Mechanical Ventilation
Nursing perspective

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Objective

- REVIEW BASIC ANATOMY AND PHYSIOLOGY
- REVIEW RSI
- REVIEW RESPIRATORY TERMINOLOGY
- CARES FOR THE VENTILATED NEONATES
- HOLDING/KANGAROO NEONATES
Large Occiput

Important: Positioning

If the baby is placed in a supine position, the neck will bend forward and can obstruct the airway.
Large Tongue

In relation to the size of their mouth

Designed for improved breast feeding; so that the baby can latch onto the nipple

can cause obstruction
SNIFFING POSITION

Hyper-extended  Slightly extended  Flexed
Long U-shape Epiglottis

Epiglottis (structure that covers the trachea when you swallow)

designed to improve suck, swallow and breathing coordination

inflammation/edema can obstruct the airway
**Nares**

Humidification system: mucosa and cilia

**TAKE CARE NOT TO DRY OUT THE MUCOSA (HFNC or NCPAP)**

Nasal passages are narrow and horizontal in infants

The septum is deviated to the left
(HINT: easier to suction or place an NG down the right nare)

Septal deviation can change depending on the length of time and the size of the tubes that are placed in the nares
Neonates are Obligate Nose Breather

- If the nares are blocked, the baby will have a hard time compensating by breathing through their mouth.

- For instance, a large NG tube or many secretions can block the nares and result in difficulty breathing.
Trachea

Shorter than in adults and is a CONE shape in infants

Easier for the ETT to be placed deep into the right mainstem

Narrowest portion is the cricoid cartilage
- Obstruction
- Can be damaged during intubation
- Poorly perfused if the ETT is too big
Main Stem Bronchi and Bronchioles

- Branches at the CARINA
- Right side more “J” shape – easier to go down
- Left side more sharper angle to make room for the heart - harder to go down with an ETT suction or catheter
Lobes

- 3 Lobes on the right
- 2 lobes on the left
- The lower lobes are the biggest and are more posterior.
- Air rises, thus placing a patient in a prone position allows them to have greater surface area for gas exchange.
**Benefit of Prone Position**

- Air rises to the lower lobes which are the largest and posterior.
- Stabilization of compliant chest wall.
- Positioning prone take the pressure of the heart off the lungs.
## Muscle Fibers

<table>
<thead>
<tr>
<th>Type 1 muscle fibers</th>
<th>VERSUS</th>
<th>Type 2 muscle Fibers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow Twitch</td>
<td>Fatigue Resistance</td>
<td>Fast Twitch</td>
</tr>
</tbody>
</table>

Neonates have **less** Type 1 fibers and **more** Type 2, thus are more prone to fatigue than adults.
Diaphragm

- Main muscle of INSPIRATION
- Left and Right side have separate nerves so it they can function separately.
  - Inspiration is ACTIVE

- OTHER MUSCLES of INSPIRATION
  - External intercostal (quiet normal breathing)

Poorly developed in newborn
And not useable in the newborn period
INTERCOSTAL RETRACTION
Abdominal Muscles

• Expiration is usually **PASSIVE** which means that the diaphragm relaxes and air exits the lungs.

• The ABDOMINAL muscles are only used during **ACTIVE** expiration such as when you’re blowing out your age in birthday candles 😊.
Rib Cages

- In adult, rib cages bows down (see diagram below). When a breath is taken, the rib cage becomes more horizontal. That increases our TIDAL VOLUME. (Take a breath and feel the ribs move up)
- In infants, the ribs are more flat and already horizontal; thus, are more limited in how much tidal volume they can get.
- To compensate for the lack of tidal volume, neonate generally increase their RR and diaphragm use in event of respiratory compromise.
- In neonates, the chest wall is nearly three times as compliant as the lung
- Inverse relationship between chest wall compliance and age
- Stiffening of the chest wall may play a major role in the ability to passively maintain resting lung volume and improved ventilatory efficiency afforded by reduced rib cage distortion.
Stages of Lung Development

**0 – 5 weeks**
- Trachea and bronchiole buds form; pulmonary vein develops

**5 – 16 weeks**
- Congenital diaphragmatic hernia (CDH)

**16 – 26 weeks**
- Conducting airway formation: main bronchus, bronchioles, and diaphragm form

**26 – 36 weeks**
- Gas-exchanging units and alveolar cells appear; type 2 pneumocyte development
- Respiratory distress syndrome (RDS), Chronic Lung Disease (CLD), pneumonia, bronchopulmonary dysplasia (BPD)

**36 – 41 weeks**
- Alveoli mature; lung size increases

- Transient tachypnea of newborn (TTN), Air leak, Meconium aspiration (MAS), Persistent pulmonary hypertension (PPHN)

- Continuation of gas exchange unit and capillary network development; surfactant production
Rapid Sequence Induction/Intubation (RSI)?

- Rapid sequence induction is an approach to emergency airway management to rapidly secure the airway.
- Rapid sequence induction is the process of administering a sedative/analgesic and muscle relaxant.
  - Patient is rendered unconscious and muscle relaxed within 1 minute.
  - Additional sedative or Anticholinergic is optional.

**Goal:** to avoid/minimize bag-mask ventilation.
Remember it’s alphabetical: A, F, S (Atropine, Fentanyl, Succs)

**Medication can be diluted to a concentration of 10mcg/ml. This must be given slowly with the medication over at least 1 minute and the flush over at least 1 minute.**

**Avoid chest wall rigidity. If chest wall rigidity occurs, give succinylcholine and intubate**

**Medication may need to be diluted to calculate a small enough dose. Optional use to prevent bradycardia**

**Medication may be obtained from a direct draw from 20mg/ml vial. This should be administered rapidly**

- Anticholinergic: Atropine 0.01 mg/kg IV
- Sedation: Fentanyl 2 mcg/kg IV
- Muscle relaxation: Succinylcholine 2 mg/kg IV
Airway & Hagen Pouseille’s Law

The smaller the airway, the HIGHER the resistance.

That’s why we suction the ETT or even put in the right size ETT for the patient

The longer the airway, the HIGHER the resistance.

That’s why we cut the ETT

A smaller diameter has more effect on resistance than length.

Small amounts of edema and mucous can have large effect on the neonatal airway

\[ R = \frac{8\eta l}{\pi r^4} \]

Try breathing through 2 different size straws. The smaller ones will be harder
By intubating a patient, the "trachea" is artificially made longer and smaller.
Common Ventilator Settings & Measurements

- Inspiratory Time ($T_i$)
- Respiratory Rate (RR)
- Expiratory Time ($T_e$) function of RR
- Peak Inspiratory Pressure (PIP or Pinsp) (measured, set and max)
- Positive End Expiratory Pressure (PEEP)
- Pmean (mean airway pressure)
- Tidal Volume ($V_t$)
- Minute Ventilation (MV = VT x RR)
- Fraction of Inspired Oxygen ($F_{iO_2}$) *Reported as a decimal/fraction
**PIP**: how much pressure the ventilator gives to "inflate" or gently move the chest.

**RR**: amount of breath a patient receives or takes in one minute.

**PEEP**: distending pressure keeping alveoli open at the end of exhalation.
FIGURE 2: RESPIRATORY PATTERN UNDER DIFFERENT MODES

IMV

SIMV

AC

PC/PS

LEGEND

* = PATIENT BREATH
\(\wedge\) = UNASSISTED BREATH
\(\Lambda\) = ASSISTED BREATH
\(\Gamma\) = PRESSURE SUPPORT

PEEP

PIP
Caffeine (Citrated)

Given to stimulate breathing and reduce apnea in premature infants

May be administered IV or PO

A loading dose is given then per day dosing is started

Loading dose = 10mg base/kg

Maintenance dose = 3-5mg base/kg/day

Maximum dose = 15mg base/kg/day

*monitor for toxicity)

- Monitor for tachycardia
  - Consider holding if HR>180 (discuss with MD)
- Monitor caffeine levels if toxicity suspected
  - Therapeutic levels 30-100mmol/L

(2mg caffeine citrate = 1mg caffeine base)
### Ventilator Associated Pneumonia (VAP) Bundle

<table>
<thead>
<tr>
<th>VAP Bundle</th>
<th>Yes - 15-30d</th>
<th>Yes</th>
<th>Yes</th>
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</thead>
<tbody>
<tr>
<td>HOB Elevated</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Vent Tubing Draining Away</td>
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<tr>
<td>Minimize Disruption of the Circuit</td>
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<tr>
<td>Mouthcare q2-4h</td>
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<tr>
<td>Team Discuss Readiness to Extubate</td>
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<tr>
<td>Reason(s) why VAP bundle not used</td>
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</table>
Oxygen Therapy Guideline, Saturation & CO2 monitoring
OXYGEN is a DRUG

• to increase oxygen delivery to vital organs and tissues
• when saturation drops and clinical signs appear, i.e. cyanosis, pale, dusky appearance and for respiratory distress.

**Oxygen Use**

• maintaining a neutral thermal environment (NTE)
• limiting stressful procedures by treating pain (sucrose/NNS) and minimizing stimulation
• Maintain normal glucose intake

**Decrease oxygen demands by**

• Set Appropriate alarms for that individual patient (hi sat and lo sat)
• Only give what the individual baby needs
• Go up slowly evaluate and increase or decrease oxygen in gradual steps

**Avoid oxygen toxicity by**
• Place sensor on the outer lateral aspect of the hand; wrap the tape around the site, ensuring that the emitter and detector are aligned.
• Change position of probe with handling to prevent pressure sores
• RIGHT HAND is PREDUCTAL
• Everything else is POST DUCTAL (usually)
A well researched strategy for improved infant outcomes

Kangaroo Care in the NICU
Background and Development of Kangaroo Care (SSC)

- Skin to skin care (SSC) originated in Bogota, Columbia as an alternative care delivery model to decrease mortality and morbidities.
- Early studies conducted in resource limited countries and involve stable preterm infants. SSC was provided continuously and babies were exclusively breastfed.
- Subsequent studies have supported the original findings.
- Intermittent SSC is the current standard of practice in most NICUs in resource rich countries.
Kangaroo Care
Benefits

- Reduced agitation
- Increased deep sleep
- Decreased infection rates
- Increased rates of lactation
- Increased parenting confidence
- Physiologic stability - lower and more stable HR and O2 Sat
- Enhanced attachment and bonding
- Increased deep sleep
- May contribute to weight gain and head growth
- Decreased hypothermia
- Positive effect on breastfeeding
- Decreases length of stay