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Dr. Davidson has published over 50 papers, contributed more than 21 chapters to other authors' textbooks, and published an additional 23 textbooks that she has cowritten, including the international bestseller, *Old’s Maternal–Newborn Nursing and Women’s Health Care Across the Lifespan* (10th ed.), which has been translated into nine languages and used throughout the world. Dr. Davidson recently published *A Nurse’s Guide to Women’s Mental Health Care*, which earned an *American Journal of Nursing* Book Award in 2012 in the category of psychiatric mental health nursing.

In 2002, Dr. Davidson established the Smith Island Foundation to provide rural health care education, screening programs, and children’s programs to a small island community in the Chesapeake Bay. She subsequently developed an immersion clinical practicum for students to participate in rural community health on Smith Island. She is also the author of the children’s book *Stowaways to Smith Island.*
FAST FACTS FOR THE NEONATAL NURSE

A Nursing Orientation and Care Guide in a Nutshell

Michele R. Davidson, PhD, CNM, CFN, RN, CPS
For my son,
Grant McPhee Davidson.
My sweet boy, whose very existence is a miracle and blessing that inspires hope and inspiration to all who cross his path. His journey in life has not been, and will not be, easy, but he continually shows others how to transform the impossible into possibilities. He brings pure joy, determination, and love into the world and is a ray of sunshine for all who meet him.
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Preface

This book provides a basic reference for nurses caring for newborns and high-risk newborns as well as care considerations for families. Nurses continue to function as valued members of a collaborative health care team, play a primary role in the assessment and care of the newborn, and provide education for new parents regarding the newborn’s needs. Families experience dramatic transformations as roles develop and change during the newborn period, and rely on the knowledge, support, and encouragement of the nurse to learn to care for their newborn and meet the newborn’s most basic needs. In-depth knowledge of the physiological changes of the newborn enables the nurse to detect possible complications that warrant additional assessment. Early identification of risk factors and complications can help ensure that proper newborn evaluation and care are provided when alterations are present.

Advancements in obstetrical care practices have led to advances and options for very premature newborns. Infants who would not have survived if born decades earlier now have far greater chances of survival, though some will have lifelong consequences as a result of birth occurring at early gestational ages. Although most births occur at term and without serious complications, 11.5% of newborns are born prematurely (before 37 completed weeks). Prematurity remains the
greatest risk factor for newborn morbidity and mortality. Prematurity is also the leading cause of disabilities in children.

In acute care facilities, it is the nurse who performs the initial newborn assessment and obtains measurements and other assessment data. A thorough knowledge of normal newborn characteristics enables the competent nurse to quickly identify deviations from normal characteristics or potential complications. If an abnormality is identified, it is the nurse’s role to notify the clinician and initiate interventions to ensure that stabilization of the newborn is promptly achieved. Most abnormalities, birth defects, or complications are identified during the newborn examination.

The nurse plays an invaluable role in providing education to the family on the proper care of the newborn, including assisting with feedings. Breastfeeding is the preferred method of feeding for all infants, regardless of gestational age. The American Academy of Pediatrics recommends exclusive breastfeeding for the first 6 months of life. Successful and long-term breastfeeding has been noted to be highest in women who receive initial breastfeeding opportunities as soon as possible after birth with assistance from educated nurses who can provide hands-on support. The nurse assists the mother in learning basic provisions for infant feeding and supports the mother’s choice of feeding method. Some women will opt not to breastfeed and continue to need guidance and education to ensure proper nutrition for the newborn.

Although the vast majority of infants are born without long-term complications, some newborns experience short-term complications. Although these conditions are short-term in nature, they do require immediate intervention and treatment. Cold stress, hypoglycemia, jaundice, respiratory distress, fluid and electrolyte conditions, and infections are usually not associated with long-term complications if they are identified early and promptly treated. Other complications have ongoing implications that may require more intensive interventions and longer treatment durations, such as prematurity or low birth weight. A small number of infants will be born with conditions that have lifelong implications and may require intensive care or management strategies, such as genetic defects or birth defects.
Although most nurses face ethical dilemmas in practice, the newborn nursery nurse, especially the neonatal intensive care unit nurse, faces these on a regular basis. Infants may be exposed to the mothers’ substance abuse and alcohol use in pregnancy, which can have lifelong consequences. Other infants are born on the edge of viability and will require intensely complex decisions to determine the most ethical and compassionate plan of care. Some of these newborns will require emergency procedures, whereas some of these newborns will need transport to obtain life-saving measures. Other newborns will have conditions that are incompatible with life, leaving families facing harrowing issues of death and dying. Any family faced with unexpected birth outcomes, whether they be birth trauma, injury, or previously unidentified disorders, needs extensive support, education, and compassion.

Newborns face multiple vulnerabilities and need specialized care from their caregivers in order to establish normal growth and development and to prevent illness and injury. Nurses must possess excellent communication skills and have knowledge of various procedures and care needs, such as immunizations, proper sleeping positions, fall precautions, and travel recommendations. Nurses give explanations in order to provide comprehensive holistic teaching to families about the initial care for the newborn in the home environment. Ongoing educational needs include the need for newborn examinations, well visits in the infant period, and infant immunizations.

The nurse caring for the newborn also provides a great deal of support and has extensive interaction with the mother and new family. Support for the postpartum family includes identifying potential risk factors, providing referrals for community support groups, and referral to appropriate multidisciplinary providers, such as pediatric providers or lactation support specialists. The nurse also has extensive interactions with the new mother and should perform postpartum depression and mood and anxiety disorders (PMAD) screening. Approximately 20% of new mothers will develop postpartum depression, which can negatively impact the family, including the newborn. Prompt identification and treatment are associated with better outcomes. Care of the
mother with a PMAD includes referral to support groups, evaluation by a skilled practitioner for possible pharmacological interventions, and a multidisciplinary approach that includes skilled professionals. Women leaving the hospital without their infant may be at risk for postpartum depression and require additional support related to their individualized circumstances.

There is no greater joy, responsibility, honor, or blessing than to be afforded the opportunity to work with growing families at this amazing time in their expanding lives. Each newborn and family is entirely unique, different and, in some way, utterly amazing. There are those who will pass through a nurse’s life and likely be uneventful, and although it is almost sad to say, will likely be, well... forgotten, blending in with the many memories that merge together in the days that will eventually create the weeks, months, and years that knit together a nursing career.

Many nurses caring for newborns likely take for granted that sweet baby smell, the smooth skin against your cheek, or the time spent in rockers quieting fussy newborns back to sleep. The daily tasks of life as a nurse can become mundane and typical, but it is my greatest hope that you will embrace each newborn and each new family who comes under your care! For nurses who have their own children, it is likely that, as with your own newborn experience, these days will eventually slip away as you move to a different patient care area, or retirement eventually takes you away, and you will be left reminiscing about your days spent in a nursery rocking chair or feeding a newborn whose mother was sound asleep from a long exhaustive labor. It is quite likely that when that time comes, you will miss those days! It is my hope that actively practicing nurses will enjoy and embrace each and every newborn encounter and that the families will permanently imprint themselves on your heart and soul, providing you with vivid images you can randomly recall. I hope each day continues to instill in you a passion that inspires you to wake up with anticipation, providing you with the reason to continue to care for families during this crucial time period in their lives!

Michele R. Davidson
When I was a new graduate nurse, I worked in the postpartum setting and the newborn nursery, and now realize it is the best nursing job there is! Later, I became a certified nurse midwife and was blessed to deliver over a thousand babies and care for thousands more families during that time. Although I loved delivering babies, it is those quiet nights sitting in rocking chairs in a downtown Washington, DC, hospital that I remember most vividly and with the fondest of memories. Throughout that time, I am not sure I was aware of the sacred gift that I had been provided, or that I truly valued the many tremendous experiences encountered, or how much I would miss those snuggly newborns when my career path moved forward. For all the families who shared their precious newborns with me and allowed me to care for their most valued life’s treasures, my genuine thanks to you!

Although I rejoiced with many families during perhaps the happiest moments in their lives, I was also privileged to care for newborns facing the greatest of challenges. I have had several newborns die in my arms because their parents couldn’t bear to watch them take their last breath. It was many of those families who in their darkest hours shared the most intimate and raw feelings of human heartache that have shaped my philosophy of nursing and of life, and ignited my
desire to provide compassionate care to all families as they navigate both the joys and heartaches that often come with having a baby! It is with immense thanks and gratitude that I would like to acknowledge all of those families for providing me with the opportunity to share their joys and tears.

Rebecca Sutter, DNP, CFNP, RN, was a contributor to this book and provided her extensive expertise in newborn assessment and newborn care areas. Becky is a knowledgeable family nurse practitioner who has vast experience in pediatrics, and is a dedicated educator and true friend. Many thanks to her for all her efforts and flawless work on making this book a valuable resource. I have now worked with Elizabeth Nieginiski of Springer Publishing on two books. She is a true professional, is extremely supportive, and always has exceptional insight. It is with great appreciation to Elizabeth, who saw this project through from conception to completion, that I give my heartfelt thanks!

Special thanks to my husband, Nathan Davidson, CFNP, who also provided support and expertise in content. His unending support and encouragement are always appreciated and valued. My mom, Geri Lewis, is always my best cheerleader and provides support and encouragement, and lends a hand caring for four active grandchildren to ensure I meet deadlines for my work projects. My father, Harry McPhee, and my “little” brother, Chet McPhee, remain avid supporters of all my work, and their ongoing encouragement is frequent and always appreciated.

My own personal experience with newborns lies with having the absolute joy of bringing home four beautiful babies: Hayden, Chloe, Caroline, and Grant, who have taught me more in their young lives than any professional education or professor could ever provide. My youngest child, Grant, was born at 30 gestational weeks and suffered spastic quadriplegia, giving me direct personal experience with unexpected birth outcomes, which over the years has enabled me to possess a greater understanding of the absolute critical need for empathy, resilience, and hope—critical attributes that families facing these unique challenges truly need. My son is a child who illustrates incredible personal strength, presents
with remarkable courage, and never gives up; he chooses to conquer life’s struggles with grace, persistence, and determination. He has taught me a great deal about the experiences of unexpected outcomes, birth defects, and losses faced by some parents. He is truly a blessing who has been an inspiration not only to me, but to everyone who has encountered him in his or her life’s journey. Our journey and his life are a testament to how one learns from life’s greatest challenges and finds the silver lining in what seems like life’s gravest events!
Share

Fast Facts for the Neonatal Nurse: A Nursing Orientation and Care Guide in a Nutshell
Physiological Adaptations to Birth

The newborn undergoes drastic physiological changes at the time of birth. The neonatal transition period represents the hours following birth when the respiratory and cardiovascular systems stabilize. Other systems may take longer to become fully functioning after birth. The nurse provides ongoing observation and performs frequent assessments during this period to ensure underlying pathological alterations are not present that could interfere with the newborn’s successful adaptation to extrauterine life.

During this part of the orientation, the nurse will be able to:

1. Identify normal and abnormal assessment findings in the newborn
2. Describe the changes required by each body system for successful adaptation to extrauterine life
3. Discuss the respiratory and cardiovascular changes that occur during the transition to extrauterine life and during stabilization
4. Describe how various factors affect the newborn’s blood values
5. Understand the steps involved in excretion of bilirubin in the newborn and discuss the reasons a newborn may develop jaundice
6. Describe the functional ability of the newborn’s liver and gastrointestinal tract
7. Discuss reasons a newborn’s kidneys have difficulty maintaining fluid and electrolyte balance
8. List the immunologic responses of the newborn
9. Describe the normal sensory abilities and behavioral states of the newborn

EQUIPMENT

Stethoscope, measuring tape, scale, thermometer.

RESPIRATORY SYSTEM

Physiology of the Respiratory System

- The development of the respiratory system in utero begins with differentiation of structures into pulmonary, vascular, and lymphatic structures.
- Fetal breathing movements, in utero practice respiratory movements, begin by 17 to 20 weeks.
- Beginning at 20 weeks, alveolar ducts begin to develop.
- By 24 to 28 weeks, alveoli differentiate into type I cells, which aid in gas exchange, and type II cells, which produce and store surfactant.
- At 28 to 32 weeks, surfactant production significantly increases, which aids in the lungs’ ability to expand and is vital during extrauterine respiration.

Physiological Adaptations Following Birth

- Initiation of neonatal breathing at birth
  - Lung fluid production decreases 24 to 26 hours prior to birth.
  - Lung expansion occurs at the time of birth.
  - Increase in pulmonary circulation occurs.
Mechanical stimuli
- Fetal gasp occurs during expulsion and is initiated by a central nervous system trigger in response to the sudden change in pressure and temperature.
- Fetal chest compression and chest recoils occur during expulsion.
- With neonatal exhalation and crying against a partially closed glottis, positive intrathoracic pressure occurs.
- Fluid is absorbed into the lymphatic system and capillaries as lung expansion occurs.

Chemical stimuli
- Transitory asphyxia occurs due to:
  - Increase in PCO₂
  - Decreases in pH and PO₂
  - Stimulation of the aortic and carotid chemoreceptors triggers the respiratory system in the medulla.
  - Prostaglandin levels drop when the cord is cut.

Other stimuli
- Changes in temperature stimulate skin sensors and rhythmic respirations occur.
- Environmental components include tactile, auditory, visual, and pain stimuli.

Indicators of Initial Normal Functioning
- Respiratory rate 30 to 60 breaths/minute
- Diaphragmatic breathing
- Initially shallow
- Irregular in depth and rhythm

Newborns born via cesarean birth may have an increased amount of fluid in their lungs and need observation for neonatal transition, and require additional bulb suctioning.
Indicators of Abnormal Functioning

- Respiratory rate less than 30 or greater than 60 breaths/minute
- Irregular depth (persistently shallow) and irregular rhythm
- Nasal flaring
- Chest retractions
- Generalized cyanosis

**FAST FACTS in a NUTSHELL**

The newborn is an obligatory nose breather and any obstruction can lead to respiratory distress; it is essential that the nurse monitor for any signs of distress.

**CARDIOVASCULAR SYSTEM**

**Physiology of the Cardiovascular System**

- Cardiovascular development begins to occur within 3 weeks of the last menstrual period (LMP), when circulation begins and the structure of the heart begins to form.
- By 4 weeks, the tubular heart beats, beginning at 28 days (post-LMP), and circulation to the fetus and placenta occurs, although detection of the fetal heart rate typically does not occur until 6 to 7 weeks.
- Atrial division occurs at 5 weeks, and the chambers are clearly defined by 6 weeks.
- By 8 weeks, the heart is fully formed and functioning.

**Physiological Adaptations Following Birth**

- The initial breath at birth decreases pulmonary vascular resistance, increasing blood flow to the lungs.
- Blood returning from the pulmonary veins increases pressure in the right atrium.

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• When the umbilical cord is clamped, umbilical venous blood flow stops completely, dropping pressure in the right atrium and increasing systemic vascular resistance.
• Complete transition from fetal circulation to neonatal cardiopulmonary adaptation involves multiple processes (Table 1.1).

### TABLE 1.1 Physiological Cardiac Changes From Fetal to Newborn Circulatory System

<table>
<thead>
<tr>
<th>Physiological Shift in Cardiac Functioning</th>
<th>Physiological Process That Occurs With Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased aortic pressure</td>
<td>Umbilical cord clamping reduces the intravascular space and halts perfusion to the umbilical cord</td>
</tr>
<tr>
<td>Decreased venous pressure</td>
<td>Aortic blood flow increases, which accommodates the systemic circulatory needs</td>
</tr>
<tr>
<td></td>
<td>Blood flow to the inferior vena cava decreases</td>
</tr>
<tr>
<td></td>
<td>Decreased right atrial pressure occurs</td>
</tr>
<tr>
<td></td>
<td>Small reduction in venous circulation occurs</td>
</tr>
<tr>
<td>Increased systemic pressure</td>
<td>Increase in systemic pressure with circulation no longer needed for the placenta</td>
</tr>
<tr>
<td>Decreased pulmonary artery pressure</td>
<td>Lung expansion increases pulmonary circulation as the pulmonary blood vessels dilate, which decreases pulmonary artery resistance</td>
</tr>
<tr>
<td></td>
<td>Systemic vascular pressure increases to increase systemic perfusion</td>
</tr>
<tr>
<td>Closure of foramen ovale</td>
<td>Closure occurs with a shift in the arterial pressure, which stops the shunting of blood between atria</td>
</tr>
<tr>
<td></td>
<td>Right atrial pressure drops in response to decreasing vascular resistance and increased pulmonary blood flow</td>
</tr>
<tr>
<td></td>
<td>Functional closure of the foramen ovale occurs after birth at 1–2 hours of age; however, complete closure does not occur until approximately 30 months</td>
</tr>
<tr>
<td></td>
<td>During crying, hypothermia, cold stress, hypoxia, or acidosis, the foramen ovale could reopen, causing a right-to-left shunt to occur</td>
</tr>
</tbody>
</table>

(continued)
**Indicators of Initial Normal Functioning**

- Initial cardiac rate is 110 to 180 beats per minute (bpm) but can be as high as 180 due to initial crying effort.
- Resting heart rate between 110 and 160 bpm
- During certain activity periods, bpm can vary
  - Deep sleep state can be as low as 80 to 100 bpm
  - Active awake state can be up to 180 bpm
- Regular rhythm and rate
- Peripheral pulses should be palpable and bilaterally equal, although pedal pulses may be difficult to palpate.
- Capillary refill time is 2 to 3 seconds.
- Blood pressure (BP) tends to be higher immediately after birth and then decreases by around 3 hours of age. It rises and stabilizes within 4 to 7 days to approximate the initial level reached immediately after birth. The average mean BP is 42 to 60 mmHg in the resting full-term newborn over 3 kg.
- Heart murmurs may be present as the circulation transfers from a fetal to neonatal state and are usually due to the incomplete closure of the ductus arteriosus or foramen ovale.

---

**TABLE 1.1 Physiological Cardiac Changes From Fetal to Newborn Circulatory System (continued)**

<table>
<thead>
<tr>
<th>Physiological Shift in Cardiac Functioning</th>
<th>Physiological Process That Occurs With Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closure of the ductus arteriosus</td>
<td>Pulmonary vascular pressure increases pulmonary blood flow by reversing the blood flow through the ductus arteriosus Increased levels of oxygen cause the ductus arteriosus to constrict Functional closure occurs 10–15 hours after birth, with complete closure occurring by 4 weeks</td>
</tr>
<tr>
<td>Closure of the ductus venosus</td>
<td>Mechanical pressures occur when the umbilical cord is clamped, blood is redistributed, and cardiac output increases, resulting in blood flow to the liver Functional closure occurs within 2 months</td>
</tr>
</tbody>
</table>
Indicators of Initial Abnormal Functioning

- Cardiac rates less than 110 or above 180 bpm
- Heart rate less than 90 bpm that does not increase with stimulation (heart block)
- Irregular rate and rhythm
- Reduction in upper extremity pulses (poor cardiac output or peripheral vasoconstriction)
- Absence of pedal pulses (poor cardiac output or peripheral vasoconstriction)
- Prolonged capillary refill time of greater than 4 seconds
- Cyanosis
  - Cyanosis is momentarily relieved by crying (choanal atresia)

Physiology of the Hematological System

- During fetal development, rudimentary blood moves through primitive vessels connecting to the yolk sac and chorionic membranes at 7 gestational weeks.
- The arterial system develops mainly from the aortic arches.
- The venous system emerges from three bilateral veins and is completed by the eighth gestational week.

Physiological Adaptations Following Birth

- Increase in catecholamines results in increased cardiac output required for maintaining increased metabolic oxygen needs related to thermogenesis, breathing, and feeding demands.
- Fetal right-sided dominance switches to left-sided dominance by 3 to 6 months of age.
- Fetal hemoglobin (HgF) is replaced with adult hemoglobin (HgA) by 6 months of age. The hemoglobin levels decline during the first 2 months of life, leading to a phenomenon known as physiological anemia of the newborn. The lowest hemoglobin level occurs around 3 months of age and is called the physiologic nadir.
Normal Newborn Laboratory Values

- Red blood cell (RBC) production and survival are lower in the newborn than in adults. The average neonatal RBC has a life span of 60 to 80 days (two thirds the life span of adult RBCs).
- Normal blood volume ranges from 80 to 90 mL/kg.
- White blood cell (WBC) count ranging from 10,000 to 30,000/mm$^3$ with polymorphonuclear leukocyte (PMN) predominance.
- Iron stores will be used to produce new RBCs, which means most infants will require supplemental iron to maintain adequate iron stores.
  - By the sixth month, bone marrow has become the chief site of blood formation.
- Leukocytosis is a normal finding due to the stress of birth and the subsequent increased production of neutrophils during the first few days of life. Neutrophils then decrease by around 2 weeks of age.
- Blood volume varies based on the amount of placental volume received during delivery. It can be altered by delayed cord clamping, gestational age, prenatal or perinatal hemorrhage, and the site of lab draw on the newborn.
- Electrolyte values change based on the age of the newborn (Table 1.2).

**FAST FACTS in a NUTSHELL**

It is always advisable to keep in mind the reference ranges from your own laboratory.

- Glucose 40 to 60 mg/dL for first 24 hours, then 50 to 90 mg/dL.
  - Low blood sugar of 40 to 45 mg/dL requires treatment.

**FAST FACTS in a NUTSHELL**

Hemoglobin levels in the newborn fall primarily due to a decrease in red blood cell mass rather than from the increasing plasma volume, causing a dilution.
<table>
<thead>
<tr>
<th>Value</th>
<th>Sodium (mEq/L)</th>
<th>Potassium (mEq/L)</th>
<th>Chloride (mEq/L)</th>
<th>Calcium (mmol/L)</th>
<th>Calcium (mmol/24 hours)</th>
<th>Phosphate (mmol/L)</th>
<th>Magnesium (mmol/L)</th>
<th>Urea (mmol/L)</th>
<th>Creatinine (mmol/L)</th>
<th>C-reactive protein (mg/L)</th>
<th>Lactate (mmol/L)</th>
<th>Albumin (g/L)</th>
<th>Thyroid-stimulating hormone</th>
<th>Cortisol (nmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cord</td>
<td>147 (126–166)</td>
<td>7.8 (5.6–12)</td>
<td>103 (98–110)</td>
<td>2.33 (2.1–2.8)</td>
<td>—</td>
<td>1.8 (1.2–2.6)</td>
<td>—</td>
<td>10.4 (7.5–14.3)</td>
<td>—</td>
<td>&lt; 7</td>
<td>1.5–4.5</td>
<td>1.5–4.5</td>
<td>200–700</td>
<td>200–700</td>
</tr>
<tr>
<td>1–12 hr</td>
<td>143 (124–156)</td>
<td>6.4 (5.3–7.3)</td>
<td>101 (80–111)</td>
<td>2.1 (1.8–2.3)</td>
<td>1.97 (1.1–2.8)</td>
<td>1.84 (0.9–2.6)</td>
<td>1.91 (1.0–2.8)</td>
<td>11.8 (3.2–22.5)</td>
<td>11.4 (4.6–27.5)</td>
<td>&lt; 7</td>
<td>—</td>
<td>1.5–4.5</td>
<td>28–300</td>
<td>28–300</td>
</tr>
<tr>
<td>12–24 hr</td>
<td>145 (132–159)</td>
<td>6.3 (5.3–8.9)</td>
<td>102 (92–114)</td>
<td>1.95 (1.7–2.4)</td>
<td>1.05–1.37</td>
<td>1.84 (0.9–2.6)</td>
<td>1.91 (1.0–2.8)</td>
<td>11.8 (3.2–22.5)</td>
<td>11.4 (4.6–27.5)</td>
<td>&lt; 7</td>
<td>—</td>
<td>1.5–4.5</td>
<td>28–300</td>
<td>28–300</td>
</tr>
<tr>
<td>24–48 hr</td>
<td>148 (134–160)</td>
<td>6.0 (5.2–7.3)</td>
<td>102 (92–114)</td>
<td>2.0 (1.5–2.5)</td>
<td>1.05–1.37</td>
<td>0.72–1.00</td>
<td>0.81–1.05</td>
<td>11.1 (5.4–24.3)</td>
<td>0.04–0.11</td>
<td>&lt; 7</td>
<td>—</td>
<td>1.5–4.5</td>
<td>28–300</td>
<td>28–300</td>
</tr>
<tr>
<td>48–72 hr</td>
<td>149 (139–162)</td>
<td>5.9 (5.0–7.7)</td>
<td>103 (93–112)</td>
<td>1.98 (1.5–2.4)</td>
<td>—</td>
<td>1.20–1.48</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&gt; 3 days</td>
<td></td>
<td></td>
<td>5.9 (5.0–7.7)</td>
<td>1.98 (1.5–2.4)</td>
<td>—</td>
<td>1.20–1.48</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

**TABLE 1.2 Blood Electrolyte Values for Term Infants**
<table>
<thead>
<tr>
<th>Value</th>
<th>Cord</th>
<th>1–12 hr</th>
<th>12–24 hr</th>
<th>24–48 hr</th>
<th>&gt; 3 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-hydroxyprogesterone (nmol/L)</td>
<td>—</td>
<td>—</td>
<td>0.7–12.4</td>
<td>0.7–12.4</td>
<td></td>
</tr>
<tr>
<td>Hemoglobin (g/L)</td>
<td>168</td>
<td>184</td>
<td>178</td>
<td>170</td>
<td></td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>53</td>
<td>58</td>
<td>55</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Mean corpuscular volume</td>
<td>107</td>
<td>108</td>
<td>99</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Reticulocytes (%)</td>
<td>3–7</td>
<td>3–7</td>
<td>1–3</td>
<td>0–1</td>
<td></td>
</tr>
<tr>
<td>White cell count ($10^9$/L)</td>
<td>11.1 (6–26)</td>
<td>11.1 (6–26)</td>
<td>11.5 (5–21)</td>
<td>12.2 (5–21)</td>
<td></td>
</tr>
<tr>
<td>Neutrophils ($10^9$/L)</td>
<td>11.5 (5–21)</td>
<td>11.5 (5–21)</td>
<td>15.5 (6–28)</td>
<td>22.8 (13–38)</td>
<td></td>
</tr>
<tr>
<td>Lymphocytes ($10^9$/L)</td>
<td>5.8 (2–11)</td>
<td>5.8 (2–11)</td>
<td>5.5 (2–11)</td>
<td>5.5 (2–11)</td>
<td></td>
</tr>
<tr>
<td>Monocytes ($10^9$/L)</td>
<td>1.2</td>
<td>1.1</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Eosinophils ($10^9$/L)</td>
<td>0.5</td>
<td>0.4</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Prothrombin time (sec)</td>
<td>11–14</td>
<td>11–14</td>
<td>11–14</td>
<td>11–14</td>
<td></td>
</tr>
<tr>
<td>Activated partial thromboplastin time (sec)</td>
<td>23–35</td>
<td>23–35</td>
<td>23–35</td>
<td>23–35</td>
<td></td>
</tr>
</tbody>
</table>
Physiology of the Hepatic System

- Human liver development begins during the third week of gestation; however, it is not fully mature until around 15 years of age. It reaches its largest relative size, about 10% of fetal weight, around the ninth week gestation and is about 5% of body weight in the healthy full-term neonate.

Physiological Adaptations Following Birth

The newborn’s liver plays a vital role in the following processes:

- Iron storage for new RBC production
  - Prenatally, if the mother’s iron intake has been adequate, there is enough iron stored to last 5 months. At around 6 months of age, food containing iron and/or iron supplements must be added to the infant’s diet.

- Coagulation
  - The absence of normal flora needed to synthesize vitamin K results in low levels of vitamin K and creates a transient blood coagulation alteration between the second and fifth days after birth.
Carbohydrate metabolism

- The newborn cord blood glucose level is 15 mg/dL lower than maternal blood glucose. The newborn’s carbohydrate reserve is relatively low, and during the first 2 hours of life the serum blood glucose level declines and then begins to rise, reaching a steady state by about 3 hours. If the fetus experiences hypoxia or stress, the glycogen stores are used and may be depleted. Glucose is the main source of energy in the first 4 to 6 hours of life.

Conjugation of bilirubin

- Conjugation is the conversion of bilirubin from the yellow fat-soluble, unconjugated/indirect form into a water-soluble, excretable/direct form.
  - Unconjugated bilirubin (fat soluble) is a potential toxin that is not an excretable form of bilirubin and must be conjugated (made water soluble) in order to be excreted from the body.
  - Unconjugated bilirubin is a breakdown product derived from the heme portion of hemoglobin that is released from destroyed RBCs.
- Physiological jaundice: occurs after the first 24 hours of life.
  - Physiological hyperbilirubinemia is a buildup of bilirubin due to the normal hemolysis of red blood cells that were needed for fetal circulation before birth and discarded afterward. The imbalance of an immature liver and an overabundance of bilirubin to process allows the yellow pigment from hemolyzed red cells to accumulate in the blood and give the skin and sclera the yellow tone we call jaundice.
  - About 50% of all infants exhibit signs of jaundice in the 2 to 3 days after birth due to decreased glucuronyl transferase.
- Pathological jaundice occurs before 24 hours of life.
  - Pathological hyperbilirubinemia is related to a condition other than normal newborn bilirubin being processed slowly by an immature liver. Such
conditions include an incompatibility between the baby’s and the mother’s blood types, incompatibility of additional blood factors, or liver problems. There is actual pathology involved that might require more aggressive and lengthier intervention than physiological bilirubin problems.

**FAST FACTS in a NUTSHELL**

In utero, the fetus lives in a state of relative hypoxia, with a PaO₂ of approximately 35 mmHg, compared to 80 mmHg for a healthy child or adult. To maximize the oxygen-carrying capacity of the blood, the fetus produces more RBCs, with a hematocrit level up to 60 being normal.

At birth, the newborn’s PaO₂ is increased, thus the excess RBCs are no longer needed for oxygen-carrying capacity, and they begin to break down. This is a normal, physiologic change that occurs at birth. The breakdown of these RBCs releases bilirubin into the bloodstream.

If something causes an excessive number of RBCs to break down (such as ABO or Rh incompatibility, birth trauma, or infection) or impairs the baby’s ability to pass bilirubin out of the gastrointestinal tract (nothing orally [NPO], delayed stooling, or meconium ileus), the bilirubin level rises. Bilirubin levels at birth are about 3 mg/dL and should not exceed 12 mg.

**FAST FACTS in a NUTSHELL**

Nursing care should include keeping the newborn well hydrated and promoting early and frequent elimination. Early feedings tend to keep bilirubin levels down by stimulating intestinal activity, thus removing the contents and not allowing reabsorption.

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GASTROINTESTINAL SYSTEM

Physiology of the Gastrointestinal System

• In utero, fetal swallowing, gastric emptying, and intestinal peristalsis occur. By the end of gestation, peristalsis is much more active in preparation for extrauterine life. Fetal peristalsis is also stimulated by anoxia, and low oxygen states in utero (postterm, placental insufficiency, fetal stress, umbilical cord compromise) can cause a premature meconium stool in utero.
• By 36 to 38 weeks of fetal life, the gastrointestinal (GI) system is sufficiently mature to support extrauterine life.

FAST FACTS in a NUTSHELL

Digestion of protein and carbohydrates is adequate; however, fat digestion and absorption are poor due to the absence of adequate pancreatic enzymes.

Physiological Adaptations Following Birth

• The newborn’s stomach holds about 50 to 60 cc and can pass meconium 24 to 48 hours after birth.
• Permeability—The newborn’s intestines lack the protective mucosal barrier that helps seal off the intestines, decreasing the risk of both bacteria and potential allergens permeating through the intestine into the bloodstream.
• Digestive enzymes—The newborn pancreas does not produce the enzymes, such as amylase, needed to digest complex carbohydrates or starches until around age 3 months. Newborns also produce less lipase during the first year of life.
• The lower esophageal sphincter is still immature and therefore opens more easily than it will later in life. This allows a small amount of food to reflux up. Infants who fail to gain weight due to a large amount of reflux should be further evaluated for gastroesophageal reflux disease.
Indicators of Initial Normal Functioning

- There is a normal physiologic weight loss in the newborn of around 6% to 10% (loss of body water) due to:
  - Diuresis
  - Expulsion of meconium
  - Withholding of water and calories
- The newborn should gain between .5 to 1 ounce per day, double its birth weight by 5 to 6 months of age, and triple birth weight by 1 year of age.
- The normal newborn’s pattern of elimination
  - Stools—Meconium is stool that contains epithelial cells, bile, and amniotic fluid. In 90% of normal newborns, meconium stools occur within 24 hours of life. This is a black, tarry stool that will transition to brownish green. Transitional stools are part meconium and part fecal stool from digestion of milk. Formula-fed infants will pass two to three bright-yellow stools per day that may appear “seedy” and may have a strong odor, depending on the type of formula. Breastfed infants will pass several small light-yellow stools per day with little or no odor. Formula-fed infants’ bowel movements (BMs) will be the consistency of toothpaste, whereas breastfed infants’ BMs will remain quite loose as there is little that is not digested. A newborn who does not pass meconium within 24 to 48 hours of birth should be examined for the possibility of imperforate anus, meconium ileus, bowel obstruction, or cystic fibrosis.

URINARY SYSTEM

Physiology of the Kidneys and Urinary System

- Urine production occurs in utero as early as the fourth month, and there are functioning nephrons by 34 to 36 weeks gestation. The glomerular filtration rate of the newborn’s kidney is low. The ability to concentrate and dilute urine is attained by 3 months of age; however, before that, monitoring of fluid therapy to prevent overhydrating or dehydration is necessary.
Physiological Adaptations Following Birth

- Many newborns void immediately after birth and 90% by 24 hours of life. A newborn who has not voided by 48 hours of life should be evaluated for adequacy of fluid intake or urinary/bladder abnormality or dysfunction.
- Normal urine is straw colored and odorless.
- In the first 2 days of life the newborn will void two to six times a day, with a urine output of 15 mg/kg/day. Subsequently, the newborn will void between 6 and 25 times every 24 hours, with a urine output of 25 mg/kg/day.
- Following the initial void the newborn’s urine is frequently cloudy, due to mucus and a high specific gravity. Pink-stained urine, called “brick dust spots,” will occasionally be seen. These are caused by urates and are harmless. Blood may also be observed on the diapers of female newborns. Pseudomenstruation is related to the maternal withdrawal of hormones.

IMMUNOLOGICAL SYSTEM

Physiology of the Immune System

The newborn’s immune system is not initiated until after birth. Due to the newborn’s limited inflammatory response, there is a failure to recognize and therefore respond to bacteria. This is why the signs and symptoms of infection in the newborn are often subtle and nonspecific.

Of the three major types of immunoglobulins (IgG, IgA, IgM), only IgG is able to cross the placenta. Newborns have what is termed passive acquired immunity against viruses to which the mother had antibodies (diphtheria, poliomyelitis, measles, mumps, varicella, tetanus, rubella, smallpox), as a result of maternal IgG that crossed the placenta. These passive maternal immunoglobulins are primarily transferred during the third trimester of pregnancy; therefore, preterm infants may be more susceptible to infection.
Although newborns are able to produce or mount a response to antigens and begin development of antibodies, their immunity is not as effective as in an older child’s. Because of this, it is customary to wait to begin the majority of routine immunizations until 2 months of age, when the infant can develop active acquired immunity more efficiently.

**FAST FACTS in a NUTSHELL**

Active acquired immunity—the mother forms antibodies in response to illness or immunization. Passive acquired immunity—transfer of immunoglobulins to the fetus in utero (IgG production begins at 20 weeks gestation) or to the infant via breast milk.

**Physiological Adaptations Following Birth**

**FAST FACTS in a NUTSHELL**

There is little immunity to herpes simplex virus (HSV), so caretakers with an active HSV infection need to wear a mask and gloves.

**NEUROLOGICAL SYSTEM**

**Physiology of the Neurological System**

- Rapid growth of the fetal brain during the last half of fetal life, with peak near time of birth

**Physiological Adaptations Following Birth**

Babies move through several transition periods in the first 6 hours after birth as their systems change and stabilize.
The newborn’s response to stimuli is simple.

**Behavioral States**

1. Quiet sleep  
   Deep sleep, no eye movement, respirations quiet and slower
2. Active sleep  
   Rapid eye movements, may move extremities or stretch
3. Drowsy  
   Transitional period, yawns, eyes glazed
4. Quiet alert  
   Infant able to focus on objects or people, tuned in to environment
5. Active alert  
   Restless, starting to fuss, faster respirations, more aware of discomfort

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**First alert period**: (15–30 minutes after birth) Baby is alert, respirations irregular, responds vigorously to stimulation

**Resting period**: (30–120 minutes after birth) Color and vital signs are stabilizing, baby sleeps and is difficult to arouse

**Second alert period**: (4–8 hours after birth) Awakening, becoming responsive to stimuli again, may have a lot of mucus to clear

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**Senses**

- **Touch**: The most significant sense in the newborn for the first few weeks of life.
- **Vision**: Newborns can see objects 8 to 12 inches from their eyes. Newborns are most drawn to faces, particularly the eyes. They are able to follow objects to center of visual field. They prefer yellow and red objects and will regard moving objects and changing light intensity.
- **Hearing**: The newborn will turn toward the sound of a voice and tends to be more alert to a high-pitched voice.
- **Taste**: They are able to discriminate between sweet/nonsweet.
- **Smell**: The newborn’s ability to smell increases over the first few days of life. The newborn is able to identify mom’s breast milk.

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**Indicators of Initial Normal Functioning**

Newborn or infant reflexes are reflexes that are normal in infants but abnormal in other age groups. Normal newborn reflexes include:

<table>
<thead>
<tr>
<th>Reflex</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moro</td>
<td>Infant’s head is gently lifted and then released suddenly, falling backward for a moment. The normal response is for the baby to have a startled look and arms should move sideways with the palms up and thumbs flexed. The baby may cry for a minute.</td>
</tr>
<tr>
<td>Reflex</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Suck</td>
<td>Sucks when area around mouth is touched.</td>
</tr>
<tr>
<td>Startle</td>
<td>Pulls arms and legs in after hearing a loud noise.</td>
</tr>
<tr>
<td>Step</td>
<td>Stepping motions when sole of foot touches hard surface.</td>
</tr>
<tr>
<td>Tonic neck (fencing position)</td>
<td>When you move the head of a child who is relaxed and lying on his back to the side, the arm on the side where the head is facing reaches straight away from the body with the hand partly open. The arm on the side away from the face is flexed and the fist is clenched tightly. Turning the baby’s face in the other direction reverses the position.</td>
</tr>
<tr>
<td>Galant (truncal incurvation)</td>
<td>Occurs when you stroke or tap along the side of the spine while the infant lays on the stomach. The infant will twitch his or her hips toward the touch in a back-and-forth motion.</td>
</tr>
<tr>
<td>Grasp</td>
<td>Occurs if you place a finger on the infant’s open palm. The hand will close around the finger. Trying to remove the finger causes the grip to tighten.</td>
</tr>
<tr>
<td>Rooting</td>
<td>When you stroke the infant’s cheek, the infant will turn toward the side that was stroked and begin to make sucking motions.</td>
</tr>
<tr>
<td>Parachute</td>
<td>Occurs in slightly older infants; when you hold the child upright and then rotate his body quickly face forward (as if falling), the baby will extend his arms forward.</td>
</tr>
<tr>
<td>Blinking</td>
<td>Blinks eyes when the eyes are touched or when a sudden bright light appears.</td>
</tr>
<tr>
<td>Cough</td>
<td>Coughs when the airway is stimulated.</td>
</tr>
<tr>
<td>Gag</td>
<td>Gags when the throat or back of the mouth is stimulated.</td>
</tr>
<tr>
<td>Sneeze</td>
<td>Sneeze when the nose is stimulated.</td>
</tr>
<tr>
<td>Yawn</td>
<td>Yawns when the body needs more oxygen.</td>
</tr>
</tbody>
</table>