Mechanical Ventilation: Standard Weaning Criteria (Respiratory Therapy)

OVERVIEW

Standard weaning criteria (SWC) evaluate respiratory muscle strength and endurance by using negative inspiratory force (NIF) and positive expiratory pressure (PEP). Another index, the rapid shallow breathing index or ratio of respiratory frequency to tidal volume (f/VT) identifies a breathing pattern associated with unsuccessful weaning.

These criteria may help determine the need for intubation, the patient's ability to tolerate weaning trials, the presence of respiratory muscle fatigue, and extubation potential.

SWC are good negative predictors that the weaning attempt will be unsuccessful but poor positive predictors that the weaning attempt will be successful.[3] Regardless, SWC provide information about respiratory muscle strength and endurance. SWC are especially helpful in following trends in strength and endurance in patients who are debilitated or weak or patients with myopathies.

NIF also is called negative inspiratory pressure (NIP) or maximal inspiratory pressure (MIP). The measurement of NIF is effort independent (meaning that the patient does not have to cooperate), and it is a reliable SWC predictor but a poor positive predictor.[3] The most common threshold cited for NIF is greater than or equal to −20 cm H_2O.[2] Because this is an effort-independent measurement, the value is reliable with good technique, unless the central respiratory drive is impaired. For example, sedation, a cuff leak, or respiratory muscle fatigue adversely affects the value.

Spontaneous tidal volume (VTS) is a measure of respiratory muscle endurance. The threshold for VTS is greater than or equal to 5 ml/kg of body weight.[2] When muscles fatigue, the compensatory breathing pattern is rapid and shallow. VTS and f are combined in a ratio called the f/VT to gauge respiratory muscle fatigue.

The rapid shallow breathing index or f/VT, where f is the number of breaths, or the spontaneous respiratory rate, and VT is the tidal volume, has been developed to identify a breathing pattern associated with unsuccessful weaning.[3] The f/VT index threshold associated with success is less than or equal to 105.[1] It is calculated by obtaining the spontaneous respiratory rate and dividing it by the VT in liters.[3] In elderly medical patients, the threshold is slightly higher. Vital capacity (VC) is also a measure of respiratory muscle endurance or reserve or both. A fatigued patient is unable to triple or even double the size of a breath. The threshold for VC is greater than or equal to 10 to 15 ml/kg (at least two to three times VTS).[1]

Measurement of VC may be especially helpful in patients with neurologic conditions, such as myasthenia gravis or Guillain-Barré syndrome. In these patients, a decrease in the VC suggests loss of reserve and impending respiratory muscle failure.

All SWC are best used in combination with other assessment data to determine the appropriateness of weaning trials or extubation.[3] Randomized controlled trials were conducted that sought to determine when and how best to wean patients from mechanical ventilatory support. The studies demonstrate the efficacy and safety of multidisciplinary protocols using a "wean screen" (a set of discrete criteria suggesting stability, such as a fraction of expired oxygen less than 0.50, positive end-expiratory pressure less than 8 cm H_2O, and no vasopressor use) followed by a carefully monitored spontaneous breathing trial

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in attaining positive outcomes.[1] These study results have greatly reduced reliance on weaning criteria as a predictive tool.

EDUCATION

- Teach the patient and family about the patient's respiratory status and any changes in therapy.
- If the patient or a family member asks about the measurements, explain the relationship between them and respiratory muscle strength and endurance.
- Discuss the sensations the patient may experience, such as transient shortness of breath and fatigue and the inability to take a breath during the test maneuver.
- Explain to the patient the importance of cooperation and maximal effort to achieve valid and reliable measurements.
- 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. Assess the patient for signs and symptoms of inadequate ventilation.

a. Increasing carbon dioxide tension in expired air or arterial blood
b. Chest-abdominal asynchrony
c. Shallow or irregular respirations
d. Tachypnea or bradypnea
e. Dyspnea
f. Restlessness, confusion, lethargy
g. Increasing or decreasing arterial blood pressure beyond a predetermined threshold
h. Tachycardia or bradycardia beyond a predetermined threshold
i. New-onset atrial or ventricular arrhythmias

5. Assess the patient's need for a long-term artificial airway and mechanical ventilatory assistance.

Preparation

1. Consider positioning the patient in a high semi-Fowler position, if his or her condition allows.

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. Attach a portable respirometer to the airway via the adapter and the series of one-way valves. If the patient is receiving positive-pressure ventilation (PPV), place him or her back on the ventilator (or manually ventilate with a self-inflating manual resuscitation bag) to rest for a few minutes between all measurements.

   Rationale: The respirometer is used to measure V_{TS} and VC. Volume and pressure may be measured while the patient is on the ventilator.

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Ensure no large cuff leak exists because a large leak adversely affects measurements.

5. Measure VTS.

a. Instruct the patient to breathe normally.
b. Count the frequency and record the minute ventilation.
c. Divide minute ventilation by f to obtain the average VTS.

If the patient's oxygen saturation decreases (this may vary with the individual patient and thresholds set by the health care team) or if other signs of intolerance of the procedure emerge, abort the test or perform it for a shorter interval, as tolerated.

6. Measure VC.

a. Verify that the respirometer is at the starting point.
b. Instruct the patient to inhale as deeply as possible.
c. Instruct the patient to exhale as much as possible.
d. The VC may be tested more than once to obtain the best effort.

A good VC effort requires a maximum inspiration followed by a maximum expiration.

7. Measure NIF.

a. Close or cap the inspiratory one-way valve, ensuring a closed system for measurement of inspiratory effort but allowing exhalation.
b. Attach the pressure manometer to the airway with the adapter and one-way valves. Some ventilators allow the measurement to be accomplished with the patient on the ventilator.

Rationale: A pressure manometer is used to measure NIF.

In most cases, the pressure manometer is attached to the airway via one-way valves. The valves (one is for inspiration and one is for expiration) are capped as necessary to ensure a closed system and a clean measurement device for attachment to the patient's artificial airway.

c. Instruct the patient to inhale as deeply as possible.
d. Observe the manometer needle during inspiration.

e. This test can be done for 20 seconds,[4] sometimes longer, with multiple attempts by the patient.
f. This test may be done even if the patient is not able to participate actively.

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g. After the patient has been attached to the closed system manometer for a few seconds, instruct him or her to initiate a series of breaths and generate a negative pressure.

Do not perform the NIF when the patient's central respiratory drive is absent because of sedation or neurologic injury.

Rationale: The goal is to obtain the patient's best effort.

h. Watch the manometer as the 20 seconds elapse[4] and stop the procedure after the NIF measurements peak within the maximum time allowed or if the patient does not tolerate the procedure (e.g., experiences agitation, bradycardia, or significant oxygen desaturation).

8. Measure PEP.

a. Cap the expiratory valve, ensuring the patient is able to breathe in but must exhale against a closed system.
b. Attach the pressure manometer to the airway via the adapter and one-way valves.
c. Instruct the patient to take a deep breath and exhale forcefully because PEP is effort dependent.
d. Instruct the patient to exhale forcefully a number of times (not to exceed 20 seconds).[4] Record the greatest positive number.[4]

Rationale: Multiple attempts ensure that the patient's best effort is recorded.

Abort the test if signs of deterioration occur, including increased respiratory rate, increased heart rate, or decreased oxygen saturation.

9. Encourage the patient throughout all measurements.
10. Discard supplies, remove gloves, and perform hand hygiene.
11. Document the procedure in the patient's record.

MONITORING AND CARE

1. Compare the SWC measurements to the desired patient goals.

Rationale: If the measurements do not meet anticipated levels, the patient may need an initiation of PPV or a continuance of mechanical ventilation. If the measurements equal or exceed the goals, initiation of weaning or extubation may be indicated.

2. Discuss the results with the team.

Rationale: Decisions related to weaning trials, intubation, or extubation are made using the results of these tests in conjunction with others.

3. Observe the patient for signs or symptoms of pain. If pain is suspected, report it to the authorized practitioner.

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EXPECTED OUTCOMES

- Valid and reliable measurements of NIF (greater than or equal to −20 cm H_2O), VC (greater than or equal to 10 ml/kg), and V_{TS} (greater than or equal to 5 ml/kg)[1]

UNEXPECTED OUTCOMES

- Invalid and unreliable measurements
- Untoward physical, emotional, or hemodynamic changes
- Stoppage of the procedure

DOCUMENTATION

- Patient and family education
- Best values obtained
- Patient's tolerance of the tests
- Unexpected outcomes and related interventions
- Respiratory interventions

OLDER ADULT CONSIDERATIONS

- Measurement of the rapid shallow breathing index, which is also f/V_T in elderly patients during spontaneous breathing, can predict the ability to successfully wean from mechanical ventilators.

REFERENCES

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3. MacIntyre, N.R. and others. (2002). Evidence-based guidelines for weaning and discontinuing ventilatory support. *Respiratory Care, 47*(1), 69-90. (classic reference)* (Level VII)
4. Marelich, G.P. and others. (2000). Protocol weaning of mechanical ventilation in medical and surgical patients by respiratory care practitioners and nurses: Effect on weaning time and incidence of ventilator-associated pneumonia. *Chest, 118*(2), 459-467. doi:10.1378/chest.118.2.459 (classic reference)* (Level II)

*In these skills, a "classic" reference is a widely cited, standard work of established excellence that significantly affects practice and may also represent the foundational research for practice.

Elsevier Skills Levels of Evidence

- Level I - Systematic review of all relevant randomized controlled trials
- Level II - At least one well-designed randomized controlled trial
- Level III - Well-designed controlled trials without randomization
- Level IV - Well-designed case-controlled or cohort studies
- Level V - Descriptive or qualitative studies
- Level VI - Single descriptive or qualitative study
- Level VII - Authority opinion or expert committee reports

ELSEVIER Clinical Skills

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Supplies

- Gloves
- Pressure manometer
- Portable respirometer
- Appropriate adapters and one-way valves
- Self-inflating manual resuscitation bag connected to an oxygen source

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