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Organization of a U.S. County System for Comprehensive Acute Stroke Care

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Abstract

BACKGROUND AND PURPOSE—Organized systems of care have the potential to improve acute stroke care delivery. The current report describes the experience of implementing a countywide system of spoke-and-hub Stroke Neurology Receiving Centers (SNRC) that incorporated several comprehensive stroke center recommendations.

METHODS—Observational study of patients with suspected stroke <5 hours duration transported by Emergency Medical System personnel to an SNRC during the first year of this system.

RESULTS—A total of 1,360 patients with suspected stroke were evaluated at 9 hub SNRCs, of which 553 (40.7%) had a discharge diagnosis of ischemic stroke. Of these 553, intravenous (IV) tPA was given to 110 patients (19.9% of ischemic strokes). Care at the 6 neurointerventional-ready SNRC was a major focus, where 25.1% (99/395) of the patients with ischemic stroke received acute IV or intraarterial reperfusion therapy, and where provision of such therapies was

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less common with milder stroke, higher age, and Hispanic origin. The door-to-needle time for IV tPA met the <60 minute target in only 25% of patients and was 37% longer (p=0.0001) when SNRCs were neurointerventional-ready.

CONCLUSIONS—A stroke system that incorporates features of comprehensive stroke centers can be effectively implemented, and with substantial rates of acute reperfusion therapy administration. Experiences potentially useful to broader implementation of comprehensive stroke centers are considered.

Keywords

Acute Care; Stroke Centers; pre-hospital systems

The rates of stroke and of hospitalization from stroke have been increasing in the U.S. each year[1, 2]. In parallel, systems of stroke care delivery have received greater attention. In 2000, the Brain Attack Coalition suggested two types of stroke centers: primary and comprehensive[3], and in 2005 described recommendations for comprehensive stroke centers[2]. In California, emergency medical systems are managed at the county level. In response to the 2005 updated Brain Attack Coalition recommendations, providers of acute stroke care from the hospitals of Orange County, CA (the nation's fifth most populous county, population over 3 million[4]) met with county Emergency Medical System (EMS) personnel and hospital administrative representatives in a grass roots effort to define a Stroke Neurology Receiving Center (SNRC) system. In May, 2009, local EMS policy was enacted, defining a plan for a countywide spoke-and-hub system that had specialized SNRC as hubs and community hopitals as spokes. The medical center hubs adopted features of comprehensive stroke centers, as practical.

A key goal for the SNRC system was to maximize use of acute reperfusion therapies for ischemic stroke. The current report describes initial experience, rate of acute therapy administration, and factors related to this rate. Areas of achievement as well as those requiring greater attention when implementing comprehensive stroke centers more broadly are highlighted.

Methods

Orange County EMS regulates, monitors, plans, and coordinates pre-hospital emergency medical services, hospital emergency programs, and trauma centers as part of the Health Care Agency of Orange County, CA. All EMS units are overseen by the County through EMS.

The criteria for an Orange County SNRC hub incorporated several of the Brain Attack Coalitions recommendations for comprehensive stroke centers[2], and approximated others. Criteria for a hub SNRC include a neurologist on-call and available to consult within 30 minutes; a neurosurgeon on-call and available to consult within 30 minutes; an emergency medicine specialist available in-house at all times; a radiologist experienced in neuroradiology on-call and available to consult within 30 minutes (with tele-radiology deemed acceptable); access to rehabilitation that is either in-house or via a documented referral protocol; a multidisciplinary institutional quality assurance committee that meets on a regular basis to monitor quality benchmarks and reviews complications; and provision of stroke education to hospital staff, other regional hospital staffs, EMS personnel, and the public. Credentialing for the radiologist experienced in neuroradiology was determined by medical staff at each hospital. An endovascular neurointerventionalist who is available around the clock was deemed a preferred, though not a required, feature.

All of the 24 acute care hospitals in Orange County in 2009 were offered the opportunity to become an SNRC hub. Nine chose to do so. Six of these hubs had an endovascular neurointerventionalist available and were assigned spoke hospitals based on EMS call volumes (one spoke in one case, two spokes in two cases, and three spokes in three cases). Three SNRC hubs did not have an endovascular neurointerventionalist and were not assigned any spoke hospitals (Figure 1).

County EMS units were required to transport patients suspected of stroke <5 hours duration to the nearest hub SNRC, while spoke SNRC transferred such patients to hubs as appropriate. Suspected ischemic stroke was operationally defined by EMS as a patient with weakness (hemiplegia, hemiparesis, pronator drift, or facial paresis), capillary glucose ≥ 80 mg/dl, no seizure prior to or during EMS arrival, and Glasgow Coma Scale score ≥ 10. Suspected hemorrhagic stroke was operationally defined by EMS as a patient with sudden severe headache in the past 5 hours plus one or more of the following: (1) repeated vomiting, (2) neurological deficit (hemiparesis or weakness, gaze to one side, or asymmetric pupils without prior eye surgery), (3) altered mental status, and (4) marked blood pressure elevation (diastolic > 100 mm Hg).

A standardized data collection sheet (see Appendix) was completed for each patient triaged into the system by field EMS units or spokes, then submitted to Orange County EMS for inclusion into a central database. Prior to initiation of the SNRC system, this data collection sheet was developed by EMS (derivation phase) with particular attention to definition and collection of each data element. After implementation of the SNRC system, the first 100 data collection sheets were reviewed (validation phase) for consistency in data element definitions. Reliability of data collected from different SNRC was assessed with the first 100 data collection sheets, as well as periodically thereafter. At each hub SNRC, this form was completed by the stroke coordinator, after being trained to do so by county EMS. A limited data set was extracted from this database for the current study. Discharge diagnosis was based on ICD-9 codes and was confirmed from a separate, countywide master EMS database. Note that all patients who were treated with IV tPA were coded as an ischemic stroke regardless of symptom duration.

The current report examines the experience from the first 12 months of SNRC operation. Missing data were not imputed. Statistical analyses used parametric methods except for NIHSS scores, which were analyzed using non-parametric statistical methods. Analysis of this limited data set was approved by the UC Irvine IRB.

Results

System implementation

No major impediments were identified in the implementation of this system. Eight of the 9 hub SNRC were either a Joint Commission-certified Primary Stroke Center or were compliant with AHA “Get With The Guidelines” at time of hub SNRC designation. Note that prior to the initiation of this system, all six neurointerventional-ready hub SNRCs already had an ER physician in-house as well as 30 minute access to a neurologist, neurosurgeon, and neuroradiologist. In 2009, four of the six hub SNRC were neurointerventional-ready 24/7/365, and over time all six were. Several case report form fields were not consistently completed by SNRCs, in particular, discharge NIHSS score was not provided in 49.8%, mortality was not described in 21.3%, and discharge diagnosis was not recorded on the case report form in 18.6% of patients and could only be identified from the master EMS database.

Subjects

From April 2009-April 2010, 1,360 EMS-transported patients with suspected stroke were evaluated at the nine hub SNRCs. Primary discharge diagnosis was ischemic stroke in 553 (40.7%), hemorrhagic stroke in 210 (15.4%), TIA in 142 (10.4%), and a non-stroke diagnosis in 443 (32.6%, most often seizure, toxic-metabolic state, and sepsis), with no diagnosis provided in 12 (0.1%). Of the hemorrhagic strokes, 185 were due to intracerebral hemorrhage (including 5 due to ruptured arteriovenous malformation) and 25 were due to aneurysmal subarachnoid hemorrhage. Age was 74 ± 15 years (mean ± SD; range 8–103). Gender was 55% female/45% male. The proportion of patients routed past a spoke hospital to a hub hospital was 18.1%. Only a small number (n=28, i.e., 2.1%) of patients were first routed to a spoke hospital and later transferred to a hub SNRC. Of these 28, 12 received IV tPA at the first facility, prior to transfer, and 22 received endovascular treatment at the second facility.

Use of IV tPA across all SNRCs

IV tPA was given to 110 patients (19.9% of ischemic strokes) as the sole reperfusion therapy. Indirect evidence suggests that this is substantially higher than the rate from the year prior, as a survey performed by EMS and required of all prospective SNRC found that only 3.4% of EMS-transported cases that were coded by EMS as acute stroke < 5 hours old received acute thrombolytic therapy in 2008, nearly all of which was IV tPA. The time from ER arrival to IV tPA initiation (door-to-needle time) across all 9 SNRCs, available in 96.4% of patients, averaged 86.4 ± 37.4 minutes, and was 37% longer at the 6 neurointerventional-ready SNRC (100 ± 38 minutes, n=54) compared to the 3 SNRC that were not neurointerventional-ready (73 ± 32 minutes, n=52, p=0.0001). The proportion of patients with door-to-needle time <60 minutes was 25%, also lower in neurointerventional-ready SNRCs (11%) compared to SNRCs not offering neurointerventional therapy (40%, p = 0.0004).

Acute reperfusion therapy at neurointerventional-ready SNRCs

Acute care for the 938 patients taken to one of the 6 neurointerventional-ready SNRCs was a major focus. Discharge diagnosis was ischemic stroke in 395, hemorrhagic stroke in 153, TIA in 88, another diagnosis in 292, with no diagnosis provided in 10. Among the 395 EMS-transported patients diagnosed with ischemic stroke, age averaged 76 ± 14 years. Ethnicity was 67% Caucasian, 14% Asian, 11% Hispanic, 1.5% Black, 4.5% other, and 2.5% not stated. The time of day at which these 395 patients arrived was unevenly distributed (p<0.0001), e.g., 26% arrived from 12 noon - 4 pm while only 5% arrived from midnight - 4 am (Figure 2). Median baseline NIHSS score, available in 90% of subjects, was 10 points. Among these 395 EMS-transported patients identified as having an ischemic stroke at a neurointerventional-ready SNRC, acute reperfusion therapy consisted of IV tPA alone in 57 (14.4%), an IA procedure alone in 32 (8.1%, includes IA tPA, MERCI, Penumbra, or any combination), and IV tPA followed by an IA procedure in 10 (2.5%), for a total of 99 (25.1%) receiving acute reperfusion therapy.

Provision of acute reperfusion therapy at a neurointerventional-ready SNRC varied in relation to baseline NIHSS score (median for those receiving acute reperfusion therapy=14, vs. 7 for those not receiving such therapy, p < 0.0001), age (73 ± 16 years in those receiving therapy vs. 77 ± 14 years in those not, p = 0.027) and ethnicity (p = 0.046, lowest in Hispanic patients, highest in Caucasian and African-American patients), but not gender. A nominal logistic model predicting whether acute reperfusion therapy was provided or not found that all three of these measures (baseline NIHSS score, age, and ethnicity) remained significant.

Discussion

This report describes the experience of developing and implementing a system for comprehensive acute stroke care in a populous US county that captured some, though not all, of the innovations proposed for comprehensive stroke centers[2]. Among EMS-transported patients with ischemic stroke taken to a neurointerventional-ready hub SNRC, 25.1% received acute reperfusion therapy. Patients receiving such therapy tended to have a more severe stroke, a lower age, and were less likely to be Hispanic. The door-to-needle time for IV tPA met the <60 minutes target in only 25% of patients and was longer when sites were neurointerventional-ready.

The Brain Attack Coalition has recommended both primary and comprehensive stroke centers[3]. Primary stroke centers are designed to stabilize and treat most acute stroke patients. Core elements include formation of an acute stroke team, integration of EMS with stroke center operations, use of an organized stroke unit, and access to neurosurgical care within 2 hours of need. A prior report from our group described the experience of becoming a primary stroke center[5]. Comprehensive stroke centers build on this, and are designed to have the "necessary personnel, infrastructure, expertise, and programs to diagnose and treat stroke patients who require a high intensity of medical and surgical care, specialized tests, or interventional therapies."[2] Key components of comprehensive stroke centers include neurologists, neurosurgeons, emergency department personnel, as well as physicians with expertise in interventional endovascular neuroradiology procedures; a full ICU staffed by properly trained personnel; the ability to have urgent neuroimaging studies interpreted within 20 minutes of acquisition; access to neurosurgical personnel within 30 minutes; door-to-needle time ≤ 60 minutes for IV tPA; and availablity of rehabilitation services. The Orange County SNRC hubs that were neurointerventional-ready exceeded the requirements of a primary center and also captured some, though not all, of the innovations proposed for comprehensive stroke centers.

Implementation of the Orange County system went smoothly. This might in part due to broad concensus developed prior to start: once there was medical consensus for the system, it was presented to the governing body for the county (the Orange County Board of Supervisors) to gain political support for the program. Several meetings with political leaders were held to inform them of the intent for the program and to obtain governmental support, and concurrently, local media and community interest groups were approached. Implementation of this system might also have been aided by the phased development of data collection methods or by the fact that all but one SNRC was either a Joint Commission-certified Primary Stroke Center or compliant with AHA "Get With The Guidelines" at the time the system was initiated. As such, the experience of initiating such a system might differ in communities whose hospitals do not have such prior certifications. IV tPA was given to 19.9% of patients with an acute ischemic stroke, a rate that is more than 5-fold higher than the rate estimated in this region for the year preceding initiation of this stroke system. This value is substantial and is consistent with reports that thrombolytic therapy usage has been increasing over time in the U.S.[6], and furthermore is specifically more frequent when patients with acute ischemic stroke are admitted to a designated stroke center[7]. The likelihood of receiving an acute reperfusion therapy in the current cohort varied in relation to age and ethnicity, with less therapy given to subjects who were older or Hispanic. The reasons for these disparities in relation to age might overlap with reasons for therapy disparity discussed in relation to post-acute stroke care, such as an age-related bias[8, 9]. The reasons for variation in relation to ethnicity are less clear and may be multifactorial[10].

There were a number of limitations to the current study. Several case report form fields were not consistently completed by SNRCs, particularly those related to patient outcomes. Also, the time of onset was coded inconsistently (duration of symptoms in some cases, time on clock in others). These points underscore the importance of bioinformatics resources for such a database. Only 2.1% of patients were transferred from spokes to hubs, and so the current experience might be of limited value to stroke systems that are more reliant on interfacility transfers. All six hub SNRC had key physicians (ER, neurology, neurosurgery, and neuroradiology) in place prior to initiation of this stroke system; system performance might differ in settings where this is not the case at baseline. Other data of interest, such as time from EMS departure from scene to ER arrival, were not recorded as part of this study.

Despite these limitations, some aspects of this experience might be instructive to broader implementation of comprehensive stroke centers. Although time of patient arrival to the ER clustered around normal working hours (Figure 2), 13% of EMS-transported patients arrived between 10pm and 6am, emphasizing the importance of around-the-clock coverage. The door-to-needle time for subjects receiving IV tPA was within the target window of 60 minutes[11] in only 25% of patients, a rate that while low is consistent with the value of 26.6% reported by Fonarow et al[12] in a recent study of 25,504 U.S. patients with ischemic stroke. Review of this result with SNRC personnel disclosed three issues in particular that might have contributed: a need to educate some ER staff and physicians about this goal, a need for greater efficiency in obtaining baseline labs, and a need to strategically time performance of additional imaging when indicated. Furthermore, the door-to-needle time was significantly longer when an SNRC offered acute neurointerventional therapies. This might reflect a preference for a more detailed diagnostic evaluation prior to therapeutic evaluation in such a setting, a possibility that requires further study.

In conclusion, a countywide stroke system that employs several of the core features of a comprehensive stroke center can provide effective acute stroke care with high rates of acute reperfusional therapy. The current report emphasizes some areas that might be of particular focus to assessing comprehensive stroke centers, such as assessing performance across age and ethnic groups, as well as monitoring door-to-needle time[11] for IV tPA.

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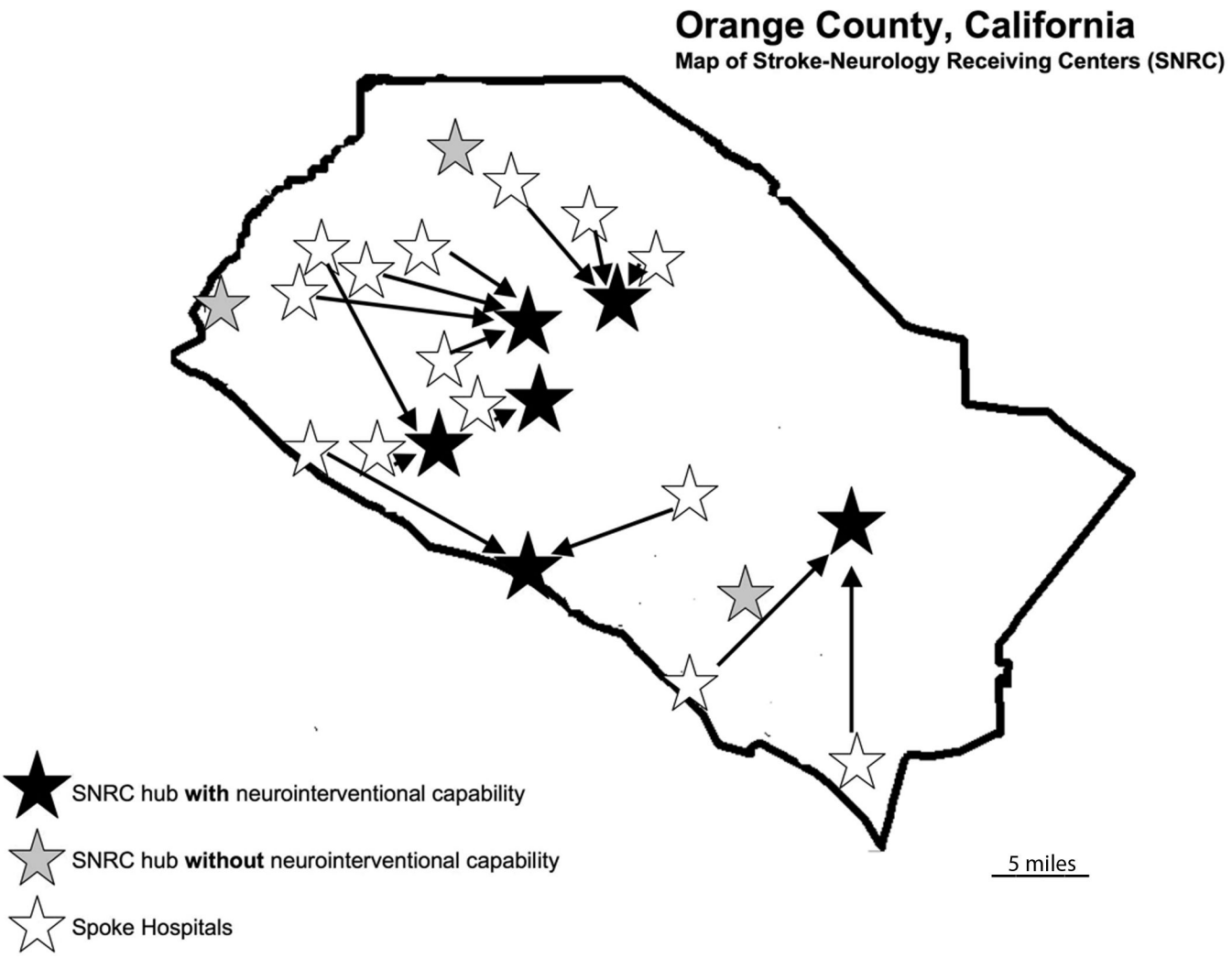

Figure 1.
The map shows the nine hub SNRC in Orange County, CA (population over 3 million, spanning 789 square miles) including the six with neurointerventional capability and the three without, as well as the 14 spoke hospitals.

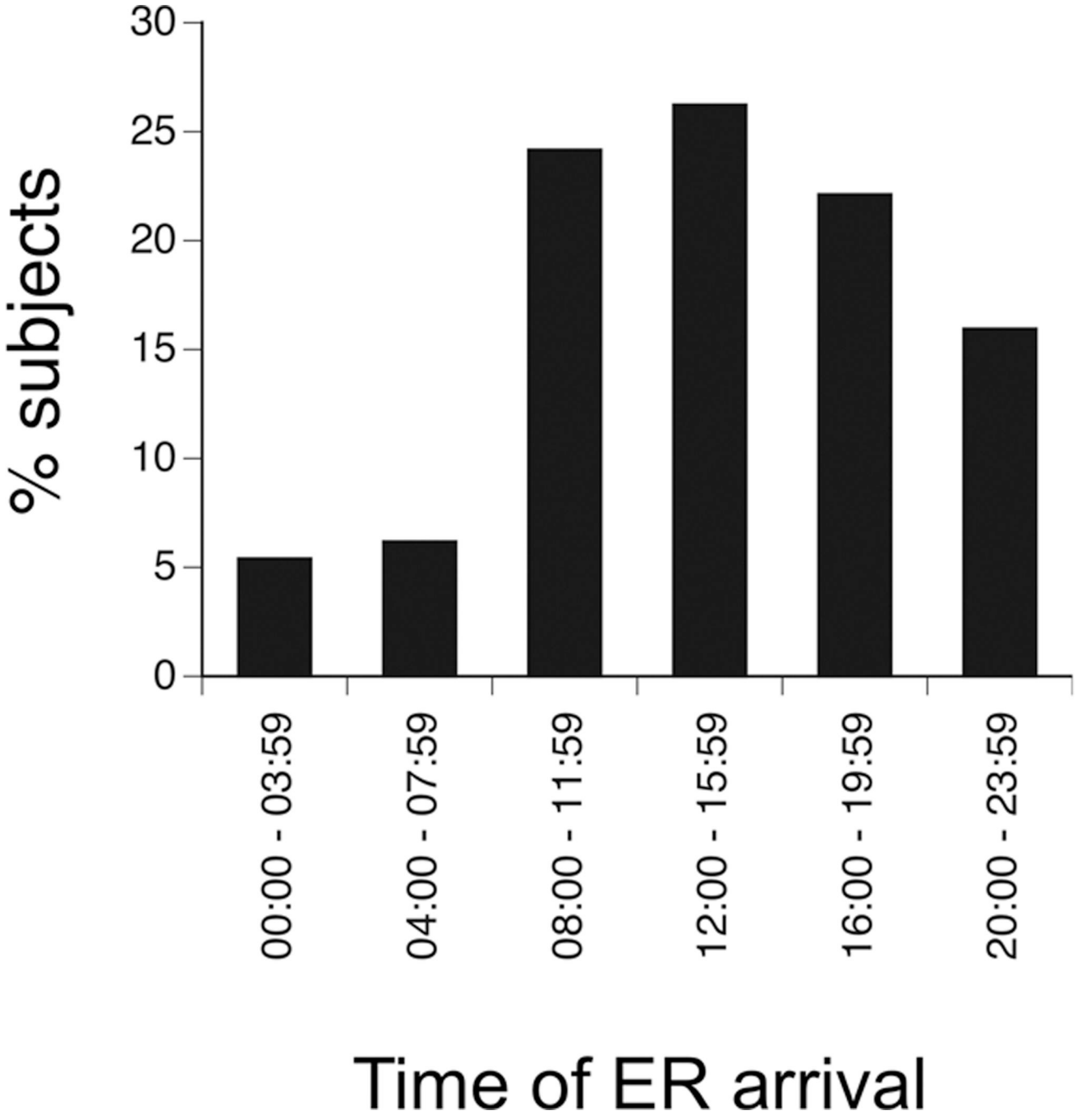

Figure 2.
Among the 395 EMS-transported patients with acute ischemic stroke taken to a neurointerventional-ready SNRC, the time of ER arrival was unevenly distributed ($p < 0.0001$).