THE NEW ZEALAND MEDICAL JOURNAL
Journal of the New Zealand Medical Association
NZMA New Zealand Medical Association

Computerised tomography indices of raised intracranial pressure and traumatic brain injury severity in a New Zealand sample

After traumatic brain injury (TBI) complex cellular and biochemical processes occur[1] including changes in blood flow and oxygenation of the brain; cerebral swelling; and raised intracranial pressure (ICP).[2] This can dramatically worsen the damage[3] and contributes to mortality.[4]

Brain imaging, including computerised tomography (CT), has a potential role in detecting raised ICP, thereby reducing the need for more invasive assessment procedures.[5] While numerous studies report a relationship between raised ICP and CT scan findings after TBI, these are restricted to severe TBI.[5,6] Yet mild TBI comprises >85% of all TBI;[7] and 4–58% of mild head injuries have intracranial lesions.[8]

We examined whether CT scan indices of raised ICP are present in individuals who have experienced a TBI, ranging from mild low risk to severe.

The 53 participants (mean age=40.66, SD=23.5; 66% male) were from a population-based TBI incidence study (see[9] for methodology). Participants provided informed written consent; and had undergone a CT scan during hospitalisation for TBI (mean=2.13 days post-TBI; SD=5.15).

In accordance with Servadei,[8] mild low risk TBI was defined as: GCS score of 15, with no skull fracture, neurological deficits, clinical findings (eg., vomiting, headache), or risk factors (eg., drug/alcohol consumption); medium risk mild was GCS score of 15, no skull fracture, neurological deficits, or risk factors, but ≥1 clinical finding; high risk mild TBI had GCS scores of 15 with/without clinical findings and either neurological deficits or skull fracture or risk factors; or GCS of 14 with/without clinical or radiological findings.

There were 3 (5.7%) with low risk mild injury, 11 (20.8%) mild-medium risk, 30 (56.6%) mild-high risk, 6 (11.3%) moderate injury, and 3 (5.7%) with severe injury. CT indices used were: Evan's ratio, bifrontal index; bicaudate index, Cella media index, and two ventricle brain ratios (VBRs).

Computerised CT scans were reviewed by two researchers (SBC, NS), 4mm thick, horizontal scans were used to take the relevant measurements. Six scans were assessed independently (MK), the resulting inter-rater reliability ranged from r=0.67 to r=0.98 with 7 of the 10 measures having very good reliability of r>0.90.

Power calculations using the data from Table 1 for the sample of 44 individuals with mild TBI suggest that this study had a 94% chance of detecting a relationship between the severity and the Evan's ratio (selected as it has the largest standard deviation value) at a two-sided 0.05 significance level, if the true change in the Evans' ratio is 3.0 units per one standard deviation change in the independent variable assuming a standard deviation of 5.51.

Table 1 presents CT scan measure by injury severity group.

Table 1. Means and standard deviations of injury severity groups across CT scan indices

CT INDICES	BRAIN INJURY SEVERITY GROUPINGS									
	Mild						Moderate		Severe	
	Low risk N=3		Medium risk N=11		High risk N=30		N=6		N=3	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Evans ratio	23.35	3.26	24.32	5.51	27.03	4.03	27.52	2.59	28.99	4.83
VBR A[2]	0.07	0.03	0.06	0.02	0.08	0.03	0.09	0.02	0.09	0.04
VBR B[10]	7.59	2.92	6.65	2.41	9.06	3.47	9.62	2.77	10.36	5.58
Bifrontal index	0.28	0.05	0.28	0.06	0.32	0.05	0.33	0.04	0.35	0.06
Bicaudate index	0.07	0.04	0.09	0.02	0.09	0.03	0.11	0.03	0.09	0.06
Cella media index	4.75	0.99	4.88	1.36	4.36	1.11	4.46	0.62	5.27	1.99

CT: computerised tomography; ICP: intra cranial pressure; VBR: ventricle-brain ratio.

Mean Evans ratio increased with severity from mild low risk to severe. Except for the mild medium risk group, this was also true for the two VBRs, and the bifrontal index. A similar increase was also noted for the bicaudate index from mild low risk to moderate injury severity, while measures on the Cella media index did not show any particular pattern of increase or decrease in relation to severity.

Non-parametric bivariate correlations between injury severity and CT measures indicate that when traditional severity groupings (mild, moderate, severe) were considered, there were no significant relationships. However, when Servadei's sub-classifications for mild TBI were included Evans ratio (rho=-0.318, p=0.020), the two ventricle brain ratios (rho=-0.290, p=0.036; rho=-0.290, p=0.039), and the bifrontal index (rho=0.340, p=0.013) were all significantly correlated with injury severity. While statistically significant, these correlations suggest that only from 8.4% to 11.6% of the variability in CT scan indices can be accounted for by TBI severity.

The findings suggest CT scan indices share a linear relationship with injury severity when five severity groupings are used. While the literature on raised ICP has focussed almost exclusively on severe TBI, CT scan indices of raised ICP may also be relevant to the mild TBI.

Despite the limitations of a small sample sizes, this shows that CT scan indices of raised ICP may be of relevance across the spectrum of injury severity. As TBI severity is predictive of TBI outcomes, our future examinations will explore if CT indices are linked to functional and cognitive outcomes following mild TBI.

Suzanne Lyn Barker-Collo, Nicola Starkey, Michael Kahan, Alice Theadom, Valery Feigin
Department of Psychology, The University of Auckland
s.barker-collo@auckland.ac.nz

References:

1. Xiong Y, Lee CP, Peterson PL. Mitochondrial dysfunction following traumatic brain injury. In: RL MLaH, ed. Head trauma: Basic, preclinical, and clinical directions. New York: John Wiley and Sons, Inc.; 2000:257–280.
2. Scalea T. Does it matter how head injured patients are resuscitated? In: Valadka AB, ed. Neurotrauma: Evidence-based answers to common questions. Thieme; 2005:3–4.
3. Park E, Bell JD, Baker AJ. Traumatic brain injury: Can the consequences be stopped? Canadian Medical Association Journal. 2008;178:1163–1170.
4. Ghajar J. Traumatic brain injury. Lancet. 2000;356:923–929.
5. Mizutani T, Manaka S, Tsutsumi H. Estimation of intracranial pressure using computed tomography scan findings in patients with severe head injury. . Surgical Neurology. 1990;33:178–184.
6. Testai FD, Aiyagari V. Acute hemorrhagic stroke pathophysiology and medical interventions: Blood pressure control, management of anticoagulant-associated brain hemorrhage and general management principles. Neurology Clinics. 2008;26:963–985.
7. Bazarian J, McClung J, Shah J, et al. Mild traumatic brain injury in the united states, 1998–2000. Brain Injury. 2005;19:85–91.
8. Servadei F, Teasdale G, Merry G. Defining acute mild head injury in adults: A proposal based on prognostic factors, diagnosis and management. Journal of Neurotrauma. 2001;18:657–664.
9. Theadom A, Barker-Collo S, Feigin VL, et al. The spectrum captured: A methodological approach to studying incidence and outcomes of traumatic brain injury on a population level. Neuroepidemiology. 2012;38:18–29.
10. Li L, Timofeev I, Czosnyka M, Hutchinson PJA. The surgical approach to the management of increased intracranial pressure after traumatic brain injury. Anesthesia Analgesia. 2010;111:736–748.