Application of Magnetic Resonance Imaging and Magnetic Resonance Angiography as Diagnostic Measures for the First Attack of Suspected Cerebrovascular Diseases in Korea

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Purpose: No precise data are available showing how magnetic resonance imaging (MRI) and magnetic resonance angiography (MRA) can be applied to diagnosis for the first attack of a suspected cerebrovascular disease in Korea. The purpose of this study was to evaluate the application level of MRI and MRA as diagnostic tools and the related factors to the use of these techniques. **Materials and Methods:** This study used the health benefit claim data of 89,890 patients who were hospitalized for the first time due to suspected cerebrovascular disease in 2007 without having visited medical institutions as an outpatient or inpatient from 2003 to 2006. **Results:** Of the 89,890 cases, 28.4% took both MRI and MRA, 10.7% took only MRI and 6.9% took only MRA. The related factors identified in the multivariate logistic regression analysis were gender, type of insurance, type of medical institution, type of department, duration of hospitalization, and type of disease. **Conclusion:** This study showed that the application level of MRI and MRA as diagnostic measures for the first attack of a suspected cerebrovascular diseases varied depending on several factors. It is necessary to study more accurate levels of computerized tomography (CT), computerized tomography angiography (CTA), MRI or MRA as measures to diagnose a first attack of suspected cerebrovascular disease.

Key Words: Cerebrovascular disease, MRA, MRI

INTRODUCTION

In Korea, the aging of the population will lead to an increase in cerebrovascular disease including cerebral infarction and cerebral hemorrhage. Korea is an aging society in which the proportion of people aged 65 years or older passed 7.2% in 2000 and accounted for 10.3% of the total population in 2008. Moreover, Korea is expected to be an aged society by 2018 and a post-aged society by 2026.[1] The incidence and prevalence of cerebrovascular disease were about 100,000 and

400,000, respectively, in 2004. The incidence of stroke is expected to increase to around 350,000 by 2030.[2,3]

The first step in treating cerebrovascular disease is an accurate diagnosis based on clinical symptoms, a neurological examination, and brain imaging. Brain magnetic resonance imaging (MRI) and computerized tomography (CT) are the most frequently used modalities for diagnosis of cerebrovascular disease.

MRI is superior to CT for detecting acute cerebral infarction within several hours, including lesions in the posterior fossa, small lesions, vascular obstruction, and cerebral edema.[4,5] Although cerebral hemorrhage can be easily observed within six hours by both CT and MRI, MRI reveals not only clinically silent parenchymal microbleeds through gradient echo images, but also more helpful than CT in determining the causes of secondary cerebral hemorrhage such as brain tumor, vascular malformation, and aneurysm.[6-9] Additionally, both magnetic resonance angiography (MRA) and computerized tomography angiography (CTA) are useful for examining intracranial vessels and are helpful for diagnosing intracranial stenosis and cerebral aneurysms of over 5 mm. However, CTA has limitations for diagnosing arterial stenosis when wall calcification is present around the cavernous portion of the internal carotid arteries, and MRA is relatively more sensitive and specific than is CTA.[10-12] Therefore, it has been suggested that both MRI and MRA should be performed to maximize the clinical diagnostic accuracy of cerebrovascular disease and to minimize cost.[13]

Although cases diagnosed by brain MRI or MRA and brain CT have been reported annually in the National Health Insurance Statistical Yearbook,[14] there is no precise data showing how many brain images (MRI or MRA) can be applied to the diagnosis of cerebrovascular disease.

This study aimed to investigate the application level of MRI and MRA as diagnostic tools for patients who are suspected to have a first attack of cerebrovascular disease, to assess factors related to the use of these techniques, and to provide objective evidence about the current application levels of MRI and MRA.

MATERIALS AND METHODS

Study subjects

The process of selecting study subjects is shown in Fig. 1. Among 168,979 patients hospitalized in Korea with cerebrovascular disease in 2007, 71,079 cerebrovascular disease patients who had visited medical institutions as an outpatient or an inpatient from 2003 to 2006 were excluded. Moreover, 8,010 patients who were admitted to medical institutes for two days or less were also excluded because it was believed that they did not receive a routine diagnostic examination for suspected cerebrovascular disease including brain imaging, as they were transferred to other medical institutions or died. Finally, 89,890 patients who were hospitalized for the first time due to suspected cerebrovascular disease for three days or longer in 2007 were chosen for analysis.

Methods

All health care institutions must submit health insurance claim to the Health Insurance Review and Assessment Service (HIRA) in Korea. The information on the use of MRI or MRA and other variables are included in the claim data. This study used benefit claim data from the HIRA.
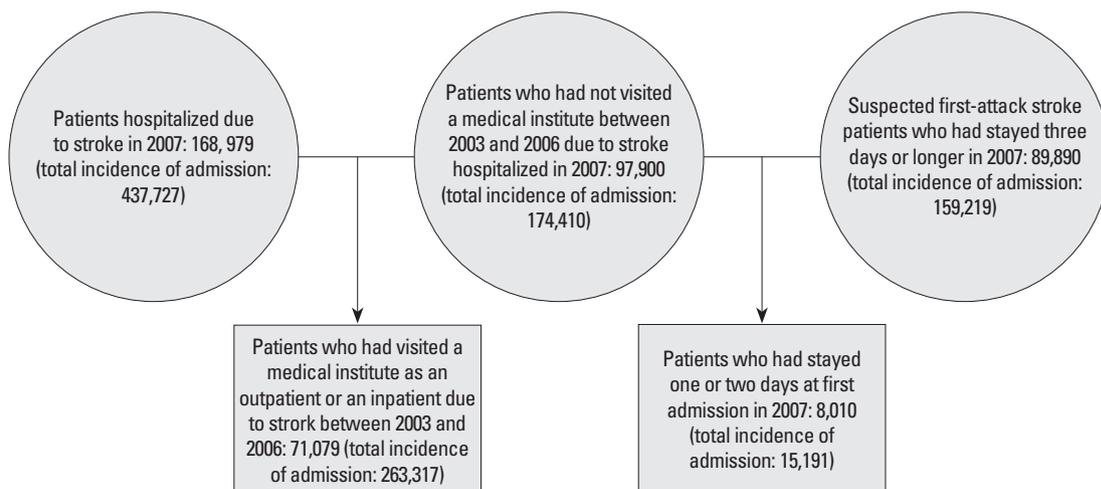

Fig. 1. Process of study subject selection.

The variables presented in the data were classified as dependent or independent variables based on the study purpose. The dependent variable was whether MRI and MRA were applied, and the independent variables were patient-related parameters (gender, age, insurance type, disease name, and duration of hospitalization) and medical institution-related factors (types of medical institutions and departments).

The application of brain imaging was examined by reviewing HE101 (brain MRI without contrast medium) and HE201 (brain MRI with contrast medium) in the claim data for MRI and HE135 (brain MRA without contrast medium) and HE235 (brain MRA with contrast medium) in the data for MRA. If both examinations were given, the case was classified in the complete study group, and if not, it was classified in the incomplete study group.

The subjects were divided into four age groups according to occupational activity: 14 years or younger, 15 to 44 years, 45 to 64 years, and 65 years or older.

Medical institutions were classified into tertiary hospitals, general hospitals, hospitals, long-term care facilities, clinics, and public health centers, which included health centers, community health centers, health subcenters, and health service centers.

The top five departments treating cerebrovascular disease in 2007 (internal medicine, neurology, neurosurgery, rehabilitation medicine, and family medicine) and the others have been investigated.[15]

The duration of hospitalization was dichotomized based on the median hospitalization duration into less than 12 days and 12 days or longer. Stroke was classified as cerebral hemorrhage or cerebral infarction.

Using the ICD-10 code, I60 (subarachnoid hemorrhage), I61 (intracerebral hemorrhage) and I62 (other nontraumatic intracranial hemorrhage) were classified as cerebral hemorrhage, and I63 (cerebral infarction), I64 (stroke, not specified as hemorrhage or infarction), I65 (occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction), I66 (occlusion and stenosis of cerebral arteries, not result-

ing in cerebral infarction), I67 (other crebrovascular disease), I68 (cerebrovascular disorders in diseases classified elsewhere), and I69 (sequelae of cerebrovascular disease) were classified as cerebral infarction.

Statistical analysis

Statistical analysis was conducted using the SAS statistical program version 8.12.

A frequency analysis assessing the application of MRI and MRA in cases of stroke and its relationship to other factors was performed. Multivariate logistic regression analysis was conducted using the significant variables in the univariate analysis, and odds ratio (OR) and 95% confidence interval (CI) were calculated. A significance level of 0.05 was used for all statistical analyses.

RESULTS

MRI and MRA application

Of the 89,890 cases investigated in this study, 48,528 (54.0%) cases did not employ both MRI and MRA, whereas 25,571 (28.4%) cases involved both MRI and MRA. Only MRI was applied in 9,602 (10.7%) cases and only MRA was applied in 6,189 (6.9%) (Table 1). Therefore, the complete study group included 28.4% of the total cases, whereas the incomplete study group included 71.6%.

Factors related to application of both MRI and MRA

The proportion of males who received a complete study (31.3%) was significantly higher than that of females (25.7%) ($p<0.001$). The 45-65 year group showed the highest frequency of complete study (30.1%), whereas the levels for those 65 years or older, 14 years or younger, and 15-44 years were 28.3%, 23.5%, and 22.9%, respectively ($p<0.001$). The proportion of the complete study group covered by health insurance was significantly higher (30.1%) than that of subjects covered by public medical aid (18.0%) ($p<0.001$). When level of application was compared accord-

Table 1. Applications of MRI and MRA for Cerebrovascular Disorders

	Cases	%	Group
MRI (-), MRA (-)	48,528	54.0	
MRI (+), MRA (-)	9,602	10.7	Incomplete study group
MRI (-), MRA (+)	6,189	6.9	
MRI (+), MRA (+)	25,571	28.4	Complete study group
Total	89,890	100.0	

MRI, magnetic resonance imaging; MRA, magnetic resonance angiography.

ing to type of medical institution, tertiary hospitals showed the highest level of complete studies (40.4%), followed by general hospitals (33.6%), hospitals (11.1%), long-term care facilities (5.3%), and clinics (0.2%) (*p*<0.001). The full-study application level for participants in the complete study group who were treated in departments of neurology was highest (51.9%), followed by those treated in departments of rehabilitation medicine (18.5%), neurosurgery (13.9%), and internal medicine (6.4%) (*p*<0.001). The application level for the complete study group hospitalized for less than 12 days was 32.0%, and this was significantly higher than that for patients hospitalized for 12 days or longer (24.7%) (*p*<0.001). Cerebral infarction also resulted in significantly higher application levels (34.2%) than did cerebral hemorrhage (8.9%) (*p*<0.001) (Table 2).

The factors identified in the multivariate logistic regression analysis as associated with patients' receiving a complete study were gender, insurance type, medical institution type, department, duration of hospitalization, and diagnosis (Table 3). The OR for application of a complete study in females compared to males was 0.899 (95% CI, 0.869-0.931), and the OR of payment by public medical aid to that by health insurance was 0.705 (95% CI, 0.666-0.746). Compared to tertiary hospitals, general hospitals, hospitals, long-term care hospitals, and clinics showed an OR for application of a complete study of 0.845 (95% CI, 0.813-0.877), 0.273 (95% CI, 0.255-0.291), 0.124 (95% CI, 0.112-0.138), and 0.004 (95% CI, 0.001-0.013), respectively, and the OR for hospitalization duration of less than 12 days compared to that of 12 days or longer was 0.803 (95% CI, 0.775-0.832). The OR of receiving a complete study for cerebral infarction compared to cerebral hemorrhage was 3.609 (95% CI, 3.402-3.828).

DISCUSSION

This study revealed that a complete study including both brain MRI and MRA as measures of diagnosing cerebro-

Table 2. Relationship between Levels of Application of Brain Imaging and Related Factors

	Variables	Complete study group (%)	Incomplete study group (%)	*p* value
	Total	25,571 (28.5)	64,319 (71.5)	
Gender	Male	13,660 (31.3)	29,952 (68.7)	0.001
	Female	11,911 (25.7)	34,367 (74.3)	
Age (yrs)	≤14	121 (23.5)	394 (76.5)	
	15-44	1,541 (22.9)	5,199 (77.1)	
	45-64	9,077 (30.1)	21,069 (69.9)	0.001
	≥65	14,832 (28.3)	37,657 (71.7)	
Type of insurance	Health insurance	23,419 (30.1)	54,511 (69.9)	
	Public medical aid	2,143 (18.0)	9,787 (82.0)	0.001
	Others	9 (30.0)	21 (70.0)	
Type of medical institution	Tertiary Hospital	9,662 (40.4)	14,232 (59.6)	
	General Hospital	13,871 (33.6)	27,431 (66.4)	
	Hospital	1,546 (11.1)	12,340 (88.9)	0.001
	Long-term Care Hospital	489 (5.3)	8,729 (94.7)	
	Clinic	3 (0.2)	1,540 (99.8)	
	Public health center	0 (0.0)	47 (100)	
Type of department	Neurology	19,191 (51.9)	17,765 (48.1)	
	Internal medicine	690 (6.4)	10,046 (93.6)	
	Neurosurgery	4,838 (13.9)	30,088 (86.1)	0.001
	Rehabilitation medicine	431 (18.5)	1,904 (81.5)	
	Family medicine	40 (2.2)	1,756 (97.8)	
	Others	381 (12.1)	2,760 (87.9)	
Duration of hospitalization (days)	3-11	14,768 (32.0)	31,343 (68.0)	0.001
	≥12	10,803 (24.7)	32,976 (75.3)	
Type of disease	Cerebral hemorrhage	1,820 (8.9)	18,675 (91.1)	0.001
	Cerebral infarction	23,751 (34.2)	45,644 (65.8)	

vascular disease was performed more frequently in men than in women, in patients aged 45-64 years than in patients aged less than 45 or over 65 years, in subjects covered by health insurance than in those covered by public medical aid, in tertiary hospitals than in general hospitals and other institutions, in departments of neurology than in other departments, in subjects hospitalized for less than 12 days than in those hospitalized for 12 days or longer, and for cerebral infarction than for cerebral hemorrhage.

Incomplete studies were probably found more often among subjects aged 15 to 44 years because, given the association between stroke risk and age, many patients in this age range probably undergo examinations for other diagnoses, as they are not likely to be stroke patients. The difference in receipt of brain imaging according to insurance type is likely related to the economic burden to the hospital. The finding that the likelihood of a complete study was highest in tertiary hospitals, followed by general hospitals, hospitals, long-term care hospitals, clinics, and public health centers shows that relatively larger-scale medical institutions use higher-level tools to improve diagnostic accuracy of cerebrovascular disease. The departments of neurology, neurosurgery, and rehabilitative medicine were more likely to use a complete study than were other departments, indicating that these three departments, which specialize in cerebrovascular disease, use tools with high diagnostic value to produce accurate diagnoses. In particular, the department of neurology utilized brain imaging well. The more frequent use of full study in cerebral infarction than in cerebral hemorrhage may be because examinations for cerebral infarction are conducted more actively, as the disease is known to have a greater variety of causes and mechanisms than cerebral hemorrhage.

Differences in the use of diagnostic measures and medical service based on gender have been reported in many studies. According to a community-based research study, the frequency of X-ray was higher in females aged 65 years or older than in males of the same age range, while the frequency of CT and MRI was higher in males than in females.[16] Another study showed that females used intensive care units and selective life-supporting treatments less frequently than did males.[17] Physicians are more likely to recommend total knee arthroplasty for male patients than for female patients, with referral rates for men being nearly 22 times higher.[18] Higher socioeconomic status is associated with increased use of MRI,[16] and higher socioeconomic status has been demonstrated to be a significant predictor of angiography use after acute myocardial infarction in Canada.[19]

This is the first study to use benefit claim data to assess the application level of MRI and MRA as measures for confirming the diagnosis in suspected first-attack cerebrovascular disease patients observed in 2007 in Korea. This

Table 3. Odds Ratio of Receiving a Complete Brain Imaging by Multivariate Logistic Regression Analysis of Associated Factors

	Variables (reference)	Odds ratio	95% Confidence interval of odds ratio
Gender (male)	Female	0.899	0.869-0.931
Age (yrs) (≤14)	15-44	1.080	0.866-1.347
	45-64	0.826	0.771-0.886
	≥65	1.007	0.970-1.045
Type of insurance (health insurance)	Public medical aid	0.705	0.666-0.746
	Others	0.830	0.349-1.969
Type of medical institution (Tertiary Hospital)	General hospital	0.845	0.813-0.877
	Hospital	0.273	0.255-0.291
	Long-term care hospital	0.124	0.112-0.138
	Clinic	0.004	0.001-0.013
	Public health center	<0.001	<0.001->999.999
Type of department (neurology)	Internal medicine	0.136	0.125-0.148
	Neurosurgery	0.246	0.236-0.257
	Rehabilitation medicine	0.345	0.307-0.387
	Family medicine	0.091	0.066-0.126
	Others	0.345	0.306-0.390
Duration of hospitalization (days)(3-11)	≥12	0.803	0.775-0.832
Type of disease (cerebral hemorrhage)	Cerebral infarction	3.609	3.402-3.828

study showed that application levels of MRI and MRA varied according to a variety of factors. Regardless of personal or institution-related factors, a medical environment conducive to the application of brain imaging to confirm suspected disease is necessary to properly treat cerebrovascular disease. But it is necessary to study more accurate levels of CT, CTA, MRI or MRA as measures to diagnose cerebrovascular disease. The designation and development of a regional heart and cerebrovascular disease center focusing on national university hospitals sponsored by the government would overcome the limitations reported here.[20]

Because this study used HIRA benefit claim data, the accuracy of diagnosis is not assured. However, to overcome this limitation, we excluded outpatients and inpatients who had visited medical institutions due to cerebrovascular disease from 2003 to 2006, as well as patients hospitalized for a short time (1-2 days) for whom diagnosis and treatment of cerebrovascular disease were unclear. With such an operational definition, the incidence of suspected cerebrovascular disease cases in 2007 was estimated to be around 89,890 cases, which was lower than the estimation of Bae[2] for 2004 (104,937 cases). Considering the characteristics of cerebrovascular disease, the possibility of visiting medical institutions when symptoms occur is very high, and the possibility of omitting cerebrovascular disease as a primary or secondary diagnosis at first admission to medical institutions is very low. Similarly, the suspected incidence rate of cancer using HIRA data is not largely different from the real incidence rate in the central cancer registry database,[21] and the approach used in this study included most patients with first-attack cerebrovascular disease in 2007.

This study also had the following limitations.

First, attention to a single diagnosis precluded recognition of variations in patient condition. For example, decreased consciousness, intractability, unstable vital signs, the presence of medical devices such as a cardiac pacemakers, and low economic status can actually hinder MRI and MRA performance. There is no detailed data about factors hindering MRI and MRA performance in Korea. However, significantly higher relative risks (range 1.62-2.36) of diagnostic imaging utilization in the highest income quintile were found in pediatric and adult patient groups at all morbidity levels receiving MRI in Canada.[22] Our study also identified the difference in MRI and MRA application according to type of insurance. It is also necessary to find more accurate factors that may hinder MRI and MRA performance. We need to know the true obstacles to a diagnostic approach to stroke and to find the solution for each problems.

Second, differences in accuracy of disease diagnosis and the ease of utilizing brain imaging based on the medical institution were also not considered. The number of specialists in cerebrovascular disease and the possession of equipment for brain imaging including brain MRI, MRA, and CT differ by medical institution. Therefore, whereas large-scaled medical institutions can diagnose a disease more accurately using medical staff specializing in a specific area, smaller institutions cannot do so. This is a large limitation of using benefit claim data. But this study presented the results according to type of medical institution and type of department to overcome this limitation. It is also necessary to educate people to visit a medical institution capable of managing stroke when it is suspected. It is also necessary to establish the network between small and large medical institutions. Recently, the establishment of nine regional referral centers sepecializing in cardiac and cerebrovascular disease is in process to achieve the goal of managing all suspected stroke patients.

Third, brain CT and CTA play important roles along with MRI and MRA in diagnosing cerebrovascular disease, with CT being the primary modality of imaging method instead of MRI according to rough global guidelines by The National Institutes of Health Stroke Scale since 1995.[23] We agree that many cases could have been evaluated with CT or CTA, but we were unable to get data for CT or CTA in this study. This study focused on the application level of MRI and MRA as diagnostic measures for first the attack of a suspected cerebrovascular disease. Next time, we should evaluate the diagnostic modalities for first attack of suspected cerebrovascular diseases including CT, CTA or transcranial Doppler in addition to MRI and MRA.

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