

Mechanical Ventilation: Lung Mechanics of Resistance and Compliance Measurement (Respiratory Therapy)

ALERT

To increase the patient's cooperation and decreased his or her anxiety, explain that he or she will be undergoing a test involving changing the ventilator settings (breath hold).

OVERVIEW

A patient's pulmonary system can be monitored for early signs of pathophysiologic changes using the measurements of respiratory mechanics. In mechanically ventilated patients, changes in respiratory mechanics may occur abruptly, or they may reveal slow trends in respiratory function.² Detection of alterations in pulmonary physiology and lung mechanics can help guide the respiratory therapist (RT) in the clinical management of the mechanically ventilated patient.

Normal compliance in a nonmechanically ventilated patient is 60 to 100 ml/cm H₂O. Low compliance of 25 to 30 ml/cm H₂O is common with pulmonary edema, interstitial lung disease, lung hyperinflation, pleural disease, obesity, bronchial intubation and ascites.²

Dynamic compliance (C_D) measures both lung compliance and airway resistance (R_{aw}). C_D is not an accurate assessment of how compliant the lungs are because it measures airflow through the airway as well as the ventilator circuit.¹ The patient's lung and chest wall elastic recoil, R_{aw} , endotracheal (ET) tube, and the patient-ventilator circuit all influence the C_D .¹

Static compliance (C_S) is a more precise indicator of lung compliance because it is measured when no airflow is in the airway or the patient-ventilator circuit. Obtaining an accurate assessment of C_S requires patient-ventilator synchrony and the absence of patient effort.¹ The normal C_S for intubated, mechanically ventilated patients is 70 to 100 ml/cm H₂O.¹ Decreasing C_S may be caused by pneumonia, atelectasis, consolidation, pneumothorax, pleural effusion, pulmonary edema, and ascites.¹

The normal R_{aw} in a nonmechanically ventilated patient is 0.6 to 2.4 cm H₂O/L/sec.¹ The normal R_{aw} in an intubated, mechanically ventilated patient is 5 to 10 cm H₂O/L/sec.² Secretions, bronchospasm, cuff herniation, airway compression, and kinking, biting, or plugging of the ET tube produce increased R_{aw} .

Lung problems can be identified easily by monitoring the changes in peak inspiratory pressure (PIP), plateau pressure (Pplat), and the difference between the PIP and Pplat. If PIP and Pplat are both increasing with no change in the delivered tidal volume (V_T) and the difference between them is constant, then the C_S is decreasing. If the PIP increases along with the difference in C_D and C_S , then R_{aw} is increasing. The C_D decreases when C_S decreases or R_{aw} increases.¹

A ventilator with the capability to display PIP, positive end-expiratory pressure (PEEP), flow rate, and V_T is used to calculate compliance and resistance. Some ventilators can display the values graphically.

EDUCATION

- Explain the procedure to the patient and family.

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- Encourage questions and answer them as they arise.

ASSESSMENT AND PREPARATION

Assessment

1. Perform hand hygiene before patient contact.
2. Introduce yourself to the patient.
3. Verify the correct patient using two identifiers.
4. Review the patient's medical record for the practitioner's order, diagnosis, chest radiograph interpretation, precautions, and possible contraindications to performing the procedure.
5. Assess the patient's vital signs and oxygen saturation.
6. If the patient's ventilator is set on a volume mode, assess PIP for gradual or acute airway compliance changes.
7. If the patient's ventilator is set on a pressure mode, assess the VT for gradual or acute airway compliance changes.

PROCEDURE

1. Perform hand hygiene and don gloves.
2. Verify the correct patient using two identifiers.
3. Explain the procedure to the patient and ensure that he or she agrees to treatment.
4. Assess the patient's breath sounds.
5. Suction the patient's airway.

Rationale: Suctioning clears the airway of secretions.

6. Measure C_D .
 - a. Obtain PIP, PEEP or total PEEP, and delivered exhaled or corrected VT.
 - b. Calculate C_D where VT is the volume delivered by the ventilator: $C_D = VT \div (PIP - PEEP)$
7. Find the Pplat.
 - a. At the end of inspiration, start an inspiratory pause (hold) for 0.5 to 1 second¹ until a Pplat is reached.

Rationale: Activation of the inspiratory pause (hold) on most ventilators automatically closes the inspiratory and expiratory valves at end inspiration. The pressure falls from PIP to a lower Pplat.

Keep Pplat below 30 cm H₂O to avoid ventilator-induced lung injury.¹

- b. Observe the Pplat displayed digitally on a graphic screen or on a pressure manometer and record it.
8. Measure C_S and R_{aw} .
 - a. Obtain PIP, PEEP or total PEEP, flow rate, and delivered exhaled or corrected VT.

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- b. Calculate C_s , where V_T is the volume delivered by the ventilator: $C_s = V_T \div (P_{plat} - PEEP)$
- c. Calculate R_{aw} : $R_{aw} = (PIP - P_{plat}) \div \text{Flow (L/second)}$
9. Remove gloves and perform hand hygiene.
10. Document the procedure in the patient's record.

MONITORING AND CARE

1. Monitor ventilator parameters.
 - a. PIP
 - b. P_{plat}
 - c. PEEP or total PEEP
 - d. Flow rate
 - e. Volume delivered by the ventilator (corrected V_T)
2. Monitor the patient for auto-PEEP.

Rationale: Gas trapped in alveoli at end expiration may cause auto-PEEP.

3. Monitor heart rate, breath sounds, and oxygen saturation.
4. Monitor the patient's overall comfort.
5. Observe the patient for signs and symptoms of pain. If pain is suspected, report it to the authorized practitioner.

EXPECTED OUTCOMES

- Accurate assessment of C_D , C_s , and R_{aw}

UNEXPECTED OUTCOMES

- Decreased partial pressure of carbon dioxide
- Increased partial pressure of oxygen
- Ventilator-induced lung injury

DOCUMENTATION

- C_D
- C_s R_{aw}
- Changes in C_D , C_s , and R_{aw}
- Unexpected outcomes and related interventions
- Patient and family education

OLDER ADULT CONSIDERATIONS

- Assess older adult patients for hearing problems, which may prevent clear understanding of the procedure, including inspiratory pause (hold) instructions.

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HOME CARE CONSIDERATIONS

- C_D may be assessed in the home setting, in most cases, C_S and R_{aw} are assessed in the acute care setting.

REFERENCES

1. Cairo, J.M. (2016). Chapter 8: Initial patient assessment. In *Pilbeam's mechanical ventilation: Physiological and clinical applications* (6th ed., pp. 118-141). St. Louis: Elsevier.
2. Piraino, T. (2017). Chapter 51: Monitoring the patient in the intensive care unit. In R.M. Kacmarek, J.K. Stoller, A.J. Heuer (Eds.), *Egan's fundamentals of respiratory care* (11th ed., pp. 1154-1189). St. Louis: Elsevier.

Supplies

- Gloves
- Pulse oximeter
- Stethoscope

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