Pediatric Body Surface Area and Medication Dosages

WHEN PATIENTS need immediate help, a quick assessment and proper dosing and administration of medication is critical. The determination of body surface area is fundamental for assessment of an injury (e.g., a burn) as well as in the calculation of a medication dosage. Fortunately, industry standards make assessment easier for the patient and the health professional.

Objectives:

1. Estimate percent of body surface area using an industry-accepted mathematical representation for the assessment of burns in children and infants.
2. Use the West Nomogram to determine body surface area.
3. Calculate pediatric medication dosages using body surface area measurements obtained from the West Nomogram.

Key Terms:

body surface area (BSA)
nomogram
West Nomogram

Calculating Pediatric Medication Dosages Using Body Surface Area

When a child enters a trauma unit or even a doctor's office with large body surface burns, it will be important to assess and estimate the percentage of body surface area affected. What is the safest and most efficient way to conduct this estimation so medication and treatment of the child can begin quickly?

Measuring the burns of the child could be a complex and highly sensitive endeavor, but industry-approved methods allow for quick calculations. Those same standards lend themselves to more accurate methods of body surface area calculations for the purpose of calculating medication dosages.

ESTIMATE PERCENT OF BODY SURFACE AREA FOR BURN ASSESSMENT

It is critical to accurately estimate the percent of body surface area for the assessment of burns in children and infants. An industry-accepted mathematical representation or standard makes this measurement easier for health professionals and patients.

Body surface area (BSA) is a measurement of the skin that covers the body; it is a measurement or calculation of the total surface area of the human body. Proportions of children and infants are very different from adults. The "Rule of Nines" used for burn assessment in adults is not accurate enough for use in children and infants.

Refer to Figure 1. You can use this diagram to learn how to estimate the percentage of body surface area for children and infants. The first form represents a child ages 1 to 4; the second represents a child ages 5 to 9; and the third represents a child ages 10 to 14. Each body part is noted with a specific percentage or number. For instance, the first form has a 15 by its legs ; the second form has a 15 by its head, and the third form has a torso with a 32 on it. Each of the numbers is indicative of percent BSA for the whole body part—anterior and posterior. So if a one-year-old child was burned on the front of one leg, the percent burned would be half or 50 percent of the number indicated. Study the three forms carefully, and memorize the percentages.

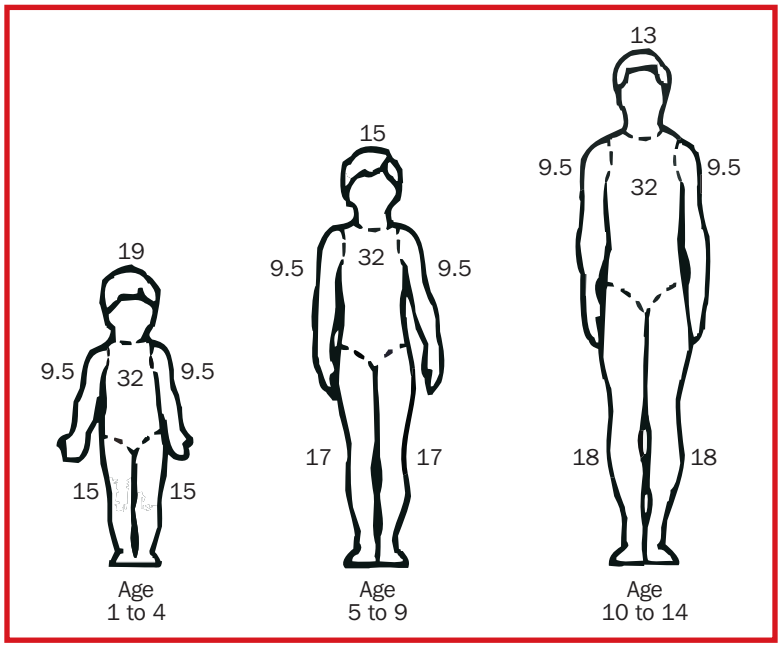

FIGURE 1. The industry-approved standard for estimating percent body surface area (BSA) for children and infants can be seen in the diagram.

The West Nomogram

While estimating BSA using the previously discussed method is acceptable for the rapid assessment of burns, a more accurate method of determining BSA is needed to calculate medi-

cation dosages for children and infants: the Mosteller Method. It is worth reviewing. There are two versions of the formula: metric and metric/English.

Metric: $x = \sqrt{\frac{\text{weight (kg)} \times \text{height (cm)}}{3600}}$ where "x" is the body surface area in square meters (BSA m^2; from weight in kilograms and height in centimeters)

Metric/English: $x = \sqrt{\frac{\text{weight (lbs)} \times \text{height (in)}}{3131}}$ where "x" is the body surface area in square meters (BSA m^2; from weight in pounds, and height in inches)

USING THE WEST NOMOGRAM

A **nomogram** is a two-dimensional mathematical device that shows the relationship between variables; a graph or chart—typically with three scales—that allows calculation of one variable when two other variables are known. The **West Nomogram** is a mathematical chart used to determine body surface area when the height and weight of a patient are known. The following website contains some useful information: http://wps.prenhall.com/wps/media/objects/2943/3014230/Nomogram.pdf.

Pediatric Medication Dosages

The formula for calculating pediatric medication dosage is:

$$\frac{\text{BSA of child}}{1.73} \times \text{adult dose} = \text{child dose}$$

(Recall that 1.73 is the approximate BSA for the average adult.) Take some time with this formula, and make sure you understand the math involved.

DETERMINING A DOSAGE

To calculate the pediatric medication dosage, begin by using the West Nomogram to determine the child's BSA. Then insert the

FIGURE 2. The West Nomogram can be used to quickly determine a child's BSA. This effective standard allows for faster patient treatment.

child's BSA measurement and the known adult dosage into the given formula. Next, perform the calculation.

For example: "A doctor orders a chemotherapy agent for a child with leukemia. The child has a height of 120 cm and a weight of 40 kg. The normal adult dose of this medication is 20 mg. What is the child dosage?" The answer: Using the West Nomogram, the child's BSA is determined to be 1.2 m^2.

FURTHER EXPLORATION...

ONLINE CONNECTION: More Practice with Estimates and Calculations

Estimating percent BSA for children and infants requires practice. The following problems have been provided for your benefit. Once you have completed these successfully, continue to the next section where you will find additional practice problems dealing with pediatric medication dosages. Remember to refer to Figure 1.

Estimate percent body surface area (BSA) involved in each of the following scenarios. (Round your answer to the nearest whole number.)

- When fireworks exploded, a 13-year-old boy received second-degree burns to the anterior portion of the right arm and the anterior torso. What is the percent of BSA affected?
- A 6-year-old girl playing with matches accidentally set her clothes on fire. When she was brought to the emergency room, she had second-degree burns on her anterior torso and on the front and back of both arms. What is the percent of BSA affected?
- A 3-year-old girl received burns to the anterior left arm, the anterior torso, and the anterior aspect of her left leg when she pulled a pan of boiling water off the stove. What is the percent of BSA affected?
- An 11-year-old boy had an accident while playing with his chemistry set. He received second-degree chemical burns to the front side of both legs. What is the percent of BSA affected?

Now try some problems where you have to calculate pediatric medication dosages. Given the height and weight of a child, determine the child's body surface area (BSA) using the West Nomogram. Using body surface area measurements in an accepted formula, determine pediatric medication dosages.

- A physician orders a strong antibiotic for a child whose height is 44 inches and whose weight is 45 lb. The normal adult dose for this antibiotic is 150 mg. Step 1: Determine the BSA using the West Nomogram. Answer: _____ m^2.
  - Step 2: Calculate the pediatric dose using the given formula. Answer: _____ mg.
- A physician orders a chemotherapy agent for a child whose height is 58 inches and whose weight is 12 kg. The normal adult dose of medication is 200 mg. Step 1: Determine the BSA using the West Nomogram. Answer: _____ m^2.
  - Step 2: Calculate the pediatric dose using the given formula. Answer: _____ mg.

Check your work using these online calculators: http://emedia.rmit.edu.au/drugcalcs/?q=nomogram and http://www.halls.md/body-surface-area/bsa.htm.

Therefore, $\frac{1.2}{1.73} \times 20 =$ child dose

$0.69 \times 20 =$ child dose
13.8 mg = child dose

Therefore, the child's dose would be 13.8 mg (or 14 mg if rounded up).

Summary:

There are health care industry-approved methods and standards for estimating body surface area. This is critical for burn assessment and the calculation of medication dosages. Strict mathematical formulas also can be used for the purpose of calculating medication dosages.

Body surface area is measured using a nomogram, which is a two-dimensional mathematical device that shows the relationship between variables; a graph or chart, typically with three scales, that allows calculation of one variable when two other variables are known. The West Nomogram is a mathematical chart used to determine body surface area when the height and weight of a patient are known. The West Nomogram results in a measurement in meters squared. This calculation can be used to calculate the proper pediatric medication dosage.

Checking Your Knowledge:

1. Define "nomogram."
2. A one-year-old infant is rescued from a burning building. The infant has burns to the face and head, the entire left arm, and the entire left leg. What is the percent of BSA affected?
3. A physician orders a chemotherapy agent for an adolescent whose BSA m^2 is 1.5. The normal adult dose for this chemotherapy agent is 50 mg. What is the appropriate pediatric dose?
4. A physician orders a chemotherapy agent for a child whose height is 40 inches and whose weight is 40 lb. The normal adult dose for this chemotherapy agent is 75 mg. Determine the BSA using the West Nomogram. Answer: _____ m^2.
5. Refer to the previous question. Now calculate the pediatric dose using the given formula. Answer: _____ mg.

Expanding Your Knowledge:

Prepare a poster that summarizes the information you just studied. Make sure to cover key terms, formulas, and diagrams. Prepare a presentation of this content and then make a video of yourself making the presentation.

Web Links:

Adult Rule of Nines and Total Body Surface Area: By Age Group
http://www.saems.net/Downloads/50152_Burn%20Center2col_f.pdf

Body Surface Area Calculator for Medication Doses
http://www.halls.md/body-surface-area/bsa.htm

Formulas for Body Surface Area
http://www.halls.md/body-surface-area/refs.htm

West Nomogram—Body Surface Area
http://wps.prenhall.com/wps/media/objects/2943/3014230/Nomogram.pdf