

## WEIGHT ESTIMATION METHOD IN EMERGENCY DEPARTMENT IN MALAYSIA: IS BROSELOW TAPE (BT) RELIABLE?

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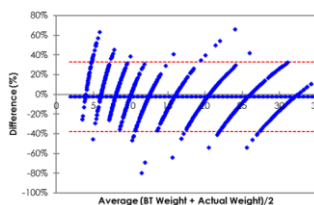
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### Graphical abstract



### abstract

Broselow tape is a well-established medical equipment to estimate body weight with pre-calculated drug dosages and emergency equipment sizes. The aim of this study is to determine whether weight estimation based on Broselow Tape corresponds to the actual weight of pediatric population in Klang Valley, Malaysia. The aim of this study is to determine the accuracy of BT usage in pediatric population attending the emergency department. A total of 1163 children attended emergency department at green zone were approached to be the sampling frame. BT weight estimation colour code was determined based on the colour which the child's heel fell on the tape. Scatter plot was done to determine the range of actual weight scattered around the range of BT. Bland-Altman plot was used to identify the bias relation between the BT and actual weight measurement. In our population, the BT was an ineffective method to predict weight of pediatric patients with body length of <0.6m and >0.9m. Incorrect estimation of children weight leads toward poor clinical judgment. Therefore, clear indication of the BT limitations should be addressed before using the method as part of emergency department standard operating procedure for management of pediatric patients.

Keywords: Broselow Tape, weight estimation, pediatric

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## 1.0 INTRODUCTION

It is paramount to respond fast when dealing with emergency involving pediatric patients as slight delay may result in morbidity and mortality [1]. Hence, resuscitation of the pediatric patients requires accurate estimation of the patients' weight to allow ideal selection of equipment sizes and proper medication dosages [2]. Therefore, Broselow height-based weight estimation was designed as solution to

reduce delay in weighing children during emergency situation.

Broselow tape (BT) was recommended by the Advanced Trauma Life Support and the Pediatric Advanced Life Support (PALS) courses and it has been widely used around the globe. It was first validated and proved to be accurate for usage among pediatric populations in the United States [3]. The estimated weight from BT was derived from noble data collected by National Center for Health Statistic (NCHS) in 1979 (based on 50<sup>th</sup> percentile body

weight of European children)[4]. Continuous validation done in several developed countries showed that the tape was still useful and relevant for estimating weight of children [5]. However, recent studies suggested that the tape may underestimate weights as most countries trend of childhood obesity increased. Conflicting results were also found on the utility of the tape in developing countries and low-income countries [6, 7]. Therefore, it is essential to assess the accuracy of the Broselow tape to be used in emergency department among Malaysian children.

## 2.0 METHODOLOGY

The study was a cross-sectional prospective study served to produce initial data of the accuracy of Broselow tape (BT) in estimating weight of Malaysian children.

### 2.1 Study Setting and Population

The sampling frame included were pediatric patients attended the emergency department of Hospital Tengku Ampuan Rahimah (HTAR) Klang with age ranged from 7 days of life until 12-year-old. BT can only be used for children weighing from 3kg to 36kg, therefore, cutoff point of age was calculated based on PALS formula for weight estimation that estimates the weight for a 12-year-old to be approximately 36kg. The study was approved by Malaysian

National Medical Research Register Ethics Committee.

The exclusion criteria include those with medical conditions known to affect their weight or height such as amputation, dwarfism, severe joints contractures or neurologic defects. The children were also excluded if their height was longer than the BT (>146cm).

### 2.2 Weight Determination

All children presenting to the emergency department HTAR were measured for their actual body weight and body length to the nearest 0.1 kg and 0.1 cm, respectively. Their heavy outerwear and shoes were removed prior the weighing. The clinicians involved in the study were all trained on usage of the BT. All subjects were measured for their body length with the BT from the top of the head to heel in supine position.

## 3.0 RESULTS AND DISCUSSION

The study recruited 1163 pediatric patients with age ranged from 3 days of life to 12 years old. Malays account more than half of total subjects, followed by Indian 23%, Chinese 8%, and other ethnics were only 3%. Their body weight ranged from 3.1kg to 36kg and their length were 0.50m to 1.49m. The distribution of gender were almost equal with 55% were boys and 45% were girls. Means of weight and length based on age group were summarized in Table 1.

**Table 1** Mean of weight and length with 95% CI

	Mean weight (kg)	95% CI	Mean length (m)	95% CI
Below 1.0 year	6.87	6.64 – 7.09	0.65	0.64 – 0.66
1.0 - 3.9 years old	10.38	10.12 – 10.64	0.83	0.82 – 0.84
4.0 - 7.9 years old	17.54	17.06 – 18.01	1.11	1.09 – 1.12
8.0 – 12.9 years old	25.21	24.56 – 25.87	1.30	1.28 – 1.31

### 3.1 BT-estimated Weight vs Actual Weight

Mean age, length, actual weight and BT-estimated weight of each group were calculated and tabulated in Table 2 below. The finding highlighted that the mean weight of subjects which fall at the extreme end of the tape were different from BT length-weight estimation. The percentage of differences was calculated to estimate percentage of bias between BT and actual weight. It was apparent from the scatter plot that the estimated differences between mean weights were high at extreme end of the tape suggesting underestimation of weight at lower end of the tape and overestimation of weight at higher end of the tape (Figure 1).

Bland Altman method of agreement was used to investigate the relationship between two different methods of measurement; BT-estimated weight and actual weight. Limits of agreement were at 95% CI for lower and upper limits respectively. The percentage difference between BT-predicted weight and the measured weight was calculated as a measure of tape bias ( $100 \times [BT - \text{estimated weight} / \text{average BT-estimated weight and actual weight}]$ ). Figure 2 exhibits the overall differences between average of actual weight and BT-estimated weight with percentage difference of BT-estimated weight and actual weight. Overall percentage difference was -2.62% (95% CI -37.9132% to .66%). Interestingly, for subjects which BT-estimated weight less or equal to 7 kg, percentage difference was -14.21% (95% CI -22.33% – 50.76%); and subjects which BT-estimated

weight more than 11.1 kg, the percentage difference was 7.3% (CI 95% -39.5% to 24.9%). Therefore, the estimation of biases strongly suggested that BT-estimated weight tend to underestimate the weight

of subjects with body length of  $\leq 0.61\text{m}$  and overestimate the weight of subjects with body length of  $\geq 0.85\text{m}$ .

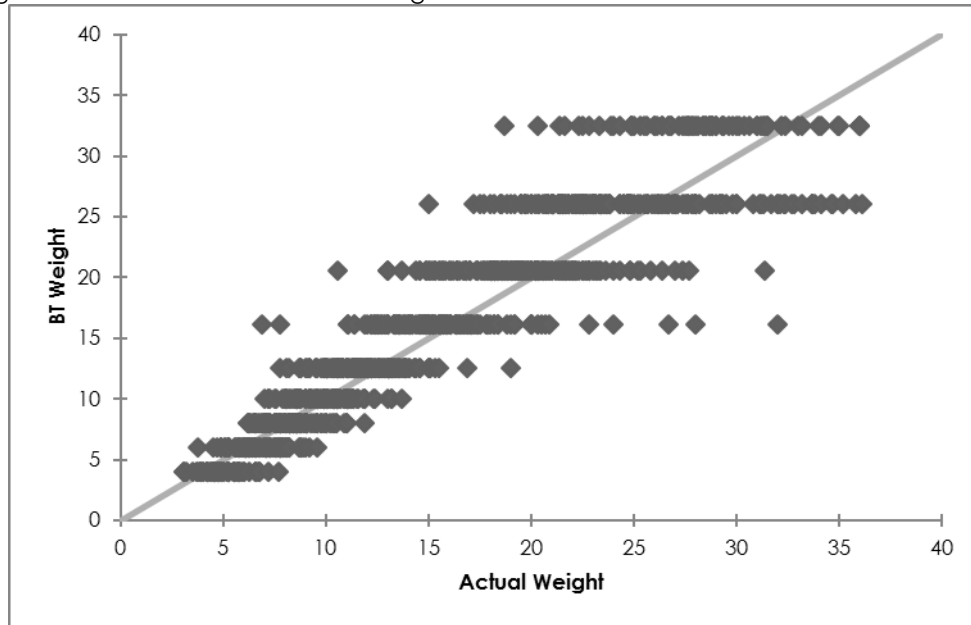


Figure 1 Scatter plot of actual weight vs BT

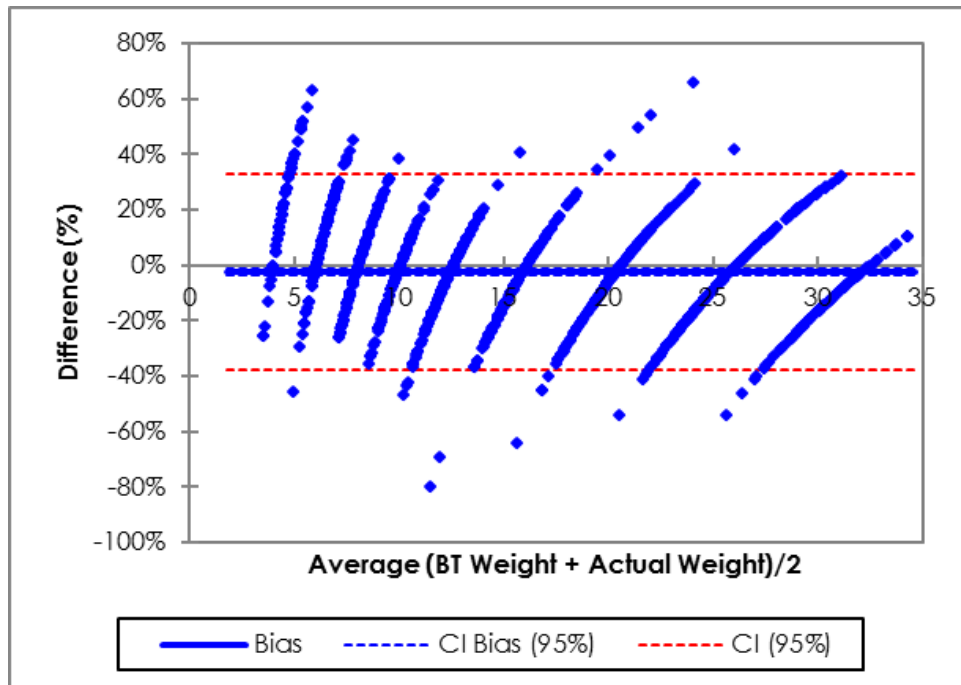


Figure 2 Bland-Altman graph of percentage differences between BT-estimated weight in kg and actual weight in kg (N: 1163).

**3.2 BT-recommended Dosage vs Actual Dosage**

The tape also includes estimation of selected drug dosages for pediatric patients. Each colour coded zones include pre-calculated medication dosages of

certain drugs. Table 2 is the comparison of mean for drug dosages based on actual weight as compared to BT-recommended drug dosages. Consistent with the differences of actual weight and BT-estimated weight, there were also significant differences on the

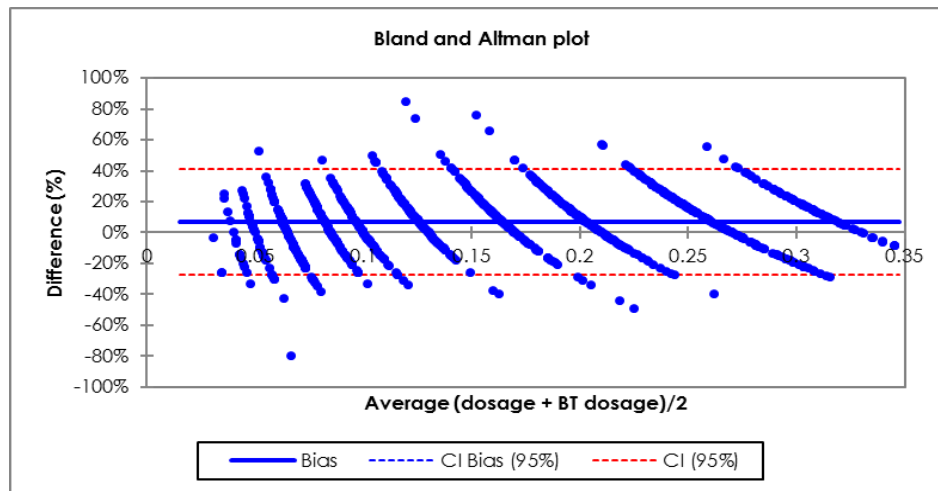
mean drug dosages for both extreme end of the tape.

**Table 2** Mean of actual drug dosages versus BT-estimated drug dosages in each colour code group

Colour code	BT-recommended dosage (mg)	Actual dosage (mg)	t-test
Grey	0.04	.051	<0.05
Pink	0.065	0.064	<0.05
Red	0.085	0.079	>0.05
Purple	0.1	0.093	>0.05
Yellow	0.13	0.11	<0.05
White	0.17	0.15	<0.05
Blue	0.21	0.18	<0.05
Orange	0.27	0.23	<0.05
Green	0.33	0.28	<0.05

Bland Altman method of agreement was also used to investigate the relationship between two different methods of measurement; BT-recommended dosage and actual drug dosage. Limits of agreement were at 95% CI for lower and

upper limits respectively. The result indicated that the percentage of difference was 6.81% (CI: -27.14% – 40.76%) with those with BT-estimated weight of more than 11kg percentage difference was 11.16% (CI: -20.33 – 42.65) (Figure 3).



**Figure 3** Bland-Altman graph of percentage differences between BT-recommended dosage in mg and actual dosage in mg (N: 1163)

### 3.3 Discussion

Broselow tape is readily available in most Emergency Department in Malaysia. The tape has been part of important tools used in emergency department to estimate body weight of pediatric patients. Usage of this tape was popular since the introduction of Pediatric Advanced Life Support in early 1990's [8]. Since then, many studies were conducted to determine accuracy of the tape in estimating weight. Earlier studies were inferring to western populations and the results suggested that BT is the most accurate method in weight estimation compared to other methods [9-11].

Consistent with findings of previous studies in other population such as Indian, Pacific Island and Maori children, this study found that BT underestimated

weight of more than half of subjects that fall on grey and pink color-code [12, 13]. The discrepancies may result in poor management of pediatric patient; for example a child with 0.50m length with actual weight of 6.5 kg, might receive half of the recommended dose of phenytoin (loading dose). The common error in pediatric management at the emergency department is incorrect drug dosage due to inaccurate weight estimation[14]. Therefore, the usage of BT may further expose our pediatric population to receive significantly reduced dose of drugs and resulted in under-resuscitation in these children[15].

In other hand, BT was also found to overestimate the weight of subjects which were more than 0.90m length (orange and green BT colour-code) and the present finding was in agreement with findings by

Varghese et al. (2006) [16]. The finding was substantially important in clinical setting because the differences may result in selection of larger endotracheal tube for the patient. The inaccuracy may cause trauma to the hypopharynx, vocal cord as well as structures surrounding it and further compromised patient's airway and breathing [17]. Obesity or overweight subject was not the issue for our study as compared to previous study in United State by Nieman et al. 2006 because there were no obese patients in the study, all subjects were within normal range [15]. Lower weight in children used for this study may not reflect factors as discussed in few studies at rural area or underdeveloped area such as under nutrition or health problems. Main factor should be considered is the fact that Malaysian is similar with other countries in Asian continents which have phenotypically lower body build-up due to genetic factor [18].

#### 4.0 CONCLUSION

In summary, application of BT among certain group of Malaysian children may result in significant discrepancies of weight estimation with mean of percentage difference of approximately 5%. Thus, the discrepancies may lead towards poor clinical judgment. Although its ease of use and its references to drug dosing and equipment sizes offer distinct advantages over other methods of weight estimation, clinicians must be aware of its limitations. Therefore other method of weight estimation should also be considered in estimating the children which heights fall into extreme end of the BT. The tape may need some modification to comply with the need of Malaysian pediatric population.

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