THE S.T.A.B.L.E.® Program

Pre-transport / Post-resuscitation Stabilization Care of Sick Infants

Guidelines for Neonatal Healthcare Providers 5th Edition

Learner Manual

Kristine A. Karlsen

This educational program provides general guidelines for the assessment and stabilization of sick infants in the post-resuscitation / pre-transport stabilization period. These guidelines are based upon evidence-based recommendations in neonatal texts and published literature whenever possible. When necessary, common neonatal stabilization care practices were evaluated and incorporated into this program. Changes in infant care may impact the recommendations contained in this program; such changes should be assessed on a regular basis. While caring for sick infants, healthcare providers may encounter situations, conditions, and illnesses not described in this manual. It is strongly recommended that additional nursing and medical education materials and consultation with neonatal experts are utilized as necessary. Prior to implementing these program guidelines, the content of this manual should be reviewed and approved for use by appropriate policy committees at your institution or facility.

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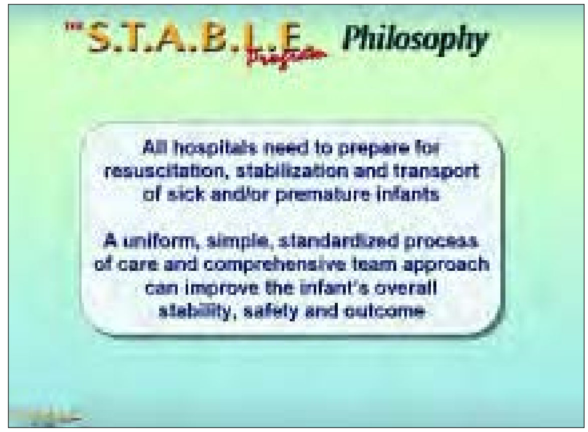
Introduction

Program Philosophy



All hospitals providing labor and delivery services need to prepare for the resuscitation, stabilization, and transport of sick and/or premature infants. Hospitals without delivery services should also prepare for the unexpected arrival of a sick and/or premature infant in the emergency department. A uniform, simple, standardized process of care and comprehensive team approach can improve the infant's overall stability, safety and outcome.

Program Goals

The S.T.A.B.L.E. Program is designed to provide important information about neonatal stabilization for maternal/infant healthcare providers in all settings – from community hospitals and birth centers, to emergency rooms and more complex hospital environments.

Goal 1: Organize this information using a mnemonic to assist with retention and recall of stabilization activities that are critical for the post-resuscitation / pre-transport care of sick infants.

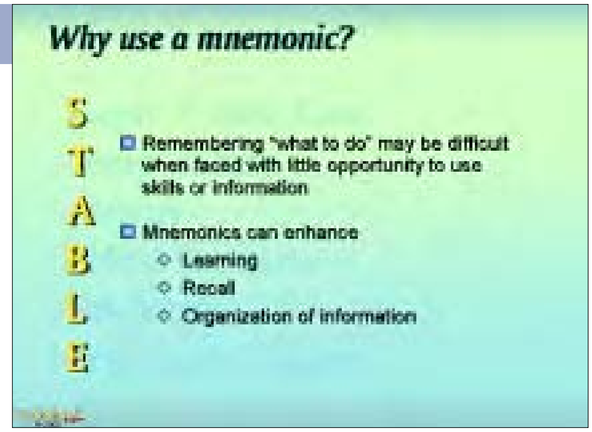
Goal 2: Improve patient safety for infants by (a) standardizing processes and approach to care, (b) encouraging teamwork, (c) identifying areas where medical errors can and do occur, and (d) reducing and eliminating preventable adverse events.

Newborn Transport

Ideally, mothers with identified high-risk pregnancies should deliver in tertiary level perinatal facilities so they may have access to care by maternal and infant specialists. However, as many as 30 to 50 percent of infants ultimately requiring neonatal intensive care do not present until the late intrapartum or early neonatal period, thus precluding safe maternal transport prior to delivery. Therefore, it is important that birth hospital providers be prepared to resuscitate and stabilize unexpectedly sick, and/or premature infants. Adequate preparation of birth hospital providers includes education and training in resuscitation and stabilization, and immediate access to necessary supplies and equipment (AAP, 2002). Combined with accurate assessment and appropriate actions, such preparation will contribute to optimizing stabilization efforts prior to arrival of the transport team.

The goal of all neonatal transport teams is to transport a well-stabilized infant. This goal is best achieved when care is provided in a timely, organized, comprehensive manner by all members of the healthcare team.

The **S.T.A.B.L.E.** Mnemonic



Because well babies far out-number those who are ill, in some settings healthcare providers may have difficulty remembering what to do for the sick infant. The mnemonic "S.T.A.B.L.E." was created to assist with information recall and to standardize and organize care in the pre-transport / post-resuscitation stabilization period.

S stands for SUGAR and SAFE care

This module reviews the initial IV fluid therapy for sick infants, infants at risk for hypoglycemia, and the IV treatment of hypoglycemia. Indications for umbilical catheters and their safe use are included.

Safe patient care, including the reduction of preventable errors, is stressed throughout this program. Whenever possible, methods to provide safe care are emphasized. This symbol is used throughout the program to draw attention to safety concerns and precautions.

T stands for TEMPERATURE

This module reviews special thermal needs of infants including ways infants lose body heat, how to reduce heat loss, consequences of hypothermia, and methods and precautions for rewarming hypothermic infants.

A stands for AIRWAY

This module reviews evaluation of respiratory distress, airway challenges, detection and treatment of a pneumothorax, blood gas interpretation, signs of respiratory failure and when to increase the level of respiratory support, how to secure an oral endotracheal tube, initial ventilator settings, and basic chest x-ray evaluation.

B stands for BLOOD PRESSURE

This module reviews the evaluation and treatment of the three major causes of shock in infants: hypovolemic, cardiogenic, and septic shock.

L stands for LAB WORK

This module focuses primarily on neonatal infection and includes interpretation of the complete blood count and the initial antibiotic treatment for suspected infection.

E stands for EMOTIONAL SUPPORT

This module reviews the crisis surrounding birth of a sick infant, and how to support families during this emotional and stressful period.

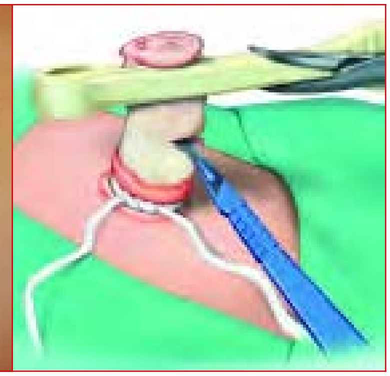
The ABCs . . . .

When faced with an unexpectedly sick newborn, caregivers often ask: "Where should I start?" In any critical care situation, rapidly assess the infant and attend to immediate resuscitation needs. As we progress through the mnemonic of **S.T.A.B.L.E.**, remember that the ABCs of resuscitation — Airway, Breathing, and Circulation — are first priority. Therefore, this program mnemonic is based upon:

ABC → S.T.A.B.L.E.

An excellent resource for neonatal resuscitation is the American Heart Association and American Academy of Pediatrics *Textbook of Neonatal Resuscitation*, also known as the Neonatal Resuscitation Program or NRP (www.aap.org). Although a resuscitation course is not a pre-requisite to participating in S.T.A.B.L.E., it is strongly recommended that participants complete the NRP or a similar course prior to studying this program.

Note: *Throughout this manual, the term "infant" will be used to describe babies from the first through the twenty-eighth day of life.*



SUGAR and SAFE Care

TEMPERATURE

AIRWAY

BLOOD PRESSURE

LAB WORK

EMOTIONAL SUPPORT

SUGAR and SAFE CARE – Module Objectives

Upon completion of this module, participants will gain an increased understanding of:

1. Issues of patient safety and error reduction in the delivery of health care to infants.
2. Techniques to increase the opportunity to deliver safe care to sick infants.
3. Infants at increased risk for developing hypoglycemia, with special attention to premature, small for gestational age, infants of the diabetic mother, and sick, stressed infants.
4. The physiologic basis of aerobic and anaerobic metabolism.
5. Recommendations for monitoring the blood glucose.
6. Signs of hypoglycemia.
7. The initial intravenous fluid therapy to provide to sick infants.
8. The principles of IV glucose therapy for hypoglycemia and post-treatment reassessment.
9. Indications for placement of umbilical venous and arterial catheters.
10. The principles for safe use of umbilical venous and arterial catheters.

Safe Patient Care

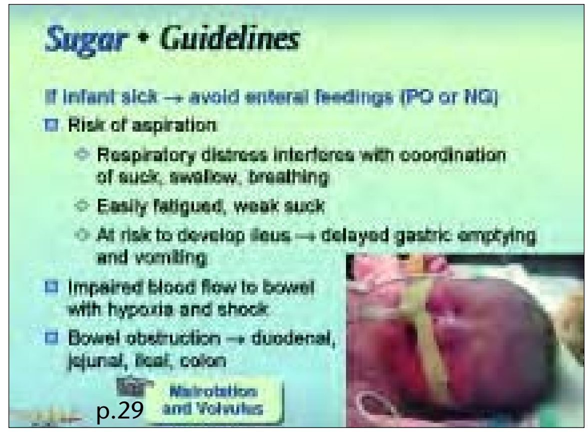
The public expects to receive safe quality care every time they interact with healthcare providers and health systems. Well babies far outnumber those who are sick, but maternal/child healthcare personnel must remain prepared for unexpectedly sick and/or premature infants. Adequate preparation includes education, skill acquisition, proper equipment, and trained personnel. Knowing how to activate the chain of command to resolve problems and concerns is also important.

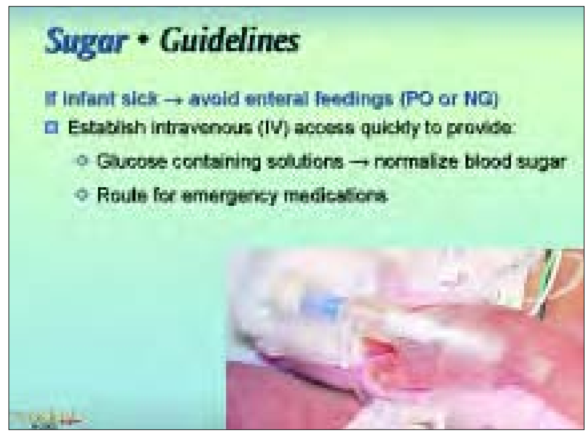
Simple, standardized care processes use protocols and guidelines to improve effectiveness of patient care and patient safety and avoid reliance on memory. Vulnerable infants require more technology, medications, treatments, and procedures - all of which increase the potential for making errors. Short- and long-term outcomes may be affected by actions taken in the first hours and days after birth. Accurate diagnosis, monitoring, and communication all contribute to patient safety and improved outcomes. More information about errors and adverse events are discussed in module seven, Quality Improvement.

Delivery of safe, quality patient care is a top priority of the S.T.A.B.L.E. Program.

The S.T.A.B.L.E. program stresses patient safety. Whenever possible, potential areas where errors can and do occur have been identified so that extra care may be taken.

Sugar — General Guidelines





I. Most infants who require transport are too sick to tolerate oral feedings.

When an infant is sick, there are good reasons to withhold bottle, breast and gavage feedings. Infants who are sick often have respiratory distress, which places them at increased risk for aspirating stomach contents into the lungs. Sucking, swallowing, and breathing are poorly coordinated when an infant is breathing fast or has labored respirations. In addition, some illnesses, including infection, may result in delayed gastric emptying because of intestinal ileus. Stomach contents may reflux up the esophagus and be aspirated into the lungs. In addition, if the infant experienced low blood oxygen levels and low blood pressure during or after birth, blood flow to the intestine may be reduced, making the intestine more susceptible to ischemic injury.

II. Provide glucose via intravenous (IV) fluids.

Supporting the energy needs of sick infants with IV fluids containing glucose is an important component of infant stabilization. Glucose is one of the body's primary fuels, amino acids being the other. **The infant brain needs a steady supply of glucose to function normally.**

Glucose-containing solutions should be given intravenously as soon as it is determined that the infant is sick. For infants, the best peripheral IV insertion sites are in the hand, foot, or scalp veins. At times it may be difficult to insert an IV, especially if the infant is in shock or if caregivers have had little opportunity to practice this skill. If having difficulty inserting a peripheral IV, remember the umbilical vein can be used for delivering IV fluid and medications. The umbilical vein can usually be cannulated for up to one week after birth.

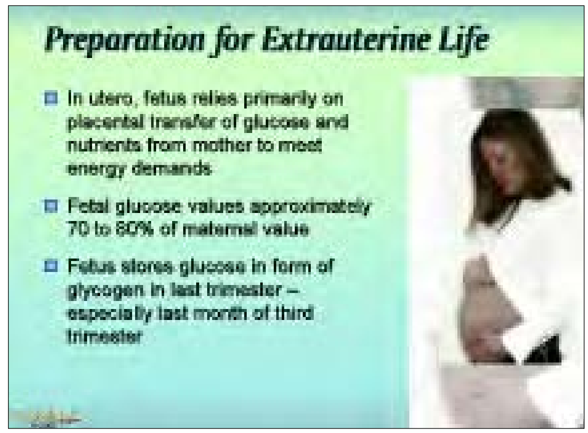
If having difficulty inserting a peripheral IV, consider placing an umbilical venous catheter. Safe use and indications for umbilical catheters will be discussed in more detail later in this module.

Clinical Tip

III. Some infants are at increased risk for low blood sugar (glucose) or "hypoglycemia."

Premature infants (less than 37 weeks gestation), small for gestational age (SGA) infants, large for gestational age (LGA) infants, infants of diabetic mothers (IDM), and stressed, sick infants are at increased risk for becoming hypoglycemic. In addition, some **medications given to pregnant women** increase the risk for hypoglycemia in the infant. These medications include:

- Beta-sympathomimetics (such as terbutaline and ritrodrine; used to treat preterm labor);
- Beta blockers (e.g. labetalol or propranolol, used to treat hypertension);
- Chlorpropamide (used to treat Type 2 diabetes);
- Benzothiazide diuretics; and
- Tricyclic antidepressants when given in the third trimester.



Preparation for Extrauterine Life and Factors that Affect Glucose Stability after Birth

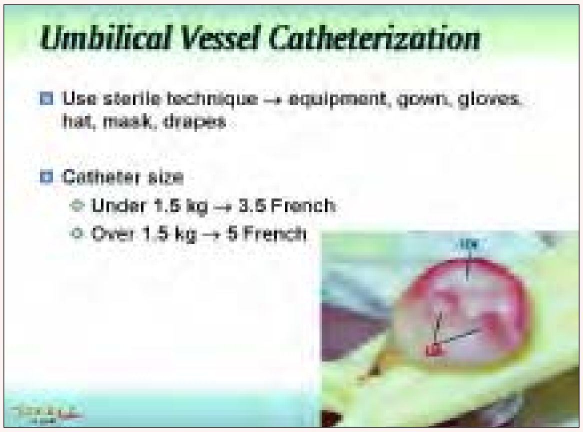
In preparation for extrauterine life, the fetus stores glucose in the form of ***glycogen***. The fetus has limited ability to convert glycogen to glucose, and therefore relies primarily on placental transfer of glucose and amino acids to meet in utero energy demands. When the cord is cut, the infant no longer receives glucose from the mother. Enzymes activate breakdown of glycogen back into glucose molecules which get released into the blood stream. This process makes glucose available to meet the infant's energy needs after birth.

Three Main Factors that Impact Blood Glucose after Birth

Three main factors that **negatively** affect an infant's ability to maintain normal blood glucose after birth include:

- Inadequate glycogen stores
- Hyperinsulinemia
- Increased glucose utilization

APPENDIX 1.10 **HYPERLINK: Umbilical Catheterization Procedure**



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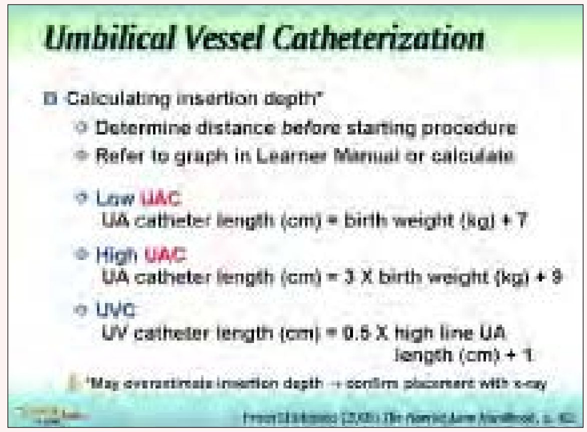

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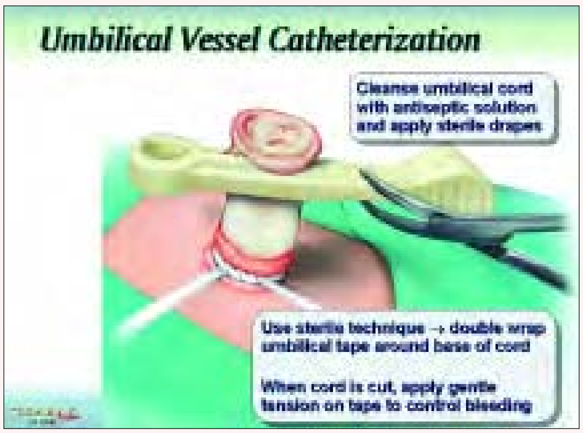

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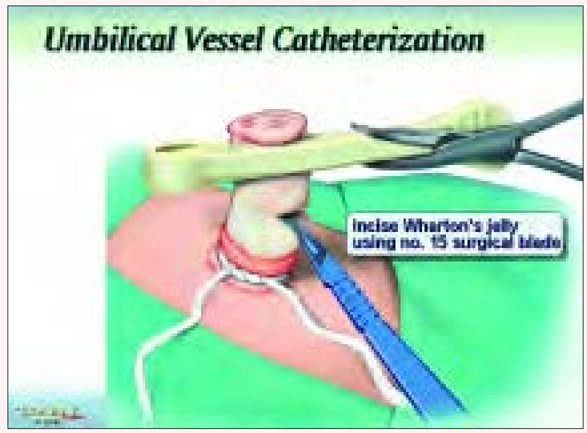

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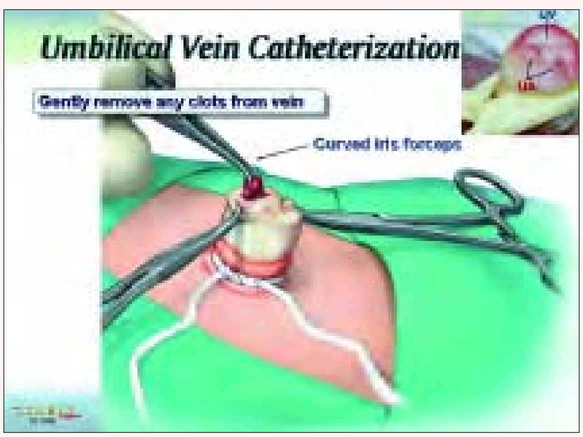

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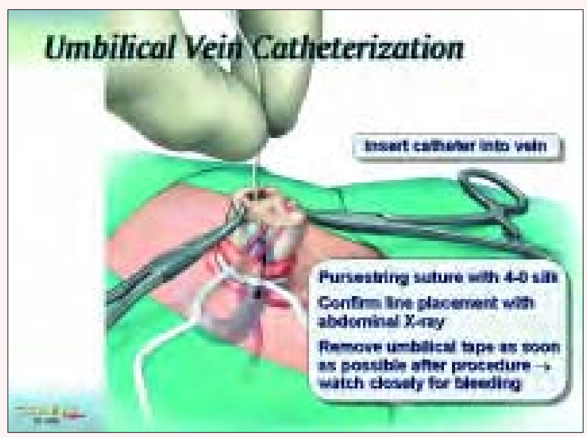

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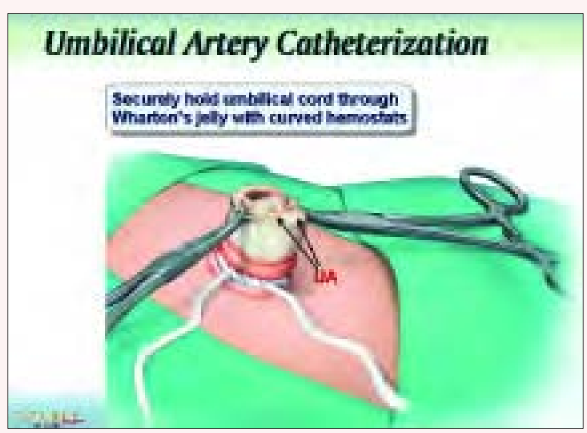


Slide 8

SUGAR and SAFE Care

TEMPERATURE

AIRWAY

BLOOD PRESSURE

LAB WORK

EMOTIONAL SUPPORT

TEMPERATURE – Module Objectives

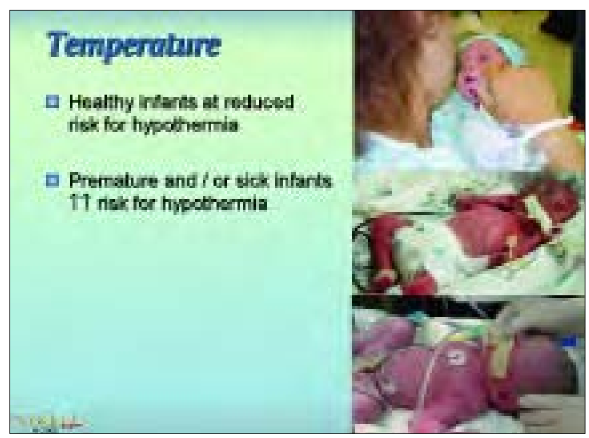
Upon completion of this module, participants will gain an increased understanding of:

1. Infants at increased risk for hypothermia.
2. The normal physiologic response to cold stress for term infants.
3. Mechanisms of heat gain and loss.
4. The physiologic response to hypothermia for term and premature infants.
5. Methods to rewarm hypothermic infants and how to monitor hypothermic infants during rewarming.

Introduction

Hypothermia is a preventable condition that has well documented impact on morbidity and mortality, especially in premature infants. Therefore, assisting the infant to maintain a normal body temperature and preventing hypothermia during stabilization is critically important.

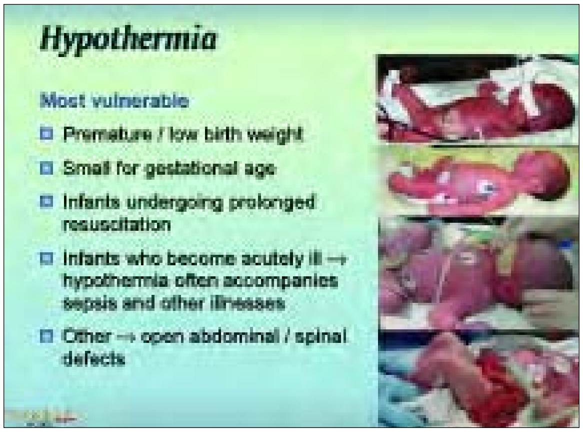
Key Concepts



I. Maintenance of a normal body temperature must be a priority whether infants are well or sick.

Routine care following birth and throughout the neonatal period includes many activities aimed at conserving the infant's body heat. For healthy term infants, these activities include removing wet linens, bundling in warm blankets, laying the infant skin-to-skin on the mother's chest, covering the infant's head with a hat, and keeping the infant clothed. When infants are acutely sick or premature however, normal care procedures are replaced with activities aimed at resuscitation and stabilization. Infants are usually undressed and placed on open radiant warming beds to permit observation and performance of intensive care procedures. During resuscitation and stabilization, the risk of cold stress and hypothermia dramatically increases; therefore, extra care should be directed at preventing hypothermia.

II. **Premature and low-birth-weight infants are especially vulnerable to severe hypothermia.**



Infants often have difficulty balancing heat losses with heat production; this problem is further amplified in premature and small for gestational age infants. Main factors contributing to this problem include larger surface area to body mass ratio, decreased amounts of insulating fat, thinner immature skin, and little, if any, brown fat. When infants are born weighing less than 1500 grams, the problem is further accentuated. If not protected from heat loss, the infant's body temperature will drop very rapidly.

III. Infants who undergo prolonged resuscitation or become acutely ill are at increased risk for hypothermia.

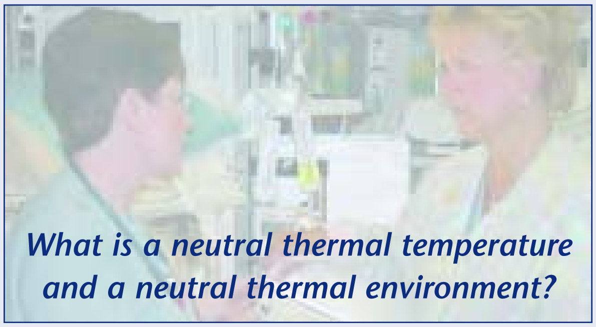
Infants who require prolonged resuscitation are usually hypoxic; therefore, they are unable to metabolize brown fat. In addition, they are often hypotonic and unable to generate heat by muscle flexion and activity.

Acutely ill infants, including those with infections or cardiac problems, are often hypothermic when they present to the healthcare provider. Infants with open abdominal or spinal defects are at increased risk for hypothermia because of their increased body surface area for losing heat and the close proximity of their blood vessels to the environment. Extra vigilance and protection from heat loss should be provided at all times.

REVIEW

Infants at highest risk for hypothermia include:

- Premature, low-birth-weight infants, especially those with birth weight less than 1500 grams.
- Small for gestational age (SGA) infants.
- Infants who require prolonged resuscitation, especially those who are hypoxic.
- Infants who become acutely ill with infectious, cardiac, neurologic, endocrine, and surgical problems, especially those with open body wall defects where heat loss is accentuated.
- Infants who have decreased activity or are hypotonic from sedatives, analgesics, paralytics, or anesthetics.



A *neutral thermal temperature* is the body temperature at which minimal energy is expended by the infant in order to maintain a normal body temperature. When minimal energy is expended then oxygen consumption is also lowest.

A *neutral thermal environment* is an environment that allows the infant to expend the least amount of energy in order to maintain a normal body temperature. Premature infants nursed in incubators require higher environmental temperatures than term infants.

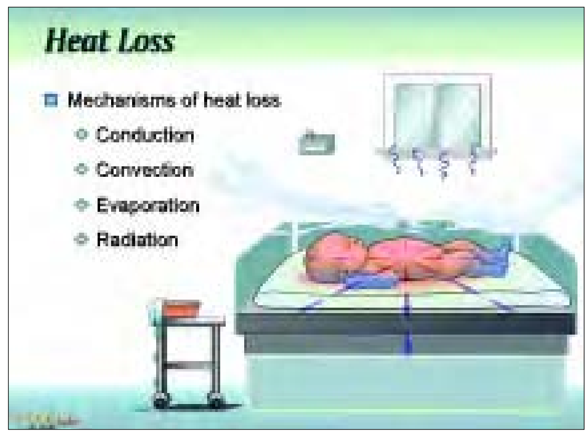
Clinical Tip

Mechanisms of Heat Loss

Body heat is lost (and gained) via four main mechanisms: conduction, convection, evaporation, and radiation.

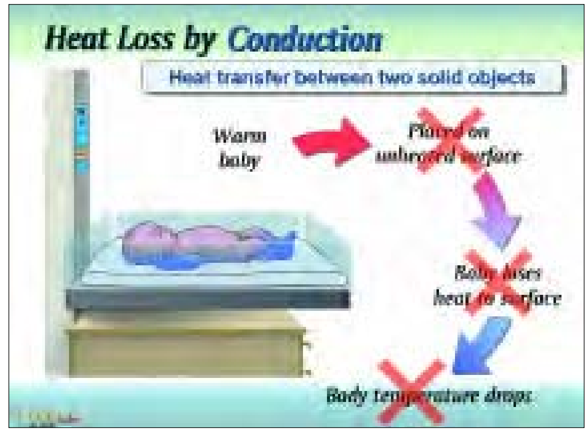
Concept #1. Heat is lost on a gradient from warmer to cooler.
The larger the gradient, the faster heat is lost. For example, if a person dressed only in a short-sleeved shirt and pants stands in a windy field with an outside temperature of 10°C (50°F), that person will lose heat much faster than if standing in the same windy field with an outside temperature of 25°C (77°F).

Concept #2. Heat loss is faster when there is more than one mechanism of heat loss.
Take the person in the previous example. If it suddenly starts to rain and that person becomes wet, then the combination of water plus wind, plus a cool environmental temperature, will dramatically increase the rate of heat loss.



Conductive Heat Loss

Conductive heat loss involves the transfer of heat between two solid objects that are in contact with each other. For example, the infant's body and another solid object like a mattress, scale, or x-ray plate. The larger the temperature gradient between the two surfaces, the faster the heat loss.



What you can do to help reduce conductive heat loss:

- Pre-warm objects before they come in contact with the infant. This includes (but is not limited to), the mattress, your hands, stethoscope, x-ray plates, and blankets.
- Provide some form of insulation between the infant's body and the cooler surface. For example, if weighing an infant, place a warm blanket on the scale, re-zero the scale, and then weigh the baby.
- Clothing and hats serve as good insulators, however, it is usually not practical to clothe the critically ill infant. Cover the infant's head with a hat whenever possible.
- If the infant is premature, place a chemical thermal mattress underneath the infant. Be sure to place a thin cover over the mattress before lying the infant on it.

To reduce the risk of HYPERthermia and burns:

- Do not overheat surfaces or place an infant on a surface hotter than the infant's skin temperature.
- Never place hot water bottles or gloves filled with hot water next to the infant's skin.
- Heat blankets in a temperature-controlled blanket warmer.
- Heat distribution is uneven and the risk of fire is increased when:
  - Blankets are heated in a microwave,
  - Blankets are placed on the top of a radiant warmer heating unit for the purpose of warming the blankets.
- Fluids heated in a microwave have uneven heat distribution and therefore, should not be heated in this manner.
- Do not apply heat directly to extremities that are poorly perfused.

SUGAR and SAFE Care

TEMPERATURE

AIRWAY

BLOOD PRESSURE

LAB WORK

EMOTIONAL SUPPORT

AIRWAY – Module Objectives

Upon completion of this module, participants will gain increased understanding of:

1. Tests to order during the post-resuscitation / pre-transport period.
2. Signs of neonatal respiratory distress and how to distinguish between mild, moderate, and severe distress.
3. Airway challenges and respiratory diseases that present in the neonatal period.
4. Signs of a pneumothorax.
5. Emergency evacuation of a pneumothorax.
6. Blood gas interpretation and treatment of respiratory, metabolic, and mixed acidosis.
7. Principles of assisted ventilation, including how to assist with endotracheal intubation, chest x-ray evaluation for endotracheal tube position, and initial ventilatory support for infants.
8. Assessment of pain and how to safely use analgesics to treat pain.

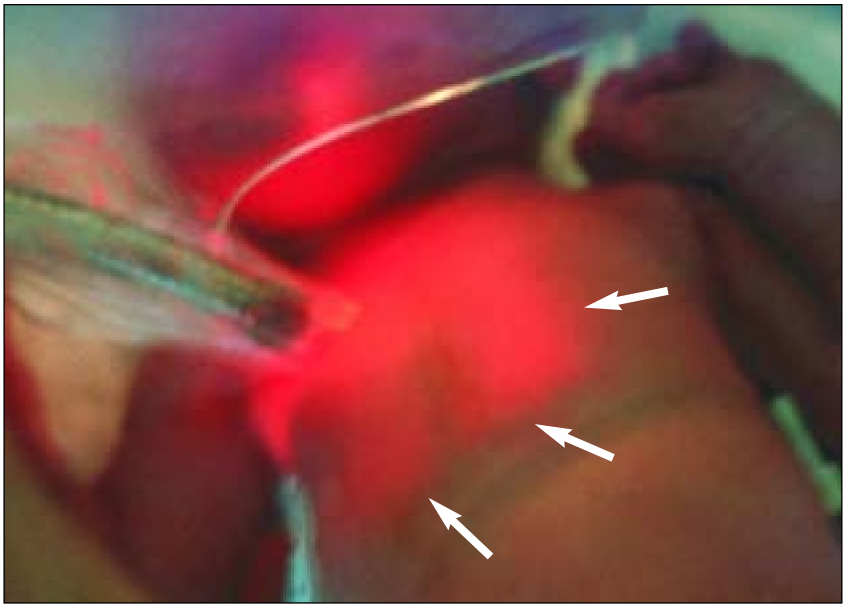
Airway — General Guidelines

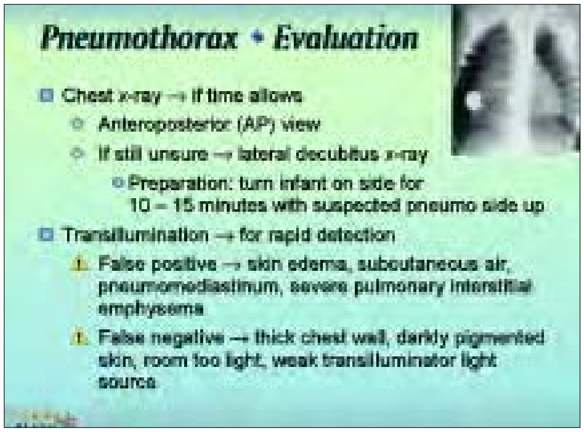
I. Infants with respiratory distress from a variety of causes represent the largest population of infants who are referred to the neonatal intensive care unit.

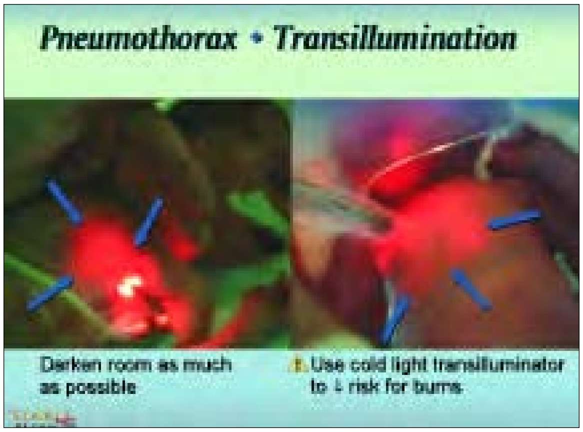
Determining the reason for respiratory distress begins with information gathering—maternal and infant history, presenting signs, timing of presentation, physical exam, and laboratory and x-ray evaluation. In the post-resuscitation period or while preparing an infant for transport, caregivers must continuously evaluate the degree of respiratory distress the infant is experiencing so that appropriate support can be provided.

II. Respiratory failure can occur rapidly.

In most cases, respiratory failure can be prevented by offering an appropriate level of respiratory support to meet the infant's needs. Respiratory support ranges from providing supplemental oxygen via a hood or nasal cannula, to continuous positive airway pressure, to endotracheal intubation and assisted ventilation.

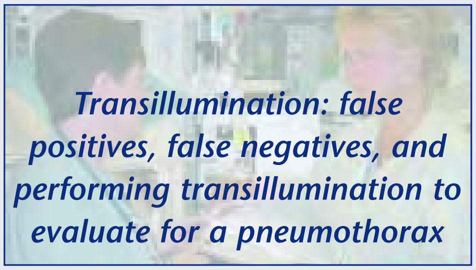






Transillumination for Pneumothorax Detection

Rapid preliminary detection of a pneumothorax can often be accomplished by transillumination using a high-intensity fiberoptic light. If transillumination is not available or you are unsure whether transillumination is positive (meaning a pneumothorax is present) then a chest x-ray should be evaluated. Definitive diagnosis of a pneumothorax is by **chest x-ray** and one should be obtained if time allows. If the anteroposterior (AP) view is insufficient to determine whether a pneumothorax is present, then a lateral decubitus x-ray should be obtained. To prepare for this x-ray, the infant should be turned to his or her side for at least ten or fifteen minutes with the suspected pneumothorax side up. Keep the infant in this position by placing a roll behind the back. The lateral x-ray is taken with the infant in this position. When finished with the x-ray, turn the infant supine to allow optimal lung inflation.



A false positive transillumination (meaning a pneumothorax appears to be present but in reality is not) may be seen if the infant has chest wall edema, as occurs with hydrops fetalis, subcutaneous air in the chest wall, a pneumomediastinum, or severe pulmonary interstitial emphysema.

A false negative transillumination (meaning a pneumothorax is present but is not detected by transillumination) may be seen if the infant has a thick chest wall or darkly pigmented skin. If the room is too light or the transilluminator light source is weak, transillumination may also be falsely negative.

When transilluminating:

Darken the room as much as possible. Compare each side by moving the light from right to left chest, under the mid-clavicular area bilaterally, in the axillae bilaterally, and under the subcostal regions bilaterally.

⚠ To prevent burns, use a cold light transilluminator.

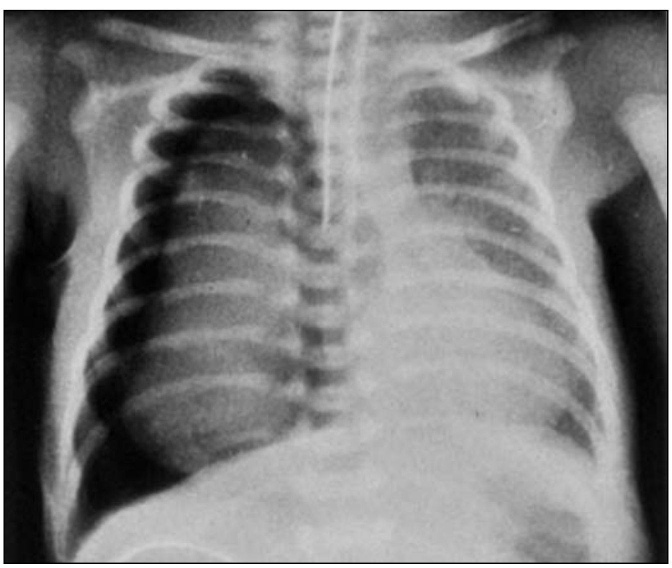
Clinical Tip

Right-sided pneumothorax with mediastinal shift to the left and left lung atelectasis

The ET tube is at T1, the UAC tip is at T6-T7 and the UVC tip is in good position at the IVC/RA junction or just in the right atrium.

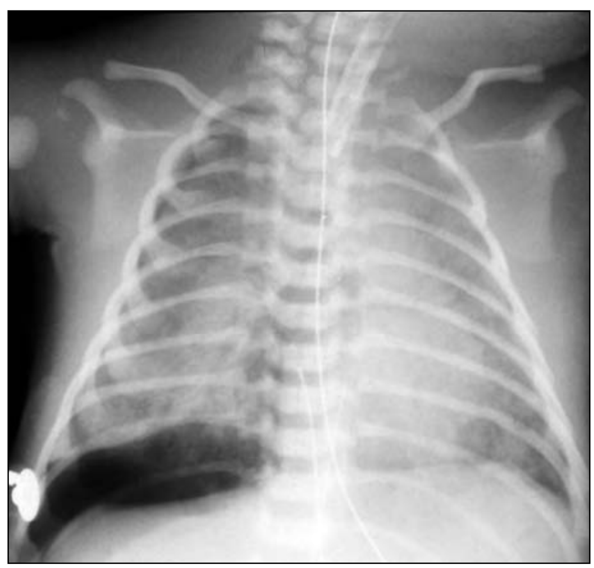
Bilateral pneumothoraces with significant collapse of both lungs and compression of the heart

Very lordotic projection which makes the ET tube appear too high. With proper x-ray projection, the ET tube may be in satisfactory position. The UAC tip is malpositioned at T11.



Right-sided pneumothorax with mediastinal shift to the left

The ET tube is in the right mainstem bronchus and there is significant collapse of the right lung.

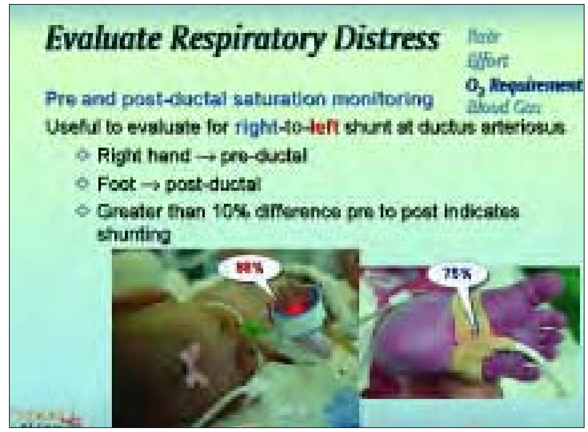


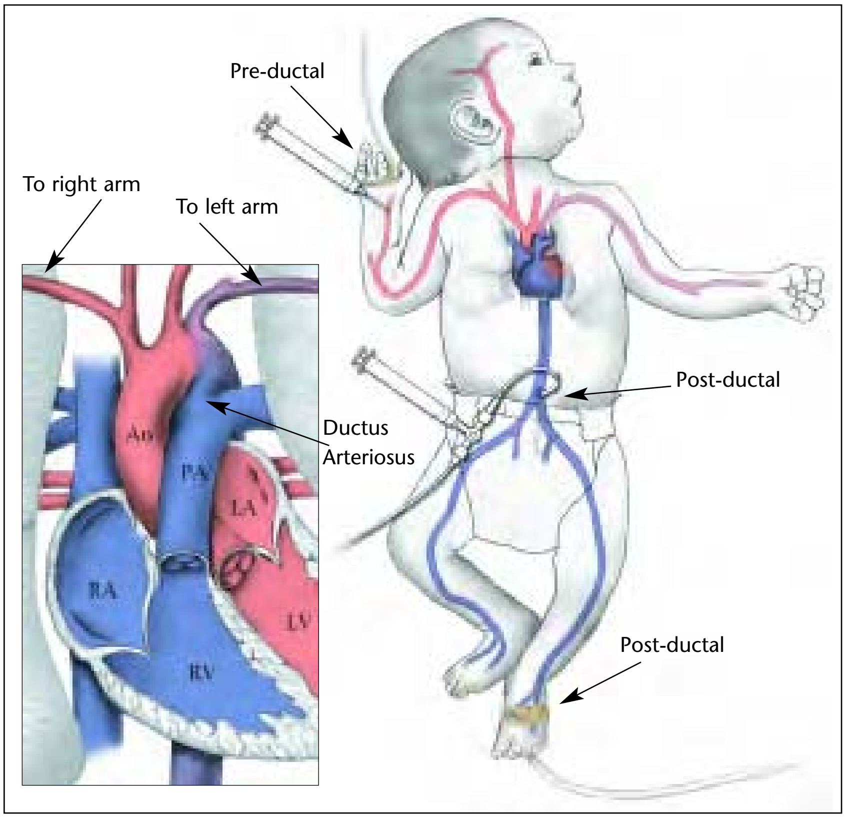
Subpulmonic pneumothorax

The lung fields demonstrate severe atelectasis and / or infiltrates. The ET tube is in good position, the UAC tip is at T8 and the UVC tip is in the right atrium.

Pre- and Post-ductal Oxygen Saturation Monitoring

It is common to evaluate the oxygen saturation in only one location, however, at times, it is of significant diagnostic value to evaluate the O_2 saturation or PO_2 in two locations at the same time. Figure 3.4 illustrates the concept of this form of monitoring, which helps determine whether there is a right-to-left shunt at the ductus arteriosus.





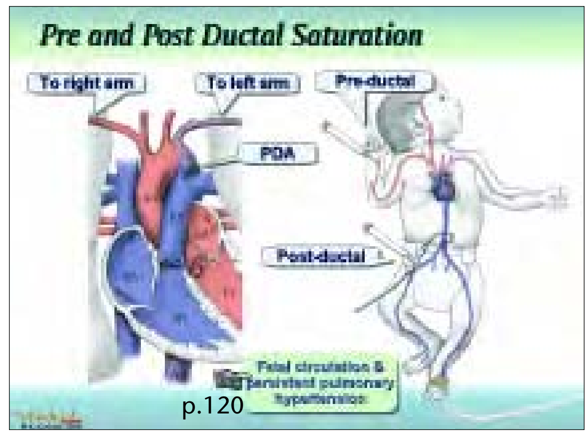


Figure 3.4. Pre- and post-ductal blood gas and O_2 saturation monitoring sites.
Pre-ductal saturation is monitored on the right hand, and a pre-ductal blood gas is obtained from the right radial artery. Post-ductal saturation is monitored on either foot, and a post-ductal blood gas is obtained from the umbilical artery or posterior tibialis artery.

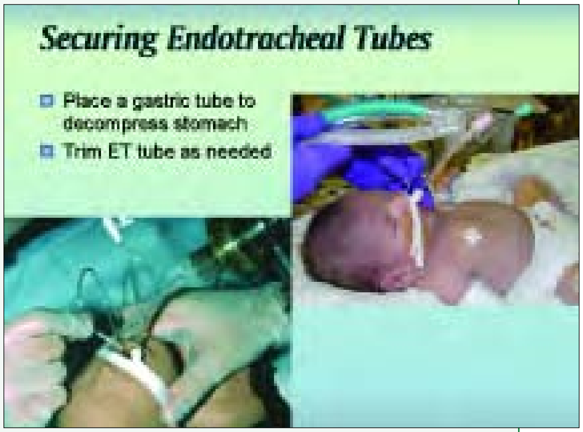
Procedure for monitoring pre- and post-ductal oxygen saturation.

Two pulse oximeters are needed to evaluate pre and post-ductal saturation. If two monitors are not available, place the oximeter probe on the right hand (pre-ductal) for several minutes, record the saturation values, and then move the probe to either foot (post-ductal) for several minutes, and record the saturations. If there is greater than a 10% saturation difference between the two sites in either direction, meaning if the pre-ductal is 10% higher or 10% lower than the foot, then report this observation to the infant's healthcare practitioner. If there is a right-to-left shunt at the foramen ovale, there will not be much, if any, difference between the pre- and post-ductal sites.

Figure 3.7. The "X" and "V" method for taping an ET tube. *(continued)*

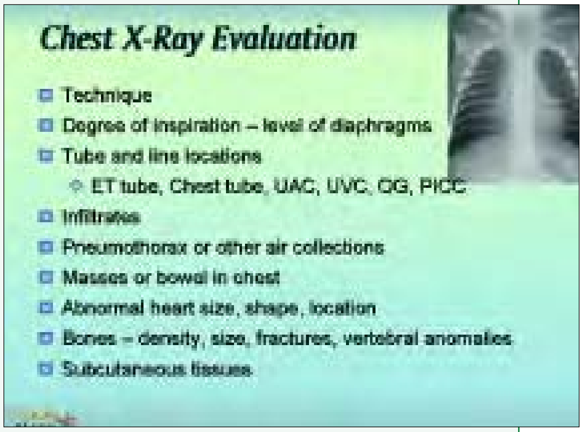
7. Fold the remaining ½ inch of tape to form a tab. This will allow for easier unfastening of the tape if the tube needs to be repositioned after the chest x-ray.

8. Once the ET tube has been secured, insert an orogastric tube to decompress the stomach.



9. Check the ET tube location on a chest x-ray. When taking an x-ray: position the infant so that the shoulders and hips lie flat on the bed or x-ray plate, with the arms in the same location on each side of the body (down by the sides rather than up over the head), and with the head turned slightly to the right or left which is a more natural way for the infant to lie once the x-ray has been taken. Ensure the bed is not tilted up or down when the x-ray is taken. If a chest x-ray must be repeated, position the infant in the same manner each time. This will allow for easier comparison between x-rays.

10. Once the ET tube tip is in good position, proceed with trimming the ET tube so that the distance from the lip to the tube connector is approximately 4 centimeters.



SUGAR and SAFE Care

TEMPERATURE

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BLOOD PRESSURE

LAB WORK

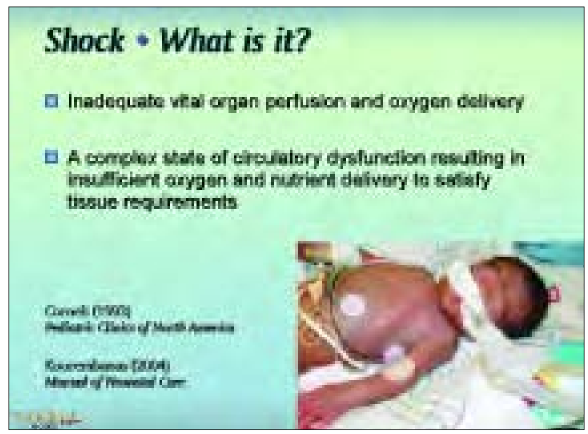
EMOTIONAL SUPPORT

BLOOD PRESSURE – Module Objectives

Upon completion of this module, participants will gain increased understanding of:

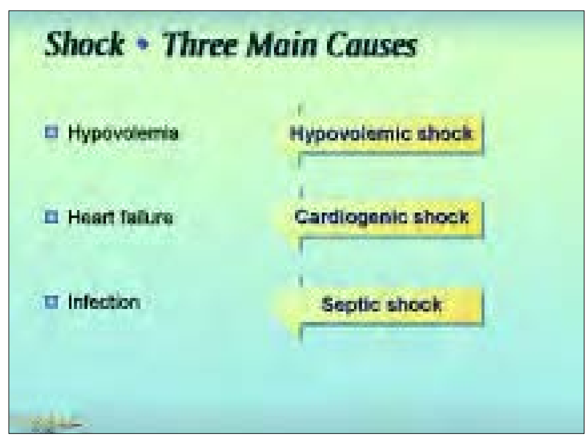
1. The causes, presentation, and initial treatment of the three major types of shock seen in infants: hypovolemic, cardiogenic, and septic shock.
2. The physical examination to evaluate for shock.
3. The principles of cardiac output and heart rate as they relate to shock.
4. Indications for, mixing, and safe administration of dopamine.

What Is Shock?



Shock is defined as "inadequate vital organ perfusion and oxygen delivery" (Corneli, 1993, p.303) or, "a complex state of circulatory dysfunction resulting in insufficient oxygen and nutrient delivery to satisfy tissue requirements" (Kourembanas, 2004, p.181). Failure to promptly recognize and treat shock may lead to multiple organ failure and even death in newborns, thus treatment must be prompt and aggressive.

The Three Types of Shock: Hypovolemic, Cardiogenic, Septic



Hypovolemic Shock

Hypovolemic shock results from a low circulating blood volume. Causes of hypovolemic shock include:

- **Acute blood loss during the intrapartum period**
  - Fetal-maternal hemorrhage
  - Placental abruption or previa
  - Umbilical cord injury
  - Twin-to-twin transfusion
  - Organ laceration (liver or spleen)

Figure 4.2. Evaluation of capillary filling time. To check capillary filling time, press firmly for five seconds and release. Count how many seconds the skin takes to re-fill. Compare the upper to lower body. If greater than 3 seconds on the upper or lower body, or if the lower body is greater than the upper body, report these findings to the infant's healthcare practitioner.

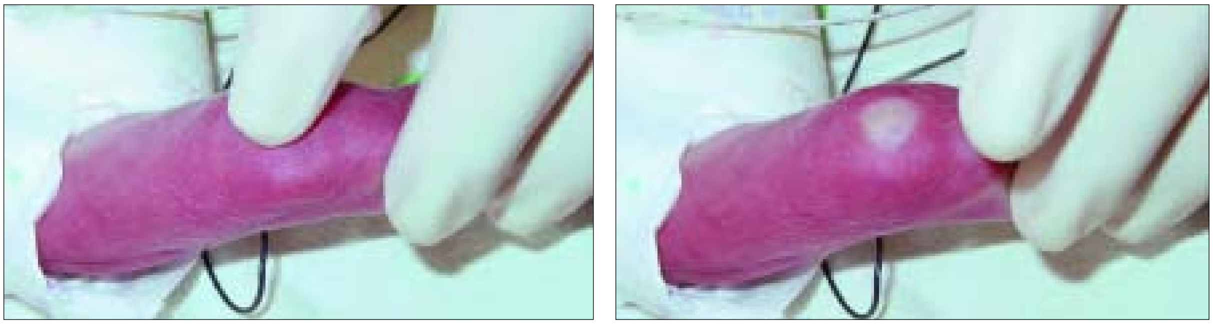


Table 4.2. Laboratory evaluation for shock.

The following lab tests are useful to evaluate shock and, if abnormal, they help determine appropriate corrective therapy:

Blood gas

Metabolic acidosis is present if the pH and bicarbonate are low. If the infant is experiencing respiratory insufficiency, then the PCO_2 will also be elevated and the infant will have a mixed respiratory and metabolic acidosis.

- pH < 7.30 is abnormal.
- pH < 7.25 is concerning especially if in combination with poor perfusion, tachycardia, and/or low blood pressure.
- pH < 7.20 is significantly abnormal.
- pH < 7.10 indicates the infant is in severe crisis.

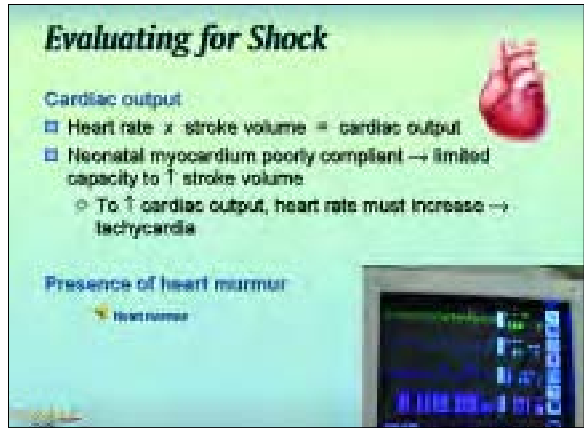
Other labs that are useful in the evaluation of shock

- Glucose
  - In response to stress, the infant may initially be hyperglycemic. Evaluate the blood sugar frequently until a pattern of stability is demonstrated.
- Electrolytes (hypo or hypernatremia, hypo or hyperkalemia)
  - If metabolic acidosis present, calculate the anion gap as follows: $[(Na + K)] – [Cl + HCO_3)]$. (Use the serum CO_2 on the electrolyte panel for the HCO_3). The normal value in a neonate is 5 to 15 mEq/L.
- Ionized calcium
- Liver function tests
- Renal function tests
- Coagulation studies (prothrombin time, partial thromboplastin time, fibrinogen, D-dimer)
- Blood lactate to confirm lactic acidosis

Other tests and observations

- Echocardiogram to evaluate cardiac function and to rule out structural congenital heart disease
- Evaluate urine output for oliguria or anuria
- Evaluate for sepsis (CBC with differential and blood culture)
- If concerned about an inborn error of metabolism, obtain an ammonia level and other metabolic screens (urine and serum amino acids and organic acids)

The Principles of Cardiac Output



Cardiac output (CO) is influenced by heart rate (HR) and stroke volume (SV) such that:

Heart rate multiplied by stroke volume equals cardiac output or

HR X SV = CO

The neonatal myocardium is poorly compliant and has limited capacity to increase stroke volume on its own, therefore, in response to shock the infant will attempt to increase cardiac output by increasing heart rate. This results in **tachycardia**.

Factors that Negatively Affect Heart Function

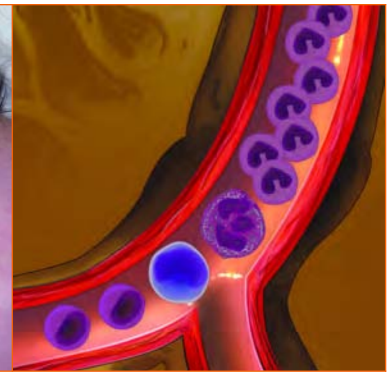
In addition to electrolyte, mineral, or energy imbalances, factors that can reduce cardiac output include the following:

- Decreased volume of venous return to the heart (preload) – the heart has less to “pump” with each contraction.
- Increased systemic vascular resistance (afterload) – requires extra work to pump blood to the body.
- Decreased myocardial contractility – heart squeeze or contraction is poor so less blood is ejected with every beat.

Treatment of Shock

The first step in the treatment of shock is to identify its source or sources. The second step is to identify and correct any related or underlying problems that may impair heart function, such as poor cardiac filling because of hypovolemia, tamponade, excessive airway pressure, electrolyte disturbances, hypoglycemia, hypoxemia, arrhythmias, etc. Figure 4.3 illustrates the principles underlying an improvement in blood pH.





SUGAR and SAFE Care

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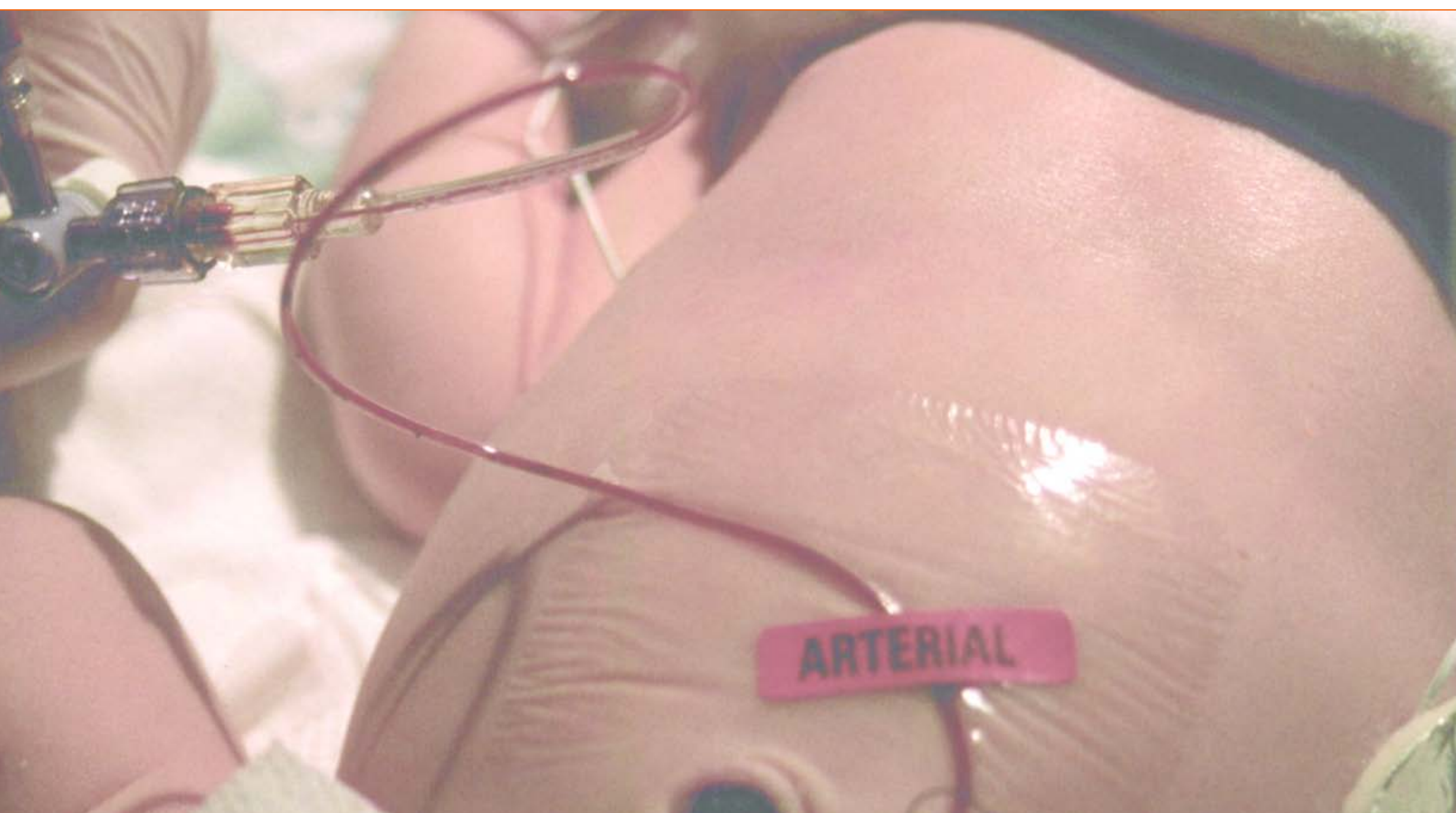
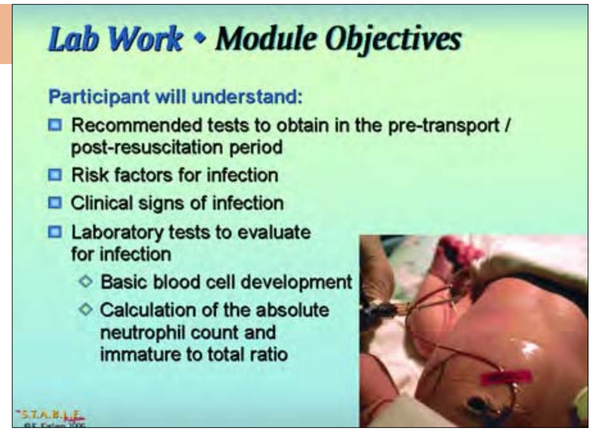


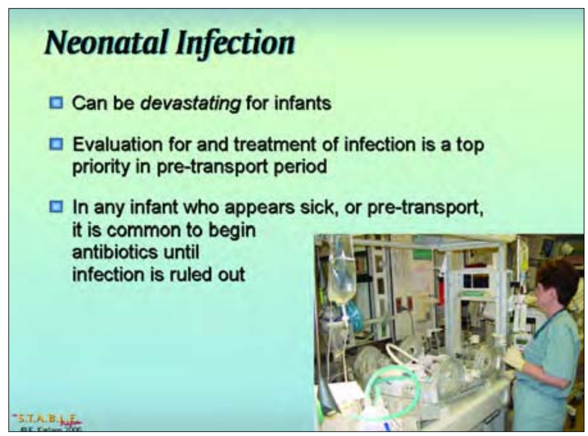
LAB WORK – Module Objectives



Upon completion of this module, participants will gain increased understanding of:

1. Lab tests to obtain in the pre-transport / post-resuscitation period.
2. Perinatal and postnatal risk factors that predispose infants to infection.
3. The clinical signs of neonatal sepsis.
4. White blood cell development, how to calculate and interpret the absolute neutrophil count and immature to total ratio.
5. The relationship of thrombocytopenia to possible sepsis.
6. The initial antibiotic treatment of an infant with suspected sepsis.

Lab work – General Guidelines



I. Neonatal infection can be devastating for the immunologically immature infant.

The neonate's immune system is immature, which places them at increased risk for acquiring infection. They also have an impaired ability to effectively eliminate invading organisms. Premature infants are at an even greater disadvantage than term infants.

Evaluation for, and treatment of suspected sepsis* should be a top priority in the pre-transport / post-resuscitation period. Table 5.1 lists risk factors that predispose an infant to infection.

II. Signs of sepsis may range from subtle and non-specific to unmistakably apparent.

These signs are presented in Table 5.2. In any infant who appears sick, or in the pre-transport period, it is common to give antibiotics until infection is ruled out. Antibiotic doses are provided on page 166.

*The term sepsis is used interchangeably with infection in this module.

Neonatal Infection

Infants may become infected because of bacterial, viral, fungal, or other pathogens. If a viral infection is suspected, carefully evaluate the maternal history for any indication of viral exposure during any of the trimesters. This includes viral illnesses among family members during the last trimester of pregnancy. In infants who present after the initial newborn period (in the neonatal intensive care unit or to the emergency room or physician's office) with evidence of sepsis, one should consider herpes simplex virus (HSV) even if there is no maternal history for herpes. Remember there is a higher risk of neonatal infection with primary maternal HSV than with recurrent maternal HSV.

Bacterial Infection

Bacterial organisms that may infect the infant include group B Streptococcus, Escherichia coli, Staphylococcus aureus, and coagulase-negative Staphylococcus. Other bacteria may also infect the infant, but not as frequently. They include (but are not limited to), Listeria monocytogenes, Streptococcus pneumoniae, Neisseria meningitidis, Klebsiella pneumoniae, Pseudomonas aeruginosa, Serratia marcescens, Enterobacter, and group A Streptococcus. A carefully obtained, adequate volume (at least 1.0 mL) blood culture becomes very important in the identification of the infecting organism.

Complete Blood Count (CBC) Interpretation

White blood cells are involved in protection against infective organisms and foreign substances and are produced in the bone marrow along with red blood cells and platelets. There are five main types of white blood cells, as illustrated in Figure 5.1: neutrophils, eosinophils, basophils, lymphocytes, and monocytes.

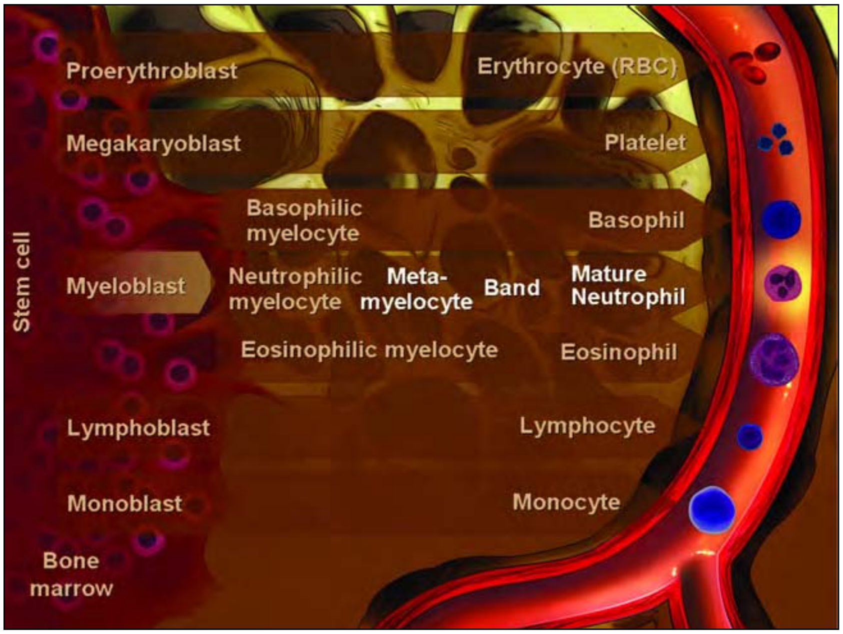
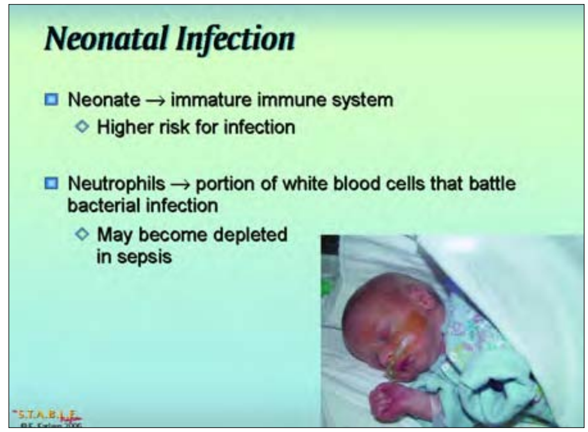


Figure 5.1. Blood cell development – from the bone marrow to the bloodstream. The stem cell differentiates into red blood cells, platelets, lymphocytes, monocytes, basophils, eosinophils, and neutrophils.

LAB WORK

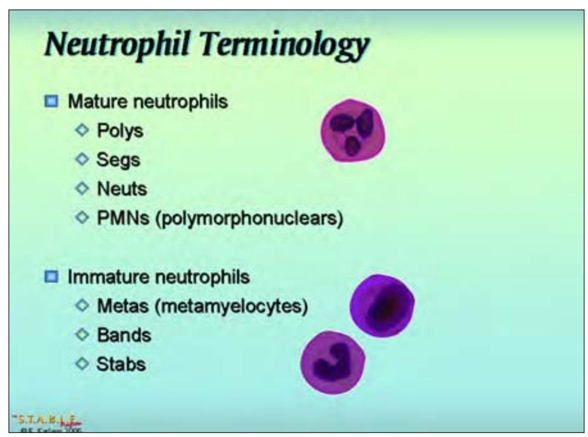
Neutrophils are the white blood cells primarily responsible for killing and digesting bacteria. In neonates, and especially in preterm neonates, neutrophil chemotaxis (movement) is immature; in the face of serious bacterial infection, the neutrophils may not be capable of mounting an adequate response. The following discussion centers around the neutrophil and how to calculate its concentration in the blood.

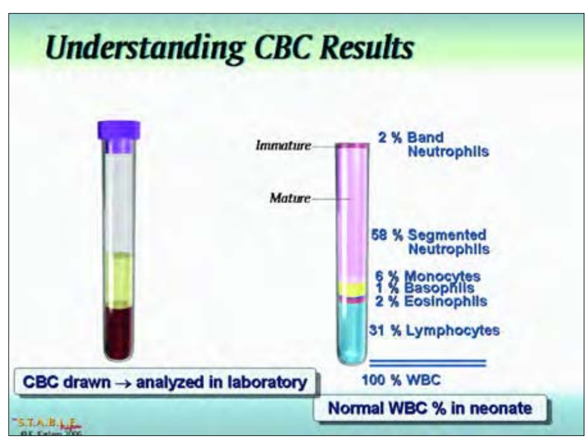


Neutrophil Maturation

As shown in Figure 5.1, the neutrophil matures in the bone marrow, from the myeloblast, to the promyelocyte, to the myelocyte, to the metamyelocyte, to the band neutrophil, and finally to the mature segmented neutrophil. In the bone marrow, the metamyelocytes, band neutrophil, and segmented neutrophil comprise what is called the **neutrophil storage pool (NSP)**. The NSP is significantly smaller, per kilogram of body weight, in neonates than in adults; depletion of the NSP may occur with severe bacterial infections. Under normal, non-infected, non-stressed, circumstances, mature segmented neutrophils are released from the NSP into the bloodstream. However, as shown in Figure 5.2, in the presence of infection, metamyelocytes, band neutrophils, and segmented neutrophils may be released into the bloodstream. The term **"left shift"** refers to the appearance of immature neutrophils in the blood. The "immature to total ratio" (I/T ratio) calculation provides information about percentages of immature and mature neutrophils in the blood and whether the bone marrow may be responding to a bacterial infection. This calculation will be discussed later in this module.

- Segmented (mature) neutrophils may also be referred to as segs, polys, polymorphonuclear, PMNs, and neuts
- Band neutrophils are also called bands, juveniles, or stabs





SUGAR and SAFE Care

TEMPERATURE

AIRWAY

BLOOD PRESSURE

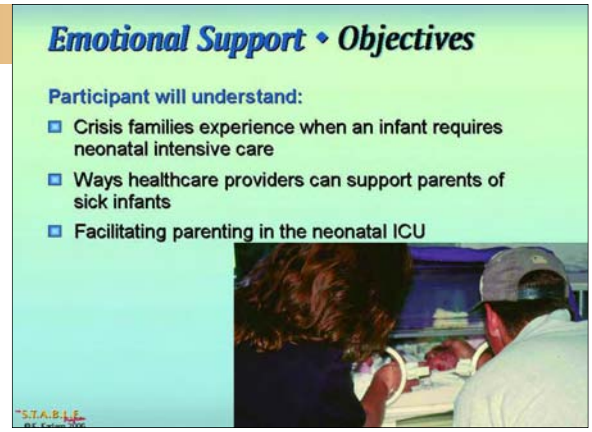
LAB WORK

EMOTIONAL SUPPORT

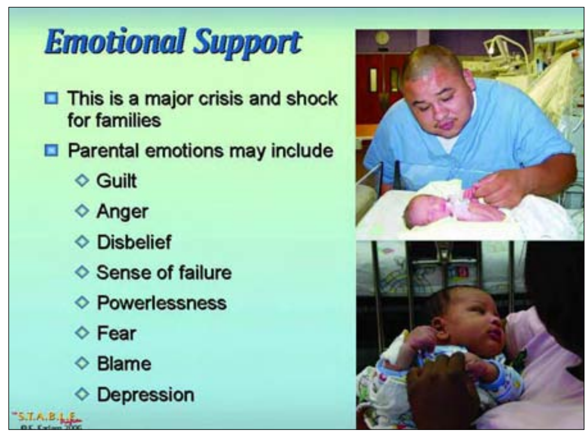
EMOTIONAL SUPPORT – Module Objectives

Upon completion of this module, participants will gain increased understanding of:

1. The crisis families experience when an infant requires transport to, or care in, a neonatal intensive care unit.
2. Ways healthcare providers can support parents of sick infants.
3. Methods neonatal healthcare providers can use to facilitate parenting in the NICU.



Introduction



The birth of an infant means many things to different families. For some, the birth represents joy and happiness, for others it involves mixed feelings, and yet for others, it means hardship. When a newborn is sick, parents endure an even more complicated crisis. Caregivers must recognize that there is a potentially complicated history that the family brings to each childbirth experience. Parental reactions are sometimes hard to interpret and styles of coping vary, as do responses seen from the parents of the same baby. It is important to approach the family in a nonjudgmental manner and to observe for nonverbal cues.

Emotions that parents may experience when their infant is sick and/or premature include guilt, anger, disbelief, a sense of failure, powerlessness, fear, blame, and depression. Commonly, however, in the early period following onset of the baby's illness, the parents may not express any specific emotion, but may appear "numb". They may not know what questions to ask, or what to do in a situation for which they were not expecting or prepared. Guilt and a sense of responsibility for the situation are likely the first and strongest emotions experienced by mothers. Whenever possible, provide support and assistance to help the family cope with this crisis and their grief. Some helpful suggestions follow.

S UGAR and SAFE Care

T EMPERATURE

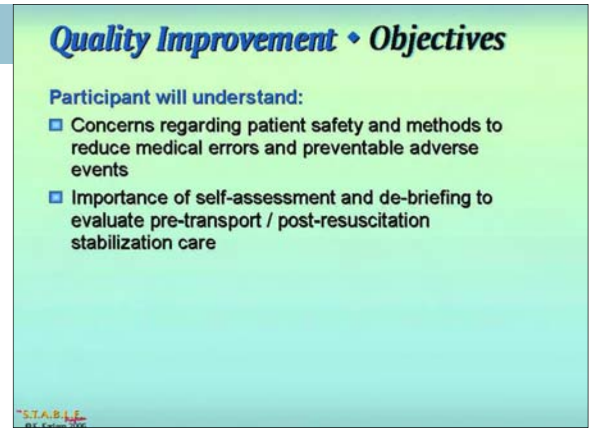
A IRWAY

B LOOD PRESSURE

L AB WORK

E MOTIONAL SUPPORT

QUALITY IMPROVEMENT– Module Objectives



Upon completion of this module, participants will gain increased understanding of:

1. Concerns regarding patient safety and methods to reduce medical errors and preventable adverse events in this vulnerable population.
2. The importance of self-assessment to evaluate care provided in the post-resuscitation/pre-transport stabilization period.

Introduction

A uniform, standardized process of care and comprehensive team approach can improve patient safety and ultimately infant outcomes. The six S.T.A.B.L.E. modules you just completed focused on the importance of assessing patient history, signs, laboratory and test data, and developing a team plan of care. It is important to remember that care of sick infants requires continual re-assessment because infants can change so rapidly. The goal of this program is to provide important, evidenced-based information that can be used to improve delivery of safe, quality care to sick, vulnerable infants.

Known mechanisms to reduce errors include standardizing processes of care, avoiding reliance on memory, and communicating in clear, direct ways. The S.T.A.B.L.E. Program, when applied by all members of the healthcare team, can help everyone to work together and in the same direction. Appropriate, timely, and correctly executed actions can impact short and long term neonatal outcomes.

Quality Improvement Evaluation

Improving patient outcomes and reducing errors and adverse events is the goal of everyone involved with delivery of health care. Some suggestions to realize this goal include knowing how to invoke the "chain of command"; using clear, unambiguous communication at all times; using simple, standardized processes of care; being prepared with knowledge, equipment, and skill for scenarios that will arise; and post-assessment evaluation of care that was delivered.

Chain of command.

Every healthcare facility has a "chain-of-command" or a "chain-of-communication" in place to help employees resolve disputes and advocate for patients. This chain is designed to identify personnel with progressively higher authority within a department or facility, who can be approached to help resolve disputes. For example, a nurse who is concerned about a physician order would first discuss her concern with the physician. If she was not satisfied

Quality Improvement Evaluation *(continued)*

with the response and felt carrying out the order would not be in the best interest of the patient, she could then discuss her concern with the charge nurse. The charge nurse can help the nurse discuss the problem with the physician, and if both are not satisfied that the problem is being addressed, the charge nurse can then go to the nursing supervisor, who can then go to the medical director of the nursery, and so on up, until the dispute is satisfactorily resolved. Knowing how to access the chain-of-command includes knowing when to invoke it, the line of authority, and steps to move up.

Clear communication.

Written and verbal communication must be clear, unambiguous, and timely. When a verbal order is given, it should be repeated back to the person giving the order to be sure that it was heard correctly. A written order should be legible and should not include medical abbreviations that may be easily mistaken for other words. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) published a Sentinel Event report (JCAHO, Issue 30, July 21, 2004) of 71 cases of infant death or permanent disability. Communication issues topped the list of identified root causes (71 percent), with 55% of the organizations citing organization culture as a barrier to effective communication and teamwork (i.e., intimidation and hierarchy, failure to function as a team, and failure to follow the chain-of-communication). One of JCAHO's recommendations was for organizations to conduct team training in perinatal areas to teach staff to work together and communicate more effectively.

Use simple, standardized, processes of care.

Training maternal-child healthcare providers in the S.T.A.B.L.E. program (and other standardized perinatal programs) will help do several things. First, it will bring everyone together on the same page so that everyone can work in concert with each other. Second, it will allow for evaluation of care and any deviations from program guidelines. At times, it is necessary to change or modify care provided to sick infants, however, inappropriate deviations are easier to identify when everyone is using the same general approach.

Be prepared for scenarios that will arise.

This includes having the knowledge, equipment, and skills to provide appropriate care for the many situations that arise in the perinatal arena. Mock codes and continuing education help prepare personnel for unexpected or infrequent occurrences.