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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.

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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: primary¹ 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 clipping and coiling 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/drainage	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
Education	Stroke registry*	235	31.7
	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/drainage	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 implemen-

tation 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 offer-

ing 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}

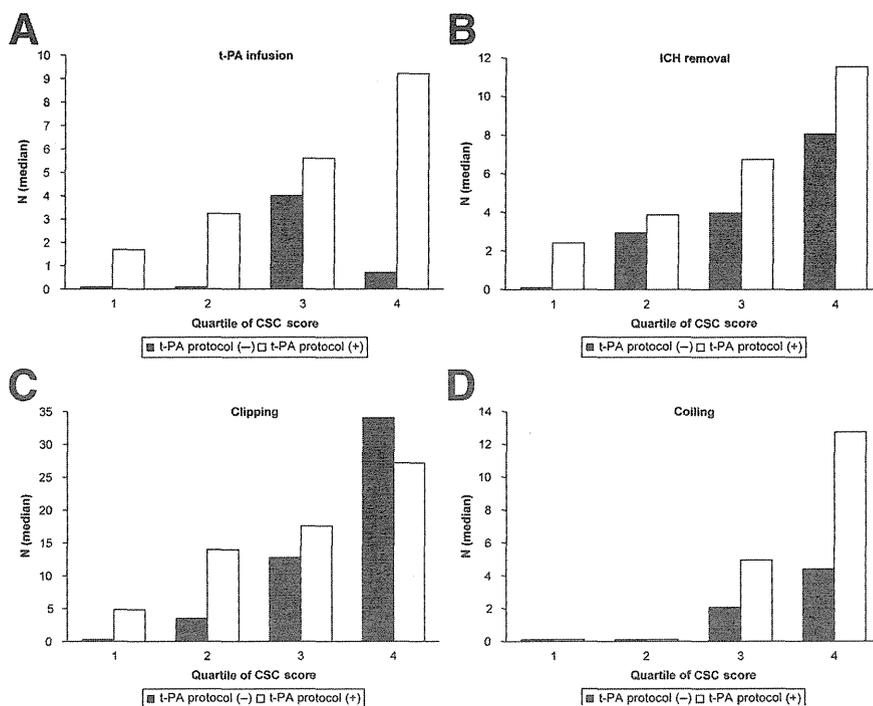
To determine the relationship between primary and comprehensive stroke care capacity, we used the implementation of a written t-PA protocol as a key item of primary stroke care capacity¹ as it is a key step in reducing t-PA-related complications.¹⁵ The availability of a t-PA protocol (85%) recorded in 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 30¹⁸ 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.

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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
 Belland 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 Seiryō 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 Shintoshō 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 Prefectural 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 Prefecture 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
 Kitamura 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
 Steel Memorial Hirohata Hospital
 Steel Memorial Yawata Hospital
 Suisaikai 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 Faculty
 of Medicine
 Tokyo Medical University Hospital
 Tokyo Medical University Ibaraki Medical Center
 Tokyo Metropolitan 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/drainage	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											<i>P</i> for trend
	Q2			Q3			Q4					
	β	<i>P</i> value	95% CI	β	<i>P</i> value	95% CI	β	<i>P</i> value	95% CI			
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*

	<i>n</i>	%	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.

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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