

Care of the Technology Dependent Child

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Disclosures

I have the following financial relationships with the manufacturer(s) of any commercial product(s) and/or provider(s) of commercial services discussed in this CME activity:

Consultant for Philips Respironics, Inc.







Goals of Home Mechanical Ventilation

- To extend life and enhance its quality
 - To palliate dyspnea
- To reduce morbidity
- To improve physiological function
- To achieve normal growth and development whenever possible
- To reduce health care costs

Adapted from O'Donohue WJ Jr., et al. Chest 90 1S; 1986

Conditions For Prolonged Mechanical Ventilation

1) Respiratory pump

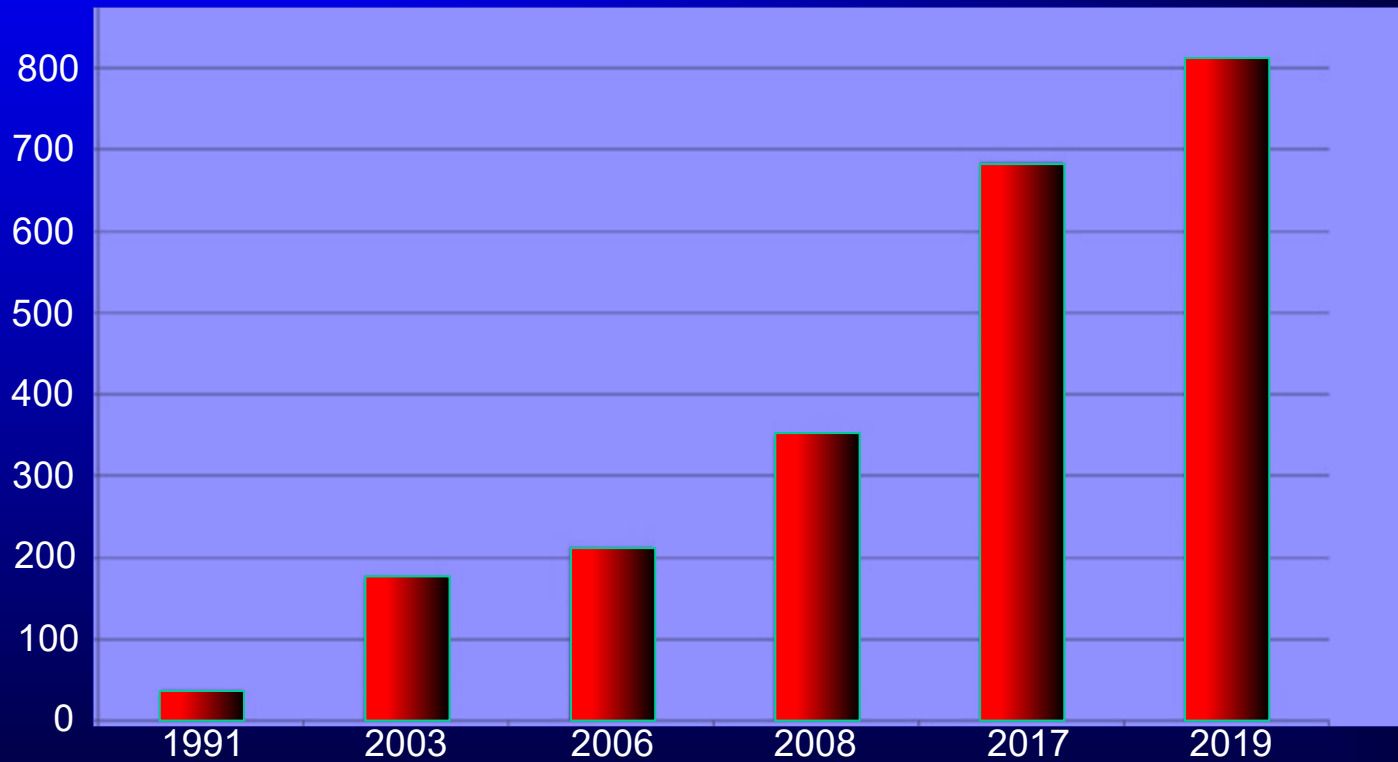
Respiratory muscles, rib cage, abdominal wall

2) Respiratory drive

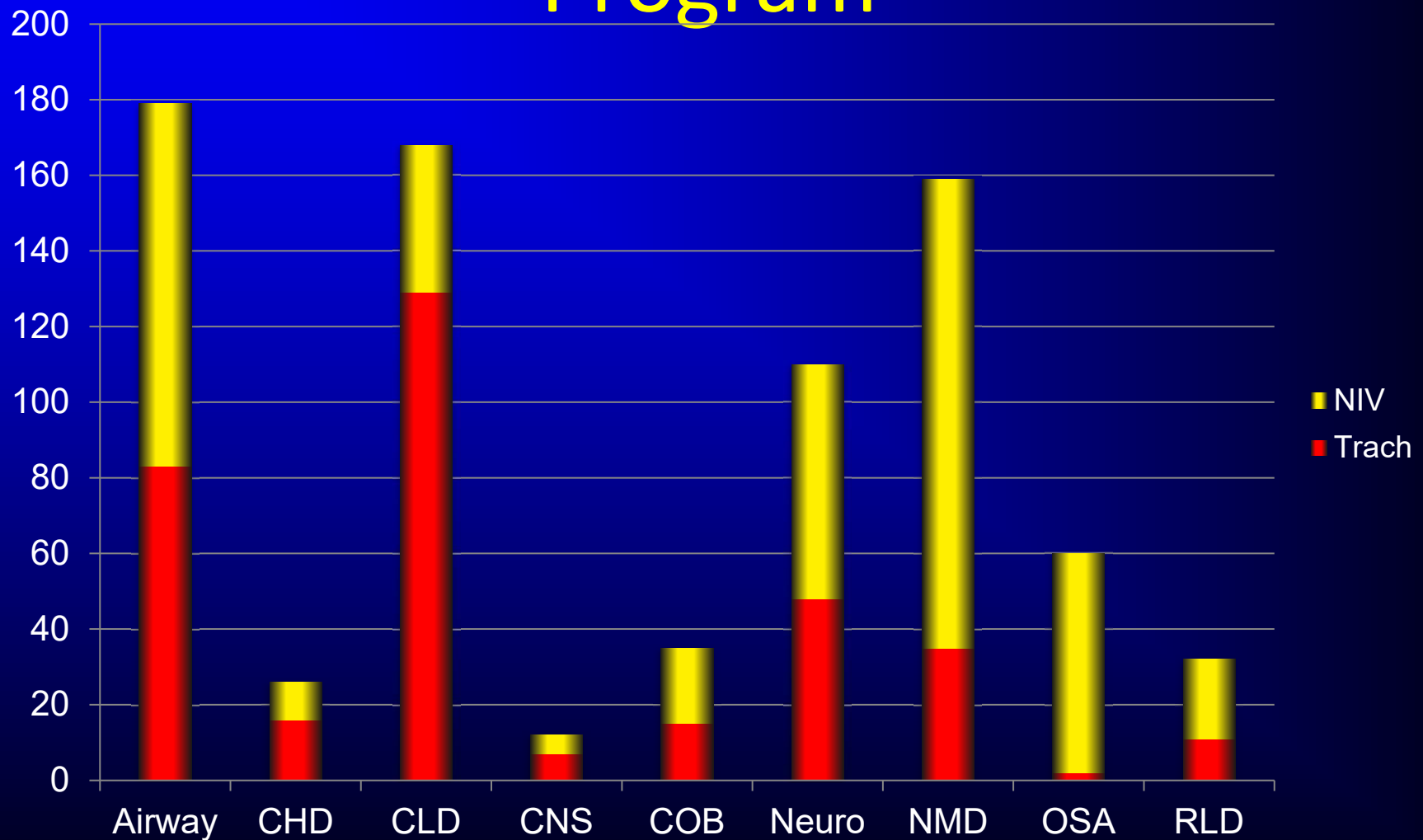
3) Extrathoracic and central airway lesions

4) Pulmonary parenchymal and vascular lesions

Growth of the Pulmonary Home Ventilation Program



Pulmonary Home Ventilation Program



Patient Eligibility

- Medical Stability
- Social – Environmental
- Reimbursement
- Organizational



Medical Stability

- Clinical
 - Positive trend on growth curve
 - Stamina for periods of play
 - No frequent fevers or infections
- Physiological
 - Stable airway
 - $\text{PaO}_2 \geq 60$ torr in $\text{FiO}_2 \leq 0.4$
 - $\text{PaCO}_2 < 50$ torr
 - Frequent ventilator changes not required
- Individualization

Adapted from Make BJ et al. Chest 113:289S; 1998

Social / Environmental

- Family members willing to:
 - Help care for patient
 - Be included in planning and selection of professional caregivers
 - Commit to the plan
- Home Environment
 - Enough space
 - Access
 - Adequate heat, electricity, water
 - Working telephone
 - Area resources (Emergency room, ambulance service)





Reimbursement

- For funding of
 - Durable medical equipment
 - Disposable supplies
 - Nursing salaries
- 3rd party payers
- Medicaid
- Model waiver programs

The Process

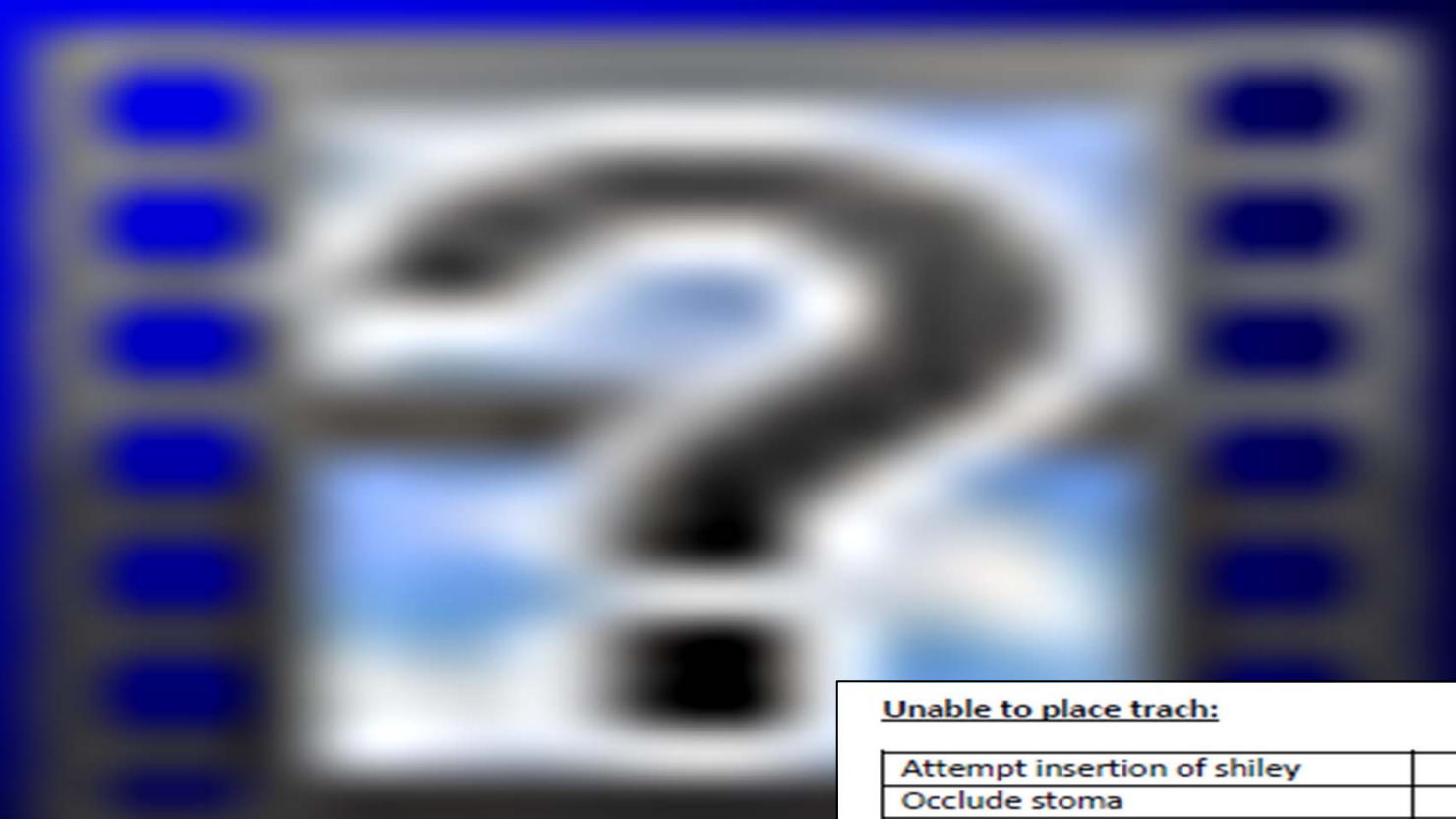
- Patient / family assessment
- Discussion and options presented
- “Contract”
- ~8 wk
program



8-Week Plan

Wk	Activity	Family	Participants
1	Meeting, training plan	*	Team, FLOC
2	Choose companies, Adaptive Equipment needs	*	Therapists, Case Manager
3	Home Eval by DME company and therapists		DME, Therapists
4	Outpatient therapies, EI plan, Home evaluation reports		DME, Therapists
5	Family meeting update, choose PCP	*	Team, FLOC
6	Identify d/c date, transport needs, WIC application	*	Team, Case Manager
7	Update equipment lists, arrange delivery, d/c meeting, 24 hr stay	*	DME, Team, FLOC
8	Deliveries, letters, Px's, Nursing schedule, OP therapies reviewed, f/u appts, CXR copied	*	Team, Case Manager

Patient Simulations



Unable to place trach:

Attempt insertion of shiley	
Occlude stoma	
Bag patient	
Call 911	

Simulation courtesy of Richard Lin, M.D.

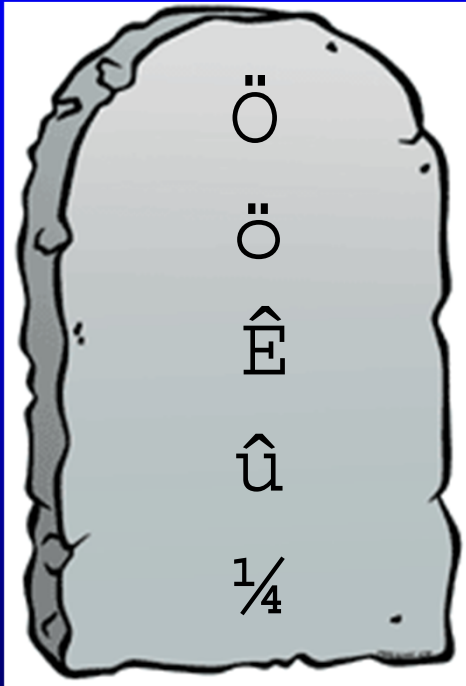
Stability Before Discharge

- 109 patients discharged over 6y 10 mo
- 44 (40%) unexpected readmission in 12 mo
 - 19 patients within first month (22/78 total)
- Any change in medical regimen within 1 wk of discharge was the ONLY significant factor
 - 8/10 readmitted
 - Vent settings
 - Chronic med changes/additions
 - Antibiotics for non-respiratory infections
 - Change in size of tracheostomy tube

Choosing a Ventilator



Choosing a Ventilator



1. Know your ventilator
2. Make sure hospital staff knows ventilator
3. Make sure DME knows ventilator
4. The ventilator serves the patient's needs
5. The ventilator is appropriate for the patient's needs

Evolution of Ventilators



1st Generation

Piston driven

Large (30-35 lbs/13.6-15.9 kg)

VC mode (SIMV, A/C)

No continuous flow

External PEEP

Pressure Trigger

Limited internal battery

2nd and 3rd Generation

Most turbines

< 15 lbs (6.8 kg)

PC/VC modes (SIMV, PSV, A/C, CPAP)

Continuous flow

PEEP mostly integrated

Flow or Pressure Trigger

More external battery options

Graphics, downloads

Some Basic Specifications



Weight	6.6 kg (14.5 lbs)	5kg (11 lbs)	3.2 kg (7.1 lbs)
Internal Battery	0.5 – 1 hr	3 hrs	8 hrs
External Battery	6 hrs	3 hrs	8 hrs X 2
Programs	1	2	4
Trend Data		SD card / Cloud	Internal Hard Drive / Cloud



PIP max (cmH ₂ O)	99	50	50
PEEP max (cmH ₂ O)	20	25	20
Ti min (sec)	0.3	0.3	0.2
Bias flow (LPM)	10	Variable (up to 200)	Variable (up to 250)

Question 1

9-month-old with NMD acquires an RSV illness.

BLPAP noninvasively in S/T mode

IPAP of 16 cmH₂O; EPAP of 6 cmH₂O; rate of 10.

She is hypercapneic despite a RR of 45/min and ventilator output shows that her inspiratory pressure does not exceed 14 cmH₂O. Which intervention would most likely increase her ventilator support?

- Increase the set IPAP to 18 cmH₂O
- Decrease the Rise Time from 2 to 1
- Increase the rate to 20/min
- Decrease the Cycle Sensitivity from 30 to 20%

Question 1

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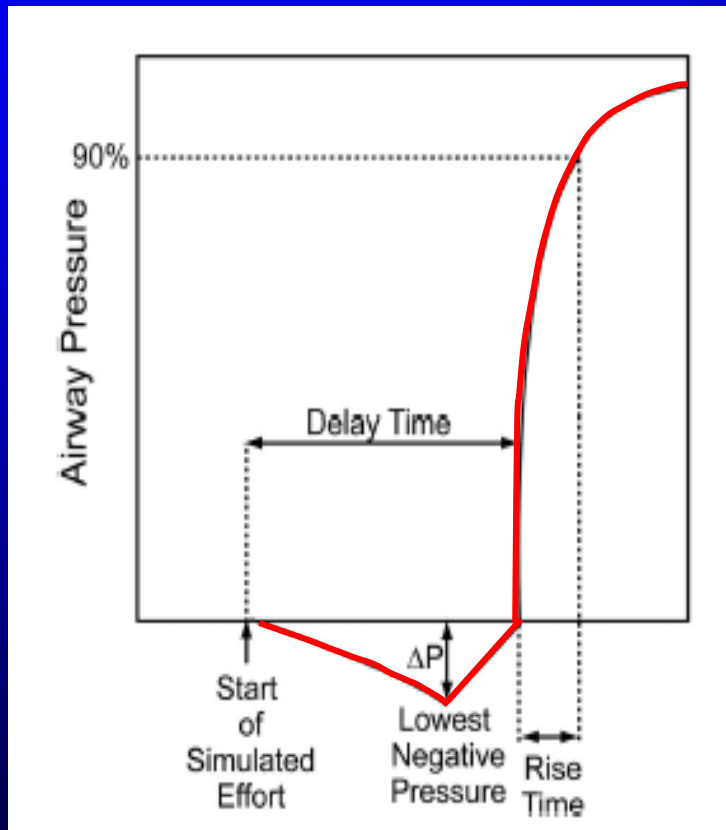
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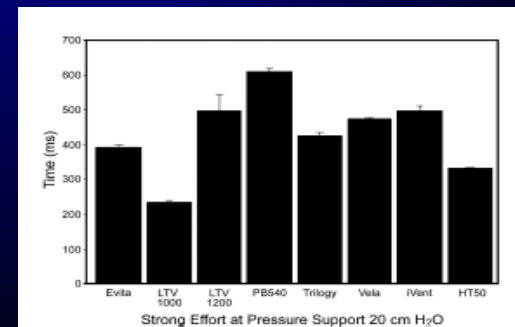
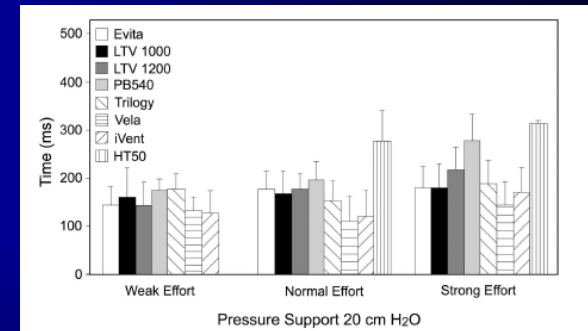
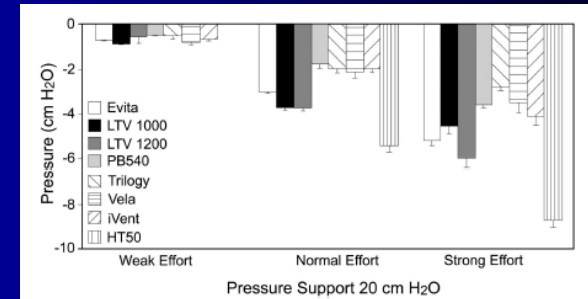
Ventilator Characteristics



Lowest negative pressure

Trigger delay

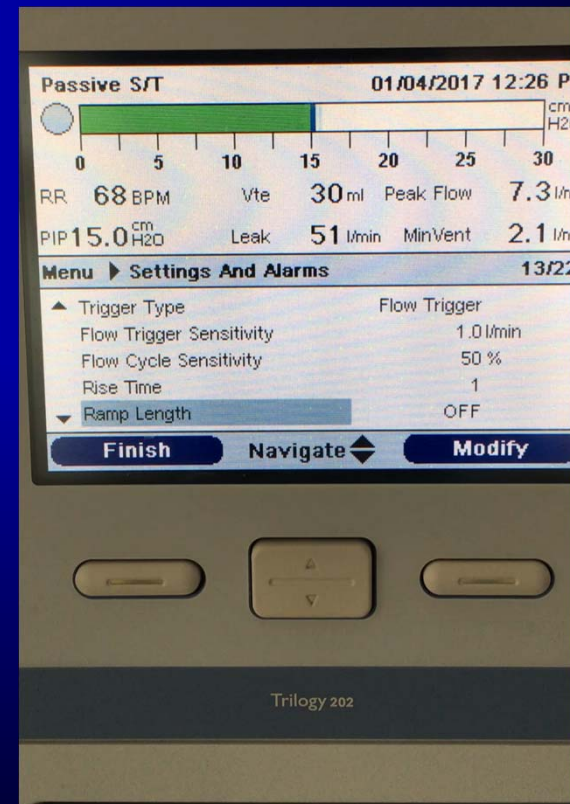
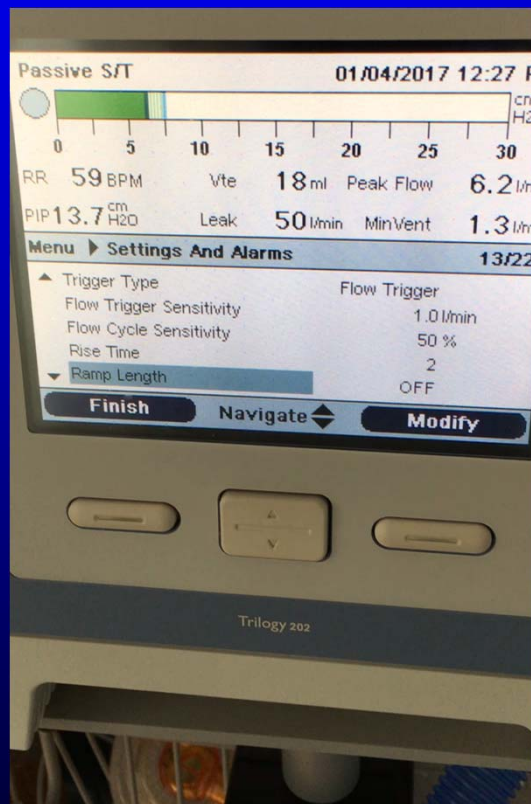
Rise time



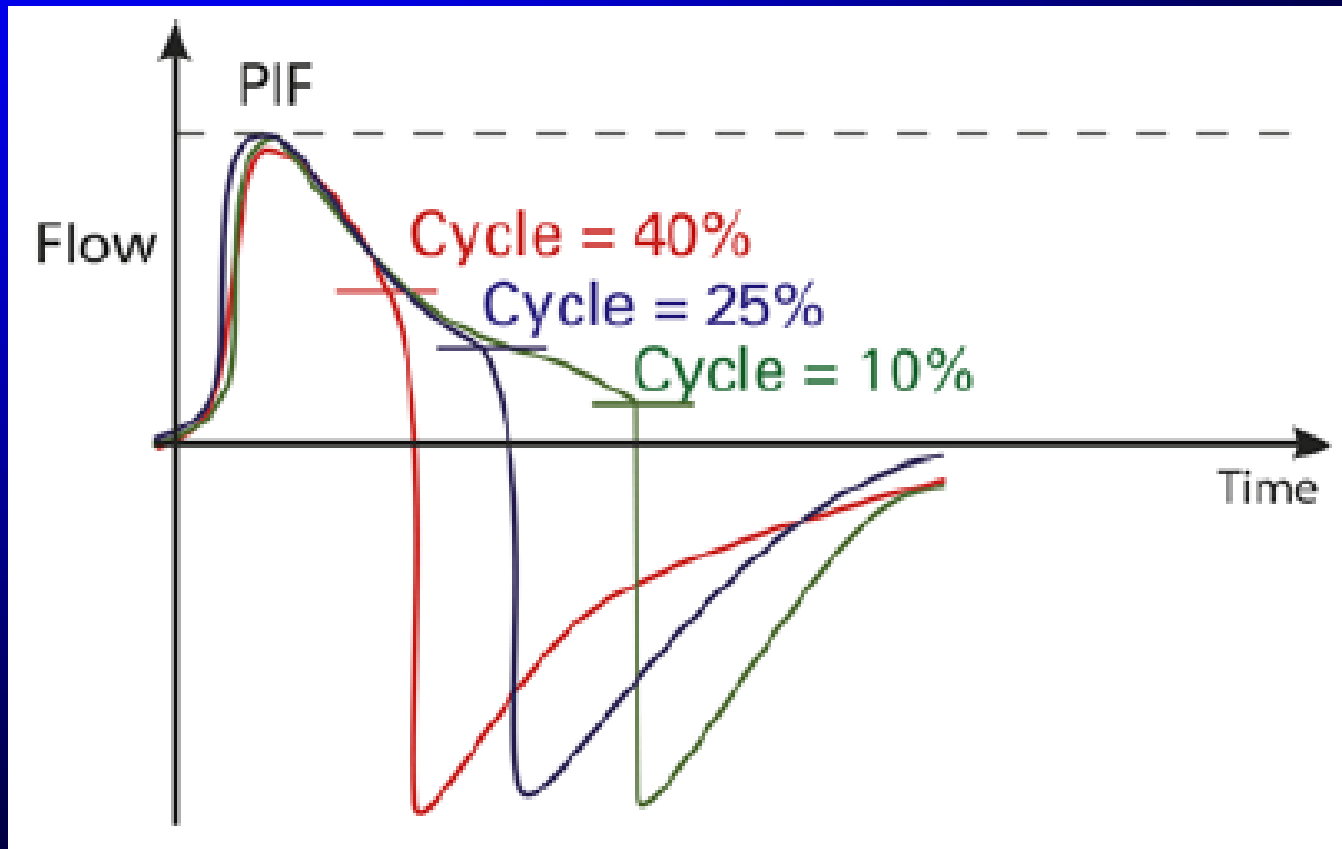
Rise Time in a Tachypneic Infant

IPAP 16 / EPAP 6, Rise 2

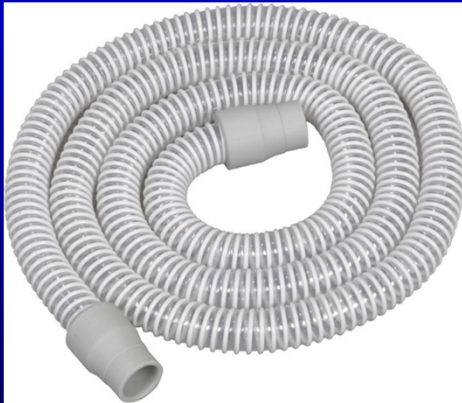
IPAP 16 / EPAP 6, Rise 1



Changing Cycle Sensitivity



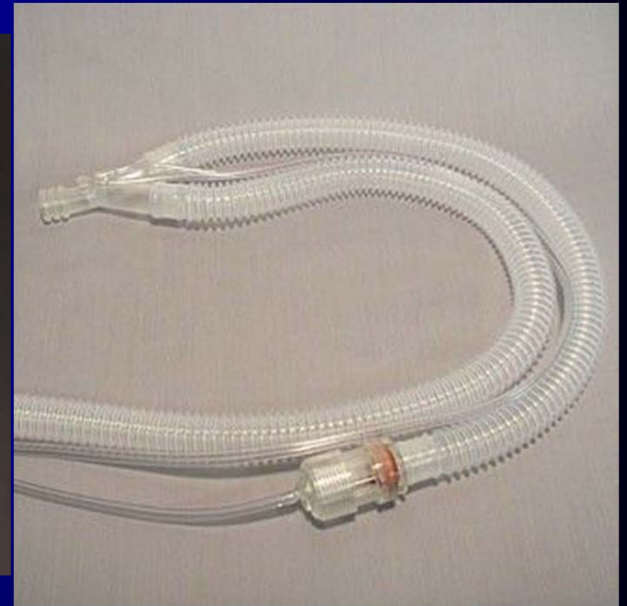
3 Types of Circuits



Passive Leak



Active PAP



Active Flow

PPV Machines and Circuit Selection

Active Flow Circuit Only



All Circuit Configurations



Attributes of Circuits

	Passive	Active PAP	Active Flow
EPAP	Required	Optional	Optional
Leak Compensation	+++	-	Available
Trigger	Flow, Auto-Trak* (*Trilogy)	Flow	Flow or Pressure* (*Astral)
Airway Pressure	Estimated	Monitored proximally	Monitored
Tidal volume	Estimated	Vti measured	Vte measured

Fierro JL and Panitch HB. Semin Fetal Neonat Med 24:101041; 2019

Characteristics of Passive Circuits

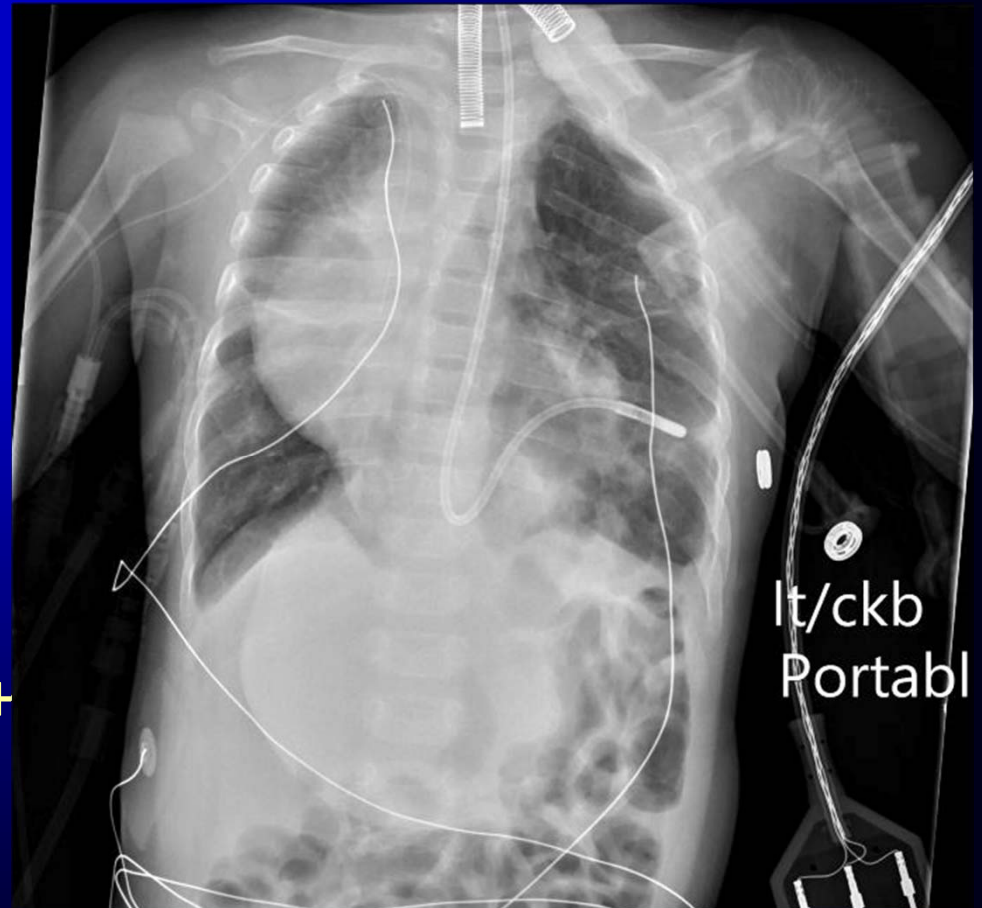
Beneficial	Detrimental
Simple, lightweight	Must have expiratory pressure (PEEP/EPAP)
Leak tolerant (better synchrony)	Variable FiO ₂
Leak Compensation	Some trigger limitations
Special algorithms for trigger / cycle	May not be capable of VC mode
Special modes (AVAPS / iVAPS)	

A Potential Complication

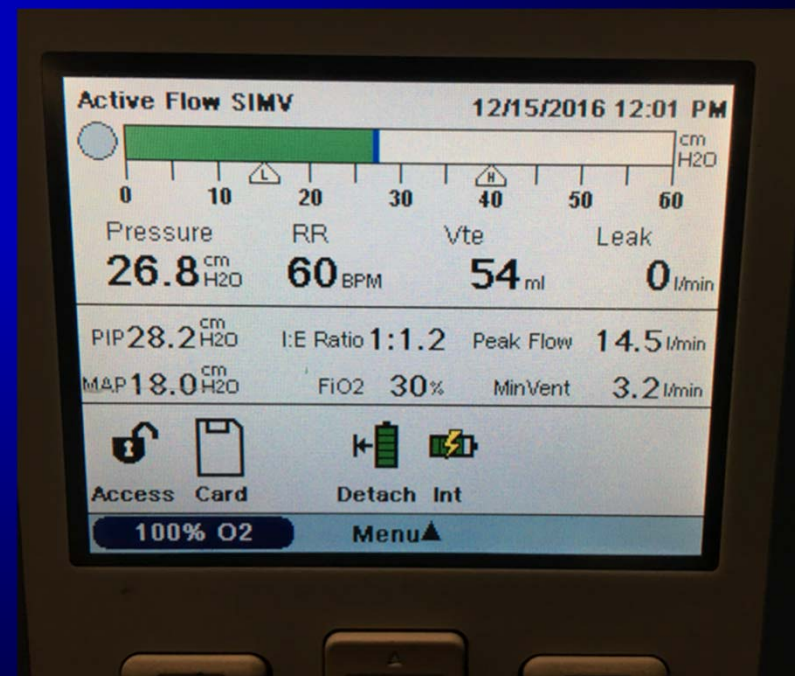


A Reason for Circuit Preference

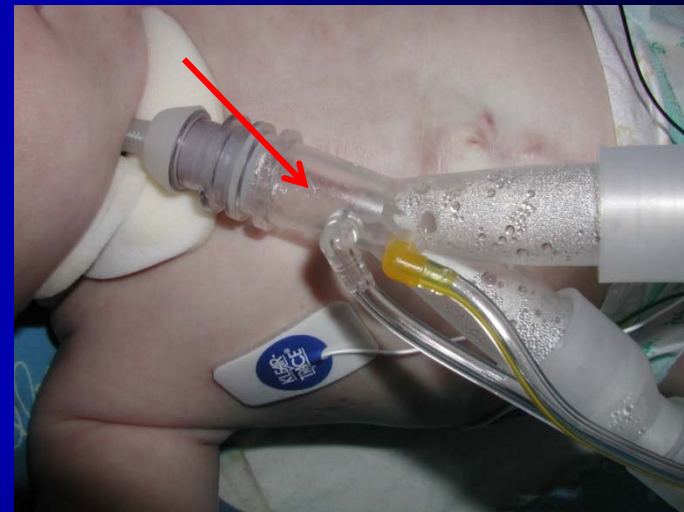
- 8 month old
- Giant omphalocele, left diaphragm eventration
- Intolerant of gastric feedings
- Passive circuit, SIMV + PSV

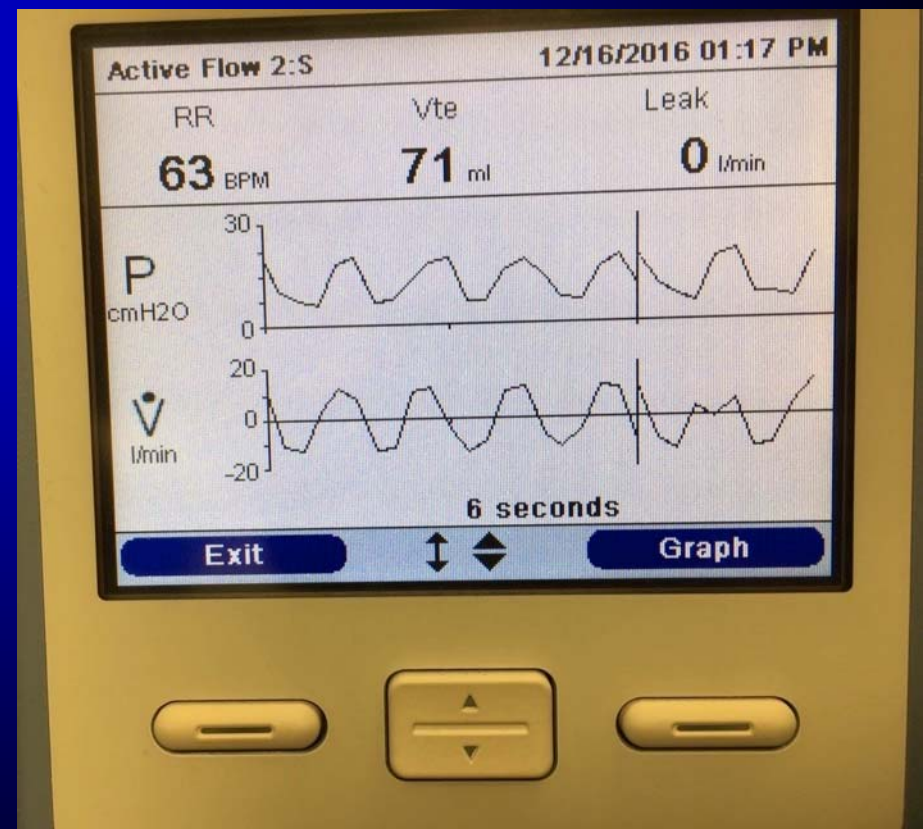


Active Flow VC-SIMV



Active Circuit with Flow Sensor



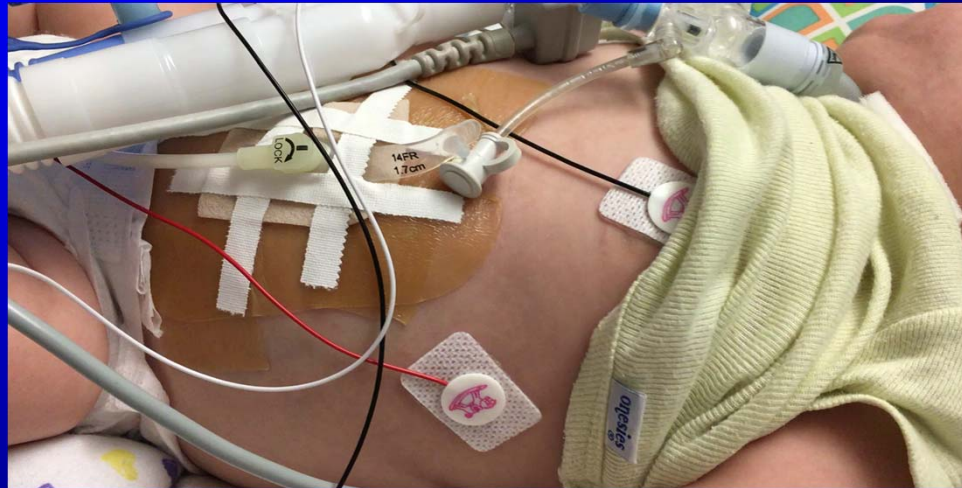


Active Flow; S mode IPAP 20 cmH₂O, EPAP 10 cmH₂O
Rise 1, Sens 1, cycle 10%

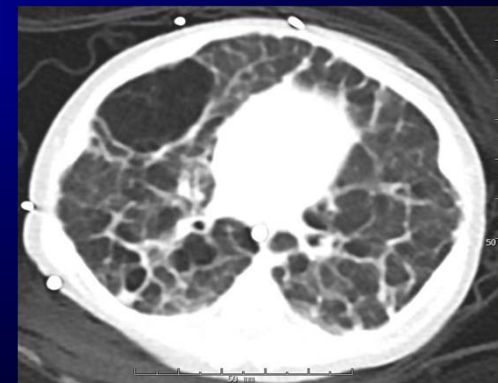
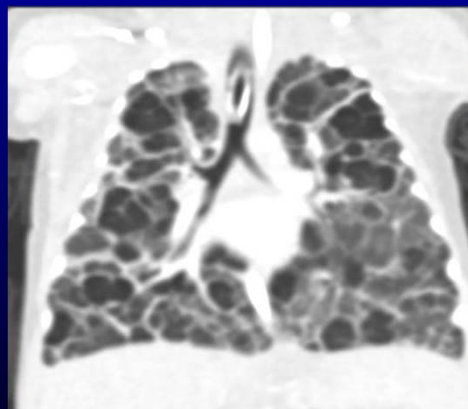
- Changed to Passive Leak Circuit
- S/T Mode
 - IPAP 24 cmH₂O
 - EPAP 9 cm H₂O
 - Backup rate 15
 - Auto-Trak Sensitive
 - 21% oxygen



A Different Reason for Active Flow Circuit



PS with Safety Volume



Why Choose 1 Circuit Over Another?

Passive Leak Circuit	Active Valve Circuit
Simple, single limb	Single or Double limb
Continuous flow; EPAP mandatory	EPAP / PEEP optional
Flow trigger / algorithms	Flow / Pressure trigger
Pressure or Volume* Modes	Pressure or Volume Modes
Variable FiO ₂	More Consistent FiO ₂
AVAPS / iVAPS	

Monitoring



Question 2

A 14-month-old with bronchopulmonary dysplasia is receiving mechanical ventilation via tracheostomy from a portable ventilator in PC-SIMV + PSV mode. He develops a mucous plug that obstructs 90% of the tracheostomy lumen. Which of the following alarms will be triggered?

- A. Low minute volume alarm
- B. High pressure alarm
- C. Low pressure alarm
- D. Low PEEP alarm

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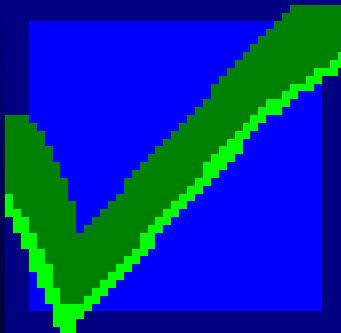
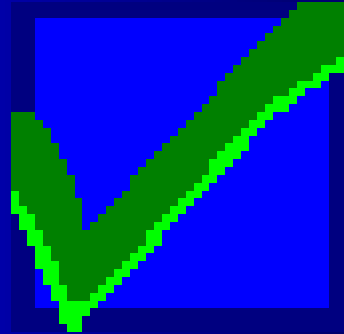
- A. Low minute volume alarm
- B. High pressure alarm
- C. Low pressure alarm
- D. Low PEEP alarm

Ability to Detect Tracheostomy Decannulation

Trach ID size (mm)	Low VS; Low PA 4	Low VS; Low PA 10	Medium VS; Low PA 4	Medium VS; Low PA 10	High VS; Low PA 4	High VS; Low PA 10
3.0	No	No	No	No	No	No
3.5	No	No	No	No	No	No
4.0	No	No	No	No	No	No
4.5	No	No	No	No	Yes	No
5.0	Yes	No	Yes	No	Yes	No
5.5	Yes	No	Yes	No	Yes	No
6.0	Yes	No	Yes	Yes	Yes	Yes

Kun S et al. Chest 119:562; 2001

Additional Monitoring



Monitoring – At Minimum

- A patient who cannot correct problem or call for help
 - Unobserved
 - Sleep
- Small tracheostomies
- Weaning trials

Patient Interventions

What can be done?

- Monitoring
 - Oximetry
 - Capnography
 - Clinical assessments
 - Sputum culture and Gram stain
 - Serum chemistries, drug levels, CBC

Respiratory Assessments (Acute Illness)

Wheezing

Oxygen requirement

Respiratory rate

Secretions

Tussis (cough) /
Tracheostomy

Fever

Energy level

Appetite

Retractions

Medical and Mechanical Ventilatory Interventions

- Ventilator Changes
 - PIP
 - Vt
 - PSV
 - Rate
 - PEEP
- Supplemental O₂
- Bronchodilators
- Corticosteroids
- Ipratropium
- Diuretics
- GER medications
- Antibiotics

TDC Team and Home Care

- Medical
- Nursing
- Respiratory Therapy
- Social Services
- Nutrition
- Support Services



Home Ventilation Team

Functions

- Coordinate care with community medical caregivers
- Review treatment plans
- Advocate for patient and family
- Provide medical direction
- Guarantee access to tertiary care

Patient Interventions

What can be done?

- Weaning trials
- Adjustments of medications and nutrition
- Acute interventions
 - Oral / inhaled antibiotics
 - Parenteral (IM) diuretics
 - Increased mechanical ventilatory support

Follow-Up Care

- Nursing / respiratory assessments
- Frequent telephone communication / home visits
- Periodic office visits
- Ongoing interventions
 - Speech, physical and occupational therapies
- Scheduled readmissions



When Should I See/Admit the Patient?

- Excessive amount of support
- Unclear cause of illness
- Lack of response to interventions
- Homecare providers *do not feel comfortable*

High Technology Home Care Challenges

- Improve quality of life
- Reduce costs
- Maintain / improve services
 - Respite care services
- Integrate new technologies (i.e., Telemedicine)
- Find best alternatives for the individual and family

