Clinical predictors of abnormal computed tomography findings in patients with altered mental status

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ABSTRACT

Introduction: While non-contrast computed tomography (CT) of the brain can be used to rapidly identify patients with altered mental status (AMS) in the emergency department (ED), with an acute intracranial bleed or infarct, a wide variation in its use exists. The aim of this pilot study was to identify the clinical predictors of an abnormal CT result in ED patients with AMS.

Methods: We conducted a retrospective study of patients aged 15 years and older presenting with undifferentiated AMS in a busy urban ED over one year. Data collected included demographical, clinical, laboratory and radiological features. The primary outcome of interest was the presence of an abnormal CT result defined as an acute infarct or intracranial bleed. Secondary outcomes were clinical predictors of an abnormal CT result. The data was analysed using descriptive statistics. Logistic regression was used to identify clinical predictors of an abnormal CT result. Odds ratios (ORs) were reported with 95 percent confidence intervals (CIs).

Results: 578 patients were recruited, of which 284 (49.1 percent) were males. 327 (56.6 percent) patients underwent CT of the brain. 128 scans (39.1 percent) were abnormal. Logistic regression revealed seven clinical features that were associated with an abnormal CT result. They were mean age greater than or equal to 73 years (OR 1.03; 95 percent CI 1.015–1.045), drowsiness or unresponsiveness (OR 1.73; 95 percent CI 0.17–17.72), previous cerebrovascular accident (OR 2.03; 95 percent CI 0.82–5.02), previous epilepsy (OR 1.63; 95 percent CI 0.63–4.19), tachycardia [greater than 120/min] (OR 1.16; 95 percent CI 0.38–3.54), bradycardia [less than 60/min] (OR 1.35; 95 percent CI 0.19–9.59) and exposure to drugs (OR 1.90; 95 percent CI 0.58–6.26).

Conclusion: We identified seven clinical predictors of an abnormal CT result in AMS patients. Future research in prospective studies is needed to validate these findings.

Keywords: altered mental status, brain infarction, cerebral computed tomography, intracranial haemorrhage

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INTRODUCTION

Altered mental status (AMS) in adult patients poses a great challenge in the emergency department (ED) as it is a symptom complex with diversified aetiologies. The challenge of the emergency physician is to identify patients with an acute neurological condition, viz. intracranial haemorrhage (ICH) or infarct, that would require timely subspecialty treatment. Non-contrast computed tomography (CT) of the brain has been recommended as the initial imaging modality in the investigation of AMS.[1] It is a neuroimaging tool that can be used to rapidly identify AMS patients with an acute ICH or infarct. However, not all AMS patients will require a CT of the brain. The challenge was thus to identify neurological patients who would benefit from a quick decision-making following a CT of the brain, from the general ED patient population with other causes of AMS. Magnetic resonance (MR) imaging of the brain has been reported to be as effective in detecting acute ICH, and it detects acute ischaemic strokes and chronic ICHs more frequently when compared to CT of the brain.[2] However, its high costs, limited availability and longer examination time, which may delay treatment, limit its widespread use in the ED. The aims of our pilot study were to describe the characteristics of the patients presenting with undifferentiated AMS to our department and to identify clinical predictors of CT findings of an acute ICH or infarct.

METHODS

We conducted a retrospective review of the patients who presented with undifferentiated AMS to our ED from

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Table I. Demographics of patients with altered mental status.

Patient demographics	No. of patients
Gender	
Male	284
Female	294
Total	578
Ethnicity	
Chinese	448
Malay	55
Indian	53
Others	22
Mean age (years)	66

Table II. Characteristics of patients who underwent computed tomography.

Patient characteristics	No. of patients
Total no. with CT brain	327
Gender	
Male	177
Female	150
Onset of altered mental status	
Acute (< 1 day)	166
Subacute (>1 day but < 1 week)	140
Chronic (> 1 week)	21
Patients with	
Past medical history	173
Cerebrovascular accident	98
Epilepsy	12
Psychiatric history	44
Trauma	
Present or suspected	59
None	268
Lateralising neurological signs	
None	301
Present	26
Exposure to drugs*	
Yes	302
No	25
Initial tests†	
Normal	295
Abnormal	32

* include benzodiazepines, tricyclic antidepressants, alcohol and selective serotonin reuptake inhibitors.
† include capillary blood sugar reading and electrocardiogram.

January 1, 2005 to December 31, 2005. Our hospital is a 1,000-bed adult tertiary hospital, and its ED receives referrals from all regions of the country. The annual ED attendance for the year 2005 was 140,946. Before the study, we reviewed the literature on AMS[3-5] and formulated a data collection form, modified from the American College of Emergency Physicians' clinical policy for the initial approach to patients presenting with AMS.[6] AMS was defined as any patient with new onset drowsiness, behavioural change, uncommunicative and unresponsive state, disorientation and confusion, agitation, hallucinations, and a Glasgow Coma Score < 15.

Our departmental workflow for patients with undifferentiated AMS included a capillary blood glucose test and an electrocardiogram at the triage point. Hypoglycaemic patients were treated accordingly and did not undergo CT of the brain, unless deemed necessary by their attending ED physician or inpatient team after the failure of initial treatment. The decision to perform CT of the brain for the rest of the patients was at the discretion of the attending ED or ward physicians. CT of the brain is available at all times in our institution. MR imaging of the brain was not included in the study as it was not the first-line neuroimaging tool in our AMS patients. All the CT scans of the brain were reviewed by two radiologists who approved the final report.

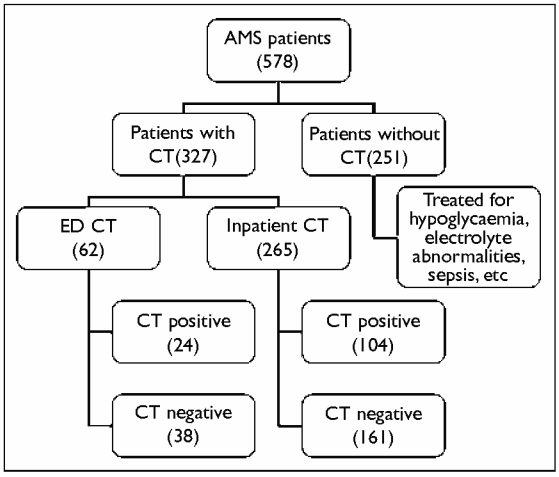

Fig. 1 Flow chart of the patients with altered mental status in the study.

The inclusion criteria were patients aged ≥ 15 years, with a diagnosis of undifferentiated AMS encoded in our departmental electronic database and without major trauma, like motor vehicle crashes and falls from heights. Patients with the cause of AMS worked out by their referring physicians were excluded. Demographical, clinical, radiological and laboratory data were collected through a retrospective review of ED charts, inpatient medical records, and laboratory and radiological reports through our hospital electronic databases. The primary outcome of interest was the presence of CT evidence of acute ICH or infarct, based on the final approved radiological report. Secondary outcomes were clinical predictors of a CT result of acute ICH or infarct. Data was analysed using descriptive analysis. Logistic regression was performed on exploratory covariates. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported as far as possible. The goodness-of-fit of the logistic regression analysis was ascertained using the Hosmer-Lemeshow test.[7] A p-value > 0.05 in the Hosmer-Lemeshow test was considered to indicate a reasonably good fit for the logistic regression model. The study was

Table III. Odds ratios of exploratory variables associated with an abnormal CT result following logistic regression.

Exploratory variable	No. (%) of patients with normal CT (n = 199)	No. (%) of patients with abnormal CT (n = 128)	Odds ratio	95% confidence interval
Mean age (years)	62	73	1.03	1.015–1.045
Gender				
Male	111 (55.8)	67 (52.3)		
Female	88 (44.2)	61 (47.7)	0.8	0.47–1.38
Ethnicity				
Chinese	153 (76.9)	106 (82.8)		
Malay	21 (10.6)	11 (8.6)	0.79	0.32–1.96
Indian and others	25 (12.6)	11 (8.6)	0.92	0.38–2.19
Drowsiness or unresponsiveness	113 (56.8)	81 (63.3)	1.73	0.17–17.72
Altered mental status				
History	73 (36.9)	29 (22.7)	0.50	0.29–0.87
Acute	108 (54.3)	58 (45.3)	0.66	0.22–2.01
Subacute	78 (39.2)	62 (48.4)	1.00	0.33–3.06
Past history of				
Cerebrovascular accident	53 (26.6)	45 (35.2)	2.03	0.82–5.02
Epilepsy	10 (5.0)	2 (1.6)	1.63	0.63–4.19
Psychiatric history	34 (17.1)	10 (7.8)	0.44	0.071–2.74
Presence/suspected trauma	44 (22.1)	15 (11.7)	0.40	0.20–0.80
Lateralising neurological signs	14 (7.0)	12 (9.4)	0.61	0.35–1.07
Upgoing plantar	5 (2.5)	8 (6.3)		
Signs and symptoms				
Fever	14 (7.0)	16 (12.5)	0.23	0.02–2.85
Hypertension	11 (5.5)	14 (10.9)	0.17	0.017–1.77
Tachycardia (> 120/min)	3 (1.5)	6 (4.7)	1.16	0.38–3.54
Bradycardia (< 60/min)	3 (1.5)	1 (0.8)	1.35	0.19–9.59
Exposure to drugs	20 (10.1)	5 (3.9)	1.90	0.58–6.26

Goodness-of-fit ascertained by Hosmer-Lemeshow test[7] (p-value = 0.78)

approved by the National Healthcare Group Research Ethics Committee.

RESULTS

A total of 578 patients were studied during the period of January 1, 2005 to December 31, 2005. This comprised 0.4% of the ED annual attendance in 2005. The demographics of the recruited patients are summarised in Table I. Fig. 1 demonstrates the flow of patients with AMS to the ED and inpatient units. 327 (56.6%) patients underwent CT of the brain to evaluate a cerebrovascular event (acute infarct or bleed) as an explanation of their AMS. In the remaining 251 (43.4%) patients, CT of the brain was deemed unnecessary by their attending physicians. 62 (19.0%) and 265 (81.0%) scans were performed at the ED and inpatient units, respectively. There were 128 (39.1%) abnormal and 199 (60.9%) normal CT results. Of the 128 abnormal CT scans, 24 (18.8%) and 104 (81.3%) scans were done at the ED and inpatient units, respectively. Of the 199 normal CT results, 38 (19.1%) were done at the ED and 161 (80.9%) at the inpatient units.

The characteristics of patients who underwent CT of the brain are depicted in Table II. Table III illustrates the results of the logistic regression analysis of various exploratory demographical, clinical and investigation results that could be associated with an abnormal CT result. Seven factors were associated with an OR > 1 for an abnormal CT result. They were mean age ≥ 73 years (OR 1.03; 95% CI 1.015–1.045), drowsiness or unresponsiveness (OR 1.73; 95% CI 0.17–17.72), previous cerebrovascular accident (OR 2.03; 95 CI 0.82–5.02), previous epilepsy (OR 1.63; 95% CI 0.63–4.19), tachycardia [> 120/min] (OR 1.16; 95 CI 0.38–3.54), bradycardia [< 60/min] (OR 1.35; 95% CI 0.19–9.59), and exposure to drugs (OR 1.90; 95% CI 0.58–6.26).

DISCUSSION

AMS continues to be a diagnostic challenge to the ED physician and inpatient team. It is a symptom complex with a wide range of causative conditions. After excluding the immediately amendable causes like hypoglycaemia, the greatest dilemma lies in the decision to judge whether a cerebrovascular event has resulted in AMS. Our study has revealed that our ED use of CT for investigating AMS was 10.7% and our rate of abnormal CT results was 38.7%. Our rate of positive findings was similar to the 43.7% reported by Kelly and Kerr.[8] In addition, we have also shown that the rate of abnormal CT results for

the ED (38.7%) and inpatient (39.2%) teams was almost identical. On one hand, it is not cost-effective to perform CT of the brain for every patient with AMS presenting to the ED.[9,10] On the other hand, the failure to exclude a cerebrovascular event has the potential downstream implications of compromising patient care, and in the case of ischaemic stroke, of possibly missing the window of opportunity for thrombolytic therapy,[11] and the logistic burden of interspecialty referral. The challenge is hence to ensure careful patient selection to only include those who require the test and to ensure it is not inappropriately used.

We have identified through our review, seven possible predictors of abnormal CT results in our AMS patients, viz. mean age, drowsiness or unresponsiveness, previous cerebrovascular accident or epilepsy, tachycardia (> 120/min), bradycardia (< 60/min), and exposure to drugs. Age is likely a confounding factor as it carries a variety of comorbidities and treatments that might explain the association. For instance, it might be associated with the use of an anti-coagulant like warfarin, that increases the risk of ICH in patients with blunt trauma.[12] As for the other predictors, however, it is not possible to comment on the significance of their association with an abnormal CT result, as the confidence intervals were wide and exceed the value of one. This observation is likely a result of our relatively small sample size. However, we wish to use this pilot study to spur further larger prospective studies to validate and explore the judicious use of CT of the brain in AMS patients, as it is a relatively expensive investigation at the ED.

Apart from the wide confidence intervals expected from a small sample size, our study had some important limitations. Our study was retrospective, and hence was subjected to bias at various levels of data collection, assessment and analysis. In addition, it was likely that we were unable to recruit every consecutive patient with AMS into the study as these patients might be coded with a definitive diagnosis and not captured in our database. Finally, this study was conducted in a single centre and generalisability could not be assumed. Our pilot study had identified seven clinical predictors of an abnormal CT result in AMS patients. Future research is required to validate these findings in larger prospective studies, to elucidate if and how this information can be used to guide the use of CT in AMS patients.

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