

# CORRELATION OF EMERGENCY DRUG DOSE BY USING BROSELOW TAPE AND SIRIRAJ'S THAI ANTHROPOMETRIC PEDIATRIC ESTIMATE (SITAPE)

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**Abstract.** Accurate weight estimation is necessary in pediatric resuscitation for drug dosages and equipment sizes. Children's weight is difficult to measure in critically ill patients. The Broselow tape, developed to provide a quick weight estimation for Caucasian children, might not be accurate for Thai children. The Thai weight-for-height correlation tape, or SiTAPE (Siriraj's Thai Anthropometric Pediatric Estimate), was developed by the Department of Emergency Medicine, Siriraj Hospital, in 2013, based on Thai national growth charts. This study aimed to determine the correlation of emergency drug doses with endotracheal tube sizes by using the Broselow Tape and SiTAPE. A total of 660 children, aged 8 years or younger and without underlying diseases, were enrolled from the outpatient pediatric clinic. Their ages, heights and body weights were recorded. The doses of adrenaline and volume of intravenous resuscitation fluid calculated from the Broselow tape and SiTAPE were compared with that from their actual weight. The body weights derived from the Broselow tape and SiTAPE closely correlated with the actual weights, particularly among children aged under 3 years. The adrenaline doses and fluid resuscitation volumes calculated from the actual weights significantly correlated with those derived from the Broselow tape and SiTAPE ( $r > 0.9$ ) in children aged under 3 years. The endotracheal tube sizes derived from the Broselow tape and SiTAPE also had excellent correlations. However, the adrenaline doses and endotracheal tube sizes derived from SiTAPE were in an acceptable range and close to the doses and the sizes calculated from the actual weights and ages.

**Keywords:** Thai children's weight estimation, The Broselow tape, Thai weight for height correlation tape

## INTRODUCTION

Dosing calculation is an integral part of the appropriate care of acutely ill children in emergency departments (EDs). Clinicians need

to accurately calculate drug doses, intravenous fluid volume, and medical equipment sizes. Calculations are generally based on children's body weight. Unfortunately, acutely ill children in the ED may be rushed through triage and not weighed appropriately. Subsequently, drug dosing is based on a crude estimation, making dosing errors common, which can cause severe adverse events (Wong *et al*, 2004).

The Broselow tape estimates children's weights by measuring their height while lying prone. This is then used to calculate the doses of

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common emergency drugs and sizes of medical equipment (such as endotracheal, nasogastric and suction tubes). The tape has been utilized extensively by most EDs since 1985. Moreover, the 2015 PALS guidelines suggest that if a child's weight is unknown, it is reasonable to use a body-length tape with precalculated doses (Class Ila, LOE C; de Caen *et al*, 2015).

The tape is for children aged 12 years or under whose body weight is less than 80 pounds (36.28 kg) and whose height is between 46 and 143 cm. It is easily used by placing the start of the tape next to the level of the vertex while the child is supine. The color block where the heels of the patient are located provides the estimated weight, drug doses and equipment size required for emergency management. Using the Broselow tape allows clinicians to bypass the actual body weight measurement in a critically ill child (Meguerdichian and Clapper, 2012). However, the Broselow tape is based on the size parameters of western children. Therefore, its applicability to Thai children remains in question.

A Thai study showed that caregivers are the most capable of giving accurate body weight information, in fact, much more so than the body weight estimated from the Broselow tape or from the estimated weight based on the 50<sup>th</sup> percentile of the Thai weight-for-height graph (Trakulsrichai *et al*, 2012). However, parents or caregivers are not always present during an emergency, making it necessary for emergency room personnel to have a reliable method to estimate the child's weight. SiTAPE was developed for this purpose, using the then-most current national information on weight and height between the 25<sup>th</sup> and 75<sup>th</sup> percentiles of Thai standard growth charts.

The purpose of this study was to compare the weight and the subsequent drug doses derived from SiTAPE and the Broselow tape with the gold standard: the drug dose calculated from the patient's actual weight.

## MATERIALS AND METHODS

This study was approved by the Institutional Review Board of the Faculty of Medicine, Siriraj Hospital, Mahidol University. Children under 8 years of age (eligible under the PALS guidelines) who attended the outpatient pediatric clinic at Siriraj Hospital, a tertiary care center in Bangkok, Thailand, between November and December 2013, were recruited. Exclusion criteria were (1) children in critical conditions (such as cardiopulmonary arrest, severe hypoxemia and decompensated shock), or any children triaged into level 1; (2) children with a weight-for-age less than the 3<sup>rd</sup> or greater than the 97<sup>th</sup> percentiles; (3) children with a height under 46 cm or over 143 cm; (4) children with a history of preterm birth, defined as a gestational age < 37 wk; (5) children with a diagnosis of renal failure, cirrhosis, nephrotic syndrome, hypoalbuminemia, or severe dehydration; and (6) congenital anomalies. After the parental informed consents were signed, the patients underwent routine weight and height measurements according to the hospital's standard operating procedures. The body weight scales were regularly calibrated. The length or height of children under 2 years were measured in the supine position, while children older than 2 years were measured in the standing position with a regularly-calibrated stadiometer. Demographic data were recorded on the case-record form.

The length of each individual participant was then plotted on the Broselow tape and the SiTAPE tape. Appropriate doses of the emergency drugs (namely, adrenaline, sodium bicarbonate, atropine, salbutamol, and diazepam), the volume of intravenous resuscitation fluid, and the size of the endotracheal tube were estimated for each type of tape before being compared with the gold standard: the values based upon the actual weight.

The correlation of the parameters (drug dose, fluid volume, body weight, endotracheal

tube size) derived from the Broselow tape and SiTAPE, and from the gold standard were analyzed using the Pearson correlation coefficient. A correlation coefficient greater than 0.75 ( $r > 0.75$ ) was regarded as a high correlation.

## RESULTS

The median age of the 660 children in the

study was 14 months, ranging between 5 days and 8 years, 9 months. Of those, 334 (50.6%) patients were boys, 422 (63.9%) were younger than 2 years, and 47 (7.1 %) were between 6-8 years (Table 1). The median (range) height and weight were 76.7 (45.5-132) cm and 10 (2.2-32.3) kg, respectively, with 326 (49.3%) patients having a body weight below 10 kg.

Table 1  
General characteristics of the study population.

Characteristic		Number (%)
Median age, years (min-max)		1.16 (0.01-8.96)
Age group	Age range (years)	
1	<1	274 (41.5)
2	1-<2	148 (22.4)
3	2-<3	58 (8.8)
4	3-<4	45 (6.8)
5	4-<5	56 (8.5)
6	5-<6	32 (4.8)
7	6-<7	25 (3.8)
8	7-<8	22 (3.3)
Gender		
Boy		334 (50.6)
Girl		326 (49.4)
Height (cm), median (min-max)		76.7 (45.5-132)
Measured weight (kg), median (min-max)		10 (2.2-32.3)
Range of weight (kg)		
≤ 5		127 (19.2)
6-7		84 (12.7)
8-9		115 (17.4)
10-11		91 (13.8)
12-14		89 (13.5)
15-16		57 (8.6)
17-18		34 (5.2)
19-23		51 (7.7)
24-28		9 (1.4)
≥ 29		3 (0.5)
Underlying disease		
Yes:	Asthma	2 (0.3)
	Allergy	5 (0.75)
	G6PD deficiency	1 (0.15)
No		652 (98.78)

The body weights derived from the Broselow tape and SiTAPE closely correlated with each other in every individual age group ( $r \geq 0.9$ ). However, the body weights from both tapes were only fairly correlated with the actual weights, especially among children older than 3 years (Fig 1). The emergency drugs dosages derived from the Broselow tape and SiTAPE (eg, adrenaline, calcium gluconate, and isotonic solution bolus) had the same correlation coefficient value as the body weights.

By contrast, the endotracheal tube (ETT) size estimates, which were generally calculated by a formula using the patient's age (uncuffed ETT size = 4 + [age (year)/4]), did not correlate well with the ETT sizes derived from both the Broselow tape and SiTAPE ( $r < 0.5$ ).

## DISCUSSION

Ideally, the calculation of drug dosages for children should be based on their actual weight (Krieser *et al*, 2007). The Pediatric Pharmacy Advocacy Group recommends that weight-based dosing should be used for children < 18 years who are < 40 kg. In children whose body weight

is > 40 kg, the drug dose should still be based upon the actual weight, provided it does not exceed the recommended adult dose (Matson *et al*, 2017).

Recently, research by Trainarongsakul *et al* (2017) utilized a similar method of measuring body length and using it to estimate the body-weight range of Thai children. That study demonstrated a 61.16% agreement with the children's actual weight, with a kappa of 0.54 (Trainarongsakul *et al*, 2017). Those outcomes are slightly less accurate than those of a previous study from the US, which had a kappa of 0.61 and a degree of agreement of 66.2% using the Broselow colored card (Nieman *et al*, 2006). On the other hand, in an emergency situation, the provider's ability to predict the actual weight of pediatric patients is of less concern than his ability to select the appropriate equipment size and deliver an accurate drug dosage. Thus, the true value of SiTAPE is its established and exact applicability in an emergency situation.

The Broslow tape is well-known for its accuracy among younger children. On the other hand, its ability to accurately predict drug doses

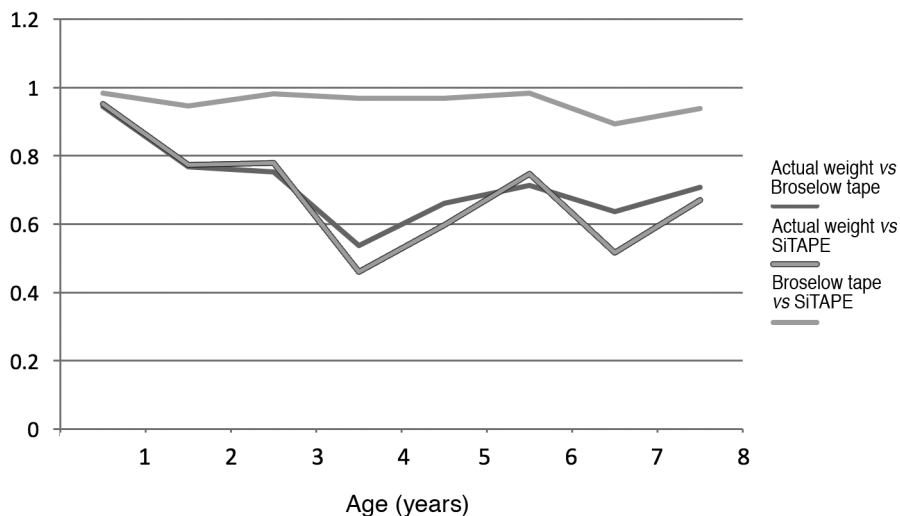


Fig 1– Correlation graphs for body weights derived from Broselow tape, SiTAPE and actual body weights, by age group.

starts to diminish among older children. Varghese's study revealed that the Broselow tape provided more accurate body weight estimates for children whose actual weight was under 15 kg, but gave overestimates for children weighing over 15 kg (Wong *et al*, 2004; Varghese *et al*, 2006). Holfer *et al* (2002) demonstrated that the Broselow tape was superior for estimating the body weight of younger children than older children; in the latter case, the tape often yielded lower estimates than the actual weight. Jang *et al* (2007) reported a similar phenomenon among children whose actual weights were greater than 20 kg. SiTAPE also possesses the same limitation for children older than 3 years (or a body weight > 14 kg.) Thus, neither the Broselow tape nor SiTAPE is superior in this regard.

More importantly, the difference in doses derived from both methods was still within the normal standard error of 10%, as defined by Miller *et al*, in 2007 (Table 2). Such inaccuracy was also observed in our study, where the biggest impact was seen in the ETT-size estimate. While the correlation of the ETT size derived from the Broselow tape and SiTAPE was excellent ( $r = 0.9-1.0$ ), both tapes were not well correlated

with the ETT size calculated from the standard formula ( $r < 0.5$ ). However, the overwhelming majority of the ETT sizes derived from the Broselow tape and SiTAPE, 99.5% and 98.3% respectively, were still within the range recommended by PALS (one size bigger to one size smaller; Table 3).

Overall, SiTAPE is able to exactly predict the ETT sizes in a larger proportion of children than the Broselow tape (76.8% vs 61.5%). On the other hand, SiTAPE also tends to underestimate the ETT size by more than 1 size in older children aged between 4 and 7 years.

For all practical purposes, the Broselow tape and SiTAPE are interchangeable tools. In Thailand, Broselow tapes are purchased through Amazon.com and imported individually at an estimated total cost of USD15-20 each. The SiTAPE tape, on the other hand, is produced locally, making it a much more accessible and cost-effective tool for wide use in prehospital and emergency-room settings.

There is one major limitation to this study. The fact that children in the older age group (> 3 years) represented only 27% of the total number

Table 2  
Dose of adrenaline from actual weight, Broselow tape and SiPET.

Age group	Adrenaline calculated from actual weight (mg)	Adrenaline from Broselow tape		Adrenaline derived from TWHCT	
		Dose (mg)	Percentage of dose by actual weight	Dose (mg)	Percentage of dose by actual weight
1	0.063	0.063	100	0.061	97
2	0.103	0.104	101	0.101	98
3	0.128	0.132	103	0.132	103
4	0.148	0.151	102	0.149	101
5	0.175	0.177	101	0.170	97
6	0.188	0.192	102	0.183	97
7	0.189	0.204	108	0.194	103
8	0.228	0.235	103	0.219	96

Table 3  
Comparison of endotracheal tube sizes derived from SiTAPE and Broselow tape to standard age-calculated sizes.

	SiTAPE		Broselow Tape	
	Frequency (%)	Accumulated %	Frequency (%)	Accumulated %
Exact	507 (76.8)	76.8	406 (61.5)	61.5
One size smaller	90 (13.6)	90.4	97 (14.7)	76.2
One size bigger	52 (7.9)	98.3	154 (23.3)	99.5
Two sizes smaller	8 (1.2)	99.5	1 (0.2)	99.7
Two sizes bigger	3 (0.5)	100	2 (0.3)	100
Total	660 (100)		660 (100)	

Endotracheal tube size (uncuffed = 4 + [age (year)/4].

of children partially explains why the findings for the older children seem more inconsistent. A further study focusing on the accuracy of SiTAPE for older children is therefore warranted.

In conclusion, the Broselow tape and SiTAPE are comparable tools which can closely estimate body weights, drug doses, ETT sizes and the volumes of intravenous fluid for Thai children. The use of SiTAPE represents a more practical and obtainable option for Thai practitioners involved in the emergency care of children nationwide.

### ACKNOWLEDGEMENTS

The authors thank the Siriraj Medical Research Center for its support with the statistical calculations, and Associate Professor Chulathida Chomchai for valuable comments.

### CONFLICTS OF INTEREST

The authors have no conflicts of interest applicable to this study.

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