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Brief Reports

BEDSIDE METHOD TO ESTIMATE ACTUAL BODY WEIGHT IN THE EMERGENCY DEPARTMENT

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☐ **Abstract—Background: Actual body weight (ABW) is important for accurate drug dosing in emergency settings. Oftentimes, patients are unable to stand to be weighed accurately or clearly state their most recent weight. Objective: Develop a bedside method to estimate ABW using simple anthropometric measurements. Methods: Prospective, blinded, cross-sectional convenience sampling of adult Emergency Department (ED) patients. A multiple linear regression equation from Derivation Phase (n = 208: 121 males, 87 females) found abdominal and thigh circumferences (AC and TC) had the best fit and an inter-rater correlation of 0.99 and 0.96, respectively: Male ABW (kg) = −47.8 + 0.78 * (AC) + 1.06 * (TC); Female ABW = −40.2 + 0.47 * (AC) + 1.30 * (TC). Results: Derivation phase: Number of patients (%) with a body weight estimation (BWE) > 10 kg from ABW for males/females were: 7 (6%)/1 (1%) for Patients, 46 (38%)/28 (32%) for Doctors, 38 (31%)/24 (27%) for Nurses, 75 (62%)/43 (49%) for 70 kg/60 kg convention, and 14 (12%)/8 (9%) using the anthropometric regression model. For validation phase (55 males, 44 females): Gold standard ABW mean (SD) male/female = 83.6 kg (14.3)/71.5 kg (18.9) vs. anthropometric regression model = 86.3 kg (14.7)/73.3 kg (15.1). R^2 = 0.89, $p < 0.001$. The number (%) for males/females with a BWE > 10 kg using the anthropometric regression model = 8 (15%)/11 (27%). Conclusions: For male patients, a regression model using supine thigh and abdominal circumference measurements seems to provide a useful and more accurate alternative to physician, nurse, or standard 70-kg male conventional estimates, but was less accurate for use in female patients. © 2011 Elsevier Inc.**

☐ **Keywords—ABW; actual body weight; anthropometric measurements; emergency medicine; drug dosing**

INTRODUCTION

Optimal dosing of many medications is based on a patient's actual body weight (ABW) (1). Precise knowledge of a patient's ABW is often difficult or impossible to obtain in the emergency department (ED) setting: many patients are unable to stand on a scale, others cannot reliably relay their ABW due to altered mental status or language barriers, and bedbound scales are often not

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available. Some patients simply do not know their own weight; others may be biased toward underestimation.

For circumstances when patients cannot relay their ABW to medical providers, an alternate method of weight determination is needed (1). Several studies have questioned the ability of medical staff to estimate a patient's weight at the bedside (2–8). Oftentimes, physicians and nurses simply rely on their "best guess" estimate or assign a conventional weight of 70 kg for a male or 60 kg for a female (9). Anthropometric measurement to estimate patient weight has been reported in the nutrition and forensic anthropology literature, but a similar method for bedside use with adults in an emergent setting has not been widely reported. The use of anthropometric measurements could potentially prove useful to accurately predict a patient's weight, improve drug dosing, and reduce the number of medication errors in the ED, similar to the use of the Broselow tape (Armstrong Medical Industries, Inc., Lincolnshire, IL) in children.

We performed a prospective study to determine the accuracy of a regression model that uses simple anthropometric measurements and compared it to patient, nurse, and physician estimates of body weight.

METHODS

Study Design

This was a prospective, double-blinded, cross-sectional observational study design that used convenience sampling. Before implementation, the institutional review board approved this study. Informed written consent was obtained for all patients.

Setting

This study took place in an urban, tertiary care, military teaching hospital ED with an annual volume of approximately 62,000 patients. The patient population is diverse in both age and ethnicities and includes active duty service members, their families, and retirees.

Selection of Participants

All patients in the ED who were 18 years of age or older, were medically stable, able to stand for a short period of time to have their height and weight measured, and able to give consent were considered eligible for enrollment. Patients with an altered mental status or who were amputees were excluded.

Patients were enrolled on a convenience basis at times when an investigator was available in the ED. Their enrollment did not depend on order of arrival in the ED or on order of triage. The times and days of enrollment included all days of the week and all hours of the day.

Methods of Measurement

Five distinct anthropometric measurements were obtained using a standard measuring tape and measured in centimeters: tibial length (TL), from the center of the medial malleolus to the tibial tuberosity; neck circumference (NC) at the level of the cricoid cartilage; chest circumference (CC) just beneath the mammary or pectoral fold; abdominal circumference (AC) at the level of the umbilicus; arm circumference (ArmC) at 10 cm above the tip of the olecranon; and thigh circumference (TC) at 10 cm above the superior pole of the patella. The tibial length determination method was a modification of the method described by Pelin and Duyar (10).

Data Collection and Processing

All patients, providers, and investigators were blinded to the patient's true balance-beam scale-measured weight when making estimates or anthropometric measurements. Weight estimates were written on note cards and handed to the investigator in a sealed envelope. Patient, nurse, and physician estimates were made in pounds, and then converted into kilograms by the standard conversion of 1 kilogram equaling 2.2 pounds.

The study was conducted in three phases. In phase one, the initial derivation phase, measurements were done in a specified order. First patients provided an estimate of their own weight. Then doctors and nurses were asked to estimate the patient's weight after visually inspecting the patient from the bedside. Next, the investigator made the five anthropometric measurements. Finally, the patient was asked to stand barefoot on a balance-beam scale to measure their true ABW. Patients enrolled in phase two, the refinement phase, also had all three estimates performed, all five anthropometric measurements made, and their ABW measured on a scale.

The first two phases were then combined into a combined derivation group for data analysis. During the third and final phase of the study, the validation phase, patients had only their true ABW measurement and the anthropometric measurements performed.

In the case of 49 patients during the developmental phase, two investigators were available during their enrollment, allowing both investigators to perform blinded anthropometric measurements to measure inter-rater agreement. The investigators for this study included an attending and resident physician, medical students, and pre-medical students. All were briefly trained in performing the anthropometric measurements.

Outcome Measures

In the developmental phases and validation phases, ABW and weights, as estimated by patients, physicians, nurses, and the anthropometric equation, were stratified by gender and summarized by mean, standard deviation, and acceptable error. Acceptable error was defined as ± 5-kilogram and 10-kilogram increments, as these seemed to be the most clinically meaningful and practical breakpoints.

Primary Data Analysis

Simple linear regression was used to evaluate the accuracy of the estimates. Forward step-wise multiple linear regression analysis and inter-rater (Pearson) correlation was used to derive an equation that would best predict weight from the various anthropometric measurements, including tibial length and abdominal, neck, chest, arm, and thigh circumferences.

The data from phases one and two were then combined to comprise the combined derivation phase, yielding a final refined regression equation to estimate ABW based on abdominal and thigh circumferences. In the validation phase, the final regression model from the derivation phase was prospectively tested. Demographic data were recorded for all patients, and means summarized.

RESULTS

Between November 2004 and July 2006, 330 patients, mean age 41 years (range 18–93 years), were enrolled in the developmental and validation phases of this study. Twenty-three patients were excluded due to missing or miscoded data elements, leaving a total of 307. Fifty-seven percent were males, 14% of the sample were Asian-Pacific Islander, 13% black, 10% Hispanic, and 59% white. As was convenient during the derivation phase, two blinded examiners performed anthropometric measurements (total 49 patients). Each measurement showed excellent inter-rater correlation: abdominal circumference 0.99, arm, thigh circumference 0.96, and tibial length 0.94.

Stepwise multiple linear regression (Figure 1) was used in the derivation phase to yield equations to predict ABW for each gender:

$$\text{Male ABW} = -47.8 + 0.78 \times \text{Abdominal Circumference} + 1.06 \times \text{Thigh Circumference};$$

$$\text{Female ABW} = -40.2 + 0.47 \times \text{Abdominal Circumference} + 1.30 \times \text{Thigh Circumference}.$$

Table 1 shows that in the derivation phase, the anthropometric regression models were more accurate than nurse, physician, or standard 70-kg (male) and 60-kg (female) estimates. Not surprisingly, when prospectively retested in the validation set of patients, the performance of the anthropometric regression model declined

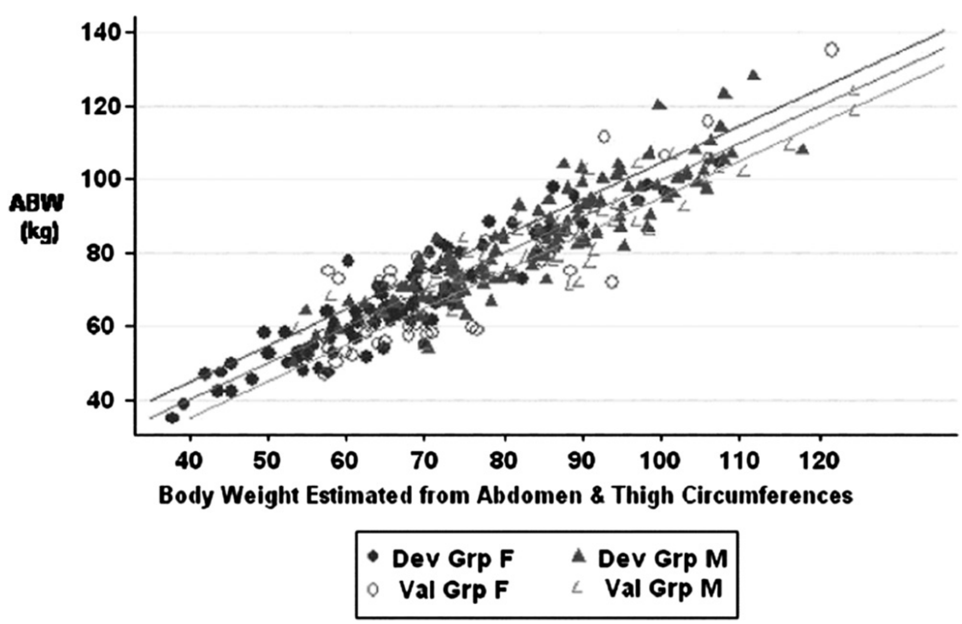

Figure 1. Plot of the anthropometric regression model estimated from abdomen and thigh circumferences plotted by gender for Derivation and Validation Groups against actual body weight (ABW). Also shown is the regression line of ABW against estimated weight bracketed by plus-or-minus 5 kg lines.

Table 1. Descriptors and Deviations from Gold-standard Actual Body Weight (ABW; Measured in Kilograms on Standing Scale) Compared to Body Weight Estimates (BWE) by Patients, Nurses, Doctors, the Regression Formula Using Thigh and Abdomen Circumferences, and Using Standard 70-kg Male/ 60-kg Female BWE from Derivation and Validation Group Data

	Male			Female		
	Mean kg (SD)	n (%) > ± 5 kg	n (%) > ± 10 kg	Mean kg (SD)	n (%) > ± 5 kg	n (%) > ± 10 kg
Derivation Group (n = 208: 121 male, 87 female)						
Actual body weight	85.0 (15.2)	—	—	66.9 (15.4)	—	—
Patient BWE	83.9 (14.7)	17 (14%)	7 (6%)	65.4 (15.2)	5 (6%)	1 (1%)
Physician BWE	82.3 (12.4)	73 (60%)	46 (38%)	67.2 (13.0)	52 (60%)	28 (32%)
Nurse BWE	84.7 (12.2)	69 (57%)	38 (31%)	66.3 (13.8)	50 (57%)	24 (27%)
Regression BWE*	85.0 (13.6)	59 (49%)	14 (12%)	66.9 (14.3)	29 (33%)	8 (9%)
Standard 70-kg male, 60-kg female BWE	70	95 (78%)	75 (62%)	60	65 (75%)	43 (49%)
Validation Group (n = 99: 55 male, 44 female)						
Actual body weight	83.6 (14.3)	—	—	71.5 (18.9)	—	—
Regression BWE*	86.3 (14.7)	28 (51%)	8 (15%)	73.3 (15.1)	30 (68%)	11 (27%)5

* Male ABW = $-47.8 + 0.78 \times$ Abdominal Circumference + $1.06 \times$ Thigh Circumference; female ABW = $-40.2 + 0.47 \times$ Abdominal Circumference + $1.30 \times$ Thigh Circumference.

compared to the developmental phase. Nonetheless, for male patients, the regression model still proved more accurate than nurse, physician, or standard 70-kg male estimates. For females, however, the anthropometric regression model proved no better than physician or nurse estimates. No form of bedside estimation was as accurate as the patient's own stated weight.

DISCUSSION

The ability to estimate a patient's actual body weight is important for the accurate dosing of many drugs used in emergency and critical care (1). This prospective, blinded, multiphase study confirmed previous findings that a patient's stated weight is superior to physician or nurse bedside estimates (2–8). When a patient cannot be relied on to accurately recall or relay their weight, a bedside method to estimate ABW using the abdominal and thigh circumferences seems to be a reliable means to obtain this information and, in the case of male patients, seems to be superior to physician or nurse estimates or simply relying on the standard 70-kg male, 60-kg female conventional estimate. For male patients, only 15% had estimated body weights more than 10 kg from their true scale weights when the anthropometric regression model was retested in the validation set.

Limitations

This study was limited by a relatively small sample size for developing a prediction model to predict weight beyond 5 kg of accuracy and precision. The small sample size also limited our ability to stratify for age or ethnicity. Finally, the study sampled ambulatory ED patients, even though the target patient group to which these findings would be applied would be acutely ill or injured patients with altered mental status.

CONCLUSIONS

A patient's stated weight remains the most accurate means to estimate actual body weight when a scale weight cannot be obtained. When faced with a situation in the ED where a patient cannot reliably state their weight or be weighed, we believe that, for male patients, measurement of abdominal and thigh circumference provides a useful alternative to the long-standing method of using a nurse's or a physician's "best guess," or to simply resorting to the conventional 70-kg man estimate. Further study and refinement using this technique in a larger sample is needed to confirm these findings and to allow for adjustment for age, gender, and ethnicity.

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ARTICLE SUMMARY

1. Why is this topic important?

Inaccurate estimation of actual body weight can lead to inaccurate drug dosing for many medications.

2. What does this study attempt to show?

This study demonstrated the potential usefulness of a regression formula that uses arm and abdominal circumference to estimate actual body weight at the bedside.

3. What are the key findings?

Use of this anthropometric regression model seems to be better than physician, nurse, or conventional 70-kg male/60-kg female standard estimates. However, this study also confirmed that a patient's stated weight remains the best method to estimate actual body weight at the bedside.

4. How is patient care impacted?

When faced with a patient in an emergency or critical care setting that cannot reliably state their own weight, using a few simple bedside measurements may improve the accuracy of drug dosing.