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Potential synergy between advanced primary stroke centers and level I or II trauma centers in the United States[☆]

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Abstract

Objective—The objective of this study is to determine the number of primary stroke centers (PSCs) that exist concurrently (synergic relationship) with designated higher level trauma centers (level I or level II trauma centers) and associated characteristics.

Methods—We identified all PSCs certified by the Joint Commission or local state authorities in 2010. Concurrently, all the higher level trauma centers (designated level I or level II) were identified using data collected from the trauma information exchange program. Additional data was collected from the Accreditation Council for Graduate Medical Education and the American hospital directory.

Results—A total of 788 existing designated PSCs were identified in 2010; coexisting PSC-trauma centers were found in 252 centers (32%) with PSCs coexisting with level I trauma centers in 138 hospitals (17.5%). The remaining 536 PSCs (68%) are based in hospitals without trauma centers. There was a higher proportion of residency training programs including neurology, neurosurgery, and general surgery in coexisting PSC-trauma centers ($P < .001$). In a proof-of-concept analysis in 1 state, PSCs with level I trauma facilities were found to have the highest rates of thrombolytic administration as compared with PSCs with level II trauma centers and PSCs without trauma facilities (12.8% vs 3.8% vs 4.9%) ($P < .0001$). Primary stroke centers with level I trauma facilities were also more likely to follow the drip-and-ship paradigm (5.7% vs 1.8% vs 0.9%) ($P < .0001$).

Conclusions—Despite evidence of higher capability among institutions with coexisting PSC-trauma centers, two thirds of PSCs are in hospitals without advanced trauma systems. These findings have implications for establishing stroke systems in the United States.

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1. Introduction

The establishment of primary stroke centers (PSC) has the potential to improve the care of patients with stroke [1]. The emergency medical response, transport, and triage of patients with stroke are very similar to the more established trauma systems. Several institutions have used preexisting trauma systems to develop effective stroke networks. Stroke treatment remains complex and, in some cases, can be optimized using existing trauma systems. Our objective is to determine the number of PSCs that are based in state designated higher level trauma facilities (level I or level II), identified as coexisting PSC-trauma centers in the current report, and to further analyze characteristics of such institutions to identify potential implications for care of patients with stroke.

2. Methods

We identified all the advanced PSCs certified by the Joint Commission in 2010. Detailed information on Advanced Certification for Primary Stroke Centers was obtained at <http://www.jointcommission.org>. Concurrently, all the advanced higher level trauma centers (designated level I or level II) were identified using data collected from the trauma information exchange program. Trauma information exchange program maintains an inventory of trauma centers in the United States; collects data and develops information related to the causes, treatment, and outcomes of injury; and facilitates the exchange of information among trauma care institutions, care providers, researchers, payers, and policy makers. Centers in all 50 states and the District of Columbia were divided into 4 Census Bureau regions (Northeast, Midwest, South, and West). Data were collected on institutional bed number and total number of discharges from the American hospital directory [2]. Presence of accredited residency training programs including neurology, neurosurgery, general surgery, and fellowship training programs in vascular neurology and vascular surgery were identified from the Accreditation Council for Graduate Medical Education (ACGME) data base [3]. Data on neurocritical care fellowship training programs were obtained from the United Council for Neurologic Subspecialties database. Hospital teaching status was ascertained from the ACGME website and later confirmed by checking the hospital's website or by contacting the hospital directly. We determined the number of PSCs located within level I and II trauma centers by the name of the facility, location, and zip code. Certain institutions had a network of hospitals, and each individual facility was treated as an independent center. We further compared the characteristics of institutions with coexisting PSC-trauma centers vs PSCs without associated trauma centers. We performed a state-wide estimate of thrombolysis and associated in-hospital characteristics from the 2008–2009 Minnesota Hospital Association data [4]. We used the *International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM)* [5] primary diagnosis codes to identify the patients admitted with ischemic stroke. Diagnostic code fields were screened for specific codes to identify patients with ischemic stroke using *ICD-9-CM* codes 433, 434, 436, 437.0, and 437.1 as primary diagnoses. Patients who underwent thrombolysis were identified by procedure code 99.10, and patients who were treated using the drip-and-ship paradigm were identified using the V45.88 code. We compared the rates of thrombolysis among patients with ischemic stroke admitted to

coexisting PSC-trauma centers with rates observed in PSCs without an associated trauma center.

Statistical analysis was performed using SAS (Cary, NC). Descriptive statistics were expressed as means with SD and frequency (percentages). Continuous and categorical variables were compared using analysis of variance and χ^2 tests, respectively. We calculated the latitude and longitude for all PSCs and trauma centers based on zip code to demonstrate geographic distribution (Fig. 1).

3. Results

A total of 788 advanced PSCs were certified by the Joint Commission in 2010 (<http://www.jointcommission.org>). Coexisting PSC-trauma centers were found in 252 (32%) of the PSCs. Coexisting PSC-level I trauma centers were observed in 138 hospitals (17.5%), and 114 PSCs (14.5%) coexisted with level II trauma centers. Of the 78 university-affiliated PSCs, a coexisting PSC-trauma center was found in 74 institutions (94.8%). University affiliation was significantly higher in hospitals with coexisting PSC-trauma centers. The related residency and fellowship training programs are presented in Table 1. The remaining 536 (68%) of 788 PSCs were based in hospitals without concomitant level I or II trauma centers. Among hospitals with level I trauma centers and PSCs, the mean number of beds $\pm$ SD was 581 ± 270 , and the mean number of annual discharges ($\pm$ SD) was $27\,614 \pm 12\,102$. The number of hospital beds was similar in hospitals with PSCs and level I or II trauma centers and PSCs alone and level I or II trauma centers alone. The mean number of annual discharges was lower in hospitals with coexisting PSC-trauma centers than PSCs alone or level I or II trauma centers alone. The highest frequency of PSCs was located in the Northeast United States. The highest frequency of coexisting PSC-trauma centers occurred in hospitals located in the Midwest United States (48 [42.8%]) with the lower frequencies observed in the South (44 [15.1%]) and Western segments (23 [14.3%]) ($P < .001$) of the United States. There was a higher proportion of residency training programs including neurology, neurosurgery, and general surgery (see Table 1) in coexisting PSC-trauma centers ($P < .001$).

There were 17,120 admissions for primary ischemic stroke in Minnesota-based hospitals. Of these admissions, 642 (3.75%) received IV recombinant tissue plasminogen activator (rt-PA). Coexisting PSC-level I trauma centers were found to have the highest rates of thrombolytic administration compared with PSCs with level II trauma centers and PSCs without trauma centers (12.8% vs 3.8% vs 4.9%) ($P < .0001$). Primary stroke centers with coexisting trauma centers received more patients through the drip-and-ship paradigm compared with PSCs with lower level trauma center designations (5.7% vs 1.8% vs 0.9%) ($P < .001$).

4. Discussion

The Joint Commission's PSC Certification Program, launched in December 2003, was developed in collaboration with the American Heart Association/American Stroke Association [6,7]. Based on compelling evidence supporting the role of PSCs, the Joint

Commission on Accreditation of Healthcare Organization adopted the Brain Attack Coalition recommendations [1,7] and started certifying hospitals as designated PSCs [7] based on site visits and review of site capabilities and performance measures. Key elements of primary stroke centers include presence of acute stroke teams, stroke units, written care protocols, and an integrated emergency response system [8]. The trauma care system is guided by principles that are applicable to improving stroke care, including enhanced communication among hospitals and emergency medical services, clear transport protocols with mandated transport to facilities with appropriate resources, strategies for treating and transporting patients who live in rural and remote areas, integration of rehabilitation services, and the use of evidence-based treatment protocols [9]. However, the question remains whether coexisting PSC-trauma centers improve patient outcomes and, subsequently, the feasibility of increasing such coexistence.

Almost all of the training programs with direct relevance to a stroke program, including neurology and neurologic surgery residencies, vascular neurology, and neurocritical care fellowships, were in coexisting PSC-trauma centers, which may increase the value of such a synergistic relationship. We had previously analyzed patient outcomes by type of institution: rural, urban nonteaching, and urban teaching in 1990 to 1991 and in 2000 to 2001 using a nationwide inpatient sample [10]. Mortality rates among patients admitted after ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage were all lower in urban teaching hospitals than in rural and urban nonteaching hospitals. Over a 10-year period, there was a reduction in mortality rates for all stroke subtypes probably related to an increase in the proportion of patients with stroke admitted to urban teaching hospitals. The lower rates of mortality were attributable to specialized care by a neurologist or organized inpatient (stroke unit) care at teaching facilities [11,12]. Therefore, hospitals with coexisting PSC-trauma centers appear to be teaching hospitals with various related training programs and devote more resources including 24–7 coverage with the same intensity of care, which can result in better management of patients and can improve the outcome for patients with stroke.

A higher utilization of IV rt-PA among hospitals with concurrent trauma facilities may also result in beneficial outcomes for patients with ischemic stroke. Patients treated early with IV rt-PA show better outcomes at 24 hours and 3 months [13]. In the proof-of-concept analysis, the rate of IV rt-PA utilization was significantly higher among coexisting PSC-trauma centers. We think that the higher utilization is a result of higher level of stroke expertise and greater level of efficiency in emergency medical services and emergency department (ED) triage due to existing trauma center. Important support services as a part of trauma centers include availability and interpretation of computed tomographic scans 24 hours per day; rapid laboratory testing are equally advantageous for acute stroke care. Higher rates of a “drip and ship” paradigm composed of IV rt-PA initiated at a peripheral hospital followed by transfer to a PSC in the proof-of-concept analysis were also seen at coexisting PSC-trauma centers presumably because stroke system-based approach for critical transfer is similar to the one used in trauma care systems.

We found that the largest proportions (68%) of PSCs were based in hospitals without concomitant level I or II trauma centers. The number of hospital beds was similar in

hospitals with PSCs and level I or II trauma centers and PSCs alone and level I or II trauma centers alone. Therefore, although coexisting PSC-trauma centers may have advantages, only a third of PSCs are currently able to use the synergy in the United States. It should be recognized that despite being based on similar principles, several important differences exist between the organization of trauma care and that of stroke care, which makes simply designating trauma systems as stroke systems inappropriate. The medical personnel involved in the evaluation and treatment of stroke and trauma differ in background and skills. Primary stroke centers require fewer resources to establish than those required for level I trauma centers. The number of physician specialties with rapid response required for level I trauma center is greater than those required for PSCs. Initial evaluation and treatment of patients with stroke can be performed by ED physicians alone as demonstrated in studies focusing on initiating rt-PA at outside EDs before transfer to a PSC [10]. The initial hemodynamic and neurologic stabilization of patients with stroke (unlike trauma patients) can be performed at most EDs [14]. Therefore, the number of PSCs should ideally be greater than level I trauma centers [9]. As stroke care is becoming more standardized, presumably an increase in the number of PSCs and PSC/trauma center synergy would be beneficial to patients with stroke. The region most likely to benefit from an increase in synergy is the South, which includes a substantial portion of the stroke belt, an area with a high incidence of stroke.

More recently, the Brain Attack Coalition has made recommendations regarding certification of comprehensive stroke centers. These areas include (1) health care personnel with specific expertise in several disciplines, including neurosurgery and vascular neurology; (2) advanced neuroimaging capabilities such as magnetic resonance imaging and various types of cerebral angiography; (3) availability of surgical and endovascular techniques, including neurosurgical and endovascular treatment of intracranial aneurysms, carotid endarterectomy, and intra-arterial thrombolytic therapy; and other specific infrastructure and program-specific elements such as an intensive care unit and prospective ascertainment of outcomes. Integration of these elements into a coordinated hospital-based program or system is likely to improve outcomes of patients with strokes and complex cerebrovascular disease who require the services of a comprehensive stroke center [15]. Eventually, as stroke care further develops, we would argue that there may be advantages to increasing the coexisting PSC-trauma center relationship across the United States and perhaps coexisting comprehensive stroke and trauma centers.

5. Conclusions

There is early evidence of higher capability of trauma levels among institutions with coexisting PSC-trauma center. However, two third of PSCs are based in hospitals without advanced trauma centers. Further studies are needed to address whether coexisting PSC-trauma centers improve patient outcomes and, subsequently, the feasibility of increasing such coexistence and whether there is any cost benefit associated with such a synergistic system.

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Fig. 1.
Geographic distribution of PSCs according to strata defined by coexistence of level I or II trauma centers.

Table 1

Characteristics of PSCs according to strata defined by coexistence of level I or II trauma centers

	PSC without trauma center	Coexisting PSC–level II trauma center	Coexisting PSC–level I trauma center	P
Total	536 (68%)	114 (14.5%)	138 (17.5%)	
Hospital bed size ^a (mean ± SD)	506 ± 2498	411 ± 183	581 ± 270	.833
Annual patient discharges ^a (mean ± SD)	16 014 ± 10 158	19 852 ± 9668	27 614 ± 12 102	<.001
Geographic region				.001
Northeast	79 (66.4%)	17 (14.3%)	23 (19.3%)	
Midwest	124 (57.1%)	45 (20.7%)	48 (22.1%)	
South	219 (75.3%)	28 (9.6%)	44 (15.1%)	
West	114 (70.8%)	24 (14.9%)	23 (14.3%)	
University affiliation	4 (5.1%)	4 (5.1%)	70 (89.7%)	<.001
Neurology residency program	2 (2.8%)	1 (1.4%)	68 (95.8%)	<.001
Neurosurgery residency	4 (5.5%)	1 (1.4%)	68 (93.2%)	<.001
General surgery residency	22 (21.4%)	6 (5.8%)	75 (72.8%)	<.001
Vascular neurology fellowship	2 (3.3%)	1 (1.7%)	57 (41.3%)	<.001
Neuro-ICU fellowship	2 (4.3%)	1 (2.1%)	44 (93.6%)	<.001
Trauma fellowship	4(7.3%)	1 (1.8%)	50 (90.9%)	<.001

ICU indicates intensive care unit.

^aInformation missing for 34 hospitals.