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Practical Anaesthetics

Physiology of Pneumoperitoneum

- Insuflation of CO_2 to av max 20mmHg
- Once intrabdominal pressure (IAP) exceeds physiological thresholds see organ effects

CVS Effects

- ↑SVR:
  - Mechanical compression of abdo aorta
  - ↑release vasopressin and activation of renin-angiotensin-aldosterone axis
- ↓CO:
  - Compression of IVC ⟹ ↓VR ⟹ ↓preload ⟹ ↓CO
    - ↳ especially if hypovolaemic
  - Cephelad displacement of diaphragm ⟹ ↑intrathroacic pressure ⟹
    - ↓VR (as above)
    - Compression pulmonary vasculature ⟹ ↑RV afterload

Resp Effects

- ↑IAP ⟹ ↓diaphragmatic excursion ⟹
  - ↑intrathroacic pressure
  - ↓compliance
  - ↓FRC
  - Atelectasis
  - Altered VQ relationships
  - Hypoxaemia
- Absorbed CO_2 ⟹ ↑PCO_2 which is worsened by VQ mismatching

GI Effects

- ↓kidney & liver blood flow - especially in mod/severe organ disease states
  - ↳ IAP 20mmHg = ↓GFR ≈ 25%
  - ↳ Mechanism thought to be ↓afferent flow (2nd to low CO) & ↓efferent flow (high venous pressure)
- IAP persistently >20 = ↓40% blood flow to mesenteric & GI mucosa ⟹ ↑acidosis

Neuro Effects

- ↑ICP:
  - ↑IAP ⟹ ↑intrathroacic pressure ⟹ ↓cerebral venous drainage
    - ↳ despite ↑ed mean cerebral arterial pressure

Physiological Effects of Positonning

Supine

- Resp:
  - ↓FRC - abdo contents encroaching on diaphragm
  - ↑VQ mismatch
  - ↓pulmonary compliance
- CVS:
  - ↑VR from LL vasculature

- ± heart failure in borderline hearts
- +/-compression of IVC in obese/pregnant ⟹ ↓↓CO & ↓↓ bp
- GI:
  - ↑risk regurgitation
- Eye:
  - Risk of corneal drying in 10mins
- Nerve injury:
  - Supraorbital & facial nerve at risk from tube ties & FMs
  - Brachial plexus (esp C8, T1) - ↑ risk of injury when:
    - Arm abducted >90
    - Hand supinated
    - Head turned away
  - Ulnar nerve (>25% all nerve injuries) - in ulnar groove, medial epicondyle (↳ x3 males > female)
- MSK:
  - Loss lumbar lordosis ⟹ ↑chance LBP
  - Pressure sores - heels, occiput, sacrum

Lateral

- VQ mismatch - dependant lung vs non dependant lung
- Greatest amount of occular complications:
  - Mostly corneal abrasions - either eye
- Nerve damage:
  - Brachial plexus - need good lateral support
  - Saphenous nerve & common peroneal - need padding between legs

Lithotomy

- Very similar to trendelenburg
- Hands and digits at the side of the patient - must be careful to avoid crush when replacing bottom of table
- Nerve damage - bilat flex of hip joints ≈
  - stretch sciatic & obturator nerves
  - Femoral nerve - direct compression under inguinal ligament
- Calf compression ⟹ VTE risk
- Compartment syndrome - mulitple causes of ↓perfusion pressure:
  - Weight of extremity against support ⟹ ↓compartment capacity
  - Elevation above heart
  - ↳ stirups no better than combined calf support
  - ↳ length of op >5hrs main risk factor

Prone

- Must try and avoid pressure on abdo by good positioning
- Effective positionning can be positive physiologically (approx 70-80% see improvement initially)
  - ↑FRC
  - ↓VQ mismatch
- BUT position assoc with most MSK injuries:
  - Eye & nose
  - UL positions: small ant flex, abducted 90deg and ext rotation

Reverse Trendelenburg

- Beneficial physiological effects:

    - ↑head & neck drainage
    - ↓ICP
    - ↓regurgitation
- Risks:
    - ↓bp
    - ↑risk venous air embolism

Seated

- Venous pooling into LLs & refractory hypotension
- Venous air embolism - esp during craniotomy:
    - Subatmospheric venous pressure & non collapsable dural sinuses

Trendelenburg

- Classic 45deg head down tilt

- CVS system
    - In healthy little long lasting effect due to quick compensation VD to overcome ↑VR
    - No RCT evidence to support trendelenburg position is of benefit in correcting acute ↓bp
    - In elderly or comorbidities with impaired vasomotor control may see ↑bp:
        - Capillaries and most of venous blood above heart
        - Incr VR ⟹ ↑preload ⟹ ↑stroke volume ⟹ ↑CO ⟹ ↑bp
          ↳ effect is marked in
            - deep inhalation: -ve pressure vent ⟹ ↑-ve intrathoracic pressure
            - high spinal/anaesthesia - sympathetic blocking ⟹ ↑VD ⟹ ↑VR
- Possibility of ↓bp is also argued:
    - ↓VR 2nd to intraabdo and pelvic organs compressing IVC
- Risk of adverse consequences in people with cormobidities:
    - Obese
    - Compromised RV EF ⟹ R heart failure
    - Pulmonary disorders
    - Head injuries
- Well leg compartment syndrome - combination of:
    - ↓arterial perfusion to raised LLs
    - Compression of leg vessels by SCDs
    - ↓femoral drainage by +/- pneumoperitoneum

- Resp system:
    - Rasied diaphragm with gravity and weight of abdo cavity organs:
        - ↓VC, ↓FRC, ↑risk basal atelectasis
          ↳ 20deg head tilt = ↓VC by 15%
    - Hypercarbia 2nd to shunt
    - Incr VQ mismatch: ventilation maximal at bases, perfusion maximal at apex 2nd to gravity
    - Endobronchial intubation - northward movement of pt with fixed position of ETT ⟹ relative southwards migration of tip of ETT further into lungs
    - Upper airway oedema 2nd to orthostatic forces (prolonged positioning)
- Airway/Positioning:
    - Movement of pt with gravity causing soft tissue damage to lips on ETT and tie
    - Danger of patient falling from surg table
- Digestive system:

- Pooling of secretions in dependant part ie nasopharynx ⟹ ↑risk laryngospasm if not suctionning pre extubation
- Increased risk of aspiration of gastric contents - if non secured airway

- Neuro:
    - Intra and extra cranial venous congestion ⟹ ↑ICP
    - ↑risk cerebral oedema
- Eye - ↑intraoccular pressure

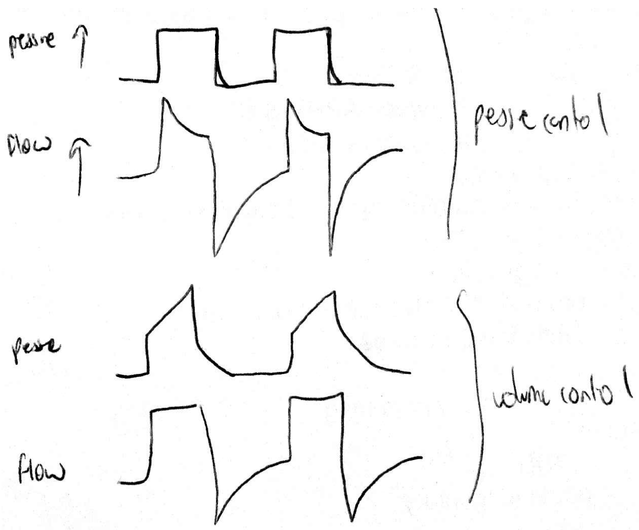
Ventilation Modes

- Invasive:
    - mandatory:
        - pressure control
        - volume control
        - high flow oscillatory ventilation (HFOV)
    - intermittent mandatory (ie mixed mandatory & spontaneous):
        - volume - SIMV
        - pressure
            - Airway pressure release ventilation (APRV)
            - BPAP
            - Adaptive Pressure Control (APC)
            - ASV
    - Spontaneous ventilation
        - Pressure support ventilation (PSV)
        - proportional assist ventilation (PAV)
- non-invasive positive pressure ventilation (NIPPV):
    - CPAP
    - BiPAP

Pressure & Volume Control

- different variables changed by clinician as based on name
- pressure control theoretically may be able to recruit more alveoli for same max pressure
    - occurs because prolonged period of constant pressure
    - in volume control pressure ramps up as volume is delivered

Pressure/Time & Flow/Time Curves



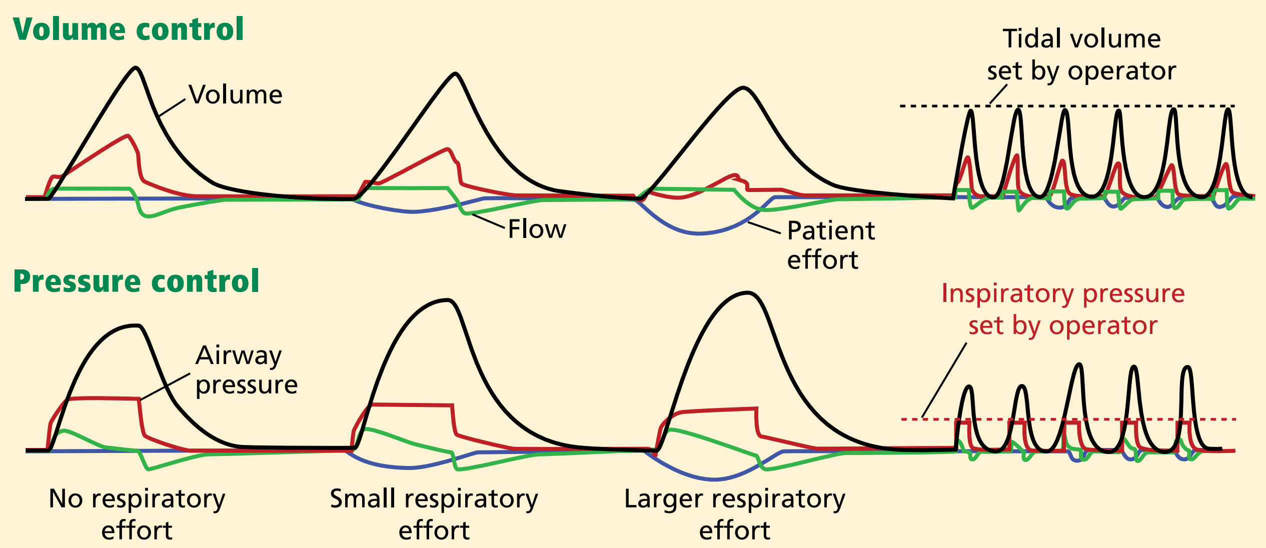


FIGURE 1. Volume control (top) and pressure control (bottom) are modes of continuous mandatory ventilation. Each mode is depicted as patient effort increases. Notice that the mode's control variable (volume or pressure) remains constant as patient effort increases. Contrast these findings with those in FIGURE 2.

High Frequency Oscillatory Ventilation (HFOV)

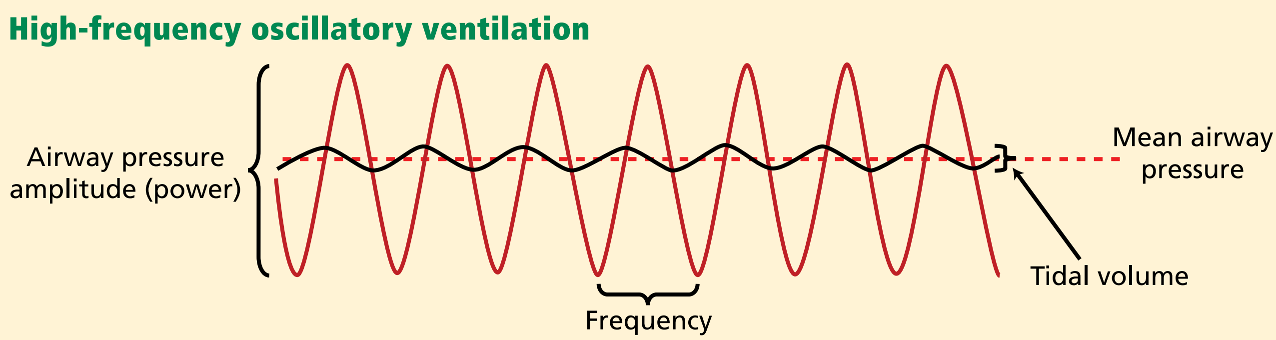


FIGURE 5. High-frequency oscillatory ventilation delivers very small mandatory breaths (oscillations) at frequencies of up to 900 breaths per minute.

- = pressure controlled intermittent mandatory ventilation
- need special vent - to deliver constant oscillations 160-900 breath/min
- pt is paralysed & deeply sedated
- settings:
    - airway pressure amplitude
    - mean airway pressure
    - %insp
    - insp bias flow
    - Fio2
- uses:
    - ARDS where conventional ventilation has failed
- avoid in ↑ICP/severe airflow obstruction
- benefits:
    - can provide the highest mean airway pressure with the lowest tidal volume of any mode
        - ↳ ie a true lung protection strategy

SIMV

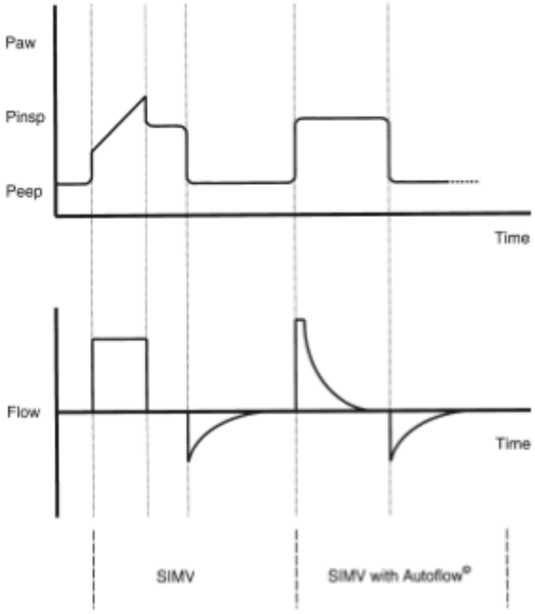


Fig. 2 SIMV and reduction in peak pressure with autoflow.

- intermittent set volume breaths
- these synchronised around the pts effort
- each mandatory vent breath has a preceeding trigger window & if spont insp effort detected an assisted synchronised breath is triggered
- opposite to PCV - set volume with variable pressure
- autoflow = allows flow to be varied by pt. effectively becoming APC but with providing set volume rather than set average volume

Airway pressure release ventilation (APRV) & Biphasic Positive Airway Pressure (BPAP or BiPAP)

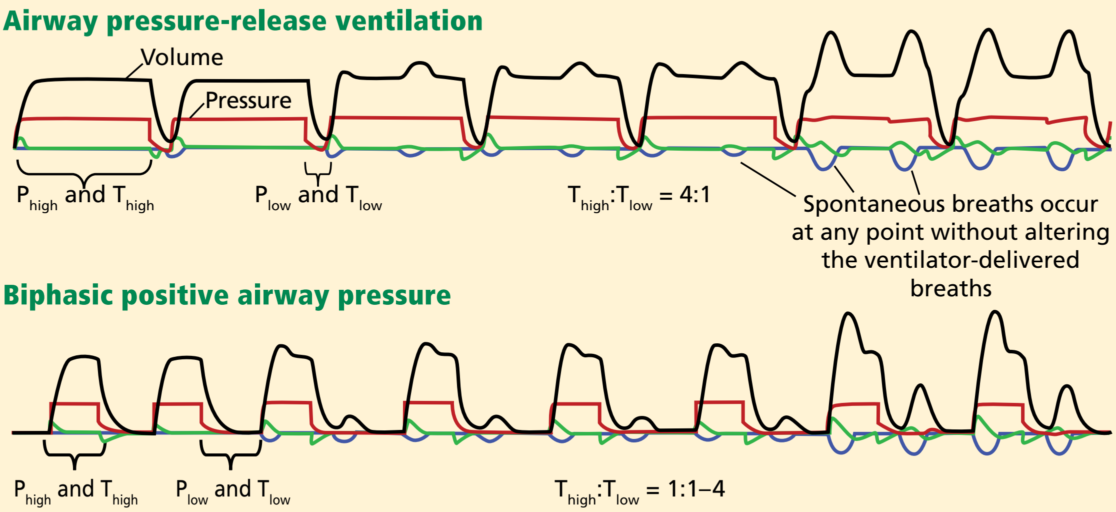


FIGURE 4. Airway pressure-release ventilation (top) and biphasic positive airway pressure (bottom) are forms of pressure-controlled intermittent mandatory ventilation in which spontaneous breaths can occur at any point without altering the ventilator-delivered breaths. The difference is that the time spent in high pressure is greater in airway pressure-release ventilation.

- set variable pressure
- deliver pressure controlled, time triggered, time cycles breaths
- pt able to take breaths at any time
- APRV = high +ve constant positive airway pressure with intermittent releases (exhalation)
  - variables =
    - T_{low} <1.5sec & T_{high}
      - ↳ diff between APRV & BPAP
      - ↳ effectively i:e ratio 4:1
    - P_{high} & P_{low}
  - pt usually breath on top if not paralysed contributing 10-40% to MV
  - concept =
    - ↑oxygenation
    - promotion of alveolar recruitment
    - ↓inflation pressures
    - ↓overinflation
    - improved VQ matching
  - uses:
    - ARDS
    - acute lung injury
- BPAP =
  - same concept as APRV but different emphasis on ratio of high to low pressure
    - ↳ ie more in line with normal breathing
  - variables:
    - Tlow & Thigh with i:e ratio more like 1:2
  - adv:
    - easier to take spont breaths at any time in cycle
    - better for weaning

Adaptive Pressure Control (APC)

- overcomes disadv of pressure control: this mode guarantees minimum minute ventilation despite changing lung mechanics/patient effort
- ∴ delivers pressure controlled breaths with adaptive targeting scheme:
  - changing insp pressure to target min Vt after a number of off target breaths
  - NB
    - not a volume control mode - the volume will change - hopefully the mean will be at target
    - flow speed will also change due to differing pressures - avoids asynchrony as seen in fixed flow volume control & pt spontaneous effort
- vent settings:
  - Vt
  - insp time
  - frequency
  - FiO2
  - PEEP
- Uses:
  - maintenance of consistent Vt but with the advantages of pressure control - include pt taking spont breaths
  - ∴ weaning while waking from anaesthesia
- Advs:
  - flow synchrony
  - less vent manipulation from operator
  - automatic vent weaning

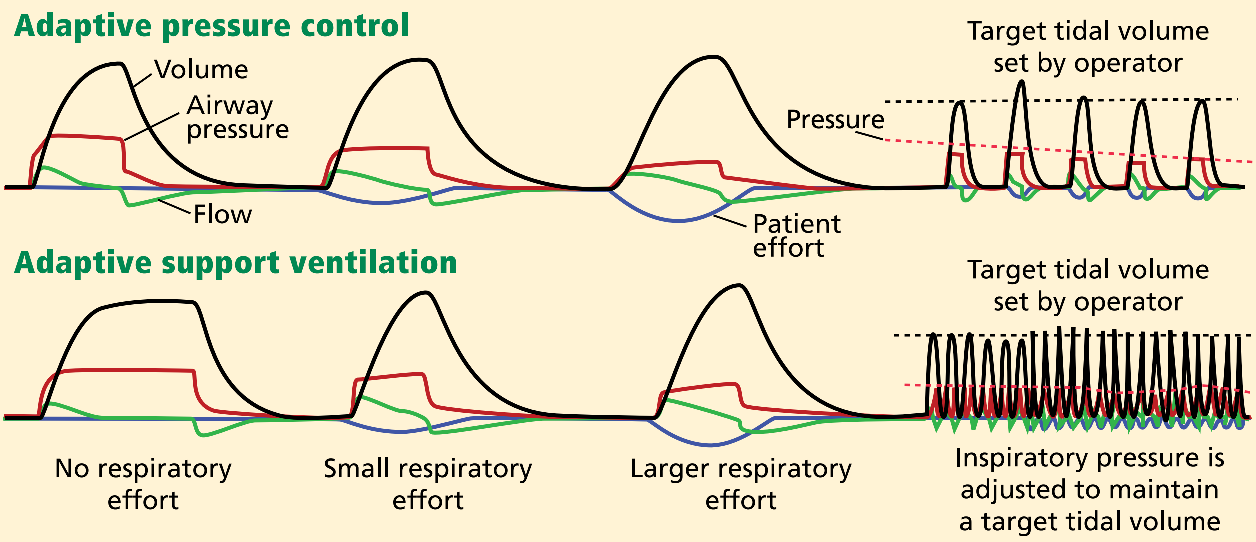


FIGURE 2. A machine in adaptive pressure control mode (top) adjusts the inspiratory pressure to maintain a set tidal volume. Adaptive support ventilation (bottom) automatically selects the appropriate tidal volume and frequency for mandatory breaths and the appropriate tidal volume for spontaneous breaths on the basis of the respiratory system mechanics and the target minute ventilation.

Adaptive Support Ventilation (ASV)

- provides mandatory minute ventilation with adaptive pressure control
- ASV automatically select best variables based on resp mechanics & target MV:
    - Vt
    - frequency of breathes
    - pressure support

    ↳ ie what the brain would do
- machine variables:
    - height & weight ⟹ machine calculates MV 100% based on ideal weight & estimated dead space (2.2ml/kg)
    - PEEP
    - sex
    - FiO2
- process:
    - machine gives test breaths & measures
        - expiratory time constant,
        - compliance,
        - resistance
    - target Vt then achieved by means of APC
- uses:
    - sole resp support from initial support to weaning

Proportional Assist Ventilation (PAV) & Pressure Support Vent (PSV)

- features:
    - PSV = pressure rises to set level & held there until change of phase
    - PAV = pressure applied is a functional of pts effort

        ↳ vent adjusts pressure breath to breath based on pts effort
- operator sets % of support to be delivered by vent

- breaths are completely spontaneous - but with a back up mode
- variables:
  - % work supported (5-95%
  - Vt limit
  - pressure limit
  - exp sensitivity

Proportional assist ventilation

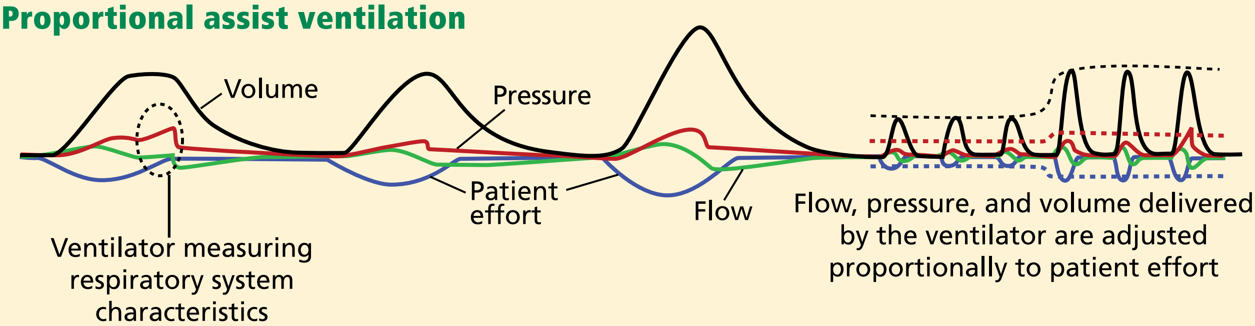


FIGURE 3. In proportional assist ventilation, the flow, pressure, and volume delivered are adjusted proportionally to the patient's effort.