CT Criteria in Vascular Dementia: A Study in Thai Population

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ABSTRACT

Objective: To evaluate CT criteria for diagnosis of vascular dementia (VaD) in Thai population.
Methods: Cranial CT was performed in the elderly from an urban community in the west of Bangkok. The evaluation of infarction (number, location and volume of infarction), white matter low attenuation, and atrophy were performed by neuroradiologists; and, the final diagnoses of dementia were done by neurologists.
Results: Ninety-one patients were recruited into the study with their mean age of 70.16 years old (range = 53-90). Twenty-seven patients were males and 64 were females. The final diagnoses were, namely: normal cognition (10=11%), vascular dementia (30=33%), Alzheimer's disease (AD) (41=45.1%), and mixed VaD and AD (10=11%). On CT, most patients had infarction of less than two lesions and the volume of infarction was less than 25 ml. Two (2.2%) patients who were diagnosed as AD and one who was diagnosed as normal had lesions more than one lesion; whereas 11 (12.1%) patients who were diagnosed as VaD had more than one lesion. No patients who were diagnosed with AD or those who were normal had infarction volume more than 25 ml, except two patients who were diagnosed with VaD had infarction volume more than 25 ml. Most patients who had white matter scale more than 2 were VaD (52%). No significant difference between atrophy and dementia was found. With the CT grading criteria of 0 for non-VaD and combined 1, 2 and 3 for VaD, the sensitivity, specificity and accuracy for diagnosis of VaD were 96%, 64.7%, and 76.5%, respectively.
Conclusion: Modified CT criteria for VaD established by reducing volume of infarction regardless of the atrophy are helpful to identify VaD patients with improved diagnostic performance.

Keywords: Dementia; Computed tomography; CT; Infarction

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Dementia is a growing problem in developing countries compounded by changing social structure and attitudes toward elderly people. In eastern countries, most elders stay with their offspring or relatives. The westernization of lifestyle has altered the care to the elderly. To give proper care to people with dementia, having a clear definition of the etiology of the disease is essential, especially to distinguish the two major types of dementia from each other, namely, vascular dementia and Alzheimer's disease. Although many studies have shown superiority of modern imaging techniques such as magnetic resonance imaging or positron emission tomography in the diagnosis dementia, limitation of healthcare resources in Thailand is a major problem. The country is still in need of most cost-effective neuroimaging in the management of the patients. So far, computed tomography (CT) is still considered beneficial to demented patients; it is used to rule out structural lesions such as infarction, neoplasm, extracerebral fluid collection and hydrocephalus. The purpose of our study is to evaluate the imaging criteria for diagnosis of vascular dementia by cranial CT in an urban population in Thailand.

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MATERIALS AND METHODS

This research is a part of a study of the Integrated Health Research Program for the Elderly (IHRE) conducted during 1998-1999 in the community of Bangkok-Yai and Bangplad areas. These areas are in central to Thonburi district in the west of Bangkok.

Computed tomography (CT) of the cranium was done at the Department of Radiology under routine protocol. The posterior fossa was scanned with 5-mm slice thickness and the rest of the brain with 10 mm. The scan was done before and after contrast enhancement.

The clinical data were then collected by an experienced neurologist and nurses who were trained to assess dementia. The final diagnosis of each case was reached by consensus of all clinical and laboratory information.

Furthermore, hard copies of CT brains were independently reviewed by two neuroradiologists who were blinded to the clinical and neuropsychological data. The radiologists determined the presence, number, location and volume of infarction, including white matter low attenuation, and atrophy. The final result was reached by consensus. The infarct volume was measured by method of Nelson et al.[1] Briefly, the longest diameter of infarct on the hard copy of the image was multiplied by the greatest

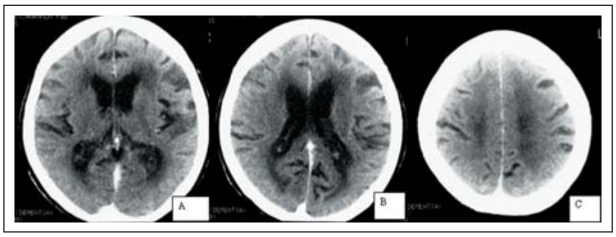

Fig 1. Axial CT at 3 levels of cranium used for evaluation of white matter scale: *A* and *B* for anterior, *B* and *C* for posterior score

diameter at the right angle to it. The product of these two measurements was multiplied by the number and thickness of scan slices showing the infarct. The resulting volume was divided by 2 to approximate an ellipsoid. The total infarct volume was reached by summation of all lesions in each patient.

The severity of white matter low attenuation was determined using the white matter scale of van Swieten et al.[2] This scale grades white matter low attenuation into 4 grades. (Fig 1) Both the frontal and occipital white matter regions were graded. Two points were scored if the low attenuation reaches the entire way from the lateral ventricle to the cortex and one point if it is restricted to the periventricular region. The scores of the most severely affected side of frontal area are added to the most severe side of occipital area to give the total white matter scale (WMS).

Atrophy was determined by calculated ventricular index (VI). This was performed by the method of Huges and Gado.[3] Four linear measurements of the ventricular system were made. Three of these were taken from the image at the level of foramen of Monro: A= the width of the third ventricle; B= the sum of the shortest distances between caudate nucleus and septum pellucidum; C= the width of the lateral ventricle just anterior to the foramen of Monro; and D was the width of the narrowest part of the bodies of the lateral ventricle. The widest interparietal distance (IP) was measured from the image showing that part of the lateral ventricle. A VI was obtained by [(A+B+C+D)/IP] x100.

CT grading for vascular dementia (VaD) was performed by using the criteria of Pullicino et al.[4] The criteria grade the likelihood of VaD from 0 to 3 by combining the number of infarction, infarction volume, white matter scale and ventricular index for consideration. Following the suggestion given in the study of Pullicino et al., we also developed modified criteria by decreasing the infarction volume to 25 and 50 ml and not considering VI as shown in Table 1.

Statistical analysis: Descriptive analysis was done at the appropriate places. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated for CT grading criteria.

TABLE 1. The modified CT criteria for vascular dementia (VaD)[4]

Grade	Description	Criteria
0	No VaD	No infarction or WMS<3
1	Unlikely VaD	Infarction volume < 25 ml or WMS=3
2	Possible VaD	Infarction volume ≤ 25ml or WMS=4
3	Probable VaD	Infarction volume ≥ 50 ml

TABLE 2. Number of patients (%) with infarction according to diagnosis of dementia.

Number of Infarction	Final Diagnosis				
	Normal(%)	VaD(%)	AD(%)	Mixed dementia(%)	Total
0	4(4.4)	4(4.4)	34(37.3)	4(4.4)	46(50.5)
1	5(5.5)	15(16.5)	5(5.5)	4(4.4)	29(31.9)
2	1(1.09)	6(6.6)	2(2.2)	1(1.09)	10(10.9)
3	0	3(3.3)	0	1(1.09)	4(4.4)
4	0	1(1.09)	0	0	1(1.09)
6	0	1(1.09)	0	0	1(1.09)
Total	10	30	41	10	91(100)
Volume (ml) 0	4(4.4)	4(4.4)	34(37.3)	4(4.4)	46(50.5)
<25	6(6.6)	24(26.4)	7(7.6)	5(5.5)	42(46.1)
>25	0	2(2.2)	0	1(1.09)	3(3.3)
Total	10	30	41	10	91(100)

VaD = vascular dementia, AD = Alzheimer's disease

TABLE 3. Number of patients (%) with white matter abnormality (van Swieten's WMS[2]) according to diagnosis.

WMS	Diagnosis				
	Normal(%)	VaD(%)	AD(%)	Mixed dementia(%)	Total
0	2(2.2)	0	15(16.5)	0	17(18.7)
1	2(2.2)	9(9.9)	10(11.0)	5(5.5)	26(28.5)
2	3(3.3)	8(8.8)	10(11.0)	2(2.2)	23(25.3)
3	2(2.2)	4(4.4)	3(3.3)	1(1.0)	10(10.9)
4	1(1.0)	9(9.9)	3(3.3)	2(2.2)	15(16.5)
Total	10	30	41	10	91(100)

WMS = white matter scale(see text), VaD = vascular dementia, AD = Alzheimer's disease

RESULTS

Ninety-one patients were recruited into the study. The range of their age was 53-90 with the mean age of 70 years. Twenty-seven patients were males and 64 were females. The final diagnoses were, namely, normal cognition in 10 (11%), vascular dementia in 30 (33%), Alzheimer's disease (AD) in 41(45.1%), and mixed VaD and AD in 10(11%).

On CT, the number of detected infarction areas ranged from 0-6 lesions. (Table 2) Most of the patients had less than two lesions with the volume of infarction less than 25 ml. When the infarction was correlated with final diagnosis, two patients who were diagnosed as AD and one normal had more than one area of infarct as compared to 11 patients who were diagnosed with VaD. No patients who were diagnosed with AD or normal had infarction volume more than 25 ml except two who were diagnosed VaD had infarction volume more than 25 ml.

Six cases of VaD, one of mixed dementia and four who were normal had cortical infarction. Two cases of normal, 18 cases of VaD, 8 cases of AD and 6 cases of mixed dementia had subcortical infarction.

Sixty cases (72.5%) had WMS less than 3. (Table 3) These were 7 normal, 17 VaD, 35 AD and 7 mixed dementia. Most patients with WMS more than 2 were VaD (13 of 25=52%).

Regarding brain atrophy, there were 46(50.5%) with VI less than 60 and 45(49.5%) more than 60. No significant difference between the diagnosis and VI was found (Fisher exact: p=0.145). The detail was shown in table 4.

TABLE 4. Number of patients (%) with atrophy classified as ventricular index.

VI	Diagnosis Normal(%)	VaD(%)	AD(%)	Mixed dementia(%)	Total
<60	7(7.6)	15(16.5)	22(24.2)	2(2.2)	46(50.5)
>60	3(3.3)	15(16.5)	19(20.9)	8(8.8)	45(49.5)
Total	10	30	41	10	91(100)

VaD = vascular dementia, AD = Alzheimer's disease

TABLE 5. Result of CT grading criteria for VaD by using Pullicino's[4] (1) and modified (2) criteria.

Grade	Diagnosis Normal (1)	Normal (2)	VaD (1)	VaD (2)	AD (1)	AD (2)	Mixed (1)	Mixed (2)	Total
0	3	3	2	1	30	30	1	1	36
1	6	6	14	19	7	8	4	6	31
2	1	1	8	9	2	3	3	2	14
3	0	0	6	1	2	0	2	1	10
Total	10	10	30	30	41	41	10	10	91

VaD = vascular dementia, AD = Alzheimer's disease, Mixed = mixed dementia

TABLE 6. Diagnostic performance of CT criteria for vascular dementia.

		Sensitivity(%)	Specificity(%)	PPV	NPV	Accuracy(%)
Pullicino's[4] :	(1)	93.3	64.7	0.61	0.94	75.3
	(2)	46.7	90.2	0.74	0.74	74
Modified criteria:	(1)	96.7	64.7	0.68	0.97	76.5
	(2)	33.3	92.2	0.71	0.70	70

(1) = grade0 for non-vascular dementia and grade 1+2+3 for vascular dementia;
(2) = grade 0+1 for non-vascular and grade 2+3 for vascular dementia.

When analysis of CT criteria for VaD was conducted, we excluded mixed dementia resulting 81 cases for the diagnostic test. Table 5 shows the results of grading of VaD and final diagnoses under the CT criteria of Pullicino. If grade 0 was used to identify the absence of VaD, and other combined grades were used to identify the presence of VaD, the accuracy of the criteria was 75.3%. If combined grade 0 and 1 were used to identify non-VaD and grade 2 and 3 for VaD, the accuracy was 74%. The diagnostic performance is shown in table 6.

By using the modified CT criteria, the result of grading is shown in table 5. If grade 0 was used to identify the absence of VaD and the other three grades were combined to identify the presence of VaD, the accuracy was 76.5%. If combined grade 0 and 1 were used to identify non-VaD and grade 2 and 3 for VaD, the accuracy was 70%. The diagnostic performance is shown in table 6.

DISCUSSION

Although the American College of Radiology gives the appropriateness criteria of 8/9 for MR imaging, 6/9 for CT and 5-6/9 for PET, financial restrain has made CT the optimal method of investigation in developing countries. All patients with suspected dementia should undergo neuroimaging and CT is useful to identify treatable causes.[5,6,7] CT also demonstrates evidence of infarction, white matter change and atrophy to help in diagnosis of VaD. Many reports have showed acceptable accuracy of CT in differentiating VaD from non-VaD, especially AD.[3,4,8] The infarction and severity of white matter change were proved to have correlation with VaD more than AD.[9] However, atrophy seems to have no relationship with the severity of dementia.[3] The difference between our study and that of Pullicino et al. was in the studied populations.[4] Apparently, our patients had infarction volume less than their patients. However, the diagnostic performance using their criteria is not significantly different between their report and ours. We demonstrated here that without considering atrophy and reducing infarct volume, the sensitivity of diagnosis VaD by CT was slightly increased, while maintaining the specificity and given slightly increased accuracy.

Concerning the prognosis of VaD and AD, the mortality rate of VaD is higher. Although both diseases are un-curable, VaD can be prevented and the process of AD can be slowed down. From all these reasons, diagnostic tool of high sensitivity is as importance as the one with high specificity. With the difference of treatment of both diseases, we recommend that if the CT grading is 0, further investigation for VaD is not necessary (with sensitivity 96-93% and NPV more than 0.9). If the CT grade is 2 or 3, the diagnosis of VaD is high (with the specificity more than 90% and PPV about 0.7). The only diagnosis that should be excluded is mixed dementia. If the grade is 1, no certainty can be concluded for VaD. In the population with low incidence of VaD, CT seems to be useful and cost-effective. We also demonstrated here that Alzheimer's disease is the most common dementia in our urban population as in western countries.

In conclusion, CT criteria for VaD were helpful to differentiate patients with VaD from non-VaD. Reduction of the volume of infarction and ignoring the degree of atrophy improved the diagnostic performance of the test.

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บทคัดย่อ

การศึกษาหลักเกณฑ์การวินิจฉัยโรคสมองเสื่อมจากการขาดเลือดในประชากรไทยโดยใช้ภาพเอกซเรย์คอมพิวเตอร์สมอง

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บทนำ: โรคภาวะสมองเสื่อมในประชากรไทยพบมากขึ้นเรื่อย ๆ จากการที่สาธารณสุขไทยพัฒนาขึ้น สาเหตุสำคัญของภาวะนี้สาเหตุหนึ่งคือการขาดเลือดเลี้ยงสมอง การวินิจฉัยที่ถูกต้องจะช่วยทำนายโรคและการป้องกันที่ถูกต้อง

วัตถุประสงค์: เพื่อประเมินคุณค่าของการใช้เอกซเรย์คอมพิวเตอร์สมองในการวินิจฉัยโรคภาวะสมองเสื่อมจากการขาดเลือดในคนไทย รูปแบบการศึกษา: ศึกษาย้อนหลัง ประชากร ผู้สูงอายุในชุมชนทางตะวันตกของกรุงเทพมหานครที่เข้าร่วมโครงการวิจัยสุขภาพในผู้สูงอายุ

วิธีการ: รังสีแพทย์ศึกษาลักษณะภาพเอกซเรย์คอมพิวเตอร์สมองของผู้เข้าร่วมโครงการ โดยศึกษาลักษณะของสมองที่ขาดเลือด (จำนวน, ตำแหน่ง และปริมาตร) ความทึบรังสีของเนื้อสมองส่วน white matter และการฝ่อของสมอง การวินิจฉัยภาวะสมองเสื่อมทำโดยแพทย์ชำนาญทางประสาทวิทยา สถิติ: ความไว, ความจำเพาะ, ความแม่นยำ

ผลการศึกษา: ผู้ร่วมโครงการที่ศึกษาในงานวิจัยนี้จำนวน 91 ราย อายุเฉลี่ย 70.16 ปี ชาย 27 และหญิง 64 ราย การวินิจฉัยสุดท้าย ภาวะความจำปกติ 10 ราย (ร้อยละ 11) ภาวะสมองเสื่อมจากการขาดเลือด 30 ราย (ร้อยละ 33) โรคอัลซัยเมอร์ 41 ราย (ร้อยละ 45.1) และภาวะสมองเสื่อมจากการขาดเลือดร่วมกับโรคอัลซัยเมอร์ 10 ราย(ร้อยละ 11) ผลจากภาพรังสีพบว่าผู้ป่วยส่วนใหญ่มีรอยโรคสมองขาดเลือดน้อยกว่า 2 จุดและปริมาตรน้อยกว่า 25 มล.ผู้ป่วยที่มีรอยโรคมากกว่า 1 รอยเป็นผู้ป่วยที่ได้รับการวินิจฉัยว่าเป็นโรคอัลซัยเมอร์ 2 ราย (ร้อยละ 2.2) ภาวะความจำปกติ 1 ราย และภาวะสมองเสื่อมจากการขาดเลือด 11 ราย (ร้อยละ 12.1) ไม่มีผู้ป่วยที่ได้รับการวินิจฉัยว่ามีภาวะความจำปกติหรือโรคอัลซัยเมอร์ มีปริมาตรของรอยโรคมากกว่า 25 มล.ไม่มีความสัมพันธ์ระหว่างการฝ่อของสมองกับการวินิจฉัยภาวะสมองเสื่อม เมื่อใช้หลักเกณฑ์การวินิจฉัยโรคสมองเสื่อมจากการขาดเลือดโดยใช้ภาพเอกซเรย์คอมพิวเตอร์สมอง พบว่า ความไว ความจำเพาะ และ ความแม่นยำร้อยละ 96, 64.7 และ 76.5 ตามลำดับ

สรุป: การใช้หลักเกณฑ์การวินิจฉัยโรคสมองเสื่อมจากการขาดเลือดโดยใช้ภาพเอกซเรย์คอมพิวเตอร์สมองช่วยในการสืบค้นผู้ป่วยภาวะสมองเสื่อมที่เกิดจากโรคนี้