

## Adult Respiratory Distress Syndrome (ARDS)

**Cause** – Massive insult to the body

### Pathophysiology

atelectasis  
decreased surfactant  
protein-rich pulmonary edema  
interstitial inflammation

### Hallmark signs of ARDS

noncardiogenic pulmonary edema  
refractory hypoxia  
dorsal lung consolidation on CT

### Definition published in JAMA in 2012

onset of dx must be acute (within 7 days of some defined event)  
bilat opacities consistent with pulm edema must be present (per CT or CXR)  
no need to exclude heart failure

May be mild, moderate, or severe

ARDS Severity	PaO <sub>2</sub> /FiO <sub>2</sub>	Mortality
Mild	200-300	27%
Moderate	100-200	32%
Severe	<100	45%
On PEEP 5+		

### Treatment - lung protective strategies

TV 5-7 cc/kg  
target plateau pressure of < 30 cm of H<sub>2</sub>O  
adjusting RR to provide adequate ventilation  
PEEP to maximize FiO<sub>2</sub> ( $\geq 10$ )

# Proning Therapy in ARDS

## Literature

first described in 1977 for ARDS patients  
can dramatically improve respiratory status and oxygenation in select patients.  
some studies showing improved mortality rates

## Indications for proning

lung protective strategies done  
above maneuvers do not result in sats > 88%  
art oxygen sat levels of > 90% are obtained, but subsequently deteriorate  
require 100% FiO<sub>2</sub> for at least 6 hrs  
require 80% FiO<sub>2</sub> for at least 12 hrs

*Almost all patients who meet the above criteria have pf ratio of < 150*

## Preparation - consider possible contraindications

patient weight > 135 kg  
facial or pelvic fractures  
burns or open wounds on the ventral body surface  
conditions associated with spinal instability (eg. Rheumatoid arthritis, trauma)  
conditions associated with increased intracranial pressure  
hemodynamic instability or life-threatening arrhythmias  
consider possible adverse effects of prone positioning on chest tube drainage

## Turning Procedures

Stage 1 – Preparation and Assessment		
Action		Rationale
1.	Assess for contraindications	To ensure patient safety
2.	Obtain necessary positioning devices: 2 flat sheets, 3 pillows, and a small pillow or foam positioner for face.	To avoid delays when team is at the bedside.
3.	Disconnect all non-essential monitoring equipment and IV lines. Ensure those remaining have the length and flexibility to accommodate turning the patient	To reduce the risk of accidental displacement and removal of lines during procedure.

	prone. Reinforce central line dressing as needed.	
4.	Disconnect enteral feeding and aspirate NG contents. Clamp NG/OG tube.	To minimize risk of regurgitation and aspiration of stomach contents during procedure.
5.	Place HOB flat; lower side rails; adjust bed height appropriately for team.	To allow for easier access to patient and safety of health care team.
6.	Ensure ETT is adequately secure.	To reduce risk of accidental tube displacement. To reduce risk of pressure damage to face.
7.	Perform ETT and oro-pharyngeal suctioning. Perform oral care.	For effective removal of secretions prior to prone positioning.
8.	Assess need for sedation, analgesics, and paralytics and administer as ordered.	To reduce the risk of patient discomfort, pain, and/or agitation during the procedure. To ensure ventilator compliance and optimal ventilation
<b>Stage 2 – Turning the Patient Prone</b>		
1.	Position one person at HOB and two people on either side of the bed.	To ensure equitable distribution of weight.
2.	Insert large flat sheet under the bottom draw sheet and position patient's arms close to their sides with palms facing thighs.	To ease turning and reduce likelihood of limb injury.
3.	Remove EKG stickers from patient's chest. Remove patient gown.	To minimize possibility of pressure ulcers while patient is prone.
4.	Position pillows: a. Across the patient's chest  b. Across the patient's pelvic area  c. Across the patient's knees	To reduce the risk of over distention (allows patient's shoulders to fall slightly forwards) of the anterior capsule of the should joint and injury to the brachial plexus. To ensure the abdomen is free. To minimize pressure exerted on the patient's knees. To minimize the risk of overstretch on the soft tissues over the ant aspect of the ankle joints.

5.	Pull flat bottom sheet straight and taut. Then place the second flat sheet over the top of the patient, matching all four corners.	To aid safe and effective turning.
6.	Uncover the patient's head and face. All personnel on either side of the bed then roll the long edges of both (top and bottom) sheets tightly together.	To ensure the roll is equally distributed and is as tight as possible. To effectively cocoon the patient within the two sheets.
7.	Once the person responsible for the head and airway is satisfied with the patient's safety, slide the cocooned patient across the bed AWAY from the ventilator to as close to the opposite edge of the bed as possible. The patient is supported by the personnel on the opposite side of the bed to the ventilator. All personnel should maintain a TIGHT grip on the rolled sheets.	To ensure clear coordination and facilitate safe and effective turning of the patient.
8.	Turn the patient to a lateral position, maintaining sheet integrity and security, TOWARDS the ventilator and then lower into the prone position, onto the original top sheet and arranged pillows. This should be performed slowly allowing personnel on either side of the bed to swap over supporting hands. Person responsible for head and airway positions head facing ventilator.	To ensure safe handling of the patient and effective use of the sandwich technique.
9.	All personnel, on the count of the person responsible for the patient's head and airway, slides the patient	For patient safety For effective multi-professional management of the patient.

	into a more central position of the bed.	
10.	Unroll top and bottom sheets. Remove sheet from patients back. Replace EKG stickers on the patient's back. Reconnect other IV lines and monitoring devices. Drape a gown over the patient's back.	To resume patient monitoring and therapies as ordered.  To provide for patient privacy.
<b>Stage 3: Patient Positioning</b>		
1.	The patient must be maintained in the swimmers position, ensure that the arms are alternated. The shoulder of the prominent arm should be positioned at 80° abduction and the elbow at 90°. Placing a rolled pillowcase in the palm of the prominent hand.	To minimize the risk of joint damage and to prevent over extension and development of limb contractions. To avoid subluxation of the shoulder.
2.	Alternate swimmers position every 2-4 hours, supporting upper arm between shoulder and elbow and lower arm between elbow and wrist. Avoid pulling on the patient's wrist. Modify the prone position ¾ facing right and left with pillows supporting the side to be lifted. Coordinate with Mobility Tech for regular passive movement exercises within the normal range.	To avoid pressure sores to the ears cheeks, and neck. To extend the wrist and allow flexion of joints. To promote effective sputum drainage. To maintain soft tissue length and mobility.
3.	Once in the prone position, place bed in the reverse Trendelenburg position (30-40°)	To minimize the development of facial edema.
<b>Stage 4: Maintenance and Evaluation Once Prone</b>		
1.	Perform oral and tracheal suctioning immediately following the procedure.	To clear oral/pulmonary secretions mobilized as a result of prone positioning.
2.	Maintain eye care.	To minimize the risk of corneal drying/abrasion/ulceration.

3.	Resume enteral feeding.	To ensure adequate nutritional intake.
4.	Observe patients O2 saturation levels.  Perform arterial blood gases 20 minutes following patient's prone positioning. Looking for at least a 20% increase in the PaO2	Initial assessment of effectiveness of treatment rise in SaO2. To monitor the effectiveness of prone positioning.
5.	Maintain the patient in the prone position for as long as they continue to demonstrate a positive response, or up to 20 hours a day, providing no deterioration or discomfort is observed.	To ensure optimal response from prone therapy.
6.	Monitor and document the patient's ABGs as individual condition requires and prior to any changes in position, e.g. from supine to prone and vice versa. Compare SaO2 to that obtained prior to the procedure (whilst supine) if lower than that value consider returning the patient to supine position	To identify those patients that will or will not benefit from prone positioning. To optimize patient oxygenation and minimize risks associated with hypoxia.

### **Additional Considerations**

If patient has copious oral secretions, place additional absorbent protection under the head to minimize the risk of tissue excoriation.

If a patient's oxygenation status deteriorates and continues to do so for 30 minutes, the patient must be returned to the supine position.

In a cardiac arrest situation, if unable to quickly rotate patient, CPR can be effectively performed in the prone position. Hands placed directly under the patient can increase the efficiency of chest compressions.

Prone positioning is most effective if performed for 16 hours per day.

### **Potential Complications**

unintentional extubation

ETT obstruction

mainstem intubation  
 loss of vascular access  
 inadvertent CT removal  
 pressure-related skin ulcers/soft tissue necrosis  
 intolerance of gastric feeding

## **NEUROMUSCULAR BLOCKING AGENTS (NMBA) IN THE ICU**

We see NMBAs used most commonly in patients with a severe lung injury, usually ARDS. Some other possible uses of NMBA in the ICU are:

- to manage increased ICP after a head injury
- for severe muscle spasms associated with seizures, tetanus, and drug overdose
- to reduce intra-abdominal hypertension
- with Therapeutic Hypothermia
- for preservation of delicate reconstructive surgery

**Nimbex and Rocuronium (Zemuron) are approved for use in the ICUs at SIH**

**Cisatracurium (Nimbex) 80mg/200mL** - Preferred agent for pts with CrCl < 30

Usual ordering parameters:

Loading dose of 0.1 mcg/kg

Usual infusion rate is 0.5-3 mcg/kg/min

Maximum dose is 10 mcg/kg/min

Titrate by 1 mcg/kg/min every 10 min

<b>Drug</b>	<b>Onset of action</b>	<b>Duration of action</b>	<b>Adverse Effects</b>
Cisatracurium	2-3 min	25-45 min	Hemodynamic instability, bronchospasm, rash
Rocuronium	30-60 secs	30 min	Hypo/ hypertension, arrhythmias, rash

NMBAs do not affect sensation or LOC so sedatives and analgesic should ALWAYS be given concurrently to minimize the patient's awareness of blocked muscle activity and discomfort.

**Prior to starting NMBAs verify that patient:**

- has a central line/PICC
- is on mechanical ventilator
- is receiving continuous sedation (RASS goal of -4)
- is receiving continuous analgesic

is receiving DVT and stress ulcer prophylaxis

## **REQUIRED MONITORING DEVICES – Bis and Train-of-Four**

### **BIS MONITOR**

The Bis Monitor is used continuously to assess sedation levels.

The level can vary between 0 (no brain activity) and 100 (wide awake)

The goal sedation range on the Bis is 40-60.

The patient should be unarousable with a RASS of -4.

Sedation should be titrated to achieve these levels.



### **TRAIN-OF-FOUR (TOF)**

The TOF monitors the level of neuromuscular blockade and is performed using a Peripheral Nerve Stimulator. Four consecutive stimulations are applied to the nerve, and the number of muscle twitches are counted.

#### **Frequency of TOF**

Perform a train-of-four (TOF):

- prior to starting NMBA

- 15 minutes after infusion initiated or changed

- every 1 hour until patient stable and desired level of sedation achieved

- every 2-4 hours while infusing

After NMBA discontinued:

- perform TOF every 15 minutes until 4 strong twitches of equal amplitude noted.

## Levels of neuromuscular blockade

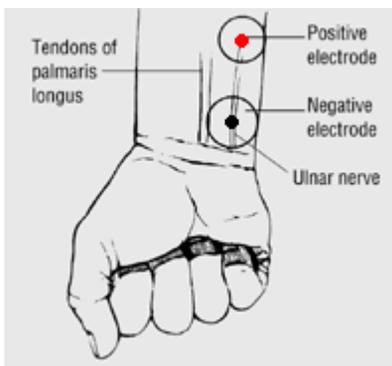
TOF Response	Approx % of Receptors Blocked	Clinical Significance
4 out of 4 twitches	75% or less blockade	May be able to move although may experience weakness. Amenable to reversal of blockade with agonist
3 out of 4 twitches	80% blockade	May need to administer additional drug to prolong relaxation. Short or intermediate acting agents may be reversible.
2 out of 4 twitches	85% blockade	Suitable for short term relaxation as well as long term mechanical ventilation
1 out of 4 twitches	90% blockade	Usually gives conditions suitable for short term procedures including intubation and long term mechanical ventilation.
0 out of 4 twitches	100% blockade	Conditions for intubation. Long term saturation may lead to prolonged effects.

**One to two twitches is the recommended level of block.**

### TOF Monitoring Sites

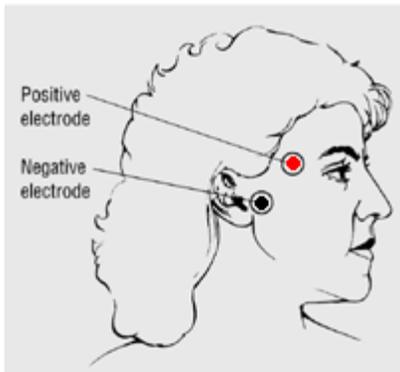
**Ulnar Nerve** - Place negative electrode (black) on the wrist in line with the smallest digit 1-2 cm below skin crease and the positive electrode (red) 2-3 cm proximal to the negative electrode. Ulnar nerve is the recommended testing location.

*Expected response: Adductor pollicis muscle – thumb adduction*



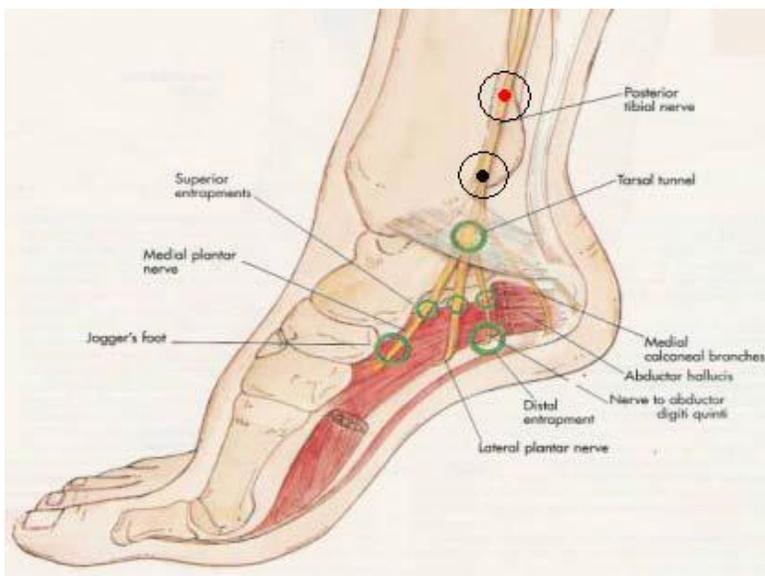
**Facial Nerve** - Place negative electrode (black) by ear lobe and the positive (red) 2 cm from the eyebrow (along facial nerve inferior and lateral to eye).

*Expected response: Orbicularis oculi muscle – eyelid twitching*



**Sural (posterior tibial) nerve** - Place the negative electrode (black) over inferolateral aspect of medial malleolus (palpate posterior tibial pulse and place electrode there) and positive electrode (red) 2-3 cm proximal to the negative electrode.

*Expected response: Flexor hallucis brevis muscle – planter flexion (curl) of big toe*



## **How to perform a TOF**

- Select location and apply stimulator
- Turn stimulator on by turning dial from 0 to 1 up to 10. Usual setting is 2-5, although a setting of 10 is sometimes necessary.
- Press the black 2/SEC button. Hold the button to deliver a “train” of four pulses where each is 0.5 seconds apart.
- Document the number of twitches observed.
- If no twitches observed, increase amperage until twitches observed. Also consider rechecking location, polarity, battery.



### **TOF Troubleshooting**

Edema of monitoring site (try alternate site)

Thick skin (try alternate site)

Electrolyte abnormalities

Previous nerve injury (try alternate site)

Neuromuscular diseases such as Myasthenia Gravis, Bell's Palsy – may not respond normally to nerve stimulation.

Do NOT place stimulator over broken, wet, greasy or hairy skin

Turn stimulator off between uses

### **Factors that alter neuromuscular blockade:**

Calcium channel blockers  
Corticosteroids  
Diuretics (furosemide and thiazides)  
Carbamazepine  
Enflurane and isoflurane (inhalants)  
Antibiotics (amikacin, clindamycin, gentamycin, kanamycin, neomycin, piperacillin, plicymycin  
A,B and E, streptomycin, tetracyclines and tobramycin)  
Anti arrhythmic medications (bretyllium, lidocaine, propranolol, quinidine)  
Electrolyte and thermal disorders (hypokalemia, hypocalcemia, hypomagnesemia,  
hyponatremia, hypothermia, acidosis)  
Organ failure (renal and hepatic)  
Neuromuscular diseases