DOI: 10.5797/jnet.oa.2020-0128

Original Article

Initial Result of Stroke Care at the Stroke Center in a New Hospital Opened by the Merger of Three Facilities with Different Management Bases: Effect of Stroke Center on Mechanical Thrombectomy

Hiroshi Sakaida,[1] Fuki Goto,[1] Atsushi Yamamoto,[1] Kazuhide Hamada,[1] Katsura Kuroki,[1] Tomoyuki Furuta,[2] Kiyomi Odachi,[2] Ryogen Sasaki,[2] Kazuhiro Furukawa,[3] Yuki Nakajima,[4] and Shigeo Arikawa[5]

Objective: The most important function required for the stroke center is prompt treatment for acute stroke. We report the initial results of stroke care under the new medical care system of stroke center in a new hospital that merges three hospitals with different management bases to verify the effect of stroke center on mechanical thrombectomy.

Methods: We investigated changes in the number of inpatients and surgical treatments compared with the past 3 years (Stages I, II, and III) with stage IV one year after the new hospital was opened, and examined the effect of establishing a stroke center on mechanical thrombectomy for acute main cerebral artery occlusion.

Results: From stage I to stage IV, the number of hospitalized patients increased from 396, 485, 482 to 630, respectively, and the proportion of patients with cerebrovascular disease increased from 57.6%, 55.7%, 60.4% to 68.3%, respectively. Total surgical treatment increased from 137, 195, 224 to 297, respectively, especially endovascular therapy increased markedly from 22, 36, 68 to 118, respectively. The main treatment contents of endovascular treatment in stage IV were ruptured cerebral aneurysm embolization 22 cases, unruptured cerebral aneurysm embolization 13 cases, carotid artery stenting 23 cases, other intracranial or extracranial artery angioplasty/stenting 9 cases, and mechanical thrombectomy 34 cases. In particular, mechanical thrombectomy was significantly increased to 34 in stage IV, compared to 4 in stage I, 4 in stage II, and 17 in stage III (degree of contribution [DC] 25.0%, contribution ratio [CR] 34.0%).

Conclusion: With the establishment of the stroke center, the number of cases of acute cerebral infarction within the adaptation time who received mechanical thrombectomy remarkably increased. It is considered that the effect and validity of function aggregation by establishing stroke center are shown.

Keywords stroke center, endovascular therapy, mechanical thrombectomy

Introduction

In the United States, recombinant tissue-type plasminogen activator (rt-PA) intravenous therapy was approved in 1996, the requirements for a primary stroke center were established in 2000 with the aim of spread of thrombolytic therapy, and facility certification was started in 2003.[1)] Furthermore, the requirements for a comprehensive stroke center were announced in 2005, and institutional approval was started in 2012.[2)] In Japan, the J-ASPECT Study Group's survey of stroke medical facilities that began in 2010 revealed regional disparities in medical care systems.[3)] The

[1]*Department of Neurosurgery, Stroke Center, Kuwana City Medical Center, Kuwana, Mie, Japan*
[2]*Department of Neurology, Stroke Center, Kuwana City Medical Center, Kuwana, Mie, Japan*
[3]*Department of Neurosurgery, Hisai Neurosurgery Clinic, Tsu, Mie, Japan*
[4]*Department of Neurology, Suzuka Kaisei Hospital, Suzuka, Mie, Japan*
[5]*Department of Neurology, Ise Municipal General Hospital, Ise, Mie, Japan*

Received: June 20, 2020; Accepted: February 9, 2021
Corresponding author: Hiroshi Sakaida. Department of Neurosurgery, Kuwana City Medical Center, 3-11, Kotobukicho, Kuwana, Mie 511-0061, Japan
Email: sakaidah@kuwanacmc.or.jp

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives International License.
©2021 The Japanese Society for Neuroendovascular Therapy

Japan Stroke Society and the Japanese Circulation Society announced the 5-year Plan for Overcoming Stroke and Cardiovascular Diseases in December 2016, and as a problem related to the medical system, there is no certification system for primary stroke centers and comprehensive stroke centers. It was pointed out that there is an urgent need to establish a stroke medical care system and certification system because no cooperation had been established with primary emergency hospitals.[4] The relevant academic societies and the administration proceeded with the preparations, and the certification of the primary stroke center of the Japan Stroke Society began in September 2019. Around this time, the Basic Act on Countermeasures for Stroke and Cardiovascular disease was enacted in December 2018, and enforced in December 2019.[5] Then came the era of legally promoting the prevention of stroke and cardiovascular disease and the establishment of an efficient and appropriate treatment system.

Kuwana City is located in the northernmost part of Mie Prefecture, on the prefectural border between Aichi and Gifu Prefectures. Kuwana City has a relatively large population as a commuting area of Nagoya City and a high proportion of the working-age population compared to other areas in Mie Prefecture. However, the full-time facility for neurosurgery was only the former Kuwana Municipal Hospital, which had an old and insufficient facility operated with a small number of staff. It was also an environment in which other circulatory diseases such as cardiology and cardiovascular surgery had to depend on other facilities. As a result, it was difficult to provide sufficient stroke medical care, and there was a problem that emergency patients leaked out of the medical service area. Other medical fields had similar problems, and it was an urgent issue to construct a functional medical system by consolidating from a small-scale distributed medical system. To solve this problem, the former Kuwana Municipal Hospital, a public hospital, became the Kuwana West Medical Center, the former Yamamoto General Hospital, a private hospital, became the Kuwana East Medical Center, and the former Hirata Cardiovascular Hospital, a private hospital, became the Kuwana South Medical Center, and these three centers were systematically integrated to establish the Kuwana City Medical Center in 2012. The construction of a new hospital started in 2015, and a new facility of the Kuwana City Medical Center opened in May 2018, realizing an integrated merger by reorganizing hospitals of public and private sectors with different management bases, although such a merged facility was extremely rare in Japan. The number of beds decreased from 662 beds in the three hospitals to 400 beds, and the number of staff decreased from 984 to 908, and 68% of all staff had no experience of specialized stroke care. Expectations for new hospital from citizens, emergency services, and nearby medical facilities were high, and a rapid increase in stroke patients was expected.

The most important function required for the stroke center is mechanical thrombectomy among various stroke medical care, because acute cerebral artery occlusion has a large number of cases, and to improve the survival rate and the ratio of favorable prognosis, it is necessary to increase the number of patients who can be delivered in time by systematic improvement. In establishing a stroke center, any facility requires a great deal of effort to improve the in-hospital system and the emergency transportation system. In this paper, we report the initial results on changes inpatient numbers, changes in surgical treatment, and increased endovascular treatment for patients with acute stroke by establishing a stroke center in a new hospital opened through a rare process.

Materials and Methods

The period from May 2018 to April 2019, 1 year after the new hospital was opened, was set as stage IV. The transitions of number of inpatients, total number of surgical therapies, and endovascular treatments performed at our stroke center were compared with May 2015–April 2016 as stage I, May 2016–April 2017 as stage II, and May 2017–April 2018 as stage III. Among endovascular treatments, we compared changes in stages I–IV for ruptured cerebral aneurysm, unruptured cerebral aneurysm, internal carotid artery stenosis, other intracranial/extracranial occlusive lesions, and acute main cerebral artery occlusions. By calculating the degree of contribution (DC) and the contribution ratio (CR), the effect of establishing a stroke center was verified.

Results

Changes in the number of inpatients (Table 1 and Fig. 1)

From stage I to stage IV, the number of hospitalized patients increased from 396, 485, 482 to 630, respectively. In particular, the increase in ischemic cerebrovascular disease was remarkable among various acute strokes, and the proportion of patients with cerebrovascular disease increased from 57.6%, 55.7%, 60.4% to 68.3%, respectively.

Table 1 Number of inpatients from stage I to stage IV

	Stage I		Stage II		Stage III		Stage IV	
	n	%	n	%	n	%	n	%
Total	396		485		482		630	
Cerebrovascular disease	228	57.6	270	55.7	291	60.4	430	68.3
Subarachnoid hemorrhage	22	5.6	20	4.1	33	6.8	38	6.0
Intracerebral hemorrhage	67	16.9	64	13.2	58	12.0	79	12.5
Ischemic cerebrovascular disease	126	31.8	160	33.0	168	34.9	249	39.5
Unruptured aneurysm	8	2.0	17	3.5	16	3.3	47	7.5
AVM/AVF	5	1.3	9	1.9	16	3.3	17	2.7
Brain tumor	7	1.8	6	1.3	12	2.5	29	4.6
Spine/spinal cord disease	15	3.8	59	12.2	34	7.1	50	7.9
Head injury	106	26.8	107	22.1	103	21.4	97	15.4
Others	40	10.1	43	8.9	42	8.7	24	3.8

The number of hospitalized patients increased from 396, 485, 482 to 630 from stage I to stage IV. In particular, ischemic stroke increased compared to other cerebrovascular diseases in stage IV. AVF: arteriovenous fistula; AVM: arteriovenous malformation

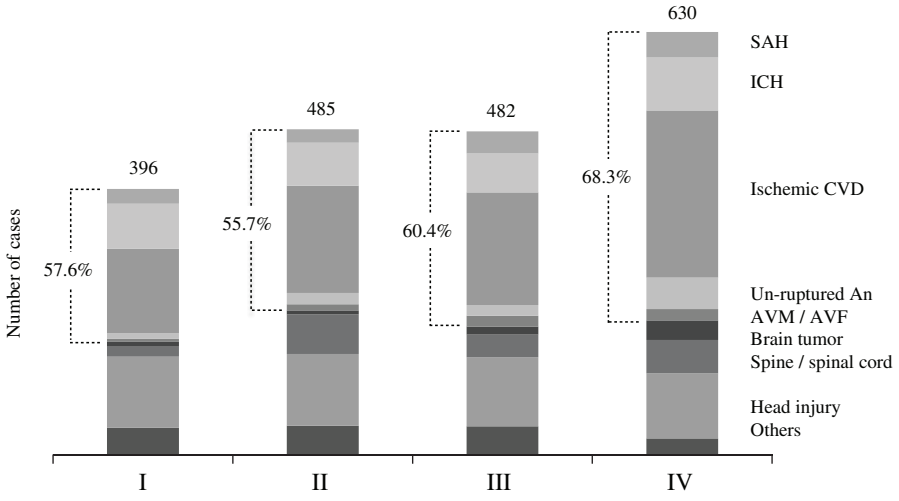

Fig. 1 Changes in the number of hospitalized patients and the proportion of cerebrovascular diseases from stage I to stage IV. The number of hospitalized patients with cerebrovascular diseases increased markedly in stage IV. The proportion of inpatients with cerebrovascular diseases from stage I to stage IV increased 57.6%, 55.7%, 60.4% to 68.3%, respectively. An: aneurysm; AVF: arteriovenous fistula; AVM: arteriovenous malformation; CVD: cerebrovascular disease; ICH: intracerebral hemorrhage; SAH: subarachnoid hemorrhage;

Changes in the total number of surgical therapy (Table 2 and Fig. 2)

From stage I to stage IV, total number of surgical therapy increased from 137, 195, 224 to 297, respectively. With the exception of head injury and others, direct surgery for cerebrovascular disease, brain tumor, and spinal disease was on the rise. Endovascular therapy increased markedly from 22, 36, 68 to 118, respectively.

Changes in the number of endovascular therapy (Table 3 and Fig. 3)

The total number of endovascular treatments before opening a new hospital was gradually increasing, with 22 in stage I, 36 in stage II, 68 in stage III, and the number of treatments in stage IV after the hospital was opened remarkably increased to 118. **Table 3** and **Fig. 3** show the number of endovascular treatments for the representative cerebrovascular diseases. The number of ruptured cerebral aneurysm, unruptured cerebral aneurysm, internal carotid artery stenosis, and other intracranial/extracranial occlusive lesions tended to increase on average, and the increase in acute main cerebral artery occlusions was particularly remarkable. **Table 3** shows the increasing ratio from the previous stage, DC, and CR for each stage. The increasing ratio was high in stage II internal carotid artery stenosis (220.0%), stage III ruptured cerebral aneurysm (183.3%), other intracranial/extracranial occlusive lesions

Table 2 Number of all surgical therapy from stage I to stage IV

	Stage I		Stage II		Stage III		Stage IV	
	n	%	n	%	n	%	n	%
Total	137		195		224		297	
Surgery								
Cerebrovascular disease	12	8.8	11	5.6	18	8.0	32	11.5
Aneurysm clipping	6	4.4	2	1.0	5	2.2	6	2.0
ICH removal	5	3.6	6	3.1	11	5	15	5.1
AVM removal	0	0.0	1	0.5	2	0.9	6	2.0
Carotid endarterectomy/bypass	1	0.7	2	1.0	0	0.0	7	2.4
Brain tumor removal	2	1.5	0	0.0	2	0.9	14	4.7
Spine/spinal cord surgery	6	4.4	32	16.4	31	13.8	35	11.8
Head injury surgery	44	32.1	60	30.8	50	22.3	51	17.2
Others	51	37.2	56	28.7	55	24.6	45	15.1
Endovascular therapy	22	16.0	36	18.5	68	30.4	118	39.7

Total number of surgical therapy increased from 137, 195, 224 to 297, respectively. In particular, endovascular therapy increased markedly from 22, 36, 68 to 118 in stage IV. AVM: arteriovenous malformation; ICH: intracerebral hemorrhage

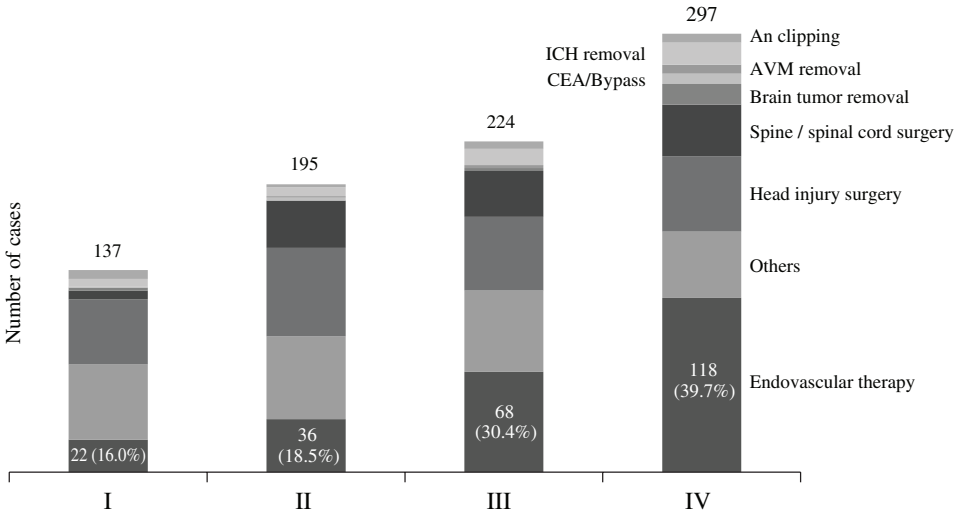

Fig. 2 Changes in the number of surgical treatments and the proportion of endovascular therapy from stage I to stage IV. The proportion of endovascular therapy to the total surgical treatments gradually increased from stage I to stage IV. Especially from stage III to stage IV, the ratio of increase in endovascular therapy had the greatest effect on the increase in the total surgical treatments. An: cerebral aneurysm; AVM: arteriovenous malformation; CEA: carotid endarterectomy; ICH: intracerebral hemorrhage

(500.0%), acute main cerebral artery occlusions (325.0%), Stage IV unruptured cerebral aneurysm (225.0%), and acute main cerebral artery occlusions (325.0%), Stage IV unruptured cerebral aneurysm (225.0%), and acute main cerebral artery occlusions (100.0%). The highest DC and CR to the increase in the number of treatments was internal carotid artery stenosis (50.0% DC and 78.6% CR) in stage II, acute main cerebral artery occlusions (36.1% DC and 40.6% CR) in stage III, and acute main cerebral artery occlusions (25.0% DC and 34.0% CR) in stage IV.

Discussion

While the establishment of stroke centers was promoted nationwide, three hospitals with different management bases were integrated and merged to open a new hospital in May 2018. Staff members who had been working in a completely different medical culture until then began to work together, and 68% of all staff of our new hospital were transferred from facilities without a full-time doctor of neurosurgery or neurology. Therefore, it was essential to

Table 3 Increasing ratio, DC, and CR of endovascular treatment for major cerebrovascular disorders from stage I to stage IV

	Stage I	Stage II				Stage III				Stage IV			
	n	n	IR	DC	CR	n	IR	DC	CR	n	IR	DC	CR
Total	22	36	63.6%			68	88.9%			118	73.5%		
Ruptured aneurysm	9	6	−33.3%	−13.6%	−21.4%	17	183.3%	30.6%	34.4%	22	29.4%	7.4%	10.0%
Unruptured aneurysm	0	7	–	31.8%	50.0%	4	−42.9%	−8.3%	−9.4%	13	225.0%	13.2%	18.0%
Cervical IC stenosis	5	16	220.0%	50.0%	78.6%	12	−25.0%	−11.1%	−12.5%	23	91.7%	16.2%	22.0%
Other occlusive lesion	3	1	−66.7%	−9.1%	−14.3%	6	500.0%	13.9%	15.6%	9	50.0%	4.4%	6.0%
Acute main cerebral artery occlusions	4	4	0.0%	0.0%	0.0%	17	325.0%	36.1%	40.6%	34	100.0%	25.0%	34.0%

DC and CR of mechanical thrombectomy for acute main cerebral artery occlusion are highest in stage III and stage IV. CR: contribution ratio; DC: degree of contribution; IC: internal carotid artery; IR: Increase ratio from the previous period

hold study sessions and conferences to educate staff in the hospital and build a cooperative environment.

Before the new hospital opened, the Kuwana West Medical Center, where neurosurgery was working full time, was in charge of the rotation only once a week. On other days, stroke patients were transferred to other hospitals. Therefore, even the patient who made an emergency call within the time was transferred to another facility, and after being diagnosed with a stroke, was transferred to the Kuwana West Medical Center. After opening, our new hospital was in charge of about half of a week. However, it was required to operate a stroke hotline so that it could respond promptly to stroke patients 365 days a year. The stroke hotline of our center started operation with the emergency team of Kuwana City Fire Department. Kuwana City Fire Department has jurisdiction over Kuwana City, Inabe City, Kisozaki Town, and Toin Town. For an area of 394.93 km^2 and a target population of approximately 220000, ambulance team are conducting emergency activities based on three fire stations and five branch stations. There are various prehospital stroke evaluation methods. Cincinnati Prehospital Stroke Scale (CPSS)[6] and Kurashiki Prehospital Stroke Scale (KPSS)[7] are especially well known to the ambulance crew of Kuwana City Fire Department, and CPSS has been used for emergency activities in this area. Considering this process, we have devoted efforts to the effective operation of the stroke hotline using CPSS.

After the opening of the new hospital, the number of inpatients increased sharply, and the proportion of patients with cerebrovascular diseases increased. **Table 1** and **Fig. 1** show that increased inpatients with cerebrovascular diseases is the main reason for the surge in total inpatients number in stage IV. As expected, the number of total surgical treatments for cerebrovascular diseases increased in an unfamiliar environment with inexperienced staff and a limited number of beds. Comparing the proportions, the increase in endovascular therapy clearly had the greatest impact on the transition of the total number of surgical therapy.

Because of low invasiveness and efficacy, the number of endovascular treatments steadily increased from stage I to stage IV. It was considered that the rapid increase in endovascular therapy in stage IV was due to the improvement of emergency transport and medical care system with the start of the stroke center. Among the increasing number of endovascular treatments, the one with the highest DC and CR was mechanical thrombectomy. The significant increase in stage IV was considered to be the result of an increase in cases that were delivered in time via the stroke hotline. In addition, improvement of emergency transport system

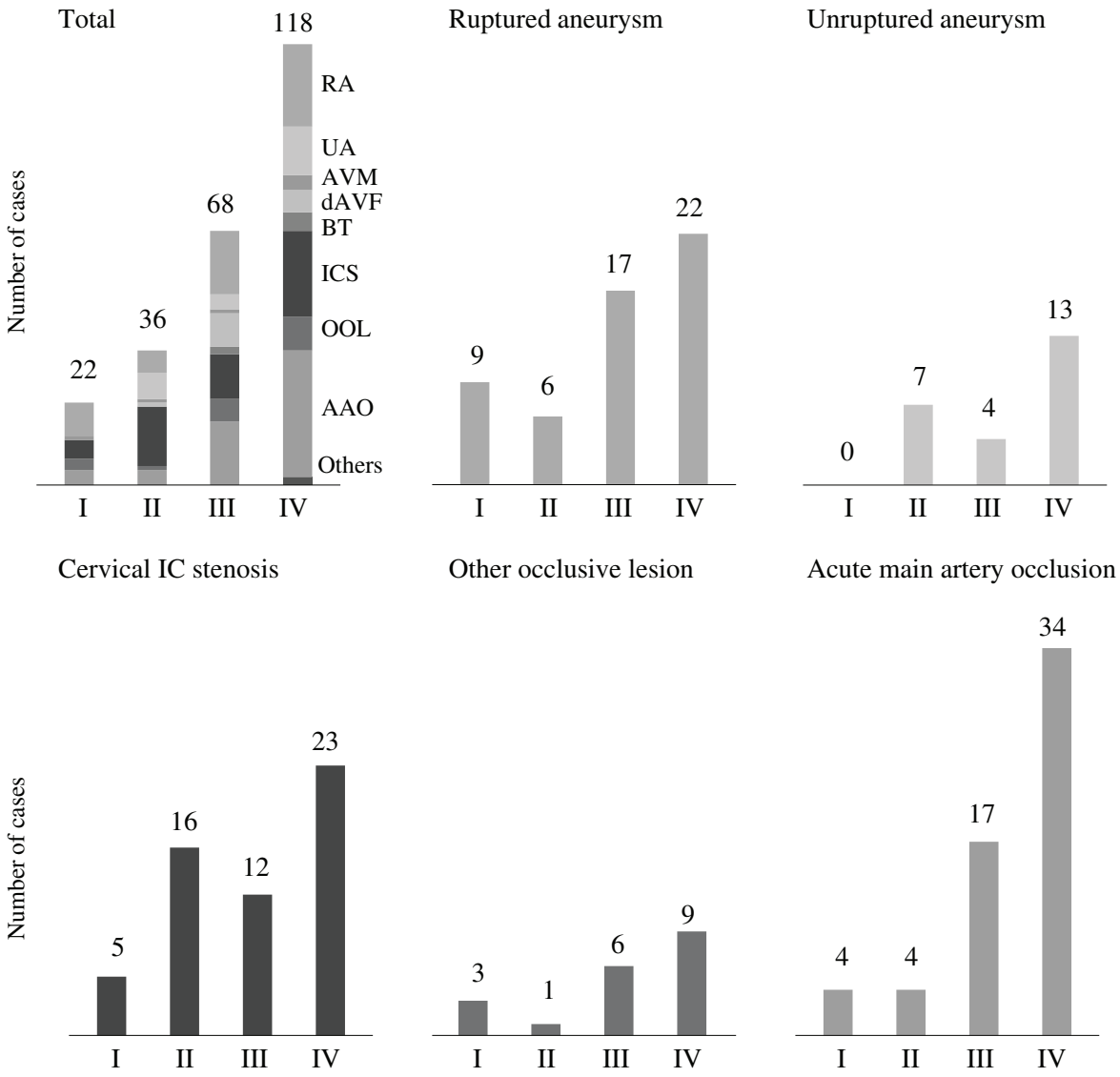

Fig. 3 Transition of endovascular therapy from stage I to stage IV. Endovascular therapy for major cerebrovascular diseases tended to increase on average, and mechanical thrombectomy for acute main artery occlusion increased remarkably. AAO: acute main cerebral artery occlusions; AVM: arteriovenous malformation; BT: brain tumor; dAVF: dural arteriovenous fistula; IC: internal carotid artery; ICS: internal carotid artery stenosis; OOL: other intracranial/extracranial occlusive lesions; RA: ruptured cerebral aneurysm; UA: unruptured cerebral aneurysm

and triage capacity of ambulance team, education of hospital staff and reformation of in-hospital system, and enlightenment activities for citizens were affected. Mechanical thrombectomy is the most important function required for a stroke center, and our result is considered to have shown the effect and validity of investing medical resources to open a stroke center. The expansion of indications according to the results of DAWN trial[8] also has an effect. Stroke medical systems are now required to have more detailed diagnostic capabilities for images. In that sense, the establishment of a stroke center is of great significance because it is necessary to gather a large number of specialized staff members and prepare a system that enables high-performance diagnostic imaging equipment to be used at any time.

To eliminate the exhaustion of medical staff and provide high-quality stroke care, there is a limit to the decentralized medical care system of small to medium-scale facilities. On the other hand, Japan has a poor track record of cost-effectiveness in setting up a stroke center with expensive investment and great effort. Because our center has just opened, it is unknown

whether the burden on stroke medical staff could be reduced. However, it is considered that the effect for acute stroke treatment was higher than expected, in spite that the operation of our stroke center was started with unique and special circumstances. Our stroke center was approved as the Japan Stroke Society's Primary Stroke Center in September 2019, and further advancement is essential to improve the treatment outcome of acute stroke patients.

Conclusion

With the establishment of a stroke center, the regional stroke medical system improved and the number of cases of acute cerebral infarction within the adaptation time who were able to receive mechanical thrombectomy remarkably increased. The results showed the effectiveness and significance of opening a stroke center by consolidating human resources and medical functions.

Acknowledgment

The authors thank Dr. Takeshi Okada, a new member of our stroke center, for his help in data analysis.

Disclosure Statement

All authors have no conflict of interest.

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) Iihara K, Nishimura K, Kada A, et al: Issues in acute stroke care system in Japan with a special emphasis on implementation of comprehensive stroke centers. *Jpn J Neurosurg (Tokyo)* 2013; 22: 678–687.
4) Japan Stroke Society, Japan Circulation Society. Stroke and Cardiovascular Disease Overcoming Five-Year Plan– To achieve Stop CVD (Cerebral Cardiovascular Disease) Healthy Longevity. 2016. https://www.jsts.gr.jp/img/five_year_plan.pdf (Accessed: June 15, 2020)
5) Basic Act on Measures Related to Stroke, Heart Disease and Other Cardiovascular Diseases to Extend Healthy Lifespan 2018. https://houseikyoku.sangiin.go.jp/bill/pdf/h30-105.pdf (Accessed: June 15, 2020).
6) Kothari RU, Pancioli A, Liu T, et al: Cincinnati Prehospital Stroke Scale: reproducibility and validity. *Ann Emerg Med* 1999; 33: 373–378.
7) Kimura K, Inoue T, Iguchi Y, et al: Kurashiki prehospital stroke scale. *Cerebrovasc Dis* 2008; 25: 189–191.
8) Nogueira RG, Jadhav AP, Haussen DC, et al: Thrombectomy 6 to 24 hours after stroke with a mismatch between deficit and infarct. *N Engl J Med* 2018; 378: 11–21.