Surface area estimation: pocket calculator $v$ nomogram

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Abstract

Three sheets of 10 surface area determinations were completed by 10 subjects using a nomogram and a formula. The formula was faster to calculate, 4.27 v 7.6 minutes for each sheet, and resulted in fewer serious errors (three v 30 errors).

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Surface area has been used to determine the dose of chemotherapy drugs for the treatment of cancer since their introduction for human subjects and, more recently, to predict biochemical adrenal suppression in children receiving treatment with inhaled corticosteroids. Clinically, surface area is estimated from measured height and weight, either with a surface area formula or with a nomogram. Mosteller's simplified pocket calculator formula (surface area ($m^2$) equals the square root of the expression height (cm) multiplied by weight (kg) divided by 3600) is a third alternative.

The most commonly used nomogram was produced by Professor C D West of the University of Cincinnati. The formula on which it is based was derived from the data of Boyd. Neither the subset of data used by West nor the formula he derived has been published.

We recommend that a plan should be available in accident and emergency departments for managing out of hospital needlestick injuries. This plan would include prophylaxis against hepatitis B and tetanus and allow referral to an appropriate expert for counselling and follow up.

We thank Dr Mok and Dr Peutherer for their help.

When all 499 paired determinations are considered (figure) the Mosteller formula gives a result which is a mean of 0·011 m$^2$ less than the nomogram (SD 0·016). On 95% of occasions the difference (nomogram surface area minus Mosteller surface area) will lie between −0·021 and 0·044 m$^2$. The differences between the two methods were greatest at the lowest and highest surface areas, and were least around 1·1 m$^2$. This curvature is due to differences between the underlying equations.

### Discussion

The most important finding of this study is the high frequency of nomogram reading errors. The volunteers were all familiar with the nomogram and although they might have checked their results more carefully had they been for clinical use, the ease with which these errors were made reveals a weakness in the method.

Adjacent scales showing weight in kilograms and pounds makes it too easy to make a clinically significant underestimate of the child’s surface area, with the risk of ineffective chemotherapy treatment for cancer. The three mistakes that occurred in the calculated surface areas highlight the value of an independent double check.

Most published surface area equations are equally consistent with the data from the largest study to measure surface area by direct methods (Bailey and Briars, unpublished). This alone might justify the clinical use of any of these methods, but the widespread use of the Boyd-West nomogram demands that this is taken as the clinical standard.

The Mosteller formula can be used interchangeably with the nomogram when an underestimate of 0·044 m$^2$ or an overestimate of 0·021 m$^2$ is not of clinical significance. It can be used with safety in all patients receiving treatment with inhaled corticosteroids because the smallest daily dose change of 50 µg is so large when corrected for surface area that differences between the nomogram and formula are insignificant.


These surface areas (range 0·35–1·80 m$^2$) had been determined from the nomogram by one observer and checked by another. Surface areas were later calculated according to Mosteller’s equation.

All 499 pairs of surface areas were subjected to Bland-Altman analysis.

### Results

Thirty (10%) errors from 300 determinations were identified. Three were spontaneously corrected by the volunteer. In three sheets (24 errors) the error was systematic. Once made it was repeated for the remaining determinations on the sheet. Errors were of two types and both types resulted in a clinically significant undercalculation of surface area. The errors were:

- (a) plotting the child’s weight in kilograms on the nomogram scale labelled ‘weight in pounds’ (29/30 errors) and
- (b) reading the second decimal place of surface area as the first that is, reading 1·04 m$^2$ as 1·4 m$^2$.

There was no significant difference in the mean time taken to complete the result sheets with and without errors (8·22 v 7·65 minutes; SE 1·31).

Three of 30 formula result sheets contained one error. One was spontaneously corrected, one resulted from the volunteer not pressing the square root key, and the third was a transcription error.

The nomogram result sheets took a mean of 7·60 minutes to complete compared with 4·27 minutes for the formula sheets (SE 0·54; p<0·001).