The weighty issue: the impact of Body Mass Index (BMI) in Asian trauma patients

沉重的問題：身體質量指數（BMI）對亞洲創傷患者的影響

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Background: The controversy surrounding the impact of Body Mass Index (BMI) on the outcome of trauma patients has been widely studied in the West. However, no such studies have looked at an Asian trauma population. The aim of our study was to investigate the impact of BMI on mortality, morbidity, severity and pattern of injury in trauma patients of multicultural Singapore. ***Methods:*** In this prospective study, we recruited all trauma patients admitted to Tan Tock Seng Hospital over a 13 month period. Both the international World Health Organization (WHO) and Asian modified classifications of BMI were used for the purpose of our study. Patient demographics, co-morbidities, mechanism of injury, injury severity score (ISS), body regions injured, morbidity and mortality were collected using inpatient medical records. ***Results:*** 964 patients with a mean age of 50.5 years were recruited. Majority of injuries sustained were due to falls. There was no association between Asian BMI and ISS. Head, neck and cervical injuries occurred less commonly in the overweight and obese group, but BMI does not confer protection from truncal injury. BMI was not a significant risk factor for morbidity or mortality. ***Conclusion:*** Being overweight does not appear to increase severity of injury in Asian trauma patients. BMI as an independent risk factor does not contribute to trauma mortality or morbidity. We conclude that BMI is not a significant contributing factor to adverse trauma outcomes in Asians. (Hong Kong j.emerg.med. 2012;19:312-318)

背景：身體質量指數（BMI）對外傷患者後果的影響，在西方已被廣泛研究。然而，沒有著眼於亞洲創傷人口的研究。我們的研究目的，是探討在多元文化的新加坡，BMI對創傷患者的死亡率，發病率，嚴重程度和損傷模式的影響。**方法：**在這項前瞻性的研究，我們招募了13個月內陳篤生醫院收治的所有外傷患者。我們的研究兼用了世界衛生組織（WHO）的國際版 BMI 分類和亞洲修正版本。我們使用住院病歷，收集病人的人口統計資料，共病，創傷機制，創傷程度評分（ISS），受傷的身體部位，發病率和死亡率。**結果：**我們招募了964例平均年齡50.5歲的患者。大部分的受傷是由於跌倒。亞洲BMI和ISS之間沒有任何關聯。頭部，頸部和頸椎創傷較少發生在超重和肥胖患者，但BMI對軀幹創傷並無保護。BMI並不是發病率或死亡率的重要危險因素。**結論：**超重看來不會令外傷患者的受傷嚴重程度增加。BMI作為一個獨立的危險因素，不影響創傷的死亡率或發病率。我們的結論是：在亞洲人的不良創傷後果， BMI 不是一個重要因素。

Keywords: Asian continental ancestry group, humans, wounds and injuries

關鍵詞：亞洲大陸祖先群體、人類、傷口和損傷

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Introduction

In Singapore, obesity in adults has been a growing problem in our local population. A review of literature revealed efforts made at studying the impact of obesity on the severity and outcome of trauma patients. Multiple studies had been done in Western institutions, using World Health Organization (WHO) International Body Mass Index (BMI) classification, with emphasis on critically injured trauma and the morbidly obese patients, specifically studying its relation to morbidity and mortality.[1-6]

Singapore is a multi-cultural and multi-ethnic society with a predominantly Asian population. Based on the Singapore Census of Population 2010 Advanced Census Release, the Chinese formed 74.1% of the population, with the Malays and Indians at 13.4% and 9.2% respectively.[7]

We note the paucity in English literature of trauma related BMI studies in Asian populations and we believe that we are well placed to study the influence of BMI on Asian trauma patients.

We aimed to be the first to investigate the relationship between BMI and trauma patients in an Asian population. Does BMI play a role as a clinical marker that needs to be taken into consideration when managing a trauma patient of Asian descent?

Our objectives were to determine whether BMI affects outcomes (in terms of mortality and morbidity) and whether BMI plays a role in the patterns and severity of injury in our local population.

Methods

Study design and population

This was a prospective observational study. We included all adult trauma patients aged 16 and above; who were admitted to Tan Tock Seng Hospital between 1st January 2010 and 31st January 2011. Patients with missing data, those who died on arrival, and those of non-Asian ethnicity were excluded.

Study setting

The study was conducted at Tan Tock Seng Hospital, the busiest acute care urban general hospital having 1,400 beds, with trauma attendances of over 5,000 per year to the Emergency Department, of which about 25% of them are admitted. Our trauma patient population reflects the cross section of our local population.

Definitions

BMI is defined as the weight in kilograms divided by the square of the height in meters (kg/m^2). International Body mass index classification (according to WHO report) and cut off points of BMI for public health action proposed for Asians were both used[8] (Table 1). This was based on cutoff point recommendations in the nationwide accepted Ministry of Health Clinical Practice Guidelines (Singapore).[9]

Data collection

Patient demographics (age, gender and race), blunt or penetrating trauma, mechanism of injury, co-morbidities, and areas of injury according to the abbreviated injury score (AIS) region definitions were collected through a review of inpatient medical records. We analysed the occurrence of injuries based on AIS: head, neck and cervical spine; face; thorax and thoracic spine; abdomen, pelvic contents and lumbar spine; extremities and pelvic girdle; and external (skin). Severity of each region was scored from 1 to 6 (from minor to non survivable), and overall severity of injuries was measured by the injury severity score (ISS).

Table 1. WHO BMI cut-off points and Asian BMI cut-off points

WHO classification	WHO BMI cut-off points for definition (kg/m^2)	Asian BMI cut-off points for action (kg/m^2)	Cardiovascular risks
Underweight	<18.5	<18.5	–
Normal	18.5-24.9	18.5-22.9	Low
Overweight	25-29.9	23.0-27.4	Moderate
Obese	≥30.0	≥27.5	High

Adapted from Singapore Clinical Practice Guidelines on Obesity[2]
BMI: Body Mass Index; WHO: World Health Organization

Outcome measures

The primary outcome measures were mortality at any time during the hospital stay, and occurrence of at least one or more complications (as described below) during the same period the patient was admitted to hospital.

Complications studied were classified into cardiovascular (includes acute myocardial infarction, heart failure or arrhythmias), respiratory (includes acute respiratory distress syndrome), neurological (includes stroke, neuropathy), thromboembolic (includes deep venous thrombosis, pulmonary embolism), infectious (includes pneumonia, urinary tract infection) and others (for example decubitus ulcers). For patients with multiple complications, they would be included under each category of complications as a single occurrence.

Statistical analysis

All statistical analyses were performed using SPSS 13.0 (SPSS Inc, Illinois, USA). For descriptive analysis, Chi-square test was used to compare categorical variables and T-test and Mann-Whitney test to compare continuous variables. Logistic regression was applied to identify the variables associated with ISS. All tests were conducted at 5% level of significance, with odds ratios (OR) and corresponding 95% confidence intervals (CI) reported where applicable.

Ethics

Ethics approval for this study was not required as all patient data obtained were anonymous and collection of data was part of a departmental clinical audit registry, which did not affect any patient outcomes.

Results

From 1st January 2010 to 31st January 2011, 964 trauma patients admitted to Tan Tock Seng Hospital were recruited. The main ethnic group in our study was Chinese (71.4%). The rest comprised of Malays (11.2%), Indians (11.1%) and others (6.3%). There were Japanese, Thais, Bangladeshis and Vietnamese in the 'others' category. Table 2 describes the baseline characteristics of our study population. Figure 1 illustrated that the most common mechanism of injury was due to falls (50.7%).

Four hundred ninety eight (57%) patients had no co-morbidities, while the rest had at least one pre-morbid condition documented (e.g. cardiovascular, respiratory, diabetes, renal, liver and others). One hundred and forty three (14.8%) patients experienced complications during their hospitalisations while mortality occurred in 92 (9.5%) patients.

Figures 2 and 3 showed the distribution of patients according to the International BMI classifications and recommended Asian public health action cut offs, respectively.

Using the WHO International BMI classification and the normal weight group as the reference category, we found that the overweight (OR 0.68, 95% CI=0.48-0.95) and obese (OR 0.37, 95% CI=0.20-0.68) groups of patients were significantly less likely to suffer from injuries to the head, neck and cervical spine, after adjusting for age. Extremities and pelvic girdle injuries were more likely to occur in the overweight group (OR 1.90, 95% CI=1.30-2.70). No significant difference was observed in the above regions in those who were underweight.

Table 2. Summary of population characteristics (N=964)

Age (years)*	50.5±20.9
Male	664 (68.9%)
Chinese	688 (71.4%)
Blunt injuries	934 (96.9%)
Injury due to falls	489 (50.7%)
Length of stay (in days)†	7 (0-18)
Injury severity score*	16.5±11.7
Complications	143 (14.8%)
Mortality	92 (9.5%)

*Mean (SD); †Median (interquartile range)

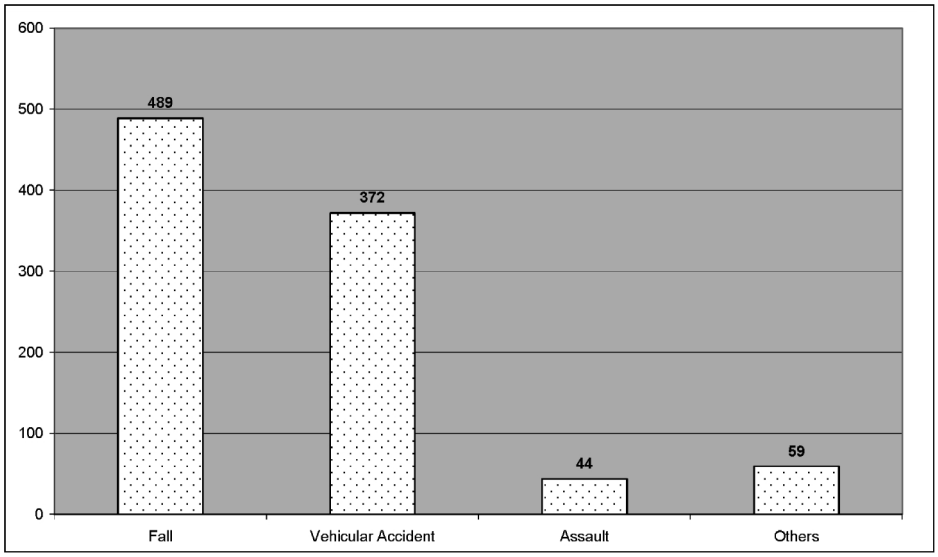

Figure 1. Mechanisms of injury.

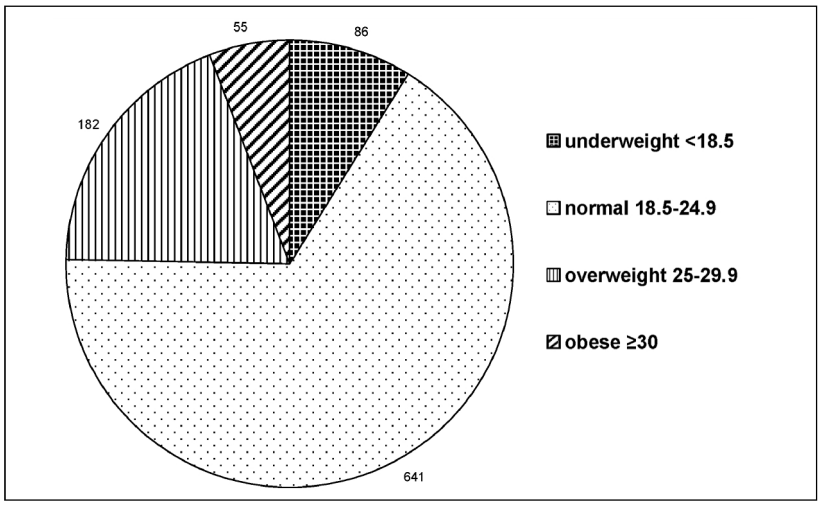

Figure 2. Distribution of BMI groups based on WHO International Classification.

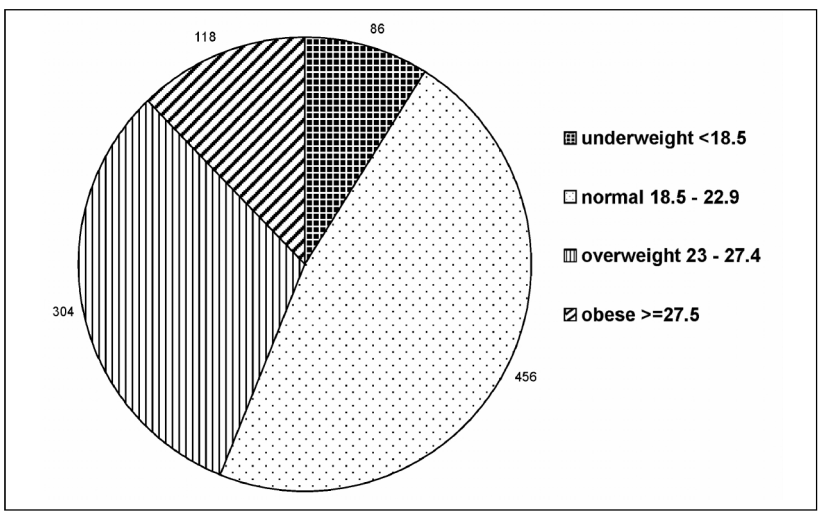

Figure 3. Distribution in BMI groups according to Asian cut-offs.

There was no significant correlation between BMI and the occurrence of injuries to the other regions (Table 3a). Analysis of patients with ISS of greater than 15 found similar patterns of injuries. After comparing BMI categories with ISS, there was no significant association found between the 2 variables (p=0.263). Mechanism of injuries were deemed potential confounders, but subgroup analysis within each mechanism of injury groups did not yield significant results.

We did the above analysis based on the BMI cut-off points for public health action in Asians and yielded similar results (Table 3b).

Using multivariate logistic regression, we found that ISS and age were independent predictors for the primary outcome of mortality. There was no significant difference found in mortality rates among the 4 BMI categories. We were also unable to demonstrate any significant relationship between BMI groups and the occurrence of inpatient complications (Tables 4 & 5).

Table 3a. Patterns of injury by the WHO BMI categories (percentages in brackets)

Area of injury	WHO International BMI categories (kg/m²)				p value
	<18.5	18.5-24.9	25.0-29.9	≥30	
Head, neck, face	46 (10.5)	310 (70.5)	70 (15.9)	14 (3.1)	0.001
Thorax	27 (10.3)	168 (64.1)	48 (18.3)	19 (7.3)	0.450
Abdomen and pelvic contents	9 (7.4)	77 (63.1)	29 (23.8)	7 (5.7)	0.497
Spine	8 (6.7)	83 (69.2)	22 (18.3)	7 (5.8)	0.812
Extremities and pelvic girdle	45 (7.7)	377 (64.3)	133 (22.7)	31 (5.3)	0.001
Skin	20 (9.3)	134 (62.3)	45 (20.9)	16 (7.4)	0.416

BMI: Body Mass Index; WHO: World Health Organization

Table 3b. Patterns of injury by the Asian BMI cut-off values (percentages in brackets)

Area of injury	WHO International BMI categories (kg/m²)				p value
	<18.5	18.5-22.9	23.0-27.4	≥27.5	
Head, neck, face	46 (10.5)	224 (50.9)	127 (28.9)	43 (9.8)	0.017
Thorax	27 (10.3)	124 (47.3)	70 (26.7)	41 (15.6)	0.077
Abdomen and pelvic contents	9 (7.4)	57 (46.7)	37 (30.3)	19 (15.6)	0.633
Spine	8 (6.7)	59 (49.2)	37 (30.8)	16 (13.3)	0.792
Extremities and pelvic girdle	45 (7.7)	260 (44.4)	205 (35.0)	76 (13.0)	0.009
Skin	20 (9.3)	90 (41.9)	71 (33.0)	34 (15.8)	0.182

BMI: Body Mass Index; WHO: World Health Organization

Table 4. Predictors for mortality

Independent variable	Adjusted OR (95% CI)	p value
BMI*		
Normal	0.54 (0.26-1.13)	0.100
Overweight	1.34 (0.56-3.19)	0.516
Obese	1.59 (0.44-5.72)	0.482
ISS >15	37.16 (14.61-94.48)	0.000
Age	1.03 (1.01-1.04)	0.000
Male	0.93 (0.54-1.61)	0.792

*Using underweight as reference BMI category

BMI: Body Mass Index; CI: confidence intervals; ISS: injury severity score; OR: odds ratios

Table 5. Predictors for complications

Independent variable	Adjusted OR (95% CI)	p value
BMI*		
Normal	2.00 (0.92-4.34)	0.080
Overweight	2.25 (0.96-5.31)	0.063
Obese	2.07 (0.69-6.25)	0.197
ISS >15	2.88 (1.98-4.20)	0.000
Age	1.01 (1.00-1.02)	0.092
Male	0.95 (0.63-1.44)	0.811

*Using underweight as reference BMI category

BMI: Body Mass Index; CI: confidence intervals; ISS: injury severity score; OR: odds ratios

Discussion

BMI has been used traditionally as a clinical marker to identify at risk individuals for adverse health risks such as hypertension, hyperlipidaemia, diabetes and cardiovascular disease. Increasing evidence has shown that body fat distribution and composition differ across populations.[8] The WHO Expert Consultation on BMI in Asian population proposed adjusted cut-off points for public health action in Asians, which has been incorporated into the Singapore's clinical practice guidelines.[9]

However, the national guidelines also state that although cut-points for action based on the risk of co-morbid diseases are lower among Asians, retention of the International WHO classification to define weight category in Asians has been recommended.[9]

Despite adjusting the BMI cut-offs for public health action in Asians, we found that there were no significant effects on the results. Therefore, we presented our findings in accordance to the International WHO weight category classification.

The theory of the cushion effect was introduced by Arbabi et al in 2003 to explain the reduced severity of abdominal injuries in overweight victims. The thicker abdominal fat layer of such patients might confer protection to the internal organs. However, excessive abdominal fat with higher mass and kinetic energy could overwhelm the protective effects in obese patients.[10] Subsequent studies revealed conflicting results upon studying patterns of injuries in obese patients. Byrens et al were unable to demonstrate specific injury patterns in their study involving 1179 patients.[1]

Our results could not support the cushion effect that was proposed by Arbabi et al. We postulated that this could be related to the difference in fat distribution in Asians and Caucasians. Comparisons in anthropometry had shown that Asians had more subcutaneous fat and more of which was concentrated in the upper body as compared to Caucasians.[11] The theory of abdominal subcutaneous layer serving as protection for the internal organs cannot be applied in that case. Therefore we were not able to demonstrate similar injury patterns that were found in Western studies. Instead, our observation was that overweight Asian patients were less likely to suffer from head and neck injuries but more likely for injuries to the extremities and pelvic girdle.

Based on our results, we not only found that BMI did not affect injury severity in Asian trauma patients, we demonstrated that being overweight or obese did not affect the outcome of our trauma patients.

Choban et al were the first to show worse outcome of overweight patients in trauma.[2] Other studies that followed also demonstrated increased rates of complications and mortality in the obese patients. The risk of obesity was suggested to be two-folds: firstly, higher incidences of cardiovascular co-morbidities such as diabetes and hypertension compromising body reserve and immunity; secondly, anatomical and physiological changes that predispose them to pulmonary, renal and thrombotic complications.

There were, however, contradictory works published which found no significant correlation between mortality and BMI. The study by Zein and colleagues consisting of 304 patients had described similar mortality rates in obese and non-obese adult patients.[3] Another study involving severely injured paediatric patients also did not find statistically significant difference in mortality between obese and non-obese children.[12]

In Byrens et al's work, it indicated that complications and increased mortality only became more common in injured patients with BMI ≥35. Patients with BMI <35 had outcomes similar to leaner patients.[1] A recent retrospective review performed by Diaz et al also demonstrated that morbid obesity was not an independent risk factor of death; rather ISS and age continued to be independent risk factors of mortality in trauma patients. However, they had chosen to study the morbidly obese with BMI ≥40.[4] Similarly, we demonstrated that ISS remained to be a predictor of outcome in trauma patients, and was independent of BMI.

As shown above, the varied study designs and non-validated BMI cut-off values for trauma patients could result in contradictory conclusions with respect to the impact of BMI in trauma outcomes and injury patterns. Notably, many of the former studies that had found obesity as a significant risk factor were retrospective in nature; used varying inclusion criteria and had mainly studied critically ill trauma patients in the intensive care setting.

We questioned on the appropriateness of using BMI in investigating the effect of body habitus on trauma outcomes. Studies have shown that although BMI correlated with total body fat, it could not adequately demonstrate body composition, in particular body adipose distribution. Other methods of demonstrating body adipose composition such as waist circumference, waist-hip-ratio or even magnetic resonance imaging may be more accurate, but may be tedious, expensive and even counter productive to measure in the context of management in a major trauma patient.

In our Asian patients, we should not use BMI as a predictor of outcome post-trauma. After adjusting the BMI cut-off values as appropriate for the Asian body habitus, we were still unable to demonstrate similar findings in studies of trauma patients in the West. ISS and age should remain as the predictors of trauma outcomes in Asian trauma patients.

We recognised the some limitations of our study. This was a single centre study, with a relatively small sample size in comparison to the local population of 5 million. Also, single rater assessment was employed in determination of complications. To our knowledge, there is currently no validated system of classifying complications in Trauma patients. Therefore, the above classification was used based on clinical relevance and applicability deemed most appropriate by the Trauma team caring for the trauma patients in our setting.

Conclusion

This study could be the first to investigate the associations between BMI, injury patterns and trauma outcomes in Asian patients. Increased BMI does not correlate with any protective effect on truncal and abdominal injuries in the Asian population. The overweight and obese are less likely to suffer from head and neck injuries, whereas injuries to the extremities and pelvic girdle occur more commonly in the overweight. BMI is not a significant predicting factor to mortality and morbidity in our Asian trauma patients; while ISS and age remains to be the main predictors for trauma outcomes.

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