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Questionnaire Survey on the Current Use of Brain Docks and Their Compliance with Guidelines in Japan

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Abstract

Brain dock is used for the early diagnosis of intracranial lesions, prevention of cerebrovascular disorders, and early detection of cognitive decline. However, its application varies per facility. This study evaluated the use of brain dock and compliance with its guidelines via a questionnaire survey on the members of the Japan Society of Ningen Dock and Preventive Medical Care and the Japan Brain Dock Society. The questionnaire included information on the respondents, facility characteristics, and brain dock implementation. The number of responses was 288 (response rate: 10.3%). Brain dock was predominantly used in combination with other diagnostic methods. In addition to magnetic resonance imaging, the other examinations performed included the assessment of stroke risk factors and dementia. Radiographic image interpretation was frequently performed by more than one person, often by a neurosurgeon or radiologist. Artificial intelligence was used less frequently. In several facilities, the results were explained to all patients in person and to those who requested the findings in other facilities. Meanwhile, 10% of centers sent the results to the patients. Neurosurgeons were the most common professionals who provided explanations to the patients, followed by outpatient physicians who used the interpretation result as a reference. Only 24% of professionals were aware of the brain dock certification program. By solving the related problems, brain docks can play a greater role in improving medical issues in Japan, where the aging society is projected to increase.

Keywords: artificial intelligence, brain screening, cerebrovascular diseases, early diagnosis, magnetic resonance imaging

Introduction

Brain dock is a type of medical screening tool used to assess brain health, diagnose brain-related diseases, and determine the risks of such diseases. The brain docks utilize not only imaging to scan the head and neck, but also incorporate data from physical examinations, blood tests, cognitive function tests, and the patient's medical history and demographic information, to diagnose brain-related disease or to the risk of disease at an early stage. In 1988, brain dock was introduced with angiographic screening for unruptured cerebral aneurysms in Sapporo and with magnetic resonance imaging (MRI) for asymptomatic cerebral infarction in Shimane. At present, there are approximately 700 facilities in Japan that provide brain docks, of which 286 are accredited by the Japan Brain Dock Society.[1)] Brain docks are currently conducted for the early diagnosis of intracranial lesions, prevention of cerebrovascular diseases, and early detection of cognitive decline. The first edition of the brain dock guidelines was published in 1997 and has been revised repeatedly since then, with the fifth edition published in 2019. Moreover, they are used as a benchmark for brain screening. However, the use of brain dock can vary per facility, and it is considered necessary to update it in line with the times. The current study aimed to disclose the extent to which the guidelines are followed

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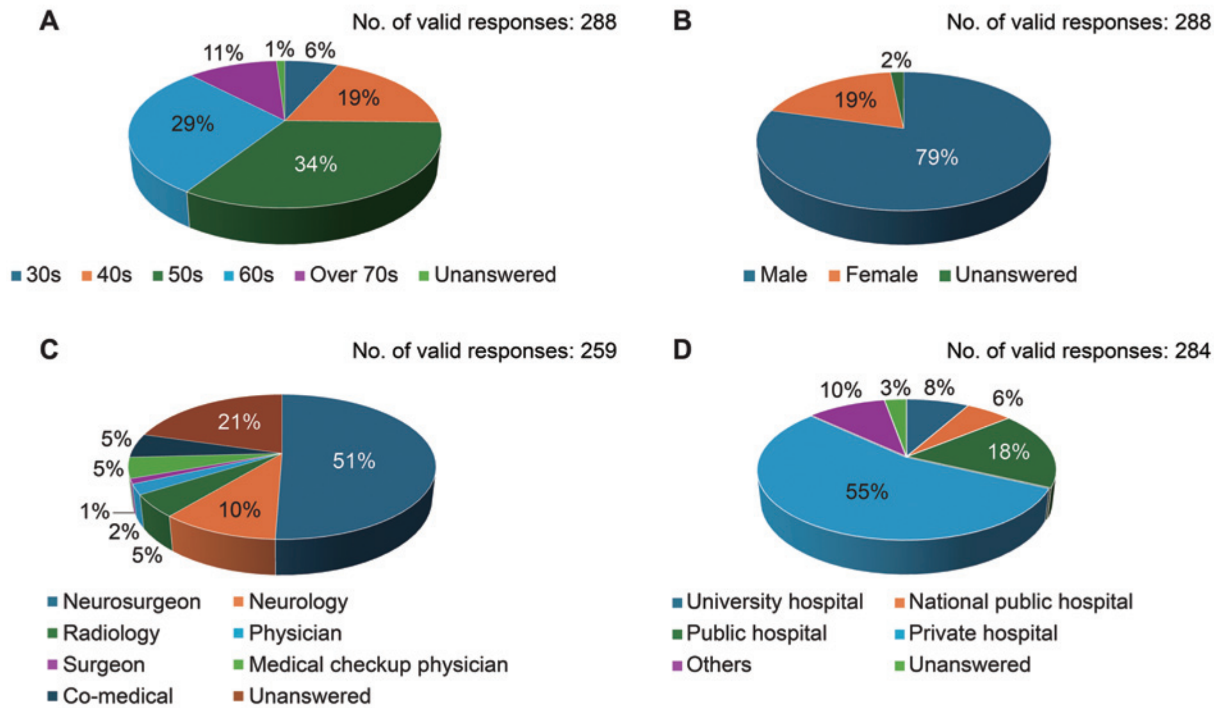

Fig. 1 Characteristics of the respondents and institutions.
A: Ages of the respondents.
B: Sex of the respondents.
C: Specialties of the respondents.
D: Institutions.

and evaluate the current use of brain docks in Japan via a questionnaire survey.

Materials and Methods

The Institutional Review Board of Hiroshima University approved this study (approval number E2023-0175). The procedures followed in experiments on human subjects were conducted in accordance with "Ethical Guidelines for Medical and Health Research Involving Human Subjects (Provisional Translation as of March 2015)" and its later amendments. The provision of informed consent was implied if the participants responded to the questionnaire in an opt-out format. A questionnaire survey was administered to members of the Japan Society of Ningen Dock and Preventive Medical Care and the Japan Brain Dock Society between January 2024 and February 2024. A written request for the survey was submitted to the heads of various facilities affiliated with the Japan Society of Ningen Dock and Preventive Medical Care and the Japan Brain Dock Society, and the format for responses was sent to members of both societies. The questionnaire was completed by a representative of each facility. The questionnaire covered the characteristics of the respondents and their facilities (age, sex, specialty, department, and institutions), the contents of the brain dock (mode of implementation, examination details, MRI sequence, magnetic resonance angiography (MRA), image readings, explanation of the results, and referral to specialists), and the brain dock certification system (Supplementary Table S1). The respondents were instructed to answer in single- or multiple-choice format.

Results

Questionnaires were sent to 1,367 members of the Japan Society of Ningen Dock and Preventive Medical Care and 1,441 members of the Japan Society of Brain Dock. In total, 288 professionals responded to the questionnaire (response rate: 10.3%). The respondents were mostly in their 50s (34%) and 60s (29%), and 80% were men (Fig. 1A and B). More than half of the respondents were affiliated to private hospitals (Fig. 1C) and half of them to neurosurgery clinics (Fig. 1D). The positions of respondents were as follows: 48.6% were facility directors, 20% were specialists or attending physicians, 26.4% held other roles (including administrative staff), and 12.2% did not respond to this question. Brain docks are often implemented in combination with other tests and examinations, rather than as standalone assessments (Fig. 2A). Of those who responded to the questions, 118 (41%) followed all of the guideline recommendations, comprising a medical interview, carotid artery examination, blood draw, electrocardiogram, MRI (in-

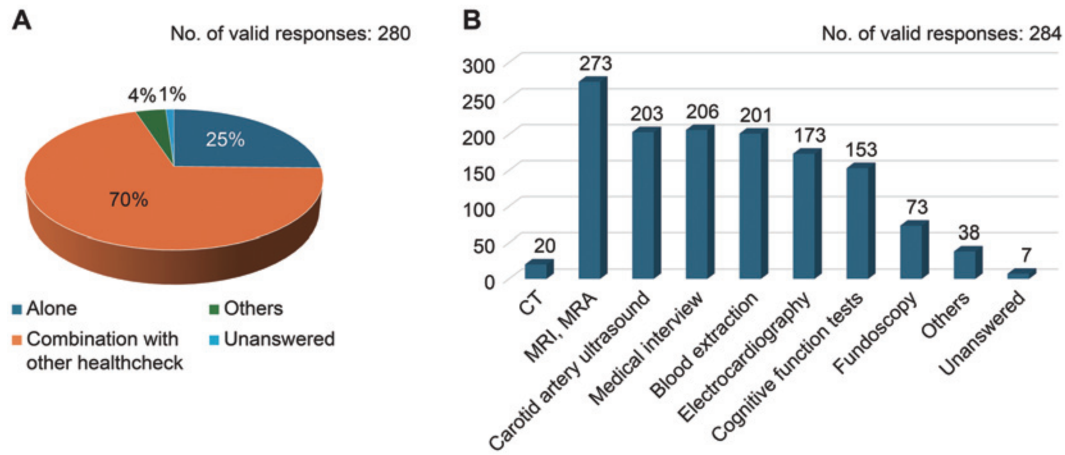

Fig. 2 Brain dock implementation form and examinations.
A. Implementation form.
B. Examination in brain dock.

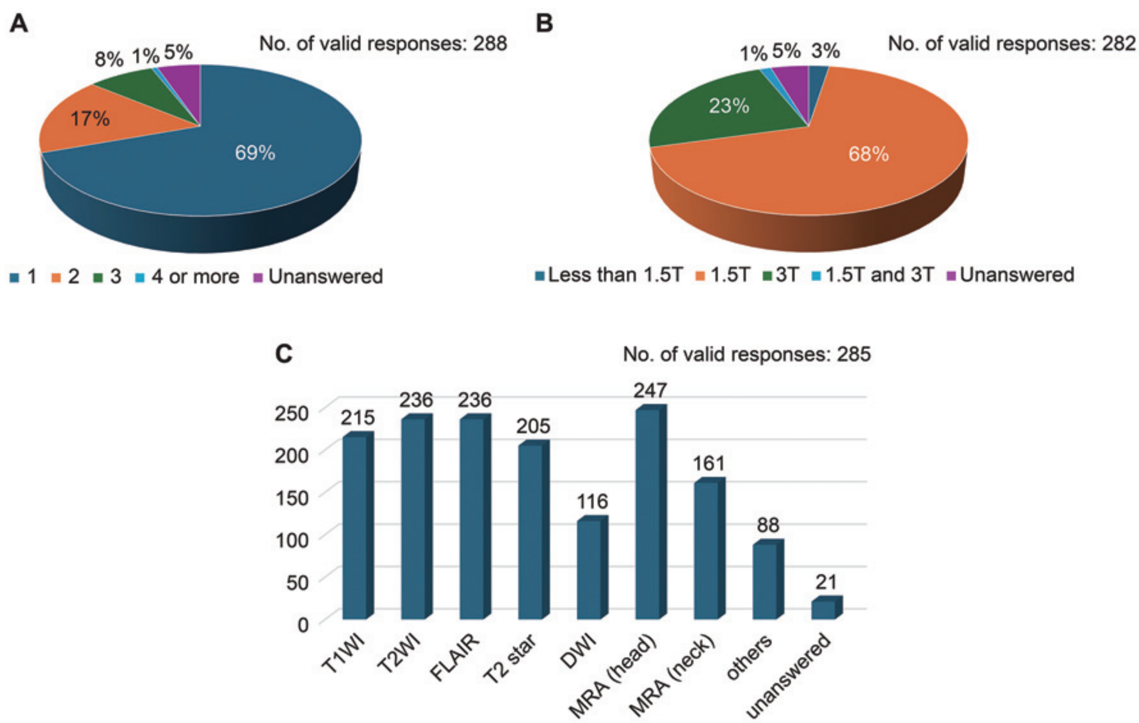

Fig. 3 MRI in brain docks.
A. Number of MRI used in brain dock.
B. Magnetic field strength of MRI used in brain dock.
C. Sequence of MRI in brain dock.
MRI: magnetic resonance imaging

cluding sequence content), and a cognitive function test. Looking at these guideline requirements item by item, we found that several patients underwent medical interviews (72.8%), blood tests (70.5%), and electrocardiography (60.7%), in addition to diagnostic imaging methods such as MRI, MRA, and carotid artery ultrasonography, to detect the risk factors of stroke. Further, more than half of the patients (53.7%) underwent cognitive function tests (Fig. 2 B). In 69% of the surveyed institutions, only one MRI was used by the brain docks (Fig. 3A). In 92% of the surveyed institutions, the MRI magnetic field strength was 1.5 or 3.0 T (Fig. 3B). In terms of MRI sequences performed in brain docks, T1-weighted imaging (T1WI) was used in 75.4% of cases, T2WI and fluid-attenuated inversion recovery

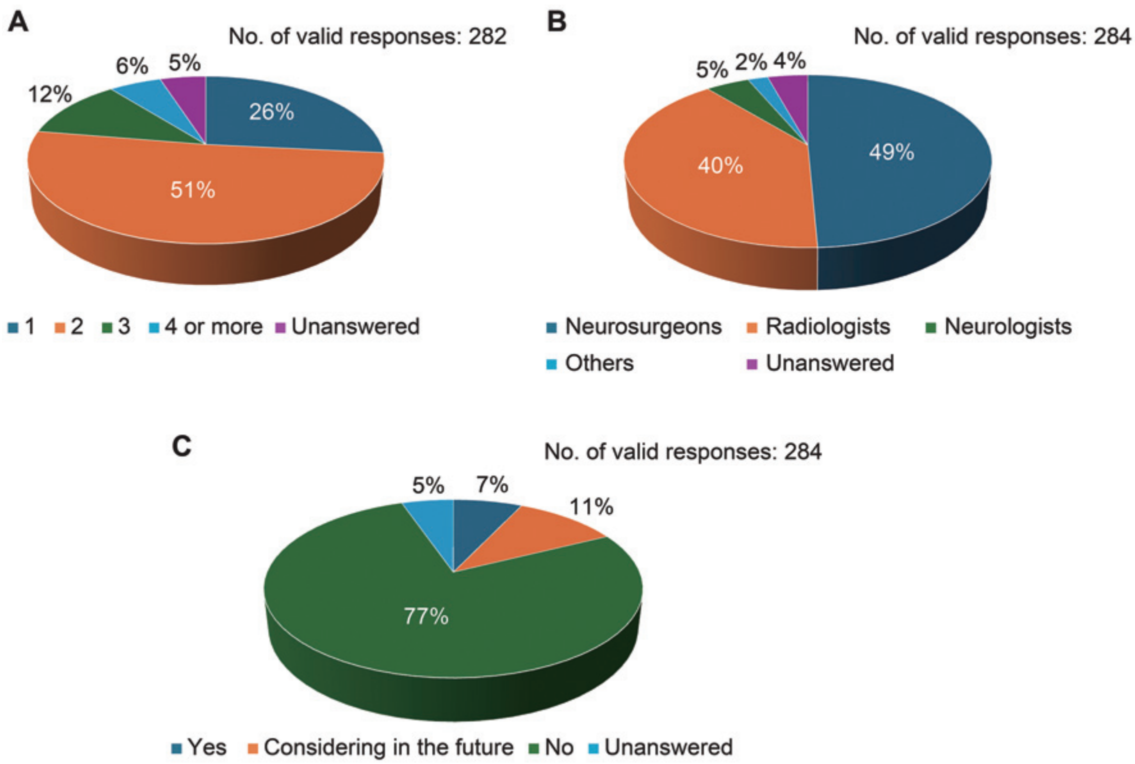

Fig. 4 Imaging readings.
A. Number of readers.
B. Specialties of the readers.
C. Uses of artificial intelligence in imaging readings.

(FLAIR) in 82.8%, and T2 star WI in 71.9%. Approximately 63.5% of respondents underwent MRI using all the required sequences required by brain dock guidelines. Among all the other sequences, diffusion-weighted imaging was the most common, and thin slice-T1WI, basi-parallel anatomical scanning, and voxel-based specific regional analysis systems were some of the responses. Approximately 86.7% and 56.5% of patients underwent head and neck MRA, respectively (Fig. 3C). Approximately 68% of facilities had more than one physician who read the results (Fig. 4A). Neurosurgeons and radiologists read 49% and 40% of the imaging results, respectively (Fig. 4B). Artificial intelligence (AI) was used to read the imaging results only in 7% of the cases (Fig. 4C). Regarding the explanation of the brain dock results, 47% of the facilities explained the results to all examinees in person, and 34% explained the results to those who requested them. However, 10% of the facilities only sent the results (Fig. 5A). Neurosurgeons were the most common professionals who provided explanations (62%), followed by outpatient physicians with reference to the reading results (18%) (Fig. 5B). Approximately 46% of the respondents were referred to specialists based on their preference, and 27% were referred due to abnormal findings. Moreover, 22% of respondents complied with the brain dock guidelines (Fig. 5C). Approximately 67% of respondents were not knowledgeable about the launch of the Brain Dock certification program. Moreover, 57% of the respondents wanted to obtain a brain dock certification.

Discussion

Currently, in Japan, dementia accounts for 23.4% of all nursing care needs, and cerebrovascular disorders for 19%.[2] If stroke and dementia occur, the medical care costs are extremely high and are consistently highly ranked.[3] Brain docks can be one option for their prevention and early detection. Brain docks were initially started in Sapporo in 1988, mainly for examining unruptured cerebral aneurysms on angiography, and in Shimane, mainly for examining asymptomatic cerebrovascular disorders with MRI. Thereafter, its use has spread nationwide. According to the home page of the Japan Brain Dock Society (https://jbds.jp), there are currently approximately 700 brain dock facilities, with 286 facilities accredited by the society.

Benefits of brain docks

Morita et al.[4] mentioned several benefits of brain docks in their narrative review. First, it can detect intracranial lesions in imaging studies. It can detect fatal cerebral aneu-

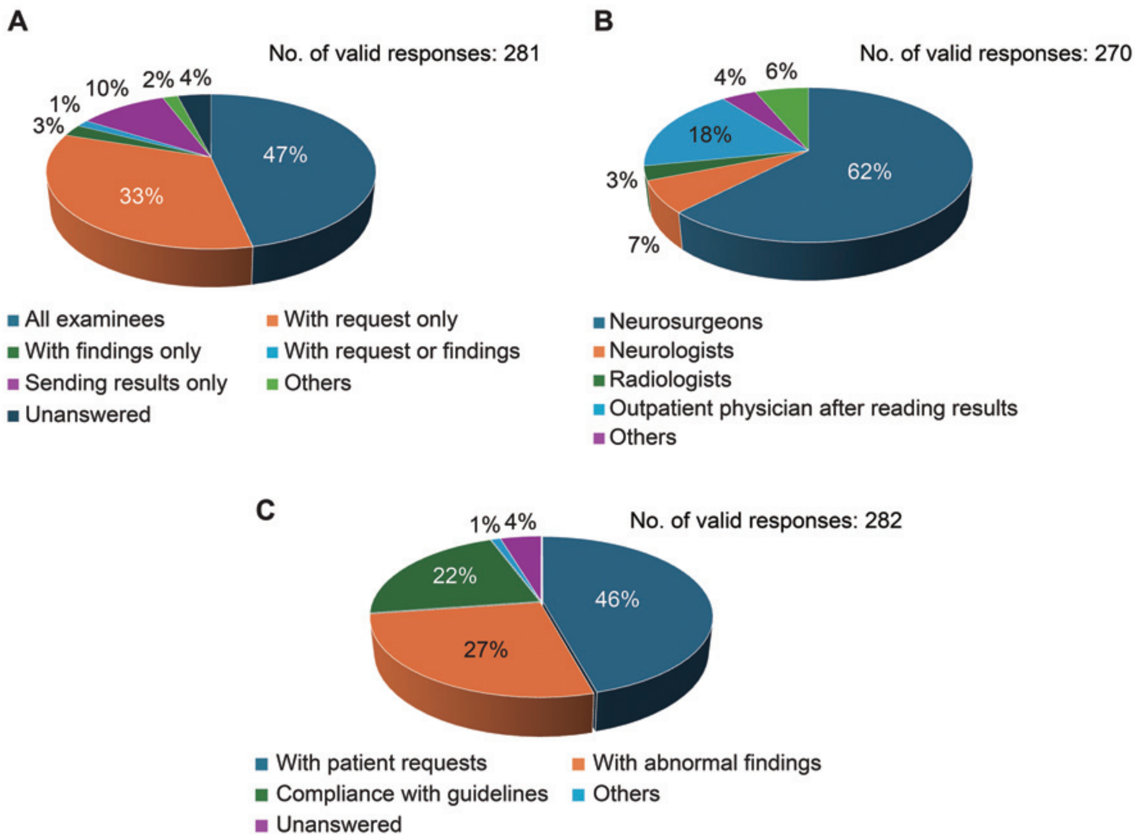

Fig. 5 Explanation of the results.
A. Result explanation target.
B. Professionals who explained the results.
C. Consultation with specialists.

rysms that can cause subarachnoid hemorrhage, prevent its development, and detect asymptomatic lesions such as asymptomatic cerebral infarction. Indeed, Imaizumi et al.[5] performed MRA examinations on 4,070 healthy Japanese subjects and reported a detection rate of 4.32% for cerebral aneurysms. Furthermore, Takahashi et al.[6] reported the simulation results of patients with cerebral aneurysms. The results revealed that among the patients with cerebral aneurysms, more patients were saved, and patient mortality was low in those who underwent brain dock compared with the patients who did not undergo brain dock. Previous studies have investigated the factors for considering treatment for small aneurysms.[7] Evaluating patients with this condition using brain docks can identify these factors and guide decision-making. Concerning white matter lesions in MRI, Yamasaki et al.[8] revealed that hypertension and obesity are remarkable risk factors for white matter changes even in young and middle-aged participants of brain docks. Previous studies have revealed that patients with silent infarction and marked white matter lesions were at higher risk of stroke, mortality, and Alzheimer's disease.[9,10] Furthermore, it has been reported that perivascular space enlargement may be an early imaging sign of atherosclerosis and cerebral amyloid angiopathy.[11] Therefore, it is important to identify asymptomatic lesions and actively manage risk factors. Magnetic resonance plaque imaging and carotid artery ultrasound are clinically useful and cost-effective risk assessment tools for asymptomatic carotid artery stenosis and primary stroke prevention;[12] these technologies can effectively identify the patients most likely to benefit from carotid endarterectomy.[13,14]

Second, brain dock can facilitate the detection and treatment of hidden risks caused by lifestyle-related diseases or their inflammatory processes, preventing strokes and other more serious conditions. The response to injury hypothesis is a well-known explanation for atherosclerosis development.[15] The hypothesis points to physical stressors such as high blood pressure, metabolic stressors such as hyperlipidemia and diabetes, and scientific stressors such as smoking as triggers for this disease. Early detection of these stressors using brain docks can ensure appropriate preventive measures and treatment, reducing the occurrence of stroke. Moreover, Ikawa et al.[16] have reported a declining trend in the estimated incidence of subarachnoid hemorrhage in Japan and suggested that lifestyle improvements have likely contributed to this trend. Identifying hidden risks with brain docks could potentially decrease incidence rates.

Third, brain docks can help in the early detection of cognitive decline, allowing early intervention to slow its progression. Previous research has identified relationships between white matter hyperintensities in T2WI and FLAIR imaging and the risk of cognitive impairment and Alzheimer's disease.[17,18] Zhang et al.[19] reported that the distribution, number, white matter lesions, and hippocampal volume of lacunae infarction were related to cognitive impairment in patients with cerebrovascular diseases. Lifestyle factors that promote gray matter volume loss have also been revealed in participants who underwent a brain scan.[20] Mori et al.[21] suggest that lifestyle changes in middle age reduce the risk of ventricular enlargement (brain atrophy) and subsequent dementia. In addition to imaging findings and biomarkers, cognitive function tests can provide early indications of dementia, allowing prompt treatment to slow its progression. The Japan Brain Dock Society guidelines recommend the Mini Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA) for evaluating cognitive function. These have high sensitivity and specificity for detecting cognitive decline.[22,23] Using such tests is important for early detection of dementia and cognitive decline, helping to identify individuals who should undergo more specialized diagnostic examinations. Notably, cognitive function tests were conducted in 53.7% of facilities. Because these tests are recommended in the official guidelines, this rate is insufficient. More implementation of these tests is necessary in the future.

Brain dock recommendations and current status

Indeed, brain dock guidelines recommend various examinations. This includes not only imaging (e.g., MRI, MRA, and carotid artery ultrasonography) but also interviews (previous medical, family, and life history), physical and neurological examinations, blood, urine, and biochemical tests, and resting electrocardiogram. This comprehensive approach aims to detect the risk of stroke, enabling the provision of early guidance and treatment for risk factor control.[24] Tests of cognitive function such as the MMSE, Hasegawa's Dementia Scale-Revised, and the MoCA are also recommended.[24] This facilitates the identification of stroke risks such as lifestyle-related diseases and arrhythmias, and the detection of early cognitive decline. In this study, several facilities performed the examinations recommended by the Japanese guidelines, thereby indicating that the guidelines are utilized purposefully. Among the items in this survey, the responses showed that 41% of the facilities completely followed the guidelines. However, more than half were unable to fully implement the guidelines, demonstrating the importance of surveys such as this, which should be performed regularly to maintain high levels of quality and uniformity in brain dock use.

T1WI, T2WI, FLAIR, and T2 star WI are mandatory MRI sequences, particularly at accredited facilities of brain dock. Three-dimensional time of flight is now the standard for MRA, and its accuracy has improved.[24] The current survey found that the sequences were more likely to be enforced according to the brain dock guidelines.

Herein, the imaging results were often read by neurosurgeons and radiologists, with many facilities having more than one physician interpreting the image results. However, 26% of facilities did not have more than one doctor in reading brain dock data. When other cancer screening methods are used, the Ministry of Health, Labor, and Welfare requires that results be determined by two clinicians.[25] For patient safety and diagnostic accuracy, double reading will also become a requirement of brain dock diagnosis.

Regarding the use of AI, the utilization rate was only 7% at this time. However, with the use of AI, the detection rate of aneurysms is as high as 91.5%-92.5%. Further, in previous research, the number of aneurysms detected increased by 4.78%-12.5% when neuroradiology readers referred to the AI diagnosis.[26] It has been reported that the volume of white matter changes shown by MRI was measured by AI and was comparable to that assessed by the radiologist.[27] AI is associated with issues such as the high number of suspected positive cases. Nevertheless, Kuwabara et al.[28] reported that this issue could be improved by changing the algorithm, and Zhang et al.[19] also reported that the improved Fussy c-Means algorithm showed a great segmentation effect and high segmentation accuracy in the MRI scans of patients with cerebrovascular disease. In mammography screening, double reading using AI for the second reading produced a similar cancer detection rate to regular double reading, and the reading workload for medical professionals was significantly reduced.[29] If AI is effectively used also in brain regions, it can reduce the burden on physicians, shorten their working time, improve diagnostic accuracy, and lower costs, leading to further expansion of the use of brain docks.

In Japan's aging society, the early detection of preclinical stages of stroke and dementia is important in maintaining a healthy and productive elderly population, and brain dock examinations are becoming increasingly important. However, according to the result of a survey performed in 2021 by SmartScan (https://smartscan.co.jp/news20211207/), awareness about brain docks is not high (53.1%), even among individuals in their 40s, which is the age group with the highest awareness. Further, even among those who are aware, only 20% have undergone brain dock, thereby indicating the need for further awareness.

Japan brain dock society certification

The Japan Brain Dock Society will launch a brain dock certification program in 2024, which can contribute to the development of brain docks in Japan by improving the quality of brain docks and the training of members who can contribute to it. This certification system and further dissemination of its guidelines will ensure and improve the quality of brain docks nationwide.

Study limitations

This questionnaire survey had several limitations. First, this was a voluntary survey with a low response rate to this survey of approximately 10% reduced the extent to which our results represent the clinical use of brain docks in Japan. Second, brain docks are only used in Japan, limiting the international value of our findings. However, surveys such as ours will promote further awareness of brain docks and their standardization, which is important for advanced preventive medicine for the aging society of Japan.

Conclusion

In conclusion, brain docks are likely to be performed in accordance with its guidelines; however, some facilities are not yet in compliance with the guidelines, and the quality of brain docks cannot be guaranteed. Thus, the use of brain dock still differs among facilities, and the recognition and consultation rates are still low. By solving these problems, the brain dock can be further developed in the future, and its utilization can increase and play a greater role in improving medical care, which is a future social issue in Japan, where the aging society is increasing.

Supplementary Material

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Author Contributions

Ikawa, Horie, and Kondo conceived and designed the study. Ikawa and Kondo contributed to the data analysis. Kondo wrote the manuscript. Ikawa, Hara, Kuwabara, Ishii, Tomimoto, and Horie provided feedback and guidance. All authors contributed to data collection and analysis. All authors have read and approved the final version of the manuscript.

Ethical Approval

This study was conducted in accordance with "Ethical Guidelines for Medical and Health Research Involving Human Subjects (Provisional Translation as of March 2015)" and their later amendments. It was approved by the Institutional Review Board of Hiroshima University (approval number E2023-0175).

Data Availability Statement

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Informed Consent

Using an opt-out format, the provision of informed consent was implied by the voluntary completion of the questionnaire by a participant.

Conflicts of Interest Disclosure

All authors have no conflict of interest.

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