Effects of PPV on the Cardiovascular, Cerebral, Renal and other Organ Systems

Chapter 16
Cardiovascular Effects

• PPV may result in significant changes in the physiological pressures in the thorax
• Extent depends on the amount of PPV applied and the cardiovascular status of the patient
Cardiac Output

PPV decreases cardiac output
Mechanism of ↓ Cardiac Output

- ↑ intrapleural pressure
- Compression of intrathoracic vessels
- ↑ central venous pressure
- ↓ venous return to the right heart
- ↓ right ventricular filling volume (preload)
- ↓ right ventricular stroke volume
- Increased resistance to blood flow through the pulmonary circulation
- ↑ right ventricular afterload/PVR
- Heart can become compressed between the lungs – cardiac tamponade effect
- ↓ coronary vessel perfusion
Compensation in Normal Patients

- Systemic hypotension rarely occurs as decreases in stroke volume normally result in an increase in sympathetic tone
  - Tachycardia
  - Increase in SVR and peripheral venous pressure
  - Peripheral shunting away from the kidneys and lower extremities

- Net effect is maintenance of BP with a decrease in cardiac output
Martti Tenhu, chief medical examiner in Helsinki, Finland, illustrates the differences between a normal human heart and one enlarged by alcoholism and high blood pressure. Covered in scar tissue, the enlarged organ is nearly twice the normal size. Such alcoholic cardiomyopathy weakens the heart so that it is unable to pump blood adequately.

Photograph by George Steinmetz

http://science.nationalgeographic.com/science/photos/heart/enlarged-heart.html
Poor/NO Compensation

• Neuroreflex integrity
  – Blocked or impaired by anesthesia
  – Spinal cord transection
  – polyneuritis

• Right heart failure
  – Cannot overcome increased PVR
  – Decrease in the RV output
  – Dilation of RV can force intraventricular septum to left

• Left heart failure
  – Left atrium and pulmonary vasculature pressures increase

• Congestive heart failure
  – Both ventricles of the heart fail together
    The heart is already overburdened cannot continue to compensate with the addition of PPV
A patient with COPD is receiving VC-CMV. The set tidal volume is increased from 700-900ml and the rate is increased from 10-18. The RT notices a progressive rise in PIP. Immediately following the change the patient’s BP drops from 145/83 to 102/60. What is the most likely cause of this problem and what should the RT recommend?

The substantial increase in mean airway pressure has caused the patient’s BP to drop. The RT should determine whether the tidal volume setting is appropriate for this patient. The RT also might recommend the use of VC-SIMV or PC-SIMV (with PSV) to reduce the mandatory rate.
Beneficial effects of PPV

• PEEP may improve cardiac function by raising PaO2 – increase myocardial oxygenation
• Increases in mean airway pressure and intrathoracic pressure lead to reduced venous return that can reduce preload to a failing heart
• The amount and duration of pressure ultimately influences the extent of the harmful effects
Paw:

- The level of positive pressure should never be maintained higher or longer than is necessary to achieve adequate ventilation.
- The lower the mean airway pressure the less marked the cardiovascular effects.
What affects Paw?

- Inspiratory flow
- I:E ratio
- Inflation hold
- PEEP
- High peak pressure from increased Raw
- IMV/SIMV
Intracranial Pressure and Cerebral Perfusion

The human brain is a 3-pound (1.4-kilogram) mass of jelly-like fats and tissues—yet it's the most complex of all known living structures. Up to one trillion nerve cells work together and coordinate the physical actions and mental processes that set humans apart from other species. Photograph by Fred Hossler/Getty Images http://science.nationalgeographic.com/science/photos/brain.html
Effects of PPV

- ↓ CPP
- ↑ ICP

Cerebral hypoxemia from reduced perfusion to the head and an increase in cerebral edema

- Normal intracranial dynamics do not develop this pattern
- Closed-head injuries
- Cerebral tumors
- Post-neurosurgery

- Historically hyperventilated
Renal Effects of PPV

• Renal responses to hemodynamic changes resulting from high intrathoracic pressures
• Humoral responses
• Abnormal pH, PaCO2 and PaO2
Effects of PPV on the Liver and Gastrointestinal function

• Malfunction due to:
  – Drop in cardiac output
  – Downward movement of the diaphragm
  – Decrease in portal venous flow
  – Increase in splanchnic resistance
  – Gastric mucosal ischemia = gastric bleeding or ulcers
  – gastric distention
Once food is swallowed, it passes through the esophagus into the stomach, the pink organ shown here above the yellow pancreas. A large, muscular chamber, the stomach produces digestive juices like pepsin, lipase, and hydrochloric acid, which digest and dissolve stomach contents.

Illustration by PureStock
Nutritional Complications

- Inadequate intake of food
- Hypermetabolism associated with fever and wound healing
- Pre-existing chronic disease

Nutritional Depletion
- Alters a patient’s ability to effectively respond to infection
- Impairs wound healing
- Reduces ability to maintain spontaneous ventilation from weakened respiratory muscles

Overfeeding
- ↑ O2 consumption; ↑CO2 production
- Need for ↑ Ve = ↑ WOB