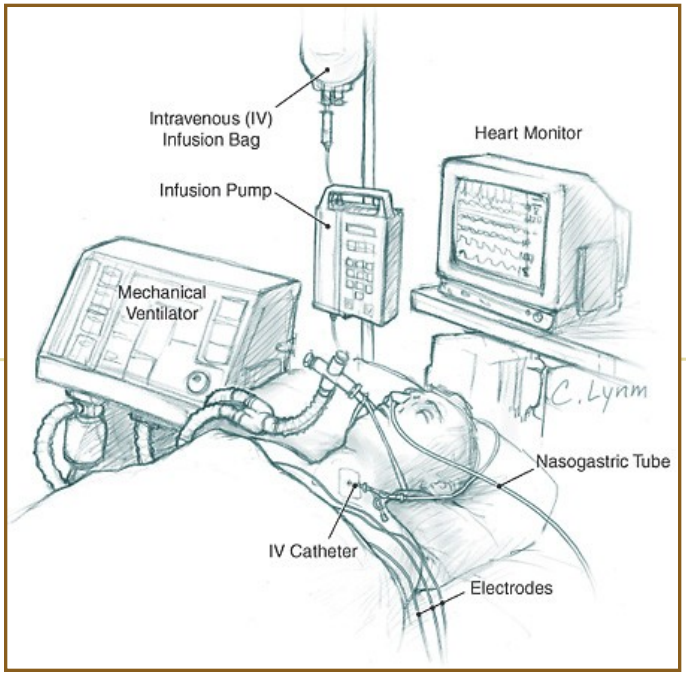
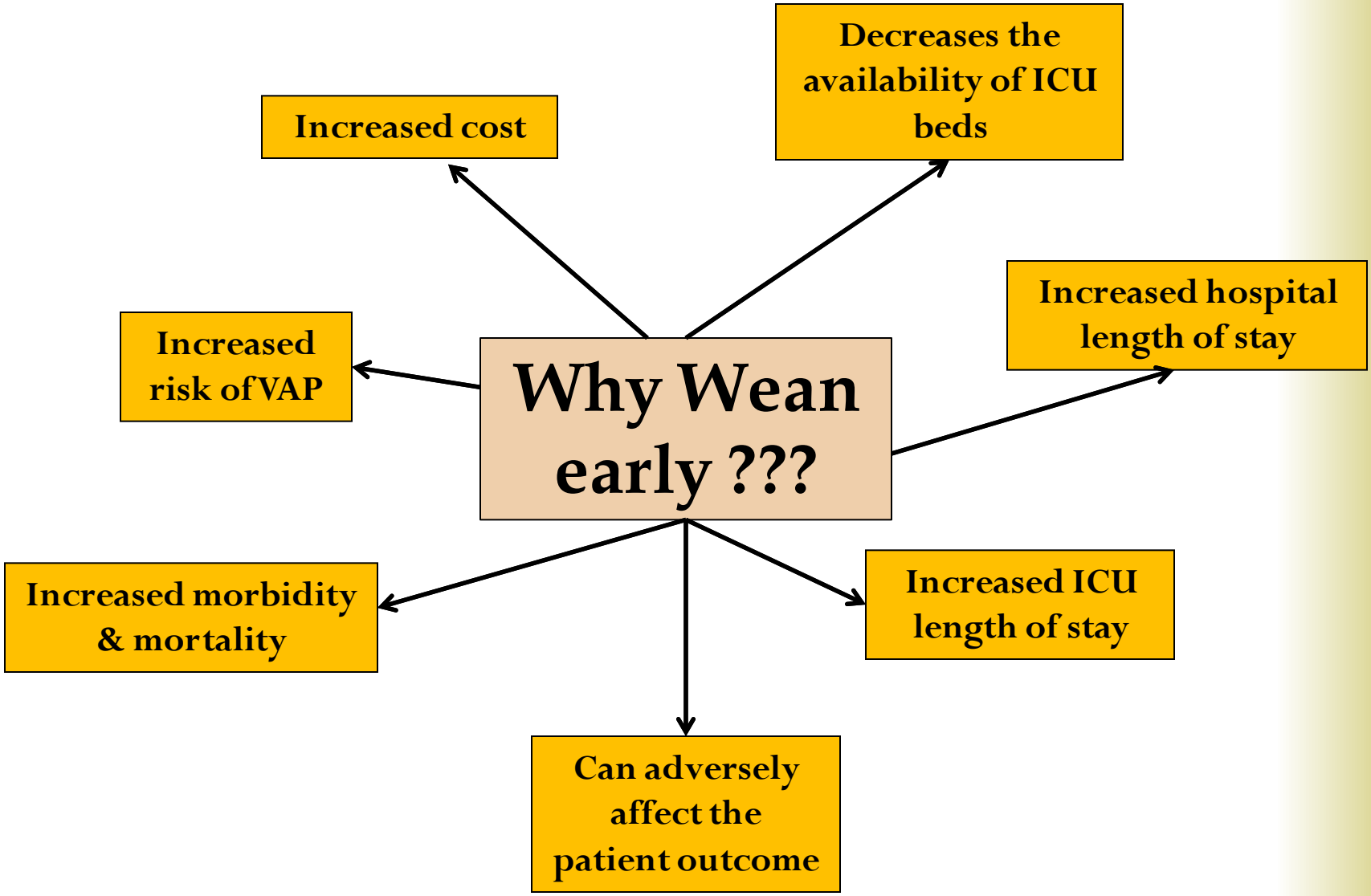
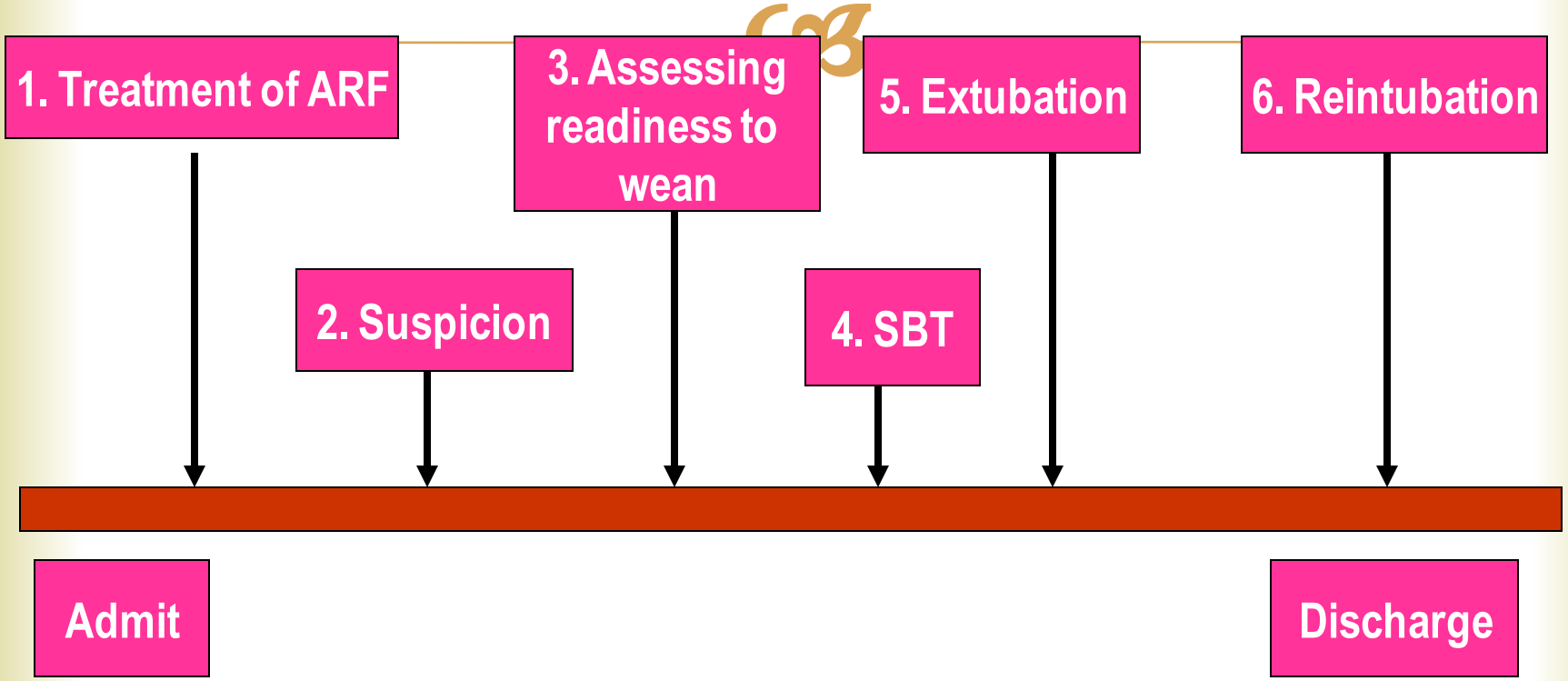

Intravenous (IV)
Infusion Bag
Heart Monitor
Infusion Pump
Mechanical
Ventilator
C.Lynm
Nasogastric Tube
IV Catheter
Electrodes

DEFINITIONS

- **Weaning** is the gradual reduction in the level of ventilator support.
- **Weaning success**: effective spontaneous breathing without any mechanical assistance for 24 hrs or more.
- **Weaning failure**: when pt is returned to mechanical ventilation after any length of weaning trial.
- **Signs of weaning failure**: abnormal blood gases, diaphoresis, tachycardia, tachypnea, arrhythmias, hypotension.


Why Wean early ???
Increased cost
Decreases the availability of ICU beds
Increased risk of VAP
Increased hospital length of stay
Increased morbidity & mortality
Increased ICU length of stay
Can adversely affect the patient outcome

Different stages in mech. Ventilated pts.

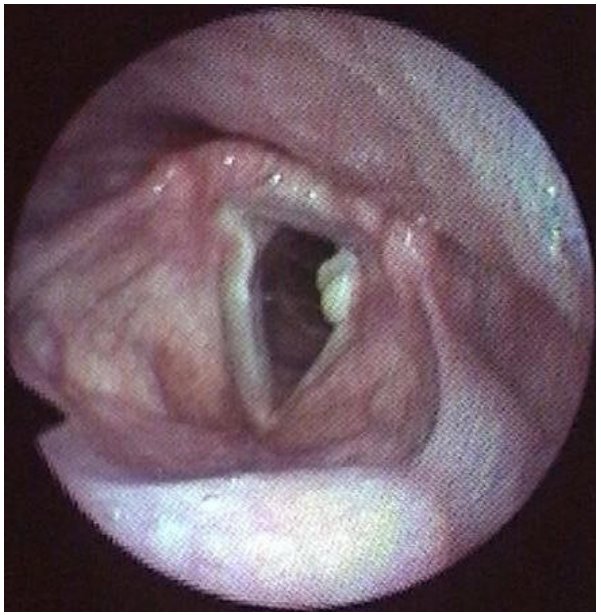


Classification of patients according to the weaning process

Group/ category	Definition
Simple weaning	Patients who proceed from initiation of weaning to successful extubation on the first attempt without difficulty
Difficult weaning	Patients who fail initial weaning and require up to three SBT or as long as 7 days from the first SBT to achieve successful weaning
Prolonged weaning	Patients who fail at least three weaning attempts or require >7 days of weaning after the first SBT

Morbidity Associated With Prolonged Intubation and Mechanical Ventilation

- Vocal cord granulomas
- Ulceration of the true vocal cords
- Circumferential fibrous stenosis of trachea
- Epithelial damage, loss of cilia, and impairment of tracheal mucus clearance
- Risk factor for nosocomial pneumonia
- Precludes oral feeding



Weaning

- Assess for readiness to wean.
- Follow a clear cut protocol
- Provide emotional support and decrease the patient's fear and anxiety
- Never try weaning at night
- If weaning once failed (fatigue, sweating, dyspneic etc..) do not attempt for the next 24-48 hours.
- Once weaning is successful, switch over to T piece
- extubate by following proper protocol

The assessment of weaning proceeds in two phases:

Phase 1: To ensure that certain basic criteria regarding initial reason for mechanical ventilation are satisfied

Phase 2: Determine whether weaning is likely to succeed on the basis of specified criteria

READINESS FOR VENTILATOR WEANING

Major determinants of ability to wean can be classified into three categories:

- oxygenation
- ventilatory pump function
- neuropsychiatric status

OXGYGENATION

- **Criteria of Adequacy**

  PaO_2 > 60 mmHg on FIO_2 <0.4 at minimal PEEP,

  PaO_2/FIO_2>200

- **Selected causes of failure:**
  - Hypoventilation: neurologic injury or drugs
  - V/Q mismatch: severe CHF
  - Anatomic (R-to-L) shunt (e.g. intracardiac, pulmonary A-V malformation).

VENTILATION

- **Criterion of Adequacy**

  $PaCO_2$ < 50 mmHg

- **Selected causes of failure**
  - respiratory drive: sedation, drug overdose.
  - resp bellows function: diaph weakness, N-m disease
  - CO_2 production *without* compensatory ↑ in alveolar Ve:
    - fever, hyper metabolism, carbohydrate overfeeding
  - dead space ventilation *without* compensatory ↑ alveolar Ve:
    - PE, bullous emphysema

NEUROPSYCHIATRIC INTEGRITY

- **Criteria of adequacy**

  Awake, alert, cooperative, with intact gag and swallowing

- **Selected causes of failure**

  Sleep deprivation/ICU psychosis

  Drug therapy

  Depression

  Psychological dependency on ventilatory support

Weaning Criteria

Clinical Criteria

- Adequate cough
- Absence of excessive tracheobronchial secretions
- Resolution of the disease acute phase for which the patient was intubated

Objective Criteria

- Ventilatory criteria
- Oxygenation criteria
- Pulmonary reserve
- Pulmonary measurements
- Other factors

VENTILATORY CRITERIA

- PaCO2: < 50 mmhg with pH >/= 7.35.
- VC: > 10 to 15 ml/kg
- Spontaneous VT: > 5 to 8 ml/kg
- Spontaneous RR: < 30/min
- Minute ventilation: < 10 lts

PaCO2 – most reliable indicator
VC and spon VT – indicate mechanical cond of lungs
A high spon RR and MV indicate ↑ WOB

Contributing factors

- Respiratory muscle power
  - Maximal negative inspiration pressure
  - Spontaneous breathing trial
    - Rapid shallow index
    - Ability to breath unassisted (T piece, pressure support,…)
- Resistance
- Compliance
- Respiratory demand
- Ventilator drive
- Cardiac dysfunction

Improving muscle power

- Nutrition
- Pro catabolic state
- Drug effect
- Electrolyte disturbance
- Hypothyroidism
- Neuromyopathy
- fatigue

Burn' s wean assessment program

- This tool was developed in 1990 by Bern et al., Which is 26 statement.
- 12 statement measure general assessment of the patient, and 14 statement measure patient's respiratory function.
- If you score 17 or higher can be used to start the process of weaning
- All parameters of pulmonary function, gas changes, physiological and psychological state of a patient

BURNS' WEAN ASSESSMENT PROGRAM (BWAP)

Patient Name _____ **Patient History Number**_____

Patient Weight _____ **kg**

I. GENERAL ASSESSMENT

YES	NO	NOT ASSESSED		
___	___	___	1.	Hemodynamically stable? (Pulse rate, cardiac output)
___	___	___	2.	Free from factors that increase or decrease metabolic rate (seizures, temperature, sepsis, bacteremia, hypo/hyper thyroid)?
___	___	___	3.	Hematocrit > 25% (or baseline)?
___	___	___	4.	Systemically hydrated? (weight at or near baseline, balanced intake and output)?
___	___	___	5.	Nourished? (albumin > 2.5, parenteral/enteral feedings maximized) If albumin is low and anasarca or third spacing is present, score for hydration should be "no."
___	___	___	6.	Electrolytes within normal limits? (including Ca^{++}, Mg^{+}, PO_4). * Correct Ca^{++} for albumin level.
___	___	___	7.	Pain controlled? (subjective determination)
___	___	___	8.	Adequate sleep/rest? (subjective determination)
___	___	___	9.	Appropriate level of anxiety and nervousness? (subjective determination)
___	___	___	10.	Absence of bowel problems (diarrhea, constipation, ileus)?
___	___	___	11.	Improved general body strength/endurance? (i.e., out of bed in chair, progressive activity program)?
___	___	___	12.	Chest x-ray improving or returned to baseline?

(continued)

II. RESPIRATORY ASSESSMENT

Gas Flow and Work of Breathing

YES	NO	NOT ASSESSED		
___	___	___	13.	Eupneic respiratory rate and pattern (spontaneous RR <25, without dyspnea, absence of accessory muscle use). * This is assessed off the ventilator while measuring #20-23. RR = _____
___	___	___	14.	Absence of adventitious breath sounds? (rhonchi, rales, wheezing)
___	___	___	15.	Secretions thin and minimal?
___	___	___	16.	Absence of neuromuscular disease/deformity?
___	___	___	17.	Absence of abdominal distention/obesity/ascites?
___	___	___	18.	Oral ETT > #7.5 or trach > #6.0 (I.D.)

Airway Clearance

___	___	___	19.	Cough and swallow reflexes adequate?

Strength

___	___	___	20.	NIP <-20 (negative inspiratory pressure) NIP = _____
___	___	___	21.	PEP >+30 (positive expiratory pressure) PEP = _____

Endurance

___	___	___	22.	STV > 5 ml/kg (spontaneous tidal volume)? Spont VT = _____ STV/BW in kg =
___	___	___	23.	VC > 10-15 ml/kg (vital capacity)? VC =

ABGs

___	___	___	24.	pH 7.30-7.45
___	___	___	25.	PaCO2~40 mm/hg (or baseline) with M.V. <10 L/min * This is evaluated while on ventilator. $PaCO_2$ = _____ MV =
___	___	___	26.	PaO2 >60 on FiO2 <40%

*If unsure how to obtain information refer to glossary for help.

Weaning success prediction

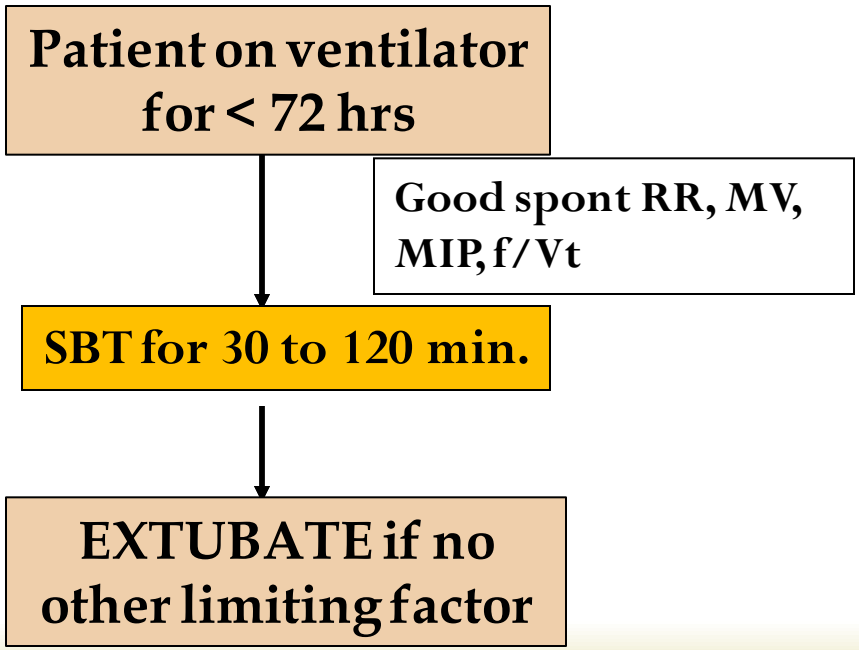
- Tidal volume ≥ 325 ml
- Tidal volume/BW ≥ 4 ml/kg
- Dynamic Compliance ≥ 22 ml/cmH_2O
- Static compliance ≥ 33 ml/cmH_2O
- Rapid shallow breathing index ≤ 105 breaths/min/L

Weaning Procedure

- Rapid ventilator discontinuation
- Spontaneous breathing trials
- Pressure support ventilation (PSV)
- SIMV
- Other Modes used for weaning

Rapid ventilator discontinuation

- Considered in patients with no underlying cardiovascular, pulmonary, neurologic, or neuromuscular disorders and patients receiving ventilatory support for short periods e.g. post-op patients



Spontaneous Breathing Trial

- T-Tube trial: allows spont. breathing several times per day interspersed with periods of ventilatory support.
- Initial SBT's may last only 5 to 30 min.
- Resume mechanical ventilation at night or if distress occurs.

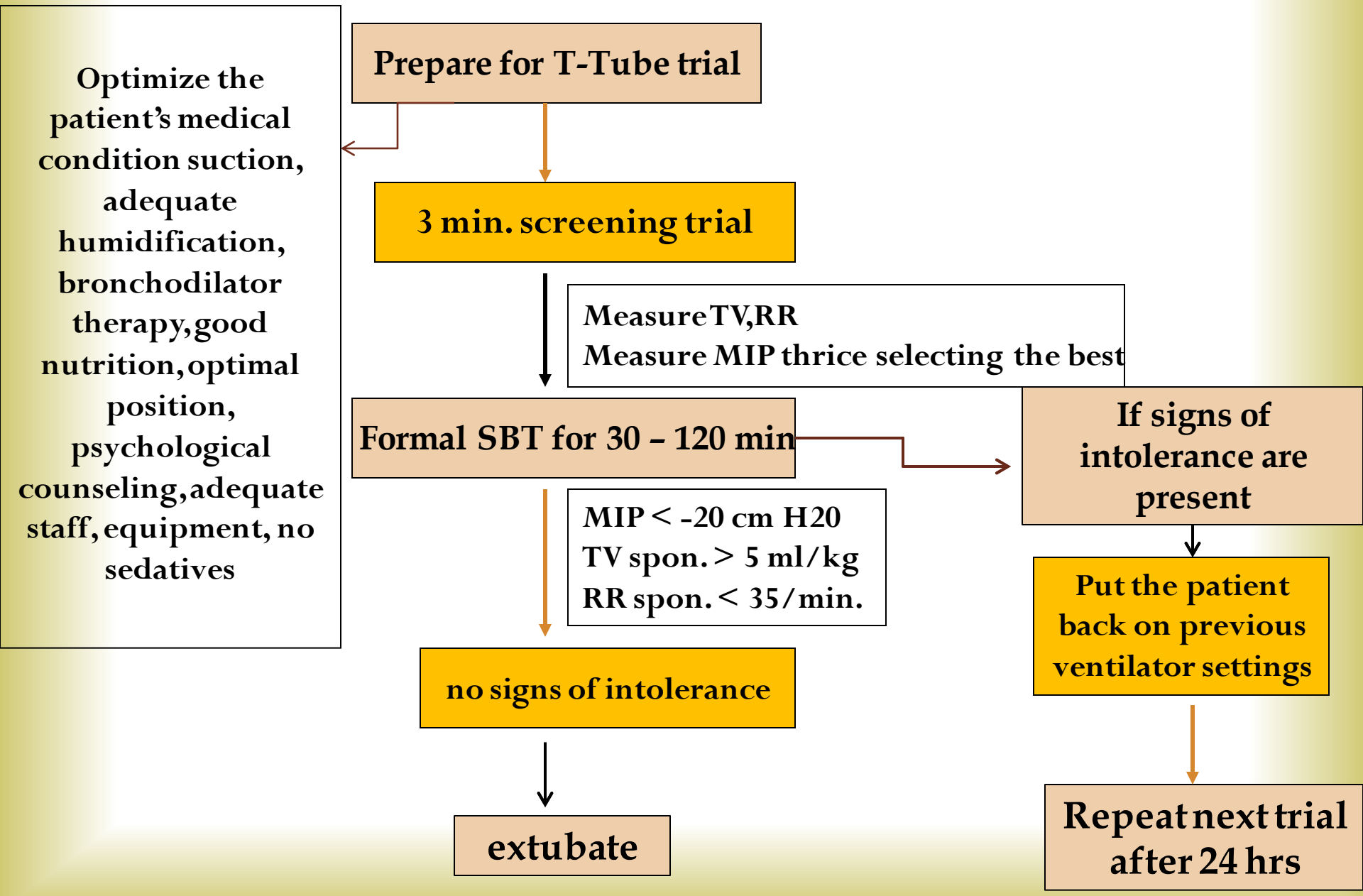
ADVANTAGES

Tests pt's spon breathing ability
Allows periods of work and rest
Weans faster than SIMV

DISADVANTAGES

Abrupt transition difficult for sm pts
No alarms, unless attached to vent.
Requires careful observn.

Weaning protocol for SBT with a T-Tube



Signs of intolerance of SBT

- Agitation, anxiety, diaphoresis or change in mental status
- RR > 30 to 35/min
- SpO2 < 90%
- > 20% ↑ or ↓ in HR or HR > 120 to 140/min
- SBP > 180 or < 90 mmhg.

Such pts are returned to full ventilatory support for 24 hrs. to allow the ventilatory msls. to recover.

Weaning with SIMV

- Breaths are either spontaneous or mandatory
- Mandatory breaths are synchronized with patient's own efforts

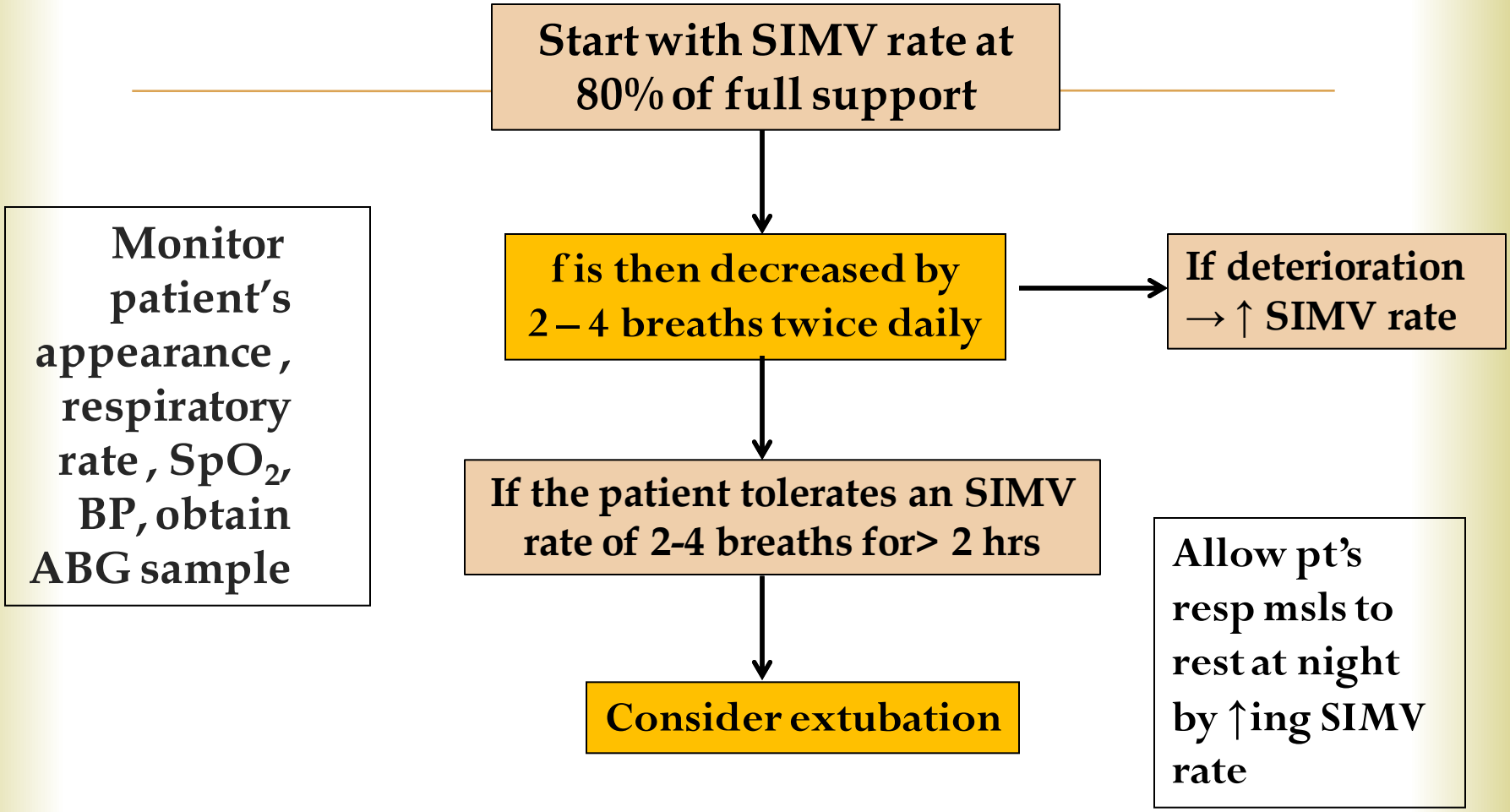
ADVANTAGES

- **Gradual transition**
- **Easy to use**
- **Minimum MV guaranteed**
- **Alarm system may be used**
- **Should be used in comb. with PSV/CPAP**

DISADVANTAGES

- **Prolongs weaning**
- **May worsen fatigue**

Protocol of SIMV Weaning



Weaning with PSV

Pressure support is given with each spontaneous breath to ensure an adequate TV

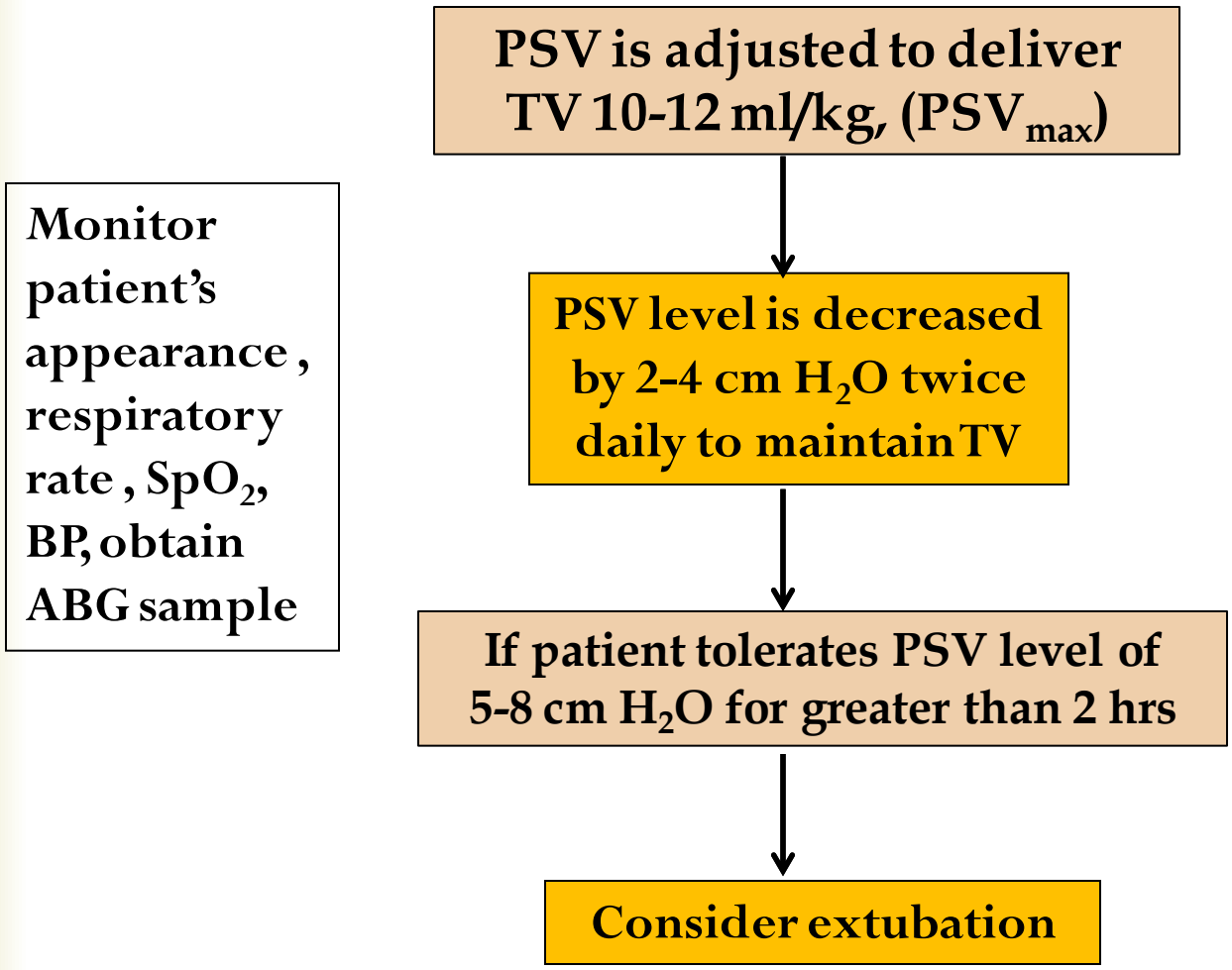
ADVANTAGES

- **Gradual transition**
- **Prevents fatigue**
- **Increased pt comfort**
- **Weans faster than SIMV alone**
- **Pt can control cycle length, rate and inspiratory flow.**
- **Overcomes resistive WOB d/t ET tube and circuit.**

DISADVANTAGES

- **↑ed MAP versus T-Tube**
- **TV not guaranteed**

Protocol of PSV weaning



Weaning protocol for SIMV + PSV

SIMV rate is set at 2 breaths/min lower than the rate given by A/C mode + PSV 15-20 cmH_2O

↓

Reduce SIMV rate in steps of 1-3 breaths/min + PSV 15-20 cm H_2O

↓

When SIMV rate becomes 5 breaths/min, stop SIMV and continue with PSV 15-20 cm H_2O

↓

Reduce PSV in steps of 2 cm H_2O until PSV is 5-6 cmH_2O

↓

Extubate the patient

Monitor patient's appearance , respiratory rate , SpO_2, BP, obtain ABG sample

Allow pt's resp msls to rest at night by ↑ing SIMV rate

Extubation Procedure

- Explain procedure to patient
- RT must be at bedside
- Wash your hands
- Suction airway and oropharynx for pooled secretions (prevents aspiration of secretions atop balloon)
- Place a towel on patient's chest
- Assure new oxygen setup is ready to use
- Deflate cuff and remove tube instructing patient to cough as tube is removed
- Apply supplemental oxygen
- Monitor pt for distress (stridor, coughing, anxiety)

Extubation

- Discontinuation of invasive PPV involves 2 steps:
  - separation of pt. from ventilator.
  - removal of artificial airway.

based on assessment of airway patency and protection

Parameters for airway protection
Effective cough
Secretion volume
Mental status

Parameters for airway patency
Cuff leak test

Qualitative	Quantitative
audible air leak	air leak< 110 ml

Weaning failure

- Defined as when pt is returned to mech. Ventilation after any length of weaning trial or is reintubated within 48 hrs following extubation.

- **Causes:**
  - ↑**ed air flow resistance-** ET tube, abdominal distention, tracheal obstruction.
  - ↓**ed compliance-** atelectasis, ARDS, tension pneumothorax, obesity, retained secretions, bronchospasm, kinking of ETtube.
  - **Electrolyte imbalance**, **inadequate nutrition.**

Indicators of weaning failure

- Blood gases- ↑ing $PaCO_2$ (>50 mmhg)
  ↓ing pH < 7.30
  ↓ing PaO_2 (<60 mmhg)
  ↓ing SpO_2 (<90%)
  ↓ing PaO_2/FiO_2 (<150 mmhg)
- Vital signs- ↑ing HR (by > 20/min. or > 110/min.)
  abnormal ECG
  changing BP (20 mmhg SBP or 10 mmhg DBP)

Indicators of weaning failure

- Respiratory parameters: ↓ing TV (< 250 ml)
  ↑ing RR (> 30/min)
  ↑ing f/TV ratio (> 105 cycles/L)
  ↓ing MIP (< -20 cm H2O)

Pathophysiology of weaning failure

NONRESPIRATORY PARAMETERS AFFECTING ABILITY TO WEAN

- Nutritional status
- Fluid balance
- Metabolic and acid-base derangements
- Cardiac Function
- Renal function
- Neuropsychiatric factors

Indicators…

Change in mental status

- Coma
- Agitation
- Anxiety
- Somnolence

Signs of increased work of breathing

- Nasal flaring
- Paradoxical breathing movements
- Use of accessory respiratory muscles

Nutritional status

Malnutrition has adverse effects on the respiratory system

- ↓respiratory muscle strength and function
- ↓diaphragmatic mass and contractility

Nutritional status

Overnutrition may impede weaning

- High CO2

  Produced by excessive CHO loading

- Other causes of increased CO_2 production: fever, sepsis, shivering, seizures, and inefficient ventilation due to dead space, PE

Metabolic abnormalities

- Hypophosphatemia
- Hypocalcemia
- Hypothyroidism

References

1. Egan's – fundamentals of respiratory care 9th ed.
2. International Anaesthesiology Clinics – Update on respiratory critical care , vol 37, no 3, 1999.
3. Anaesthesia newsletter ,Indore city ,June 2009, vol 10, no 2
4. David W Chang, Clinical application of mechanical ventilation 2nd ed
5. Paul L Marino, The ICU Book, 3rd ed.
6. Weaning from mech. Ventilation, Eur. Respi. J 2007; 29: 1033 – 1056.

THANK YOU

PULMONARY RESERVE AND MEASUREMENTS

Pulmonary reserve:

Max. voluntary ventilation – 2×min. vent@FiO2 upto 0.4

Max. Insp. Pressure < -20 to -30 cmH2O in 20 sec.

Pulmonary measurements:

Static compliance > 30 ml/cm H2O

Vd/Vt < 60%

Pulmonary reserve requires active pt cooperation
Pulmonary measurements indicate workload needed to support spont. ventilation

Extubation

- Discontinuation of invasive PPV involves 2 steps:
  - * separation of pt. from vent
  - * removal of artificial airway.

  based on assessment of airway patency & protection

Parameters for airway patency

Cuff leak test

- **Qualitative**: **audible air leak**
- **Quantitative**: **air leak< 110 ml**

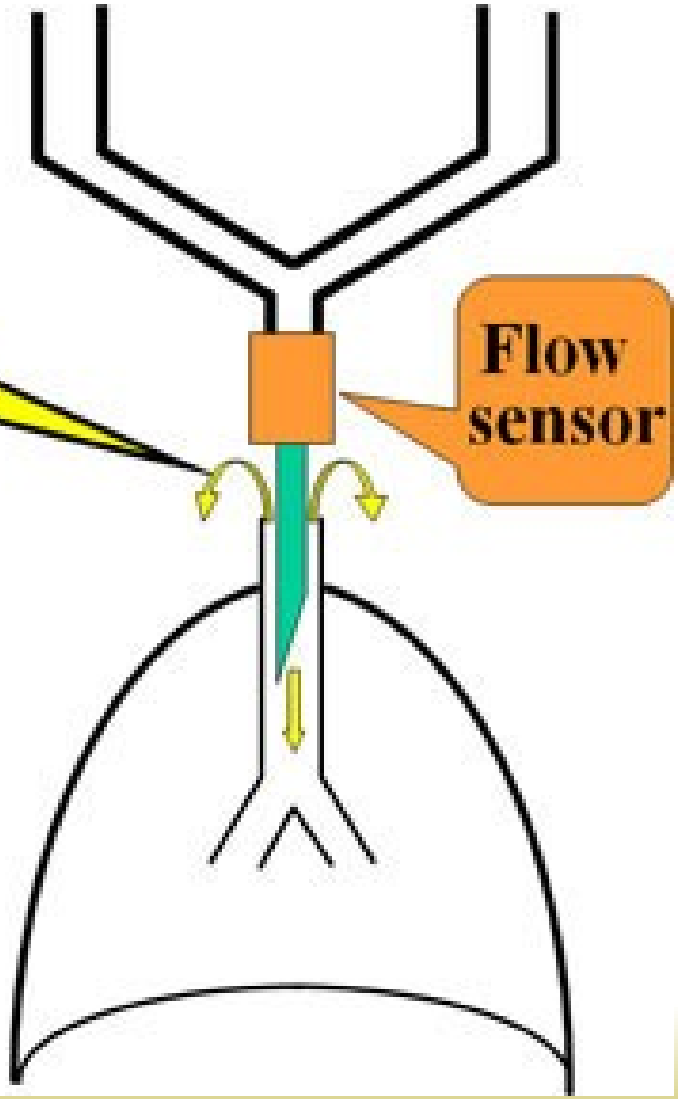
Parameters for airway protection

- **Effective cough**
- **Secretion volume**
- **Mental status**

Extubation failure

- Defined as need for reinstitution of vent. Support within 24 – 72 hrs. of ETT removal.
- Occurs in 2 – 25 % of pts.
- Predisposing factors
  - * advanced age
  - * duration of mech. Vent.
  - * anemia
  - * use of cont. IV sedation
  - * semirecumbent positioning after extubation.
- Find & manage the cause.

Cuff leak test



Higher pressure during inspiration:

Dilates trachea, may open a leak and increases leak size.

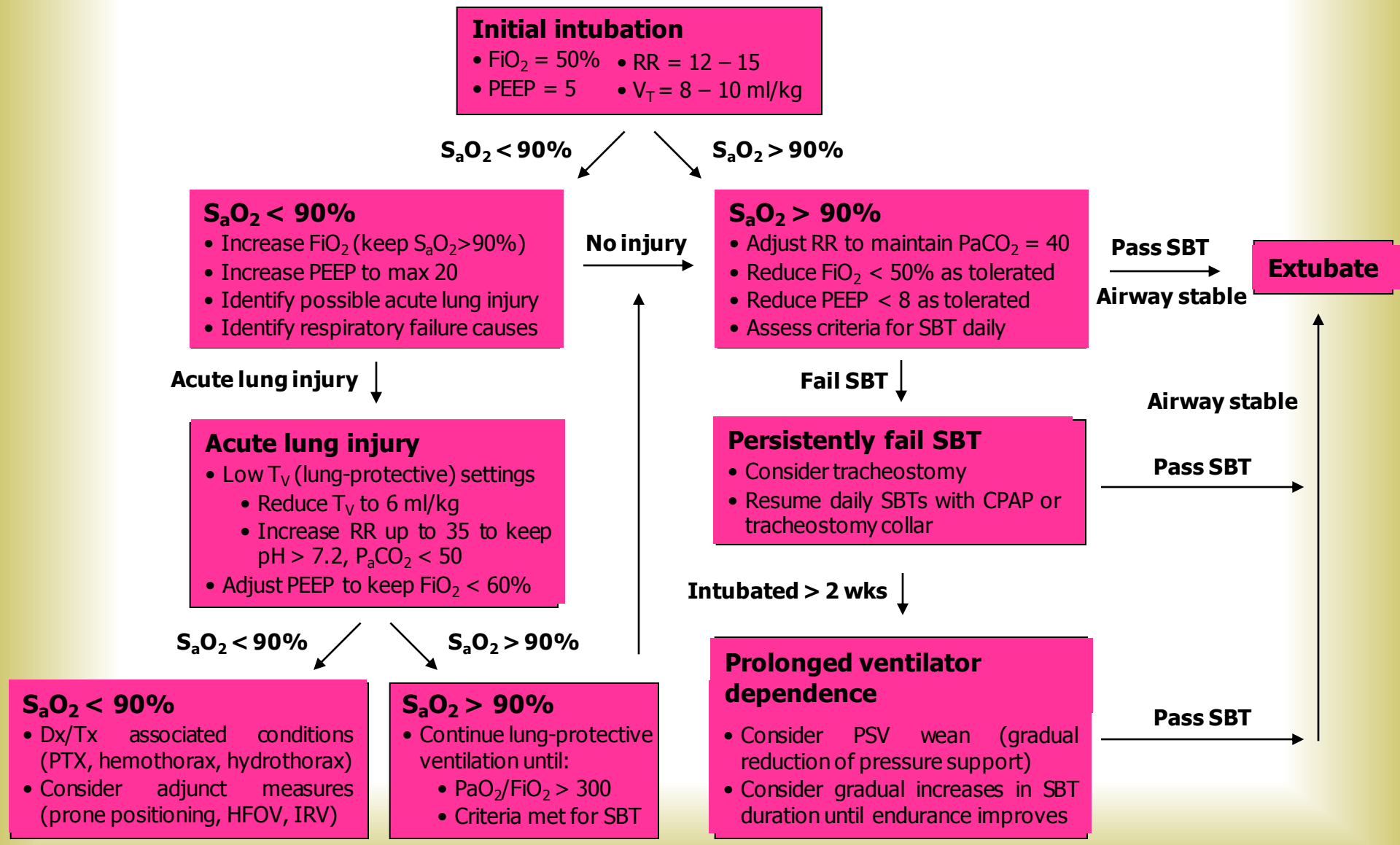
PEEP during expiration:

ETT usually sealed.

Terminal weaning

- Defined as withdrawal of mechanical ventilation that results in death of the pt.
- 3 concerns must be evaluated and discussed
  * pt's informed consent
  * medical futility
  * reduction of pain and suffering
- Carries many ethical and legal implications.

Ventilator management algorithim



Weaning : Selecting an Approach!!!

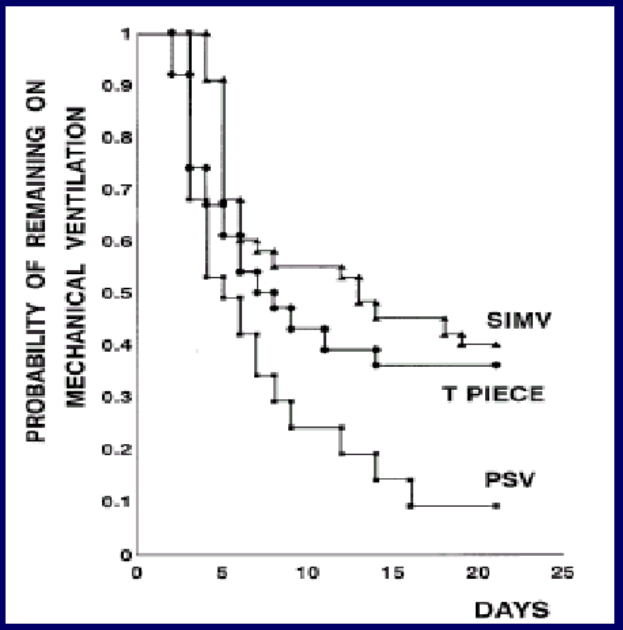
- Many studies have compared the different methods of weaning

- Common conclusions are

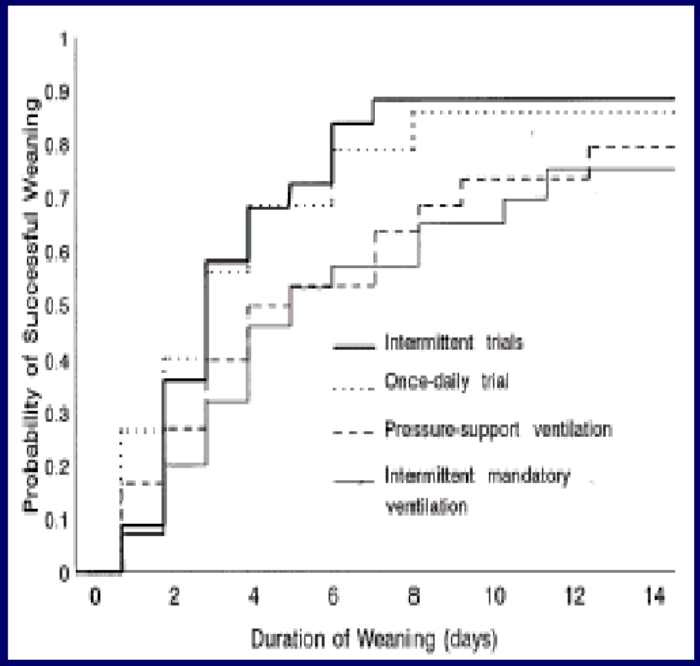
✓ No clear superiority exists between **T-tube weaning** and **pressure support** based weaning

✓ **SIMV** is the least efficient technique of weaning

Weaning :Selecting an Approach!!!



Weaning : Selecting an Approach!!!



OXYGENATION CRITERIA

- PaO2 without PEEP > 60 mmhg @FiO2 upto 0.4
- PaO2 with PEEP > 100 mmhg @ FiO2 upto 0.4
- SaO2 > 90% @ FiO2 upto 0.4
- PaO2/FiO2 > 200 mmhg

In pts with anemia or dysfunct Hb, PaO2 and SaO2 don't reflect true oxygenation status
So arterial oxygen content should be measured

Weaning with SIMV +PSV

- The addition of pressure support with SIMV can overcome the work of breathing during "spontaneous breaths" due to endotracheal and tracheostomy tubes, demand flow systems and ventilator circuits
- The pressure support level needed to overcome the imposed work of breathing during IMV weaning can be estimated as
- PSV = $\frac{(PIP-Pplat)}{Vmech} \times V\ max$

PIP =peak inspiratory pressure during a machine delivered breath

Pplat = pateau pressure during a mechanical inspiratory volume hold

Vmech = flow during a machine breath

Vmax = patient's spontaneous peak inspiratory flow