

Module 5 - Mechanically Augmented Ventilation

This module will allow the learner to describe the application of mechanical ventilation in terms of modes, breath types, alarms, troubleshooting and monitoring across various patient populations.

Rationale

Why is it important for you to learn this material?

Registered Respiratory Therapists play a large role in critical care including the initiation, management, weaning, and discontinuation of mechanical ventilation. Registered Respiratory Therapists should be familiar with the modern concepts and current strategies involving mechanical ventilation. With continuous technological advances, the Registered Respiratory Therapist can apply these fundamentals safely and effectively across various generations of equipment.

Learning Outcome

When you complete this module you will be able to

Describe the application of mechanical ventilation in terms of modes, breath types, alarms, troubleshooting, and monitoring across various patient populations.

Learning Objectives

Here is what you will be able to do when you complete each objective.

1. Describe a mandatory breath in various terms.
2. Describe a spontaneous breath in various terms.
3. Describe the direct and indirect control interactions for each breath type.
4. Compare common ventilation modes.
5. Analyze the functional characteristics of breath types using waveforms.
6. Describe the functional characteristics of the lung and airways using waveforms.
7. Describe the clinical indications for the use of mechanical ventilation including evaluation methods and criteria for mode selection.
8. Discuss the measurement, validation, and significance of various parameters in the application
9. Discuss selection of ventilatory parameters in relation to patient need.
10. Describe patient assessment in terms of mechanical ventilation.
11. Explain the harmful effects of mechanical ventilation.
12. Compare the methods of minimizing the harmful effects of mechanical ventilation.
13. Discuss the factors contributing to ventilator dependence.
14. Assess the physiological and psychological indications for successful weaning.
15. Discuss different weaning methods.
16. Discuss patient management techniques.
17. Discuss physiological effects of non-invasive ventilation.
18. Discuss Non-Invasive Positive Pressure Ventilation (NIPPV).
19. Describe NIPPV devices.

Objective 1

When you complete this objective you will be able to...

Describe a mandatory breath in terms of types, supported or non-supported, flow, time and pressure, factors affecting volume, indications, and contraindications.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

1. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section VI – Acute and Critical Care
 - i. Chapter 39 – Mechanical Ventilators
 1. Heading: How Ventilators Work
 2. Heading: Output Waveforms
 3. Heading: Clinical Application of Modes
2. Mosby's Respiratory Care Equipment, 7th Edition:
 - i. Chapter 11– Introduction to Ventilators
 1. Part II: Basic Components of Breath Delivery
 2. Part III: Basic Modes of Ventilation

Objective Checklist:

Concerning indications & contraindications:

- Can you identify indications for mandatory volume-controlled breaths?
- Can you identify indications for mandatory pressure-controlled breaths?
- Can you identify indications for mandatory dual-controlled breaths?
- Concerning breath types:
- Can you describe a mandatory breath in terms of trigger, limit, and cycle?
- Can you differentiate between a mandatory breath and a spontaneous breath?
- Can you differentiate between a mandatory breath and an assisted breath?
- Can you differentiate between a volume-controlled, pressure-controlled, and dual-controlled breath type?

Concerning supported vs. non-supported:

- Can you describe mandatory breaths in terms of supported or non-supported?
- Can you discuss how to recognize inadequate support settings for volume-controlled breaths?
- Can you discuss how to recognize inadequate support settings for pressure-controlled breaths?
- Can you discuss how to recognize inadequate support settings for dual-controlled breaths?

Concerning factors affecting volume:

- Can you describe how maximum safety pressure could affect volume delivery?
- Can you describe how tubing compliance affects volume delivery?
- Given volume control settings and airway pressure measurements, can you calculate volume lost due to tubing compliance?
- Can you describe how changes in airways resistance affect volume in a pressure-controlled breath?
- Can you describe how auto-peep impacts volume delivery in pressure-controlled breaths?
- Can you describe how inspiratory pause affects volume delivery in mandatory breaths?

Concerning flow:

- Can you describe the patterns of flow available for volume-controlled breaths?
- Can you describe the pattern of flow for a pressure-controlled breath?

Concerning time:

- Can you describe the relationship between time, volume, and flow?
- Referring to phase variables, can you describe how time defines a mandatory breath?

Concerning pressure:

- Can you describe expected patterns of pressure for volume-controlled breaths?
- Can you describe the pattern of pressure for a pressure-controlled breath?
- Can you describe the pattern of pressure for dual-controlled breaths?

Objective 2

When you complete this objective you will be able to...

Describe a spontaneous breath in terms of types, supported or non-supported, flow, time and pressure, factors affecting volume, indications, and contraindications.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

1. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section VI – Acute and Critical Care
 - i. Chapter 39 – Mechanical Ventilators
 1. Heading: How Ventilators Work
 2. Heading: Output Waveforms
 3. Heading: Clinical Application of Modes
2. Mosby's Respiratory Care Equipment, 7th Edition:
 - i. Chapter 11– Introduction to Ventilators
 1. Part II: Basic Components of Breath Delivery
 2. Part III: Basic Modes of Ventilation

Objective Checklist:

Concerning indications & contraindications:

- Can you identify indications for spontaneous breaths during mechanical ventilation?
- Can you identify contraindications for spontaneous breaths during mechanical ventilation?

Concerning breath type:

- Can you describe a spontaneous breath in terms of trigger, limit, and cycle?
- Can you differentiate between a spontaneous breath and a mandatory breath?

Concerning supported vs. non-supported:

- Can you differentiate between a supported spontaneous breath and a non-supported spontaneous breath?
- Can you identify three types of supported spontaneous breaths?
- Can you apply the terms supported or non-supported to the types of spontaneous breaths available?

Concerning factors affecting volume:

- Can you describe why volume delivery is variable for spontaneous breaths?

Concerning flow:

- Can you describe the expected patterns of flow during spontaneous breaths?
- Can you describe how flow influences the respiratory cycle in terms of phase variables?

Concerning time:

- Can you describe why T_i and $I:E$ are variable during spontaneous breathing?

Concerning pressure:

- Can you describe the expected patterns of pressure during non-supported spontaneous breaths?
- Can you describe the expected patterns of pressure during the various types of supported spontaneous breaths?

Objective 3

When you complete this objective you will be able to...

Describe the direct and indirect control interactions for each breath type.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

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 - i. Chapter 39 – Mechanical Ventilators
 1. Heading: How Ventilators Work
 2. Heading: Output Waveforms
 3. Heading: Clinical Application of Modes
2. Mosby's Respiratory Care Equipment, 7th Edition:
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Objective Checklist:

Concerning control interactions of a mandatory breath:

- Can you describe the control parameters DIRECTLY set during a mandatory volume-controlled breath?
- Can you describe the parameters INDIRECTLY controlled by mandatory volume control settings?
- Can you describe the control parameters DIRECTLY set during a mandatory pressure-controlled breath?
- Can you describe the parameters INDIRECTLY controlled by mandatory pressure control settings?
- Can you describe the control parameters DIRECTLY set during a mandatory dual-controlled breath?
- Can you describe the parameters INDIRECTLY controlled by mandatory dual-control settings?

Concerning control interactions of a spontaneous breath:

- Can you describe the control parameters DIRECTLY set during a non-supported spontaneous breath?
- Can you describe the control parameters DIRECTLY set during the various types of supported spontaneous breaths?
- Can you describe the parameters INDIRECTLY controlled by spontaneous breath type settings?

Objective 4

When you complete this objective you will be able to...

Compare common ventilation modes.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

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 1. Heading: How Ventilators Work
 2. Heading: Output Waveforms
 3. Heading: Clinical Application of Modes
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Objective Checklist:

- Can you describe the breath types available in control modes?
- Can you differentiate between control and assist/control?

Concerning volume control:

- Can you describe Volume Control (VC) in terms of control, trigger, limit, cycle, and baseline variables?

Concerning pressure control:

- Can you describe Pressure Control (PC) in terms of control, trigger, limit, cycle, and baseline variables?

Concerning pressure support:

- Can you describe Pressure Support (PS) in terms of control, trigger, limit, cycle, and baseline variables?

Concerning Intermittent Mandatory Ventilation (IMV), Synchronized Intermittent Mandatory Ventilation (SIMV,) and Minimum Mandatory Ventilation (MMV):

- Can you describe the breath types available in IMV, SIMV, and MMV?
- Can you differentiate between IMV and SIMV?
- Can you describe how MMV differs from IMV and SIMV?

Concerning Pressure-Regulated Volume Control (PRVC):

- Can you describe the dual-control mode of pressure-regulated volume control (PRVC) in terms of control, trigger, limit, cycle, and baseline variables?
- Can you describe similarities and differences of PRVC to pressure control?
- Can you describe similarities and differences of PRVC to volume control?

Concerning Volume Support (VS):

- Can you describe the dual-control mode volume support (VS) in terms of control, trigger, limit, cycle, and baseline variables?
- Can you describe the similarities and differences of VS to pressure support?
- Can you describe the dual-control mode Volume-Assured Pressure Support (VAPS) in terms of control, trigger, limit, cycle, and baseline variables?
- Can you describe similarities and differences of VAPS to pressure support?
- Can you describe similarities and differences of VAPS to VS?
- Can you describe similarities and differences of VAPS and VS to MMV?

Concerning Airway Pressure Release Ventilation (APRV):

- Can you describe Airway Pressure Release Ventilation (APRV) in terms of control, trigger, limit, cycle, and baseline variables?
- Can you describe similarities and differences of APRV to SIMV with Pressure Control?
- Can you describe similarities and differences of APRV to PC?

Objective 5

When you complete this objective you will be able to...

Analyze the functional characteristics of breath types using waveforms.

Learning Activity

Complete each of the Learning Activities listed below.

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 - i. Chapter 39 – Mechanical Ventilators
 1. Heading: How Ventilators Work
 2. Heading: Output Waveforms
 3. Heading: Clinical Application of Modes
2. Mosby's Respiratory Care Equipment, 7th Edition:
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Objective Checklist:

- Can you define pressure, flow, and volume scalars?
- Can you draw the expected pressure, flow, and volume scalars that would reflect the mode of volume control with constant flow?
- In volume control, can you describe the change in pattern in the pressure scalar if you switch from a constant flow to a decelerating flow pattern?
- Can you describe the expected pressure, flow, and volume scalars that would reflect the mode of pressure control?
- Using scalars, can you describe how assisted breaths can be distinguished from mandatory breaths?
- Can you describe the initial sequence expected in pressure, flow, and volume scalars that would reflect the dual-control mode pressure-regulated volume control?
- Can you describe the expected pressure, flow, and volume scalars that would reflect non-supported spontaneous breathing (CPAP)?
- Can you describe the expected pressure, flow, and volume scalars that would reflect the mode of pressure support?
- Can you describe the pressure, flow, and volume scalars that would reflect the dual-control mode volume support?
- Using scalars, can you describe the variations in waveform morphology available in the mode of volume-assured pressure support?

- Can you illustrate expected pressure, flow, and volume scalars given the breath types available in modes IMV, SIMV, and MMV?

Objective 6

When you complete this objective you will be able to...

Describe clinical indications for the use of mechanical ventilation.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

1. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section VI – Acute and Critical Care
 - i. Chapter 38 – Respiratory Failure and the Need for Ventilatory Support
 - ii. Chapter 40 – Physiology of Ventilatory Support
 - iii. Chapter 41 – Initiating and Adjusting Ventilatory Support
2. Mosby's Respiratory Care Equipment, 7th Edition:
 - i. Chapter 11 – Introduction to Ventilators
 1. Part III: Basic Modes of Ventilation
 2. <http://www-users.med.cornell.edu/~spon/picu/calc/oxyindex.htm>

Objective Checklist:

- Can you identify 4 major indications for mechanical ventilatory support?
- Can you describe type I respiratory failure?
- Can you describe type II respiratory failure?
- Can you differentiate between type I and type II respiratory failure?
- Can you differentiate between acute and chronic versions of respiratory failure?
- Can you describe the mechanisms governing type II respiratory failure?
- Can you list physiological indicators for ventilatory support, their normal values, and when support is indicated?
- Can you rationalize recommended ventilator modes and settings for rapidly reversible hypoxemic respiratory failure?
- Can you rationalize recommended ventilator modes and settings for slowly reversible hypoxemic respiratory failure?
- Can you rationalize recommended ventilator modes and settings for acute alveolar hypoventilation?
- Can you rationalize recommended ventilator modes and settings for chronic alveolar hypoventilation?
- Can you rationalize recommended ventilator modes and settings for altered mental status?
- Can you rationalize recommended ventilator modes and settings for acute respiratory muscle fatigue?

- Can you rationalize recommended ventilator modes and settings for chronic needs for ventilatory support?

Objective 8

When you complete this objective you will be able to...

Discuss the measurement, validation, and significance of various parameters in the application of mechanical ventilation.

Learning Activity

Complete each of the Learning Activities listed below.

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 - a. Section VI – Acute and Critical Care
 - i. Chapter 39 – Mechanical Ventilators
 - ii. Chapter 40 – Physiology of Ventilatory Support
 - iii. Chapter 41 – Initiating and Adjusting Ventilatory Support
 - iv. Chapter 43 – Monitoring and Management of the Patient in the ICU
2. Mosby's Respiratory Care Equipment, 7th Edition:
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Objective Checklist:

Concerning pressure, flow and volume waveforms (scalars):

- Can you discuss the advantages that pressure, flow, and volume waveforms have to offer in terms of ventilator management?

Concerning peak airway pressures (PIP):

- Can you describe how to determine PIP on a pressure scalar?
- Can you describe acceptable PIP levels?
- Can you describe which parameters influence the PIP level in volume-controlled mandatory breaths?
- Can you describe how peak airway pressure can be determined using the equation of motion?
- Can you describe which parameters influence PIP level in pressure-controlled mandatory breaths?
- Can you describe which parameters influence the PIP level in dual-controlled mandatory breaths?

Concerning plateau airway pressure (Pplat):

- Can you describe how to determine (Pplat) on a pressure scalar?
- Can you describe how to validate a Pplat reading?
- Can you describe acceptable Pplat levels?
- Can you describe which parameters influence Pplat levels in volume-controlled mandatory breaths?
- Can you describe how Pplat can be determined using the equation of motion?
- Can you describe which parameters confirm Pplat in pressure-limited breath types?

Concerning Peak End Expiratory Pressure (PEEP):

- Can you describe how to determine PEEP from a pressure scalar?
- Can you describe the benefits of PEEP?
- Can you describe the relationship between PEEP and Mean Airway Pressure (MAP)?
- Can you describe possible detriments related to PEEP application?

Concerning mandatory tidal volumes (Vt):

- Can you describe modes that guarantee tidal volume delivery?
- Can you describe how a mandatory tidal volume is measured?
- Can you describe the appropriate range for mandatory tidal volumes?
- Can you describe the appropriate range for mandatory tidal volumes when using lung protective strategies?

Concerning effective tidal volume (Vt effective):

- Can you define effective tidal volume?
- Can you calculate effective tidal volume given the mandatory tidal volume, tubing compliance factor, and appropriate airway pressures?
- Can you describe the significance of tubing compliance factor as it pertains to effective tidal volume?
- Can you describe the merit of ventilators which take into account the tubing compliance factor in determining volume delivered?

Concerning spontaneous tidal volume (Vt spontaneous):

- Can you define a spontaneous tidal volume?
- Can you describe the appropriate range for spontaneous tidal volumes?
- Can you describe in which modes you can expect to see spontaneous tidal volumes?

Concerning airways resistance (Raw):

- Can you describe how airway resistance is calculated?
- Can you describe expected airway resistance values given the size and length of an endotracheal tube?
- Can you identify the parameters required to calculate airway resistance?
- Can you calculate airway resistance?
- Can you identify the accepted units for airway resistance?
- Can you describe the clinical significance of airway resistance as a single value or as a trend?

Concerning static compliance (Cst) and dynamic compliance (Cdyn):

- Can you describe how static compliance is calculated?
- Can you describe expected static compliance values while intubated and mechanically ventilated?
- Can you describe normal static compliance values while non-intubated and spontaneously breathing?
- Can you identify the parameters required to calculate static compliance?
- Can you identify accepted units for compliance?
- Can you describe the clinical significance of static compliance as a single value or as a trend?
- Can you describe how dynamic compliance is calculated?
- Can you describe expected dynamic compliance values relative to static values?
- Can you describe the clinical significance of a dynamic compliance measurement?

Concerning spontaneous and mandatory Respiratory Rates (RR):

- Can you identify how the modes in a spontaneous respiratory rate can be determined?
- Can you identify the modes in which a mandatory respiratory rate has a role?
- Can you describe the clinical significance of determining a spontaneous respiratory rate?
- Can you describe the clinical significance in establishing a mandatory respiratory rate?
- Can you describe an acceptable range for a spontaneous respiratory rate?

Concerning deadspace (VD) and deadspace tidal volume ratios (VD/VT):

- Can you describe the equipment required in order to measure deadspace?
- Can you describe the procedure in which to measure deadspace?
- Can you describe the significance of the deadspace tidal volume ratio?
- Can you describe the normal range for V_d/V_t ?
- Can you describe the critical value for V_d/V_t ?
- Can you describe the components of the mechanical ventilation setup that contribute to deadspace?
- Can you discuss ventilation strategies which may reduce deadspace?
- Can you describe how to validate the impact of changes in deadspace?

Concerning alveolar ventilation:

- Can you describe how to determine alveolar ventilation?
- Can you describe how to validate the clinical significance of alveolar ventilation?

Concerning static and dynamic inspiratory time (T_i):

- Using scalars, can you identify T_i dynamic?
- Using scalars, can you identify T_i static?
- Can you identify where airway pressures are equal to alveolar pressures?
- Can you describe the clinical significance of ensuring, increasing, or decreasing T_i static?
- Given volume-control settings, can you calculate T_i dynamic and T_i static?

Concerning I:E ratios:

- Given ventilator parameters, can you calculate I:E ratio?
- Can you describe the range for normal I:E ratios?
- Can you describe the advantages of 1:1 or inversed I:E ratios?
- Can you describe the potential side effects of 1:1 or inversed I:E ratio?

Concerning mean airway pressure:

- Can you describe parameters that affect mean airway pressure?
- Can you describe the clinical benefits of increased mean airway pressure?
- Can you describe the potential clinical disadvantages of an increased mean airway pressure?

Concerning Cardiac Output (CO), shunt (Q_s/Q_t) and Venous Return (VR):

- Can you describe how cardiac output is measured?
- Can you describe the parameters required to calculate shunt?
- Can you identify normal ranges for shunt?
- Can you identify clinically significant ranges for shunt?
- Given the appropriate parameters, can you calculate shunt using the classic shunt equation?
- Can you describe how positive pressure ventilation affects venous return, cardiac output, and shunt?

Concerning hemodynamics:

- Can you explain how positive pressure ventilation affects CVP?
- Can you explain how positive pressure ventilation affects PAP?
- Can you explain how positive pressure ventilation affects PCWP?
- Can you describe when to accurately record hemodynamic parameters during a positive pressure breath cycle?

Concerning auto-peep:

- Using scalars, can you describe how to identify the presence of auto-peep?
- Can you describe the procedure required to quantify auto-peep?
- Can you discuss the clinical significance of auto-peep?
- Can you discuss the impact of auto-peep on ventilator/patient synchrony?
- Can you discuss the impact of auto-peep on mean airway pressure?

Concerning occlusion pressure (P0.1):

- Can you define P0.1?
- Can you identify a normal value for P0.1?
- Can you identify a critical value for P0.1?
- Can you describe how P0.1 is measured?

Concerning Work Of Breathing (WOB):

- Can you describe how a mechanically ventilated patient may present with increased WOB?
- Can you describe which measurements may suggest an increased WOB?
- Can you describe how waveforms may suggest increased WOB?

Concerning Vt/RR index:

- Can you describe when a VT/RR index may be helpful?
- Can you describe a normal VT/RR index?
- Can you identify a critical value for a VT/RR index?
- Can you describe the clinical significance of the VT/RR index?

Concern Oxygen Index (OI):

- Can you identify the parameters required to calculate an Oxygen Index (OI)?
- Can you identify a normal OI?
- Can you identify a critical value for OI?
- Can you discuss the clinical significance of OI?

Concerning oxygenation:

- Can you identify parameters which help improve oxygenation?
- Can you describe the clinical significance of appropriate oxygenation?

Objective 8

When you complete this objective you will be able to...

Discuss selection of ventilatory parameters in relation to patient need.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

1. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section VI – Acute and Critical Care
 - i. Chapter 38 – Respiratory Failure and the Need for Ventilatory Support
 - ii. Chapter 39 – Mechanical Ventilators
 - iii. Chapter 40 – Physiology of Ventilatory Support
 - iv. Chapter 41 – Initiating and Adjusting Ventilatory Support
 - v. Chapter 43 – Monitoring and Management of the Patient in the ICU
 - b. SECTION V – Basic Therapeutics
 - i. Chapter 32 – Humidity and Bland Aerosol Therapy
2. Mosby's Respiratory Care Equipment, 7th Edition:
 - i. Chapter 11 – Introduction to Ventilators
 1. Part II: Basic Components of Breath Delivery
 2. Part III: Basic Modes of Ventilation

Objective Checklist:

Concerning airway pressures:

- Can you identify critical airway pressure values?
- Can you justify critical airway pressure values?
- Can you identify conditions which are more appropriately managed with lower airway pressures?

Concerning Positive End Expiratory Pressure (PEEP):

- Can you describe patient conditions which are appropriately managed with Positive End Expiratory Pressure (PEEP)?
- Can you describe typical initial levels of PEEP?
- Can you describe conditions which are appropriately managed with higher levels of PEEP?
- Can you identify disadvantages of PEEP?

Concerning humidity and temperature:

- Can you describe appropriate active humidity and temperature settings?
- Can you justify a normal setting for active heat and humidity in ventilator circuits?
- Can you describe the impact of inappropriately set humidity levels?
- Can you describe indications for the use of Heat and Moisture Exchangers (HME)?
- Can you describe disadvantages of HMEs relative to active humidity?
- Can you describe conditions which are more appropriately managed with active humidity relative to a Heat and Moisture Exchanger (HME)?

Concerning alarms/safety systems:

- Can you describe where high-pressure alarms are set?
- Can you justify high-pressure alarm settings?
- Can you describe where low inspiratory pressure alarms are set?
- Can you justify low inspiratory pressure alarm settings?
- Can you describe where low peep alarms are set?
- Can you justify low peep alarm settings?
- Can you describe appropriate settings for apnea parameters?
- Can you describe where to set manual pressure relief valves if available?
- Can you describe where low exhaled tidal volume alarms are set?
- Can you justify low exhaled volume settings?
- Can you describe how low minute volume alarms are set?
- Can you justify low minute volume alarm settings?
- Can you describe where respiratory rate alarms are set?
- Can you justify respiratory rate alarm settings?

Concerning effective volume:

- Can you describe a normal range for mandatory tidal volumes?
- Can you describe a normal range for spontaneous tidal volumes?
- Can you describe how tidal volume is assessed for appropriate levels?
- Can you describe conditions in which lower tidal volumes may be desired?
- Can you explain how to validate mandatory tidal volume levels?
- Can you explain how to validate spontaneous tidal volumes levels?

Concerning flow and flow pattern:

- Can you describe flow patterns available in volume-control modes?
- Can you describe conditions in which a decelerating ramp waveform would be used?
- Can you describe conditions in which a square flow waveform pattern would be used?
- Can you describe potential disadvantages to using a square flow waveform pattern?
- Can you describe potential disadvantages to using a decelerating flow waveform pattern?

- Can you explain how to validate the choice of a given flow waveform pattern?

Concerning respiratory rate:

- Can you describe a normal respiratory rate range for adults?
- Can you describe a critical respiratory rate level?
- Can you describe how to validate respiratory rate levels?

Concerning inspiratory time (Ti):

- Can you describe normal inspiratory time (Ti) for adult ventilation?
- Can you identify conditions which are more appropriately managed with short inspiratory times?
- Can you rationalize the use of shorter inspiratory times?
- Can you describe the potential disadvantages to using short inspiratory times?
- Can you identify conditions which are more appropriately managed with long inspiratory times?
- Can you rationalize the use of longer inspiratory times?
- Can you describe disadvantages to using long inspiratory times?

Concerning expiratory time (Te):

- Can you explain why expiratory time (Te) is critical for a patient?
- Can you identify conditions which are more appropriately managed with long expiratory times?
- Can you rationalize the use of longer expiratory times?
- Can you describe potential disadvantages to using long expiratory times?
- Can you identify conditions in which short expiratory times may be necessary?
- Can you rationalize the use of shorter expiratory times?
- Can you describe probable disadvantages associated with short expiratory times?

Concerning I:E ratios:

- Can you describe normal I:E ratios?
- Can you identify conditions which are more appropriately managed with I:E ratios of 1:1 or inversed?
- Can you rationalize the use of inversed I:E ratios?
- Can you describe potential disadvantages to inverse I:E ratios?
- Can you identify conditions which are more appropriately managed with small I:E ratios?
- Can you describe potential disadvantages in using small I:E ratios?
- Can you explain how to establish an appropriate I:E ratio, Ti and Te?

Concerning modes of ventilation:

- Can you describe patient conditions which are appropriately managed with CMV ventilation?
- Can you explain how to validate the appropriateness of CMV ventilation?

- Can you describe when a pressure-limited strategy would be preferred to a volume-limited/controlled strategy?
- Can you describe clinical manifestations that suggest CMV ventilation is an inappropriate mode?
- Can you describe patient conditions which are appropriately managed with PSV?
- Can you explain how to validate the appropriateness of PSV ventilation?
- Can you describe clinical manifestations that suggest PSV is an inappropriate mode?
- Can you describe patient conditions which are appropriately managed with SIMV?
- Can you describe how to validate the appropriateness of SIMV ventilation?
- Can you describe clinical manifestations that suggest SIMV ventilation is an inappropriate mode?

Concerning Fractional Index of Oxygen (FiO₂):

- Can you describe how to validate FiO₂ settings?

Concerning triggering:

- Can you identify a normal pressure trigger range?
- Can you describe how to validate pressure trigger levels?
- Can you describe potential disadvantages to pressure triggering?
- Can you describe theoretical advantages to flow triggering?
- Can you identify a normal flow triggering range?
- Can you describe potential disadvantages to flow triggering?
- Can you describe benefits to volume triggering mechanisms?
- Can you describe potential disadvantages to volume triggering?
- Can you explain how to validate trigger level settings?

Objective 9

When you complete this objective you will be able to...

Describe effective assessment of patients being mechanically ventilated.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

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 - i. Chapter 40 – Physiology of Ventilatory Support
 - ii. Chapter 41 – Initiating and Adjusting Ventilatory Support
 - iii. Chapter 43 – Monitoring and Management of the Patient in the ICU
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Objective Checklist:

- Can you describe invasive and non-invasive methods for assessing gas exchange?
- Can you explain how to validate the effectiveness of alveolar ventilation?
- Can you describe methods by which to measure deadspace?
- Can you describe settings which can affect patient ventilator synchrony?
- Can you explain how to validate appropriate patient-ventilator synchrony?
- Can you describe the hemodynamic responses to mechanical ventilation?
- With respect to hemodynamic responses, can you explain how to validate chosen ventilator settings?
- With respect to the pulmonary system, can you describe how to validate chosen ventilator settings?
- With respect to neurological responses, can you describe how to validate chosen ventilator settings?
- With respect to renal responses, can you describe how to validate chosen ventilator settings?
- With respect to oxygenation, can you describe how to validate chosen ventilator settings?

Objective 10

When you complete this objective you will be able to...

Explain the harmful effects of mechanical ventilation.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

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 - a. Section VI – Acute and Critical Care
 - b. Chapter 40 – Physiology of Ventilatory Support
 - c. Chapter 41 – Initiating and Adjusting Ventilatory Support
 - d. Chapter 43 – Monitoring and Management of the Patient in the ICU

Objective Checklist:

- Can you explain potential harmful effects of mechanical ventilation on the pulmonary system?
- Can you explain potential harmful effects of mechanical ventilation on the cardiovascular system?
- Can you explain potential harmful effects of mechanical ventilation on renal function?
- Can you explain potential harmful effects of mechanical ventilation on muscle function?
- Can you explain how mechanical ventilation impacts metabolism and nutritional status?
- Can you explain potential neurological and psychological harmful effects of mechanical ventilation?

Objective 11

When you complete this objective you will be able to...

Compare the methods of minimizing the harmful effects of mechanical ventilation.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

2. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section VI – Acute and Critical Care
 - i. Chapter 40 – Physiology of Ventilatory Support
 - ii. Chapter 41 – Initiating and Adjusting Ventilatory Support
 - iii. Chapter 43 – Monitoring and Management of the Patient in the ICU

Objective Checklist:

- Can you describe methods which can minimize the harmful effect of mechanical ventilation on the pulmonary system?
- Can you describe methods which can minimize the harmful effect of mechanical ventilation on the cardiovascular system?
- Can you describe methods which can minimize the harmful effect of mechanical ventilation on renal function?
- Can you describe methods which can minimize the harmful effect of mechanical ventilation on muscle function?
- Can you describe methods which can minimize the harmful effect of mechanical ventilation on metabolism and nutritional status?
- Can you describe methods which can minimize the harmful effect of mechanical ventilation on neurological and psychological status?

Objective 12

When you complete this objective you will be able to...

Discuss the factors contributing to ventilator dependence.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

1. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section VI – Acute and Critical Care
 - i. Chapter 43 – Monitoring and Management of the Patient in the ICU
 - ii. Chapter 44 – Discontinuing Ventilatory Support

Objective Checklist:

- Can you list facts that contribute to ventilator dependency in terms of cardiovascular function?
- Can you list facts that contribute to ventilator dependency in terms of psychological factors and CNS assessment?
- Can you relate sleep deprivation to poor success in weaning and ventilatory discontinuation?
- Can you list factors that contribute to ventilator dependency in terms of acid-base balance and metabolic status?

Objective 13

When you complete this objective you will be able to...

Assess the physiological and psychological indications for successful weaning.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

1. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section VI – Acute and Critical Care
 - i. Chapter 43 – Monitoring and Management of the Patient in the ICU
 - ii. Chapter 44 – Discontinuing Ventilatory Support

Objective Checklist:

- Can you list 8 oxygenation indices and the criterion used to predict success for weaning and ventilator discontinuation?
- Can you list 2 indices and their associated criterion with ventilation and acid-base, used to predict success for weaning and discontinuation?
- Can you list 5 indices and their associated criterion with pulmonary mechanics, used to predict success for weaning and ventilator discontinuation?
- Can you describe the rapid shallow breathing index?
- Can you identify (with its criterion) a weaning parameter associated with respiratory muscle strength?
- Can you list weaning parameters and their criterion, associated with ventilatory demand, work of breathing, and ventilatory reserve?
- Can you describe nutritional considerations that promote success for weaning and ventilator discontinuation?
- Can you describe cardiovascular function associated with successful weaning and ventilator discontinuation?
- Can you describe renal function and electrolyte balance associated with successful weaning and ventilator discontinuation?
- Can you describe CNS parameters associated with successful weaning and ventilator discontinuation?
- Can you describe how long-term ventilatory support can affect the predictability of weaning using weaning indices?

Objective 14

When you complete this objective you will be able to...

Discuss different weaning methods.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

1. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section VI – Acute and Critical Care
 - i. Chapter 43 – Monitoring and Management of the Patient in the ICU
 - ii. Chapter 44 – Discontinuing Ventilatory Support

Objective Checklist:

- Can you discuss the use of SBT as a weaning strategy?
- Can you explain the logic behind using SBT as a weaning strategy?
- Can you discuss the use of CPAP as a weaning strategy?
- Can you explain the rationale in using CPAP as a weaning strategy?
- Can you discuss weaning strategies using IMV or SIMV?
- Can you explain the rationale of IMV/SIMV weaning strategies?
- Can you discuss weaning strategies using MMV?
- Can you explain the rationale behind using MMV as a weaning strategy?
- Can you discuss weaning strategies using PSV?
- Can you explain the rationale of PSV weaning strategies?
- Can you explain the role of BiPAP in weaning and ventilator discontinuance?

Objective 15

When you complete this objective you will be able to...

Discuss patient management techniques.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

1. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section V – Basic Therapeutics
 - i. Chapter 30 – Airway Management
 1. Heading: Suctioning
 - ii. Chapter 37 – Bronchial Hygiene Therapy
 - b. Section VI – Acute and Critical Care
 - i. Chapter 43 – Monitoring and Management of the Patient in the ICU
 - ii. Chapter 44 – Discontinuing Ventilatory Support
 - c. Section VII – Preventative and Long-Term Care
 - d. Chapter 48 – Cardiopulmonary Rehabilitation
2. Pilbeam S: Mechanical Ventilation – Physiological and Clinical Application 3rd ed.
 - i. Chapter 12 – Basic Patient Assessment and Methods to Improve Ventilation
 - ii. Chapter 14 – Airways, Circuit Changes, Medications, Positioning, and Other Patient Issues

Objective Checklist:

- Can you discuss the need for bronchial hygiene during mechanical ventilation?
- Can you describe the goal of breathing control methods?
- Can you describe open and closed suction techniques?
- Can you describe the effects of patient position on ventilation?
- Can you discuss appropriate use of sedation and analgesics during mechanical ventilation?

Objective 16

When you complete this objective you will be able to...

Discuss physiological effects of non-invasive ventilation.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

1. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section VI – Acute and Critical Care
 - i. Chapter 41 – Initiating and Adjusting Ventilatory Support
 - ii. Chapter 42 – Noninvasive Positive Pressure Ventilation
2. Mosby's Respiratory Care Equipment, 7th Edition:
 - i. Chapter 14 – Transport, Home-Care and Alternative Ventilatory Devices

Objective Checklist:

- Can you describe physiologic benefits with CPAP application?
- Can you describe potential physiologic disadvantages with CPAP application?
- Can you describe physiologic benefits with bi-level NIPPV application?
- Can you describe potential physiologic disadvantages or complications specifically associated with bi-level NIPPV application?

Objective 17

When you complete this objective you will be able to...

Discuss Non-Invasive Positive Pressure Ventilatory (NIPPV) support.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

1. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section VI – Acute and Critical Care
 - i. Chapter 41 – Initiating and Adjusting Ventilatory Support
 - ii. Chapter 42 – Noninvasive Positive Pressure Ventilation
2. Mosby's Respiratory Care Equipment, 7th Edition:
 - i. Chapter 14 – Transport, Home-Care and Alternative Ventilatory Devices

Objective Checklist:

- Can you define NIPPV?
- Can you list indications for NIPPV?
- Can you identify when NIPPV should be attempted instead of intubation and traditional mechanical ventilations?
- Can you list contra-indications for NIPPV use?
- Can you identify advantages NIPPV has over traditional intubation and mechanical ventilations?
- Can you identify some disadvantages the NIPPV strategy has relative to traditional intubation and mechanical ventilation?
- Can you describe some of the hazards and complications specifically associated with NIPPV?

Objective 18

When you complete this objective you will be able to...

Describe Non-Invasive Positive Pressure Ventilatory (NIPPV) devices.

Learning Activity

Complete each of the Learning Activities listed below.

Please read and review the following:

1. Egan's Fundamentals of Respiratory Care, 8th Edition:
 - a. Section VI – Acute and Critical Care
 - i. Chapter 41 – Initiating and Adjusting Ventilatory Support
 - ii. Chapter 42 – Noninvasive Positive Pressure Ventilation
2. Mosby's Respiratory Care Equipment, 7th Edition:
 - i. Chapter 14 – Transport, Home-Care and Alternative Ventilatory Devices

Objective Checklist:

- Can you describe a non-invasive continuous positive airway pressure device, its circuit, and components?
- Can you describe a non-invasive bi-level positive pressure ventilatory support device, its circuit, and components?
- Can you describe the components within an NIPPV circuit?
- Can you describe the recommended delivery mechanism for humidity through an NIPPV?
- Can you describe the type of humidification system which is appropriate with NIPPV use?
- Can you describe the various mask type interfaces available for NIPPV, CPAP, and BiPAP?
- Can you describe the added features required on a full face mask compared to a nasal mask?
- Can you describe how to evaluate a nasal mask for appropriate fit?
- Can you describe how to evaluate a full face mask for appropriate fit?
- Can you describe other interfaces available to patients for NIPPV use?
- Can you describe parameters that should be monitored using a CPAP machine?
- Can you describe parameters that should be monitored when using a bi-level NIPPV machine?
- Can you discuss what should be incorporated into patient education with respect to NIPPV use at home?
- Can you list the functional components in a typical NIPPV setup?
- Can you describe functional components that would be more appropriate for acute use rather than chronic use?
- Can you describe strategies to minimize discomfort to the user of NIPPV?
- Can you describe how quality control is maintained when initially setting up NIPPV for use?
- Can you describe how quality control is maintained on an ongoing basis for NIPPV currently in use?

- Can you describe features available either in the interface that ensures patient safety?
- Can you describe features available in the circuit which ensures patient safety?
- Can you describe features available in the NIPPV machine or programming that ensure patient safety?