Canadian Journal of Rural Medicine
CJRM CMR
Journal canadien de la médecine rurale

Original Article
Article original

Accuracy of the Broselow tape in estimating the weight of First Nations children

Stephanie Bourdeau, MD
Department of Family Medicine, University of British Columbia, Vancouver, BC

Julie Copeland, MD, CCFP
Department of Family Medicine, University of Western Ontario, London, Ont.

W. Ken Milne, MD, MSc, CCFP(EM), FCFP
Division of Emergency Medicine, University of Western Ontario, London, Ont.

Correspondence to:
Dr. W. Ken Milne, Department of Emergency Medicine, South Huron Hospital, 24 Huron St. W, Exeter ON N0M 1S2;
monycon@hurontel.on.ca

This article has been peer reviewed.

Introduction: During resuscitation, the Broselow tape (BT) is the standard method of estimating pediatric weight based on body length. The First Nations population has a higher prevalence of obesity and experiences more injury than the non-First Nations population. The prevalence of obesity has raised the concern that the BT may not accurately estimate weight in this population. The purpose of this study was to validate the BT in 8 First Nations communities.

Methods: We performed a search of the electronic medical records of 2 community health centres that serve 8 local First Nations communities. We searched for the most recent clinic visit during which height and weight had been recorded in the records of patients less than 10 years of age with a postal code indicating residence in a First Nations community. The patients' actual weight was compared with their BT weight estimates using the Bland–Altman method. The Spearman coefficient of rank and percentage error was also calculated.

Results: A total of 243 children were included in the study (119 girls, 124 boys). The mean age was 33.3 months (95% confidence interval [CI] 29.7 to 36.9), mean height was 91.8 cm (95% CI 89.0 to 94.6), mean weight was 16.2 kg (95% CI 15.0 to 17.3) and mean BT weight was 14.0 kg (95% CI 13.1 to 14.8). The Bland–Altman percent difference was 11.9% (95% CI –17.3% to 41.1%). The Spearman coefficient of rank correlation was 0.963 ($p < 0.001$). The BT had a percentage error greater than 10% error 51.8% of the time, with 49.4% being underestimations.

Conclusion: The BT was often not accurate at estimating the weight of children in 8 First Nations communities; it underestimated their weight almost half of the time.

Introduction : Pendant la réanimation, la règle de Broselow est la méthode standard d'estimation du poids de l'enfant en fonction de sa taille. Or, les peuples des Premières Nations présentent une prévalence plus forte de cas d'obésité et sont plus sujets aux blessures, comparativement au reste de la population. Compte tenu de la prévalence de l'obésité, il y a lieu de se demander si la règle de Broselow permet d'estimer avec justesse le poids dans cette population. Cette étude avait pour but de valider la règle de Broselow dans huit communautés autochtones.

Méthodes : Nous avons procédé à une interrogation des dossiers médicaux électroniques de deux centres de santé communautaires desservant huit communautés autochtones locales. Nous avons retracé les visites médicales les plus récentes au cours desquelles la taille et le poids avaient été enregistrés dans les dossiers de patients de moins de dix ans dont le code postal indiquait qu'ils résidaient dans des communautés autochtones. Le poids réel des patients a été comparé aux estimations obtenues selon la règle de Broselow en se basant sur la méthode Bland–Altman. On a également calculé le coefficient de corrélation de Spearman et le pourcentage d'erreur.

Résultats : En tout, l'étude a regroupé 243 enfants (119 filles, 124 garçons). L'âge moyen était de 33,3 mois (intervalle de confiance [IC] à 95 %, 29,7 à 36,9), la taille moyenne était de 91,8 cm (IC à 95 %, 89,0 à 94,6), le poids moyen était de 16,2 kg (IC à 95 %, 15,0 à 17,3) et le poids moyen selon la règle de Broselow était de 14,0 kg (IC à 95 %, 13,1 à

14,8). La différence en pourcentage selon la méthode Bland–Altman était de 11,9 % (IC à 95 %, –17,3 % à 41,1 %). Le coefficient de corrélation de Spearman était de 0,963 (p < 0,001). La règle de Broselow affichait un pourcentage d'erreur supérieur à 10 %, dans 51,8 % des cas, dont 49,4 % représentaient des sous-estimations.
Conclusion : La règle de Broselow s'est souvent révélée inexacte lors de l'estimation du poids des enfants de huit communautés autochtones; elle a sous-estimé leur poids près de la moitié du temps.

INTRODUCTION

The Broselow tape (BT) is the standard method for expedient estimation of pediatric weight during resuscitation.[1,2] Accurate measurements of weight are important because appropriate drug doses, energy (joules) used to defibrillate and endotracheal tube sizes are based on weight.[3,4]

Childhood obesity is a growing problem. The World Health Organization has called it a global pandemic and considers it to be a new chronic disease that overshadows all other pediatric diseases.[5,6] The rate of childhood obesity in Canada has been increasing over the past few decades, and up to 1 in 3 children are considered overweight or obese.[7–12]

Multiple studies have attempted to validate the BT in a variety of populations with mixed results.[13–17] A study by Theron and colleagues concluded that the BT underestimates weight for 2 large-for-age ethnic populations, Pacific Islanders and Maoris, the indigenous Polynesian people of New Zealand.[18] The only 2 Canadian studies have shown that the BT underestimates the weight of children living in rural and urban regions.[19,20]

Canada's First Nations population has also been shown to have a higher prevalence of obesity than the non–First Nations population.[21–24] In addition, the First Nations population is more likely to experience traumatic injuries.[25,26] Thus, the BT may underestimate the weight of this high-risk group during resuscitations.

The objective of this study was to determine how accurately the BT estimates the weight of First Nations children in 8 First Nations communities in Ontario.

METHODS

Design and setting

A retrospective chart review was performed using the electronic medical records at 2 health centres that provide medical care to 8 First Nations communities. The Southwest Middlesex Health Centre is located in Mount Bridges and serves the Oneida Nation of the Thames, the Munsee–Delaware Nation and Chippewa of the Thames First Nation. The North Eastern Manitoulin Family Health Team is located on Manitoulin Island. It provides health care to the Wikwemikong, Sheguiandah, Aundeck Omni Kaning, Whitefish River and M'Chigeeng First Nations communities.

Ethics approval was obtained from the University of Western Ontario Health Sciences Research Ethics Board, and band councils consented to the study.

Data collection

Electronic medical records were searched for the most recent clinic visit during which height and weight had been recorded. Inclusion criteria were patients with postal codes matching one of the local First Nations communities and age less than 10 years. Children were excluded if their weight was greater than 35 kg or their length was outside the BT range (< 45.9 cm or > 146.6 cm).

Infants had been weighed in their diapers using an electronic infant scale, and length had been determined using a standard medical measuring tape. Older children had been weighed using a standard beam scale while they were wearing light clothing or underwear, and height had been determined using the same equipment and without shoes.

Statistical analysis

The actual measured weight was compared with the predicted BT weight. A Bland–Altman plot was created to summarize the relation between the 2 methods of measurement, as means with standard deviations. A Spearman coefficient of rank and mean percentage error (PE) was also calculated as a measure of weight discrepancy across all age groups.

Statistical analyses were performed using MedCalc for Windows, version 9.6.0.0.

RESULTS

In total, 243 records were found for children with postal codes belonging to one of the First Nations communities, with age less than 10 years and with body weights and lengths within our inclusion criteria. There were 119 girls (49%) and 124 boys (51%).

The mean age of those included was 33.3 months (95% confidence interval [CI] 29.7 to 36.9), mean height was 91.8 cm (95% CI 89.0 to 94.6), mean actual weight was 16.2 kg (95% CI 15.0 to 17.3) and the mean BT weight was 14.0 kg (95% CI 13.1 to 14.8).

The Bland–Altman mean percentage difference between the BT predicted weight and the actual weight was 11.9% (95% CI –17.3% to 41.1%), indicating an underestimation of the actual weight by the BT (Fig. 1). The Spearman coefficient of rank correlation (rho) was 0.968 ($p < 0.001$), 95% CI 0.959 to 0.975). The BT-estimated weights were within 10% error 43.2% of the time. The percentage error was 10% error or greater 33.3% of the time and was 20% error or greater 18.5% of the time (Table 1). A percentage error of 10% or greater was considered significant.

DISCUSSION

In crisis situations, it is often impossible to determine a pediatric patient's weight by traditional methods. An accurate weight is required for appropriate medication dosing, defibrillation energy (joules) and proper endotracheal tube size.[1–4] As such, a variety of methods have been developed to rapidly estimate a child's body weight.[14,27,28] The BT estimates weight based on a child's supine length and has become the standard of care.[2] The BT has been found to be the most accurate method when compared with other methods of weight estimation.[14] However, the BT was formulated based on 50th-percentile data from a 1970s population of European ancestry. Increasing childhood obesity,[7–12] specifically in First Nations people,[21–24] calls into question the validity of the BT, and one recent study questioned its accuracy in Pacific Island and Maori children.[18]

Our study found that the BT significantly underestimated the weight of First Nations children almost half (49.4%) of the time. The BT method rarely overestimated the weight of First Nations children (2.4%). This finding is consistent with the results of Theron and colleagues' study, which involved Australia's indigenous populations,[18] and with 2 other Canadian studies that looked at rural and urban populations.[19,20]

This inaccuracy could have serious implications in the care of critically injured or ill First Nations children who present to an emergency department. The doses of resuscitation drugs for children are based on weight. One of the most common errors in pediatric emergency departments is incorrect dosing due to inaccurate weight measurements or estimations.[29] As an example, the Pediatric Advanced Life Support (PALS) guideline recommends a dose of 0.01 mg/kg of adrenaline in certain cases via intravenous or intraosseous infusion.[3] Our study suggests that 49.4% of First Nations children would receive a significantly reduced dose of adrenaline than recommended by the PALS guideline if their weight was estimated using the BT. Although no randomized controlled dosing studies have been done to determine the best dose of adrenaline, it would be best to eliminate any errors if possible. An insufficient drug dose may result in underresuscitation in these children.

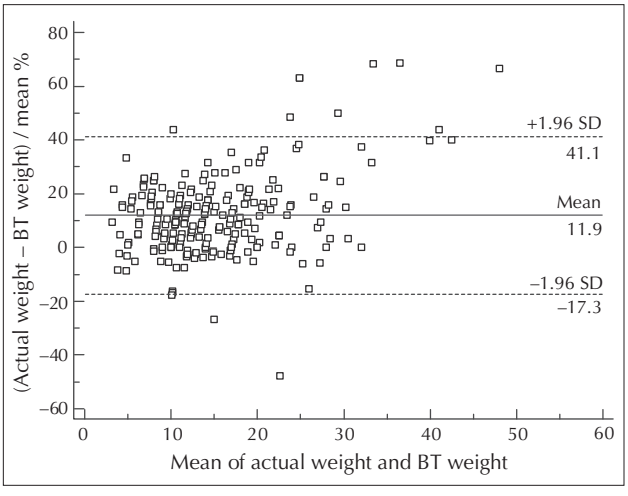

Fig. 1. Bland–Altman graph of percentage differences between actual weight in kilograms and weight in kilograms estimated by the Broselow tape (BT), in 243 children. SD = standard deviation.

Table 1. Percentage error of the Broselow tape in estimating the weight of First Nations children (n = 243)

Percentage error	Under (%)	Over (%)	Total (%)
Exact	—	—	12 (4.9)
< 10%	71 (29.2)	34 (14.0)	105 (43.2)
≥ 10%	77 (31.7)	4 (1.6)	81 (33.3)
≥ 20%	43 (17.7)	2 (0.8)	45 (18.5)
Total	191 (78.6)	40 (16.5)	243 (100.0)

Another life-saving treatment used in the emergency department is defibrillation. The PALS guideline for the amount of joules or energy used in a ventricular fibrillation or pulseless ventricular tachycardia is also a weight-based formula. The PALS manual suggests up to 3 shocks of increasing intensity of 2 J/kg, 2–4 J/kg and 4 J/kg.[3] Our study suggests that one-half of First Nations children would have received lower doses of joules during resuscitation than suggested by the PALS guideline. Although the American Heart Association acknowledges that the safe limits for defibrillation in children are unknown because the evidence is considered poor, the elimination of all potential for errors should be the goal.

A third important resuscitation treatment used in the emergency department is assisted ventilation with the use of endotracheal tubes. The BT method suggests endotracheal tube size based on the estimated weight. Underestimation of a child's weight could result in intubation with an undersized endotracheal tube. It should be noted that the PALS guidelines use an age-based formula for size of endotracheal tubes. Regardless, use of the BT method for selection of endotracheal tubes in First Nations children would lead to an undersized tube size based on our study. Undersized tubes may lead to air leaks, inadequate ventilation and, ultimately, insufficient oxygenation.[13]

The BT was a great advance in standardizing pediatric resuscitation when introduced almost 30 years ago. It reduced the amount of memorization, estimation and calculations needed during critical emergency situations. However, the trend of childhood obesity calls into question the validity of a method based on body length. Various studies in a number of different populations, including those done in Canada, have shown that the BT is not accurate,[19,20] whereas studies done in some specific ethnic populations (India[15] and Korea[16]) have shown the BT still works well. Our results show that the BT underestimates the weight of First Nations children, which is consistent with Theron and colleagues' study involving Australia's indigenous populations.[18] Health professionals should take this into account when faced with the resuscitation of First Nations children.

A study published in 2009 by Yamamoto and colleagues looked at adding a body habitus modifier to the BT.[30] They found this improved accuracy, especially in children over 3 years of age.

One possible solution would be to increase the BT estimates by 12% for the First Nations population. However, a better solution would be to no longer estimate the weight of any children. New technology should be developed that could safely and accurately weigh children who present to the emergency department. This could be combined with computer-assisted algorithms to provide the emergency physician with the correct drug dose, joules for defibrillation and size of endotracheal tube. Then, every child could receive the proper standardized treatment when presenting with a life-threatening illness or critical injury.

Limitations

Limitations of this study include the relatively small sample size compared with other studies. Also, our sample did not involve many children who weighed more than 20 kg. This study assumes that the sample population has the same weight as the population of children who undergo resuscitations, which may or may not be true. In addition, not all First Nations populations may have the same rates of obesity. We looked at 2 medical centres that provided care to 8 First Nations communities, but the external validity to other First Nations communities is not known.

CONCLUSION

Multiple studies have shown that the BT, although the best method currently available for estimating pediatric weight, is not accurate in a variety of populations. Our study adds to the current literature in demonstrating that the BT underestimates weight almost half the time in 8 First Nations communities. Health professionals should consider this information when using the BT for pediatric resuscitation.

Acknowledgements: The authors thank the Southwest Middlesex Health Centre and the North Eastern Manitoulin Family Health Team for participating in this study. The authors also thank Susan Oke and Linda Wilcox for their excellent library skills.

Competing interests: None declared.

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