11. Ohta T, Waga S, Handa W, Saito I, Takeuchi K (1974) [new grading of level of disordered consiousness (author's transl)]. No Shinkei Geka 2: 623–627.
12. Teasdale G, Jennett B (1974) Assessment of coma and impaired consciousness. A practical scale. Lancet 2: 81–84.
13. Shahian DM, Normand SL (2008) Comparison of "risk-adjusted" hospital outcomes. Circulation 117: 1955–1963.
14. Seghieri C, Mimmi S, Lenzi J, Fantini MP (2012) 30-day in-hospital mortality after acute myocardial infarction in Tuscany (Italy): An observational study using hospital discharge data. BMC Med Res Methodol 12: 170.
15. Cramer SC, Stradling D, Brown DM, Carrillo-Nunez IM, Ciabarra A, et al. (2012) Organization of a United States county system for comprehensive acute stroke care. Stroke 43: 1089–1093.
16. Qureshi AI, Chaudhry SA, Rodriguez GJ, Suri MF, Lakshminarayan K, et al. (2012) Outcome of the 'drip-and-ship' paradigm among patients with acute ischemic stroke: Results of a statewide study. Cerebrovasc Dis Extra 2: 1-8.
17. Ali SF, Singhal AB, Viswanathan A, Rost NS, Schwamm LH (2013) Characteristics and outcomes among patients transferred to a regional comprehensive stroke center for tertiary care. Stroke 44: 3148–3153.
18. Smith EE, Shobha N, Dai D, Olson DM, Reeves MJ, et al. (2010) Risk score for in-hospital ischemic stroke mortality derived and validated within the Get With the Guidelines-Stroke Program. Circulation 122: 1496–1504.
19. Fonarow GC, Pan W, Saver JL, Smith EE, Reeves MJ, et al. (2012) Comparison of 30-day mortality models for profiling hospital performance in acute ischemic stroke with vs without adjustment for stroke severity. JAMA 308: 257–264.
20. Cucchiara BL, Kasner SE, Wolk DA, Lyden PD, Knappertz VA, et al. (2004) Early impairment in consciousness predicts mortality after hemispheric ischemic stroke. Crit Care Med 32: 241–245.
21. Hemphill JC 3rd, Farrant M, Neill TA Jr (2009) Prospective validation of the ICH Score for 12-month functional outcome. Neurology 73: 1088–1094.
22. Weimar C, Benemann J, Diener HC, German Stroke Study Collaboration (2006) Development and validation of the Essen Intracerebral Haemorrhage Score. J Neurol Neurosurg Psychiatry 77: 601–605.
23. Schwamm LH, Fonarow GC, Reeves MJ, Pan W, Frankel MR, et al. (2009) Get With the Guidelines-Stroke is associated with sustained improvement in care for patients hospitalized with acute stroke or transient ischemic attack. Circulation 119: 107–115.
24. Qureshi AI, Majidi S, Chaudhry SA, Qureshi MH, Suri MF (2013) Validation of intracerebral hemorrhage-specific intensity of care quality metrics. J Stroke Cerebrovasc Dis 22: 661–667.
25. Leys D, Ringelstein EB, Kaste M, Hacke W, Executive Committee of the European Stroke Initiative (2007) Facilities available in European hospitals treating stroke patients. Stroke 38: 2985–2991.
26. Localio AR, Berlin JA, Ten Have TR, Kimmel SE (2001) Adjustments for center in multicenter studies: an overview. Ann Intern Med 135: 112–123.

The Impact of Comprehensive Stroke Care Capacity on the Hospital Volume of Stroke Interventions: A Nationwide Study in Japan: J-ASPECT Study

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Background: The association between comprehensive stroke care capacity and hospital volume of stroke interventions remains uncertain. We performed a nationwide survey in Japan to examine the impact of comprehensive stroke care capacity on the hospital volume of stroke interventions. *Methods:* A questionnaire on hospital characteristics, having tissue plasminogen activator (t-PA) protocols, and 25 items regarding personnel, diagnostic, specific expertise, infrastructure, and educational components recommended for comprehensive stroke centers (CSCs) was sent to 1369 professional training institutions. We examined the effect of hospital characteristics, having a t-PA protocol, and the number of fulfilled CSC items (total CSC score) on the hospital volume of t-PA infusion, removal of intracerebral hemorrhage, and coiling and clipping of intracranial aneurysms performed in 2009. *Results:* Approximately 55% of hospitals responded to the survey. Facilities with t-PA protocols (85%) had a significantly higher likelihood of having 23 CSC items, for example, personnel (eg, neurosurgeons: 97.3% versus 66.1% and neurologists: 51.3% versus 27.7%), diagnostic (eg, digital cerebral angiography: 87.4% versus 43.2%), specific expertise (eg, clipping and coiling: 97.2% and 54% versus 58.9% and 14.3%, respectively), infrastructure (eg, intensive care unit: 63.9% versus 33.9%), and education (eg, professional education: 65.2% versus 20.7%). On multivariate analysis adjusted for hospital characteristics, total CSC score, but not having a t-PA protocol, was associated with the volume of all types of interventions with a clear increasing trend (P for trend $< .001$). *Conclusion:* We demonstrated a significant association between

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comprehensive stroke care capacity and the hospital volume of stroke interventions in Japan. **Key Words:** Stroke facilities—stroke units—ischemic stroke—intracerebral hemorrhage—subarachnoid hemorrhage—acute stroke therapy.

Introduction

Stroke is the third leading cause of death worldwide and a leading cause of long-term disability. In 2000, the Brain Attack Coalition discussed the concept of stroke centers and proposed 2 types of centers: primary[1] and comprehensive.[2] Most stroke patients can be treated appropriately at primary stroke centers (PSCs), and the Joint Commission has established programs for the certification of, and measurement of performance in, PSCs. The concept of a comprehensive stroke center (CSC) enables intensive care and the use of specialized techniques, which are not available at most PSCs.[2] A set of metrics and associated data elements that cover the major types of care that distinguish CSCs from PSCs have been published recently.[3] At present, when the certification of CSCs has been initiated worldwide, there are no nationwide reports on the associations between primary and comprehensive stroke care capacity and impact of comprehensive stroke care capacity on hospital volume of stroke interventions.

Aims

We performed a nationwide survey in Japan to determine the association between primary and comprehensive stroke care capacity and the impact of comprehensive stroke care capacity on the annual hospital volume of tissue plasminogen activator (t-PA) infusion, removal of intracerebral hemorrhage (ICH), and coiling and clipping of intracranial aneurysms (IAs).

Methods

Eligible Hospitals

The J-ASPECT study (Nationwide survey of Acute Stroke care capacity for Proper dEsignation of Comprehensive stroke cenTer in Japan) group developed a 49-question survey regarding hospital characteristics (eg, bed number, academic status, geographic location, and participation in the diagnosis procedure combination [DPC] payment system), primary and comprehensive stroke care capacity, and hospital volume of stroke interventions. The questionnaire was mailed on February 2011 to the 1369 certified training institutions of the Japan Neurosurgical Society, the Japanese Society of Neurology, and the Japan Stroke Society. In the case of nonresponders, a second mail was sent to the medical directors to ensure that the questionnaire was completed and returned.

Assessment of Comprehensive and Primary Stroke Care Capacities and Hospital Volume of Stroke Interventions

This survey included 25 items related to the 5 major components of CSCs (personnel, diagnostic programs, specific expertise, infrastructure, and educational components) and 5 items related to PSC certification (Tables 1 and 2).[2] Personnel were assessed according to 7 categories (eg, board-certified neurologists, board-certified neurosurgeons, and board-certified endovascular physicians). Because the original questions were highly specific, they were modified if necessary. Six advanced neuroimaging capabilities (eg, magnetic resonance imaging [MRI] with diffusion-weighted imaging [DWI] and digital cerebral angiography [DSA]) were investigated based on their availability 24 h/d, 7 d/wk (24/7). The availability of specific expertise for the stroke interventions was examined according to 5 categories (eg, carotid endarterectomy [CEA] and clipping and coiling of IAs). Regarding infrastructure, the availability of 5 items (eg, stroke unit and intensive care unit [ICU]) was surveyed.

Table 1. *Characteristics of the responding hospitals and items of primary stroke care capacity*

Variables	Category	*n*	%
Number of beds	<50	20	2.7
	50-99	30	4
	100-299	232	31
	300-499	260	34.7
	≥500	207	27.6
Academic hospital		90	12
DPC hospital		553	73.8
Geographic locations	MEA-central	381	50.9
	MEA-outlying	239	31.9
	McEA-central	90	12
	McEA-outlying	12	1.6
	Unclassified	27	3.6
PSC component	t-PA protocol	637	85
	t-PA physician*	688	92
	NIHSS*	529	70.7
	Acute stroke team*	198	26.5
	Direct phone with EMS*	435	58.5

Abbreviations: DPC, diagnosis procedure combination; EMS, emergency medical services; MEA, metropolitan employment area; McEA, micropolitan employment area; NIHSS, National Institutes of Health Stroke Scale; PSC, primary stroke center; t-PA, tissue plasminogen activator.

*Data missing: t-PA physician, 1; NIHSS, 1; acute stroke team, 1; direct phone with EMS, 5.

Table 2. *Number (percentage) of responding hospitals (n = 749) with the recommended items of comprehensive stroke care capacity*

Components	Items	*n*	%
Personnel	Neurologists	358	47.8
	Neurosurgeons	694	92.7
	Endovascular physicians	272	36.3
	Critical care medicine	162	21.6
	Physical medicine and rehabilitation	113	15.1
	Rehabilitation therapy	742	99.1
	Stroke rehabilitation nurses*	102	13.8
Diagnostic (24/7)	CT*	742	99.2
	MRI with diffusion	647	86.4
	Digital cerebral angiography*	602	80.8
	CT angiography*	627	84
	Carotid duplex ultrasound*	257	34.5
	TCD*	121	16.2
Specific expertise	Carotid endarterectomy*	603	80.6
	Clipping of IA	685	91.5
	Hematoma removal/ draining	689	91.9
	Coiling of IA	360	48.1
	Intra-arterial reperfusion therapy	498	66.5
Infrastructure	Stroke unit*	132	17.6
	Intensive care unit	445	59.4
	Operating room staffed 24/7*	451	60.4
	Interventional services coverage 24/7	279	37.3
	Stroke registry*	235	31.7
Education	Community education*	369	49.4
	Professional education*	436	58.6

Abbreviations: CT, computed tomography; IA, intracranial aneurysm; MRI, magnetic resonance imaging; TCD, transcranial Doppler.

*Data missing: stroke rehabilitation nurse, 9; CT, 1; digital cerebral angiography, 4; CT angiography, 3; carotid endarterectomy, 1; carotid duplex, 3; TCD, 3; stroke unit, 1; operating room staffed, 2; stroke registry, 7; community education, 2; professional education, 5.

Educational/research programs were assessed according to 2 items (community and professional education). Overall organizational and staffing levels of the hospitals in terms of CSC capacity were scored on the basis of the results of a questionnaire referring to 25 items originally recommended by the Brain Attack Coalition (total CSC score). A score of 1 was assigned for meeting each recommended item, and the maximum total CSC score was 25. Hospital volume of stroke interventions (eg, t-PA infusion, removal of ICH, and clipping and coiling of IAs) performed in 2009 was assessed.

Other Hospital Characteristics

Hospital characteristics pertaining to the number of beds, academic status (university/nonuniversity hospital), participation in the DPC-based payment system, and geographic location were described. The DPC database is a nationwide database in Japan comprising discharge abstract and administrative claim data.[4,5] In 2010, approximately 1388 acute care hospitals in Japan, representing approximately 18% and 50% of the number of hospitals and hospital beds, respectively, adopted the DPC-based payment system.[6] The geographic location of the hospitals was classified according to urban employment areas,[7] which are divided into Metropolitan Employment Areas (MEAs) and Micropolitan Employment Areas (McEAs). The MEAs and McEAs are further classified into central and outlying areas based on the commuting pattern of their inhabitants. These classifications are based on the 2005 population census.[8]

Selection Bias of the Responding Hospitals

To overcome selection bias, we compared the proportion of hospitals that adopted the Japanese DPC-based payment system (DPC hospital) between the responding and nonresponding hospitals. Among the eligible DPC hospitals, we compared the proportion of hospitals that treated more than 10 cases of ischemic stroke (IS), ICH, and subarachnoid hemorrhage between July and December 2008, by using the DPC data from the responding and nonresponding hospitals.

Statistical Analyses

We used Fisher's exact test to detect significant differences in the proportions of hospitals. Kruskal-Wallis and Wilcoxon tests were used to determine differences in categorical and total CSC scores. Multiple linear regression analysis was used to examine the impact of total CSC score and availability of t-PA protocol adjusted for other hospital characteristics on hospital volume of stroke interventions. We also calculated *P* values (2 tailed) for trend across total CSC score categorized into quartiles, and *P* less than .05 was considered significant. Percentages were calculated excluding missing data. SAS version 9.2 (SAS Institute, Inc., Cary, NC) and STATA version 12 (STATA Corp., College Station, TX) were used for all statistical analyses.

Ethics

This research was approved by the Institutional Review Board of the National Cerebral and Cardiovascular Center, which waived the requirement for individual informed consent.

Results

Response Rate and Responding-Hospital Characteristics

In total, 55% (749 hospitals) of the eligible institutions completed the questionnaire. The characteristics of the responding hospitals are shown in Table 1. DPC hospitals represented 65.3% of the eligible hospitals and 73.8% and 55% of the responding and nonresponding hospitals, respectively ($P < .0001$). The response rate of the DPC hospitals was significantly higher than that of the remaining hospitals (61.9% versus 41.3%, $P < .0001$). Among the DPC hospitals, a greater proportion of responding hospitals, rather than nonresponding hospitals, treated more than 10 cases of ICH (65.6% versus 49.9%, $P < .0001$) and subarachnoid hemorrhage (30.7% versus 17%, $P < .0001$) per 6 months but not of IS (79% versus 76.8%, $P = .454$).

Primary Stroke Care Capacity Recommended for PSCs

Written t-PA protocols were available in 85% of hospitals, and the National Institutes of Health Stroke Scale score was routinely documented in 70.7% of hospitals; however, an acute stroke team was available only in 26.5% of hospitals (Table 1).

Comprehensive Stroke Care Capacity Recommended for CSCs

Regarding the recommended personnel components of CSCs, 92.7% of hospitals had a neurosurgeon, 47.8% had a neurologist, and 36.3% had an endovascular physician (Table 2). The proportion of hospitals with critical care medicine physicians and physical medicine and stroke rehabilitation nurses was 21.6% and 15.1% and 13.8%, respectively. The availability of the personnel component ranged from 0 to 7 (median, 3; interquartile range [IQR], 2-4).

Computed tomography (CT), MRI with DWI, DSA, and CT angiography (CTA) were available 24/7 in 99.2%, 86.4%, 80.8%, and 84% of institutions, respectively, whereas carotid duplex ultrasonography and transcranial Doppler (TCD) were available only in 34.5% and 16.2% of hospitals, respectively. The availability of diagnostic components ranged from 0 to 6 (median, 4; IQR, 4-5).

CEA, clipping of IAs, and removal of ICH were available in 80.6%, 91.5%, and 91.9% of hospitals, respectively, whereas coiling of IAs and intra-arterial thrombolysis were available in 48.1% and 66.5% of hospitals, respectively. The availability of surgical and interventional components ranged from 0 to 5 (median, 4; IQR, 3-5).

A stroke unit and an ICU were available in 17.6% and 59.4% of hospitals, respectively. The availability of interventional service coverage on a 24-hour basis was observed in 37.3% of hospitals, whereas an operating room staffed 24/7 was available in 60.4% of hospitals. The availability of infrastructure components ranged from 0 to 5 (median, 2; IQR, 1-3).

Professional and community education were available in 58.6% and 49.4% of institutions, respectively (Table 2). The availability of the educational component ranged from 0 to 2 (median, 1; IQR, 0-2).

Geographical Disparity of Primary and Comprehensive Stroke Care Capacity

Among certified personnels, the proportion of neurologists, interventional physicians, and stroke nurses available at MEA-central institutes was significantly higher ($P < .001$, $P < .001$, and $P = .045$, respectively), whereas neurosurgeons, critical care medicine, and physical medicine were in place, irrespective of the location. Imaging techniques, such as MRI, diffusion-weighted MRI, CTA, digital subtraction angiography, and carotid duplex ultrasonography, were available on a 24-hour basis in similar proportions irrespective of the location, whereas TCD was available in a significantly higher proportion at MEA-central institutes except for TCD ($P = .003$). Specific surgical and interventional services for CEA ($P = .002$), coiling of IAs ($P < .001$), and intra-arterial reperfusion therapy ($P = .04$) were available in a significantly higher proportion at MEA-central institutes. The availability of stroke unit ($P < .001$), operating room staffed, and interventional services on a 24/7 basis ($P < .001$) was significantly more established at MEA-central institutes, whereas no significant differences were found with regard to the ICU. Community ($P = .011$) and professional education ($P = .003$) were more established at MEA-central institutes (Appendix Tables 2 and 3).

Associations between the Implementation of a t-PA Protocol and Comprehensive Stroke Care Capacity

Facilities with t-PA protocols had a higher likelihood of having a neurosurgeon (97.3% versus 66.1%, $P < .0001$), neurologist (51.3% versus 27.7%, $P < .0001$), endovascular physician (41.1% versus 8.9%, $P < .0001$), and physicians in critical care medicine (23.7% versus 9.8%, $P = .0007$) and physical medicine and rehabilitation (16.5% versus 7.1%, $P = .006$) (Table 3). There were no differences in the availability of personnel in rehabilitation therapy ($P = .355$) or of stroke rehabilitation nurses ($P = .695$). Facilities with t-PA protocols had a higher percentage of 24/7 availability of CT (99.5% versus 97.3%, $P = .042$), MRI with DWI (89.6% versus 67.9%, $P < .0001$), DSA (87.4% versus 43.2%, $P < .0001$), carotid duplex ultrasonography (37% versus 19.8%, $P = .0003$), and TCD (18.1% versus 5.4%, $P = .0002$). Moreover, hospitals with a t-PA protocol had greater availability of CEA (87.1% versus 43.8%, $P < .0001$), clipping of IAs (97.2% versus 58.9%, $P < .0001$), removal of ICH (97.5% versus 60.7%, $P < .0001$), coiling of IAs (54% versus 14.3%, $P < .0001$), and intra-arterial thrombolysis (73% versus 29.5%, $P < .0001$) and greater availability of a stroke unit (20.1% versus 3.6%, $P < .0001$), an ICU (63.9% versus

Table 3. *Characteristics of comprehensive stroke care capacity according to the presence or absence of a t-PA protocol*

Variables	t-PA protocol (+) *n*, %		t-PA protocol (−) *n*, %		OR	95% CI	*P* value
Personnel							
Neurologists	327	51.3	31	27.7	2.8	1.8-4.3	<.0001
Neurosurgeons	620	97.3	74	66.1	18.7	10.1-34.8	<.0001
Endovascular physicians	262	41.1	10	8.9	7.1	3.7-13.9	<.0001
Critical care medicine	151	23.7	11	9.8	2.9	1.5-5.5	.0007
Physical medicine and rehabilitation	105	16.5	8	7.1	2.3	1.2-5.4	.006
Rehabilitation therapy	632	99.2	110	98.2	1.14	0.4-12	.355
Stroke rehabilitation nurses	88	14	14	12.6	1.1	0.6-2.1	.695
Diagnostic							
CT*	634	99.5	108	97.3	5.9	1.2-29.5	.042
MRI with diffusion	571	89.6	76	67.9	4.1	2.6-6.6	<.0001
Digital cerebral angiography*	554	87.4	48	43.2	9.1	5.8-14.2	<.0001
CT angiography*	566	89.1	61	55	6.7	4.3-10.5	<.0001
Carotid duplex ultrasound*	235	37	22	19.8	2.4	1.5-3.9	.0003
TCD*	115	18.1	6	5.4	3.9	1.7-9.1	.0002
Specific expertise							
Carotid endarterectomy*	554	87.1	49	43.8	8.7	5.6-13.5	<.0001
Clipping of IA	619	97.2	66	58.9	24	13.1-43.7	<.0001
Hematoma removal/draining	621	97.5	68	60.7	25.1	13.4-46.9	<.0001
Coiling of IA	344	54	16	14.3	7	4.1-12.2	<.0001
Intra-arterial reperfusion therapy	465	73	33	29.5	6.5	4.2-10.1	<.0001
Infrastructure							
Stroke unit*	128	20.1	4	3.6	6.8	2.5-18.8	<.0001
Intensive care unit	407	63.9	38	33.9	3.4	2.3-5.3	<.0001
Operating room staffed 24/7	426	67.1	25	22.3	7.1	4.4-11.4	<.0001
Interventional services coverage 24/7	268	42.1	11	9.8	6.7	3.5-12.7	<.0001
Stroke registry*	229	36.3	6	5.4	10	4.3-23.1	<.0001
Education							
Community education*	348	54.8	21	18.8	5.3	3.2-8.7	<.0001
Professional education*	413	65.2	23	20.7	7.2	4.4-11.7	<.0001

Abbreviations: CI, confidence interval; CT, computed tomography; IA, intracranial aneurysm; MRI, magnetic resonance imaging; OR, odds ratio; TCD, transcranial Doppler.

*Data missing: CT, 1; digital cerebral angiography, 4; carotid U/S, 3; TCD, 3; carotid endarterectomy, 1; stroke unit, 1; stroke registry, 7; community education, 2; professional education, 5.

33.9%, $P < .0001$), an operating room staffed 24/7 (67.1% versus 22.3%, $P < .0001$), interventional service coverage 24/7 (42.1% versus 9.8%, $P < .0001$), and a stroke registry (36.3% versus 5.4%, $P < .0001$). Finally, hospitals with a t-PA protocol had greater availability of professional (65.2% versus 20.7%, $P < .0001$) and community (54.8% versus 18.8%, $P < .0001$) education (Table 3).

Impact of Total CSC Score on Hospital Volume of Stroke Interventions

The total CSC score, which ranged from 0 to 24 (median, 14; IQR, 11-18), was significantly higher in facilities with a t-PA protocol than in other facilities (median, IQR: 15, 12.5-18 versus 9, 5-11; $P < .0001$). On univariate analysis, the implementation of a t-PA protocol and total CSC score categorized into quartiles (Q1, 0-10; Q2, 11-13; Q3, 14-17; and Q4, 18-24) were each significantly associated with hospital volume of stroke interventions, as shown in Table 4. The impact of total CSC score (Q1-Q4) and the implementation of a tPA protocol on the annual case volume of stroke interventions in the participating hospitals was shown in Figure 1. On multiple linear regression analysis, the availability of a t-PA protocol and total CSC score each had a significant impact on the hospital volume of the stroke interventions after adjustment for other hospital characteristics (Appendix Tables 4-6). The inclusion of total CSC score, availability of a t-PA protocol, and other hospital characteristics in the model revealed that total CSC score, but not availability of a t-PA protocol, was significantly associated with the hospital volume of stroke interventions (Table 5).

Discussion

This study demonstrated a significant impact of comprehensive stroke care capacity represented by the total CSC score on the hospital volume of stroke interventions and unique aspects of comprehensive stroke care capacity in Japan.

Table 4. *Impact of the availability of a t-PA protocol and of total CSC score on hospital volume of stroke interventions performed in 2009: hospital volume of stroke interventions based on the availability of a t-PA protocol and on total CSC score (univariate analysis)*

	t-PA protocol			Total CSC score				
	(+)	(−)	*P* value	Q1	Q2	Q3	Q4	*P* value
t-PA infusion	5 (2-11)	0 (0-1)	<.0001	1 (0-3)	4 (1-7)	6 (4-10.5)	10 (5-16)	<.0001
Removal of ICH	7 (3-13)	0 (0-3)	<.0001	2 (0-4)	5 (3-9)	7.5 (3-15)	11.5 (6-18)	<.0001
Clipping of IA	17 (8-29)	0 (0-10)	<.0001	3 (0-11.5)	12 (6-21.25)	18 (10-30)	27 (18-43.75)	<.0001
Coiling of IA	4 (0-13)	0 (0-1)	<.0001	0 (0-1)	1 (0-4)	5.5 (1.25-13)	13 (5-22)	<.0001

Abbreviations: CSC, comprehensive stroke center; IA, intracranial aneurysm; ICH, intracerebral hemorrhage; t-PA, tissue plasminogen activator.

Unique Aspects of Comprehensive Stroke Care Capacity in Japan

This study illustrated several unique aspects of comprehensive stroke care capacity in Japan, for example, higher availability of neurosurgeons (92.7% versus 24%-54% in the United States)[9,10] and endovascular surgeons (36.3% versus 15%-22% in the United States),[9-11] which was in sharp contrast with the relative shortage of neurologists (47.8% versus 31%-73% in the United States) and other personnel.[9-11] In the United States, only 7% of neurosurgeons play an active role in nontraumatic cranial emergencies,[12] whereas in Japan, 59% of the board-certified neurosurgeons are engaged in stroke care. The proportion of Japanese hospitals offering MRI with DWI and CTA corresponded with the gradual increase in the availability of certain special diagnostic tests in the United States, whereas the availability of DSA (80.8%) was in contrast with the temporal decrease in the availability of catheter angiography observed in North Carolina (from 38% in 1998 to 30% in 2008) because of declines in the proportion of hospitals with neurointerventionalists.[11]

A stroke unit/stroke care unit as the critical infrastructure for acute stroke, which has been proven to reduce the number of deaths and long-term dependency,[13] was available in only 17.6% of hospitals in Japan; this was comparable with the proportion observed in hospitals in the United States (6.6%-28%).[9-11,14]

To determine the relationship between primary and comprehensive stroke care capacity, we used the implementation of a written t-PA protocol as a key item of primary stroke care capacity[1] as it is a key step in reducing t-PA–related complications.[15] The availability of a t-PA protocol (85%) recorded in the present study was comparable with that reported in 2 US statewide studies performed in Illinois in 2000 (72.8%)[9] and in North Carolina between 1998 (43%) and 2008 (69%).[11] Notably, facilities with a t-PA protocol in Japan had a higher availability of nearly all (92%) recommended items of comprehensive stroke care capacity, with the exception of personnel in rehabilitation therapy and stroke rehabilitation nurses. In a previous study performed in the United States,[9] however, no significant differences were noted in the availability of a larger number of critical items corresponding to the CSC items in this study (eg, endovascular physicians, CTA, conventional cerebral angiography, carotid duplex ultrasound, intra-arterial thrombolysis, stroke unit, and community stroke awareness program) according to the presence or absence of a t-PA protocol. Therefore, comprehensive stroke care capacity tended to coexist in hospitals with primary stroke care capacity in Japan than in the United States. A relatively larger commitment of neurosurgeons in acute stroke care (eg, t-PA infusion) in Japan may explain such a coexistence.

Table 5. *Impact of the availability of a t-PA protocol and of total CSC score on hospital volume of stroke interventions performed in 2009: multivariate linear regression analysis of the impact of total CSC score and availability of a t-PA protocol on hospital volume of stroke interventions*

	β	*P* value	95% CI	
tPA				
Total CSC score	.83	<.001	.67	.98
tPA protocol (+)	−1.31	.117	−2.95	.33
ICH				
Total CSC score	.97	<.001	.76	1.18
tPA protocol (+)	−1.17	.297	−3.36	1.03
Clipping				
Total CSC score	2.23	<.001	1.68	2.79
tPA protocol (+)	−4.33	.146	−10.17	1.51
Coiling				
Total CSC score	1.20	<.001	.92	1.48
tPA protocol (+)	−1.01	.496	−3.92	1.90

Abbreviations: CI, confidence interval; CSC, comprehensive stroke center; IA, intracranial aneurysm; ICH, intracerebral hemorrhage; t-PA, tissue plasminogen activator; Total CSC score, availability of a t-PA protocol, and other hospital characteristics were included in the model as independent variables.

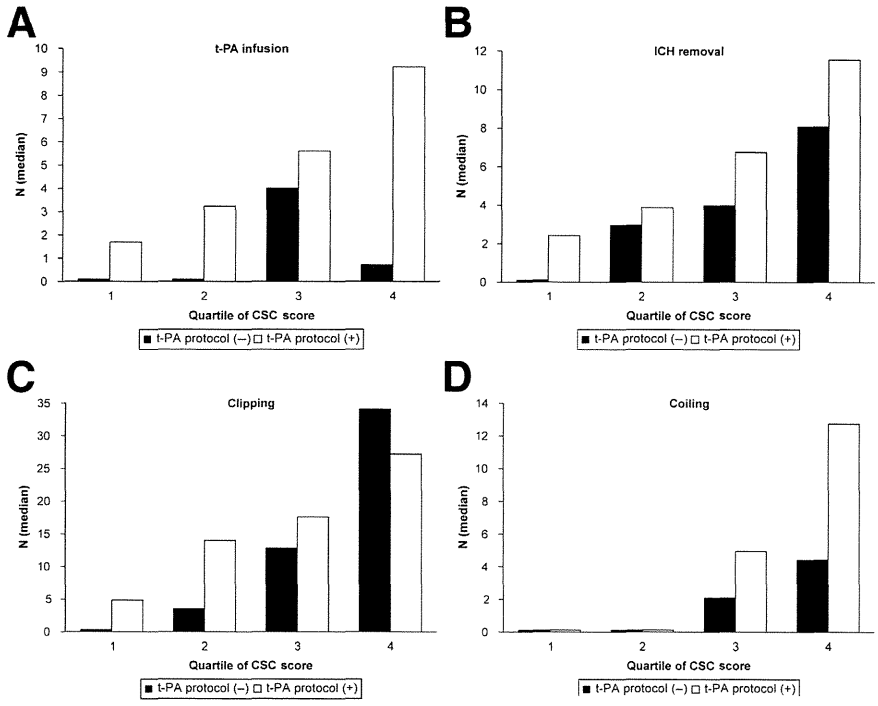

Figure 1. *A bar graph showing the impact of total CSC score (Q1-Q4) and the implementation of a tPA protocol on the annual case volume of stroke interventions (A, t-PA infusion; B, ICH removal; C, clipping; and D, coiling of intracranial aneurysms) in the participating hospitals. Abbreviations: CSC, comprehensive stroke center; t-PA, tissue plasminogen activator.*

Geographical Disparity of Primary and Comprehensive Stroke Care in Japan

These findings could assist in identifying underserved, high-population density areas that may benefit from professional and hospital education by national organizations, such as the Japan Stroke Society and Japan Neurosurgical Society. In light of insufficient advanced acute stroke capacities, these findings represent fundamental information for the establishment of a spoke-and-hub stroke care system.[2] Such a system could maximize use of acute reperfusion therapies for IS and surgical/endovascular management of hemorrhagic stroke, depending on the personnel and specific expertise of the hospital and the geographical access of the potential population in Japan.

The Impact of Comprehensive Stroke Care Capacity on the Hospital Volume of Stroke Interventions

The present study demonstrated a significant impact of comprehensive stroke care capacity, as represented by the total CSC score, but not the availability of a t-PA protocol, on the hospital volume of stroke interventions performed in Japan in 2009, after adjustment for other hospital characteristics. High volume is associated with better outcomes across a wide range of procedures and conditions; however, the magnitude of the association varies greatly.[16] High annual hospital volume was reported to be consistently associated with lower IS mortality.[17] In the field of comprehensive stroke care, in-hospital mortality increases when the annual number of craniotomies for aneurysms is lower than 30[18] and when CEA is performed by less experienced surgeons (<5 procedures/y).[19] Conversely, a previous Japanese nationwide study found no correlation between case volume and outcome after cerebral aneurysm clipping.[20] The mechanism via which volume influences outcomes remains uncertain. Specific processes of care, which are correlated with volume, are the most likely explanatory factors.[16] The strong associations between comprehensive stroke care capacity and hospital volume of the stroke interventions observed in this study may support this notion. Further studies are necessary to establish the association between comprehensive stroke care capacity and in-hospital mortality after all types of stroke. If such association is established, as recently reported for PSC,[21] the total CSC score may be used as a quality indicator of comprehensive stroke care capacity for benchmarking purposes.

Limitations

This study was likely to have included a potential information bias (self-report, recall, and nonresponse). Hospitals actively working to improve stroke care are more likely to respond to the questionnaire. The fact that a greater proportion of the responding DPC hospitals treated more than 10 cases of hemorrhagic stroke in the latter half of the previous year than did the nonresponding DPC hospitals may support such selection bias. We did not attempt to assess the self-report bias as no official information was available that could have been used to verify the data.

Conclusion

The present study demonstrated a significant impact of comprehensive stroke care capacity, as represented by the total CSC score on the hospital volume of stroke

interventions and unique aspects of comprehensive stroke care capacity in Japan.

References

1. Alberts MJ, Hademenos G, Latchaw RE, et al. Recommendations for the establishment of primary stroke centers. Brain Attack Coalition. JAMA 2000;283:3102-3109.
2. Alberts MJ, Latchaw RE, Selman WR, et al. Recommendations for comprehensive stroke centers: a consensus statement from the Brain Attack Coalition. Stroke 2005; 36:1597-1616.
3. Leifer D, Bravata DM, Connors JJ III, et al. Metrics for measuring quality of care in comprehensive stroke centers: detailed follow-up to Brain Attack Coalition comprehensive stroke center recommendations: a statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2011;42:849-877.
4. Kadono Y, Yasunaga H, Horiguchi H, et al. Statistics for orthopedic surgery 2006-2007: data from the Japanese Diagnosis Procedure Combination database. J Orthop Sci 2010;15:162-170.
5. Shoda N, Yasunaga H, Horiguchi H, et al. Risk factors affecting in-hospital mortality after hip fracture: retrospective analysis using the Japanese Diagnosis Procedure Combination Database. BMJ Open 2012;2. http://dx.doi.org/10.1136/bmjopen-2011-000416.
6. Current status of DPC hospitals [online]. Available at: http://www.mhlw.go.jp/stf/shingi/2r9852000000bartatt/2r9852000000bc5v.pdf. Accessed January 19, 2013.
7. Kanemoto Y, Kurima R. Urban employment areas: defining Japanese metropolitan areas and constructing the statistical database for them. In: Okabe A, ed. GIS-based studies in the humanities and social sciences. Boca Raton, FL: CRC Taylor & Francis 2006:85-97.
8. Population census [online]. Available at: http://www.stat.go.jp/english/data/kokusei/2005/outline.htm. Accessed September 15, 2013.
9. Ruland S, Gorelick PB, Schneck M, et al. Acute stroke care in Illinois: a statewide assessment of diagnostic and treatment capabilities. Stroke 2002;33:1334-1339.
10. Shultis W, Graff R, Chamie C, et al. Striking rural-urban disparities observed in acute stroke care capacity and services in the pacific northwest: implications and recommendations. Stroke 2010;41:2278-2282.
11. Goldstein LB. Statewide hospital-based stroke services in North Carolina: changes over 10 years. Stroke 2010; 41:778-783.
12. Seaver MJ. Baseline ER survey explores system's cracks: 2004 AANS/CNS neurosurgical emergency and trauma services survey [online]. Available at: http://www.aans.org/Media/Article.aspx?ArticleId=26367. Accessed January 23, 2013.
13. Organised inpatient (stroke unit) care for stroke. Cochrane Database Syst Rev 2007. CD000197.
14. Kidwell CS, Shephard T, Tonn S, et al. Establishment of primary stroke centers: a survey of physician attitudes and hospital resources. Neurology 2003;60:1452-1456.
15. Albers GW, Bates VE, Clark WM, et al. Intravenous tissue-type plasminogen activator for treatment of acute stroke: the Standard Treatment with Alteplase to Reverse Stroke (STARS) study. JAMA 2000;283:1145-1150.
16. Halm EA, Lee C, Chassin MR. Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. Ann Intern Med 2002;137:511-520.
17. Saposnik G, Baibergenova A, O'Donnell M, et al. Hospital volume and stroke outcome: does it matter? Neurology 2007;69:1142-1151.
18. Solomon RA, Mayer SA, Tarmey JJ. Relationship between the volume of craniotomies for cerebral aneurysm performed at New York state hospitals and in-hospital mortality. Stroke 1996;27:13-17.
19. Hannan EL, Popp AJ, Tranmer B, et al. Relationship between provider volume and mortality for carotid endarterectomies in New York state. Stroke 1998;29: 2292-2297.
20. Hattori N, Katayama Y, Abe T. Case volume does not correlate with outcome after cerebral aneurysm clipping: a nationwide study in Japan. Neurol Med Chir (Tokyo) 2007;47:95-100. discussion 1.
21. Lichtman JH, Jones SB, Wang Y, et al. Outcomes after ischemic stroke for hospitals with and without Joint Commission-certified primary stroke centers. Neurology 2011;76:1976-1982.

Appendix Table 1. *List of the responding hospitals*

Abashiri Neurosurgical Rehabilitation Hospital
Ageo Central General Hospital
Aichi Medical University Hospital
Aidu Chuo Hospital
Aizawa Hospital
Akiba Hospital
Akiru Municipal Medical Center
Akita General Hospital
Akita Kumiai General Hospital
Akita Rosai Hospital
Akita University Hospital
Ako Central Hospital
Ako City Hospital
Almeida Memorial Hospital
Amakusa Medical Center
Anji Kosei Hospital
Aomori Kyoritsu Hospital
Aomori Municipal Hospital
Aomori Rosai Hospital
Aoyama Hospital
Araki Neurosurgical Hospital
Arao City Hospital
Arita Kyouritsu Hospital
Asahikawa Medical University Hospital
Asahikawa Red Cross Hospital
Asao General Hospital
Ashikaga Red Cross Hospital
Atsumi Hospital
Ayabe City Hospital
Azuma Neurosurgical Hospital
Azumi General Hospital
Azumino Red Cross Hospital
Baba Memorial Hospital
Bellland General Hospital
Beppu Medical Center, National Hospital Organization
Bizen Municipal Hospital
Central Gunma Neurosurgical Hospital
Chiba Cardiovascular Center
Chiba Central Medical Center
Chiba Emergency Medical Center
Chiba Neurosurgical Clinic
Chiba University Hospital
Chichibu City Hospital
Chigasaki City Hospital
Chikamori Hospital
Chubu-Tokusyukai Hospital
Chugoku Rousai Hospital
Chuno Kosei Hospital
Daiichi Hospital
Daini Okamoto General Hospital
Daiwa Hospital
Dohtoh Neurosurgical Hospital
Dokkyo Medical University Hospital
Ehime Prefectural Central Hospital
Ehime Prefectural Imabari Hospital
Ehime University Hospital
Enshu Hospital
Fuchu Hospital

(*Continued*)

Appendix Table 1. *(Continued)*

Fuji Brain Institute and Hospital
Fuji City General Hospital
Fujii Neurosurgical Hospital
Fujimoto Hayasuzu Hospital
Fujisawa City Hospital
Fujisawa Neurosurgical Hospital
Fujita General Hospital
Fujita Health University Hospital
Fujiyoshida Municipal Medical Center
Fukaya Red Cross Hospital
Fukui Red Cross Hospital
Fukui General Hospital
Fukui Kosei Hospital
Fukui Social Insurance Hospital
Fukui University Hospital
Fukuoka City Hospital
Fukuoka Kieikai Hospital
Fukuoka Seishukai Hospital
Fukuoka Shin Mizumaki Hospital
Fukuoka Tokushukai Medical Center
Fukuoka University Hospital
Fukuroi Municipal Hospital
Fukushima Medical University Hospital
Fukushima Prefectural Aizu General Hospital
Fukushima Red Cross Hospital
Fukushima Takanori Memorial Hospital
Furukawa Seiryo Hospital
Fussa Hospital
Gamagohri City Hospital
Geriatrics Research Institute and Hospital
Gifu Central Hospital
Gifu Municipal Hospital
Gifu Prefectural General Medical Center
Gifu Prefectural Tajimi Hospital
Gifu University Hospital
Goshi Hospital
Gunma University Hospital
Hachinohe Heiwa Hospital
Hachisuga Hospital
Hakodate Neurosurgical Hospital
Hakodate Shintoshi Hospital
Hakuai Hospital
Hakuo-kai Sumi Hospital
Hamamatsu Medical Center
Hamamatsu University School of Medicine, University Hospital
Hamamatu Rosai Hospital
Hamanomachi Hospital
Hanwa Memorial Hospital
Harada Hospital
Hashima City Hospital
Hata Kenmin Hospital
Hayashi Hospital
Health Insurance Amakusa Chuo General Hospital
Health Insurance Nankai Hospital
Health Insurance Naruto Hospital
Heart Life Hospital
Heisei Memorial Hospital

(*Continued*)

Appendix Table 1. *(Continued)*

Heisei Neurosurgical Hospital
Hibino Hospital
Hidaka General Hospital
Higashimatsuyama Medical Association Hospital
Higashiyamato Hospital
Hikone Municipal Hospital
Himeji Central Hospital
Himi Municipal Hospital
Hiratsuka City Hospital
Hirosaki University Hospital
Hiroshima City Asa Hospital
Hiroshima General Hospital
Hiroshima Prefectural Hospital
Hiroshima Red Cross Hospital and Atomic-bomb Survivors Hospital
Hiroshima University Hospital
Hokkaido Neurosurgical Memorial Hospital
Hokkaido University Hospital
Hokushin General Hospital Nagano Prifectural Fideration of Agricultural Cooperatives for Health and Welfare
Hokushinkai Megumono Hospital
Hokuto Hospital
Hoshigaoka Koseinenkin Hospital
Houetsu Hospital
Hskinan Municipal Hospital
Hyogo Brain and Heart Center
Hyogo Prefectural Amagasaki Hospital
Hyogo Prefectural Awaji Hospital
Hyogo Prefectural Nishinomiya Hospital
Ibaraki Prefectural Central Hospital
Ibaraki Seinan Medical Center Hospital
Ibi Kousei Hospital
Ichinomiya Neurosurgery Hospital
Ichinomiya West Hospital
Ichinose Hospital
Iida Municipal Hospital
Iizuka Hospital
Ikeda Neurosurgical Center Hospital
Ikuwakai Memorial Hospital
Imakiire General Hospital
Imamura Bun-in Hospital
Inagi Municipal Hospital
International University of Health and Welfare ATAMI HOSPITAL
Inuyama Chuo Hospital
Iseikai Hospital
Iseikai Yahata Central Hospital
Isesaki Municipal Hospital
Ishikawa Prefectural Central Hospital
Ishinkai Yao General Hospital
Ishinomaki City Hospital
Ishioka Dai-Ichi Hospital
Isogo Central Hospital
Itami Kousei Neurosurgical Hospital
Itoigawa General Hospital
Itsukaichi Memorial Hospital
Iwaki Kyoritsu Hospital
Iwamizawa Municipal General Hospital

(Continued)

Appendix Table 1. *(Continued)*

Iwata City Hospital
Iwate Medical University Hospital
Iwate Prefectural Iwai Hospital
Iwate Prefectural Ninohe Hospital
Iwate Prefecturel Isawa Hospital
Izumi General Medical Center
Izumino Hospital
Izumu Municipal Hospital
JA Kochi Hospital
JA Toride Medical Center
Japan Medical Alliance Higashi Saitama General Hospital
Japanese Red Cross Hadano Hospital
Japanese Red Cross Kitami Hospital
Japanese Red Cross Kobe Hospital
Japanese Red Cross Kochi Hospital
Japanese Red Cross Koga Hospital
Japanese Red Cross Kyoto Daini Hospital
Japanese Red Cross Medical Center
Japanese Red Cross Nagasaki Genbaku Hospital
Japanese Red Cross Ogawa Hospital
Japanese Red Cross Society Hachinohe Medical Center
Japanese Red Cross Society Himeji Hospital
Jiaikai Kajiura Hospital
Jichi Medical University Hospital
JR Tokyo General Hospital
Junshin Hospital
Juntendo University Hospital
Juntendo University Nerima Hospital
Juntendo University Urayasu Hospital
Junwakai Kinen Hospital
Juzenkai Hospital
Jyuzen General Hospital
Kaga City Hospital
Kagawa Prefectural Central Hospital
Kagawa Rosai Hospital
Kagawa University Hospital
Kagoshima City Hospital
Kagoshima prefectural Oshima Hospital
Kagoshima Tokushukai Hospital
Kagoshima University Medical and Dental Hospital
Kainan Hospital
Kaiseikai Onishi Hospital
Kakegawa Municipal General Hospital
Kakizoe Hospital
Kakogawa City Hospital
Kameda Medical Center
Kameoka Shimizu Hospital
Kamiichi General Hospital
Kamitsuga General Hospital
Kanazawa Medical University Hospital
Kanazawa Municipal Hospital
Kanazawa Neurosurgical Hospital
Kanazawa University Hospital
Kanetsu Hospital
Kanoya Medical Center
Kansai Medical University Takii Hospital
Kanto Central Hospital for Public School Teachers
Kantoh Neurosurgical Hospital

(Continued)

Appendix Table 1. *(Continued)*

Karatsu Red Cross Hospital
Kariya Toyota General Hospital
Kasai Cardiology Neurosurgery Hospital
Kasaoka Daiichi Hospital
Kashima Rosai Hospital
Kashiwaba Neurosurgical Hospital
Kashiwazaki General Hospital and Medical Center
Kasugai Municipal Hospital
Kasukabe Chuo General Hospital
Katagi Neurosurgical Hospital
Katano Hospital
Katsuta Hospital
Kawachi General Hospital
Kawakita General Hospital
Kawano Neurosurgical Hospital
Kawasaki Hospital
Kawasaki Medical School Hospital
Kawasaki municipal Hospital
Kawasaki Municipal Tama Hospital
Kawasakisaiwai Hospital
Kazuno Kosei Hospital
Keijin Kai Kawasaki Hospital
Keiwakai Ebetsu Hospital
Kenwakai Otemachi Hospital
Kimitsu Chuo Hospital
Kinan Hospital
Kinki University Hospital
Kiryuu Kohsei General Hospital
Kishiwada Tokushukai Hospital
Kitakyushu Municipal Medical Center
Kitamurayama Hospital
Kitano Hospital
Kizawa Memorial Hospital
KKR Sapporo Medical Center
Kobari General Hospital
Kobe University Hospital
Kochi Health Sciences Center
Kochi Medical School Hospital
Kofu Jonan Hospital
Kofu Municipal Hospital
Kofu Neurosurgical Hospital
Kohka Public Hospital
Kohnan Hospital
Kokubu Neurosurgical Clinic
Kokura Memorial Hospital
Komaki City Hospital
Komatsu Municipal Hospital
Komono Kosei Hospital
Konan Kosei Hospital
Konan Tobu General Hospital
Kosei Hospital
Koshigaya Municipal Hospital
Koto Memorial Hospital
Kousei General Hospital
Kouseikai Takai Hospital
Kouseiren Murakami Hospital
Kugayama Hospital
Kumamoto City Hospital

(Continued)

Appendix Table 1. *(Continued)*

Kumamoto Red Cross Hospital
Kumamoto Rousai Hospital
Kumamoto Takumadai Hospital
Kumamoto University Hospital
Kurashiki Central Hospital
Kurashiki Heisei Hospital
Kure Kyosai Hospital
Kurobe City Hospital
Kuroishi City Hospital
Kurosawa Hospital
Kurosu Hospital
Kurume University Hospital
Kusatsu General Hospital
Kushiro Kojinkai Memorial Hospital
Kushiro Rosai Hospital
Kuwana Hospital
Kuwana West Medical Center
Kyorin University Hospital
Kyoritsu General Hospital
Kyosai Tachikawa Hospital
Kyoto City Hospital
Kyoto Kujo Hospital
Kyoto Min-iren Chuo Hospital
Kyushu University Hospital
Machida Municipal Hospital
Maebashi Red Cross Hospital
Makita General Hospital
Masu Memorial Hospital
Matsudo City Hospital
Matsunami General Hospital
Matsushita Memorial Hospital
Matsuyama Red Cross Hospital
Matsuyama Shimin Hospital
Mattoh-Ishikawa Central Hospital
Mazda Hospital
Medical Corporation Kawamura Society Kubokawa Hospital
Meisei Hospital
Meitetsu Hospital
Midorigaoka Hospital
Mie Prefectural General Medical Center
Mie University Hospital
Mihara Memorial Hospital
Minamata City General Hospital and Medical Center
Minamisoma City General Hospital
Minase Hospital
Mine City Hospital
Minei Daiichi Hospital
Mino Municipal Hospital
Minoh City Hospital
Mishuku Hospital
Mishuku Hospital
Mito Medical Center
Mito Saiseikai General Hospital
Mitoyo General Hospital
Mitsugi General Hospital
Miyakonojo Regional Medical Center
Miyoshi Central Hospital

(Continued)

Appendix Table 1. *(Continued)*

Mizushima Central Hospital
Morioka JRC Hospital
Moriya-daiichi General Hospital
Murakami Memorial Hospital Asahi University
Murata Hospital
Muroran City General Hospital
Musashino General Hospital
Nadogaya Hospital
Naga District Hospital
Nagahama City Hospital
Nagahama Red Cross Hospital
Nagano Municipal Hospital
Nagano Prefectural Kiso Hospital
Nagano Prefectural Suzaka Hospital
Nagano Red Cross Hospital
Nagaoka Chuo General Hospital
Nagaoka Red Cross Hospital
Nagareyama Central Hospital
Nagasaki Kawatana Medical Center
Nagasaki Municipal Hospital
Nagasaki Prefecture Shimabara Hospital
Nagasaki University Hospital
Nagatomi Neurosurgical Hospital
Nagoya Daini Red Cross Hospital
Nagoya Ekisaikai Hospital
Nagoya Medical Center
Nagoya Memorial Hospital
Nagoya University Hospital
Naha City Hospital
Nakamura Memorial Hospital
Nakamura Memorial South Hospital
Nakano General Hospital
Nakatsu Gastrointestinal Hospital
Namegata District General Hospital
Nanbu Tokushukai Hospital
Nantan General Hospital
Nantan General Hospital
Nara City Hospital
Nara Medical University Hospital
Nara Prefectural Hospital
Nara Prefectural Mimuro Hospital
Narita Red Cross Hospital
Nasu Neurosurgical Hospital
Nasu Red Cross Hospital
National Cancer Center Hospital
National Center for Child Health and Development
National Center for Global Health and Medicine
National Cerebral and Cardiovascular Center
National Disaster Medical Center
National Fukuoka-Higashi Medical Center
National Hospital Organization Chiba Medical Center
National Hospital Organization Hamada Medical Center
National Hospital Organization Himeji Medical Center
National Hospital Organization Kanazawa Medical Center
National Hospital Organization Kanmon Medical Center
National Hospital Organization Kobe Medical Center

(Continued)

Appendix Table 1. *(Continued)*

National Hospital Organization Kumamoto Medical Center
National Hospital Organization Kure Medical Center
National Hospital Organization Maizuru Medical Center
National Hospital Organization Minami Wakayama Medical Center
National Hospital Organization Nagasaki Medical Center
National Hospital Organization Nara Medical Center
National Hospital Organization Okayama Medical Center
National Hospital Organization Osaka Minami Medical Center
National Hospital Organization Saitama National Hospital
National Hospital Organization Shizuoka Medical Center
National Hospital Organization Takasaki General Medical Center
National Hospital Organization Ureshino Medical Center
National Hospital Organization Utano Hospital
National Hospital Organization Yokohama Medical Center
National Kyushu Medical Center
Nayoro City General Hospital
Nihon University Itabashi Hospital
Niigata City General Hospital
Niigata Minami Hospital
Niigata Neurosurgical Hospital and Brain Research Center
Niigata Prefectural Cancer Center Hospital
Niigata Prefectural Central Hospital
Niigata Prefectural Shibata Hospital
Niigata Prefectural Tokamachi Hospital
Niigata Rosai Hospital
Niigata University Medical and Dental Hospital
Nippon Medical School Chiba Hokusoh Hospital
Nippon Medical School Hospital
Nippon Medical School Musashi Kosugi Hospital
Nippon Medical School Tama-Nagayama Hospital
Nipponbashi Hospital
Nishi-Agatsuma Welfare Hospital
Nishi-Kobe Medical Center
Nishinara Tyuou Hospital
Nishinomiya Kyoritsu Neurosurgical Hospital
Nishio Municipal Hospital
Nishisaitama-chuo National Hospital
Nishiwaki Municipal Hospital
North Fukushima Medical Center
North Osaka Police Hospital
NTT Medical Center Tokyo
Obara Hospital
Obihiro-Kosei General Hospital
Odate Municipal General Hospital
Odawara Municipal Hospital
Oe Kyodou Hospital
Ofunato Hospital
Ogachi Central Hospital
Ogaki Municipal Hospital
Ogori Daiichi General Hospital

(Continued)

Appendix Table 1. *(Continued)*

Ohda Municipal Hospital
Ohkawara Neurosurgical Hospital
Ohmiya Chuo General Hospital
Ohnishi Neurological Center
Ohta General Hospital
Oita Prefectural Hospital
Oita University Hospital
Oita-Oka-Hospital
Okayama City Hospital
Okayama East Neurosurgical Clinic
Okayama Kyokuto Hospital
Okayama Kyoritsu General Hospital
Okayama Rosai Hospital
Okayama University Hospital
Okazaki City Hospital
Okinawa Chubu Hospital
Okinawa Hokubu Hospital
Okinawa Kyodo Hospital
Okinawa Prefectural Miyako Hospital
Okinawa Prefectural Nanbu Medical Center and Children's Medical Center
Okinawa Prefectural Yaeyama Hospital
Okitama Public General Hospital
Okyama East Neurosurgical clinic
Omihachiman Community Medical Center
Omori Red Cross Hospital
Omuta City Hospital
Ooi-Byouin
Ookuma Hospital
Ota Memorial Hospital
Osaka City General Hospital
Osaka City University Hospital
Osaka General Medical Center
Osaka Kosei-Nenkin Hospital
Osaka Medical Center
Osaka Medical College Hospital
Osaka Mishima Critical Care Medical Center
Osaka Neurological Institute
Osaka Neurosurgical Hospital
Osaka Police Hospital
Osaka Prefectural Senshu Critical Care Medical Center
Osaka Red Cross Hospital
Osaka Rosai Hospital
Osaka University Hospital
Otemae Hospital
Otsu Municipal Hospital
Research Institute for Brain and Blood Vessels Akita
Rumoi Central Clinic
Sadamoto Hospital
Saga Prefectural Hospital Koseikan
Saga Social Insurance Hospital
Sagamihara Kyodo Hospital
Sagamihara–chuo Hospital
Saisei-kai Yokohama-shi Nanbu Hospital
Saiseikai Central Hospital
Saiseikai Fukuoka General Hospital
Saiseikai Gose Hospital
Saiseikai Hita Hospital

(Continued)

Appendix Table 1. *(Continued)*

Saiseikai Hyuga Hospital
Saiseikai Imabari Hospital
Saiseikai Kumamoto Hospital
Saiseikai Kurihashi Hospital
Saiseikai Kyoto Hospital
Saiseikai Matsusaka General Hospital
Saiseikai Matsuyama Hospital
Saiseikai Nagasaki Hospital
Saiseikai Nakatsu Hospital
Saiseikai Nara Hospital
Saiseikai Noe Hospital
Saiseikai Saijo Hospital
Saiseikai Shimonoseki General Hospital
Saiseikai Toyama Hospital
Saiseikai Utsunomiya Hospital
Saiseikai Yahata General Hospital
Saiseikai Yamaguchi Hospital
Saiseikai Yokohanashi Tobu Hospital
Saiseikai-Chuwa Hospital
Saitama Cancer Center Hospital
Saitama Cardiovascular and Respiratory Center
Saitama Medical Center
Saitama Medical Center Jichi Medical University
Saitama Medical University Hospital
Saitama Medical University International Medical Center
Saitama Municipal Hospital
Saito Memorial Hospital
Sakai City Hospital
Sakai Hospital Kinki University Faculty of Medicine
Sakaide Municipal General Hospital
Saku Central Hospital
Sakura General Hospital
Sakurakai Hospital
Sanda City Hospital
Sankoukai Miyazaki Hospital
Sannocho Hospital
Sano Kousei General Hospital
Sanyudo Hospital
Sapporo City General Hospital
Sapporo Higashi-Tokushukai Hospital
Sasebo Chuo Hospital
Sasebo City General Hospital
Sayama Hospital
Seguchi Neurosurgery Hospital
Seirei Hamamatsu General Hospital
Seirei Memorial Hospital
Seirei Mikatagahara General Hospital
Seirei Yokohama Hospital
Seiyu Memorial Hospital
Sendai City Hospital
Sendai Medical Association Hospital
Sendai Open Hospital
Senpo Tokyo Takanawa Hospital
Senseki Hospital
Shakaihoken Kobe Central Hospital
Shakaihoken Shimonoseki Kosei Hospital
Shiga Medical Center for Adults
Shiga University of Medical Science Hospital

(Continued)

Appendix Table 1. *(Continued)*

Shimada City Hospital
Shimane Prefectural Central Hospital
Shimane University Hospital
Shimonoseki City Hospital
Shimotsuga General Hospital
Shin Koga Hospital
Shin Yukuhashi Hospital
Shin-Tokyo Hospital
Shingu Municipal Medical Center
Shinko Hospital
Shinoda General Hospital
Shinonoi General Hospital
Shinrakuen Hospital
Shinseikai Toyama Hospital
Shinshu Ueda Medical Center
Shinsuma Hospital
Shirahama Hamayu Hospital
Shirakawa Kosei General Hospital
Shiroishi neurosurgical Hospital
Shiroyama Hospital
Shiseikai Daini Hospital
Shizuoka Children's Hospital
Shizuoka City Hospital
Shizuoka General Hospital
Shobara Red Cross Hospital
Shonai Hospital
Shonan Kamakura General Hospital
Showa General Hospital
Showa Inan General Hospital
Showa University Fujigaoka Hospital
Showa University Hospital
Social Insurance Chukyo Hospital
Social Insurance Chuo General Hospital
Social Insurance Takahama Hospital
Soseikai General Hospital
South Miyagi Medical Center
Southern Tohoku General Hospital
St Marianna University School of Medicine Toyoko Hospital
St Francisco Hospital
St Marianna University School of Medicine Hospital
Steeel Memorial Hirohata Hospital
Steel Memorial Yawata Hospital
Suiseikai Kajikawa Hospital
Suita Municipal Hospital
Suwa Central Hospital
Suwakohan Hospital
Suzuka Kaisei Hospital
Tachikawa Medical Center
Takada Chuo Hospital
Takamatsu Municipal Hospital
Takamatsu Red Cross Hospital
Takarazuka City Hospital
Takarazuka Daiichi Hospital
Takashima Municipal Hospital
Takatsuki General Hospital
Takeda General Hospital
Takikawa Neurosurgery Hospital

(Continued)

Appendix Table 1. *(Continued)*

Tama-Hokubu Medical Center
Tama-Nanbu Chiiki Hospital
Tamana Central Hospital
Tane General Hospital
Tano Hospital
Tanushimaru Central Hospital
Tatebayashi Kosei Hospital
Teiko University Chiba Medical Center
Teikyo University School of Medicine Hospital, Mizonokuchi
Tekeda Hospital
Tenshindo Hetsugi Hospital
The Taiju-Kai Foundation Social Medical Corporation Kaisei General Hospital
Tochigi National Hospital
Toho University Ohashi Medical Center
Tohoku KoseiNenkin Hospital
Tokai Central Hospital of the Mutual Aid Association of Public School Teachers
Tokai University Hachioji Hospital
Tokai University Hospital
Tokai University Oiso Hospital
Toki General Hospital
Tokuda Neurosurgical Hospital
Tokushima Prefectural Central Hospital
Tokushima Prefectural Kaifu Hospital
Tokushima University Hospital
Tokuyama Central Hospital
Tokyo Kyosai Hospital
Tokyo Medical And Dental University Hospital Faculity of Medicine
Tokyo Medical University Hospital
Tokyo Medical University Ibaraki Medical Center
Tokyo Metropalitan Hiroo Hospital
Tokyo Metropolitan Health and Medical Corporation Toshima Hospital
Tokyo Metropolitan Ohtsuka Hospital
Tokyo Metropolitan Police Hospital
Tokyo Women's Medical University Hospital
Tokyo Women's Medical University Yachiyo Medical Center
Tokyo Women's University Medical Center East
Tokyo-Teishin Hospital
Tokyo-West Tokushukai Hospital
Tokyu Medical University Hachioji Medical Center
Tomakomai Neurosurgical Hospital
Tomakomai Nissho Hospital
Tomei Atsugi Hospital
Tominaga Hospital
Tomioka General Hospital
Tonami General Hospital
Tone Central Hospital
Tosei General Hospital
Tottori Pref.Kousei Hospital
Tottori Red Cross Hospital
Tottori Seikyo Hospital
Tottori University Hospital
Toyama City Hospital

(Continued)

Appendix Table 1. *(Continued)*

Toyama Prefectural Central Hospital
Toyama Rosai Hospital
Toyohashi Medical Center
Toyokawa City Hospital
Toyooka Chuo Hospital
Toyooka Public Hospitals' association Toyooka Hospital
Toyota Kosei Hospital
Tsuchiura Kyodo General Hospital
Tsukazaki Hospital
Tsukuba Medical Center Hospital
Tsushima City Hospital
Tsuyama Central Hospital
Ube Industries, ltd. Central Hospital
Ueyama Hospital.
Ugadake Hospital
University Hospital of the Ryukyus
University of Miyazaki Hospital
University of Tokyo Hospital
University of Tsukuba Hospital
University of Yamanashi Hospital
Urasoe General Hospital
Ushiku Aiwa General Hospital
Ushioda General Hospital
Uwajima City Hospital
Uwajima Tokushukai Hospital
Veritas Hospital
Wada Hospital
Wakakusa Dai-ichi Hospital
Wakayama Co-operative Hospital
Wakayama Medical University Hospital
Wakayama Medical University Kihoku Hospital
Wakayama Rosai Hospital
Wakayama Saiseikai Hospital
Yaentoge Neurosurgery Hospital
Yagi Neurosurgical Hospital
Yaizu City General Hospital
Yamachika Memorial Hospital
Yamada Kinen Hospital
Yamada Red Cross Hospital
Yamagata City Hospital Saiseikan
Yamagata Prefectural Kahoku Hospital
Yamagata Prefectural Shinjo Hospital
Yamagata University Hospital
Yamaguchi Grand Medical Center
Yamaguchi Red Cross Hospital
Yamaguchi Rousai Hospital
Yamaguchi University Hospital
Yamamoto Memorial Hospital
Yamanashi Kosei Hospital
Yamanashi Prefectural Central Hospital
Yamanashi Red Cross Hospital
Yamashiro Public Hospital
Yamato Municipal Hospital
Yao Tokushukai General Hospital
Yasugi municipal Hospital
Yatsuo General Hospital
Yatsushiro Health Insurance General Hospital
Yahata General Hospital

(Continued)

Appendix Table 1. *(Continued)*

Yayoigaoka Hospital
Yodogawa Christian Hospital
Yokkaichi Municipal Hospital
Yokohama Central Hospital
Yokohama City Minato Red Cross Hospital
Yokohama City University Hospital
Yokohama City University Medical Center
Yokohama General Hospital
Yokohama Rosai Hospital
Yokohama Sakae Kyosai Hospital
Yokohama Shin-midori General Hospital
Yokohama Stroke and Brain Center
Yokohamashintoshi Neurosurgical Hospital
Yokosuka General Hospital Uwamachi
Yomeikai Obase Hospital
Yonabaru Chu-ou Hospital
Yonago Medical Center
Yonezawa City Hospital
Yuaikai Hospital
Yukioka Hospital

Appendix Table 2. *Number (%) of responding hospitals* (n = *724) with the recommended elements of acute stroke care capacity in Japan, based on geographical classification*

Category	Components	*n*	%	MEA-central (*n* = 382)	MEA-outlying (*n* = 240)	McEA-central (*n* = 90)	McEA-outlying (*n* = 12)	*P* value*
Personnel	Board-certified neurologist	351	48.5	210 (55)	109 (45.4)†	28 (31.1)†	4 (33.3)	<.001
	Board-certified neurosurgeon	673	93.0	359 (94)	220 (91.7)	85 (94.4)	9 (75)	.084
	Interventional/endovascular physicians	269	37.2	174 (45.5)	78 (32.5)†	16 (17.8)†	1 (8.3)†	<.001
	Critical care medicine	157	21.7	90 (23.6)	53 (22.1)	14 (15.6)	0 (0)	.098
	Physical medicine and rehabilitation	110	15.2	64 (16.8)	37 (15.4)	8 (8.9)	1 (8.3)	.279
	Rehabilitation therapy	716	98.9	379 (99.2)	236 (98.3)	90 (100)	11 (91.7)	.099
	Stroke rehabilitation nurses	99	13.7	64 (16.8)	28 (11.7)	7 (7.8)†	0 (0)	.045
Diagnostic (24/7)	CT	716	98.9	379 (99.2)	236 (98.3)	90 (100)	11 (91.7)	.099
	MRI with diffusion	621	85.8	334 (87.4)	198 (82.5)	77 (85.6)	11 (91.7)	.365
	Digital cerebral angiography	585	80.8	316 (82.7)	184 (76.7)	77 (85.6)	8 (66.7)	.084
	CTA	606	83.7	323 (84.6)	197 (82.1)	77 (85.6)	9 (75)	.616
	Carotid duplex U/S	248	34.3	142 (37.2)	73 (30.4)	29 (32.2)	4 (33.3)	.365
	TCD	121	16.7	80 (20.9)	34 (14.2)†	7 (7.8)†	0 (0)	.003
Surgical	CEA	587 (673)	87.2	329 (91.1)	184 (84.8)†	66 (78.6)†	8 (72.7)	.002
	Clipping of IA	657 (699)	94.0	350 (95.1)	215 (92.7)	83 (94.3)	9 (81.8)	.182
	Hematoma removal/draining	660 (701)	94.2	353 (95.4)	216 (93.1)	82 (93.2)	9 (81.8)	.151
	Coiling of IA	348 (624)	55.8	215 (64)	107 (52.7)†	23 (31.1)†	3 (27.2)†	<.001
	IA reperfusion therapy	486 (639)	76.1	272 (79.8)	156 (73.9)	52 (68.4)	6 (54.6)	.035
Infrastructure	Stroke unit	126 (712)	17.7	83 (22.1)	37 (15.7)	6 (6.7)†	0 (0)	.001
	ICU	346 (724)	47.8	186 (48.7)	115 (47.9)	39 (43.3)	6 (50)	.835
	Operating room staffed 24/7	443	61.2	256 (67.0)	142 (59.2)	42 (46.7)†	3 (25.0)†	<.001
	Interventional services coverage 24/7	275	38.0	182 (47.6)	77 (32.1)†	15 (16.7)†	1 (8.3)†	<.001
	Stroke registry	228	31.5	134 (35.1)	69 (28.8)	23 (25.6)	2 (16.7)	.133
Education	Community education	358	49.4	196 (51.3)	127 (52.9)	31 (34.4)†	4 (33.3)	.011
	Professional education	424	58.6	238 (62.3)	143 (59.6)	39 (43.3)†	4 (33.3)	.003
PSC Elements	t-PA–certified physician	662 (706)	93.8	360 (95.7)	214 (93)	79 (88.8)†	9 (81.8)	.021
	Acute stroke team	183 (702)	26.1	120 (32.4)	50 (21.7)†	10 (11.1)†	3 (25)	<.001
	NIHSS	514 (721)	71.3	296 (77.5)	165 (69.3)†	47 (52.2)†	6 (50)	<.001
	Written t-PA protocol	616 (721)	85.4	338 (88.7)	201 (84.1)	69 (76.7)†	8 (72.7)	.012
	Hotline with emergency medical services	418 (718)	58.2	218 (57.2)	138 (58.7)	53 (58.9)	9 (75)	.700

Abbreviations: CEA, carotid endarterectomy; CT, computed tomography; CSC, comprehensive stroke center; CTA, computed tomography angiography; IA, intracranial aneurysm; ICH, intracerebral hemorrhage; ICU, intensive care unit; McEA, micropolitan employment areas; MRI, magnetic resonance imaging; NIHSS, National Institutes of Health Stroke Scale; TCD, transcranial Doppler; t-PA, tissue plasminogen activator; U/S, ultrasonography.

*Fisher's exact test.

†$P < .05$ versus MEA-central, Fisher's exact test.

Appendix Table 3. *Categorical and total CSC scores of the responding hospitals based on geographical classifications*

	Category	MEA-central (n = 382)	MEA-outlying (n = 240)	McEA-central (n = 90)	McEA-outlying (n = 12)	P value*
CSC scores (median, IQR)	Personnel	3 (3-4)	3 (2-4)†	2 (2-3)†	2 (2-3)†	<.001
	Diagnostic	4 (4-5)	4 (3-5)†	4 (4-5)	4 (3-4.5)	.077
	Surgical/interventional	5 (3-5)	4 (3-5)†	4 (3-4)†	3.5 (1.0-4.5)†	<.001
	Infrastructure	2 (1-3)	2 (1-3)†	1 (0-2)†	1 (0-2)†	<.001
	Education	1 (0-2)	1 (0-2)	1 (0-1)†	0 (0-1.5)	<.001
	Total	16 (12-18)	14 (11-17)†	13 (10-15)†	12.5 (6.5-14)†	<.001

Abbreviations: CSC, comprehensive stroke center; IQR, interquartile range; MEA, metropolitan employment areas; McEA, micropolitan employment areas.

*Kruskal-Wallis test.

†Wilcoxon test, $P < .05$ versus MEA-central.

Appendix Table 4. *The impact of availability of t-PA protocol on the volume of stroke interventions on multivariate linear regressions adjusted for other hospital characteristics*

	t-PA protocol (+)			
	β	P value	95% CI	
t-PA	6.40	<.001	4.73	8.08
ICH	6.79	<.001	4.55	9.03
Clipping	14.22	<.001	8.32	20.12
Coiling	5.73	<.001	2.84	8.63

Abbreviations: CI, confidence interval; ICH, intracerebral hemorrhage; t-PA, tissue plasminogen activator.

The hospitals without a t-PA protocol (t-PA (-) were considered as a reference.

Appendix Table 5. *The impact of the total CSC score on the volume of stroke interventions on multivariate linear regressions adjusted for other hospital characteristics*

	Total CSC score											
	Q2				Q3				Q4				
	β	*P* value	95% CI		β	*P* value	95% CI		β	*P* value	95% CI		*P* for trend
t-PA	3.13	<.001	1.63	4.63	6.85	<.001	5.42	8.29	12.21	<.001	10.49	13.94	<.001
ICH	4.45	<.001	2.36	6.53	8.63	<.001	6.63	10.63	13.30	<.001	10.89	15.72	<.001
Clipping	8.08	.004	2.60	13.56	16.15	<.001	10.91	21.38	34.82	<.001	28.47	41.18	<.001
Coiling	1.44	.304	−1.30	4.18	8.09	<.001	5.48	10.71	15.74	<.001	12.57	18.91	<.001

Abbreviations: CI, confidence interval; DPC, diagnosis procedure combination; ICH, intracerebral hemorrhage; t-PA, tissue plasminogen activator.

Total CSC scores were categorized into quartiles (Q1: 0-10, Q2: 11-13, Q3: 14-17, and Q4: 18-24) and treated as dummy variables. The hospitals with the total CSC score classified into Q1 were considered as a reference. Other adjustment covariates were the number of beds, academic status, geographical locations, and participation on the DPC-based payment system.

Appendix Table 6. *The volume of stroke interventions in 2009 in the responding hospitals*

	n	%	Median	IQR	Range
t-PA infusion	727	97.1	5	2-10	0-60
Clipping of IA	724	96.7	15	15-27	0-356
ICH removal	720	96.1	5.5	2-12	0-85
CEA	678	90.5	0	0-2	0-41
Coiling of IA	698	93.2	3	0-11	0-116
i.a. reperfusion	678	90.5	0	0-2	0-41
CAS	697	93.1	1	0-7	0-164

Abbreviations: CAS, carotid stenting; CEA, carotid endarterectomy; i.a., intra-arterial; IA, intracranial aneurysm; IQR, interquartile range; t-PA, tissue plasminogen activator.

n, number of hospitals replying to the question of case volume of stroke interventions performed in 2009; %, percentage of hospitals replying to the question of case volume of stroke interventions performed in 2009 in the responding hospitals.

ORIGINAL RESEARCH

Consciousness Level and Off-Hour Admission Affect Discharge Outcome of Acute Stroke Patients: A J-ASPECT Study

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***Background*—**Poor outcomes have been reported for stroke patients admitted outside of regular working hours. However, few studies have adjusted for case severity. In this nationwide assessment, we examined relationships between hospital admission time and disabilities at discharge while considering case severity.

***Methods and Results*—**We analyzed 35 685 acute stroke patients admitted to 262 hospitals between April 2010 and May 2011 for ischemic stroke (IS), intracerebral hemorrhage (ICH), or subarachnoid hemorrhage (SAH). The proportion of disabilities/death at discharge as measured by the modified Rankin Scale (mRS) was quantified. We constructed 2 hierarchical logistic regression models to estimate the effect of admission time, one adjusted for age, sex, comorbidities, and number of beds; and the second adjusted for the effect of consciousness levels and the above variables at admission. The percentage of severe disabilities/death at discharge increased for patients admitted outside of regular hours (22.8%, 27.2%, and 28.2% for working-hour, off-hour, and nighttime; $P<0.001$). These tendencies were significant in the bivariate and multivariable models without adjusting for consciousness level. However, the effects of off-hour or nighttime admissions were negated when adjusted for consciousness levels at admission (adjusted OR, 1.00 and 0.99; 95% CI, 1.00 to 1.13 and 0.89 to 1.10; $P=0.067$ and 0.851 for off-hour and nighttime, respectively, versus working-hour). The same trend was observed when each stroke subtype was stratified.

***Conclusions*—**The well-known off-hour effect might be attributed to the severely ill patient population. Thus, sustained stroke care that is sufficient to treat severely ill patients during off-hours is important. **(*J Am Heart Assoc.* 2014;3:e001059 doi: 10.1161/JAHA.114.001059)**

Key Words: hemorrhagic stroke • ischemic stroke • mortality • stroke • weekend effect

Stroke is a major cause of death in Japan, and residual disability after stroke is a heavy societal burden.[1] Death risk tendencies are high for patients hospitalized with serious medical conditions (including stroke) during off hours, especially on weekends.[2–7] Reduced quality of care during off hours because of insufficient physician volume, uneven staffing pattern for urgent procedures, and insufficient management of operative procedures, are among the possible reasons for this tendency.[2,3,6–9] Acute stroke severity is an important prognostic factor,[10] and stroke symptom severity is associated with healthcare-seeking behavior.[11–13] However, only 5 previous studies have

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