	0.04
Myocardial infarction	3.60	1.58–8.19	0.002	2.60	0.87–7.82	0.09
Cerebrovascular disease	2.39	1.61–3.54	<0.0001	1.83	0.75–4.50	0.19
Hemiplegia	1.68	1.00–2.81	0.05	2.91	1.29–6.53	0.01
Dementia	3.60	0.72–18.06	0.12	1.65	0.18–15.30	0.66
Mild liver disease	0.91	0.28–3.01	0.88			
Moderate/severe liver disease	2.14	0.25–18.51	0.49			
Moderate/severe renal disease	5.68	2.84–11.37	<0.0001	6.69	2.37–18.87	0.0003
Uncomplicated diabetes mellitus	2.95	1.64–5.30	0.0003	4.09	1.67–10.06	0.002
Cancer w/o metastases	1.93	1.04–3.61	0.04	3.85	1.38–10.74	0.01
Cancer w/ metastases	2.18	1.04–4.59	0.04	4.75	1.54–14.67	0.007
Total no. of comorbidities	1.33	1.19–1.50	<0.0001	0.45	0.26–0.78	0.004
Diagnosis category						
Spine*						
Cerebrovascular	8.10	3.68–17.85	<0.0001	14.18	5.76–34.88	<0.0001
Hydrocephalus & related disorders	1.16	0.36–3.72	0.80	1.80	0.54–5.97	0.34
Cranial trauma	5.57	2.27–13.60	0.0002	5.02	1.93–13.08	0.001
Neurooncology	1.42	0.29–7.00	0.67	1.65	0.32–8.58	0.55
Peripheral nerve	<0.001	0.00–99.99	0.99	<0.001	0.00–99.99	0.99
Wound care	<0.001	0.00–99.99	0.99	<0.001	0.00–99.99	0.99
Infection	5.59	1.55–20.15	0.009	6.04	1.53–23.88	0.01
Other	3.21	0.64–16.20	0.16	3.59	0.67–19.20	0.14
Day of week of procedure						
Weekday*						
Weekend	1.07	0.70–1.63	0.75			
SST						
07:00–15:00*						
15:01–06:59	1.82	1.20–2.76	0.005	1.70	1.08–2.67	0.02
Resident level						
Junior resident*						
Senior resident	0.76	0.45–1.28	0.30			

* Indicates that this is a reference category.

A number of factors are associated with the initiation of CC shortly after an emergent neurosurgical intervention. As would be expected, patients older than 70 years had significantly greater odds of initiating CC than younger patients. This could be explained by the fact that such pa-

tients have a poorer chance of recovery and a shorter life expectancy. We also identified that patients who had an SST outside of typical operating times were also significantly more likely to initiate CC measures. We have previously reported an increased incidence of surgical com-

TABLE 3. Univariate and multivariate analyses for patients with a cerebrovascular pathology

Variable	Univariate Analysis			Multivariate Analysis		
	OR	95% CI	p Value	OR	95% CI	p Value
Age (yrs)						
<50*						
50–59	1.65	0.80–3.40	0.17	1.95	0.87–4.37	0.10
60–69	1.43	0.64–3.19	0.38	1.21	0.50–2.95	0.68
70–79	4.64	1.97–10.93	0.0004	4.08	1.59–10.51	0.004
≥80	10.82	3.56–32.85	<0.0001	12.06	3.42–42.59	0.0001
Sex						
Female	0.50	0.31–0.84	0.008	0.62	0.34–1.14	0.12
Charlson coded comorbidities						
Chronic obstructive pulmonary disease	1.16	0.56–2.41	0.69			
Peripheral vascular disease	0.41	0.23–0.74	0.003	0.38	0.17–0.83	0.02
Congestive heart failure	1.88	0.93–3.80	0.08	1.03	0.37–2.81	0.96
Myocardial infarction	2.65	1.04–6.75	0.04	1.58	0.46–5.43	0.47
Cerebrovascular disease	0.71	0.42–1.19	0.19	0.86	0.42–1.78	0.69
Hemiplegia	1.49	0.80–2.75	0.21			
Dementia	2.70	0.24–30.11	0.42			
Mild liver disease	0.19	0.03–1.46	0.11	0.21	0.02–1.81	0.15
Moderate/severe liver disease	<0.001	0.00–99.99	0.99			
Moderate/severe renal disease	5.00	2.07–12.06	0.0003	6.99	2.17–22.55	0.001
Uncomplicated diabetes mellitus	2.34	1.17–4.71	0.02	1.75	0.72–4.29	0.22
Cancer w/o metastases	1.85	0.71–4.83	0.21			
Cancer w/ metastases	1.56	0.50–4.87	0.45			
Total no. of comorbidities	1.04	0.90–1.20	0.62			
Cerebrovascular pathology						
Subarachnoid hemorrhage*						
Intraparenchymal hemorrhage	2.35	1.25–4.43	0.008	1.39	0.64–3.02	0.40
Stroke	2.94	1.52–5.68	0.001	1.49	0.68–3.27	0.32
Other	0.14	0.02–1.08	0.06	0.13	0.02–1.01	0.05
Day of week of procedure						
Weekday*						
Weekend	0.81	0.47–1.40	0.45			
Surgical start time						
07:00–15:00*						
15:01–06:59	1.90	1.12–3.22	0.02	2.02	1.10–3.74	0.02
Resident level						
Junior resident*						
Senior resident	0.89	0.49–1.63	0.71			

* Indicates that this is a reference category.

plications following operations with a late SST.¹⁵ These differences could reflect surgeon fatigue, the more chaotic nature of a night encounter, or the desire for heroic operations that may have been declined during the day. It could also represent the fact that, at our institution, the neurosurgical resident serves as the primary person offering surgery during “off hours,” whereas the entire team, including neurosurgical attending personnel, is available for discussion with the family during “on-hour” presentations. During off-hours there may be a tendency for trainees without significant neurosurgical experience to be overly cautious

and thus offer surgical interventions to gravely ill patients whose prognosis is poor that would not have been offered in the presence of an experienced attending surgeon. Such a hypothesis is best tested and evaluated with further analysis regarding the qualitative decision-making by family members regarding the initiation of CC measures.

The majority of the patients who initiated CC presented with a cerebrovascular pathology, and, as would be expected, markers of more severe cerebrovascular illness (higher Hunt and Hess grade) were associated with increased likelihood of initiating CC. Nearly 16% of all

FIG. 2. Percentage of patients presenting with SAH who initiated comfort care according to Hunt and Hess grade. Figure is available in color online only.

patients with a cerebrovascular pathology initiated CC during their initial hospitalization. While emergencies occur in all neurosurgical subspecialties, cerebrovascular emergencies are often more common and disabling. Given that cerebrovascular pathologies present with sudden emergent symptoms, there is often little time for families to adequately deliberate regarding end-of-life care if the topic has not been previously discussed, potentially increasing the likelihood for aggressive interventions. In a retrospective analysis of stroke-related deaths, Quadri et al.²³ reported that only 1.6% of the patients had preexisting advanced care planning. The lack of advanced care planning coupled with the sudden, disorienting nature of intraparenchymal hemorrhage and stroke often leaves patients and loved ones with little idea of how to best proceed with medical planning. As a surgeon, making end-of-life decisions for incapacitated patients is complicated due to unclear prognosis and individual surgeons' anecdotal experiences with certain pathologies.²⁶ There is often significant variation among surgeons over how aggressively to treat the emergent patient for whom an accurate prognosis is difficult to make.^{6,38}

Surgeon variability in recommending CC has been studied and demonstrates that focused training in palliative care measures is associated with an increased utilization of CC.³⁴ Since palliative care training is accumulated throughout residency, we hypothesized that there would be an increased utilization of CC measures among senior

residents. However, when we looked at the trends of CC initiation according to the seniority of the resident taking primary responsibility for the patient, we did not see any difference between junior and senior residents. This discrepancy could be explained by a number of factors: 1) junior residents take the majority of calls at our institution and thus deal with the majority of emergent cases (the study may have been insufficiently powered to detect a difference), 2) the increased skill and comfort level of senior residents may predispose them to an aggressive approach to treatment, or 3) formal palliative care training may be lacking throughout residency.

The initiation of CC is a multifaceted decision that should ideally take into account the medical condition of the patient and the expressed desires of the patient and loved ones. We demonstrate that patients who were older and who had more medical comorbidities were more likely to initiate CC during their initial admission. In addition, patients with more severe cerebrovascular pathologies (high Hunt and Hess grade) were significantly more likely to initiate CC. However, without preexisting advanced care planning, even with the knowledge that older, sicker patients with more severe pathology are more likely to initiate CC, it is difficult to delineate which patients should be operated on and which should immediately enter CC upon admission.

While this study focused on the initiation of CC following an emergent operation, future studies will focus on the

proportion of patients who are referred to the neurosurgical department and immediately initiate CC measures without undergoing an operation. This companion study will allow us to more fully understand and compare the types of patients who undergo an operation and then enter CC compared to those who are never offered surgery and proceed directly into CC. Further research efforts should be invested into understanding the qualitative decision-making of patients and providers concerning whether to operate or initiate CC measures. Additionally, the recently expanded window for stroke intervention will likely alter the proportion of patients presenting with a cerebrovascular pathology who initiate CC measures.^{1,18} These differences should be quantified in further research studies.

This study is limited by the retrospective nature of the analysis, the possibility that not all emergent operations were properly coded to reflect their emergent nature, and the possibility that not all cases of CC were identified. Failing to identify CC orders would potentially bias our results toward underrepresentation of the true utilization of CC measures, whereas inaccurate coding of routine versus emergent cases could lead to an overrepresentation. However, we attempted to negate this limitation by identifying CC both through comfort care order sets and through individual chart review via EMERSE.⁹ In addition, the proportion of our population that entered CC was relatively similar to other published reports looking at disease-specific initiation of CC.^{17,22} Also, we were limited by the granularity of details we were able to obtain, including the presence of an advanced directive, the degree of family involvement, the utilization of inpatient palliative care, and the baseline disease severity. In the future, we hope to design a prospective study to gather detailed data regarding disease severity for a more robust analysis. Additionally, since we selected only those patients who had an urgent or emergent operation, we did not capture the portion of the population who initiated CC without first undergoing an emergent operation. Last, this study is limited by the lack of qualitative analysis that could potentially illuminate the reasoning of the patient and/or surgeons in the decision to operate and subsequently initiate CC.

Conclusions

Initiation of CC after emergent neurosurgical and endovascular procedures in the same hospital admission is a relatively common occurrence, particularly when the patient presents with a cerebrovascular pathology, thus presenting an opportunity for better resource utilization within this patient population.

Acknowledgments

This study was supported by a TL1 Training Grant (J.R.L. and J.L.N.; 1-TL1-TR-002242-01) and an NS-007222 grant (D.A.W.), both from the National Institutes of Health.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Pandey, Linzey, Burke. Acquisition of data: Pandey, Linzey, Burke. Analysis and interpretation of data: Pandey, Linzey, Burke, Savastano. Drafting the article: all authors. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Pandey. Statistical analysis: Pandey, Linzey, Burke, Nadel. Administrative/technical/material support: Pandey. Study supervision: Pandey, Burke.

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