ORIGINAL ARTICLE

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Computed tomography evaluation in acute stroke: retrospective study

急性中風的電腦斷層照相術評價：回顧研究

Objective. To determine the accuracy with which ‘frontline’ hospital doctors interpret computed tomography brain scans.
Design. Retrospective study.
Setting. University teaching hospital, Hong Kong.
Participants. Medical and emergency room doctors.
Main outcome measure. Accuracy in correctly identifying features of acute stroke on 18 computed tomography brain scans.
Results. Computed tomography brain scan images showing easily detectable haemorrhage and infarct were identified in 91% and 90% of scans, respectively; but difficult-to-interpret scans with subtle features of haemorrhage or infarct were only correctly identified in 46% and 45% of readings, respectively. More experienced doctors did not perform better than junior doctors (P=0.69; 95% confidence interval, -1.84 to 2.73) and the mean total score for doctors from the emergency department did not differ significantly from that of doctors from the medical department (P=0.57; 95% confidence interval, -2.98 to 1.67).
Conclusion. Early signs of infarct and small bleeds on computed tomography brain scans are not well recognised by doctors, regardless of clinical exposure or seniority. Ineligible patients may be treated with thrombolytic therapy as a result of such computed tomography scan misinterpretation.

目的：確定前線醫院醫生分析電腦斷層腦掃描的準確性。
設計：回顧研究。
安排：大學教學醫院，香港。
參與者：內科和急症室醫生。
主要結果測量：從 18 張電腦腦掃描中，正確識別出急性中風特徵的準確性。
結果：對於較容易辨認出血和栓塞的電腦掃描片，識別率分別為 91% 和 90%，但對於難於識別出輕微的出血和栓塞，識別率分別僅為 46% 和 45%。經驗豐富的醫生的表現並不比初級醫生好(P=0.69；95%置信區間，-1.84至2.73)，急症室醫生的平均得分與內科醫生無顯著差別(P=0.57；95% 置信區間， -2.98 至 1.67)。
結論：醫生不能容易辨別電腦腦掃描上所顯示的血栓的早期徵兆和輕微出血的情況，這與醫生的臨床經驗和職位高低無關。由於對電腦腦掃描的曲解，非血栓的患者可能被施以溶解血栓劑治療。

Key words:
Cerebral infarction;
Cerebrovascular accident;
Tomography, X-ray computed

關鍵詞：
腦血栓；
腦血管意外；
電腦斷層照相術

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Introduction

Stroke is a neurological emergency and is a major cause of death and disability. As clinical differentiation between haemorrhagic and ischaemic stroke is unreliable, an urgent computed tomography (CT) scan of the brain is the gold standard for categorising these two major subtypes.[1] Computed tomography may also reveal diseases that mimic stroke.[2] There are more data on the reliability and utility of CT in this situation than that on any other imaging modality. Acute reduction in blood flow below a critical level initiates a number of biochemical processes known as the ischaemic cascade. This results in cytotoxic and vasogenic oedema, and neuronal death.[3,4] These biochemical processes are the basis for the early signs of infarction seen on initial CT scans—sulcal effacement, loss of grey-white matter differentiation, loss of basal ganglia outline, faint hypodensity, and obscuration of the lentiform nucleus.[5-11] The dense middle cerebral artery (MCA) sign is another important radiological feature and is due to the presence of thrombus in the MCA. Thrombolysis is an effective treatment for cerebral infarction, but in view of the increased risk of haemorrhage, it should be avoided in patients with intracranial bleeding and in those with large infarcts; the latter group being prone to rapid deterioration due to oedema, herniation, and haemorrhagic transformation.[3,12,13] Current guidelines recommend that patients with visible infarction encompassing more than one third of the territory supplied by the MCA should not be given thrombolytic therapy.[14-16] The objective of this study was to investigate 'frontline' doctors' ability to recognise the features of acute stroke and their accuracy in cranial CT interpretation.

Methods

Brain CT scans from stroke patients were reviewed by a neurologist and a neuroradiologist. A total of 18 scans were selected. This number enabled a representative sample of radiological abnormalities to be viewed without inducing reading fatigue. The films were chosen to illustrate specific abnormalities commonly seen in patients admitted with an acute stroke. They were then, by consensus, classified as easy or hard according to the degree of difficulty inherent in their interpretation. The scans were divided into three groups. The first group consisted of seven cranial CT scans showing evidence of bleeding. These included four CT images in which haemorrhage was easily recognised and three images in which the signs were subtle (Fig 1). The second group consisted of seven scans demonstrating easily detectable (four scans) and early, subtle infarcts (three scans) [Fig 2]. Included were examples of large ischaemic strokes for which anticoagulation or thrombolysis would be contraindicated due to the increased risk of haemorrhagic transformation. The third group comprised four scans, each showing one confounding feature which could be mistaken for acute ischaemic stroke (brain tumour and old infarcts) [Fig 3] and features which could be mistaken for haemorrhage (falx cerebri and calcifications). These sets of CT scans were shown to doctors from the medical and emergency departments of a teaching hospital. The doctors were categorised into two groups based on experience and seniority. Senior doctors were defined as physicians with a minimum of 7 years of postgraduate experience and Fellows of the Hong Kong Academy of Medicine (FHKAM). The junior group comprised members of the Hong Kong Colleges of Medicine and Emergency Medicine. The doctors were informed that all CTs were derived from actual patients admitted with an initial clinical diagnosis of acute stroke and that there were no other non-radiological contraindications for thrombolysis. Full sets of films were made available for analysis at a viewing station. There was no time restriction; participants were allowed to review an earlier scan if they wished. Background information such as the age, sex, and the side of weakness for each patient was provided. Subjects scored one point for each correct answer (maximum score: 18 points). The accuracy of CT reading skills of junior versus senior doctors and of doctors from the emergency versus the medical departments were compared. Data were analysed by non-parametric (Mann-Whitney U test) or parametric (Student's t test) tests as appropriate, after initial analysis of data distribution.

Results

Twenty-eight doctors agreed to participate in the study—10 from the emergency department and 18 from the medical department. Eleven doctors were in the senior group and

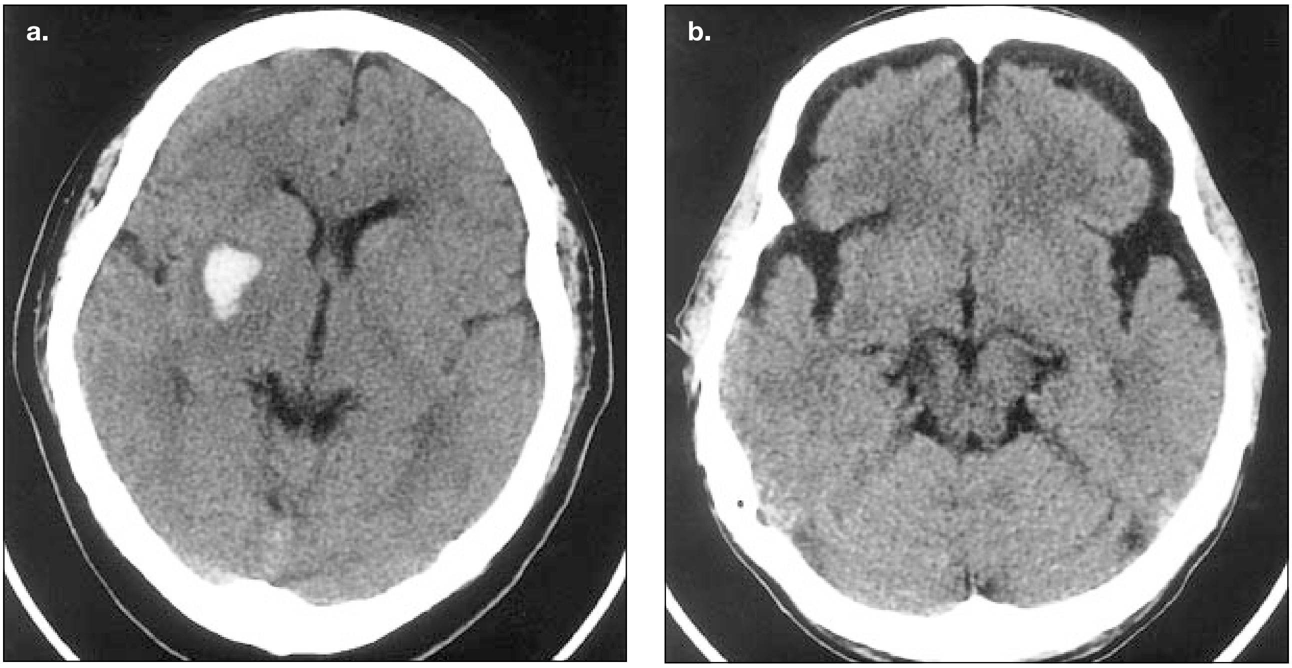

Fig 1. Cerebral haemorrhage as seen on axial brain computed tomography scans
(a) Example of obvious bleeding: right basal ganglion haematoma in a 40-year-old man with left hemiparesis; and (b) example of subtle bleeding: left frontal subdural haemorrhage in a 61-year-old man with right hemiparesis

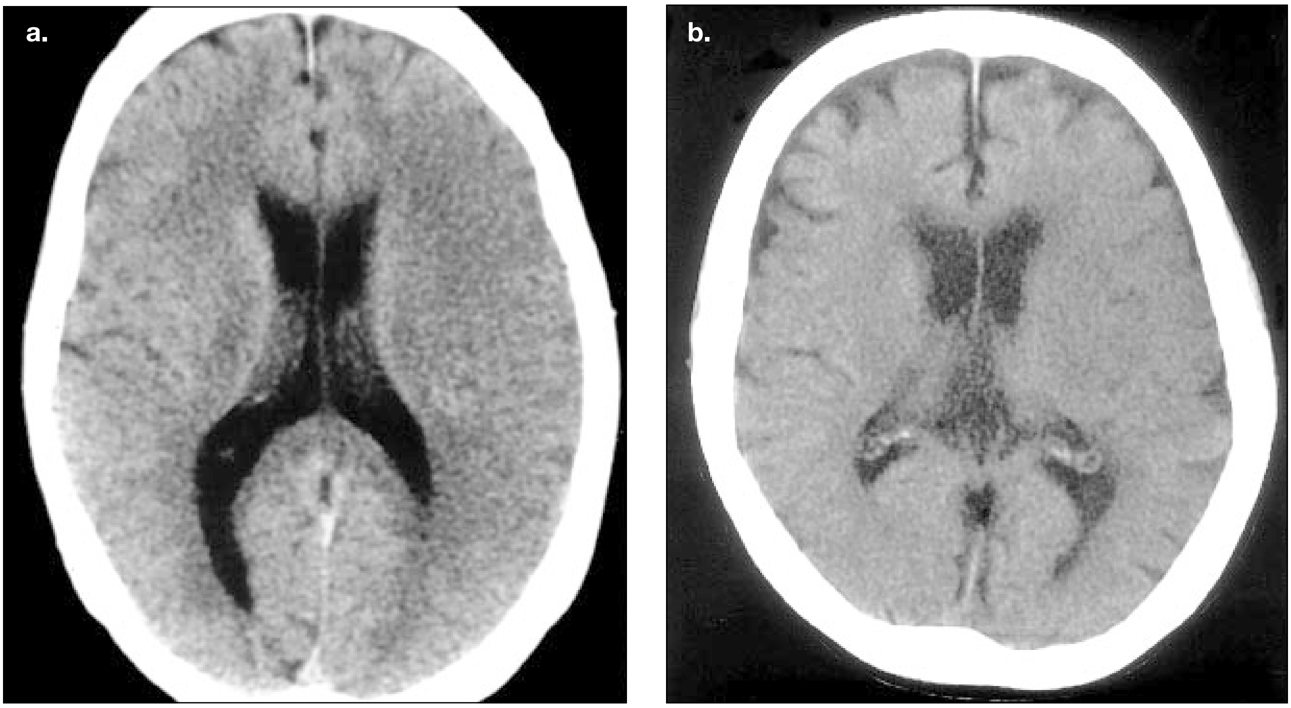

Fig 2. Cerebral infarct as seen on axial brain computed tomography scans
(a) Example of an obvious infarct: left total anterior circulation infarct in a 69-year-old woman with right hemiparesis, demonstrating sulcal effacement, loss of grey-white matter differentiation, and hypodensity changes; and (b) example of a subtle infarct: infarct in the left middle cerebral artery territory in a 81-year-old man with right hemiparesis

17 in the junior group, with each participant reading the total 18 scans. Ninety-one percent of the CT images that showed easily detectable haemorrhages were identified but subtle haemorrhages were only reported by 46% of viewers. For the second group of scans, 90% of the CTs with obvious infarcts were correctly identified while 45% of difficult infarcts were noted. Features confused with haemorrhage (bright falx and calcifications) were correctly identified by 68% and 86% of the subjects, respectively, while confounding features for acute infarcts (brain tumour and an old infarct) were identified by 43% and 86%, respectively. The senior doctors scored a mean of 13.09 points and the junior doctors a mean of 12.65 (Table). The more experienced group of doctors did not perform significantly better than the junior group (P=0.69; 95% confidence interval [CI], -1.84 to 2.73). The mean total score for doctors from the emergency department was 12.40 points and for those from the medical department 13.06 points (Table). There was no difference seen between the two departments in terms of doctor performance (P=0.57; 95% CI, -2.98 to 1.67).

Discussion

During the 3 hour window of opportunity between stroke onset and potential administration of thrombolytics, the patient must arrive at casualty, undergo clinical and laboratory evaluation, provide informed consent, and have a CT brain scan which is correctly interpreted. The decision to use other drugs such as antiplatelet agents, anticoagulant drugs, and the appropriate treatment of hypertension in stroke depend on the initial CT findings. Errors of interpretation may lead to errors in treatment and in randomisation to acute stroke trials. This problem has been previously highlighted in reports from the US and the UK, in which only 65% to 77% of CTs were correctly interpreted.[17,18]

In the current study, over 90% of CT images showing clear evidence of acute stroke were recognised by physicians but the accuracy rate dropped to 46% and 45% for scans demonstrating subtle signs of bleeding or infarct, respectively. Results showed that 54% of scans of difficult-to-detect haemorrhage were interpreted as normal. This suggests that in practice, patients with a clear contraindication to thrombolysis may be given this treatment. Fifty-five percent of scans showing large subtle infarcts, another indication of risk of bleeding, were also misread. Experienced physicians did not perform better than junior colleagues. In local hospitals, doctors from the medical unit are usually responsible for the first reading of the CT scan. Notably however, this study showed no difference in the accuracy of interpretation between members of the medical and emergency departments.

The accuracy of CT interpretation may have been underestimated in this study as a function of the informal setting in which the CT scans were viewed. On the other

Table. Comparison of participants' total score (maximum=18)

Doctors	Mean	SD	95% CI	Median	Range
Senior	13.09	3.14	10.98-15.20	14.0	9-17
Junior	12.65	2.69	11.65-14.03	12.0	7-18
Emergency department	12.40	2.84	10.37-14.43	12.0	9-17
Medical department	13.06	2.88	11.62-14.40	12.5	7-18

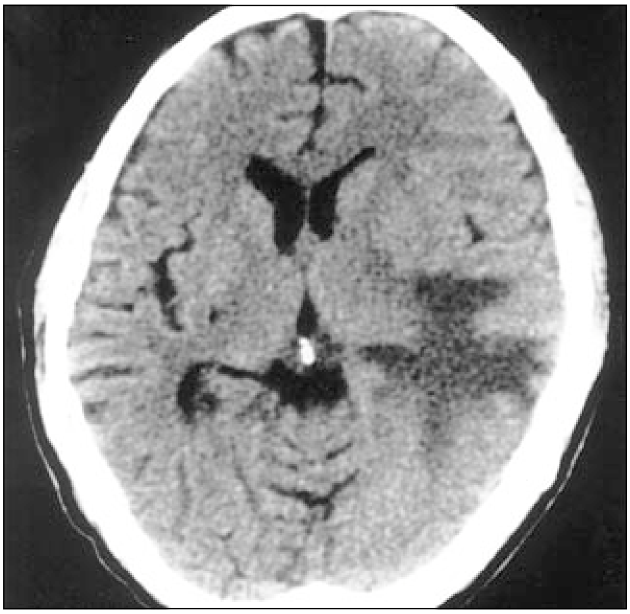

Fig 3. Appearance resembling cerebral infarct
Axial brain computed tomography in a 69-year-old man with right hemiparesis, showing predominantly white matter involvement with oedema over the left temporal and left parietal regions. The final diagnosis in this case was brain metastasis

hand, doctors may respond differently to the task of interpreting CT scans in the stressful environment of a real-life clinical situation. Another potential source of bias in the study was the fact that all the doctors who participated were volunteers. Possibly doctors who felt unsure of their CT reading skills might have been more likely to decline the testing opportunity. Whether the performance of this group of doctors is representative of 'frontline' staff in other institutions is also uncertain.

Interobserver agreement in detecting early CT signs of stroke within 3 hours of onset has been reported as 'fair'.[19,20] Attempting to identify subtle features of acute infarction on CT scan may not be the optimum approach. The ideal radiological tool in acute stroke should be able to localise and quantify the ischaemic injury, specify the arteries involved, measure the brain perfusion deficit, and be performed within 20 minutes or less.[21] Newer radiological techniques such as diffusion-perfusion magnetic resonance (MR) imaging, Xenon CT, MR angiography, and single-photon CT allow more accurate risk stratification of patients. Magnetic resonance with echo-planar imaging capacity detects early stroke with higher sensitivity than CT scanning and may identify vessel occlusion and salvageable tissue. Patients at high risk of haemorrhagic transformation can also be detected.[21]

In practice, however, CT imaging will remain the initial radiological investigation of choice for the foreseeable future, as it is widely available and can exclude haemorrhage. Currently, 'frontline' medical personnel may not have adequate training to reliably interpret CT scans in patients with acute stroke. Educating staff on the subtle features of acute cerebrovascular disease may improve competency in CT reading. Alternatively, the accuracy of CT scan interpretation could be improved by increased use of neuroradiologists and neurologists in the acute setting, or by the installation of telemedicine equipment allowing film interpretation to be completed at a distance by appropriately skilled staff.

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