

## CLINICAL REVIEW

# Respiratory Rate and Breathing Pattern

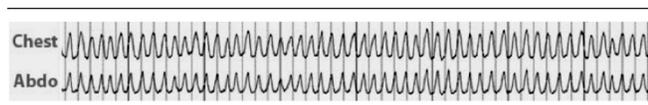
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### ABSTRACT

The respiratory rate is a vital sign with an underappreciated significance that can, in acute situations, prognosticate patients' mortality rate and need for invasive ventilation. In addition, identifying abnormal breathing patterns can localize disorders within the respiratory system and help refine the differential diagnosis. Understanding how to properly measure and interpret the respiratory rate is a valuable clinical skill.

### INTRODUCTION

The respiratory system delivers oxygen and removes carbon dioxide to tightly regulate the partial pressures of oxygen and carbon dioxide in arterial blood. These roles are accomplished in part by setting the respiratory rate and tidal volume which in turn are controlled by the concerted action of chemoreceptors sensing oxygen, carbon dioxide and pH; mechanoreceptors of the lungs; and the respiratory centers of the medulla and pons. Normal tidal breathing is comprised of inspiratory and expiratory phases and occurs with the synchronous movement of the thorax and abdomen (Figure 1).



**Figure 1. Normal awake breathing:** Note the symmetry between movement of the chest wall and abdomen, which are recorded by respiratory inductance plethysmography. Transducer bands are placed around the chest and abdomen, and upward deflections indicate outward movement. Each large box represents 30 seconds.

### IMPORTANCE OF RESPIRATORY RATE

The respiratory rate and tidal volume vary in response to metabolic demand and increase with physical activity or in disease states such as infection. Importantly, the magnitude of the metabolic demand is reflected in the respiratory rate, and patients with an elevated respiratory rate often have a more serious illness. Severity of disease classification

systems including the Acute Physiology and Chronic Health Evaluation (APACHE), CURB-65, and pneumonia severity index (PSI) all incorporate the respiratory rate to identify the most critically ill patients.<sup>1-3</sup>

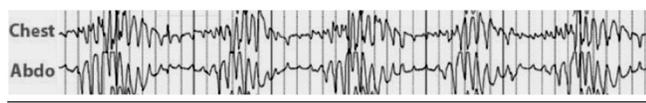
A prospective observational study of 1025 emergency room patients found that a respiratory rate greater 20 breaths per min was predictive of cardiopulmonary arrest within 72 hours (OR-3.93) and death within 30 days (OR- 3.56).<sup>4</sup> A similar evaluation of general medicine inpatients found that a respiratory rate of greater than 27 breaths per minute was predictive of cardiopulmonary arrest within 72 hours (OR-5.56).<sup>5</sup> In a prospective observational study of 1695 acute medical admissions, patients with a composite outcome of cardiopulmonary arrest, intensive care admission, or death within 24 hours had a mean respiratory rate of 27 compared to controls who had a mean respiratory rate of 19.<sup>6</sup>

Close monitoring of inpatients with elevated respiratory rates is advised as over 50% of general medicine inpatients had deterioration of their respiratory function at least 8 hours prior to a cardiopulmonary arrest.<sup>7</sup> Regrettably, the respiratory rate is frequently not assessed or improperly assessed.<sup>8,9</sup> Review of recorded vital signs of 58 medical inpatients revealed that 40 patients had a respiratory rate of exactly 20, and 98% of patients had a respiratory rate between 18 and 22.<sup>10</sup> When the patients were carefully reassessed, their respiratory rates were found to range from 11 to 33, and two patients were found to demonstrate Cheyne-Stokes respiration which had not been previously recognized.<sup>10</sup>

## ABNORMAL BREATHING PATTERNS

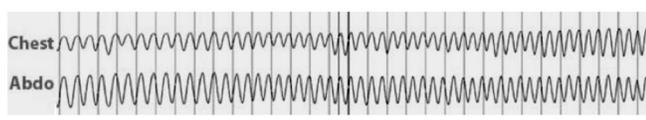
Inspection of the pattern of breathing will often yield clues of the disease process, independent of the rate measurement. Abnormal patterns of breathing are frequently caused by injury to respiratory centres in pons and medulla, use of narcotic medications, metabolic derangements, and respiratory muscle weakness.

**Thoracoabdominal Asynchrony/Paradox** – refers to the asynchronous movement of the thorax and abdomen that can be seen with respiratory muscle dysfunction and increased work of breathing. This can be seen as a time lag/phase shift of thoracoabdominal motion or as pure paradox where the thorax and abdomen are moving in completely opposite directions at the same time (Figure 2).



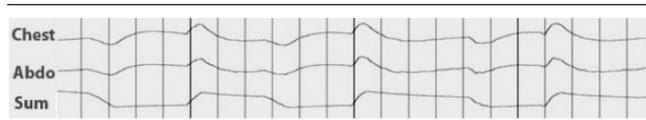
**Figure 2. Thoracoabdominal paradox.** The chest and abdominal movements as recorded by respiratory inductance plethysmography are in clear paradox. The upward deflections from the chest lead are matched to downward deflections from the abdomen. Each large box represents 30 seconds.

**Kussmaul's breathing** – refers to a pattern with regular increased frequency and increased tidal volume and can often be seen to be gasping. This pattern is often seen with a severe metabolic acidosis (Figure 3).



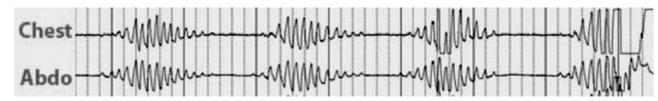
**Figure 3. Simulated Kussmaul's breathing.** Synchronous chest and abdominal movements measured by respiratory inductance plethysmography are rapid and of large amplitude. Each large box represents 30 seconds.

**Apneustic breathing** – refers to breathing where every inspiration is followed by a prolonged inspiratory pause, and each expiration is followed by a prolonged expiratory pause that is often mistaken for an apnea (Figure 4). This is often caused by damage to the respiratory center in the upper pons.



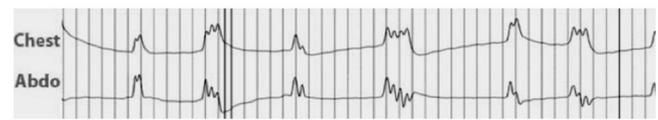
**Figure 4. Simulated apneustic breathing.** Note the pauses following each upward deflection (inspiration) and downward deflection (expiration) of the chest and abdomen as measured by respiratory inductance plethysmography. Each large box represents 30 seconds.

**Cheyne-Stokes respiration** – refers to a cyclical crescendo-decrescendo pattern of breathing, followed by periods of central apnea (Figure 5). This form of breathing is often seen in patients with stroke, brain tumour, traumatic brain injury, carbon monoxide poisoning, metabolic encephalopathy, altitude sickness, narcotics use, and in non-rapid eye movement sleep of patients with congestive heart failure.

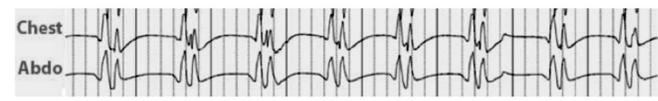


**Figure 5: Cheyne-Stokes respiration.** Note the crescendo-decrescendo pattern of chest and abdominal movements as measured by respiratory inductance plethysmography. Each large box represents 30 seconds.

**Ataxic and Biot's breathing** – these forms of breathing are sometimes lumped together and usually are related to brainstem strokes or narcotic medications. Ataxic breathing refers to breathing with irregular frequency and tidal volume interspersed with unpredictable pauses in breathing or periods of apnea (Figure 6). Biot's breathing refers to a high frequency and regular tidal volume breathing interspersed with periods of apnea (Figure 7).



**Figure 6. Simulated ataxic breathing.** Note the irregular chest and abdominal movements, as measured by respiratory inductance plethysmography, followed by apneas. Each large box represents 30 seconds.

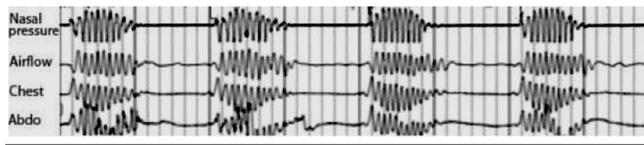


**Figure 7. Biot's breathing.** Note the regular large amplitude chest and abdominal movements, as measured by respiratory inductance plethysmography, followed by apneas. Each large box represents 30 seconds.

**Agonal breathing** – refers to a pattern of irregular and sporadic breathing with gasping seen in dying patients before their terminal apnea. The duration of agonal breathing varies from one to two breaths to several hours and can be seen in up to 40% of patients in cardiac arrest. It is important to note that this form of breathing is inadequate to sustain life.<sup>11</sup>

**Central sleep apnea** – occurs during sleep when the brain temporarily stops sending signals to the muscles that control breathing and is characterized by the absence of nasal flow and pressure along with absent chest and abdominal effort

(Figure 8). It can be caused by a myriad of conditions including injury to cervical spine or the base of the skull, neurodegenerative illnesses such as Parkinson's, obesity, primary hypoventilation syndrome, and use of certain medications such as narcotics.



**Figure 8. Central apnea.** Note the lack of nasal pressure, airflow, and chest and abdominal movements. Each large box represents 30 seconds.

### EXAMINING THE RESPIRATORY RATE AND BREATHING PATTERN

Respiratory rate has been measured using 15, 30 and 60 second counts; however, the 60 second count is most accurate as shorter durations often overestimate the number of breaths per minute.<sup>12</sup> In a pediatric study, respiratory rates counted with a stethoscope as opposed to visually were 20-50% higher and more accurate suggesting that only larger tidal volume breaths tend to be counted visually and rapid shallow breaths may be missed.<sup>13</sup> Agitation, anxiety and fever may cause an elevation in respiratory rate not associated with respiratory distress.

Average resting respiratory rates by age:<sup>13,14</sup>

- Birth to 6 weeks: 30-60 breaths per minute
- 6 months: 25-40 breaths per minute
- 3 years: 20-30 breaths per minute
- 6 years: 18-25 breaths per minute
- 10 years: 15-20 breaths per minute
- Adults: 12-20 breaths per minute

Breathing patterns are best assessed with respectful exposure of the patients to the waist area. Observe for any chest wall deformities such as pectus deformity, kyphoscoliosis and scars. Observe for movement of the chest wall and abdomen and whether the movement is synchronous or asynchronous. Note the pattern in rate and depth and regularity of breathing.

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