

# Weaning and extubation in PICU

## An evidence-based approach

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**Respiratory failure**



**Assisted mechanical ventilation**

**Why**

**When**

**How**



**Weaning from mechanical ventilation**



**Extubation**

## Weaning: Why??

### Benefits of reduced ventilation times

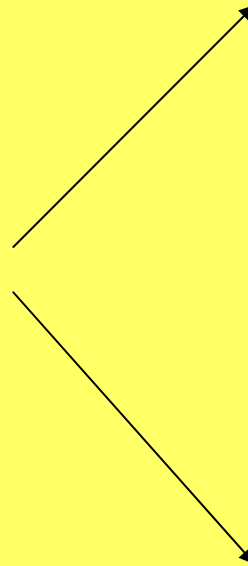
- ✓ ↓ risk of VAP
- ✓ ↓ PICU stay and costs
- ✓ ↓ patient and family stress level
- ✓ Earlier return to normal daily life

# Weaning: When??

Inappropriate time  
of weaning

Weaning  
failure

Delayed  
weaning



## Weaning: When??

### Recommendation in adult (Evidence grade B)

- ✓ Some reversal of the underlying cause of respiratory failure
- ✓ Adequate oxygenation and pH
- ✓ Stable hemodynamic
- ✓ Able to initiate an inspiratory effort

## Weaning: When??

Adequate oxygenation

✓  $\text{PaO}_2/\text{FiO}_2 > 150-200$

( $\text{PEEP} \leq 5-8 \text{ cmH}_2\text{O}$ ,  $\text{FiO}_2 \leq 0.4-0.5$ )

Adequate pH:  $\geq 7.25$

## Weaning: When??

### Other criteria

- ✓ Afebrile
- ✓  $Hb \geq 8-10$  gm/dL
- ✓ arousable,  $GCS \geq 13$ , no continuous sedative infusions)
- ✓ Stable metabolic status
- ✓ Adequate cough

## Weaning: How??

- Protocol-directed vs. physician-directed?
- Mode of weaning?



## Weaning: How??

Protocol-directed vs. physician-directed?

Recommendation in adult (Evidence grade A)

Weaning/discontinuation protocol that are designed for nonphysician health-care professionals should be developed and implemented by ICU.

## Protocol vs. nonprotocol - directed

Study in adults

- ↓ ventilator weaning time
- ↓ ICU cost

## Protocol vs. nonprotocol - directed

### Study in pediatric population: inconsistency

- ↓ ventilator weaning time
- No change in overall ventilator duration

*Respir Care 2001:772-82.*

*J Intensive Care Med 2004:274-84.*

- No difference between protocol vs.  
nonprotocol-directed

*Intensive care Crit Nurse 2003; 186-97.*

*JAMA 2002: 2561-8.*

# Discrepancy of study results

Adult  $\neq$  infants & children

- Lung physiology
- Causes of ALI
- Baseline lung function
- Weaning time

## Weaning protocol

- ✓ Cannot replace clinical judgment
- ✓ Should be customized to local practice and patient populations
- ✓ Require adequate staffing

## Weaning technique

- Spontaneous breathing via t-tube, CPAP, PS
- IMV
- SIMV
- SIMV with PS
- Pressure support
- Volume support
- Non invasive PPV

# Weaning technique

## Recommendation in pediatrics

Currently there are no generally accepted weaning protocols and techniques for children.

## Weaning technique

- Spontaneous breathing via t-tube, CPAP, PS
- IMV
- SIMV
- SIMV with PS
- Pressure support
- Volume support
- Non invasive PPV



## Spontaneous breathing trial

Criteria used to define tolerance of SBT

- ✓ Acceptable gas exchange
  - $\text{SpO}_2 \geq 85\text{-}90\%$
  - $\text{PaO}_2 \geq 50\text{-}60 \text{ mmHg}$
  - $\text{pH} \geq 7.32$
  - $\uparrow \text{PaCO}_2 \leq 10 \text{ mmHg}$
- ✓ Stable hemodynamic
- ✓ Stable ventilatory pattern

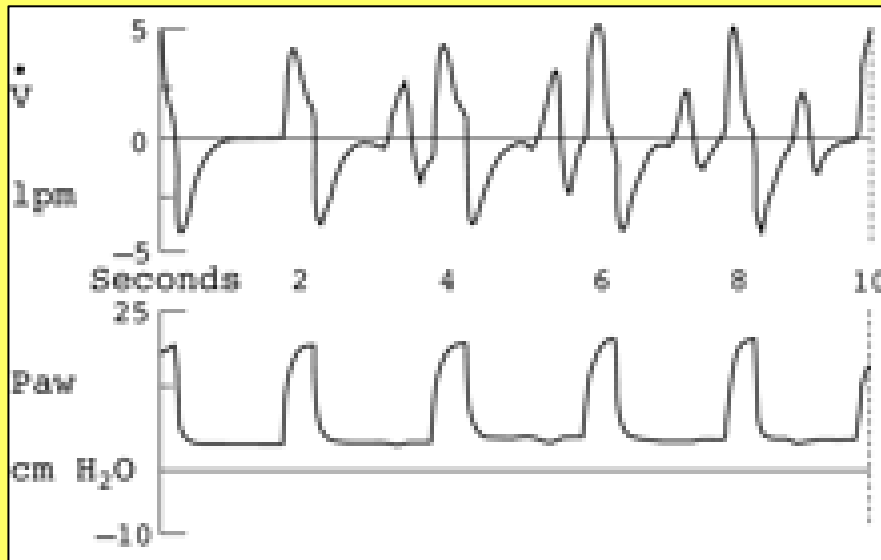
## Spontaneous breathing trial

Criteria used to define tolerance of SBT

- ✓ No change in mental status
- ✓ No signs of ↑ WOB
- ✓ No sign of patient discomfort

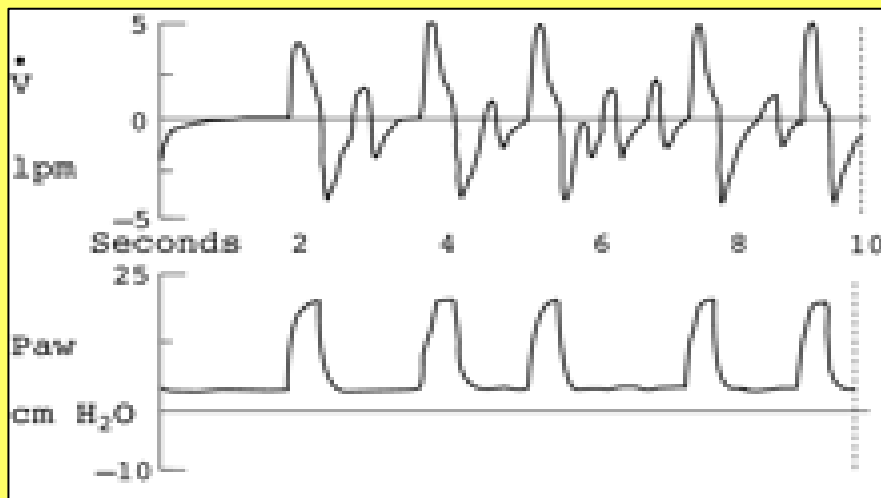
## Weaning technique

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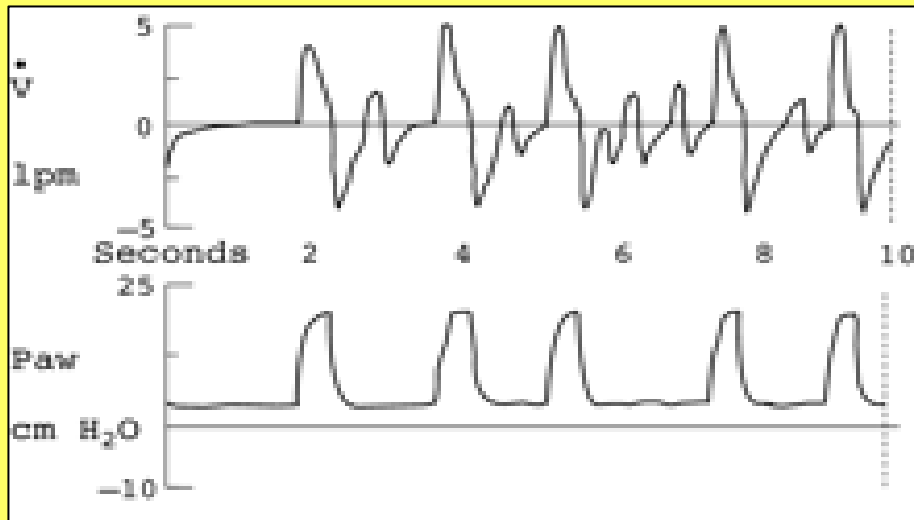
## IMV

Patient-ventilator dyssynchrony



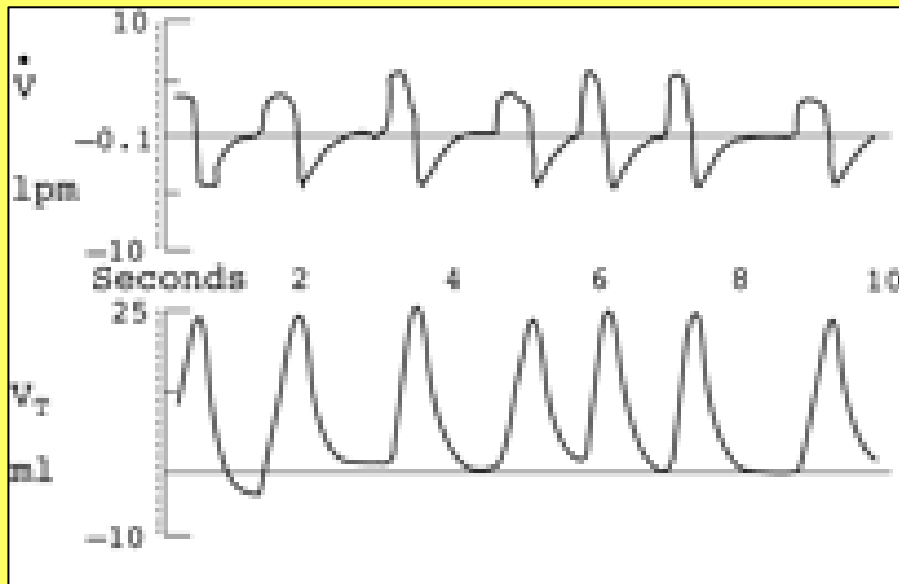
## SIMV

- ↓ patient-ventilator dyssynchrony
- ↑ WOB during spontaneous breathing unless appropriate triggering system



## SIMV

- ↓ patient-ventilator dyssynchrony
- ↑ WOB during spontaneous breathing unless appropriate triggering system



## SIMV+PS

- ↓ WOB during spontaneous breathing with adequate PS
- ↓ duration of ventilator time

# SIMV

- Initial SIMV rate: half of the controlled ventilation
- Gradually ↓ SIMV rate (2-4 breaths/min) according to the patient

↓ SIMV rate

Infant - wean to 2-4 breaths/min

Older child - wean to CPAP mode

*Rogers MC. Textbook of Pediatric Intensive Care*

## Pressure support ventilation

- Flow cycled, pressure limited
- Decelerating flow
- TV, IT, RR are determined by the patient
- Expiration occurs when
  - inspiratory flow <25% of initial flow or
  - time >80% of respiratory cycle
- Need spontaneous inspiration
- No back up for apnea

## Pressure support ventilation

- Inspiratory pressure boost during spontaneous breathing
- Overcome WOB created by ETT and ventilator circuit

Minimal PS adjusted for ETT size

ETT size 3.0-3.5    PS = 10

ETT size 4.0-4.5    PS = 8

ETT size  $\geq 5.0$     PS = 6



## Pressure support ventilation

- Initial PS level - clinically determined (patient breathes comfortably)
- Adjust PS to achieve exhaled TV = 5-7 ml/kg
- ↓ PS 2 cmH<sub>2</sub>O q 4 hrs or earlier if exhaled TV > 7 ml/kg or ↑ PS 2 cmH<sub>2</sub>O if TV < 5 ml/kg
- Monitor exhaled TV, RR and SpO<sub>2</sub>

## Pressure support ventilation

Consider extubation if

Adequate exhaled TV and SpO<sub>2</sub> with acceptable RR for at least 2 hrs at

- FiO<sub>2</sub> ≤ 0.5 and PEEP ≤ 5 cmH<sub>2</sub>O
- Minimal PS adjusted for ETT size

# Pressure support ventilation

Acceptable range of RR for age

< 6 mo.	20-60/min
6 mo.-2 yrs	15-45/min
2-5 yrs	15-40/min
> 5 yrs	10-35/min

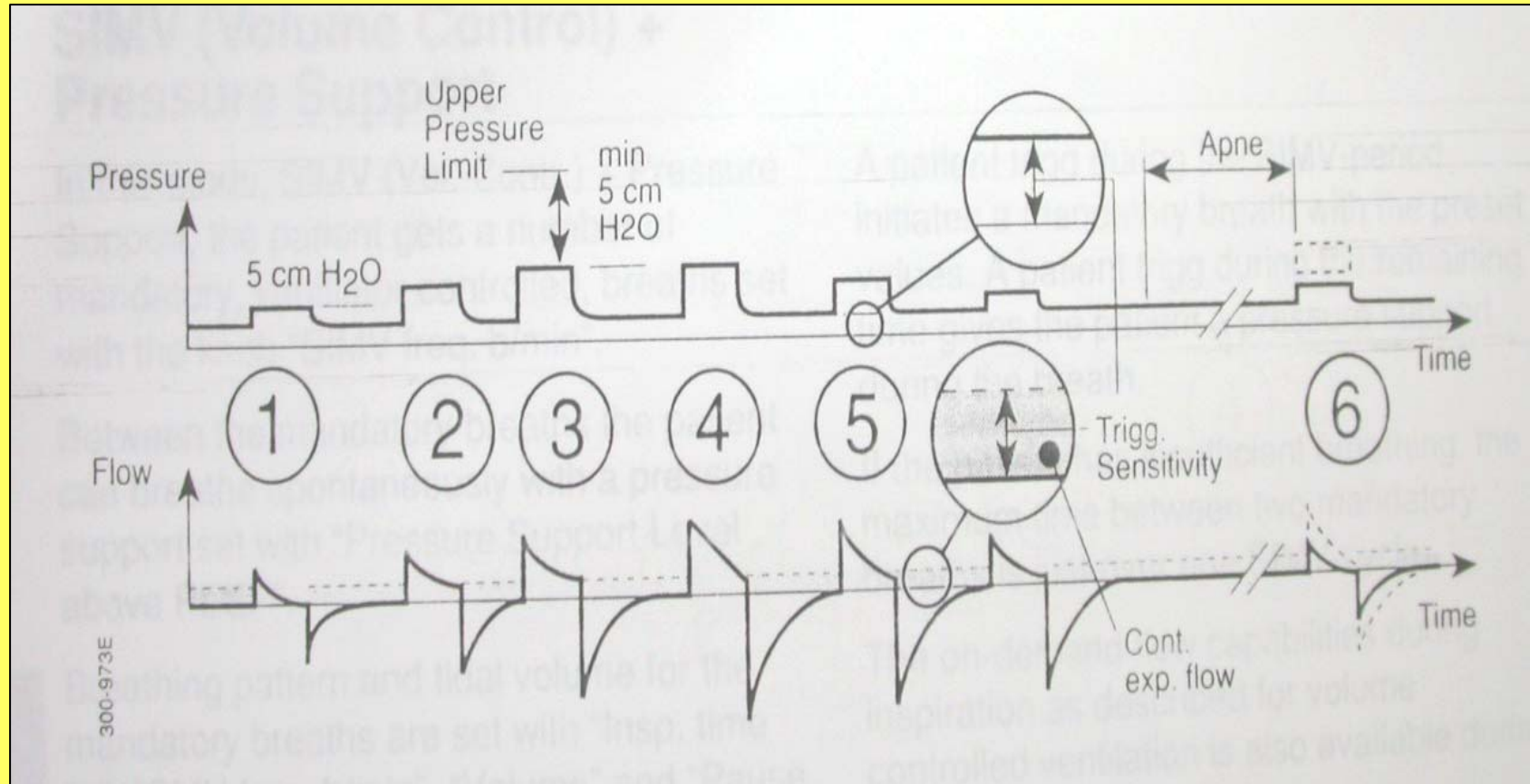
## Weaning technique

- Spontaneous breathing via t-tube, CPAP, PS
- IMV
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- SIMV with PS
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## Volume support ventilation

- Pressure support - volume guaranteed
- Flow cycled, pressure limited
- Decelerating flow
- IT, RR are determined by the patient
- Max. pressure = 5 cmH<sub>2</sub>O below set  
"Upper pressure limit"

# Volume support ventilation



## Volume support ventilation

- Expiration occurs when
  - inspiratory flow  $< 5\%$  of initial flow or
  - time  $> 80\%$  of respiratory cycle
- Need spontaneous inspiration
- Back up with PRVC

# Volume support ventilation

## VSV protocol

- Adjust initial set insp.TV to achieve exhaled TV of 6 ml/kg
- Set back up rate according to age
  - < 6 mo. 16/min
  - 6 mo.-2 yrs 14/min
  - 2-5 yrs 12/min
  - > 5 yrs 10/min



# Volume support ventilation

## VSV protocol

- Monitor TV to ensure that they remain 5-7 ml/kg
- Consider extubation when  $PIP \leq 20 \text{ cmH}_2\text{O}$ ,  $SpO_2 \geq 95\%$ , acceptable RR with  $FiO_2 \leq 0.5$  and  $PEEP \leq 5 \text{ cmH}_2\text{O}$

## Weaning technique

- Spontaneous breathing via t-tube, CPAP, PS
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## Non invasive PPV

### RCT study in adults

- ↓ complications related to intubation, ICU stay, overall mortality
- Most were done in COPD

*Chest 2001:4745-4765*

### Study in pediatrics

- Scanty
- Case reports in NMD

*Respir Care 2003:442-53.*

*Singapore Med J 2004; 232-4.*

## Non invasive PPV

Main reasons for failure NPPV

- Lack of co-operation
- Excessive secretion
- Severe strength-load imbalance
- Unstable hemodynamic

*Minerva Anesthesiol 2005:243-7*

## Recognition of weaning failure

- ✓ Tachypnea
- ✓ Hypoxemia
- ✓ Tachycardia
- ✓ Bradycardia
- ✓ Hypertension
- ✓ Hypotension
- ✓ Agitation, diaphoresis, anxiety

**Respiratory failure**



**Assisted mechanical ventilation**



**Weaning from mechanical ventilation**

**Why**

**When**

**How**



**Extubation**