ลักษณะภาพวินิจฉัยจากเครื่องเอกซเรย์คอมพิวเตอร์ในผู้ป่วยระบบทางด่วนรักษาโรคหลอดเลือดสมองที่โรงพยาบาลสมเด็จพระยุพราชท่าบ่อ (ก่อนและหลังได้รับยาละลายลิ่มเลือด)

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Abstract: Computed Tomography Findings of the Brain in Stroke Fast Track at Thabo Crown Prince Hospital (Pre and Post Thrombolytic Therapy)

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Background: The incidence of strokes in Thailand has been increasing annually. The stroke fast track network aims to promptly provide intravenous thrombolytic drugs to acute ischemic stroke patients. Objective: To analyze the demographics, clinical presentations, and computed tomography (CT) findings of the brain (pre- and post-thrombolytic therapy) of stroke fast track patients at Thabo Crown Hospital. Method: This retrospective descriptive study was conducted from July 1, 2019, to December 31, 2021. The data were analyzed by descriptive statistics, i.e., percentage and frequency. Result: A total of 52 stroke fast track patients diagnosed with acute ischemic stroke and who underwent intravenous thrombolytic therapy were recruited. The majority sex was male (54%) and 71-90 years old (36.5%). The most frequent clinical presentations were 48.1% of right hemiparesis, followed by left hemiparesis, dysarthria or aphasia, facial palsy, and paresthesia, respectively. The first abnormal CT scan findings (pre-thrombolytic therapy) were obscuration of the lentiform nucleus, loss of the insular ribbon, parenchymal hypodensity, and hyperdense middle cerebral artery, respectively, the same as the second abnormal (post-thrombolytic therapy) findings with 11.5% hemorrhagic transformation. The six patients were normal first CT scan findings (pre-thrombolytic therapy). In contrast, parenchymal hypodensity, followed by obscuration of the lentiform nucleus and hemispheric sulcal effacement, respectively, were found in the second CT scan. Conclusion: The earliest CT finding of stroke fast track patients (pre- and post-thrombolytic therapy) found from this study is obscuration of the lentiform nucleus. At the same time, patients with no abnormal findings on the first CT scan are mostly found with parenchymal hypodensity on the post-thrombolytic CT scan (24 hours later).

Keyword: Stroke fast track, Acute ischemic stroke, Computed Tomography of the brain

บทคัดย่อ

ภูมิหลัง: อุบัติการณ์ของโรคหลอดเลือดสมองในประเทศไทยเพิ่มขึ้นในทุก ๆ ปี ระบบทางด่วนโรคหลอดเลือดสมอง (stroke fast track) มีวัตถุประสงค์เพื่อให้ผู้ป่วยที่มีภาวะสมองขาดเลือดเฉียบพลันได้รับการรักษาด้วยยาละลายลิ่มเลือดได้อย่างทันท่วงที วัตถุประสงค์: เพื่อศึกษาข้อมูลพื้นฐาน อาการสำคัญทางคลินิกและลักษณะภาพเอกซเรย์คอมพิวเตอร์สมองก่อนและหลังได้รับยาละลายลิ่มเลือดของผู้ป่วยระบบทางด่วนโรคหลอดเลือดสมองในโรงพยาบาลสมเด็จพระยุพราชท่าบ่อ วิธีการ: การศึกษาเชิงพรรณนาย้อนหลัง ตั้งแต่ 1 กรกฎาคม 2562 จนถึง 31 ธันวาคม 2564 วิเคราะห์โดยใช้สถิติเชิงพรรณนา ได้แก่ ร้อยละและความถี่ ผล: ผู้ป่วยทั้งหมด 52 ราย ที่เข้าเกณฑ์ระบบทางด่วนโรคหลอดเลือดสมองได้รับการวินิจฉัยว่าเป็นโรคสมองขาดเลือดเฉียบพลันและได้รับการรักษาด้วยยาละลายลิ่มเลือด โดยพบว่าส่วนใหญ่เป็นเพศชาย (ร้อยละ 54) อยู่ในช่วงอายุ 71-90 ปี (ร้อยละ 36.5) อาการสำคัญทางคลินิกที่พบมากที่สุด ได้แก่ แขน/ ขาอ่อนแรงด้านขวา ร้อยละ 48.1 รองลงมาคือ แขน/ ขาอ่อนแรงด้านซ้าย พูดไม่ชัดหรือไม่พูด ปากเบี้ยว และชา ตามลำดับ ลักษณะภาพเอกซเรย์

คอมพิวเตอร์สมองครั้งที่ 1 (ก่อนได้รับยาละลายลิ่มเลือด) พบลักษณะผิดปกติ คือ obscuration of the lentiform nucleus, loss of the insular ribbon, parenchymal hypodensity, hemispheric sulcal effacement ตามลำดับ เช่นเดียวกับลักษณะผิดปกติ ของภาพเอกซเรย์คอมพิวเตอร์สมองครั้งที่ 2 (หลังได้รับยาละลายลิ่มเลือด) และพบเลือดออกบริเวณที่สมองขาดเลือด (hemorrhagic transformation) ร้อยละ 11.5 มีผู้ป่วยจำนวน 6 รายที่ไม่พบลักษณะความผิดปกติในภาพเอกซเรย์คอมพิวเตอร์สมองครั้งที่ 1 (ก่อนได้รับยาละลายลิ่มเลือด) แต่พบความผิดปกติในภาพเอกซเรย์คอมพิวเตอร์สมองครั้งที่ 2 (หลังได้รับยาละลายลิ่มเลือด) โดยพบความผิดปกติ parenchymal hypodensity มากที่สุด รองลงมาคือ obscuration of the lentiform nucleus และ hemispheric sulcul effacement ตามลำดับ **สรุป:** ลักษณะภาพเอกซเรย์คอมพิวเตอร์สมองของผู้ป่วยสมองขาดเลือดเฉียบพลันในระยะเริ่มแรกทั้งก่อนและหลังได้รับยาละลายลิ่มเลือดจากการศึกษานี้ พบลักษณะผิดปกติเป็น obscuration of the lentiform nucleus มากที่สุด สำหรับผู้ป่วยที่ไม่พบภาพเอกซเรย์คอมพิวเตอร์สมองผิดปกติในการตรวจครั้งแรกจะพบลักษณะของ parenchymal hypodensity มากที่สุดในการตรวจครั้งที่ 2 หลังได้รับยาละลายลิ่มเลือด (24 ชั่วโมงถัดมา)

คำสำคัญ: ระบบทางด่วนโรคหลอดเลือดสมอง โรคสมองขาดเลือดเฉียบพลัน ภาพเอกซเรย์คอมพิวเตอร์สมอง

Introduction

Stroke is one of the leading causes of death and long-term disability worldwide.[1] It is the second most common cause of mortality worldwide. According to the World Health Organization (WHO), stroke is the second leading cause of death for people above 60 years old and the fifth leading cause in people aged 15 to 59 years old.[2] The prevalence of stroke is estimated to be 1,880 per 100,000 among adults aged 45 years and older. According to the Ministry of Public Health in Thailand, more than 50,000 deaths from stroke annually.

Intravenous thrombolysis with recombinant tissue plasminogen activator (rt-PA) is now the standard treatment for patients with acute ischemic stroke and is recommended by the Thai Stroke Guidelines.[3] The first patient ever treated with intravenous thrombolysis was in 1996, and later on, the stroke fast track program was developed.[4] This FDA-approved treatment has been shown to reduce long-term disability and improve stroke outcomes in ischemic stroke patients.

The Thai Stroke Society and Thabo Crown Prince Hospital have established the stroke fast track network, which has been in practice for more than ten years, to improve stroke care. This pathway classifies stroke patients who arrive at the hospital within the three-hour window (must not exceed 4.5 hours) and makes sure that they receive rt-PA therapy if deemed eligible.

Therefore, this study aimed to analyze the demographic, clinical presentations, and CT findings of the brain (pre- and post-thrombolytic therapy) of stroke fast track patients at Thabo Crown Hospital. The data from this study will be important information that will lead to the development of the stroke fast track Network at Thabo Crown Prince Hospital to be more efficient, including reducing complications, mortality, disability rates, and improving patients' quality of life.

Materials and Methods

This retrospective descriptive study was conducted in the Radiology department of Thabo Crown Prince Hospital from July 1, 2019, to December 31, 2021. Stroke fast track patients were referred to the Radiology department for CT scan of the brain at Thabo Crown Prince Hospital (pre- and post-thrombolytic therapy). Data collected included demographic characteristics and clinical presentations using the data from inpatient-outpatient medical records and a database from the HOSxP program of Thabo Crown Prince Hospital. The recorded and analyzed data included age, sex, and clinical presentations such as weakness, dysarthria, aphasia, facial palsy, paresthesia, dizziness, and other symptoms. CT findings in stroke fast track patients obtained information from the CT center and a picture archiving and communication system (PACS) of Thabo Crown Prince Hospital. The recorded and analyzed data included time of onset, time to first CT brain (pre-thrombolytic therapy), time between first and second CT brain (pre- and post-thrombolytic therapy), the abnormal CT scan findings of the brain (early signs of acute ischemic stroke), i.e., loss of the insular ribbon, obscuration of the lentiform nucleus, parenchymal hypodensity, hemispheric sulcal effacement, hyperdense middle cerebral artery and MCA dot sign (Figure 1 and Table 1). The data were analyzed by descriptive statistics, i.e., percentage and frequency. The study was approved by the Institutional Ethical Committee. The written consent was waived by the ethics committee

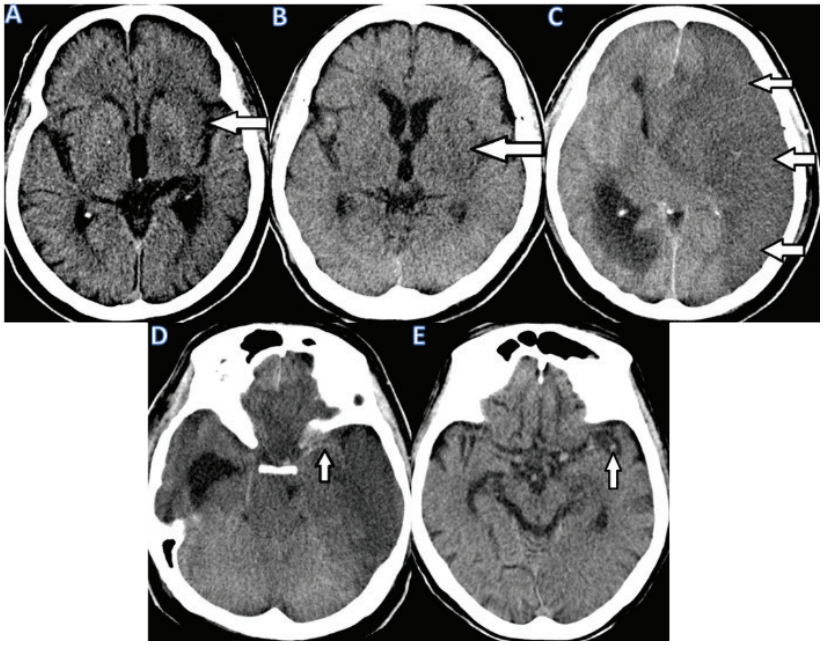

Figure 1 The abnormal CT scan findings of the brain (early signs of acute ischemic stroke)
(A) Loss of the insular ribbon. (B) Obscuration of the lentiform nucleus.
(C) Parenchymal hypodensity and hemispheric sulcal effacement.
(D) Hyperdense middle cerebral artery (MCA). (E) MCA dot sign.

Table 1 Definitions of Early CT Signs of Ischemic Stroke

CT Sign	Definition
Loss of the insular ribbon	Decreased precision in the delineation of gray-white interface at lateral margin of the insula
Obscuration of the lentiform nucleus	Decreased attenuation involving the lentiform nucleus and inducing the loss of the precise delineation of this area
Parenchymal hypodensity	New areas of low attenuation in the hemispheric white matter or cortex
Hemispheric sulcal effacement	Decreased contrast, loss of precise delineation of the grey-white interface in the margins of the cortical sulci, corresponding to localized mass effect
Hyperdense middle cerebral artery (MCA)	Attenuation higher than that in any other visualized artery or vein
MCA dot sign	The hyperdensity of an arterial structure (seen as a dot) in the Sylvian fissure relative to the contralateral side or to other vessels within the Sylvian fissure

Results

A total of 52 stroke fast track patients diagnosed with acute ischemic stroke and who underwent intravenous thrombolytic therapy were recruited. There were 28 (54%) males and 24 (46%) females. The age of the patients ranged from 41 to 90 years old, with a mean age was 67.1 ± 10.8 years, and most of them were over 60 years old age group (71.2%), as shown in Table 2.

Table 2 Patients' demographic characteristics (*n* = 52)

Age (years)	Male Number (%)	Female Number (%)	Total Number (%)
21-50	3 (5.8)	1 (1.9)	4 (7.7)
51-60	6 (11.5)	5 (9.6)	11 (21.2)
61-70	12 (23)	6 (11.5)	18 (34.6)
71-90	7 (13.5)	12 (23.1)	19 (36.5)
Total	28 (53.8)	24 (46.2)	52 (100)

The most frequent clinical presentations were 48.1% of right side weakness, followed by left side weakness (44.2%), then dysarthria or aphasia (38.6%), facial palsy (25%), and paresthesia (3.8%), respectively, as shown in Table 3.

The average time between the onset of symptoms and the first CT brain (pre-thrombolytic therapy) was 117.0 minutes (106.2 – 126.8 minutes). The average time between first and second CT brain (pre- and post-thrombolytic therapy) was 23.3 hours. (22.4 – 24.2 hours)

Table 3 Patients' clinical presentations (n = 52)

Clinical presentations	Male Number (%)	Female Number (%)	Total Number (%)
Right hemiparesis	15 (28.8)	10 (19.2)	25 (48.1)
Left hemiparesis	12 (23.1)	11 (21.2)	23 (44.2)
Dysarthria or aphasia	11 (21.2)	9 (17.3)	20 (38.6)
Facial palsy	7 (13.5)	6 (11.5)	13 (25)
Paresthesia	1 (1.9)	1 (1.9)	2 (3.8)

The first CT scan findings (pre-thrombolytic therapy) were abnormal in 36 patients (69.2%), which included obscuration of the lentiform nucleus (65.4%), followed by loss of the insular ribbon (61.5%), parenchymal hypodensity (53.8%), hyperdense middle cerebral artery (42.3%), hemispheric sulcal effacement (38.5%), and MCA dot sign (3.8%), respectively. In most patients, there was more than one abnormality, with only one abnormality found in only 5 cases (9.6%). For the second CT scan findings (post-thrombolytic therapy) were abnormal in 42 patients (80.8%), which included obscuration of the lentiform nucleus (69.2%) then followed by loss of the insular ribbon (63.5%), parenchymal hypodensity (61.5%), hemispheric sulcal effacement (55.8%), hyperdense middle cerebral artery (34.6%), and MCA dot sign (3.8%), respectively. 4 The first and second CT scan findings (pre- and post-thrombolytic therapy) were recorded from the same patient. Table 4 demonstrates the first and second abnormal CT scan findings (pre- and post-thrombolytic therapy).

Table 4 The first and second abnormal CT scan findings (pre- and post-thrombolytic therapy)

Abnormal findings (Early CT Signs)	1st CT scan Number (%)	2nd CT scan Number (%)
Loss of the insular ribbon	32 (61.5)	33 (63.5)
Obscuration of the lentiform nucleus	34 (65.4)	36 (69.2)
Parenchymal hypodensity	28 (53.8)	32 (61.5)
Hemispheric sulcal effacement	20 (38.5)	29 (55.8)
Hyperdense middle cerebral artery (MCA)	22 (42.3)	18 (34.6)
MCA dot sign	2 (3.8)	2 (3.8)

The six patients were normal first CT scan findings (pre-thrombolytic therapy) whereas mostly found parenchymal hypodensity (4 of 6 patients), followed by obscuration of the lentiform nucleus and hemispheric sulcal effacement, respectively, in second CT scan findings.

In addition, the hemorrhagic transformation was found in the second CT scan findings in 6 patients (11.5%).

Discussion

The most recent Thai Epidemiological Stroke Study found that the prevalence of stroke in populations over the age of 45 is 1.88%.[1] Men had a higher prevalence of stroke than women in all age groups. In this study, the majority sex was male and 60-90 years old age group. The most frequent clinical presentations were hemiparesis, dysarthria or aphasia, facial palsy, and paresthesia. This finding has no significant difference from other studies[5,7-9].

Obscuration of the lentiform nucleus (pallidum, putamen), predominantly gray matter, and the surrounding white matter tracks from the internal and external capsules. This sign was first described by Tomura et al.[5] in 1988. Tomura et al. evaluated CT scans within the first 6 hours of ictus in 25 patients with involvement of the middle cerebral artery (MCA) territory. Twenty-three patients (92%) demonstrated obscuring of the lentiform nucleus. Bozzao et al.[6] evaluated CT scans performed four hours from the onset in 36 patients with supratentorial stroke. Nineteen patients (53%) had obscuring of the lentiform nucleus. In this study, 34 patients (65.4%) showed obscuration of the lentiform nucleus on the first CT scan findings.

Loss of clear margin between the insular cortex (gray matter) and external and extreme capsule (white matter) 'loss of insular ribbon', anatomically, insular ribbon refers to the claustrum, extreme capsule, and insular cortex. This sign is a frequent early sign of ischemia, first described by Truwit et al.[7] in 1990. In this study, 32 patients (61.5%) showed loss of insular ribbon on the first CT scan findings, which is less than the study of Truwit et al. found in 77% of patients. This difference is probably because this study did not select groups of specific patients with involvement in the middle cerebral artery (MCA) territory.

Another early particular but less sensitive sign that has been extensively described is the unilateral hyperdense middle cerebral artery (HMCA) sign that represents thromboembolism within the artery and is associated with large MCA territory infarction. Barber et al.[8] described the MCA "dot" sign, a hyperdensity in the distal MCA, and its branches are seen in the Sylvian fissure. In this study, the HMCA sign was seen in 42.3 % of patients on the first CT scan findings (pre-thrombolytic therapy) and decreased to 34.6% on the second CT scan findings (34.6%), probably due to CT scan after patients received intravenous thrombolytic therapy.

Due to focal cortical edema led to loss of normal attenuation between cortical gray and white matter (Parenchymal hypodensity), with compression of CSF spaces leading to relative obliteration of cortical sulci (Hemispheric sulcal effacement). Parenchymal hypodensity was seen in 53.8 % of patients in this study, higher than that of Tomura et al.[5] (30%) and Patel et al.[10] (27%). Hemispheric sulcal effacement was seen in 38.5 % of patients in this study, higher than Patel et al. (14%).

Brain edema plays a major role in the pathophysiology of ischemic stroke.[8] If cerebral blood flow decreases to 10-15 ml/100 g/min, a loss of electrical activity occurs within seconds. Therefore, ion pumps within the cell membrane are unable to continue their

function resulting in cytotoxic edema.[9-12] Any increase in tissue water content results in a decrease in x-ray attenuation. A number of CT findings have been identified, which generally involve a loss of appreciation of the attenuation difference between gray matter and white matter. They include obscuration of the lentiform nucleus, loss of insular ribbon, and focal cortical hypoattenuation.[11]

Conversely, a normal CT scan in a patient with stroke indicates a lesser degree of hypoperfusion and indicates potential reversibility of the functional disturbance.[9,11] In this study, the first CT scan (pre-thrombolytic therapy) showed normal findings in 16 patients, then abnormality was found in the second CT scan findings in 6 patients. Non-contrast CT of the brain remains the mainstay of imaging in the setting of an acute stroke. However, its main limitation is the limited sensitivity in the acute setting. Detection depends on the territory, the experience of the interpreting radiologist, and of course, the time of the scan from the onset of symptoms. Therefore 24-hour follow-up brain CT scans are routinely obtained to assess the location and size of the infarcts, including hemorrhagic transformation, for the benefit of considering treatment after 24 hours.

There were some limitations of the study. First, it was a retrospective study in which the recorded data included demographic characteristics and clinical presentations using the data from inpatient-outpatient medical records, and a database from the HOSxP program may be incomplete and inaccurate. Second, there was a relatively small size of the studied population. Therefore, it was unable to analyze the factors affecting the abnormalities of the brain CT scan in different groups. Finally, this study was the absence of a "gold standard." Therefore, there were unable to calculate the sensitivity or specificity of these signs. Further studies should attempt to validate these CT findings with either MRI/MR angiography of the brain or formal angiography.

Conclusion

The earliest CT findings of stroke fast track patients found from this study are obscuration of the lentiform nucleus, followed by loss of the insular ribbon, parenchymal hypodensity, hyperdense middle cerebral artery, hemispheric sulcal effacement, and MCA dot sign, respectively. At the same time, patients with no abnormal findings on the first CT scan are mostly found with parenchymal hypodensity on the post-thrombolytic CT scan (24 hours later), followed by obscuration of the lentiform nucleus and hemispheric sulcal effacement, respectively. The stroke fast track should be developed and encouraged to recruit more patients to implement these findings in early clinical management and prognosis.

References

1. Ministry of Public Health. Burden of disease and injuries in Thailand. Priority setting for policy 2002: A14-6.
2. Prasad K, Vibha D, Meenakshi. Cerebrovascular disease in South Asia - Part I: A burning problem. JRSM Cardiovasc Dis 2012; 1: 1-7.
3. Park TH, Ko Y, Lee SJ, Lee KB, Lee J, Han MK, et al. Identifying target risk factors using population attributable risks of ischemic stroke by age and sex. J Stroke. 2015; 17:302-11.
4. National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. Tissue plasminogen activator for acute ischemic stroke. N Engl J Med. 1995; 333: 1581-7.
5. Tomura N, Uemura K, Inugami A, Fujita H, Higano S, Shishido F. Early CT finding in cerebral infarction: obscuration of the lentiform nucleus. Radiology 1988; 168: 463-7.
6. Bozzao L, Bastianello S, Fantozzi LM, Angeloni U, Argentino C, Fieschi C. Correlation of angiographic and sequential CT findings in patients with evolving cerebral infarction. AJNR 1989; 10: 1215-22.
7. Truwit CL, Barkovich AJ, Gean-Marton A, Hibri N, Norman D. Loss of the insular ribbon: another early CT sign of acute middle cerebral artery infarction. Radiology 1990; 176: 801–6.
8. Barber PA, Demchuk AM, Hudon ME, Pexman JH, Hill MD, Buchan AM. Hyperdense sylvian fissure MCA "dot" sign A CT marker of acute ischemia. Stroke 2001; 32: 84-8.
9. Wardlaw JM, Lewis SC, Dennis MS, Counsell C, McDowall M. Is visible infarction on computed tomography associated with an adverse prognosis in acute ischemic stroke? Stroke. 1998; 29: 1315-9.
10. Patel SC, Levine SR, Tilley BC, Grotta JC, Lu M, Frankel M, et al. Lack of clinical significance of early ischemic changes on computed tomography in acute stroke. JAMA 2001; 286: 2830–8.
11. Von Kummer R, Allen KL, Holle R, Bozzao L, Bastianello S, Manelfe C, et al. Acute stroke: usefulness of early CT findings before thrombolytic therapy. Radiology 1997; 205: 327-33.
12. Pressman BD, Tourje EJ, Thompson JR: An early sign of ischemic infarction increased density in the middle cerebral artery. AJNR 1987; 8: 645-8.