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Selected Topics: Neurological Emergencies

NEUROLOGIC EMERGENCIES PRESENTING AS TRAUMA ACTIVATIONS TO AN URBAN LEVEL I TRAUMA CENTER

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Abstract—Background: It is speculated that there is overlap between neurologic emergencies and trauma, yet to date there has not been a study looking at the prevalence of neurologic emergencies amongst trauma activations. **Objectives:** We sought to determine the prevalence of neurologic emergencies in patients presenting to a level I trauma center as trauma team activations (TTAs). We explored a subset of acute ischemic stroke patients to determine delays in management. **Methods:** This was a retrospective review of trauma registry data capturing all TTAs at a level I trauma and stroke center from 2011 to 2016. Neurologic emergencies were defined as ischemic stroke, intracerebral hemorrhage, subarachnoid hemorrhage, or status epilepticus. Among patients diagnosed with acute ischemic strokes, we compared stroke metrics with hospital stroke data during the same period. **Results:** There were 18,859 trauma activations during the study period, of which 117 (0.6%) had a neurologic emergency. There were 52 patients with ischemic stroke (45%), 39 with intracerebral hemorrhage (34%), 15 with subarachnoid hemorrhage (13%), and 10 with status epilepticus (9%). Among the 52 patients with ischemic stroke, 20 (38%) received intravenous thrombolysis. The median time to computed tomography scan was 23 min and the median time to thrombolysis (tissue plasminogen

activator) was 60 min. When compared with non-TTA patients during the same time period, both median time to computed tomography scan and time to tissue plasminogen activator were similar ($p = 0.16$ and $p = 0.6$, respectively). **Conclusions:** Neurologic emergencies, though relatively uncommon, do exist among TTAs. Despite the TTA, eligible patients met the benchmarks for acute stroke care delivery. © 2019 Elsevier Inc. All rights reserved.

Keywords—intracerebral hemorrhage; neurologic; status epilepticus; stroke; trauma activation

INTRODUCTION

Patients who present to the emergency department as trauma team activations (TTAs) remain a diagnostic challenge given the extent of their injuries. In particular, the “found down” patient, often admitted as a TTA, can carry a variety of acute medical diagnoses. Up to two-thirds of patients who are found down can be expected to carry acute medical diagnoses, and >2% are likely to have suffered from cerebrovascular accidents (1,2). Not only are TTAs diagnostically complex, but it has been suggested

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that a TTA can impact the care of nontrauma patients by increasing their length of stay in the ED and possibly leading to delays in diagnoses (3–5). In the context of neurologic emergencies, however, it is unclear how TTAs may impact the care of patients who require time-sensitive imaging and treatment. While some studies have shown a reduction in time to computed tomography (CT) scan in patients with concurrent TTAs with suspected neurologic injury, it is unclear if these results are applicable to patients with confirmed acute ischemic strokes (6,7).

While the true prevalence of acute neurologic emergency in patients admitted under TTAs has yet to be shown, this is a diagnosis that must be made rapidly by the trauma team in order to avoid potentially catastrophic consequences. To date, no study has evaluated the prevalence of acute neurologic emergency in patients who present to the ED as TTAs. In addition, it is unclear if patients who come to the ED as TTAs are more likely to experience delays with respect to time-sensitive imaging and therapies (i.e., time to CT scan, and time to tissue plasminogen activator [tPA] thrombolysis, or thrombectomy).

We aimed to determine the prevalence of neurologic emergencies at an urban level I trauma and primary stroke center, as well as characterize the clinical and demographic features of these patients. In addition, we sought to compare a subset of these patients with acute ischemic strokes to hospital-wide metrics of time to CT scan and time to intravenous thrombolysis, if applicable, during the study time period. We hypothesized that patients with acute ischemic strokes who were admitted as TTAs would have increased average time to CT scan, tPA administration, and thrombectomy (if applicable).

METHODS

Study Design

This was an institutional review board–approved retrospective review of trauma registry data capturing all TTAs at the Zuckerberg San Francisco General Hospital and Trauma Center (ZSFG) from June 2011 to June 2016. Patients that arrived at ZSFG were activated according to the modified American College of Surgeons TTA criteria (see [Appendix](#)). A full TTA, called a “900 activation” at ZSFG, includes an attending trauma surgeon, a senior surgical resident, and a junior resident from the trauma service along with an emergency medicine attending physician and an emergency medicine resident. A limited trauma activation, called a “911 activation” at ZSFG, includes the same emergency medicine personnel and a junior and senior surgical resident at time of arrival of the patient.

A prospectively collected trauma registry was queried for admitted patients who received a consultation from or who were admitted to the neurology service after a TTA. Data abstracting for the trauma registry is completed by trauma performance improvement nurses who are experienced registered nurses with critical care or emergency nursing experience and who receive a 1-on-1 orientation with an experienced performance improvement nurse. There is an ongoing data validation auditing process to ensure data accuracy. Records from June 2011 to June 2016 were reviewed to identify patients with a confirmed diagnosis of ischemic stroke, intracerebral hemorrhage, subarachnoid hemorrhage, or status epilepticus. Various clinical and demographic factors were assessed by clinician researchers through review of the electronic medical record.

We completed our subset analysis of patients with acute ischemic stroke by calculating times from admission to CT imaging and therapies, if applicable. Time of admission was based on initial ED triage notes. Time of CT scan was retrieved from the radiologic notes. Time of administration of intravenous thrombolysis and thrombectomy were found in the electronic medical record. These time intervals were then compared with patients diagnosed with acute ischemic stroke without TTA during the same study period. All data was collected by experienced stroke performance improvement nurses responsible for obtaining and reporting hospital-wide data.

Study Setting and Population

The ZSFG is a high-volume, urban, academic, level I trauma center and primary stroke center that serves the city and county of San Francisco. During the 2015–2016 year, approximately 100,000 patients were seen and >4500 TTAs occurred according to the ZSFG ED census. Trauma activations are initiated by out-of-hospital personnel and a trauma team is assembled. Trauma activations are automatically entered into a registry that includes key historical and examination findings on presentation and the final disposition. If a stroke is suspected in the hospital, a “code stroke” is activated, by which the on-call neurology resident and stroke fellow are notified via the hospital paging system. The CT technician is also directly notified in order to accommodate space in the CT scanner for the patient.

Study Protocol

All patients who were admitted as TTAs during the study time period and had confirmed diagnoses of neurologic emergencies (as defined by acute ischemic stroke, intracerebral hemorrhage, subarachnoid hemorrhage, or status

epilepticus) were included in the initial study design. Patients <18 years of age and patients who were incarcerated were excluded.

After patients were identified for inclusion, further demographic, clinical, and outcome data were then abstracted from the electronic medical record. ED physical examination documentation was reviewed for the presence of focal neurologic findings and for presenting Glasgow Coma Scale (Figure 1).

Measurements

The primary outcome was prevalence of neurologic emergency among patients who presented to the ZSFG ED as TTAs. Secondary outcomes included demographic and clinical information pertaining to patients' initial presentations, as well as a subsequent analysis of acute ischemic stroke patients who were admitted as TTAs. We were interested in this cohort's door-to-CT scan time, door to thrombolysis ("door-to-needle") time, and time to mechanical thrombectomy, as recommended by The Joint Commission, compared with patients with non-TTA ischemic stroke from June 2011 to June 2016 (8).

Data Analysis

Main data outcomes are reported as mean (standard deviation), median (interquartile range [IQR]), or percentage. Statistical significance of differences observed in normally distributed and non-normally distributed data was determined using the Student *t* and Wilcoxon rank sum tests, respectively. Statistical significance was determined

at $\alpha > 0.05$ level. Statistical and descriptive analyses were performed using IBM SPSS software (version 24.0; IBM Corp., Armonk, NY).

RESULTS

A total of 18,859 trauma activations were captured in the registry during the study period. One hundred sixteen patients (0.6%) were found to have a neurologic emergency. Of these 116 patients, there were 52 patients with ischemic stroke (45%), 39 patients with intracerebral hemorrhage (ICH) (34%), 15 patients with subarachnoid hemorrhage (SAH) (13%), and 10 patients with status epilepticus (9%). Characteristics of the primary sample are shown in Table 1.

The mean age was 67 years, and two-thirds of the patients were male. The mean Glasgow Coma Scale score on presentation was 10. Forty-three percent of patients were intubated in the emergency department. Six patients (5%) presented after motor vehicle accidents. Seven patients (6%) had detectable blood levels of ethanol and 26 (22%) had positive toxicology screens. The most common focal neurologic finding documented was hemiplegia (33%) followed by pupillary abnormalities (9%).

Twenty stroke patients (38%) received intravenous thrombolysis and 10 (19%) underwent mechanical thrombectomy. The remaining stroke patients were found down without a last seen normal time available and therefore were not eligible for acute stroke interventions.

During the study period there were 52 patients with ischemic stroke who arrived at the emergency department as a TTA and 988 patients with non-TTA ischemic stroke. The groups were similar with respect to sex (42.3% female in the TTA group vs. 42.2% female in the non-TTA group; $p = 0.63$); however, the groups had significant differences with respect to age, race, and median National Institutes of Health Stroke Scale (NIHSS) score. The median age of the TTA group was 80.5 years (IQR 66–86 years) versus 63 years (IQR 55–76 years) in the non-TTA group ($p < 0.01$). The TTA patients were more likely to be white and non-Hispanic than in the non-TTA group (36.5% vs. 18.0%; $p < 0.01$). The median NIHSS score in the TTA group was 13.5 (IQR 6–17) compared with a median NIHSS score of 6 (IQR 3–14) in the non-TTA group ($p < 0.01$). With respect to medical comorbidities, the TTA group was far more likely to have a medical history of atrial fibrillation (48.1%) than the non-TTA group (24.8%) ($p < 0.01$). The characteristics of both the TTA and non-TTA ischemic stroke patients can be found in Table 2.

Among the 52 patients with TTA acute ischemic stroke, the median time to CT scan was 23 min (IQR 17–44 min) compared with 28 min (IQR 18–55 min) ($p = 0.16$) for the patients with non-TTA ischemic stroke.

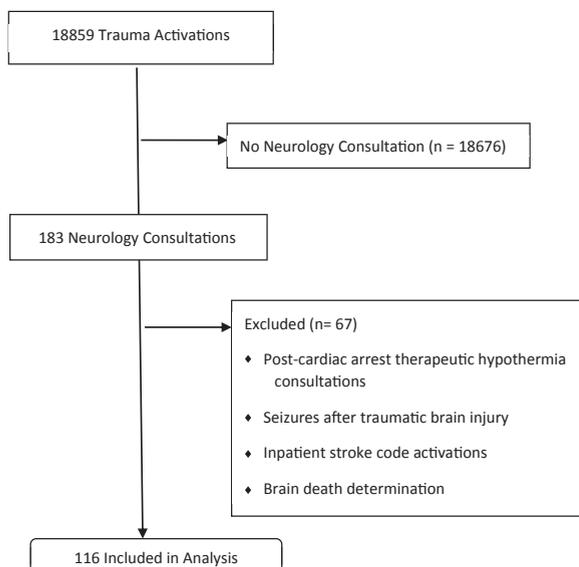


Figure 1. Diagram of the study protocol.

Table 1. Characteristics of Patients with Neurologic Emergencies Presenting as Trauma Activations

	n	Mean Age, y	Male	Mean GCS Score	Intubated, n (%)	Survival, n (%)
Acute ischemic stroke	52	74.4	56%	11	17 (33)	41 (79)
Intracerebral hemorrhage	39	71.5	56%	10	20 (51)	26 (67)
Subarachnoid hemorrhage	15	63.2	67%	10	8 (53)	11 (73)
Status epilepticus	10	42.9	80%	10	5 (50)	10 (100)
All	116					

GCS = Glasgow Coma Scale.

Of the 20 patients with thrombolysis in our ischemic stroke sample, the median door-to-needle time was 60 min (IQR 50–86 min) compared with 57 min (IQR 42–77 min) for the non-TTA population ($p = 0.6$). The median time to groin puncture (mechanical thrombectomy) was 117 min (IQR 100–130 min) compared with 129 min (IQR 105–155) in patients with non-TTA during the same time period ($p = 0.15$). A comparison of stroke treatment process metrics is shown in [Table 3](#).

DISCUSSION

The ZSFG is the only level I trauma center in the city and county of San Francisco, serving 1.5 million people of San Francisco and northern San Mateo counties. During the study period from June 2011 to June 2016, nearly 20,000 trauma activations occurred. It is speculated that there is an overlap between neurologic emergencies and trauma, yet to date there has not been a study looking at the prevalence of neurologic emergencies among TTAs. We sought to find the prevalence of this entity and to identify whether patients with ischemic stroke who present as a TTA suffer from delays in diagnosis and management.

We found that the prevalence of neurologic emergencies was relatively low in this sample (0.6%) and that sur-

prisingly, a TTA did not have an adverse impact on stroke treatment performance metrics among eligible patients with ischemic stroke in this cohort. This confirms what has been seen previously in that stroke patients who present as a TTA actually have shorter door-to-CT times than patients with non-TTA stroke (6). This also highlights the efficiency of obtaining CT imaging for TTAs (7). Beyond door-to-CT times, door-to-tPA and door-to-groin puncture times were similar among eligible patients in the TTA and non-TTA groups. It is possible that door-to-needle times for TTA patients may have benefitted from the expedited door-to-CT times.

Our study did identify differences between patients with and without a TTA. Ischemic stroke patients with a TTA are more likely to be older in age, white, non-Hispanic, and have a more severe stroke, as indicated by higher NIHSS scores. These patients are also more likely to have a medical history of atrial fibrillation. Given these findings, it is also possible that the severity of symptoms prompted a stroke diagnosis for the ED and trauma team and mitigated delays in diagnosis and treatment.

Published literature has documented a higher prevalence of neurologic injury in trauma patients who are found down, and our analysis supports this finding given

Table 2. Characteristics of TTA and Non-TTA Stroke Patients

	All, n = 1040	Non-TTA, n = 988	TTA, n = 52	<i>p</i> Value
Median age, y (IQR)	64 (56–77)	63 (55–76)	80.5 (66–86)	<0.01
Female, n (%)	439 (42.2)	417 (42.2)	22 (42.3)	0.63
Race or ethnic group, n (%)				<0.01
White, non-Hispanic	197 (18.9)	178 (18.0)	19 (36.5)	
Black	238 (22.9)	234 (23.7)	4 (7.7)	
Hispanic	127 (12.2)	126 (12.8)	1 (1.9)	
Asian	315 (30.3)	297 (30.1)	18 (34.6)	
Other/Unknown	163 (15.7)	153 (15.5)	10 (19.2)	
Median NIHSS score (IQR)	6 (3–14)	6 (3–14)	13.5 (6–17)	<0.01
Medical history, n (%)				
Stroke or TIA	122 (11.7)	113 (11.4)	9 (17.3)	0.20
Diabetes mellitus	217 (20.9)	210 (21.3)	7 (13.4)	0.18
Hypertension	454 (43.7)	426 (43.1)	28 (53.9)	0.13
Dyslipidemia	248 (23.9)	237 (24.0)	11 (21.2)	0.64
Atrial fibrillation	270 (26.0)	245 (24.8)	25 (48.1)	<0.01
Tobacco use	269 (25.9)	260 (26.3)	9 (17.3)	0.15

IQR = interquartile ratio; NIHSS = National Institutes of Health Stroke Scale; SD = standard deviation; TIA = transient ischemic attack; TTA = trauma team activation.

Table 3. Comparison of Stroke Treatment Process Metrics for TTA and Non-TTA Stroke Patients

Median (IQR), Mean (SD)	All	Non-TTA	TTA	Comparison
Door to CT scan	28 (18–55), 158 (659)	28 (18–57), 168 (685)	23 (17–44), 37 (44)	0.16
Door to needle	58 (42–77), 69 (65)	57 (42–77), 69 (68)	60 (50–86), 65 (25)	0.6
Door to groin puncture	124 (105–154), 145 (93)	129 (105–155), 150 (100)	117 (100–130), 115 (21)	0.15

CT = computed tomography; IQR = interquartile ratio; SD = standard deviation; TTA = trauma team activation.

that 70 of 116 (60.3%) patients had a chief complaint of found down according to their ED triage notes (1). In our study, these found down patients frequently have alteration of mental status with signs of trauma, which could frame the trauma team's diagnostic workup to prioritize traumatic over neurologic injuries. Whether or not this leads to delays in diagnosis of nontraumatic injuries remains to be seen given that these patients were not candidates for acute therapy because they lacked an accurate last seen normal time. While it is difficult to determine if there were delays in care attributable to the trauma activation itself, it is extremely important to be mindful of neurologic illnesses like acute ischemic stroke because patients can quickly miss the opportunity for life-saving therapies and with the advent of extended time windows for thrombectomy (9,10).

The trauma protocol has been designed to quickly gather information from a variety of systems in order to not miss potentially life-threatening injuries (11). We found that 0.6% of patients who were initially admitted to the ED at an urban level I trauma center as TTAs had acute neurologic emergencies. Most of these patients were activated as traumas because they were found down and had an altered mental status, and many had suffered from acute ischemic strokes. Trauma teams should therefore include neurologic emergencies as important diagnoses of exclusion in this subset of TTAs.

Of the 52 patients with ischemic stroke who presented to the ED as TTAs, there were no significant delays in their diagnosis (i.e., time to CT scan) and ultimate treatment (i.e., time to tPA and time to thrombectomy) for those who were eligible. The patients at highest risk of stroke were found down, were older, had a medical history of atrial fibrillation, and presented with severe stroke symptoms. This gives a foundation for improving diagnosis and quality of care in stroke patients that present as TTAs and may be applicable to other large medical centers that have an extensive trauma and stroke overlap.

Limitations

Our query of TTAs presents the first epidemiologic assessment of patients who are admitted under trauma activations and are subsequently diagnosed with acute neurologic injuries. The relatively low prevalence of

neurologic emergencies that we found in this sample is likely explained by the high quantity of trauma activations (>18,000) during the study period. Hospitals use a variety of criteria to determine if a patient is to be brought to the ED as a TTA, and these vary regionally (12–14). Our institution uses the American College of Surgeons guidelines to guide trauma activations, which may create a conservatively high denominator in our prevalence calculation.

Our prevalence rate likely does not capture all neurologic emergencies that occur under the umbrella of TTAs. For example, some patients may never receive a formal neurologic diagnosis after a TTA is initiated because they die from their injuries before receiving a CT scan. Other patients may have had concurrent neurologic and traumatic injuries and died intraoperatively without receiving an inpatient neurology consultation. As other reviews have shown, overlapping acute medical diagnoses are common in trauma patients (2).

While some studies report an advantage to trauma activations with respect to time to imaging and diagnosis, it is unclear how this protocol affects the outcomes of patients with neurologic injuries (6,7,15). We were unable to report how TTAs impacted clinical outcomes of these patients without a direct comparison of clinical outcomes from patients who were admitted with neurologic injuries without concurrent TTAs.

Our results are limited by the relatively low sample size ($n = 116$), particularly with respect to the subset analysis. In addition, these data were only collected at one medical center and it is unclear how generalizable the findings would be to other sites, especially those that are not both trauma and primary stroke centers. Future research is necessary to determine the impact of these findings across other locations.

CONCLUSIONS

We found that neurologic emergencies that present as TTAs are relatively uncommon and that ischemic stroke patients who present as TTAs are more likely to be older, white, non-Hispanic, and suffer from more severe, and cardioembolic strokes. The patients most vulnerable to delays in diagnosis and treatment are patients who are found down with an unclear last seen normal time. It is

especially important to recognize ischemic stroke as a potential diagnosis in these trauma patients because they may be candidates for thrombectomy in the extended time window of eligibility.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.jemermed.2019.05.025>.

REFERENCES

1. Kornblith LZ, Kutcher ME, Evans AE, et al. The “found down” patient: a diagnostic dilemma. *J Trauma Acute Care Surg* 2013;74:1548–52.
2. Jacobs BG, Turnipseed SD, Nguyen AN, Salcedo ES, Nishijima DK. Acute medical diagnoses are common in “found down” adult patients presenting to the emergency department as trauma. *J Emerg Med* 2015;49:992–7.
3. Arya R, Dossantos F, Ohman-Strickland P, Merlin MA. Impact of trauma activation on the ED length of stay for nontraumatic patients. *Am J Emerg Med* 2012;30:311–6.
4. Fishman PE, Shofer FS, Robey JL, et al. The impact of trauma activations on the care of emergency department patients with potential acute coronary syndromes. *Ann Emerg Med* 2006;48:347–53.
5. Smith DC, Chapital A, Burgess Uperesa BM, Smith ER, Ho C, Ahana A. Trauma activations and their effects on non-trauma patients. *J Emerg Med* 2011;41:90–4.
6. Chen EH, Mills AM, Lee BY, et al. The impact of a concurrent trauma alert evaluation on time to head computed tomography in patients with suspected stroke. *Acad Emerg Med* 2006;13:349–52.
7. Rados A, Tiruta C, Xiao Z, et al. Does trauma team activation associate with the time to CT scan for those suspected of serious head injuries? *World J Emerg Surg* 2013;8:48.
8. Jauch EC, Saver JL, Adams HP Jr, et al. Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke* 2013;44:870–947.
9. Nogueira RG, Jadhav AP, Haussen DC, et al. Thrombectomy 6 to 24 hours after stroke with a mismatch between deficit and infarct. *N Engl J Med* 2018;378:11–21.
10. Albers GW, Marks MP, Kemp S, et al. Thrombectomy for stroke at 6 to 16 hours with selection by perfusion imaging. *N Engl J Med* 2018;378:708–18.
11. Cameron PA, Gabbe BJ, Smith K, Mitra B. Triaging the right patient to the right place in the shortest time. *Br J Anaesth* 2014;113:226–33.
12. Kohn MA, Hammel JM, Bretz SW, Stangby A. Trauma team activation criteria as predictors of patient disposition from the emergency department. *Acad Emerg Med* 2004;11:1–9.
13. Egberink RE, Otten HJ, IJzerman MJ, van Vugt AB, Doggen CJ. Trauma team activation varies across Dutch emergency departments: a national survey. *Scand J Trauma Resusc Emerg Med* 2015;23:100.
14. Larsen KT, Uleberg O, Skogvoll E. Differences in trauma team activation criteria among Norwegian hospitals. *Scand J Trauma Resusc Emerg Med* 2010;18:21.
15. Wang C-H, Hsiao K-Y, Shih H-M, Tsai Y-H, Chen IC. The role of trauma team activation by emergency physicians on outcomes in severe trauma patients. *J Acute Med* 2014;4:1–5.

ARTICLE SUMMARY

1. Why is this topic important?

Although neurologic emergencies presenting as traumas are anecdotally a common occurrence, to date, there has never been a study examining the prevalence of neurologic emergencies among patients presenting as trauma activations.

2. What does this study attempt to show?

We examined the prevalence of neurologic emergencies presenting as trauma activations at a trauma center, as well as the effect on diagnosis and treatment for the subset of acute ischemic stroke patients.

3. What are the key findings?

The actual prevalence of neurologic emergencies amongst trauma activations at a level I trauma center and stroke center is low (0.6%). Amongst these cases, the subset of acute ischemic stroke patients experienced statistically significant delays in time to CT and thrombolysis.

4. How is patient care impacted?

Neurologic emergencies, though relatively uncommon among trauma activations, represent an important diagnosis of exclusion in this patient population. These patients experience significant delays in time to diagnosis and treatment.