

Perspective

Integrating the Physical Examination of The Respiratory System With Hand-Held Devices

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ABSTRACT

Educators have repeatedly commented on the poor physical examination (PE) skills that students display during clerkship rotations, and since the 1970s, there have been calls to replace the traditional head-to-toe examination by other teaching approaches. The need to update the teaching of the PE is further indicated by the availability of hand-held devices. In this monograph we propose an approach to teaching the respiratory PE that consists of (a) teaching by purpose of the PE and by its clinical context (b) restricting the number of PE maneuvers by discerning between "essential", "important" and "optional" PE signs, and (c) combining the instruction of the PE with the use of hand-held devices.

Keywords: Medical education, Physical examination, Basic clinical skills, hand-held pulse oximeters, Peak-flow meters, Point of care ultrasound devices.

Introduction

As late as the 2010s, most undergraduate teaching programs of physical examination (PE) in the USA used the traditional "head-to-toe" approach [1]. However, this approach does not fully achieve its objective, and several authors [2,3] have commented on the poor PE skills that students display during their clerkship rotations.

Consequently, since the 1970s, there have been repeated calls to revise the instruction of the PE. Some authors [2-7] suggested encouraging students to approach clinical problems by raising diagnostic hypotheses and then performing a reflective ("hypothesis-driven") PE aimed at testing these hypotheses. This approach is much closer to real life than the "head to toe" examination as doctors use the hypothesis-driven PE in their daily encounters with both outpatients and in-patients. Other authors suggested that, rather than overwhelming the learners with an all-inclusive list of PE signs, teaching should focus on signs selected for their diagnostic accuracy [8-10] or clinical importance [11-13]. The need to update the instruction of the PE has further increased since the advent of hand-held devices. For example, the electronic digital stethoscope [14] offers a possibility of increasing the volume of heart and respiratory sounds with higher frequency range and clarity of murmurs. Other hand-held innovations are pulse oximeters, peak-flow meters and point of care ultrasound (PoCUS).

Today, the use of PoCUS is considered to be in the domain of specialists. However, it stands to reason that, in the near future, an ever-increasing proportion of emergency and primary care physicians will use hand-held devices. The miniaturization of diagnostic technology signals a change in practice that should begin with student education. PoCUS training of students is feasible [15-17]. It has been commonly integrated into gross anatomy and PE courses in order to provide real-time feedback on examination findings, and thereby it *improves* students' traditional PE techniques.

The diagnostic value of a finding is determined not only by its sensitivity and specificity, but also by the pretest probability of the diagnosis under consideration. In other words, a PE sign may have higher diagnostic value in one clinical context than in another. Therefore, it has been proposed to first, restructure the teaching of PE by clinical contexts, rather than by organ systems, and encourage students to conduct a hypothesis-driven history; second, avoid overwhelming students with PE signs by focusing on "essential" PE signs of life-threatening conditions and "important" signs aimed to test diagnostic hypotheses; and third, to add hand-held devices to the stethoscope, sphygmomanometer, ophthalmoscope, otoscope, reflex hammer and tuning fork that doctors already use during patient examination [18]. The objective of this paper is to apply this proposal to teaching the PE of the respiratory system.

Methods

We reclassified the respiratory symptoms and PE signs described in two texts [10,19] and in a review [20] by *purpose* of the examination and its clinical *context.*

Outline of the proposed teaching approach

(Table 1) lists some essential ("core") respiratory PE signs and findings of hand-held devices that may indicate life-threatening conditions. For example, a patient, who presents with any degree of respiratory abnormality (tachypnea, bradypnea, apnea, labored breathing, stridor, accessory muscle recruitment or paradoxical breathing), is in respiratory distress. Its detection mandates immediate treatment with oxygen, if hypoxemic, and a sustained effort to establish the cause by looking for stridor (croup, epiglottitis), wheezes (bronchial asthma, bronchitis),

Table 1: Examples of "essential" respiratory signs of possible life-threatening conditions in specific clinical contexts. Please note: the differential diagnosis in the various contexts is limited to pulmonary disorders only.

Context	Sign	Possible respiratory diagnosis
Any context	Pulse oximetry: Low oxygen levels	Hypoxemia
Sudden stridor or choking	Swelling of lips and tongue after exposure to vaccination, medication, bee sting	Anaphylaxis
	While swallowing	Aspiration
	Fever	Croup, epiglottitis
	At night, during sleep	Gastro esophageal reflux with aspiration
Sudden chest pain	Reduced breath sounds, changes in percussion note, tracheal deviation. PoCUS: Pneumothorax	Pneumothorax
	Kussmaul's sign (paradoxical elevation of jugular pressure during inspiration)	Pulmonary emboli
Hypoxemia or any respiratory abnormality / distress	Shallow breathing (hypopnea), paradoxical breathing, confusion, silent chest	Life threatening bronchial asthma
	Bradypnea	Exposure to toxins, drugs, head injury
	Reduced breath sounds and changes in percussion note, tracheal deviation. PoCUS: Pneumothorax, pleural effusion	Pneumothorax, pleural effusion
	Swollen leg, pleuritic chest pain, syncope, hemoptysis, tachycardia	Pulmonary emboli
	Fever, cough, sputum production, dullness on percussion, bronchial breathing	Pneumonia
	Jugular distention; respiratory rales; sweaty cold extremities	Acute exacerbation of a chronic obstructive airway disease, primary pulmonary hypertension
	Jugular distention; Kussmaul's sign	Pulmonary emboli
	Wheezing. Peak-flow meter: reduced airflow	Bronchial asthma, emphysema, acute bronchitis, COPD exacerbation
	Uplift of the left or right lower sternal area; Palpable or loud P2. PoCUS: Right ventricular strain and hypertrophy	Pulmonary hypertension
Pregnancy	Jugular distention; Kussmaul's sign	Pulmonary emboli
	Palpable or loud P2; sustained movement of the left or right lower sternal area; jugular distension. PoCUS: Right ventricular strain and hypertrophy	Pulmonary hypertension
Dyspnea and decline in blood pressure on sitting or standing	Paradoxical pulse; swollen leg; cardiac third sound; asymmetric chest percussion and breath sounds	Massive pulmonary embolus
	Paradoxical pulse; asymmetric chest percussion and breath sounds. PoCUS: Pneumothorax	Tension pneumothorax
Chest trauma	Respiratory rate >20/min, breath sounds unilaterally diminished. PoCUS: Pleural air and effusion	Hemo-pneumothorax

reduced breath sounds and changes in percussion note (pneumothorax or pleural effusion), and for signs suggesting pulmonary emboli.

Medical students should be proficient at detecting essential signs by both PE and PoCUS. For example, given a patient in respiratory distress, students would be expected to detect reduced breath sounds, changes in percussion note and deviation of the trachea in order to diagnose pneumothorax or pleural effusion. Students would be expected also to use PoCUS to determine inferior vena cava caliber in order to differentiate between hypovolemic, obstructive, cardiogenic and distributive shock in patients with massive pulmonary embolus.

Important PE signs are those that supplement the core PE as clinically indicated (Table 2). Thus, given a patient with acute respiratory symptoms, students would be expected to detect hypoxemia, increased vocal fremitus, dullness on percussion, pleural friction rub, bronchial breathing, increased vocal resonance, and inspiratory crackles in order to diagnose pneumonia.

The least important PE signs (Table 3) are those that are no longer employed because of the availability of ancillary tests. For example, pulse oximetry may detect reduced blood oxygenation at earlier stages than cyanosis; hand-held peak-flow meter provides an easier and more precise assessment of obstructive airway disease than Hoover's sign and pulsus paradoxus. Reduced peak-flow may also alert physicians to the possibility of mild pulmonary disorders, and it may be used for monitoring patients with chronic conditions such as asthma and cystic fibrosis.

Table 2: Examples of "important" respiratory symptoms and signs to be sought in specific contexts in order to test diagnostic hypotheses in patients with focal complaints. The differential diagnosis in the various contexts is limited to pulmonary disorders only.

Shortness of breath, chest pain	Sustained movement of the left or right lower sternal or epigastric area ("right ventricular uplift"); palpable or loud P_2. PoCUS: Right ventricular strain and hypertrophy	Pulmonary hypertension
Peripheral edema or ascites	Jugular distension, hepatomegaly Peak-flow meter: Reduced airflow. PoCUS: Right ventricular strain and hypertrophy	Obstructive airway disease, primary pulmonary hypertension
Fever, sore throat, no cough	Tonsillar exudates and cervical adenopathy	Streptococcal tonsillitis
Fever, running nose, cough, sore throat	No tonsillar exudates	Viral respiratory infection
Fever, colored nasal discharge	Blurred sinus trans-illumination	Sinusitis
Fever, acute respiratory symptoms, acute cough	Heart rate > 120/min; low oxygen saturation; asymmetric expansion of the chest; increased vocal fremitus; dullness on percussion; pleural friction rub; bronchial breathing; increased vocal resonance; inspiratory crackles	Pneumonia
	Diminished vocal fremitus and vocal resonance; dullness on percussion; Diminished breath sounds; pleural friction rub	Pleural effusion
Acute on chronic respiratory symptoms	Accessory respiratory muscle use;Peak-flow meter: reduced airflow	Severe obstructive airway disease
	Wheezes; "noisy breathing"; Peak-flow meter: reduced airflow	Chronic bronchitis, bronchial asthma
Chronic respiratory symptoms	Hyper resonance; inspiratory crackles, reduced breath sounds. Peak-flow meter: reduced airflow	Chronic obstructive airway disease
	Reduced diaphragmatic motion; barrel chest. Peak-flow meter: reduced airflow.	Emphysema
	Dry crackles	Interstitial lung disease / fibrosis
	Clubbing of the fingers	Lung tumor, bronchiectasis, lung abscess, empyema, interstitial fibrosis, cystic fibrosis
Easy fatigability, shortness of breath, chest pain	Sustained movement of the left or right lower sternal area; palpable P_2	Pulmonary hypertension.
	Physiologic wide splitting of S_2; late P_2	Acute cor pulmonale.

Table 3: Examples of optional respiratory symptoms and signs that are nice to know but no longer clinically useful.

Sign or symptom	Possible cause / diagnosis
Central cyanosis	Hypoxemia
Pulsus paradoxus in a patient with engorged neck veins, tachycardia, dyspnea	Bronchial asthma
Skodaic resonance	Hyper-resonance on percussion above a pleural effusion
Grocco's triangle	Right angled triangle of dullness over the posterior region of the chest opposite a large pleural effusion
Kronig's isthmus	Narrow band of resonance over each lung apex. Reduced with infiltrates of the lung apices.
Abnormal vocal resonance (sound of the patient's voice heard through a stethoscope placed on the patient's chest) Bronchophony (Loud voice) Petriloquy (Intelligible spoken words) Egophony ("E to A change" of the patient's voice)	Pneumonia (lung consolidation)
Hoover's sign	Chronic obstructive airway disease
Percussion of the heart – absent cardiac dullness	Emphysema

Discussion

The clinical importance of the respiratory PE has been debated ever since the advent of chest radiography [21], and more recently, this debate was renewed by the advent of hand-held diagnostic devices. On the one hand, these devices provide real-time and low-cost detection of abnormalities, and a controlled trial revealed that the average time needed for PoCUS diagnosis of pneumonia, pleural effusion and pneumothorax was even shorter than that for standard evaluation [22]. On the other hand, the same trial indicated that standard evaluation performed better than PoCUS in the diagnosis of obstructive airway disease, bronchial asthma and pulmonary embolism [22]; and most studies that detected a poor accuracy of PE signs have failed to control for disease severity and examiners' PE skills, and may have thereby underestimated the diagnostic value and utility of the PE in patients with suspected respiratory disease [20].

We believe that considering the strengths and weaknesses of the PE and hand-held devices, students should be taught to use both, and hopefully, this will reduce diagnostic errors. The most common reported errors in patients with respiratory disorders have been failure to diagnose pneumonia and pleural effusion [23]. Hence the importance of emphasizing PE signs with high likelihood ratios positive for pneumonia, such as asymmetric expansion of the chest and increased vocal fremitus [24] and dullness on percussion and pleural friction rub [25] and for pleural effusion, such as dullness on percussion and diminished vocal fremitus and breath sounds and [26].

Other frequent PE errors that we encountered in students were in palpating the expansion of the chest and in locating the position of the diaphragm. Students needed to be reminded of the anatomical landmarks of the Lewis angle (second intercostal space), and the tip of the scapula (seventh intercostal space); they also needed to be shown that, during expiration, the location of the diaphragm is on the 6th, 8th and 10th intercostal spaces on the front, side and back, respectively; and that restricting the examination of the lungs to the back leaves the upper lobe unexamined [27].

Conclusion

We anticipate that hand-held diagnostic devices will be readily available to future doctors. Therefore, we call to integrate the use such devices into the teaching the PE of the respiratory system and further adapt teaching the PE to future technological advances. Evidence suggests that teaching PoCUS improves students' overall traditional PE skills, and therefore, similar to other authors, we believe that the integration of hand-held devices with the PE will *reverse* the ever-diminishing role of the PE over the last decades and restore confidence in it.

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