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Comparison of two-dimensional methods versus three-dimensional scanning systems in the assessment of total body surface area estimation in burn patients

Helene Retrouvey [a,*], *Justin Chan* [b], *Shahriar Shahrokhi* [a]

[a] *Ross Tilley Burn Centre, Sunnybrook Health Sciences Centre, 2075 Bayview Ave, D716, Toronto, ON M4N 3M5, Canada*

[b] *Faculty of Medicine, University of Toronto, Medical Sciences Building, 1 King's College Cir #3172, Toronto, ON M5S 1A8, Canada*

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ABSTRACT

Background: Accurate measurement of percent total body surface area (%TBSA) burn is crucial in the management of burn patients for calculating the estimated fluid resuscitation, determining the need to transfer to a specialized burn unit and probability of mortality. % TBSA can be estimated using many methods, all of which are relatively inaccurate. Three-dimensional (3D) systems have been developed to improve %TBSA calculation and consequently optimize clinical decision-making. The objective of this study was to compare the accuracy of percent total burn surface area calculation by conventional methods against novel 3D methods.

Methods: This prospective cohort study included all acute burn patients admitted in 2016 who consented to participate. The staff burn surgeon determined the %TBSA using conventional methods. In parallel, a researcher determined 3D %TBSA using the BurnCase 3D program (RISC Software GmbH, Hagenberg, Austria). Demographic data and injury characteristics were also collected. Wilcoxon Signed Rank test was used to determine differences between each measure of %TBSA, with assessment of the influence of body mass index (BMI) and gender on accuracy.

Results: Thirty-five patients were included in the study (6 female and 29 male). Average age was 47.5 years, with a median BMI of 26.6 kg/m^2. %TBSA determined by BurnCase 3D program was statistically significantly different from conventional %TBSA assessment ($p=0.007$), with the %TBSA measured using Burn Case 3D being lower than the %TBSA determined using conventional means (Lund and Browder Diagram) by 1.3% (inter-quartile range −0.6% to 5.6%). BMI and gender did not have an impact on the estimation of the %TBSA.

Conclusion: The BurnCase 3D program underestimated %TBSA by 1.3%, as compared to conventional methods. Although statistically significant, this difference is not clinically significant as it has minimal impact on fluid resuscitation and on the decision to transfer a patient to a burn unit. 3D %TBSA evaluation systems are valid tools to estimate %TBSA, and should therefore be considered to improve %TBSA estimation at centers with no available

* *Corresponding author at*: Division of Plastic and Reconstructive Surgery, University of Toronto, 149 College Street, Suite 508, Toronto, ON M5T 1P5, Canada. Fax: +1 416 978 7316.
E-mail addresses: helene.retrouvey@mail.utoronto.ca (H. Retrouvey), justinc.chan@mail.utoronto.ca (J. Chan), shar.shahrokhi@sunnybrook.ca (S. Shahrokhi).
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experienced burn staff surgeon. Their use may ultimately prevent inappropriate transfers and allow for improved management of patients with acute burns.

1. Introduction

Successful calculation of the percent total body surface area (%TBSA) of a burn plays a critical role in the acute management of burn patients. Accurate measurement of %TBSA is of benefit to determine the need for transfer to a burn center, acute fluid resuscitation, surgical management, and overall prognosis [1–3]. Currently, determination of %TBSA is performed using two-dimensional (2D) methods such as the Wallace Rule of Nines, the Lund and Browder Chart, and the Rule of Palms [2,4–6]. Inaccuracy of these 2D methods have been well described in the literature [3,7,8]. Errors in %TBSA estimation occur due to variability in body shapes between individuals, mainly influenced by age, gender, physical deformities and physiological status [7,8]. Additionally, errors are related to the level of expertise of health care workers with burn care and methods of choice to estimate burn surface area [6,9,10].

Accurate %TBSA calculation is imperative as all formulae for fluid resuscitation following burn benefit from the accurate measurement of %TBSA. Incorrect %TBSA calculation can lead to under- or over-resuscitation, which can have severe consequences to the patient [3,11,12]. Under-resuscitation can lead to end-organ failure such as acute kidney injury and cardiac failure [12]. Over-resuscitation may lead to pulmonary edema, burn depth conversion, obstructed airway, extremity compartment syndrome, abdominal compartment syndrome, and even death [12]. Hagstrom et al. reviewed emergency department estimation of %TBSA prior to transfer to a burn center and found that %TBSA measured by emergency department staff was 23.9% (range, 5–70%) compared to the intensive care burn unit staff average of 17.8% (range, 2–55%) [13]. This led to 30% of patients being over-resuscitated and 47% under-resuscitated [13].

As a solution to the inaccuracies of estimating %TBSA, three-dimensional (3D) scanning systems been developed to optimize %TBSA assessment [14,15]. These 3D methods improve %TBSA determination by allowing for representation of all body regions (including the lateral sides), and accounting for patient's age, gender, height and weight [14]. A recent study evaluated the reliability and validity of the BurnCase 3D using three mannequins [16]. The study concluded that BurnCase 3D was a valid and reliable tool for the determination of %TBSA in standard models [16]. The authors highlighted the need for further validity studies of the instrument in different populations, such as overweight patients. Our study was designed to verify the accuracy and validity of the BurnCase 3D system in evaluating real world %TBSA in adult burn patients with varying ages and body habitus. In our study, we compared the %TBSA calculation of all acute burns admitted at our ABA verified adult burn center who consented to participate in our study by a traditional 2D method (Lund and Browder Chart) versus a 3D method. The novel 3D systems, if found to be accurate and valid, may be introduced in centers without burn experience to improve their acute burn patient management.

2. Methods

This study was approved by the the Research Ethics Board at our institution. This study is a prospective cohort study of 35 patients conducted between January 2016 and December 2016. Patients included in the study consisted of patients admitted to the burn unit during this period with an acute burn. Furthermore, patients or their substitute decision makers needed to consent to the use of their admission photographs for research purposes to be included in the study.

2.1. *Data collected*

Demographic data and injury characteristics were collected through a retrospective chart review. Demographic data consisted of patient's age, gender, weight and height. Injury characteristics included admission date, injury date, type of burn and conventional %TBSA estimation.

2.2. *Burn size calculation*

Patients with acute burns were admitted to the burn unit following the standard admission protocol. Upon admission, the burn surgeon evaluated the burn size using the conventional Lund and Browder chart.

For the purposes of the study, photographs of the patients were also obtained on admission. A Panasonic Lumix DMC-FX50 with Leica lens captured photographs of all burnt areas. A member of the research team later transferred these photographs onto a research computer for 3D %TBSA calculation using the BurnCase 3D program (RISC Software GmbH, Hagenberg, Austria). The BurnCase 3D software accounted for the patient's gender, age, height, weight, and body shape. Three-dimensional %TBSA calculation was obtained by marking the burnt area on the 3D model using both visual inspection of the burnt area on the digital photographs and translation onto the 3D model as well as by superimposing the photographs onto the 3D model (Fig. 1). Of note, during this process, the member of the research team was blinded to the conventional 2D %TBSA estimation.

2.3. *Statistical analysis*

Patient's demographic and injury characteristics were collected using Excel (Microsoft Office, Excel, Version 2010). Two separate documents were used to collect the conventional 2D %TBSA and the 3D %TBSA for each recruited patient. Data was merged upon completion of the study.

Analysis was completed using SAS University Edition software. Categorical variables were assessed using counts,

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