Nursing’s Role in Minimizing O₂ Demand

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Imbalance of Oxygen Supply & Demand

Supply/Demand Relationship

SUPPLY

DEMAND

Aerobic Metabolism

O₂ Supply/Demand Compensatory Mechanisms

- Improve pulmonary gas exchange
  - Increase PVR
  - Increase minute ventilation
- Increase oxygen delivery
  - Increase heart rate/CO/ extraction
  - Adrenal stimulation
- Alter the distribution of blood flow: Local
  - Decrease arteriolar tone
  - Decrease precapillary sphincter
  - Increase local blood flow
  - Capillary recruitment


Re-Examining Impact of Basic Care Activities

O₂ Supply/Demand Relationship

Supply/Demand Relationship

Supply/Demand Relationship

Oxygen Consumption

Oxygen Delivery (600mL/min/m²)

Oxygen Consumption

Supply/Demand Relationship

Abnormal delivery
Cellular Deficit
Misdistribution of flow
Impair oxygen diffusion

Oxygen Delivery
**O₂ Supply Debt**

**Physiological Factors That Increase Demand**

<table>
<thead>
<tr>
<th>Illness &amp; Injury</th>
<th>% ↑ VO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical trauma/skeletal injuries</td>
<td>10-30%</td>
</tr>
<tr>
<td>MODS</td>
<td>20-80%</td>
</tr>
<tr>
<td>Sepsis</td>
<td>50-100%</td>
</tr>
<tr>
<td>Head injury-sedated</td>
<td>69%</td>
</tr>
<tr>
<td>Head injury-not sedated</td>
<td>138%</td>
</tr>
<tr>
<td>Chest Trauma</td>
<td>60%</td>
</tr>
<tr>
<td>Seizing</td>
<td>100%</td>
</tr>
<tr>
<td>Shivering</td>
<td>50-100%</td>
</tr>
<tr>
<td>Work of breathing</td>
<td>20-40%</td>
</tr>
<tr>
<td>Agitation</td>
<td>18%</td>
</tr>
<tr>
<td>Fever</td>
<td>10-13%</td>
</tr>
</tbody>
</table>


**Physiological Factors That Reduce Demand**

<table>
<thead>
<tr>
<th>Variables</th>
<th>% ↓ VO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothermia (per 1° C)</td>
<td>7%</td>
</tr>
<tr>
<td>Morphine (.5mg/kg IVP)</td>
<td>9-21%</td>
</tr>
<tr>
<td>Morphine (.2-.5mg/hr)</td>
<td>21%</td>
</tr>
<tr>
<td>Anesthesia</td>
<td>30%</td>
</tr>
<tr>
<td>Assist/control ventilation</td>
<td>30%</td>
</tr>
<tr>
<td>Neuromuscular blockade</td>
<td></td>
</tr>
</tbody>
</table>


**Nursing Activities Which Increase Demand**

- Lateral turn & dangling results in a 8-12% decrease in SvO₂ which takes 5-10 minutes to return to baseline
- VO₂ sustained increase of 30-40% for 30 minutes post turn (Weissman C., et al. Chest, 1984;86:815)
- In lower cardiac output states, SvO₂ ↓ to 22% and slower to recover
- Appears the act of turning has the greatest impact on any instability seen

Shively M. Heart & Lung, 1988;17(1):51-59
Patients at Risk for Intolerance to Positioning

- Elderly
- Diabetes with neuropathy
- Prolonged bed rest
- Multiple events occur during turning (coughing, suctioning, agitation)
- Low Hb an cardiovascular reserve
- Prolonged gravitational equilibrium

Gawinski A. J Cardiovasc Nurs, 1993;7(4):71-81

Suggested Strategies to Reduce Demand for Positioning

- Lateral rotation: for critical phases where manual turning may cause significant hemodynamic instability. May be used as a training tool
- Minimize factors which contribute to imbalances in oxygen supply & demand before turning
- Position to maximize V/Q relationships to reduce work of breathing
- Slow manual turn: reduces disequilibrium
- Space activities: allows adaptation
- Assessing tolerance: 5-10 minutes

Endotracheal Suctioning

- ET suctioning consequences include:
  - Hypoxemia, hemodynamic compromise, dysrhythmias, & cardiac arrest
  - Open suctioning: ↓ Svo2 21% from baseline (Walsh JM et al. Chest, 1989;95:162)
  - Open vs. Closed suctioning with pre/post hyperoxygenation: O2 with open suctioning used. Sustain for 4 minutes post event (p< .03). 5% change in HR from baseline. No difference with open vs. closed (Clark AP. et. al. Heart & Lung, 1990;19(5):552-557)
  - Impact on ICP: <20mm Hg, transient effect returning to baseline, > 20 mmHg, may cause serious effect
  - Hyperinflation causes significant hemodynamic Δ in HR, MAP, CO.

Saline Administration

- No physiologic benefit demonstrated by administering saline
- ↑ force of the cough
- Does not thin or liquefy secretions
- Delays recovery of oxygenation saturation & Svo2
- Flushes bacteria deeper in the lungs
- Increases the risk of pneumonia
- Potentially costly unnecessary procedure
- Not recommended for routine use

Raymond SJ. AJCC. 1995;4(4):267-71

Strategies to Reduce Demand During Suctioning

- Space activities
- "Suction < 10-15 seconds, minimum effective negative pressure"
- "Size of cath not to exceed ½ internal diameter of ET"
- "Hyperoxegenation throughout the procedure/open or closed suctioning"
- Appropriate pain management
- Suction only when necessary (presence of secretions in the upper airway) and do not use saline instillation

**Physiologic Responses to Anxiety**


**Strategies to Reduce Anxiety in the Critically Ill Patient**

- Non-Pharmacological & Pharmacological
  - Communication
    - Therapeutic (Tassadak J. K. of Adv Nurs, 1995;22:76-86)
    - Instructional (Thomas LA, AACN clinical Issues, 2003:14:73-81)
  - Full physical presence (Moser DK, et al. Inter & Crit Care Nurs, 2003;19:276-284)
  - Sedation: anxiolytic &/or pain control
    - Morphine results in a 9-21% ↓ VO2
  - Consider melatonin

**Melatonin Therapy to Improve Nocturnal Sleep**

**Methodology**
- RCT- double blind-placebo controlled trial
- 24 ICU patients with tracheostomy
- 10mg of oral melatonin or placebo given 9pm x4 nights
- Nocturnal sleep monitored by BIS and express as sleep efficiency index (SEI), area under the curve (AUC) & nurse/patient assessments

**Results**
- Sleep time for placebo: 2.5 hrs
- Sleep time for melatonin: 3.5 hrs (p=0.09)
- BIS AUC denoting better sleep for melatonin group (p=0.04)
- Pharmokinetic analysis suggests dose may be too high

**Impact of Bathing on Demand**

- Nurse administered bed-bath: anterior cleaning minimal impact on demand, the turn had the greatest significance
- SVO2 ↓ 71 ± 7% to 59 ± 9% during bathing. Returned to baseline 6.5 ± 7.4 mins post completion
  - 20% ↑ in VO2 with bathing & ROM
  - Post stimulation, metabolic rate elevated for 45 min
  - 31% ↑ in VO2 with turning,19% ↑ in VO2 with bathing
- ↑ in VO2 with bathing was met more by O2 extraction than ↑ in CO. ↑ in lactate seen (De Backer D, et al. SCCM, 1995)

**Post Acute MI Δ in VO2 with 3 Different Bathing Techniques**

Effect of Routine Interventions on Metabolic Rate

![Graph of metabolic rate changes with different bathing techniques](image)
Activities That Increase VO₂ while Bathing

- Dressing change 10%
- Agitation 18%
- Bath 23%
- Suctioning 27%
- Increased work of breathing 40%
- Weigh on sling scale 36%
- Position change 31%
- Linen change – occupied bed 22%
- Chest physiotherapy 35%

Routine Activities That Increase VO₂

- Physical exam 20%
- Chest X-ray 25%
- Electrocardiogram 16%
- Routine post op procedures 7%
- Visitor 22%

Strategies to Optimize Patient’s Tolerance to Activities

- Space activities
- Monitor for signs of intolerance
- Pre/post hyperoxygenate
- Determine if the intervention is essential
- Control variables that increase consumption
  - Pain management
  - Agitation management
  - Partial temp regulation
  - Shivering

How Do We Monitor Supply/Demand Relationship

- SvO₂: indicator of global tissue oxygen balance
  - Reflects alterations in delivery or demand when abnormal
  - Early warning: ∆ in SvO₂ > 10% from baseline
  - Monitored via a pulmonary artery catheter (PAC)
- ScvO₂: 5% higher than SvO₂ but correlates well and can be monitored through a triple lumen type catheter vs. PAC
- StO₂: non-invasive real time monitoring of tissue perfusion status (normal range > 75%)
  - Functioned as well as base deficit in indicating hypoperfusion in trauma patients (Cohn SM. Et al. J Trauma, 2007;62(1):44-55)
Areas for Further Research

- Energy expenditure with a mechanical turn and assist position change versus manual in the acute phase of illness
- Energy expenditure during a basin bath in a variety of critically ill patients versus newer bathing technology
- Impact on supply/demand relationship following a routine day of care activities and procedures
- RCT testing of non-pharmacological measures to reduce anxiety and enhance recovery
- Determining best strategies & least invasive to perform real time assessment of the supply/demand relationship with regards to the impact of routine nursing care

Looking Through A Different Lens