The Role of Repeat Head Computed Tomography in The Management of Mild Traumatic Brain Injury Patients with A Positive Initial Head CT

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SUMMARY

This was a prospective observational study done to evaluate the role of a repeat head CT in patients with mild traumatic brain injury. The aim was to evaluate wether the repeat head CT were useful in providing information that leads to any neurosurgical intervention. 279 adult patients with a mild head injury (GCS 13-15) were enrolled, and these comprised of patients with an initial traumatic intracranial haemorrhage not warranting any surgical intervention. All patients were subjected to a repeat head CT within 48 hours of admission and these showed no change or improvements of the brain lesion in 217 patients (79.2%) and worsening in 62 patients (20.8%). In thirty-one patients, surgical intervention was done following the repeat head CT. All of these patients had a clinical deterioration prior to the repeat head CT. Even if a repeat head CT had not been ordered on these patients, they would have had a repeat head CT due to deteriorating neurological status. When the 62 patients with a worsening repeat head CT were compared with the 217 patients with an improved or unchanged repeat head CT, they were found to have older age, lower GCS on admission, presenting symptoms of headache, higher incidence of multiple traumatic intracranial pathology and lower haemoglobin level on admission. On stepwise multiple logistic regression analysis, three factors were found to independently predict a worse repeat head CT (Table IV). This includes age of 65 years or older, GCS score of less than 15 and multiple traumatic intracranial lesion on initial head CT. As a conclusion, we recommend that, in patients with a MTBI and a normal neurological examination, a repeat cranial CT is not indicated, as it resulted in no change in management or neurosurgical intervention. Close monitoring is warranted in a subset of patients with risk factors for a worsening repeat head CT.

INTRODUCTION

The advent of Computed Tomographic (CT) scan has revolutionized our approach to head injury, and the the use of head CT has been firmly established as part of the initial management of patients with mild traumatic brain injury[1]. It is now a standard practice in most institutions for patients with mild traumatic brain injury (MTBI) to undergo a head CT. A repeat head CT is frequently ordered in the presence of a traumatic lesion on the initial scan. This practice has yet to show any clear benefit in terms of better outcome. Recent retrospective studies have shown that routine serial head CT in MTBI patients does not increase the likelihood of any neurosurgical intervention[2,3]. Over-utilisation of CT scan in Malaysia burdens what limited resources is available and prudent use of available imaging modalities are crucial in maintaining a sustainable healthcare system. This study aims to evaluate the role of a repeat head CT in providing useful information that leads to any neurosurgical intervention.

MATERIALS AND METHODS

Patients who were admitted to the Neurosurgery Ward, Sultanah Aminah Hospital Johor Bahru with MTBI from 1st June 2008 to 30th September 2009, were identified. MTBI was defined as Glasgow Coma Scale (GCS) score of 13, 14 or 15 with loss of consciousness, post-traumatic amnesia, headache, vomiting or dizziness. These patients were then included in the study if they met the inclusion and exclusion criteria (Table I). Neurological status (GCS, neurologic deficits) of these patients were monitored every 4 hours and they would then undergo a routine repeat head CT within 24 to 48 hours. The timings of the repeat head CT varied according to the individual patients. Both the initial and subsequent CT would be interpreted by the attending neurosurgeon or by the radiologist report. A head CT was considered positive if there was suspicion or clear indication of a traumatic pathology. A repeat head CT would be categorised as unchanged (no change could be assessed based on the size of the injury), improving (resolution or improvement based on the size of the injury) or worsened (increase in size or evidence of new intracranial lesion).

Table I: Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
admission GCS of 13-15	previous history of head injury
12 years and older	on anticoagulation therapy (aspirin, heparin or warfarin)
positive initial head CT	polytrauma causing unstable haemodynamic status
isolated blunt head injury	admitted to the NICU for close observation
presented within 24 hour of initial injury	severe underlying medical disorders such as major organ failure, endocrinological or haematological disorder, suspected drug or alcohol intoxication, mentally subnormal or history of chronic epilepsy before the event of head trauma
	Patients with surgically treatable traumatic brain lesion

This article was accepted: 9 January 2012
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Data on demographics, GCS score on admission, symptoms on admission, initial and repeat head CT findings, head-injury related complications and final outcome were collected. Primary outcome was surgical intervention after a repeat head CT. Surgical interventions was defined as craniotomy, intracranial pressure monitor placement or intubation. Secondary outcome was worsening of brain lesion on repeat head CT. Patients with a repeat head CT that remained unchanged or improved from the initial.

CT were compared with patients with a repeat head CT that worsened from the initial CT. Categorical variables were analysed and reported as frequency and percentages. Continuous variables were analysed and reported as means and standard deviations. Pearson Chi - square Test was used for categorical data between two groups (unchanged/ improved CT and worsening CT), and Independent T - test was used for continuous variable. Variables that reached a p value of 0.05 were then analysed using multiple logistic regression to determine risk factors associated with worsening repeat head CT. Patient who had surgical interventions after a repeat head CT was also analysed using the same method.

RESULTS

During the study period, there were 279 MTBI patients treated in the Neurosurgical Ward after selection criteria were met to enable enrolment into the study. 26 had a GCS score of 13 (9.3%), 46 had a GCS score of 14 (16.5%) and 207 had a GCS score of 15 (74.2%). The demographics, characteristics and initial CT findings of these patients were summarized in Table II.

Table II: Two hundred and seventy nine patients with MTBI

Male	227 (81.4%)
Female	52 (18.6%)
Age (years)	39 ± 20
≥ 65 years old	59 (21.1%)
Ethnic groups	
Malay	168 (60.2%)
Chinese	48 (17.2%)
Indian	47 (16.8%)
Others	16 (5.7%)
Mechanism of injury	
MVA	248 (88.9%)
Fall	23 (8.2%)
Others	8 (2.9%)
Glasgow Coma Score on admission	
13	26 (9.3%)
14	46 (16.5%)
15	207 (74.2%)
Associated symptoms	
Post-traumatic amnesia	175 (62.7%)
Headache	191 (68.5%)
Vomiting	150 (53.8%)
Dizziness	148 (53%)
Findings of 1st head CT	
Epidural hemorrhage	70 (25.1%)
Subdural hemorrhage	109 (39.1%)
Contusion	147 (52.7%)
Subarachnoid hemorrhage	129 (46.2%)
Solitary lesion	135 (48.4%)
Multiple lesion	144 (51.6%)
Base of skull fracture	92 (33%)
Convexity fracture	102 (36.6%)
Patients underwent surgical procedure	31 (11.1%)
Hospital length of stay	5 ± 3
Mortality	3 (1.1%)

Table III: Comparison of patients with an improved or unchanged repeat head CT with patients with a worsened repeat head CT

Parameter	Improved or unchanged repeat head CT (n = 217)	Worsened repeat head CT (n = 62)	p value
Male	173 (79.7%)	54 (87.1%)	.
Female	44 (20.3%)	8 (12.9%)	0.189
Age (years)			
≥ 65 years old	29 (13.4%)	30 (48.4%)	< 0.001
Ethnic groups			
Malay	129 (59.4%)	39 (62.9%)	.
Non-Malay	88 (40.6%)	23 (37.1%)	0.624
Mechanism of injury			
MVA	195 (89.9%)	53 (85.5%)	.
Others	22 (10.1%)	9 (14.5%)	0.333
Glasgow Coma Score on admission			
15	170 (78.3%)	37 (59.7%)	.
<15	47 (21.7%)	25 (40.3%)	0.003
Associated symptoms			
Post-traumatic amnesia	130 (59.9%)	45 (72.6%)	0.069
Headache	141 (65.0%)	50 (80.6%)	0.019
Vomiting	114 (52.5%)	36 (58.1%)	0.441
Dizziness	119 (54.8%)	29 (46.8%)	0.262
Solitary lesion	117 (53.9%)	18 (29.0%)	.
Multiple lesion	100 (46.1%)	44 (71.0%)	0.001
Base of skull fracture	71 (32.7%)	21 (33.9%)	0.865
Convexity fracture	80 (36.9%)	22 (35.5%)	0.842
Hb (g/litre) on admission	150 ± 20	143 ± 20	0.009
INR on admission	1.2 ± 0.3	1.2 ± 0.3	0.388
Neurological deterioration	41 (18.9%)	25 (40.3%)	< 0.001
Surgical intervention	11 (5.1%)	20 (32.3%)	< 0.001
Hospital length of stay	4 ± 3	6 ± 4	<0.001
Mortality	0 (0%)	3 (4.8%)	0.001

Table IV: Independent risk factors for a worsening repeat head CT

Parameter	Lower 95% CI	Upper 95% CI	p value
Age ≥ 65	0.098	0.364	< 0.001
Multiple lesions on initial head CT	0.239	0.877	0.018
GCS score < 15 (13 or 14)	1.164	4.333	0.016

There were 135 patients with solitary lesion noted on the initial CT scan, of which 22 (16.4%) had a subdural haemorrhage, 16 (11.6%) had an extradural haemorrhage, 55 (40.8%) had contusions and 42 (31.2%) having subarachnoid haemorrhage. Additionally, there were 144 patients with multiple lesions on initial CT scan. There were also 92 patients who sustained base of skull fracture and 102 sustained convexity fracture.

All patients were subjected to a repeat head CT and these showed improvements of the brain lesion in 45 patients (16.1%), no change in 176 patients (63.1%), and worsening in 58 patients (20.8%). In thirty-one patients, surgical intervention was done following the repeat head CT. All of these patients had a clinical deterioration prior to the repeat head CT. Even if a repeat head CT had not been ordered on these patients, they would have had a repeat head CT due to deteriorating neurological status. This deteriorating neurologic status consisted of persistent or increasing confusion, disorientation or sleepiness; or increasing severity of presenting symptoms (e.g. headache).

When the 62 patients with a worsening repeat head CT were compared with the 217 patients with an improved or unchanged repeat head CT, they were found to have; i) older age; ii) lower GCS on admission; iii) presenting symptoms of headache; iv) higher incidence of multiple traumatic intracranial pathology; and v) lower haemoglobin level on admission.

There was no difference in gender, ethnic groups, mechanism of injury, other associated symptoms on admission, presence of convexity or base of skull fracture, and INR values on admission. Patients with a worse repeat head CT had a higher incidence of neurological deterioration, higher incidence of surgical intervention and longer hospital stay.

On stepwise multiple logistic regression analysis, three factors were found to independently predict a worse repeat head CT (Table IV). This includes age of 65 years or older, GCS score of less than 15 and multiple traumatic intracranial lesion on initial head CT.

DISCUSSION

The value of head CT scanning in patients after MTBI has been unequivocally demonstrated in prospective studies and is considered the standard of care [4-6]. However, the same can't be said of the utilization of repeat head CT in subsequent management of these patients. The data presented here clearly shows that routine repeat head CT is unnecessary in the majority of patients. There was no incidence in which the routine ordering of a repeat head CT has clinical benefit. In the 11.1% of patients who required surgical intervention for an evolving brain lesions, there was a documented clinical deterioration which preceded the repeat head CT and this would have prompted the repeat imaging anyway. Other studies have quoted surgical intervention rates of 3.5% [2], 2.5%[3] and 4% [7]. Including this study, all of the reported cases that required intervention, neurological deterioration preceded and prompted the repeat head CT. This study adds to the body of literature reiterating that in the absence of clinical deterioration, a repeat head CT never changed the management.

Neurological deterioration was seen in 66 patients (23.7%) and this was significantly associated with a worsening on repeat head CT (p value < 0.001). Two studies have also reported that changes in neurological examination was predictive of progression of injury on repeat head CT [8, 9]. One other study done on patients with MTBI showed statistically significant association (p value = 0.007) between an abnormal neurological status with worsening repeat head CT findings [3]. These findings are fairly indicative of the importance of continuous neurological assessment in the observation period. Several guidelines recommends an observation period from 12 hour to 24 hours or longer [10, 11]. The main goal of continuous clinical observation and neurological assessments are to detect, at an early stage, progressive development of intracranial complications and to avoid secondary brain injury resulting from these complications.

There are 3 mortality cases in this study. All three cases was elderly patients (age of 80, 74 and 72 years old) with more than 2 lesion on initial CT (subdural haemorrhage, contusion and/or subarachnoid haemorrhage). None of the patients had an extradural haemorrhage. All three had a neurological deterioration within 24 hours and prompted a repeat CT scan. All three patients then undergone surgical intervention (craniotomy and clot evacuation with ICP monitoring). All of them succumbed to the illness, with the longest being in the hospital care for 19 days.

In mild traumatic brain injury with a non-surgical lesion on an initial head CT, routine use of repeat head CT with an improving or persistently normal clinical neurological examination is unlikely to result in any neurosurgical intervention or change in management. Therefore it can be safely concluded that routine use of repeat head CT is unwarranted. Patients with a GCS score of 13-15 can be easily monitored with due vigilance and any neurological deterioration can be detected early. Correct identification of risk factors for clinical deterioration and the need for intervention is important as it allows for proper identification of patients in need of more intensive monitoring and early discharge of those without said risk factors.

Repeat head CT is a luxury and resources are limited in this country as evident by the number government hospitals with a CT facility of less than 30. As access is inadequate, it puts an enormous strain on the hospital resources. Repeat head CT also requires transportation of patients on multiple occasions and although it was not quantified in this study, intrahospital transportation has been associated with complications such as dislodgement of airway with subsequent worsening of secondary insults and possible cardiopulmonary arrest [12]. Repeated CT scans also exposes patients to high doses of radiation and this is particularly important in children as medical ionising radiation in childhood has been associated with long-term cognitive defects in adults [13].

CONCLUSION

This study recommends that routine use of repeat head CT in MTBI patients with a non-surgical lesion on initial head CT should be abandoned, and to be used only in a subset of patients having one or more of the risk factors associated with an increased risk for evolution of intracranial pathology. Ordering of tests without clinical indications shows lack of commitment on our part as the primary care giver to provide adequate continuous care to our patients. Decreasing the number of additional CT scans could result in decreased hospital costs, decreased staff and patient exposure to radiation, and fewer problems with patient transportation and total length of stay without compromising the safety of patients. It appeared that radiologic images are being performed solely because of fears of occult worsening of head injury that may require neurosurgical interventions. These data indicate that these fears may not be justified in this population.

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