

Color Coding to Reduce Errors

The Broselow–Luten system streamlines pediatric emergency treatment.

Few situations instill more fear in the hearts of even the most experienced nurses than those involving a critically ill or arresting child. Resuscitation courses such as the Pediatric Advanced Life Support Course and the Emergency Nursing Pediatric Course have been invaluable in training emergency and pediatric nurses in the priorities for resuscitation, but they may not be enough.

Most participants in pediatric emergency courses and programs rely on the “big M”: memorization. Nurses memorize protocols, medication names and dosages, and algorithms. But because of infrequent usage and the stressors associated with treating children in life-or-death situations, health care workers often forget these when they need them most. It’s difficult, if not impossible, for clinicians to remember all of the highly detailed information they need when they’re faced with stressful situations.¹ In fact, a 1998 study of in-hospital medication errors in one facility showed that the pediatric service had a 69% error rate, the highest incidence of reported errors.² And when caring for children, a one-decimal-point shift can result in a potentially lethal error in dosing. The old method of memorization and math can easily lead to another “big M”: mistakes.

Once the initial assessment has determined that a child is critically ill or injured, many clinicians rely on a variety of techniques to serve as “memory mistake minimizers.” For example, “cheat sheets,” often consisting of notebooks that have

been filled with common medication doses, tube sizes, and normal vital signs, may be found in the pockets of scrubs or laboratory coats and taped to carts or walls. Such techniques can help to jog memories at the most stressful times, but often they lack uniformity, consistency, or completeness. What is needed is a system that can help one determine the approximate weight of a child quickly so that appropriate and safe treatment can be delivered.

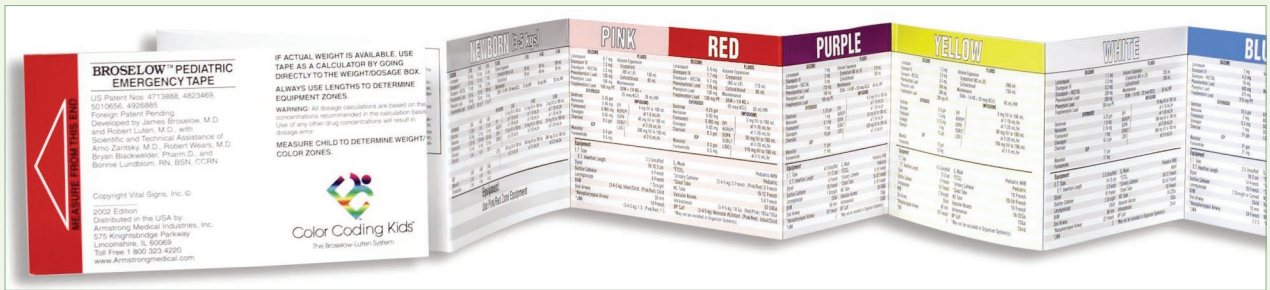
BROSELOW TAPE

In 1986, after encountering several critically ill children, James Broselow, an emergency physician in a community hospital (and one of the authors of this article), was determined to find a better method of handling those highly stressful situations. With the completion of initial unpublished studies by Broselow showing that a child’s ideal lean body weight corresponded accurately with length, he created the Broselow tape (Broselow later teamed with Robert Luten, MD, to create a color-coded system for pediatric emergency situations).^{3,4} The tape is used to measure the length of the child and provide an accurate estimation of weight. Given lengths also correspond to color zones that provide information on appropriate drug doses, sizes of commonly used equipment (such as endotracheal and nasogastric tubes), and IV fluid volumes. In an emergency, each color zone can provide a guideline for treatment until the patient can be weighed.^{1,5}

The Broselow tape was created in acknowledgment of the fact that determining the size, and more important, lean body weight, of children is vitally important to ensuring appropriate treatment, as well as the fact that it’s not realistic to delay treatment to weigh an arresting or multiple-trauma patient. Some studies have shown that the practice of estimating a child’s weight visually is not acceptably accurate.^{6,7} In addition, studies confirm that a child’s weight is more precisely estimated using length rather than using age, and

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Author disclosure: James Broselow holds patents for the Broselow tape and Broselow–Luten system and receives royalties from Vital Signs, Inc., Totowa, NJ, for all products mentioned in this article.



Courtesy of Armstrong Medical Industries, Inc., Lincolnshire, IL

The Broselow tape is divided into color-coded segments that give an estimate of a child's weight based on length, as well as corresponding doses of certain emergency drugs.

research has shown that the concept behind the Broselow tape applies in some cases of pediatric obesity.⁸ If a child is obviously larger than the weight range on the measured color zone, Luten suggests “bumping” the child up a color to compensate for the obesity. As several medication dosages are calculated on the basis of ideal lean body mass, in such cases the child's actual weight (above or below average) is not a factor in the calculation. When an actual or recent weight is obtainable, that should be used to determine the child's color zone.

Use of the Broselow tape. As the patient lies supine with the knees straight, the red arrow of the tape that reads “Measure from This End” is placed at the top of the child's head (“red to the head”; see photograph above). The tape is unfolded to the child's heel, not his toes—the correct color zone is at his heels. The tape can be laminated or enclosed in plastic and hung on a wall or a cart. Consistently hanging the tape with the red arrow pointing up can help minimize possible errors caused by placing the wrong end of the tape at the patient's head.

There are color-coded pediatric-resuscitation carts that can be used in conjunction with the tape (see photograph, page 70). These carts, usually used in the ED and on pediatric units, have color-coded drawers that correspond to the color zones of the Broselow–Luten system and can be stocked with age- and size-appropriate emergency equipment.^{9,10} A source of possible error is the difference between the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) recommended standardized infusion concentrations and the tape's guide to individual preparation of infusions.^{11,12} In response to this issue, new color-coded IV infusion bag labels for standard dosing of acute care medications will be introduced by late 2005. Once these new labels have been finalized, an updated version of the Broselow tape, without the individual “Rule of 6” guide to infusion preparations (multiplication of an infant's weight in kilograms

by 6 to arrive at the milligrams of drug added to 100 mL of solution so that a flow rate of 1 mL per hour equals 1 microgram per kilogram per minute), will be made available. During this transition to standardized concentrations, if an organization has been using the Rule of 6 and the Broselow tape as part of its system, it may continue to use it for that purpose, as long as it has received approval of a “Request for Review of an Alternative Approach” from JCAHO (see www.jcaho.org/accredited+organizations/patient+safety/05+npsg/05_npsg_rfr.htm) and is complying with the criteria for transitioning from the Rule of 6 to the standardized concentrations. It should be noted that the 1998 version of the tape gives doses in milliliters, in contrast to milligram dosing presented in the 2002 version. And because of the size of the tape, it does not present all medications available for every emergency.

Continuing education. Use of the Broselow tape requires training and practice. The tape has undergone several revisions, as implied above; the current version (from 2002) features updated weight ranges and color zones. Resuscitation carts should be maintained to reflect the most current version. Drills can help to prevent potential mistakes, such as clinicians interpreting the list of medications as suggestions for treatment rather than merely a presentation of the available medications.¹³

APPLICATIONS OF THE COLOR-CODING SYSTEM

Broselow and Luten have expanded the color-coding concept into the Broselow–Luten system, which includes equipment guidelines, emergency medications, doses, defibrillation–cardioversion energies, and normal vital sign ranges.

Spinal immobilization. In trauma management, patients are considered to have a cervical spine injury until proven otherwise. Although this is being challenged in some circles, many pediatric trauma patients are still immobilized until satisfactory

clinical or radiographic clearance of the spine can be established. Part of the process of spinal immobilization involves placing a hard cervical collar around the neck and laying the patient supine on a spinal board. Children younger than six years of age have what might be described as “big head, little body” syndrome. The head, especially the occiput, is disproportionately large. Placing children flat on their backs (regardless of whether they have experienced trauma), with the back of the head at the same level as the shoulders, can cause their chins to be on their chests. This position

poses potential problems both in terms of compromising and possibly occluding of the airway, as well as preventing proper alignment of the cervical spine.

There are cervical collars for children that accommodate the larger occiput and are color coded to work with the Broselow–Luten system. Collars are colored and labeled to match the color zones on the Broselow tape. The NecLoc Kids pediatric extrication collar (for prehospital use) and the Miami Jr. pediatric collar (for in-hospital use) are labeled to decrease the chance of error when choosing a cervical collar size. The AirWay PAD (pediatric alignment device) is a dual-purpose item that, when unfolded, can work like the Broselow tape to identify the patient’s color zone (see photograph, page 71). When folded to the right level and placed under the child’s shoulders, it helps to ensure proper airway and cervical spine positioning. (The AirWay PAD is used in the folded position and does not contain all of the information included on the Broselow tape.)

Diagnostic imaging. A 2001 study demonstrated that the use of the Broselow color-coded format minimized children’s exposure to radiation.¹⁴ The study compared the hospital’s conventional computed tomography (CT) protocol, which used a weight-based chart format for pediatric CT, with the color-coded Broselow–Luten system. There was significantly less variation in tube current and table speed when using the Broselow–Luten system, compared with the conventional chart format. CT technicians who took part in this study preferred the color-coded method for its ease of use.

Resource materials. Color-coded emergency resource materials are being introduced to clinicians in printed and electronic handbooks, including versions for handheld and desktop computers. These guides provide color-coded information, including resuscitation guidelines and medication dosages, as well as protocols for initial burn care, sedation, pain management, antibiotic use, and respiratory emergencies such as asthma and croup. These print and digital references identify not only the correct doses, but also provide guidance on the preparation and administration of common and not-so-common medications.



Courtesy of Armstrong Medical Industries, Inc., Lincolnshire, IL

Color-coded pediatric-resuscitation carts have color-coded drawers that correspond to the color zones of the Broselow tape. Each drawer holds the emergency equipment necessary to perform resuscitation on a child in a weight range designated by color.

FUTURE POSSIBILITIES FOR COLOR CODING

It's likely that the use of color coding in areas in which children are treated, such as inpatient units, surgery, radiology, schools, and prehospital emergency settings, will become more common. In such settings, it's not always possible to weigh pediatric patients; the tape could therefore be used to estimate weight and the corresponding color put on an identification wrist band and in the child's chart. The combination of the color-coded identification band and chart stickers will ensure that appropriate equipment and medications can be determined at a glance.

Future possibilities for using a color-coding system include a neonatal version of the tape, IV infusion pumps, medication dispensing systems such as Pyxis or Sure-Med, intraosseous needles such as those used with the Bone Injection Gun, defibrillators, and other resuscitation equipment. Preparing and administering medications such as midazolam (Versed) with various indications (such as intubation, treatment of seizures, and induction of sedation) and routes of administration (oral, nasal, intramuscular, and IV) could be simplified with the use of separate color-coded pages for each color zone and application. Having proper medication protocols easily identifiable by a patient's color zone may be especially important for clarifying orders and reducing the risk of medication errors, even in emergency situations, when verbal orders may be given as, "Ativan, yellow seizure dose, IV STAT" or "Rocephin, blue high dose, IV now."

Outside of the hospital setting, we may see color-coded car seats, "watch me grow" wall charts, and even dosing guides and medicine cups in a variety of languages. In a 2004 study, caregivers' ability to give the correct dose of over-the-counter medications such as acetaminophen (Tylenol and others) or ibuprofen (Motrin and others) to children improved when using a color-coded system.¹⁵ ▼

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The AirWay PAD and NecLoc Kids cervical collars are designed to ensure effective spinal immobilization. Unfolded, the AirWay PAD can be used to identify the child's color zone and, when folded, helps with proper cervical spine positioning. Color-coded NecLoc collars allow for a child's disproportionately large occiput, preventing cervical hyperflexion that can lead to airway compromise and occlusion.

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