Gather Clinical Information

CHAPTER 2

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Collecting and interpreting patient data via interview, physical examination, and review of x-rays constitutes the third largest topic on the TMC exam and is extensively covered in case simulations on the CSE. Thus, proficiency in this area is essential if you want to do well on these exams.

OBJECTIVES

In preparing for this section of the NBRC exams, you should demonstrate the knowledge needed to:

1. Interview patients to obtain information regarding the following:
   a. Level of consciousness, pain, emotional state, and ability to cooperate
   b. Breathing difficulties, exercise tolerance, and sputum production
   c. Smoking history and environmental exposures
   d. Activities of daily living
   e. Learning needs (e.g., literacy, culture, preferred learning style)
2. Assess a patient's overall cardiopulmonary status by inspection, palpation, percussion, and auscultation
3. Review and interpret chest and lateral neck radiographs

WHAT TO EXPECT ON THIS CATEGORY OF THE NBRC EXAMS

TMC exam: 13 questions; 2 recall, 7 application, and 4 analysis
CSE exam: indeterminate number of questions; however, exam I-B knowledge is a prerequisite to succeed on the CSE, especially on Information Gathering sections.

WHAT YOU NEED TO KNOW: ESSENTIAL CONTENT

Interviewing the Patient

Interviewing provides essential information about a patient's (1) level of consciousness, emotional state, and ability to cooperate; (2) experience of pain; (3) degree of dyspnea and exercise tolerance; (4) sputum production; (5) smoking history; (6) environmental exposures; (7) activities of daily living; and (8) learning needs.

Level of Consciousness, Emotional State, and Ability to Cooperate

- To quickly assess level of consciousness or "sensorium," ask patients for the time of day (time), where they are (place), and who they are (person).
- Alert patients are well oriented to time, place, and person—"oriented × 3."
- Common causes of disorientation include the following:
  - Neurologic injury
  - Sedation and analgesics (especially opioid)
  - Severe hypoxemia or hypercapnia
- *In general, only alert patients can fully cooperate and participate in their own care.*

You also should try to assess the emotional state of alert patients. A normal emotional state is evident when patients respond with changing facial expressions suitable to the conversation, describe

themselves as appropriately concerned about their condition, and appear either relaxed or moderately anxious. Patients in an abnormal emotional state typically appear depressed, overly anxious, or irritable. They may also have difficulty focusing and exhibit breathlessness, dizziness, trembling, palpitations, or chest pain. *In general, patients in an abnormal emotional state will be difficult to manage until their anxiety can be resolved.*

A more comprehensive but easy-to-apply assessment that includes evaluation of alertness is the AVPU Scale. AVPU stands for **A**lert; responds to **V**erbal stimulus; responds to **P**ain; **U**nresponsive. The following box outline the AVPU Scale criteria:

A	**Alert** and oriented. Signifies orientation to time, place, and person. Reported as "oriented × 1, 2, or 3," noting any disorientation—for example, "oriented × 2, unaware of time."
V	Responds to **Verbal** stimulus. Indicates that the patient only responds when verbally prompted. Note if the response is appropriate or inappropriate—for example, if you ask "What is your name?" and the answer is unclear or confused, you have obtained a verbal response, but the patient is not appropriately oriented.
P	Responds to **Pain**. If the patient does not respond to verbal stimuli, firmly pinch the patient's skin and note if there is a response (e.g., moaning or withdrawal from the stimulus).
U	**Unresponsive**. If the patient fails to respond to painful stimulus on one side, try the other. A patient who remains flaccid without moving or making a sound is unresponsive.

The Glasgow Coma Scale (GCS) provides the most objective assessment of consciousness (**Table 2-1**). To apply this scale, you assess the patient's eye, verbal, and motor responses and score each component on a numeric scale. You then sum the three values to yield a total score, with the lowest value being 3 (deep coma) and the highest value being 15 (fully alert). Relative impairment is interpreted as follows:

- Mild impairment: 13–15
- Moderate impairment: 9–12
- Severe impairment (coma): ≤ 8

Glasgow component scores are often reported in shorthand. For example, a Glasgow score recorded as "E3, V2, M2" indicates an Eyes rating of 3, a Verbal rating of 2, and a Motor rating of 2, for a total score of 7—indicating severe impairment.

Level of Pain

- To determine if an alert patient is experiencing pain, ask, "Are you having any pain or discomfort now?"
- If the answer is yes, then the patient is in pain.
- Have the patient rate severity on a scale of 0 (no pain) to 10 (the worst possible pain).
- Patients can use the same scale to pinpoint their maximum tolerable level of pain.

Table 2-1 Glasgow Coma Scale

	1	2	3	4	5	6
Eyes	Does not open eyes	Opens eyes in response to painful stimuli	Opens eyes in response to verbal stimuli	Opens eyes spontaneously	N/A	N/A
Verbal	Makes no sounds	Unintelligible speech	Utters inappropriate words	Confused, disoriented	Oriented, converses normally	N/A
Motor	Makes no movements (flaccid)	Extension in response to painful stimuli	Abnormal flexion in response to painful stimuli	Flexion/ withdrawal in response to painful stimuli	Localizes painful stimuli	Obeys commands

For young children or those unable to express themselves, you can interview family members to get information about behaviors the patient typically exhibits with pain and activities that may cause or worsen it. Without such information, you may have to rely on observing behaviors such as moaning or looking for facial expressions such as grimacing or tearing.

After you determine the severity of pain, you should assess how much it interferes with the patient's daily activities. To do so, use a similar 10-point scale, with 0 signifying "no interference" and 10 signifying "unable to carry out usual activities." *Whenever you encounter an interference rating greater than 4, report this finding to the patient's physician*.

Breathing Difficulties and Exercise Tolerance

The evaluation of patients' breathing difficulties (dyspnea, orthopnea, work of breathing) and exercise tolerance is a critical skill for all respiratory therapists (RTs).

Dyspnea is a patient's sensation of breathlessness. *Orthopnea* is a patient's sensation of uncomfortable breathing when lying down, which typically is relieved by sitting or standing up. Both dyspnea and orthopnea are associated with a variety of cardiac and pulmonary disorders.

The most common method used to quantify a patient's dyspnea is the Borg Scale (**Table 2-2**). Like the pain scale, the Borg Scale ranges from 0 to 10, with 0 representing no sensation of dyspnea and 10 representing maximal sensation. As indicated in Table 2-2, the Borg Scale can be used to assess a patient's dyspnea *or* degree of exertion and is always applied in association with a predefined level of activity (e.g., exercise test level, end of a 6-minute walk). To administer the Borg Scale, have the patient stop the activity, review the ratings, and select the number corresponding to the breathing difficulty being experienced at that moment.

Usually in combination with dyspnea, the following observations indicate that a patient is experiencing an abnormally high work of breathing:

- Tachypnea
- Thoracic–abdominal dyssynchrony or paradox ("see-saw" motion)
- Use of accessory muscles of respiration

The gold standard for assessing a patient's exercise tolerance is a graded cardiopulmonary exercise test. A less rigorous but very useful alternative for evaluating exercise tolerance is the 6-minute walk test (6MWT). Procedures for these tests are covered in Chapter 3, with their interpretation discussed in Chapter 4.

Table 2-2 Modified Borg Scale

Rating	For Rating Dyspnea	For Rating Exertion
0	Nothing at all	Nothing at all
0.5	Very, very slight (just noticeable)	Very, very weak (just noticeable)
1	Very slight	Very weak
2	Slight	Weak (light)
3	Moderate	Moderate
4	Somewhat severe	Somewhat strong
5	Severe	Strong (heavy)
6*		
7	Very severe	Very strong
8*		
9	Very, very severe (almost maximal)	Very, very strong (almost maximal)
10	Maximal	Maximal
*It allows the patient to choose a middle level of intensity between the preceding and subsequent level of intensity.		

Table 2-3 American Thoracic Society Breathlessness Scale*

Grade	Degree	Description of Breathlessness
0	None	Not troubled with breathlessness except with strenuous exercise
1	Slight	Troubled by shortness of breath when hurrying on level ground or walking up a slight hill
2	Moderate	Walks slower than people of the same age on level ground because of breathlessness or has to stop for breath when walking at own pace on level ground
3	Severe	Stops for breath after walking about 100 yards or after a few minutes on level ground
4	Very severe	Too breathless to leave the house or breathless when dressing and undressing
*Essentially the same as the Medical Research Council Breathlessness Scale (UK).		

A simpler measure for assessing exercise tolerance is the American Thoracic Society Breathlessness Scale (**Table 2-3**). By inquiring as to when a patient first notices breathlessness, you can assign a grade of 0–4 to the symptom, with a descriptive term indicating the degree of impairment.

Sputum Production

Sputum assessment should be included in patient history taking and also be conducted whenever secretion clearance takes place. Typically, you evaluate the volume, color, and consistency of sputum, as described later in this chapter.

When asking about sputum volume, use familiar measures such as a teaspoon (5 mL), tablespoon (15 mL), or shot glass full (1 oz or 30 mL). When collecting sputum, use a calibrated sputum cup for measurement. *As a rule of thumb, sputum production greater than 30 mL/day indicates the need for airway clearance.*

Smoking History

You should obtain the smoking history of all patients, including whether the habit involves primarily cigarettes, cigars, pipe smoking and electronic cigarettes. For former smokers, determine how long ago they quit. For current or former cigarette smokers, quantify their smoking history in *pack-years* as follows:

Pack-years = daily packs of cigarettes smoked × number of years smoking

Example: A 38-year-old patient has been smoking 1-1/2 packs per day for 20 years.

Pack-years = 1.5 × 20 = 30 pack-years

The number of cigarettes smoked per day (1 pack = 20 cigarettes) also is a good indicator of nicotine dependence, along with how soon after waking up the patient begins smoking. Patients who smoke more than one pack a day and those who must have their first cigarette upon waking are heavily nicotine dependent. Note that nicotine dependence can also occur in individuals who inhale nicotine vapor using electronic cigarettes ("vaping"). However, the health effects of vaping are not yet fully understood.

Environmental Exposure

Due to its importance in diagnosis, the occupational and environmental exposure history is often considered a separate category of the interview. The accompanying box outlines the key areas for questioning patients regarding their occupational and environmental exposure history.

Outline of Occupational and Environmental Exposure History

Part 1. Exposure Survey

A. Exposures

- Current and past exposure to metals, dust, fibers, fumes, chemicals, biologic hazards, radiation, or noise
- Typical workday (job tasks, location, materials, and agents used)
- Changes in routines or processes
- Other employees or household members similarly affected

B. Health and Safety Practices at Work Site

- Ventilation
- Personal protective equipment (e.g., respirators, gloves, and coveralls)
- Personal habits (Smoke and/or eat in work area? Wash hands with solvents?)

Part 2. Work History

- Description of all previous jobs, including short term, seasonal, part time, and military service
- Description of present jobs

Part 3. Environmental History

- Present and previous home locations
- Jobs of household members
- Home insulating and heating/cooling system
- Home cleaning agents
- Pesticide exposure
- Water supply
- Recent renovation/remodeling
- Air pollution, indoor and outdoor
- Hobbies (e.g., painting, sculpting, ceramics, welding, woodworking, automobiles, gardening)
- Hazardous wastes/spill exposure

Data from Carter W, et al. *Taking an exposure history.* Atlanta, GA: U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry; 2000.

Activities of Daily Living

Activities of daily living (ADLs) represent the basic tasks of everyday life. Measurement of ADLs is important because they are predictive of both healthcare use (such as hospital admissions) and outcomes (such as mortality).

The simplest measure of basic ADLs is depicted in **Table 2-4**, which addresses an individual's degree of independence with common self-care activities. Each of the six questions is answered as a "yes" or "no," with the scale score being the number of "yes" answers. A score of 6 indicates full function; 4, moderate impairment; and 2 or less, severe impairment. Patients unable to perform these activities usually require daily caregiver support.

Learning Needs

Patient education fosters healthy behaviors and increases patients' involvement in their healthcare decisions. It is also an essential component of disease management (Chapter 17).

The first step in patient education is assessment of the individual's learning needs, abilities, and readiness to learn. Normally, this is performed via a comprehensive educational assessment conducted upon admission to a care unit and documented in the patient's chart (**Figure 2-1).**

Table 2-4 Basic Activities of Daily Living

Category	Description	Independent?	
		Yes	No
1. Bathing	Receives no assistance or assistance in bathing only part of body	☐	☐
2. Dressing	Gets clothed and dresses without assistance except for tying shoes	☐	☐
3. Toileting	Goes to toilet room, uses toilet, and returns without any assistance (may use cane or walker for support and may use bedpan or urinal at night)	☐	☐
4. Transferring	Moves in and out of bed and chair without assistance (may use cane or walker)	☐	☐
5. Continence	Controls bowel and bladder completely by self (without occasional accidents)	☐	☐
6. Feeding	Feeds self without assistance (except for cutting meat or buttering bread)	☐	☐

Data from Katz S, DownsTD, Cash HR, et al. Progress in the development of the index of ADL. *Gerontologist*. 1970;10:20–30.

Patient/Family Education Record

Teaching/Learning Assessment	Assessment of Patient Ability to Learn	Assessment of Patient Readiness to Learn
Speaks English? ☐Y ☐N If no, primary language _____ Preferred learning method: ☐ Listening ☐ Television ☐ Doing ☐ Demonstration ☐ Reading ☐ Other (specify) _____	☐ No barriers noted ☐ Cannot assess Specific barriers noted: ☐ Physical ☐ Emotional ☐ Cognitive ☐ Motivational ☐ Cultural ☐ Language ☐ Religious ☐ Developmental ☐ Other: _____	Receptive to learning? Patient: ☐Y ☐N ☐NA Other ☐Y ☐N ☐NA (specify) _____ Capable of learning? Patient: ☐Y ☐N ☐NA Other ☐Y ☐N ☐NA

Date	What Was Taught	To Whom	How (Method)	Response	Signature

Acceptable Abbreviations

What	D/C = discharge instruction; EQ = equipment; REHAB = rehabilitation techniques; MED = drugs
To Whom	PT = patient; SP = spouse; PR = parent; SO = significant other (e.g., other family member, partner)
How	D = demonstration; T = television/video; V = verbal instructions; W = written materials
Response	AV = attentive verbal response; RD = return demonstration; DI = seems disinterested; NR = needs reinforcement

Figure 2-1 Example of a Patient/Family Educational Documentation Form. Such forms typically include assessment of the patient's learning ability and needs, as well as documentation of the education provided to meet those needs.

Courtesy of Strategic Learning Associates, LLC, Little Silver, New Jersey.

As indicated in Figure 2-1, you first determine whether any language barrier is present. If so, you may need to request a certified medical translator to interview the patient. The use of family members is strongly discouraged due to privacy concerns (among other issues) unless it is an emergency situation.

You then determine the patient's preferred learning method. To do so, have patients tell you about something they recently learned and how they learned it or how they would have liked to learn it. Hints as to preferred ways of learning also can be gleaned from questions about the patient's work and hobbies.

The next step is to identify any barriers affecting learning, as revealed by review of the record or via patient interview. **Table 2-5** outlines the most common barriers to learning and suggests ways to address them. Note the importance of gaining family assistance in overcoming many of these barriers.

In terms of health literacy—the ability of a person to understand and act on basic health information—a low educational level (less than high school completion) should raise a red flag. You also should suspect literacy problems in the following situations:

- The patient offers excuses when asked to read (e.g., left eyeglasses at home).
- The patient does not reorient the materials provided so that they are readable (e.g., leaves materials upside down).
- The patient identifies medications by their appearance (e.g., color or shape) rather than by name.
- The patient fails to take medications correctly or cannot describe how to take them.
- The patient has difficulty correctly filling out forms.

Differences in culture and/or religion also may create unique patient needs that providers should identify and address. Key guidelines in regard to determining cultural and spiritual needs include the following:

- Identify the patient's preferred language for discussing health care, either by
  - noting the patient's preferred language in the medical record;
  - asking the patient, "In what language do you prefer to discuss your health care?"; or
  - arranging for language services to help identify the patient's preferred language.

Table 2-5 Accommodating Common Barriers to Patient Learning

Barrier to Learning	Accommodations
Age (young child)	Keep teaching/learning episodes short. Use a "fun and games" approach. Enlist family assistance.
Reduced level of consciousness	Postpone until the patient becomes alert. Apply methods that don't require cooperation.
Presence of pain	Recommend analgesia. Postpone until pain management is effective.
Presence of anxiety	Postpone until anxiety management is effective. Enlist family assistance. Recommend anxiolytic (anti-anxiety) therapy.
Physical limitations	Ascertain specific limitations. Apply methods that circumvent the limitations. Enlist family assistance.
Educational level/health literacy	Assess for health literacy problems. Adjust language level and presentation (oral, written, visual) as appropriate.
Cultural, language, or religious factors	Ascertain key factors affecting care. Modify to accommodate. Enlist family assistance.
Vision difficulty	Have the patient wear glasses. Emphasize sound and touch. Enlist family assistance.
Hearing difficulty	Have the patient use a hearing aid. Emphasize visualization and touch. Enlist family assistance.

- Ask the patient if there are any cultural or religious practices that might affect treatment (e.g., dietary needs, prayer times).
- Determine if there are certain garments or religious items that need to be worn.
- Determine if anything in the hospital environment conflicts with the patient's cultural or spiritual beliefs (e.g., a crucifix); if so, either remove or cover the items
- Respect the patient's modesty/need for privacy by
  - arranging for culturally acceptable providers (e.g., by gender or age);
  - respecting any cultural or religion restrictions on touching or personal space;
  - exposing only body areas needed to examine or treat the patient;
  - providing privacy in toileting and other hygiene activities; and
  - using full gowns or robes for ambulation and transport.
- Determine if the patient engages in any alternative health practices (e.g., yoga exercises for asthma), and if not contraindicated, recommend that they be included in the care plan.
- If requested, make available a private area for prayer.
- Determine if there are specific times to avoid tests or procedures due to cultural or religious practices.
- Record any cultural or religious needs/preferences you identify in the patient's chart, and communicate these to other members of the care team.

After identifying barriers to learning, you should assess the patient's readiness to learn. Especially useful in this regard is the desire of patients to learn more about their condition. When patients are ready to learn, they tend to express discomfort with their current situation.

The last step is to determine the patient's learning needs as related to the care you will provide. To do so, you should ask the following questions, using language appropriate to the patient's ability to understand:

- Does the patient understand his or her current condition?
- Is the patient knowledgeable about his or her medications?
- Is the patient familiar with the procedures you will implement?
- Is the patient familiar with the equipment you plan to use?

If answers to any of these questions indicate a shortcoming or "knowledge gap," you have identified a learning need. In addition to identifying needs, you should determine the patient's "wants"—that is, any specific things the patient desires to learn. In combination, these needs and wants provide the basis for setting education goals.

As outlined in **Table 2-6**, how you evaluate a patient's learning depends on whether your focus was on improving knowledge, developing skills, or changing attitudes.

Like all patient interventions, patient education episodes should be documented in the medical record. Such documentation must include who was taught (patient and/or family), what was taught, how it was taught, and what relevant outcomes were achieved (Figure 2-1).

Assess a Patient's Overall Cardiopulmonary Status by Inspection

In regard to inspection, the NBRC expects candidates to be proficient in evaluating a patient's general appearance, examining the airway, and evaluating cough and sputum production. In addition, you should understand the basic procedures used to assess an infant's cardiopulmonary status.

Table 2-6 Evaluating Patient Learning

Change That You Are Evaluating	Method to Evaluate the Change
Patient knowledge	Teach-back (patients to repeat in their own words the information you are trying to get them to understand)
Patient skill level	Return demonstration (patients perform the procedure after you have demonstrated it to them)
Patient attitudes	Discussion with patient and/or family or observation of behavioral change

General Appearance

Table 2-7 summarizes the major observations arising from patient inspection.

Regarding cyanosis, the NBRC expects you to know the difference between the central and peripheral types, as follows:

- Central cyanosis
  - Indicates low Sa_{O_2} associated with poor oxygenation of the blood by the lungs
  - Usually evident as a bluish tint of the mucous membranes of the lips and mouth
  - With normal Hb content, generally first appears when Sa_{O_2} drops below 80% (Pa_{O_2} 45–50 torr)
- Peripheral cyanosis (aka *acrocyanosis*)
  - Due to poor blood flow
  - Tends to appear only in the extremities
  - Can occur with normal Sa_{O_2} saturation
  - When seen together with cool extremities, suggests circulatory failure

Table 2-7 Signs Observed During Patient Inspection and Their Implications

Sign	Observation	Potential Implications
General		
Body habitus	Weak/emaciated (cachexic)	General ill health/malnutrition
	Obesity (BMI > 30 kg/m^2)	Obstructive sleep apnea Obesity-hypoventilation syndrome
Position	Sitting/leaning forward	Respiratory distress
	Always elevated with pillows	Orthopnea, congestive heart failure (CHF)
Respiratory rate	Tachypnea	Respiratory distress, restrictive disease
Breathing pattern	Prolonged exhalation	Expiratory obstruction (asthma, COPD)
	Prolonged inspiration	Upper airway obstruction (croup, epiglottitis)
	Rapid and shallow	Loss of lung volume (atelectasis, fibrosis, ARDS, pulmonary edema)
	Kussmaul breathing (deep and fast)	Diabetic ketoacidosis
	Biot breathing (irregular breathing with periods of apnea)	Increased intracranial pressure
	Cheyne-Stokes breathing (waxing and waning)	CNS disease or severe CHF
Speech pattern	Interrupted	Respiratory distress
Skin	Diaphoretic (sweating)	Fever, increased metabolism, acute anxiety
	Mottled/acrocyanosis	Poor peripheral perfusion
Facial expression	Anxious	Fear, pain
Personal hygiene	Poor	Illness affecting patient's daily activities (ADLs)
Sensorium	Depressed	Poor cerebral oxygenation, degenerative brain disorders, drug overdose
Head/Neck		
Nose	Nasal flaring (especially in infants)	Increased work of breathing
Lips/oral mucosa	Central cyanosis	Arterial hypoxemia

(*continues*)

Table 2-7 Signs Observed During Patient Inspection and Their Implications (continued)

Sign	Observation	Potential Implications
Head/Neck		
Lips	Pursed-lip breathing	Expiratory airway obstruction
Jugular veins	Distended	Right heart failure (cor pulmonale)
Trachea	Not in midline	Atelectasis, pneumothorax, pleural effusion (large)
Neck circumference	> 43 cm (17 in.) men; > 37 cm (15 in.) women	Obstructive sleep apnea
Thorax		
Configuration	Barrel chest	COPD
	Kyphoscoliosis	Restrictive lung defect
	Pectus excavatum (sunken sternum)	Restrictive lung defect
Muscle activity	Accessory muscle use	Increased work of breathing, loss of normal diaphragm function
	Abdominal paradox	Diaphragmatic fatigue or paralysis, increased work of breathing
	Retractions	Reduced lung volume, decreased lung compliance, increased work of breathing
Extremities		
Digits	Clubbing	Bronchogenic carcinoma, COPD, cystic fibrosis, chronic cardiovascular disease
Capillary beds	Peripheral cyanosis (acrocyanosis)	Poor perfusion

ARDS = acute respiratory distress syndrome; BMI = body mass index; CNS = central nervous system; COPD = chronic obstructive pulmonary disease.

Regardless of type, the intensity of cyanosis increases with the amount of Hb in the blood. For this reason, patients with polycythemia can be cyanotic yet still have adequate O_2 content. Conversely, patients with anemia can be severely hypoxic before cyanosis ever appears.

Airway Assessment

Assessment of the airway can help identify the cause of other findings, such as snoring and sleep apnea. Airway assessment also can help determine whether special procedures or equipment will be needed for artificial airway insertion. To assess the airway, you should follow these steps:

1. Inspect the patient's external nose, noting any asymmetry or deformities.
2. Test for nasal patency by separately occluding each nostril as the patient breathes in.
3. Inspect the nasal cavities (use a nasal speculum and penlight if needed) for a deviated septum, polyps, edema, erythema, bleeding, or lesions.
4. With the patient's mouth open widely and the tongue extended, look for dentures or other dental appliances, and inspect the tongue, hard/soft palate, uvula, and tonsillar pillars.
5. Inspect the neck for length and circumference; have the patient flex and extend the neck as far as possible while you view the motion from the side.

Table 2-8 outlines the potential significance of the most common observations associated with the assessment of a patient's airway.

Cough and Sputum

Table 2-9 describes some of the common types of cough and their likely causes. As indicated in Table 2-9, several conditions are associated with a productive cough, such as chronic bronchitis,

Table 2-8 Inspection of the Airway

Area	Observation	Significance
Nostrils/ nasal cavity	Broken, misshapen, swollen nose; occluded nasal passages; deviated septum	Compromised nasal route for O_2 or airway insertion
Oral cavity and pharynx	Dentures or dental appliances present	Potential aspiration risk; may need to be removed for airway access
	Macroglossia (large tongue)	Associated with difficult intubation and may impair aerosol delivery via the mouth
	Mallampati classification of pharyngeal anatomy: Class 1: Full visibility of tonsils, uvula, and soft palate Class 2: Visibility of hard and soft palate, upper portion of tonsils, and uvula Class 3: Soft and hard palate and base of the uvula are visible Class 4: Only hard palate visible	Class 4 is associated with difficult intubation as well as a high incidence of sleep apnea
Neck	Short/thick (circumference > 43 cm [17 in.] men; > 37 cm [15 in.] women	Difficult endotracheal (ET) intubation; difficult tracheostomy tube fit
	Poor range of motion (patient cannot touch tip of chin to chest and/or cannot extend neck)	Difficult bag-valve-mask (BVM) ventilation; difficult ET intubation

Table 2-9 Common Types of Coughs with Likely Causes

Description	Likely Causes
Acute (< 3 weeks)	Postnasal drip, allergies, and infections (especially common cold, bronchitis, and laryngitis)
Chronic (> 3 weeks) or recurrent (adults)	Postnasal drip, asthma, gastroesophageal reflux, chronic bronchitis, bronchiectasis, chronic obstructive pulmonary disease (COPD), tuberculosis (TB), lung tumor, angiotensin-converting enzyme (ACE) inhibitors, congestive heart failure (CHF)
Recurrent (children)	Viral bronchitis, asthma, allergies
Barking	Epiglottitis, croup, influenza, laryngotracheal bronchitis
Brassy or hoarse	Laryngitis, laryngeal paralysis, laryngotracheal bronchitis, pressure on laryngeal nerve, mediastinal tumor, aortic aneurysm
Wheezy	Bronchospasm, asthma, cystic fibrosis, bronchitis
Dry/unproductive	Viral infections, inhalation of irritant gases, interstitial lung diseases, tumor, pleural effusion, cardiac conditions, nervous habit, radiation or chemotherapy
Dry progressing to productive	Atypical pneumonias, Legionnaires' disease, pulmonary embolus, pulmonary edema, lung abscess, asthma, silicosis, emphysema (late phase), smoking, AIDS
Chronic productive	Bronchiectasis, chronic bronchitis, lung abscess, asthma, fungal infections, bacterial pneumonias, TB
Paroxysmal (especially at night)	Aspiration, asthma, CHF
Positional, especially when lying down	Bronchiectasis, CHF, chronic postnasal drip or sinusitis, gastroesophageal reflux with aspiration
Associated with eating or drinking	Neuromuscular disorders affecting the upper airway, esophageal problems, aspiration
Data from Heuer, AJ and Scanlan CL. *Clinical Assessment in Respiratory Care* (7th ed.). St. Louis, MO: Mosby; 2013.	

infections, bronchiectasis, lung abscess, and asthma. Sputum assessment should be included in patient history taking and also be conducted whenever secretion clearance takes place. Typically, you evaluate the volume, color, consistency, and odor of sputum.

In terms of color, sputum is typically described as being either clear/white, pinkish, red, yellow, or green. Consistency is typically described as being thin/watery, frothy, or thick/viscous. Foul-smelling or *fetid* sputum suggests tissue necrosis. In combination, these characteristics help classify the sputum "type" as being mucoid, mucopurulent, purulent, or bloody and indicate the likely disorder (**Table 2-10**).

Neonatal Inspection

The NBRC expects you to be proficient in basic fetal/neonatal assessment methods, including Apgar scoring, evaluation of gestational age, and transillumination.

Apgar Score

The Apgar score (**Table 2-11**) is used to assess neonates at 1 and 5 minutes after birth. The score's five dimensions (**A**ppearance, **P**ulse, **G**rimace, **A**ctivity, **R**espirations) are rated from 0 to 2, with a maximum score of 10 and a minimum score of 0 (stillborn). An Apgar score of 7–10 is normal. Babies scoring 4–6 typically need more intensive support, and those scoring 0–3 usually undergo resuscitation. *Needed interventions should never be delayed to obtain the Apgar score.*

Gestational Age

Normal gestation lasts 38–42 weeks. Knowledge of gestational age can help clinicians anticipate perinatal problems and establish sound care plans. **Table 2-12** summarizes the methods commonly used to estimate gestational age *before* birth. After birth, clinicians determine gestational age by careful assessment of selected neuromuscular and physical characteristics using methods developed by

Table 2-10 Sputum Assessment

	Color and Consistency	Likely Conditions
Mucoid	Clear/white, thin to thick	Asthma
Mucopurulent	Clear to yellowish, thick	Chronic bronchitis, cystic fibrosis, pneumonia (blood streaked)
Purulent	Yellow to green, thick	Aspiration pneumonia, bronchiectasis (fetid/foul-smelling, may separate into layers), lung abscess (fetid/foul-smelling, may separate into layers)
Bloody	Pink to red/dark red, thin (unless coagulated)	Tuberculosis (red), lung cancer (red), pulmonary infarction (red), pulmonary edema (pink, watery, frothy)
Data from MacIntyre NR. Respiratory monitoring without machinery. *Respir Care.* 1990;35:546–553.		

Table 2-11 Apgar Score

Parameter	Acronym	0	1	2
Color	Appearance	Blue or pale	Pink body with peripheral cyanosis (acrocyanosis)	Completely pink
Heart rate	Pulse	Absent	$<$ 100 beats/min	$>$ 100 beats/min
Reflex irritability	Grimace	Unresponsive	Grimace when stimulated*	Active movement, crying, coughing
Muscle tone	Activity	Flaccid, limp	Some flexion of extremities	Active movement
Respiratory effort	Respirations	Absent	Slow, irregular, weak, gasping	Crying, vigorous breathing
*Catheter in nares or tactile stimulation.				

Table 2-12 Methods Used to Estimate Gestational Age Before Birth

Method	Measurement	Comments
Time since last menses	Weeks since end of last normal menstrual period + 2	Traditional but unreliable
Ultrasonography	1. Crown to rump length up to 14 weeks 2. Fetal head diameter (biparietal diameter) between 14 and 20 weeks' gestation	Accurate and reliable
Biochemical analysis (measurement of amniotic fluid phospholipid levels)*	1. Lecithin/sphingomyelin (L/S) ratio > 2.0 2. Presence of phosphatidylglycerol (PG) 3. Lecithin/albumin (L/A) ratio ≥ 40.0 mg/g	Fetal maturity indicated by L/S ratio > 2; presence of PG; or L/A ratio > 40.0 mg/g
*Used primarily to indicate fetal lung maturity and/or predict infant respiratory distress syndrome.		

Dubowitz and Ballard. Although RTs normally do not conduct this assessment, you should be familiar with the assessment components.

Figure 2-2 depicts the Ballard Gestational Age Assessment and scoring system. Scores are summed across both components to yield a composite score. A composite score of 10 or less indicates significant prematurity (≤ 28 weeks' gestation). An infant born at full term (38–42 weeks) typically scores in the 35–45 range, with higher values indicating a post-term baby.

Transillumination of Chest

Transillumination uses high-intensity fiber-optic light applied to the chest wall to detect pneumothoraces in infants. You should recommend transillumination for high-risk infants (especially those receiving mechanical ventilation) with clinical signs of pneumothorax—that is, retractions, tachypnea, cyanosis, hypotension, and asymmetrical chest motion.

The accompanying box outlines the basic procedure. Normally, a halo of only about 1 cm forms under the light. If the underlying chest broadly "lights up," a pneumothorax is likely. Note that if the test is negative but the infant still exhibits signs suggesting a pneumothorax, you should recommend an immediate chest x-ray.

Transillumination Procedure

1. Place the infant in the supine position and switch on the light.
2. Hold the light against the skin along the midaxillary line about halfway down the chest on the affected side.
3. Observe whether or not the chest illuminates (lights up). In a normal chest (no air present) an even, round shadow will be seen around the light ('halo' sign).
4. Repeat the assessment on the same side at the midclavicular line halfway down the chest.
5. Repeat the assessment on the opposite side of the chest to compare the degree of illumination.

Assess a Patient's Overall Cardiopulmonary Status by Palpation

You palpate a patient to (1) evaluate heart rate, rhythm, and force; (2) assess accessory muscle activity and tracheal position; (3) evaluate vocal/tactile fremitus; (4) estimate thoracic expansion; and (5) assess the skin and tissues of the chest and extremities.

Heart Rate, Rhythm, and Pulse Strength

To evaluate a patient's heart's rate, rhythm, and force, you should palpate both peripheral and apical pulses (over the precordium). You palpate the peripheral pulse to measure a patient's heart rate, typically using the radial artery. You palpate the apical pulse to assess the location and strength of the heart's point of maximum impulse (PMI).

Neuromuscular Maturity

	–1	0	1	2	3	4	5
Posture							
Square Window (wrist)	>90°	90°	60°	45°	30°	0°	
Arm Recoil		180°	140°–180°	110°–140°	90°–110°	<90°	
Popliteal Angle	180°	160°	140°	120°	100°	90°	<90°
Scarf Sign							
Heel to Ear							

Physical Maturity

Skin	Sticky; friable; transparent	Gelatinous; red; translucent	Smooth; pink; visible veins	Superficial peeling and/or rash; few veins	Cracking; pale areas; rare veins	Parchment; deep cracking; no vessels	Leathery; cracked; wrinkled
Lanugo	None	Sparse	Abundant	Thinning	Bald areas	Mostly bald	
Plantar Surface	Heel-toe 40–50 mm: –1 <40 mm: –2	>50 mm; no crease	Faint red marks	Anterior transverse crease only	Creases ant. 2/3	Creases over entire sole	
Breast	Imperceptible	Barely perceptible	Flat areola; no bud	Stippled areola; 1–2 mm bud	Raised areola; 3–4 mm bud	Full areola; 5–10 mm bud	
Eye/ear	Lids fused loosely: –1 tightly: –2	Lids open; pinna flat; stays folded	Slightly curved pinna; soft; slow recoil	Well-curved pinna; soft but ready recoil	Formed and firm; instant recoil	Thick cartilage; ear stiff	
Genitals Male	Scrotum flat; smooth	Scrotum empty; faint rugae	Testes in upper canal; rare rugae	Testes descending; few rugae	Testes down; good rugae	Testes pendulous; deep rugae	
Genitals Female	Clitoris prominent; labia flat	Prominent clitoris; small labia minora	Prominent clitoris; enlarging minora	Majora and minora equally prominent	Majora large; minora small	Majora cover clitoris and minora	

Maturity Rating

Score	Weeks
–10	20
–5	22
0	24
5	26
10	28
15	30
20	32
25	34
30	36
35	38
40	40
45	42
50	44

Figure 2-2 Ballard Gestational Age Assessment

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Normal references ranges for heart rates by age group are specified in Chapter 1. Based on this knowledge, you determine whether the rate is normal or whether the patient has tachycardia or bradycardia. **Table 2-13** outlines the most common causes of tachycardia and bradycardia.

To detect if the pulse is regular or irregular, you may need to palpate it for a full minute. Minor irregularities are common, particularly in children (sinus arrhythmia). If you detect an irregularity, repeat your assessment with a second clinician simultaneously measuring the apical rate via palpation or auscultation. If the apical rate exceeds the peripheral rate, a *pulse deficit* exists. A pulse deficit usually indicates a cardiac arrhythmia, such as atrial fibrillation or flutter, premature ventricular contractions (PVCs), or heart block.

Careful assessment of the peripheral pulse also can reveal variation in strength. **Table 2-14** summarizes the most common findings and their likely causes.

For apical pulse assessment, the following guidelines apply:

- Locate/palpate the heart's point of maximum impulse (PMI), normally at or near the fifth intercostal space, midclavicular line.
- A weak impulse may indicate hyperinflation (as with chronic obstructive pulmonary disease [COPD]) or decreased cardiac contractility.
- Abnormally strong pulsations or a downward/left shift of the PMI suggests left ventricular hypertrophy.
- The PMI moves when the mediastinum is displaced: *toward* areas of atelectasis and *away from* space-occupying lesions such as pneumothoraces or pleural effusions.

Table 2-13 Common Causes of Abnormal Heart Rate

Tachycardia	Bradycardia

• Fever
• Hypoxemia
• Pain
• Shock
• Anemia
• Cardiac arrhythmias
• Hyperthyroidism
• Thyrotoxicosis
• Drugs
  ○ Beta agonists
  ○ Cholinergic blockers (e.g., atropine)
  ○ Stimulants (e.g., nicotine, caffeine)
  ○ Illicit drugs (e.g., amphetamines, cocaine)
	• Vasovagal reflex
	• Cardiac arrhythmias
	• Increased intracranial pressure
	• Hypothyroidism
	• Hypothermia
	• Electrolyte imbalances
	• Drugs
	  ○ Beta-adrenergic blockers
	  ○ Calcium-channel blockers
	  ○ Digoxin
	  ○ Antiarrhythmic agents

Table 2-14 Summary of Pulse Findings

Type	Description	Causes
Strong	Easy to palpate	Increased stroke volume (e.g., exercise); hypertension
Weak or thready	Hard to palpate	Decreased cardiac contractility; decreased blood volume; loss of vascular tone (e.g., septic shock); aortic stenosis
Bounding	Rapid/strong initial pressure rise followed by a quick fall-off	Aortic insufficiency; patent ductus arteriosus; atherosclerosis
Pulsus alternans	Pulse alternates in strength from beat to beat	Left-sided heart failure/congestive heart failure (CHF)
Pulsus paradoxus	Pulsations vary with the breathing cycle (weaker pulses during inspiration)	Severe airway obstruction (status asthmaticus); cardiac tamponade

Accessory Muscle Activity

The accessory muscles of inspiration include the sternocleidomastoid, scalenes, upper trapezius, and pectoralis major. Normally, these muscles of the upper thorax and neck are minimally active during quiet breathing. Increased activity at rest is commonly observed in patients with emphysema and any patient experiencing an increased work of breathing. Increased activity at rest also is common in patients with impaired diaphragm function, such as those with spinal cord injury or certain chronic neuromuscular conditions.

Thoracic Expansion/Chest Movements

Palpation can help determine if chest expansion is equal on both sides. Anteriorly, you place your hands over the lower lateral chest wall, with the thumbs extended along the lower rib margins. Posteriorly, you position your hands over the lateral chest with the thumbs meeting at about the eighth thoracic vertebra. When the patient takes a full, deep breath, each thumb should move equally about 1–2 inches from the midline. Lesser or unequal movement is abnormal. Bilateral reductions in chest expansion are seen in COPD patients and those with neuromuscular disorders. Unilateral reductions in chest movement (on the affected side) occur with lobar pneumonia, atelectasis, pleural effusion, pneumothorax, and unilateral (right or left) phrenic nerve paralysis.

Tracheal Position

Normally, the trachea lies in the midline of the neck, which can be confirmed by palpating it just above the sternum, between the clavicles. Shifts away from the midline can be visualized and confirmed on the patient's chest x-ray, with the direction of the shift suggesting the potential causes. For more detail, see the subsequent discussion of tracheal position on the chest x-ray.

Fremitus

- Vibrations that you can feel on the chest wall
- Rhonchial fremitus
  - Associated with excess secretions in the large airways
  - Detected by placing the flat of your hand on the chest to either side of the sternum
  - Diminishes or clears with coughing or after suctioning/airway clearance therapy
- Vocal fremitus
  - Result of voice sounds being transmitted to the chest wall
  - Assessed with the patient saying "ninety-nine" while you palpate the chest wall
  - Increased in conditions increasing lung tissue density (e.g., pneumonia, atelectasis)
  - Decreased in the following conditions:
    - Severe obesity (fat tissue impedes sound transmission)
    - COPD (hyperinflation decreases sound transmission)
    - Pneumothorax or pleural effusion (lungs separated from chest wall)
    - Lung lobe or segment blocked by a mucus plug or foreign body

Skin and Soft Tissues

You can palpate the skin and soft tissues to determine temperature and assess for crepitus, edema, capillary refill, and tenderness.

When blood flow is poor, blood vessels in the extremities constrict to help direct flow to the vital organs. With less blood flow, the extremities tend to cool. For this reason, cold hands and feet usually indicate poor perfusion.

Especially in patients receiving positive-pressure ventilation, gas can leak into the tissues around the head, neck, and chest, forming subcutaneous bubbles, a condition called *subcutaneous emphysema*. When palpated, these bubbles produce a crackling sensation called *crepitus*. Although subcutaneous emphysema itself is harmless, it often occurs in conjunction with a pneumothorax. For this reason, *if you detect crepitus, assess the patient for a pneumothorax, and immediately communicate your findings to the patient's physician*. Most clinicians also recommend a chest x-ray whenever crepitus occurs in mechanically ventilated patients.

Many patients with chronic heart failure exhibit gravity-dependent tissue edema, typically in the feet and ankles (pedal edema). Firmly pressing on edematous tissue with a finger causes it to "pit" or indent. The degree of pitting is usually rated on a 3-point scale, with +3 being the most serious. In general, the farther up the legs the edema can be detected, the more severe the heart failure.

You assess capillary refill by pressing firmly on a patient's fingernails, then releasing the pressure and noting how quickly blood flow returns. When cardiac output is reduced and digital perfusion is poor, capillary refill is slow, taking 3 seconds or longer.

Abdomen

You palpate the abdomen for evidence of distension and tenderness. Abdominal distension and pain can restrict diaphragmatic movement, impair coughing and deep breathing, and contribute to respiratory insufficiency. Typically, the right upper quadrant of the abdomen is palpated for tenderness and to estimate the size of the liver. Abdominal tenderness and an enlarged liver (hepatomegaly) may be seen in patients with chronic cor pulmonale.

Assess a Patient's Overall Cardiopulmonary Status by Percussion

In a complete thoracic exam, you should percuss the lung fields on both sides of the chest, being sure to avoid bony structures and female breasts. To move the scapulae out of the way for posterior

percussion, have the patient raise his or her arms. Key points regarding percussion include the following:

- Percussion over normal air-filled lung tissue produces a moderately low-pitched sound that is easily heard—*normal resonance*.
- A hollow/loud and low-pitched percussion note is termed *increased resonance*—typically indicating hyperinflation (acute asthma, COPD) or pneumothorax.
- A *dull/flat percussion note* (short, muted, high-pitched) occur over areas of increased tissue density, as observed in patients with pneumonia, atelectasis, or lung tumors.
- *Decreased resonance* occurs if there is fluid in the pleural space.

Percussion over the lower posterior thorax can help determine the position of the diaphragm and its range of motion. As you percuss downward over the lower lung fields, the sound changes from normal resonance to a dull note, indicating the level of the diaphragm. The difference between the maximum inspiratory and expiratory levels represents the full range of diaphragm motion, which in adults ranges from 5 to 7 cm. Diaphragm motion typically is decreased in patients with neuromuscular disorders and severe hyperinflation.

Assess a Patient's Overall Cardiopulmonary Status by Auscultation

You auscultate the thorax to identify lung and heart sounds. In general, you should use the stethoscope's diaphragm for auscultation of higher-pitched breath sounds, whereas the bell is recommended to listen to lower-pitched heart sounds.

Breath Sounds

Table 2-15 summarizes the characteristics of normal breath sounds, *which are considered normal only if noted at the specified location*. Normal sounds identified at abnormal locations are abnormal! For example, bronchial breath sounds are abnormal when heard over the lung periphery. They tend to replace normal vesicular sounds when lung tissue increases in density, as in atelectasis and pneumonia/consolidation.

Breath sounds are diminished when the patient's breathing is shallow or slow. Decreased breath sounds also occur when airways are obstructed or the lung is hyperinflated, as in asthma or COPD. Air or fluid in the pleural space and obesity can reduce breath sounds as well.

Abnormal or *adventitious* breath sounds include rhonchi, wheezes, crackles (rales), and stridor. **Table 2-16** summarizes the characteristics, likely mechanisms, and common causes of these adventitious breath sounds.

Heart Sounds

Heart sounds are generated when the heart valves close. The first heart sound (S_1) signals closure of the mitral and tricuspid valves, and the second heart sound (S_2) occurs with closure of the pulmonic and aortic valves. You listen to heart sounds to assess the apical heart rate and to identify gross abnormalities in structure or function.

Table 2-15 Normal Breath Sounds

Breath Sound	Description	Normally Heard at (Location)
Vesicular	Low-pitched, soft sounds; heard primarily during inhalation, with only a minimal exhalation component	Periphery of lungs
Bronchial	High-pitched, loud, tubular sounds with an expiratory phase equal to or longer than the inspiratory phase	Over trachea
Bronchovesicular	Moderate pitch and intensity; equal inspiratory and expiratory phases	Around upper sternum (anterior); between scapulae (posterior)

Table 2-16 Adventitious Breath Sounds

Lung Sounds	Characteristics	Likely Mechanism	Causes
Rhonchi	Coarse, discontinuous	Airflow through mucus	Pneumonia, bronchitis, inadequate cough
Wheezes	High pitched; usually expiratory	Rapid airflow through partially obstructed airways	Asthma, congestive heart failure, bronchitis
Stridor	High pitched, monophonic; commonly inspiratory	Rapid airflow through obstructed upper airway	Croup, epiglottitis, post-extubation edema
Pleural friction rub	Creaking or grating sound heard mainly during inhalation (can occur during both phases of breathing)	Inflamed pleural surfaces rubbing together during breathing	Pleurisy
Crackles: inspiratory and expiratory	Coarse; often clear with coughing	Excess airway secretions moving with airflow	Bronchitis, respiratory infections
Crackles: early inspiratory	Scanty, transmitted to mouth; not affected by cough	Sudden opening of atelectatic bronchi	Bronchitis, emphysema, asthma
Crackles: late inspiratory	Diffuse, fine; occur initially in the dependent regions	Sudden opening of collapsed peripheral airways	Atelectasis, pneumonia, pulmonary edema, fibrosis

- Heart sound intensity is diminished in the following conditions:
  - COPD, pleural effusion, pneumothorax, and obesity (poor transmission of sound to chest wall)
  - Heart failure, hypotension, and shock (decreased cardiac contractility or blood volume)
- Heart sound intensity is increased in the following patients:
  - Patients with partial obstruction to outflow from the ventricles, as in mitral stenosis (affecting S_1) and pulmonary hypertension (affecting S_2)
  - Children and thin-chested patients (decreased transmission distance)
- Heart sound intensity (especially S_1) can vary with cardiac arrhythmias that alter ventricular filling, such as atrial fibrillation and complete heart block.

You will sometimes hear a third heart sound (S_3) occurring just after S_2. The presence of this extra sound creates a galloping pattern, often equated with the saying the word "Kentucky." S_3 often can be heard in normal children and in well-conditioned athletes. Its presence in older patients usually indicates congestive heart failure (CHF).

Cardiac murmurs indicate turbulent flow through a heart valve. Systolic murmurs are heard when either an atrioventricular (AV) valve allows backflow (regurgitation) or a semilunar valve restricts outflow (stenosis). Diastolic murmurs occur with semilunar valve regurgitation or AV valve stenosis.

Auscultatory Assessment of Blood Pressure

You also use auscultation to manually measure blood pressure. As you deflate the cuff, you listen for the *Korotkoff sounds*, caused by turbulent flow through the partially obstructed artery. The pressure at which the Korotkoff sounds first appear is the systolic pressure, and the point at which these sounds suddenly become muffled and disappear is the diastolic pressure. **Table 2-17** describes several situations demanding special consideration when auscultating a patient's blood pressure.

Integrating Physical Examination Findings

Table 2-18 summarizes the major physical findings associated with various common clinical disorders.

Table 2-17 Special Considerations in Manually Measuring Blood Pressure by Auscultation

Problem	Caused by	Solution
Inaudible blood pressure	Poor technique	Use proper technique.
	Severe hypotension or shock	Consider arterial line monitoring.
	Venous engorgement (due to repeated measurements)	Remove the cuff and have the patient raise his or her arm over the head for 1–2 minutes before repeating the measurement. Use the other arm.
Irregular cardiac rhythms	Atrial fibrillation, frequent premature ventricular contractions (PVCs), heart block	Make several measurements and use the average.
Auscultatory gap	A silent interval between systolic and diastolic sounds that can result in underestimating systolic pressure or overestimating diastolic pressure; usually caused by hypertension	Measure and record three pressures: (1) the opening systolic or "snap" pressure, (2) the pressure at which continuous pulses again are heard, and (3) the diastolic pressure.
Paradoxical pulse (*pulsus paradoxus*)	A larger than normal drop (more than 6–8 mm Hg) in systolic pressure during inspiration in patients with severe airway obstruction (such as acute asthma) or conditions that impair ventricular filling (such as cardiac tamponade)	To measure paradoxical pulse, slowly deflate the cuff until you hear sounds only on exhalation (point 1). Then reduce the pressure again until you can hear sounds throughout the breathing cycle (point 2). The difference in pressures between points 1 and 2 is the paradoxical pulse measurement.

Table 2-18 Physical Findings Associated with Various Common Clinical Disorders

Abnormality	Inspection	Palpation	Percussion	Auscultation
Asthma	Use of accessory muscles	Reduced expansion	Increased resonance	Expiratory wheezing
Chronic obstructive pulmonary disease (COPD)	Increased anterior–posterior (AP) diameter; accessory muscles use	Reduced expansion	Increased resonance	Diffuse decrease in breath sounds; early inspiratory crackles
Consolidation (pneumonia or tumor)	Inspiratory lag	Increased vocal fremitus	Dull note	Bronchial breath sounds; late inspiratory crackles
Pneumothorax	Unilateral expansion	Tracheal shift away; decreased vocal fremitus	Increased resonance	Absent breath sounds
Pleural effusion	Unilateral expansion	Tracheal shift away; absent vocal fremitus	Dull note	Absent breath sounds
Atelectasis	Unilateral expansion	Tracheal shift toward; absent vocal fremitus	Dull note	Absent breath sounds
Diffuse interstitial fibrosis	Rapid shallow breathing	Often normal; increased fremitus	Slight decrease in resonance	Late inspiratory crackles
Upper airway obstruction (e.g., croup, foreign body)	Labored breathing	Often normal	Often normal	Inspiratory and/or expiratory stridor and possible unilateral wheezing (foreign body aspiration)

Review and Interpret the Chest Radiograph

Chapter 1 outlines the various imaging studies used in the diagnosis and management of respiratory disorders. Here we describe the process of reviewing a chest x-ray, including what to look for during assessment. The accompanying box outlines the basic steps in reviewing a chest x-ray.

Basic Steps in Review of a Chest X-Ray

1. Obtain image; verify identification (patient, date), orientation (using side marker), and image quality.
2. Identify the view of the film (anteroposterior [AP] or posteroanterior [PA]).
3. Review the entire film for symmetry and identify the following:
   a. Clavicles, scapulae, and ribs
   b. Spinal column (note whether it is midline)
   c. Lungs, right and left
   d. Level of hemidiaphragms and costophrenic angles (sharp or blunted)
   e. Gastric air bubble
   f. Breast shadows
4. Trace the outline of each rib, noting the angle and any fractures or other abnormalities.
5. Observe the tracheal position.
6. Identify the carina and the mainstem bronchi.
7. Examine the hila for size and position.
8. Identify the lung markings.
9. Identify the aortic knob and the heart shadow.
10. Estimate the cardiothoracic ratio.
11. Note the presence and position of any artificial airways or catheters.
12. State an overall impression of the film.
13. Compare with previous films is available.

Image Orientation and Quality

The first step in reviewing an x-ray is to verify the patient and date of the film and assess image orientation and quality. As outlined in **Table 2-19**, you can use the mnemonic R-I-P-E to assess image orientation and quality.

Lung Fields

Because a radiograph is a negative, areas of increased whiteness or *radiopacity* indicate high-density objects, such as bone or consolidated tissue, whereas areas of darkness or *radiolucency* indicate low-density matter, such as air. **Table 2-20** lists the most common causes of radiopacity and radiolucency seen on an x-ray.

Position of Hemidiaphragms

Table 2-21 summarizes key findings related to the position or appearance of the hemidiaphragms.

Tracheal Position

As visualized on x-ray, the trachea should lie in the midline of the neck, overlying the spinal column on the anterior–posterior (AP) view. In general, the trachea can be seen on x-ray shifting *toward* areas of collapse/atelectasis and *away from* space-occupying lesions such as pneumothoraces, large effusions, and tumors.

Table 2-19 R-I-P-E Mnemonic for Assessing Chest Radiograph Quality

R	Rotation	The patient's shoulders should be perfectly perpendicular to the x-ray beam (i.e., not rotated left or right). The patient is aligned "straight" if the thoracic spine aligns in the center of the sternum and equally between the medial end of each clavicle.
I	Inspiration	A good inspiration is needed to properly visualize lung structures, especially at the bases. Inspiration is adequate if the diaphragm is at the level of the 10th posterior rib (8th to 9th posterior ribs in anterior–posterior [AP] films) or 6th anterior rib on the right.
P	Position	Verify AP versus posterior–anterior (PA) view. • The AP view is most common in bedridden patients. In the typical AP view, the medial borders of the scapula are seen in the upper lung fields, the ribs appear more horizontal, and the heart appears more magnified. • In the typical PA view, the borders of the scapula are clear of the upper lung fields, the ribs are angled downward, and the heart appears less magnified. Verify left versus right sides of the film. If not labeled with a side marker, both the gastric bubble (upright posture only) and the apex of a normal heart should appear on the right side of the film (patient's left side). Verify proper angulation (head/toe). In the AP view, the clavicle should be at about the level of the third rib.
E	Exposure	Verify proper intensity of the x-ray beam passing through the patient. In a good exposure, the intervertebral disks should be barely visible through the heart, and the costophrenic angles should be well defined (assuming proper inspiration and no effusions). Overexposed = too dark; underexposed = too white.

Table 2-20 Common Pulmonary Abnormalities Altering Lung Field Density on Chest X-Rays

Increased Radiopacity	Increased Radiolucency
• Atelectasis	• Pulmonary emphysema
• Consolidation	• Pneumothorax
• Interstitial lung disease	• Pneumomediastinum
• Pulmonary infiltrates/edema	• Pneumopericardium
• Pleural effusion	• Subcutaneous emphysema
• Lung/mediastinal tumors	• Pulmonary interstitial emphysema
• Calcification	

Table 2-21 Chest X-Ray Abnormalities Associated with Changes in the Hemidiaphragms

Abnormality	Likely Problem
Blunted costophrenic angles (affected side)	Lower-lobe pneumonia, pleural effusion
Flattened hemidiaphragm (affected side)	Hyperinflation, tension pneumothorax
Elevated hemidiaphragm (affected side)	Phrenic nerve paralysis, hepatomegaly, atelectasis
Air under diaphragms (differentiate from normal gastric air bubble)	Perforated gastrointestinal tract

Heart Size and Position

A chest radiograph can help differentiate heart failure from primary pulmonary disease, especially in patients who present with dyspnea. Findings suggesting heart failure include the following:

- Cardiomegaly
- Prominent upper lobe vascular markings

- Kerley B lines
- Pleural effusion(s)

The term *cardiomegaly* most commonly refers to an enlarged heart seen on a chest x-ray. Normally, the heart width is less than 50% of the width of the thoracic cage. Cardiomegaly exits when the ratio of cardiac to thoracic width (CT ratio) exceeds 50% on a posterior–anterior (PA) chest radiograph. Note that because the heart lies primarily in the anterior chest, it is magnified on an AP film. In addition, factors such as patient rotation or an incomplete inspiration can exaggerate heart size on both PA and AP views.

In terms of position, the heart lies within the mediastinum and normally is visualized primarily to the left of the midline/spine (right side of x-ray), consisting mostly of the lateral border of the left ventricle. A smaller portion of the heart (right atrial border) normally lies to the right of the midline/spine (left side of x-ray). Any lateral movement of the mediastinum away from the midline will also shift the heart position in the same direction. As with the trachea, a chest film typically will show the heart/mediastinum being pulled as follows:

- ***Toward*** areas of decreased lung volume
  - Atelectasis
  - Fibrosis
  - Surgical resection
- ***Away from*** space-occupying lesions
  - Pneumothorax
  - Large pleural effusion
  - Large mass lesions (e.g., tumors)

Position of Endotracheal or Tracheostomy Tubes

An AP chest x-ray is the most common method used to confirm proper placement of an endotracheal (ET) or tracheostomy tube. Ideally, the tube tip should be positioned 4–6 cm above the carina. This normally corresponds to a location between thoracic vertebrae T2 and T4, or about the same level as the superior border of the aortic knob.

Position of Indwelling Tubes, Catheters, and Foreign Objects

Objects visible on a chest radiograph not "of" the patient are *foreign bodies*. Foreign bodies include those appearing by accident or trauma—such as an aspirated tooth or bullet—as well as purposefully placed medical devices (e.g., cardiac pacemakers). Aspiration of small objects is the most common source of accidental foreign-body ingestion, especially in children. This possibility always should be considered when encountering airway obstruction in children and justifies recommending both a chest *and* lateral neck and chest x-ray.

Other than some plastics and aspirated food matter, most foreign bodies are denser than human tissues. Thus, these objects appear radiopaque, with their shape often helping identify their origin. For example, an aspirated coin will appear as a solid white, round object on a radiograph. Likewise, devices such as surgical staples are easily identifiable by their shape and position.

In contrast, low-density plastic devices, such as ET tubes and vascular catheters, are more difficult to visualize on an x-ray. For this reason, radiopaque markers are embedded in these devices. **Table 2-22** outlines common medical devices that may be visualized on a chest radiograph.

Review Lateral Neck Radiographs

When used together with a chest radiograph, lateral neck x-rays are useful in assessing for upper airway obstruction, especially in children. The most common causes of upper airway obstruction in children are aspirated foreign bodies and infection. As indicated previously, high-density aspirated objects are readily visualized on x-ray. Some plastic objects or food matter may be more difficult to identify and often require laryngoscopy or bronchoscopy to confirm and resolve.

In terms of serious upper airway infections in pediatric patients, croup and epiglottitis are the most commonly encountered diseases. **Table 2-23** compares the typical radiographic findings in these two conditions.

Table 2-22 Medical Devices Visualized on the Chest Radiograph

Devices	Comments
Extrathoracic	
Electrocardiogram (ECG) leads	Three electrodes and lead wires typically are visible.
Clamps, syringes, and other instruments	May be on top of or under the patient but can appear to be "inside" the thorax and thus confuse interpretation.
Ventilator circuits, heating wires, temperature sensors	Adult circuits normally exhibit typical corrugated appearance; wires/sensors may be confused with intrathoracic devices such as pacemakers.
Breast implants	Either unilateral or bilateral; shadows can be confused with lung pathology.
Intrathoracic	
Thoracostomy (chest) tubes	To evacuate air (pneumothorax), the tube normally is positioned anterosuperiorly; to evacuate fluid, it is positioned posteroinferiorly.
Endotracheal tubes	The tube tip should be 4–6 cm above the carina, or between T2 and T4.
Nasogastric or feeding tubes	Visualized passing through the mediastinum and diaphragm into the stomach. Misplacement high in the esophagus or in the trachea can result in aspiration.
Central venous catheter	Should be seen in the superior vena cava or right atrium.
Pulmonary artery (PA) catheter	The catheter tip should appear in the lower lobe, ideally posteriorly. Improper placement can result in false pulmonary artery wedge pressure (PAWP) readings.
Implanted cardiac pacemakers and cardioverter/defibrillators	The pulse generator is usually visualized below the clavicle; one or two pacing wires should appear coursing through the superior vena cava into the heart chamber(s).
Sternal wires	Appear on the chest radiograph as several opaque "tied" loops running up and down the sternum (in patients after median sternotomy for cardiac surgery).
Metallic heart valves	Appear in the same location as what they replace (mitral and aortic being the most common); bioprosthetic porcine or bovine tissue valve replacements not easily visualized.
Intra-aortic counterpulsation balloon device (IACB or IABP)	Consists of an inflatable balloon about 25 cm long, the tip of which normally can be visualized just distal to the left subclavian artery in the descending thoracic aorta, 2 cm form the aortic arch.

Table 2-23 Radiographic Findings: Croup Versus Epiglottitis

View	Condition	
	Croup	Epiglottitis
Chest film (anterior–posterior [AP])	"Steeple sign" (i.e., narrowed and tapering airway below larynx due to subglottic edema); tracheal dilation possibly present if film was taken during expiration	Usually appears normal (little or no evidence of subglottic involvement)
Lateral neck film	May appear normal (little or no evidence of supraglottic involvement)	"Thumb sign" due to prominent shadow caused by swollen epiglottis

T⁴—TOP TEST-TAKING TIPS

You can improve your score on this section of the NBRC exam by reviewing these tips:

- Only alert patients ("oriented × 3") can fully cooperate and participate in their own care.
- A Glasgow Coma Scale score of < 8 indicates coma.
- A patient's pain/interference rating of > 4 requires intervention.
- Use/recommend the Borg Scale to assess a patient's dyspnea or degree of exertion; values ≥ 5 indicate severe dyspnea/strong exertion.
- Tachypnea, thoracic–abdominal dyssynchrony, and the use of accessory muscles always indicate increased work of breathing.
- Sputum production > 30 mL/day indicates the need for airway clearance.
- Job *and* home factors must be included in an environmental assessment
- Health literacy is associated with low educational levels and manifests as lack of knowledge regarding care or difficulty following a care plan.
- Use teach-back (knowledge) or return demonstration (skills) to evaluate patient learning.
- Peripheral cyanosis (acrocyanosis), coolness of the extremities, and slow capillary refills indicate circulatory failure.
- A short/thick neck, large tongue, and limited visibility of pharyngeal structures (Mallampati classification) predict difficult intubation.
- Pink, watery, frothy secretions suggest pulmonary edema.
- An infant with an Apgar score (**A**ppearance, **P**ulse, **G**rimace, **A**ctivity, **R**espirations) of < 4 should be resuscitated.
- Fetal maturity is indicated by a Lecithin/Sphingomyelin ratio of > 2 and the presence of phosphatidylglycerol.
- A pulse deficit usually indicates a cardiac arrhythmia, such as atrial fibrillation or flutter, PVCs, or heart block.
- A pulse that varies with the breathing cycle (pulsus paradoxus) indicates severe airway obstruction (e.g., status asthmaticus) or cardiac tamponade.
- The trachea tends to shift *toward areas of collapse/atelectasis* and *away from space-occupying lesions,* such as pneumothoraces.
- Rhonchial fremitus is associated with excess secretions in the large airways.
- Especially in patients receiving positive-pressure ventilation, neck/upper chest crepitus suggests pneumothorax.
- Increased percussion resonance indicates hyperinflation, whereas a dull/flat note suggests increased tissue density (e.g., pneumonia, atelectasis).
- "All that wheezes is not asthma"—consider CHF/pulmonary edema in adults and foreign-body obstruction in toddlers/children.
- Stridor indicates tracheal/laryngeal/upper airway obstruction (e.g., croup, epiglottitis, post-extubation edema).
- A chest x-ray is properly aligned if the thoracic spine lines up under the center of the sternum and equally between the medial ends of each clavicle.
- A blunted costophrenic angle on x-ray suggests pleural effusion.
- On AP x-ray, croup may show narrowing and tapering of the trachea below the larynx ("steeple sign"); epiglottitis may appear on lateral neck films as a prominent shadow in the laryngopharynx ("thumb sign").

POST-TEST

To confirm your mastery of each chapter's topical content, you should create a content post-test, available online via the Navigate Premier Access for Comprehensive Respiratory Therapy Exam Preparation Guide which contains Navigate TestPrep (access code provided with every new text). You can create multiple topical content post-tests varying in length from 10 to 20 questions, with each attempt presenting a different set of items. You can select questions from all three

major NBRC TMC sections: Patient Data Evaluation and Recommendations, Troubleshooting and Quality Control of Equipment and Infection Control, and Initiation and Modification of Interventions. A score of at least 70–80% indicates that you are adequately prepared for this section of the NBRC TMC exam. If you score below 70%, you should first carefully assess your test answers (particularly your wrong answers) and the correct answer explanations. Then return to the chapter to re-review the applicable content. Only then should you re-attempt a new post-test. Repeat this process of identifying your shortcomings and reviewing the pertinent content until your test results demonstrate mastery.