An Orientation Manual To The Special Care Nursery

An Honors Creative Project/Thesis (ID 499)
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Ball State University
Muncie, Indiana
February, 1991

Class of 1991
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Before the end of World War II, little attention had been given to the health and welfare of the newborn infant. With the exception of a few pediatricians, there was also little focus on the premature infant. The neonatal mortality rate dropped only from 28/1000 births in 1940 to 21/1000 birth in 1950, a very small change in comparison to the advances that had been made in the treatment of older infants and children health care. (1)

However, certain events that occurred in the early 1960's helped focus the nation's attention on the neglected problems of the newborn infant. Several organizations directed at increasing awareness of treatment of newborns were developed, national conferences were held, and research was initiated to examine the uniqueness of the newborn infant. Possibly, baby Patrick Kennedy's death from hyaline membrane disease in 1963 further stimulated the push towards investigating new ways to increase the survival rate of all newborns. (2) During this time, Alexander Schaffer coined the term "neonatology." or the study of newborn infant diseases and premature births. (3)

Hundreds of changes in the treatment of premature and term infants were researched and investigated and new protocols for prenatal care were developed. Advances in other areas, such as neurology, hematology and surgery have also played a
part in decreasing the mortality rate of newborns. However, technological gains have not come without great costs, both economical and social. Several questions suddenly need to be asked. How small is too small for a premature infant? Who will pay for the runaway cost of neonatal care? Malpractice rates are keeping obstetricians uninterested in providing care for high-risk pregnancies. When the prognosis of chronic lung disease or severe neurological problems is made, who decides when care should be aggressive or discontinued? As with any new discovery of knowledge, the questions of how to use it need to be answered. Recognizing the risks and benefits of technology, L. Eisenberg, M.D. states, "At long last, we are beginning to ask, not can it be done, but should it be done." (4) The question concerning prolonging life when the prognosis is grim is not a new one, but in the area of neonatology, it has a different twist. The death of a child almost always presents itself as a tragedy, when the death of an elderly patient can often be accepted with the feelings that he/she led a long life. Parents can rarely be expected to understand the reality of the situation for a very sick infant; the visions of a normal, healthy baby are still too fresh in their minds. It also is almost impossible to make parents understand what it is like to take care of a permanently brain damaged child, what the consequences of aggressive neonatal care may be, and most of all, that in deciding to discontinue aggressive
treatment, they are not "killing" their child. Babies, whether brain damaged or not, act similarly. It's a very difficult task to counsel parents of a chronic infant on the permanent implications of their child's condition.

This is just one of the many aspects of neonatal care. After I began my internship, many asked if it was depressing watching all those babies die." The Wishard Special Care Nursery is the first home for a multitude of newborns. Infants are admitted for a multitude of reasons: possible sepsis, maternal drug abuse, prematurity, respiratory distress, etc. Basically, if a baby doesn't present itself as "normal" at birth, it is observed and usually treated in the SCN. A majority of my experiences in the SCN are associated with winning a battle that used to be unfightable. There is no way to describe what it is like to carry a 537 gram (1 pound and 3 ounces) infant into the nursery and bundle that same (8 pounds and 15 ounces) baby up in a snowsuit seven months later to send him home with his mother. Sometimes the baby goes home with a good prognosis and the parents can expect no abnormal problems. Sometimes, just making it home alive is a victory, considering how compromised the infant was from birth. And sometimes, though not often, the infant doesn't make it home. However, in my 15 months of working in the SCN, we have only lost 11 infants, many who were so sick it appeared as a blessing to most. It's the "victories" that I remember, though.
This "creative project" is a sampling of information that I feel will be useful to all newcomers to the NICU, especially nurse extenders at the Wishard SCN. NICU's will vary from hospital to hospital; the policies and practices mentioned in here are mainly the ones used at Wishard. This manual also could be used as an orientation guide for new nurse extenders. Included is information that can aid in understanding the uniqueness of the newborn infant.

My internship was filled with learning experiences, not only academically, but emotionally, socially, and professionally. I learned how applicable the seemingly "usless" information I learned in such classes as organic chemistry and microbiology was. I also learned that despite my four years of post-secondary education, I still have very little clinical skills. I learned how the high-stress level of a medical career affects communication in the workplace. I learned how to feel responsible for my work, whether it is taking care of babies or running an experiment in a lab. I learned how to work in a "dependent" role, as an assistant. I learned how to react in an emergency. I learned....

This forward would not be complete without mentioning the people who assisted me with developing the idea, the format, and the information for this project. It was a year-long task and I could develop a list with a hundred names on it who aided me in some way. The limited version of it starts with my sponsor from Ball State, Dr. Jon Hendrix, and continues with Jennifer Dennenman, R.N., Carol Andrews,
R.N., Joyce Carrico, R.N., Mariel Reynolds, R.N., and Dana Hardin, M.D. for all their advice and answering of my incessant questioning. Most of all, I should dedicate my final, firm commitment to study medicine as a profession to a few people, all who coincidentally weigh under ten pounds. Thank you Emmitt, Shannetetta, Asia, Marshi, Tony, Joshua, Timmy, Erika, and all the eventual "newcomers." A special mention should be made of Mercedes DuBouis Dixon Miles, a little girl who fought very hard to live despite everything the world did to end her life. Her forty four days of life did have a purpose.
"Baby Blues"

"More than anything, it's the eyes that haunt you. All at once full of wonder, bewildered, yet somehow accusing. You can see almost anything you want in them if you look long enough. Trust perhaps? Or is it resignation? A glimmer of understanding that seems to vanish in an instant."

"It's always the eyes you remember."

"They lie in a sea of high-powered technology, some rocking gently on the water mattresses meant to simulate the womb from which they were thrust too fast, too soon, unprepared, and ill-equipped. Small clenched fists not grasping rattles, or brightly colored toys, but arterial lines and plastic tubing. Silent cries from babies whose first pacifier is an endotracheal tube."

"The world of an infant intensive care unit, a fluorescent, timeless place where children cry without sound and lullabies are barely audible above the gentle whoosh of the ventilators and the rhythmic beeping of the cardiac monitors."

"We make our daily rounds, glibly discussing the RDS in three or the possible NEC in six, gently probing tiny abdomens, listening to the harsh crackles of immature lungs straining to expand, checking the rapid patter of hearts no larger than a silver dollar. We adjust infusion rates, calculate fluid balance, and estimate maintenance requirements for bodies whose entire blood volume would fit in a teacup."

"Across the room, two parent watch silently as their child gives a sleepy yawn, oblivious to the array of gauges and alarms that tell the precarious balance in which this new life hangs. A furry stuffed toy nuzzles gently below his subclavian catheter line. An oversized baseball cap sits atop a recent craniotomy."

"As I peer up from a clipboard chock full of 'the numbers' on each of my newborn charges, I find a pair of crystal blue eyes peering intently into my own. For a moment, I feel compelled to apologize, to justify, to explain why all this is necessary. I place my finger in the tiny palm to be reassured by the grasp reflex, which somehow doesn't seem quite so primitive right now. The eyes close in seeming silent understanding."

"From isolette to isolette, each time it's the same. Always the eyes."

"Placing my stethoscope on the chest of a sleeping, 28-weeker, I'm met with another pair of questioning eyes."

"'Where am I?' they seem to ask."

"ICU, little one. A place that someday, when you're strong and healthy, you'll never remember."

"ICU, little one. Can you really see me?"

-Daniel J. Waters D.O.
from "A Piece Of My Mind"
Ballantine Books, 1988
Special Care Nursery
Orientation Checklist
Nurse Extender

Orienteer: __________________
Preceptor: ________________

I. Introduction of preceptor and shift staff to orientee.

II. Definition of "Special Care Nursery;" what patients are treated here, principle of decreasing infant mortality with the availability of neonatal intensive care facilities, etc.

III. Describe how unit is staffed (RN's, LPN's, SNA's, RT's NNP's, MD's etc.), the lines of communication, and the role of the nurse extender as a dependent position, assisting the professional staff.

IV. Discuss policies concerning communication on the phone. (proper way to answer, giving information concerning patients, receiving lab results, etc.)

V. Discuss visitation policy.
VI. Discuss infection control policy regarding initial scrub, gown requirements, cleaning equipment after use, jewelry and watches, clean and dirty utility areas, and isolation procedures.

VII. Discuss importance of asking questions, of understanding "why" something is done instead of just "how" something is done, and of reporting any unusual findings to a professional staff member.

IX. Tour of MCH Area- Third Floor
A. Pediatrics
B. OBICU
   1. Triage
   2. The "Board"
   3. labor rooms
   4. labor/delivery rooms
   5. sterile delivery rooms
   6. recovery rooms
C. SCN Office
D. SCN BPD/Annex Unit
E. Mother Baby Unit
   1. admission nursery
   2. nurse's station
F. Dumbwaiter
G. Doctors Call Room
H. Break Room/Mailboxes
I. Operation Coordinators Office
J. Locker Rooms

X. Introduction to Equipment-(reasons used, mechanisms, alarms).
   A. Cardiac/Apnea Monitors
   B. Dinamap Blood Pressure Machine
   C. AVI Infusion Pump (resetting on even hours)
   D. Pulse Oximeters (BIOX, TCM)
   E. Ventilators
   F. Suction Equipment (including bulb syringe)
   G. Warmers
   H. Phototherapy Equipment
   I. Isolettes
   J. Scales
   K. Hematocrit Centrifuge
   L. Oxygen Equipment
      1. Blender
      2. Mask/Hood/Nasal Cannula
      3. Per Isolette
      4. Flowmeter
      5. "Blow by" oxygen with ambu or tubing

XI. Special Care Nursery Supplies Sheet

XII. Orientation to Bedside
   A. Kardex
   B. SCN "Board"
C. Blue Charts

D. Bedside Charts
   1. Flow Sheets
   2. Vital Sign Sheet
   3. Weights Sheet
   4. Care Plans
   5. Other documentation sheets on chart

E. Equipment at bedside
   1. Stethoscope
   2. Thermometer
   3. Bulb Syringe
   4. Other

F. Equipment at Warmer/Set-Up in Admission Room

XIII. Independent Procedures- methods, normal/abnormal findings, significance of findings, etc.
(Also refer to "SCN Procedures Manual" for specific guidelines)

A. Vital Signs
B. Weighing Infants
C. Blood Pressure
D. Baths/A.M. Care
E. Cord Care
F. Circumcision Care
G. Placement of Oral/Nasogastric Tube
H. Breast Milk Thawing
I. Preparation of Formula (half strength, extra caloric)
J. Feeding
1. Oral/Nasogastric
2. Gastrostomy/Transpyloric
3. Continuous/Intermittent
4. Oral Feeding Procedures

K. Suctioning with Bulb Syringe
L. Heelsticks
M. Dextrostix
N. Hemetest (stools, gastric)
O. APT Test for maternal vs. fecal blood
P. Weighing diapers
   1. specific gravity
   2. urinalysis
   3. pH
Q. Hematocrit
R. Stocking Cribs
S. Placing Infant in Isolette
T. Placing Infant under Radiant Warmer
U. Placing Infant in Phototherapy
V. Weaning Infant from Isolette
X. Placing Infant in Pumpkin/Car Seat/Swing

XIV. Assisting MD/NNP/RN with Procedures
   (refer to SCN "Procedure Manual")
A. Admissions
   1. Observation
   2. Stable
   3. Critical
B. Peripheral Intravenous Line (PIV) Placement
C. Venipuncture/Radial Arterial Blood Draws
D. Obtaining Blood Cultures
E. Lumbar Puncture/Spinal Tap
F. Intubation
G. Placement of Umbilical Lines
H. Extubation
I. Weighing of Unstable Infants
J. Delivery Room Setup/Location of Supplies in OBICU
K. Septic Workup
L. Transport to UH/JWR
M. Suctioning
N. X-Rays

XV. Discussion of parent communication and teaching methods, assessment of opportunities for parents to become involved in caretaking, and assisting professional staff with interventions.

XIV. Documentation
A. Acceptable abbreviations
B. Parent Calls/Visits/Feedings
C. Flowsheet/Nursing Notes—discussion of what extender can chart and what needs to be charted by a professional, when to chart and what to chart.
D. Patient Classifications
E. Various Ward Secretary Duties
   1. Use of Phone (transfers, holding calls).
   2. Patient charge sheets, cards.
3. Making lab requisitions.
4. Putting together new charts.
5. Ordering supplies.
Orientation Checklist Guide

I. Each orientee will have a preceptor assigned for every shift worked.

II. See Forward.

III. See Staffing.

IV. The phone should be answered as soon as possible, usually by the ward secretary. There is a procedure for proper phone use and answering in the nursery. It is probably a good idea to refrain from answering the phone at first because information concerning lab results, etc. may be given very "quickly" and may be difficult to understand at first. Everyone in the hospital will be asked to give their name after taking a message or receiving results of tests to insure that messages are accurate, so it is important ask if you are not sure about the message.

V. Parents may visit at any time. All other visitors need written permission to visit without the parents presence or may visit with the parents. The mother may deny visitation rights to anyone in writing. Information concerning the infant's condition may be given over the phone only to the parents and anyone who has written permission from the parents. Of course, these policies can be varied in practice when the situation warrants.
VI. A three minute scrub should be done before entering the nursery. Yellow gowns need to be worn when one is wearing street clothes or holding an infant. All community equipment should be cleaned after individual use. Watches and all jewelry on the hands needs to be pinned to the scrubs while at work. Detailed infection control policies are discussed in the "Sepsis" section.

VII. Discuss with preceptor.

IX. It is important to become familiar with the MCH area because the SCN works in all these axillary units.

X. Demonstrate proper use.

XI. See Supplies.

XII. Discuss with preceptor.

XIII. These will take time to learn how to do independently. Your preceptor will help you to develop a technique.

XIV. See XIII. Assisting with the tasks may take awhile because they are not performed every day.

XV. See Abbreviations, discuss with preceptor and ward secretary. Often the nurse extender will need to be responsible for paperwork when the nursery is busy.
Obstetrical Intensive Care Unit (OBICU)

The OBICU or Labor and Delivery Unit ("L and D") communicates with the SCN concerning all high risk births. One way the SCN becomes aware of potential deliveries that they will be attending is by looking at the "board" in the OBICU. This lists all the information pertinent to the nursery about the pregnancy and labor of a high risk infant. L and D information is also included in every SCN patient's chart because the maternal history is very important to assessing the infant's condition.

The following an explanation of the terminology with it's significance:

**Age:** Mother's age: the mortality rate for teenaged mothers is high due to risk of anemia, preeclampsia (pregnancy induced hypertension) and prematurity; mothers over 35 are at risk for hypertension (5,6).

**G/P:** refers to terminology "gravida" or a woman who is or has been pregnant (no regard given to the outcome of the pregnancy) and "para" or past pregnancies that have resulted in a live birth; a woman who is pregnant for the second time and has one live child is G2/P1; this terminology is expanded in the SCN to "GPTPAL" or "Gravida, Para, Term Infants, Preterm Infants, Abortions, Infants currently alive;" this may be abbreviated GxPy#### with the appropriate numbers substituted in (7,8).
**WKS:** current gestational age of infant in weeks.

**TIME:** time information was last updated.

**BOW:** refers to "bag of water" or condition of amniotic sac; terminology includes intact, meaning the membranes of the sac have not ruptured, ROM, meaning "rupture of membranes", PROM, meaning "premature rupture of membranes", and AROM, meaning "artificial rupture of membranes"; ROM for greater than 24 hours before delivery puts the fetus at risk for sepsis; AROM is a method used to induce labor (9).

**DILA/STA:** refers to "dilation of the cervix, station of the presenting part of the fetus;" the dilation is given in centimeters; 0-5 cm usually means that the labor is in the early stages and 5-10 cm indicates that delivery is near. Station is given in centimeters, either positive or negative, relating the distance of the presenting part of the fetus to the mother's ischial spines of the pelvis; sometimes a third category, affacement, will appear before the dilation measurement. This refers to the percentage of thinning the cervix has done before it is actually dilated. Complete thinning (100 percent) is indicated by "C" (10).

**PRES:** refers to presentation of the fetus. There are several presentation categories, but the most general are breech (buttocks or lower extremities first), cephalic (head) or
shoulder. Breech deliveries are always attended by the SCN due to risk of delayed delivery of the head. Head presentation is sometimes indicated as "V" (11).

**CTX:** refers to time between contractions of the uterus. This may be listed as "infrequent" to a time in minutes. Active labor is indicated by contraction 2-3 minutes apart (12).

**COMMENTS:** Lists any medications the mother has had, such as narcotics, magnesium sulfate or antibiotics, other medical complications, such as diabetes or preeclampsia, condition of the placenta, such as incomplete, or presence of meconium in amniotic fluid (13). "VBAC" refers to "vaginal birth after cesarean." These deliveries are attended by the SCN due to risk that the uterine scar from the previous cesarean will break and the uterus muscles will be ineffective, delaying the delivery of the fetus (14).
Neonatal Resuscitation In The Delivery Room

The Special Care Nursery is called to attend all "high risk" deliveries which included, but are not limited to, prematurity (twenty to thirty-six weeks gestation), fetal distress (fetal heart rate is low or remains under 80 after a contraction late in labor), maternal temperature (sign of infection in mother and therefore possibly in infant), maternal diabetes (infant may be hypoglycemic due to mother taking insulin), severe intrauterine growth retardation (infant is small for gestational age, usually due to lack of prenatal care or other complications), meconium-stained amniotic fluid (indicates that infant has had first bowel movement due to stress of labor, possibility of aspiration of fluid and persistent fetal circulation), multiple births, low pH (indication of respiratory stress), and cesarean section (delivery is "fast", no compression due to traveling down birth canal, possibility for apnea and birth depression) (15).

The set up in the delivery room will include use of a radiant warmer over a table or bed, oxygen source, ambu (positive pressure ventilation) bag with a "pop-off" safety valve, used to prevent high pressure ventilation resulting in a pneumothorax, face mask (either term infant or premature size), neonatal stethoscope, emergency box containing the following: laryngoscope with term and premature blades, extra batteries for the laryngoscope light, endotracheal
tubes (2.5, 3.0, 3.5mm internal diameter) stylet ("stiffener" fo ET tube) and a meconium aspirator (used to suction meconium from the trachea and under the vocal cord). Suction equipment, including 8, 10, and 14 french catheters, suction tubing and lining, should be set up also. Towels for drying the infant off, a bulb syringe for additional suctioning of the mouth and nares, and a sterile "catch sheet" for the pediatrician to transport the infant from the delivery site to the warmer should also be ready. If indicated, emergency drugs also should be drawn up according to estimated fetal weight. Narcan, or naloxone, an opiate antidote, is especially important to have ready if the mother has received any narcotics during the delivery. This would be administered in case of fetal depression (16,17,18,19,20).

When the infant in delivered, it's mouth and nares are suctioned by the obstetrician before delivering the body and clamping off the umbilical cord. Upon delivery to the warmer, the mouth and nares should again be suctioned with a syringe and the infant should be dried off with the towels, especially on the face, head and back which comprise nearly twenty percent of the body surface area (21,22). The infant's heart rate, respiratory rate, tone, color and reflex irritability should be assessed by the pediatrician to direct further resuscitation efforts. The infant may require some "blow by" oxygen which is administered with one hundred percent oxygen at five to seven litres/minute flow via oxygen tubing positioned four to six inches above the
infant's nares. Too high of a flow rate or directing the unhumidified, cold oxygen used in the delivery room into the infant's mouth can cause bradycardia (23,24). Directing the flow into the infant's mouth is also ineffective as the infant is an obligate nose breather. Lower concentrations of oxygen are also not as effective and may lead to the infant requiring positive pressure ventilation or "bagging." If the heart rate falls below 100 beats/minute, bagging should be started at 40 breaths/minute for thirty seconds. Proper positioning of the infant is essential for effective ventilation. A rolled towel under the shoulders will help achieve this. After thirty seconds, the heart rate should be evaluated again. If the heart rate is under 60 beats/minute, cardiac massage or chest compression should be initiated at two fingers below the nipple line at 120 compression/minute. After thirty seconds, heart rate should be evaluated again. If it is 80 beats/minute and rising or over 100 beats/minute, chest compressions should be discontinued and bagging should be continued until the infant makes respiratory effort. If bagging continues for more than two minutes, an oralgastric tube should be inserted in the stomach and the excess air drawn off. The tube should remain open and in place (25,26,27,28).

Usually, these measures should be adequate for stabilizing the infant for transport to the nursery if necessary. At one minute and at five minutes after the birth, assessment scores or Apgar scores are given. Either zero, one or two points are given for the following signs:
heart rate, respiratory effort, muscle tone, reflex irritability, and color. (A mnemonic device is Appearance or color, Pulse, or heart rate, Grimace, or muscle tone, Aggravation, or reflex irritability, and Respirations) (29,30,31,32). The scores are assigned by the pediatrician or nurse practitioner at the delivery and are guidelines for further resuscitation efforts. Apgars need to be assigned every five minutes after the first five minutes until they are above seven (33). Usually, infants with a one minute Apgar of 8-10 require no resuscitation, infants with a score of 5-7 need stimulation and blow by oxygen, infants with scores 3-4 need some ventilation and possible cardiac massage, and infants with Apgars of 0-3 need immediate and vigorous resuscitation requiring three or more people (34,35).

If the infant has received adequate Apgars at five minutes of life, gastric aspiration can be done. It should not be attempted sooner than at five minutes because the suctioning process is found to cause bradycardia in the early newborn (36,37,38). The heart rate should be monitored as the suction catheter is passed down both nares and possibly the mouth to suction the stomach. By this time, the infant can have a stocking cap on to assist in thermoregulation and is ready for transport to the newborn nursery or to the mother's bedside as soon as it is warm.

If the heart rate is not maintained at 100 beats/minute after adequate oxygenation, endotracheal intubation needs to be performed. The proper size of ET tube should be selected and
suctioning equipment should be ready before intubation is started. The infant needs to be positioned with the body aligned straight. The physician will use a laryngoscope with a light to visualize the vocal cords and the trachea. A ET tube with a stylet is positioned in the trachea above the carina as to provide equal ventilation to both lungs. The stylet is removed and the ambu bag is attached to the tube for ventilation to be continued. Proper placement of the ET tube is checked by equal breath sounds and adequate chest movement. A "lasso", or taping mechanism, needs to be prepared to secure the ET tube in place once placement has been verified (39,40,41,42,43).

If, after intubation and several breaths of 100 percent oxygen, the heart rate fails to rise above 60 beats/minute, cardiac massage needs to be started to maintain adequate circulation (44,45,46). If, by 3-5 minutes after the delivery, a heart rate of 100 beats/minute has not been achieved, code drugs need to be initiated to correct acidosis that has occurred due to inadequate circulation, to provide glucose to the myocardium, to reverse low cardiac output, low blood pressure, and to replace volume depletion. These drugs usually include sodium bicarbonate, epinephrine, and plasma in normal situations. (Other "code drugs" and their indications are listed in Appendix E) The drugs are ideally administered through the umbilical vein, but epinephrine may also be administered through the ET tube (47,48,49,50).

A special alteration of the resuscitation procedure is
sed in the situation of meconium stained amniotic fluid. Instead of stimulation, the vocal cords are visualized with the laryngoscope and suctioned out with a ET tube and meconium aspirating device, ideally before the infant takes it's first breath. The resuscitation procedures should be continued as normal (51,52).

The pediatrician or nurse practitioner will evaluate the infant as to whether it needs to be transported to the Special Care Nursery or not. Low Apgars are obvious reasons, as well as infants at risk for sepsis (maternal indications of sepsis such as temperature, rupture of the membranes for longer that 24 hours before birth, mother on antibiotics for known infection, foul smelling amniotic fluid, etc..), small for gestational age, premature, low birth weight, congenitally malformed, sustaining birth trauma, and displaying respiratory difficulty all should be transported to the NICU for evaluation (53,54).
Assessment Of Gestational Age

An assessment of gestational age should be done on all infants to initiate a care plan that will include interventions and screenings for all possible problems associated with the infant's maturity ranking. The gestational age can be measured by obstetrical methods and pediatric methods (55,56).

Obstetrical assessments have already been made by the time the infant reaches the nursery, but the caregiver should be familiar with them. The most obvious way of determining gestational age is by the mother's last menstrual period. This method is very accurate if the mother is sure of her dates. Amniocentesis (amniotic fluid analysis) and ultrasound are also methods of determining the gestational age before the birth of the infant. The pregnancy can also be dated by fetal heart tones (57,58,59).

Pediatric methods of assessing gestational age are based on physical characteristics and neurological examinations. There are several charts available for this. (See Appendix for copies). Usually a physical exam can be done within the first twenty four hours of life, but an accurate neurological exam should wait until birth recovery is allowed to occur.

Several physical characteristics are examined. Weight, length, and head circumference can all be plotted on a standard curve. (see Appendix) Neuromuscular and physical maturity are assessed according to the listed categories and a "X" is placed in the box that most accurately describes the
infant. The numbers corresponding to the "X"s are added up and used to obtain a maturity rating and a gestational age. The following physical characteristics are assessed: vernix, skin, lanugo, sole creases, eyes, ears, breast development, and genitalia (60,61,62).

Vernix is produced at 20 to 24 weeks by the sebaceous glands. The white, cheeselike material is high in fat content and protects the skin from bacteria and the amniotic fluid. The amount and location of vernix on the infant's skin is an indication of gestational age; at 36 weeks, the vernix begins to disappear and is gone at 41 weeks (63,64).

The condition of the skin progresses from thin and transparent with easily visible veins to tougher, thicker and less transparent. By 37 weeks, very few veins are visible and the loss of vernix begins to cause wrinkling. The skin turgor, color, texture and visibility of veins should be noted for the assessment (65).

Languno is fine hair, sometimes barely visible, that is characteristic in infants at 20 to 28 weeks, especially on the back, shoulders, forehead and cheek. At 28 weeks it begins to disappear from the face and the back. At term, some lanugo may still be present on the shoulders (66).

Sole creases develop from toe to heel and must be assessed before the skin dries and the creases are no longer a reliable indicator, usually in the first twelve hours. Creases down approximately one third of the foot indicate 31 to 33 weeks, down two-thirds of the foot indicate 34-38 weeks, covering the foot indicate a term infant (67).
The pinna of the ear is still flat at 24 to 26 weeks and will stay folded when bent down. As the infant matures, the pinna curves and develops more cartilage so when, folded down, will recoil faster. By term, the pinna will be thick and stiff (68).

Breast development is measured by presence of an areola and size of the nodule. It is the result of growth of the glandular tissue related to high maternal estrogen levels and fat deposition (69).

Male genitalia can be assessed by the testes position and the presence of rugae (ridges) on the scrotum. The testes begin to descend from the abdomen at 28 weeks and are high in the scrotum at 37 weeks. By term, the testes are completely descended, and the scrotum is lower and covered with rugae (wrinkles on skin) (70).

Female genitalia is assessed by the labia development in relation to the clitoris. At 26 to 28 weeks, the labia minora and clitoris are very prominent. As the infant mature, the labia majora covers the labia minora and clitoris (71).

The physical characteristics should be assessed by two people to insure objectivity (72). After sufficient time has elapsed for the infant to recover from the birth, the neuromuscular exam shold be done. The infant should be supine and six assessments are used: posture, wrist (square window), arm recoil, popliteal angle, scarf sign, and the heel to ear test. Findings are compared to the pictures on the chart and, again, the scores are added up to obtain a
Posture is observed by merely looking at the infant. As the infant matures, its posture will become more flexed.

The square window test is performed by applying pressure to the infant's hand and forearm causing as much flexion as possible. The angle between the ventral forearm and the palm is measured visibly. Infants that are very premature will have an 90 degree angle while term infants will approach zero degrees.

Arm recoil is measured by flexing the forearm for 5 seconds and then grabbing the hands and fully extending the arms. When the hands are released, a term infant will demonstrate full recoil while less mature infants will have less recoil.

The popliteal angle is measured by placing the infant's thighs on its chest and the applying pressure to the leg on the back of the ankle towards the chest. The angle is measured at the popliteal space, behind the knee. A popliteal angle of 180 degrees is found in very immature infants while term infants will demonstrate angles of ninety degrees or less.

The scarf sign is measured by pulling the infant's hand over the opposite shoulder and around the neck as far as possible. The term infant's arm may only cross the chest while the very preterm infant will go very far around the neck.

With the infant's pelvis flat on the table, the heel is
manipulated towards the ear. The closer the heel can be put to ear, the less mature the infant (80).

After a gestational age is reached and a weight percentile, based on the gestational age, is determined, the infant can be placed into two categories. The first relates to maturity and the second to size. Prematurity is defined as any infant being born before 38 weeks gestation. Term is any infant at 38-42 weeks and post-term is any infant greater than 42 weeks gestation. Appropriate for gestational age (AGA) is defined as an infant whose weight is within the 10th to 90th percentile when compared with other infants of his gestational age. Small for gestational age (SGA) refers to an infant whose weight is less than the 10th percentile for that gestational age and large for gestational age (LGA) is an infant whose weight is greater than the 90th percentile (81,82,83).

Problems associated with prematurity include Hyaline membrane disease (respiratory problem discussed later), apnea, inability to maintain adequate temperature, hypoglycemia, difficulty in feeding, intracranial hemorrhages, hypocalcemia, infection, jaundice, pnemothorax and bronchopulmonary dysplasia (BPD, discussed later) (84,85,86,87).

Etiology of prematurity is not always understood, but some common findings associated with premature infants include premature rupture of the membranes, young maternal age (less than 16 years old), maternal surgery in the last trimester, anesthesia, uterine and cervical anomalies, mother with past
history of premature deliveries, multiple births, placental abnormalities, mid trimester bleeding, low socioeconomic class, chronic disease, urinary tract infection, spontaneous abortion, and toxemia (88,89,90).

Problems associated with SGA infants include hypoglycemia, hypocalcemia, asphyxia at birth, meconium aspiration, polycythemia (hyperviscosity of the blood), impaired immune system resulting in increased chance for infection, pulmonary hemorrhage, and other problems associated with the etiology of the infant's poor intrauterine growth. The etiology of intrauterine growth retardation (IUGR or just SGA) includes intrauterine infections (rubella, syphilis, toxemia), severe congenital anomalies, severe maternal malnutrition, maternal disease, chronic vascular disease, heart disease, renal disease, anemia, hypertension, sickle cell disease, pulmonary disease, anything that may interfere with placental blood flow and oxygenation), chromosomal abnormalities, maternal smoking, syndromes with short stature later in life, postmaturity, high altitude, placental pathology (tumor, infarction), and "constitutional" reasons (small mother) (91,92,93,94,95).

Problems associated with postmaturity include hypoglycemia, fetal distress in labor, neonatal asphyxia, meconium aspiration and SGA. Problems associated with LGA infants include hypoglycemia and birth trauma, resulting in possible central nervous system problems. Common reasons for LGA infants include diabetic mother, edema, multiparity (several
pregnancies, usually four or more), transposition of the greater vessels (heart anomaly), constitutional (large mother), Beckwith-Wiedemann syndrome, a disease characterized by hyperinsulinemia or an abnormally high level of insulin in the body, and erythroblastosis fetalis (Rh incompatibility) (96,97,98).
Thermoregulation of the Newborn

As humans, we are homeotherms; that is, we regulate our body temperature internally and, through our physiological mechanisms, we can maintain a constant body temperature. However, newborns, particularly premature newborns, are not as efficient in maintaining a normal body temperature as older children are. Several reasons for this include the large surface area to body mass ratio, inadequate insulation (less "brown fat" stores), less subcutaneous tissue, a flaccid posture (increased exposure of body surface), inability to consume enough calories to fulfill metabolic demands for temperature regulation and lowered oxygen consumption due to pulmonary problems. Thermoregulation is said to be the single most significant factor in the survival of low birth weight infants, but the difficulty in meeting this challenge is due to the infant's inability to maintain a normal body temperature outside of a narrow environmental range (99,100,101,102).

The normal skin temperature for an infant is 36-36.5 degrees Celsius. Normal axillary (under the arm) and rectal temperature is 36.5-37 degrees Celsius. Axillary measurements are most often used because of the invasiveness of a rectal temperature and because the rectal temperature represents the infant's core temperature which may be within normal limits even when the infant is suffering from low skin temperature, hypothermia (103,104,105). The infant's response to cold stress, hypothermia, is peripheral vasoconstriction.
This leads to anaerobic metabolism and then to metabolic acidosis. Pulmonary vessel constriction occurs leading to hypoxia, which further interferes with the infant's ability to respond to cold. The infant's oxygen requirements will also increase, sabotaging other efforts to resolve respiratory difficulties. The infant's attempts to produce surfactant will also be futile when cold stressed. Another problem with chronic cold stress is caloric loss, or simply put, the infant using precious calories for thermoregulation instead of weight gain (106,107,108,109).

The newborn uses four primary methods to respond to changes in its environmental temperature. Vasomotor methods include vasoconstriction and vasodilation, decreasing or increasing the blood flow to the skin, respectively. Thermal insulation refers to the white fat content in the body. The fetus doesn't accumulate a useful amount until 32 weeks, so many premature infants cannot rely on this method for insulation. Shivering is an effective method for heat production in adults, but one with little use for infants. However, nonshivering heat produced by metabolizing brown fat appears to be used by all newborns, despite gestational age or birth weight. Brown fat is found around the neck, head, heart, great vessels, kidneys, adrenal glands and in the axillae. Brown fat is innervated by sympathetic neurons. When an infant faces a cold stress, the nervous system produces norepinephrine, which is received in the brown fat to simulate metabolism of lipids. The products of this breakdown, free fatty acids (FFA) react, producing heat.
This production of heat increases the oxygen demand in the infant, and many premature infants will not have the ability to meet this demand (110,111,112).

Newborn lose heat in four basic ways: conduction, convection, radiation, and evaporation. Conduction involves heat loss through direct contact with a surface area that is cooler than body temperature. While this type of heat loss is minimal, it can occur any time an infant is placed on a cold scale or a leg rests against a cold isolette wall. The heat in the infant is transferred immediately to the cooler object to establish equilibrium. Simple actions, such as placing a blanket on the cooler surface will keep this loss to a minimum (113,114). Convection is when heat losses are enhanced by air currents passing over the infant's skin. This exchange is dependent on the air temperature and speed of the currents and occurs most frequently in the delivery room or by cool oxygen currents. This problem is resolved by the use of air shields or isolettes (115,116).

Radiation involves heat transfer to cooler object that are not necessarily in contact with the skin. This is the most significant loss of heat outside of the delivery room. Examples of objects include walls of isolettes, room walls, windows and air conditioners. This loss can be kept to a minimum by keeping the isolette away from cold objects (117,118).

Evaporation is loss of heat when skin becomes wet in a relatively dry environment. Evaporation of amniotic fluid,
water from baths, mist treatments, and "prep" solutions (i.e. alcohol or betadine) are examples. Maintaining adequate humidity in the isolette, approximately 75 percent, as well as using warm, humidified oxygen (the same temperature as the environment it is being used) in can minimize this loss (119,120).

The neutral thermal zone of an infant (NTZ) is defined as the environment (air temperature) in which the body temperature is normal and oxygen consumption is minimal. This can be determined according to tables with a given infant's weight. However, other factors may be useful in making a selection of temperature for a given infant, including infants with excessive motor activity (seizures, irritability), infants who are clothed, and infants who are known to be metabolically compromised (hypoxic, congestive heart failure, cyanotic heart disease) (121,122,123).

Servo probes are used to assess skin temperature for infants in double wall isolettes or under radiant warmers. Skin temperature change is the first indication of heat or cold stress. However, because the use of servo results in the infant's temperature governing changes in the environmental temperature, attention must be paid to changes in the environment's temperature (124,125). While radiant warmers provide excellent access to an infant, prolonged periods of use will increase fluid requirements (126).

Other interventions to maintain adequate thermoregulation include use of warm water filled gloves,
wrapping the infant's head and extremities in plastic wrap, lining the isolette with aluminum foil, and using "bubble" blankets under heat shields (127,128).
Fluid and Electrolyte Balance in the Newborn

Fluid and electrolyte management is governed by the changes that occur at birth in the infant's integument (skin), renal functions, neuroendocrine functions and body composition. It is essential that precise balance be maintained, especially in the treatment of low birth weight and/or premature infants (129,130).

A preterm infant's total body water composition (TBW) is 80 percent of its body weight in comparison to an adult TBW of 73-75 percent its body weight. TBW consists of extracellular fluid (ECF), or intravascular (blood) and interstitial (plasma) fluids and intracellular fluid (ICF), or all cytoplasmic inclusions. Approximately 66 percent of a premature infant's TBW will be ECF, a reverse of the ratio found in adults. TBW losses occur as a result of evaporation, leading to dehydration (131,132,133,134).

A premature infant's low body weight results in a large ratio of surface area exposed to the environment to the body weight, often 3 to 5 times greater than the ratio found in a term infant. This fact is impacted by the flaccid posturing of the premature infant as compared to the "curled up" position characteristic of a term infant. The open posture results in even a greater amount of body surface area exposed to the environment for water loss (135,136,137).

The metabolic rate of an infant is two times that of an adult due to the high proportion of surface area exposed and the large amount of active growth tissue (AGT) (138). This
increase in metabolic rate requires increased fluid requirements and a higher caloric intake. This is especially important, for example, in a SGA infant, because caloric loss is increased by a higher activity level than that of a premature infant of the same weight (139,140).

Before birth, the placenta regulates fluid balance. At birth, the premature kidney only has 50 percent of the functioning capacity of that of an adult. Also at birth, physiological changes cause the ECF volume to be reduced. As the kidneys mature, urine output increases, resulting in a characteristic weight loss found in all infants during the first few days of life. Filtration and reabsorption abilities of the kidneys are less effective in the premature infant, so less sodium is lost in the urine and the kidneys reabsorb less sodium from the tubules. After 32 weeks gestational age is reached, the kidneys are more effective, but until then, these impairments result not only in fluid loss, but electrolyte imbalance (141,142,143).

Insensible water loss (IWL) refers to fluid lost in evaporation via the skin (70 percent) or the respiratory tract (30 percent) (144). Maintaining the neutral thermal zone and employing factors that maintain ambient humidity will decrease IWL to an acceptable amount (35 cc/kg/day). Use of a plexiglass heat shield, isolette (especially a double wall), "bubble blankets" under the infant, as well as clothes and blankets will help decrease IWL. As the infant grows and matures, the IWL will also decrease. Use of radiant warmers and phototherapy ("bililights" used in
treatment of jaundice) can increase the IWL by 50 to 200 percent a day. The higher temperature dilates the peripheral blood vessels causing a greater blood flow to the surface and a subsequent greater water loss. Low temperatures and humidity result in higher oxygen requirements due to cold stress. This will lead to a higher metabolic rate and a higher fluid requirement. A margin of one to two degrees outside of the neutral thermal zone is all that it takes to expect this outcome, therefore the infant's temperature and environment need to be monitored very closely. Respiratory distress with rapid and labored breathing will also result in a high IWL (145,146,147,148).

Sensible water loss refers to fluid loss in urine and stool. Normal urine output for an infant is 1-2 cc/kg/hour or 25-75 cc/kg/day (149,150). The infant should also void 24-48 hours after birth, or renal problems or dehydration should be considered (151). A high urine output can be the result of a high caloric intake and the obligate water loss that occurs with the high concentration of glucose. In this case, the glucose "pulls" water out with it in the urine. Presence of glucose in the urine can be detected by used of a urinalysis chemistry strip. A level of 2+ indicates a high level of glucose being excreted (152,153). Water loss due to stool is rather insignificant, amounting to only 5cc/kg/day. However, factors such as the use of phototherapy (producing frequent, loose stools in effort to excrete excess bilirubin) and lactose intolerance (resulting in diarrhea) can elevate SWL due to stool to a level of concern (154).
Overall, the TBW requirements to make up for all loses are 100-140cc/kg/day in a premature infant and 90cc/kg/day in a term infant (155).

Fluid replacement in newborns is calculated to allow for proper ECF loss while preventing dehydration from IWL. Specific protocol is designed to give the proper amount of fluid and glucose intravenously based on the size and maturity of the infant. Fluid and electrolyte balance can be assessed in several ways. Daily body weights are essential. Excessive weight loss beyond the expected percentage suggests uncompensated IWL while inadequate weight loss may be the result of excessive fluid administration. A hematocrit increase suggests inadequate fluid therapy. Blood urea nitrogen (BUN) and creatinine give information about the ECF volume and the rate of filtration in the kidneys. Elevated levels also suggest a need for more fluid (156,157).

The main electrolytes in the body are potassium (K+), sodium (Na+), and chlorine (Cl-). Potassium is present in the ICF and sodium and chlorine in the ECF. Sodium is of greatest concern in newborns. Potassium cannot be adequately measured in serum electrolytes (reflects ECF, not ICF), but potassium imbalance is uncommon. Changes in chloride tend to parallel changes in sodium. Normal levels of electrolytes are:

Sodium: 135-145 mEq/L
Potassium: 3.5-5.5 mEq/L
Chloride: 95-105 mEq/L
BUN: 5-15 mgm%
Calcium: 8-10 mEq/L (158)
Other methods of fluid balance assessment include tissue turgor (low turgor is result of dehydration and inadequate fluids), urine output and concentration, and accurate recording of input and output ("I's and O's") (159). One clinical point to keep in mind is to weigh diapers (to calculate urine output) when the diaper is "fresh"; waiting too long can allow evaporation of the fluid and an inaccurate reading (160).

Dehydration is one outcome of mismanaged fluid and electrolyte balance. Dehydration simply means the fluid/electrolyte output is greater than the input. The first sign of dehydration is reduced urine output and increased urine concentration. Skin color may be ashen, grey or mottled. Mucous membrane will be parched, the fontanelle ("soft spot" on infant's head) may be sunken, and the eyes may appear sunken or soft. The body temperature may be higher or lower than normal, the pulse quick and thready, and the blood pressure normal to high. Respirations may be high and the behavior may be irritable or lethargic. High levels of fluid/electrolyte loss can result in hypovolemia (low volume) if they reach over ten percent of the infant's total volume of 100cc/kg. Treatment includes readjusting the fluid intake, making up for ongoing losses if possible (161,162,163,164).

Edema, or overhydration, is a result most commonly of excessive administration of fluid, but also is seen in infant's suffering from congenital heart disease, sepsis, and neuromuscular paralysis. It most commonly is diagnosed by puffy extremities and eyelids and possibly by an
abnormal weight gain. The presence of edema implies excessive sodium intake, so the amount of sodium administered should be restricted as well as possibly the amount of fluid (165,166).

Hyponatremia (low serum sodium levels) is most often caused by low sodium administration and excessive sodium losses from the kidney or by overadministration of water. Less often, hyponatremia indicates Syndrome of Inappropriate Antidiuretic Hormone or oversecretion of ADH secondary to brain injury resulting from perinatal asphyxia, intracranial hemorrhage or meningitis. It is most commonly seen in term infants but can occur in preterm infants as early as 27 weeks gestation. ADH produces an antidiuretic effect, lowering the water loss from the kidneys by promoting or inhibiting the reabsorption of water from the renal tubules. It is released in response to a need for retention or excretion of water to allow for normal sodium levels in the serum. Therefore, SIADH causes concentrated urine output due to decreased dilution in the kidney and results in low sodium serum levels. However, hyponatremia usually is just the result of the immature kidney's lack of reabsorption of sodium, combined with other factors such as overadministration of water (sometimes necessary to dilute glucose optimally, however, a balance must be reached) or overestimation of IWL, which will decrease dramatically after the first two weeks of life (167,168).

Hypernatremia is less commonly seen in premature infants. It can be the result of many things, usually due to inadequate compensation for IWL that occurs secondary to
radiant warmers used in conjunction with phototherapy (169). It also may be a result of hyperglycemia (high glucose). Glucose excretion requires a high obligate water loss thus limiting the dilution of sodium in the serum. Overadministration of sodium bicarbonate to correct acidosis also will result in hypernatremia as well as frequent intravenous and umbilical artery flush solutions of normal saline (10 percent sodium). Flush solutions of D5W (5 percent dextrose in water) can be substituted to correct this problem (170).

In summary, dehydration is first characterized by high urine output and high urine concentration, followed next by significant weight loss, high sodium levels, dry skin and low skin turgor. An elevated hematocrit, serum protein and low blood volume occur next, sending the infant into shock following more than 20 percent of total fluid lost.

Overhydration is first characterized by excessive urine output and low urine concentration. A weight gain is usually seen, followed by a high serum sodium level. Subcutaneous edema (visible by puffy skin) and possibly pulmonary edema (excessive fluid in the lungs) occur along with a lower hematocrit, low serum protein and possibly increased blood volume. The stress placed on this infant due to the increased fluid in the body and particularly in the lungs can lead to cardiac failure (171,172,173).
Hypoglycemia

Hypoglycemia is defined as having a blood serum glucose level of 40 mg/dl or lower. Normal levels are 90-130 mg/dl. Hypoglycemia is a common problem in newborns, especially low birth weight infants. It is a sign of underlying pathological problems associated with the utilization or production of glucose by the infant. An adequate level of glucose must be maintained by the human body because the brain is dependent on a constant circulating supply of glucose. If the brain is deprived of glucose, neurological impairment may occur (174,175,176,177).

The fetus receives glucose continuously across the placenta from the maternal blood. Glucose is the primary fetal source of energy. The glucose level is the fetus is usually 25 to 30 percent less that that of the mother. In cases of maternal malnutrition, the fetus glucose level is inadequate and the fetus may use ketones (protein) to provide energy. When maternal hyperglycemia exist, as it does in the case of maternal diabetes, the most common cause of hypoglycemia, the fetal glucose levels are elevated. The continuous elevated glucose level causes the fetus to overproduce insulin and results in hyperplastic insulin producing islet cells. Normally, the fetus does not need to regulate it's insulin production because the maternal glucose level is regulated. However, insulin does not cross the placenta, so the negative feedback mechanism of glucose level regulation does not occur in the fetus. The high
level of glucose eliminates the need for the fetus to synthesize its own energy from other noncarbohydrate sources. Energy supplied for the fetus is reserved not only for growth and development but also for resources to rely on during the birthing process and postnatal life, situations that require a large amount of energy with a subsequent "cutoff" of the energy source, the placenta. Situations such as asphyxia, cold stress, activation of muscle tone and activity, as well as extra-uterine breathing all demand a high energy expenditure. Essentially what occurs is a switch from relying on maternal sources of glucose to relying on external and internal sources of glucose. In a normal, term infant, this is accomplished by the utilization of glycogen from the liver (gluconeogenesis), free fatty acids (lipolysis), and external sources of glucose. Therefore, hypoglycemia is most likely to occur in infants that are compromised and unable to carry out these processes to self regulate their energy needs (178,179,180,181,182,183,184).

There are several common causes of hypoglycemia. Some are of transient duration, others of prolonged duration. Clinical signs include apnea (cessation of breathing), cyanosis, jitteriness, limpness, high pitched cry, poor feeding, irregular respirations, seizures, coma, and sweating. These symptoms are also present in other serious conditions, such as maternal drug overdose, heart disease, renal and liver failure, sepsis, and asphyxia, however, without hypoglycemia being present. If these symptoms do not clear a short time after administration of adequate glucose, these
Causes of neonatal hypoglycemia are plentiful. Intrauterine malnutrition results in low liver glycogen storage and therefore a lack of resource for glycogenesis immediately after birth. Fetal asphyxia and cold stress result in glycogen depletion from the liver store, as addition glucose and energy is required in these conditions to maintain adequate glucose levels in the brain. Erythoblastotic infants, infant with Rh incompatibility with the mother resulting in clumping and lysis of the red blood cells, often are hypoglycemic. It is believed that a secretion from the lysed blood cells, glutathione, stimulates overproduction of insulin from the islet cells of the pancreas by abruptly inactivating the circulating insulin (187). Maternal use of oral antidiabetic agents that cross the placenta also can result in transient hypoglycemia (188). Abrupt stop of intravenous glucose (result of disconnected or infiltrated intravenous lines) also, as expected, will result in a drastic drop in glucose levels. Defective glycogen breakdown (glycogen storage disease) and defective conversion of galactose to glucose (galactose intolerance) will result in protracted hypoglycemia. Hypoglycemia also occurs in premature, low birth weight infants due to several associated conditions, including low liver glycogen stores, cold stress, asphyxia, and respiratory difficulty (189,190,191).

Infants of diabetic mothers almost always present themselves as hypoglycemic. However, with proper management