Early Mechanical Ventilation

- **Primary forms**
  - CPAP
  - Time-cycled, pressure-limited IMV

- **Limitations**
  - Neonatal diseases not well understood
  - Equipment was primitive
  - Monitoring capabilities limited
  - Similar treatment regardless of newborn condition
Evolution of Neonatal Mechanical Ventilation

• 1970s
  – Continuous monitors (TCM)
  – Echocardiography
  – New styles of ventilation
Evolution of Neonatal Mechanical Ventilation

- **1980s**
  - Proliferation of new technologies
  - Widespread clinical trials
  - Development of disease specific strategies
- **End of 1980s**
  - Pulse oximetry was a standard of care
  - Testing of surfactant replacement therapy
  - HFV established as alternative therapy
  - ECMO was ultimate rescue therapy for term and near-term infants
Evolution of Neonatal Mechanical Ventilation

- **1990s**
  - Surfactant therapy and antenatal corticosteroids
  - Real time pulmonary graphic monitoring
  - Many new ventilatory techniques
  - Efficacy of inhaled NO demonstrated
  - Better understanding of mechanisms of lung injury (BPD, CLD)
Evolution of Neonatal Mechanical Ventilation

- Twenty-first Century
  - No consensus on how to manage neonatal respiratory failure
  - Need for a disease-specific approach
  - Need for flexibility
Respiratory Distress Syndrome

- Surfactant replacement therapy has had significant impact
- Still significant mortality & morbidity
- CLD still is a problem
- Variance in management styles
- Limited clear evidence upon which to draw conclusions
- Where is the line for extrauterine viability?
Meconium Aspiration

- Treatment controversial
- Varies depending upon the presence of PPHN
- Role of surfactant replacement is being explored
- Traditional suctioning of meconium stained newborns has been challenged
Persistent Pulmonary Hypertension of the Newborn (PPHN)

- Aggressive hyperventilation and induced alkalosis
- Conservative ventilation
Bronchopulmonary Dysplasia

• Now more often called CLD
• Definitions often not helpful
  – Oxygen dependence at 28 days or 36 weeks post conception
  – Does not account for episodic apnea or desaturations in absence of lung disease that respond to oxygen therapy
• Combined therapy which uses oxygen, mechanical ventilation, cardiotonic agents, diuretics, and corticosteroids adds to confusion in management
Goals of Mechanical Ventilation

- Achieve and maintain adequate gas exchange
- Minimize risk of lung injury and other complications
- Reduce work of breathing
- Optimize patient comfort
Continuous Positive Airway Pressure (CPAP)

- May be invasive (endotracheal tube) or noninvasive (nasal prongs)
- Regardless CPAP includes 3 major components
  - Circuit to provide continuous flow of gas
  - Interface to connect circuit to infant airway (usually binasal tubes or prongs)
  - Device to set and maintain the positive pressure desired usually by resistive air leak in circuit just proximal to patient connection (except in “poor man’s CPAP”)

CPAP strategies

• Technique for avoiding intubation and mechanical ventilation
  – Often accepting marginal blood gases
• Weaning technique
• Role of surfactant replacement has added new complexity to decision making process
Conventional Mechanical Ventilation

- Traditional modes (IMV, SIMV, AC)
  - IMV (machine triggered)
  - SIMV and AC (patient triggered)
- Target variable (usually pressure): which cannot be exceeded during delivery of a breath
- Cycling mechanism (usually time)
IMV vs SIMV & AC

• IMV often presented with asynchrony in ventilation. Strategies to overcome asynchrony:
  – Knock out stimulus to ventilate with high rate
  – Sedatives and/or paralytics

• SIMV and AC
  – Spontaneous breaths are always patient triggered reducing problems with asynchrony
  – Back up rate assures reasonable adequacy of ventilation
Pressure Support Ventilation

- Long available for adult patients, PSV is available in newer infant ventilators
- Is a patient-triggered mode and shares the good features of SIMV and AC
- Varies from usual pressure-limited ventilation
  - Flow varies based on patient effort
  - Time of inspiration is variable because it is flow-cycled rather than time-cycled
Brief Comments on Weaning

- With SIMV, rate reduction is used.
- With AC, rate reduction will not help, may reduce PIP or switch to SIMV.
- PSV can be incorporated into weaning strategies.
MAP and Oxygenation

- Long understood that oxygenation could be influenced by $F_1O_2$ and/or airway pressure changes
- CPAP was often increased to avoid high $F_1O_2$
- Also PIP and TI influence oxygenation
- Led to use of higher pressure to avoid high $F_1O_2$
- Short term gains in oxygenation were offset by increase in CLD and other barotrauma
- More emphasis on “gentle” ventilation
Pressure Controlled Ventilation

- Similar to traditional pressure limited, time cycled ventilation except that flow is variable to allow PIP to be reached in early inspiration
- Some ventilators use adjustable rise time to allow adjustment of the slope of pressure waveform
- Volume delivery is function of settings and pulmonary compliance
Volume Ventilation

• Not usually used in neonatal ventilation due to concerns of leaks with uncuffed tracheal tubes and the very small volumes mandated for these patients.

• However, the importance of getting appropriate volumes should not be ignored
  – Volume-targeted
  – Volume-limited
  – Volume-controlled
Newer Techniques

• Volume Guarantee (Drager Babylog 8000plus)
  – Pressure-limited breath at fixed flow
  – Target tidal volume set
  – Ventilator establishes tidal volume based on previous 8 breaths and adjusts the pressure except cannot override pressure limit
Newer Techniques

- Pressure-Regulated Volume Control (Siemens Servo 300)
  - Used only with AC
  - Variably decelerating flow waveform with time-cycled breaths
  - Learning period
    - P-V relationship determined and compliance calculated
    - Compared to target volume and inspiratory pressure adjusted to approach target volume
    - PIP limited to 5 cm $H_2O$ below preset pressure limit
Newer Techniques

• Volume-Assured Pressure Support (VIASYS Healthcare’s VIP Bird Gold)
  – Target volume is set
  – Breaths start as pressure-limited, flow-cycled breaths
  – When inspiratory flow has decelerated to a minimum set level, delivered volume is measured
  – If assured volume is not met, inspiration is prolonged at minimum flow and increasing pressure until target volume is met
  – Safety features include ability to limit pressure and TI
Other Ventilation Concepts

- Conservative or “Gentle” Ventilation
  - Minimal acceptable gas exchange with least ventilator settings
  - Several studies advocate this approach for PPHN which is a significant departure

- Permissive hypercapnea
Other Ventilation Concepts

- Nasopharyngeal SIMV
  - Basically, ventilating through a nasopharyngeal tube
  - Usually, a weaning technique
High-Frequency Ventilation

- High-frequency jet ventilation (Bunnell Life Pulse High Frequency “Jet” Ventilator)
  - Used with background conventional ventilator
    - Provides gas flow for “jet” ventilator
    - Provides PEEP
    - Provides an intermittent conventional breath
  - Frequency range is 240-660 breaths/minute
  - Often directed to reduce incidence or resolve instances of barotrauma
High-Frequency Ventilation

• High-frequency oscillatory ventilation (Sensormedics 3100A)
  – Small volume, extremely high rate (5-15 Hz)
  – Active exhalation from diaphragm or piston
  – Primarily used as a rescue technique, not primary treatment modality
Extracorporeal Membrane Oxygenation

- Highly invasive and expensive mode of gas exchange
- Inclusion and exclusion criteria vary from center
  - Usually term or near-term infants
  - Intractable, but potentially reversible respiratory failure
- Use had declined since the advent of HFV, surfactant replacement therapy, and inhaled NO
Final Thoughts and Questions

- Understand
- Buy into the plan
- Apply diligently
- Observe
- Ask questions
- Use a team approach