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Hand burns surface area: A rule of thumb

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ABSTRACT

Introduction: Rapid estimation of acute hand burns is important for communication, standardisation of assessment, rehabilitation and research. Use of an individual's own thumbprint area as a fraction of their total hand surface area was evaluated to assess potential utility in hand burn evaluation.

Materials and methods: Ten health professionals used an ink-covered dominant thumb pulp to cover the surfaces of their own non-dominant hand using the contralateral thumb. Thumbprints were assessed on the web spaces, sides of digits and dorsum and palm beyond the distal wrist crease. Hand surface area was estimated using the Banerjee and Sen method, and thumbprint ellipse area calculated to assess correlation.

Results: Mean estimated total hand surface area was 390.0 $cm^2 \pm$ SD 51.5 (328.3–469.0), mean thumbprint ellipse area was 5.5 $cm^2 \pm$ SD 1.3 (3.7–8.4), and mean estimated print number was 73.5 ± SD 11.0 (range 53.1–87.8, 95% CI 6.8). The mean observed number of thumbprints on one hand was 80.1 ± SD 5.9 (range 70.0–88.0, 95% CI 3.7), $\chi^2 = 0.009$.

The combined mean of digital prints was 42, comprising a mean of two prints each on volar, dorsal, radial and ulnar digit surfaces, except volar middle and ring (3 prints each). Palmar prints were 15 (11–19), dorsal 15 (11–19), ulnar palm border 3, first web space 2, and second, third and fourth web spaces one each.

Using the surface of the palm alone, excluding digits, as 0.5% of total body surface area, the area of one thumbprint was approximated as 1/30th of 1%.

Conclusions: We have demonstrated how thumbprint area serves as a simple method for evaluating hand burn surface area.

1. Introduction

Burns to the hand are common, vary in size, depth and complexity, and may result in functional deficit despite optimal treatment. At present, there is no standardised method for assessing the surface area of a burn to the hand. The hand burn severity score [1] has been proposed to predict the necessity for surgery based on burn depth within three distinct zones of the hand, however the size of the hand burn is not quantified.

In clinical practice, volar surface of the palm and digits combined is often used when completing the Lund and Browder chart [2] and using the rule of nines [3] to estimate 1% of total body surface area (TBSA) as is widely taught as such at Advanced Trauma and Life Support® [4] and Emergency Management of Severe Burns™ [5] courses. A systematic analysis of hand surface area trials showed that volar hand surface area was 0.87%, and palm surface area 0.5% of total body surface area, respectively [6]. Total hand surface area has been estimated as 2.4% of total body surface area (TBSA) [7].

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The Du Bois and Du Bois formula for estimating hand surface area [8] (hand surface area = 2.2 × hand length × hand circumference) was derived from 9 participants in 1916. Hand surface area may also be estimated according to the formula described by Banerjee and Sen [9] (hand surface area = 2.432 × hand length × hand circumference) derived from 15 Indian participants, which was associated with the lowest error rates when compared to direct measurement using alginate in 65 Korean participants [7]. The Banerjee and Sen formula correlated more closely than that of Du Bois and Du Bois [8], or Mignano and Konz [10], or the United States Environmental Protection Agency [11].

This study was performed to form an estimate of the mean number of thumbprints in one hand in total, on each of the various surfaces of the hand, and assess for a correlation between the estimated and observed number of prints based on thumbprint area and estimated hand area. The TBSA represented by one thumbprint was sought, and an estimation of total hand surface area using the thumbprint method was calculated.

2. Methods

Ten clinical health professionals familiar with estimating burn surface area, comprising doctors, nurses, hand therapists and physiotherapists from the burn centre in our institution, were asked to assess the number of thumbprints that could be placed on their non-dominant hand.

Participants were asked to cover the surface of one hand with thumbprints from their contralateral thumb pulp, without overlapping. The entire surface area distal to the distal wrist crease was included. An inkpad was used to create the thumbprints, and Skintact® flexible rulers 15 cm long (Leonard Lang, Innsbruck, Austria) were used to measure hand length and hand circumference (Fig. 1a).

Hand length was measured as the distance from the distal wrist crease to the tip of the middle finger. Hand circumference (metacarpophalangeal joint width) was measured as the maximum width of distal metacarpals on the volar aspect of the palm. Thumbprint width and length were measured directly on the inked dominant thumb pulp. All measurements were made to the nearest millimetre.

The thumbprint was modelled as an ellipse. Elliptical area was calculated according to the formula: πab where a represents the semi-major axis and b the semi-minor axis.

The surfaces of the hand were divided into five categories to facilitate comparison: digits, web spaces, palm, dorsum and ulnar border. Digits were further subdivided into their respective surfaces: volar, dorsal, radial and ulnar, and fingernails were excluded.

The mean total number of prints was used to derive the hand surface area represented by one thumbprint, and the relative areas of each of the five categories estimated as a percentage of total hand surface area. An estimate of total hand surface area was made using the formula by Banerjee and Sen [9], for comparison, and the chi-squared test was used to compare the observed printed area from thumbprints with the formula estimate.

For all estimates of surface area, the hand was assumed to be in line with the forearm, and digits adducted. Volar surface area (VSA) included the palm and the volar surfaces of all five digits, and was defined by the distal palmar crease proximally. Palm surface area (PSA) was defined as the area between the distal wrist crease and the palmodigital creases. Total hand surface area (THSA) was defined as the entire surface of the hand distal to the level of the distal wrist crease, including volar, dorsal, radial and ulnar aspects of the hand and digits.

No power calculation was performed due to absence of similar trials examining this subject. Normally distributed discrete variables were presented as mean ± standard deviation (SD), and range. 95% confidence intervals (CI) were presented for the observed and expected numbers of prints, and means compared using the chi-squared test, and significance set at $p < 0.05$. Microsoft® Excel® (Microsoft Corporation, Redmond, WA, USA) was used for statistical analysis.

3. Results

Four male and 6 female participants agreed to participate, 9 of whom were right-handed. An example of the technique is shown in Fig. 1a and b. Hand measurements are provided in Table 1. The mean observed number of prints on one hand was 80.1 ± SD 5.9 (range 70.0–88.0, 95% CI 3.7). The mean number of prints observed in each area is provided in Table 2, and the rounded totals represented diagrammatically in Fig. 2. The combined means of the observed totals for each area was 80.7 prints. The sum of the rounded mean totals for each area was 80, including a second print at the first web space. The mean observed number of prints differed significantly from the expected 73.5 ± SD 11.0 (range 53.1–87.8, 95% CI 6.8) with $\chi^2 = 0.009$, but both lie within the 95% confidence intervals.

Both the Banerjee and Sen [9], and original Dubois and Dubois [8] formulae for hand surface area have been cited as using the lower posterior border of the radius to the tip of the 'second' finger to determine hand length [7], as opposed to the distal wrist crease in the current study. Hand length is the cause of the majority of variation in hand surface area estimation [7]. The distal wrist crease is 13.5 mm from the radiocarpal joint [12]. To control for this, an additional calculation was performed adding 13.5 mm to each hand length measurement. The recalculated expected number of prints controlling for hand length was 79.0 ± SD 11.8 (range 56.8–94.4), which was notably similar to the observed, demonstrating no significant difference on chi-squared $p = 0.11$ (Table 1). As can be seen in Fig. 1a, the prints did occasionally cross the distal wrist crease.

Using the estimate of 0.5% for palmar surface area, and as the palm contains 15 prints, one thumbprint equals 1/15th of 0.5%, which is 0.0333% recurring, or 1/30th of 1% of TBSA (Table 2). The total surface area of the hand calculated as 80 thumbprints, in this cohort of ten participants, would be 2.666% recurring (80 × 0.0333%). As the volar surface area contains 26 prints including digits, this equates to 0.87% TBSA (26 × 0.0333%), which incidentally is the exact figure quoted by meta-analysis for the volar surface area of the hand [6].

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