Nutrition support for the Mechanically Ventilated Patient
April 1, 2020

Disclosure

• Support for this program is provided by Abbott Nutrition
• The speaker is a member of the Abbott Nutrition Sales Force
• The program is not intended for continuing education credits for any healthcare professional
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Clinical Liaison - Chicago, IL

Here’s what Health Care Providers are asking:

• What formula should I be feeding patients who are mechanically ventilated?
• What research exists for nutrition support in this patient population?
• Should I be using immune-modulating formulas with my patients?
• Should I be re-evaluating my formulary during this time?
Objectives

• Examine the complications that cause patients to be admitted to the ICU and how complications influence nutrition care planning

• Understand nutrition support and benefits of individual nutrients for critically ill, mechanically ventilated patients

• Review gravity tube feeding best practice

Acute Lung Injuries in the ICU
Normal Lung Function

- Primary function of the lung: Gas Exchange
- The lung is made up of capillaries and alveoli that aid in gas exchange.
- Inhale: O₂ goes into the lung and delivered to body
- Exhale: CO₂ leave the body through the lung

*During critical illness, perfusion and gas exchange abnormalities, infection, and signs of malnutrition may be present.*

Normal Immune Response

- Appropriate immune response:
  - Helps fight infection
  - Attenuates the metabolic stress response
  - Supports healing and recovery
- Normal inflammatory response is balanced between pro-inflammatory and anti-inflammatory mediators

*Many of the symptoms that make a person suffer during an infection—result from the activities of the immune system trying to eliminate the infection from the body including:*
  - Fever, tiredness, dry cough, aches and pains, headache
Inflammation and Immunosuppression


Acute Lung Injury Leads to a Potent Local Proinflammatory Response

Nutrition Support During Respiratory System Failure\textsuperscript{1,2}

Common Medical Indications:
- COPD
- Pulmonary Edema
- Inflammation
- Pneumonia
- Chronic Pulmonary Diseases

Nutrition Goals:
- Reduce Energy Deficit
- Modulate Inflammation
- Support the Immune System
- Mitigate nosocomial infections
- Protect Lean Body Mass

\textsuperscript{1} Allen K, and Hoffman L. \textit{Clin Pract}. 2019(34)4;540-557.

Acute Respiratory Distress Syndrome (ARDS)
Feeding During Acute Respiratory Distress Syndrome (ARDS)

Definition:

Severe Form of Respiratory Failure as Defined by Berlin Criteria¹
1) Symptoms within 7 days of clinical insult (PNA or sepsis)
2) Bilateral Lung Opacities unexplained by heart or lung failure or fluid overload
3) Oxygenation Impairment as indicated by P:F ratio

Feeding Recommendations

• Research surrounding immunonutrition in ARDS is difficult to decipher d/t lack of homogeneity of the research.
• ASPEN 2016 Critical Care Guidelines:²

"C2. We recommend that either trophic or full nutrition by EN is appropriate for patients with acute respiratory distress syndrome (ARDS)/acute lung injury (ALI) and those expected to have a duration of mechanical ventilation ≥72 hours, as these 2 strategies of feeding have similar patient outcomes over the first week of hospitalization."

[Quality of Evidence: High]


What is ECMO?

• Initiated when heart and lung are unable to deliver adequate gas exchange or perfusion to sustain life¹
• Provides prolonged cardiac and respiratory support
• Pumps and oxygenates blood outside of the body
• ECMO has 2 configurations:
  • VV ECMO: cannulation via venovenous route (respiratory support only)
  • VA ECMO: cannulation via venous-arterial route (more invasive; respiratory and cardiac support)

Nutrition Support and ECMO

• Extracorporeal Life Support Organization (ELSO): “full caloric and protein nutritional support is essential”¹
• Delayed gastric emptying common in ECMO patients receiving EN²
• Data show use of prokinetics/postpyloric feeding in >50% of patients³
• Frequent EN interruptions (frequent OR and beside procedures)
• EN can be well-tolerated by patients who are receiving ECMO⁴
• Early EN (VA ECMO) is associated with lower in-hospital mortality and 28-day mortality⁵
• In patients receiving VA ECMO and high-dose vasopressor that are in severe shock, consider delaying EN for a short time with daily review⁶

Mechanical Ventilation (MV) for Patients in a Prone Position (PP)\textsuperscript{1,2}

**What is PP during MV?**
- Patient is placed lying flat, their chest down, and back up
- Compared with a supine position, PP improves oxygenation
- Widely implemented in patients with ARDS

**Nutrition Support and PP**
- Theoretical concerns to EN include increased GRVs, vomiting, aspiration
- EN delivered during PP does not suggest substantial increase in complications compared to supine\textsuperscript{1}
- No difference in GRVs, high GRV events, vomiting, or diet regurgitation compared to supine\textsuperscript{2}
- Prokinetic use may be effective to increase the volume of EN administered

The Sepsis Continuum\textsuperscript{1,2}

\begin{itemize}
\item **Infection or Trauma**
\item **SIRS**
\item **Sepsis**
\item **Severe Sepsis**
\end{itemize}

**Adult Criteria**
A clinical response arising from a nonspecific insult, including \geq 2 of the following:
- Temperature \geq 38^\circ\text{C}, or \leq 36^\circ\text{C}
- HR \geq 90 beats/min
- Respirations \geq 20/min
- WBC count: \geq 12,000/\text{mm}^3, or \leq 4,000/\text{mm}^3, or \geq 10% immature neutrophils

**SIRS with a presumed or confirmed infectious process**

**Sepsis with \geq 1 sign of organ dysfunction, for example:**
- Cardiovascular (refractory hypotension) SHOCK
- Renal
- Respiratory
- Hepatic
- Hematologic
- CNS
- Unexplained metabolic acidosis (lactic acidosis \geq 4 \text{mmol/L})

Early enteral feeding in the critically ill

Early Enteral Feeding Is Associated with Improved Outcomes in Several Critically Ill Patient Populations

- Reduced mortality rates\textsuperscript{1,3}
- Fewer incidences of new organ failure\textsuperscript{3,3}
- Fewer episodes of severe sepsis or septic shock\textsuperscript{4}
- Fewer days on ventilator support\textsuperscript{3-4}

Provision of higher calories and protein are associated with increased Ventilator Free Days (VFDs)

In 2,772 mechanically ventilated patients who received an average of 1,034 kcal/day and 47 g/protein, the provision of higher calories was associated with:\textsuperscript{1}

\[ VFDs = 3.5 \pm 1.5 \]

(95% CI 0.61-0.95, \( P = 0.014 \))

Overall Mortality\textsuperscript{5}

(95% CI 1.2-5.9, \( P = 0.003 \))

VFD = Ventilator Free Days
\textsuperscript{1} The adjusted risk ratio (OR) for 60-day mortality for every 1,000 kcal/day provided was 0.76 (95% confidence interval CI 0.61-0.95, \( P = 0.014 \)). No mortality benefit was seen in the BMI group 25 to 35.
\textsuperscript{2} VFD unit: placebo: 1,000 g/day,
\textsuperscript{3} VFD: weight gain of 1,000 g/day
\textsuperscript{4} Other authors, 2009: 2010 1738-1737
Protein Considerations in Respiratory Failure

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**Objective:**
- Examine outcomes in respect to timing of protein delivery

**Study Design: Retrospective Cohort**
- 2253 ICU patients grouped based on the amount of protein delivered
  - 1040 patients received >0.7g/kg in first 3 days of admission
  - 1213 patients received <0.7g/kg in first 3 days of admission

**Results:**
- At 60 days, 371 (36%) in the EP and 517 (43%) in the LP group had died ($P < 0.001$ for difference)
### Hemodynamic Instability

#### Early Enteral Nutrition Results in Improved Outcomes in Hemodynamically Unstable Patients

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Early enteral nutrition</th>
<th>Late enteral nutrition</th>
<th>P</th>
<th>Odds ratio</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total group</td>
<td>239/707 (33.8%)</td>
<td>205/467 (43.9%)</td>
<td>0.001</td>
<td>0.65</td>
<td>0.48-0.99</td>
</tr>
<tr>
<td>Censored at 28 days</td>
<td>213/707 (30.3%)</td>
<td>184/467 (39.4%)</td>
<td>0.001</td>
<td>0.69</td>
<td>0.50-0.93</td>
</tr>
<tr>
<td>Number of Pressors 1</td>
<td>209/608 (32.9%)</td>
<td>159/985 (41.3%)</td>
<td>0.001</td>
<td>0.7</td>
<td>0.50-0.98</td>
</tr>
<tr>
<td>&gt;1</td>
<td>39/99 (39.4%)</td>
<td>46/82 (56.1%)</td>
<td>0.03</td>
<td>0.36</td>
<td>0.15-0.85</td>
</tr>
<tr>
<td>Early improvement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>100/358 (27.9%)</td>
<td>72/221 (32.6%)</td>
<td>0.24</td>
<td>0.67</td>
<td>0.42-1.08</td>
</tr>
<tr>
<td>No</td>
<td>139/349 (39.8%)</td>
<td>133/246 (54.1%)</td>
<td>0.001</td>
<td>0.59</td>
<td>0.39-0.90</td>
</tr>
<tr>
<td>Moribund at discharge from the intensive care unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>24/30 (80.0%)</td>
<td>28/36 (77.8%)</td>
<td>0.83</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>No</td>
<td>215/677 (31.8%)</td>
<td>177/431 (41.1%)</td>
<td>0.002</td>
<td>0.65</td>
<td>0.48-0.90</td>
</tr>
</tbody>
</table>

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Guidelines Supporting Feeding Patients with ARDS

**2016 SCCM/ASPEN Critical Care Guidelines:**

“C2. We recommend that either trophic or full nutrition by EN is appropriate for patients with acute respiratory distress syndrome (ARDS) / acute lung injury (ALI) and those expected to have a duration of mechanical ventilation $\geq 72$ hours, as these 2 strategies of feeding have similar patient outcomes over the first week of hospitalization.”

“E3. We cannot make a recommendation at this time regarding the routine use of an enteral formulation characterized by an antiinflammatory lipid profile (e.g., omega-3 FOs, borage oil) and antioxidants, in patients with ARDS and severe ALI, given conflicting data.”

Guidelines Supporting Feeding Patients with ARDS

2017 European Society of Intensive Care Medicine (ESICM) Guidelines:

“Recommendation 6. We suggest using EEN in adult patients receiving extracorporeal membrane oxygenation (Grade 2D).”

“Recommendation 7. We suggest that EN should not be delayed solely because of prone positioning (Grade 2D).”

“Remark: We suggest considering early use of prokinetics followed by post-pyloric feeding in case of persisting gastric retention”

Sepsis and EN: What do the Guidelines Say?

“E2. We suggest immune-modulating enteral formulations (arginine with other agents, including eicosapentaenoic acid [EPA], docosahexaenoic acid [DHA], glutamine, and nucleic acid) should not be used routinely in the MICU. Consideration for these formulations should be reserved for patients with TBI and perioperative patients in the SICU (see sections O and M).”

“N4: Based on expert consensus, we suggest the provision of trophic feeding (defined as 10–20 kcal/h or up to 500 kcal/d) for the initial phase of sepsis, advancing as tolerated after 24–48 hours to >80% of target energy goal over the first week. We suggest delivery of 1.2–2 g protein/kg/d.”
Specific Ingredients to Help Support Critically Ill Patients

Arginine in the Critically Ill: Where Are We Now?¹

<table>
<thead>
<tr>
<th>Study</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kao, et al (2009)</td>
<td>&quot;whole-body arginine production and NO synthesis were similar in patients with sepsis/septic shock and healthy controls. Despite increased proteolysis in sepsis, there is a decreased arginine plasma concentration, suggesting inadequate de novo synthesis secondary to decreased citrulline production&quot;</td>
</tr>
<tr>
<td>Visser, et al (2012)</td>
<td>&quot;arginine: ADMA ratio showed an association (OR 0.976, 95% CI 0.963, 0.997, P = 0.025) and a diagnostic accuracy (area under the curve 0.721, 95% CI 0.560, 0.882, P = 0.016) for hospital mortality; whereas the arginine or ADMA concentration alone or APACHE II predicted mortality failed to do so&quot;</td>
</tr>
<tr>
<td>Luiking (2015)</td>
<td>&quot;septic patients demonstrated elevated protein breakdown at baseline (P &lt; 0.001 compared with healthy controls), whereas protein breakdown decreased during arginine infusion (P &lt; 0.0001). Mean arterial pressure, mean pulmonary pressure and regional gastric mucosal carbon dioxide (PrCO₂ - measured by tonometry) did not change during arginine infusion (P &gt; 0.05), whereas stroke volume (SV) increased (P &lt; 0.05) and arterial lactate decreased (P &lt; 0.05)&quot;</td>
</tr>
</tbody>
</table>

Arginine in the Critically Ill: Where Are We Now?

“Ultimately, just because arginine can be a substrate for [nitric oxide] NO production (which can be a significant vasoactive agent) doesn’t necessarily mean it will affect the systemic circulatory system.”

Conclusions based on data reviewed suggest that supplemental arginine and citrulline:
- “do not alter NO production”
- “confirms that sepsis is an arginine deficient state”
- “do not cause hemodynamic changes”
- “can improve morbidity and mortality in the critically ill”

Arginine and fish oil work synergistically to improve outcomes in Surgical ICU Patients

**Arginine**

**Immune Function**
- Primary fuel source for T & B cells during stress
- T cell proliferation is linearly dependent on plasma arginine concentrations

**Hydroxyproline**
- Arginine → ornithine + urea → hydroxyproline

**Nitric Oxide**
- NO deficiency correlated with wound breakdown and poor wound healing
- ↑ vasodilation and + effect on ability to fight infection

**Fish Oil**

↑ resolvins and protectins
- Inflammation
- Wound healing

Lowers levels of arachidonic acid to attenuate inflammatory response

Improve lymphocyte function

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Antioxidants Act as Free Radical Scavengers

Antioxidants
- Vitamins E & C
- β-Carotene
- Selenium

Recommendations for and Benefits Associated with Immune-Modulating Nutrition in Surgical ICU Patients

- Routine use of immune-modulating formulas (containing both arginine and fish oil) in the SICU for the postoperative patient who requires EN therapy is recommended
- Immune modulating formulas containing both arginine and fish oils, both must be present to see outcome benefits.
- Timing is important and influenced by the nutritional status of the patients.

Associated with improved patient outcomes, including reduced:
- Wound complications
- Hospital length of stay
- Hospital costs

Feeding Modalities

Gravity Feeding - Administration

1. Pour the formula into the feeding container / feedbag
2. Hang the container on an IV pole or a wall hook about 2 feet above and to the side of the feeding tube. Ensure that the head of the bed is in the proper position (approximately 30° – 45°).
3. Remove the cover from the end of the feeding set. The roller clamp should be closed.
4. Prime the feeding set by allowing the formula to flow into the tube.
5. Insert the tip of the feeding set (ENFit®) into the feeding tube.
6. Slowly open the clamp on the tubing.
7. Set the flow to the desired gravity drip rate. Use the clamp to control the flow until desired rate is achieved. Make the flow faster by slowly opening the clamp. Make the flow slower by partially closing the clamp.
8. When the feeding is complete, close the clamp.
9. If extra water is desired after feedings, pour the prescribed amount into the container to flush the tube.
10. Open the clamp and let the water drip until gone.
11. Close the clamp and disconnect the feeding set.

Note: This information is for educational purposes and should not replace medical advice. Always refer to the Feeding Plan recommended by the health care professional. When using any feeding set, instructions for use from the feeding set manufacturer must be followed.
Gravity Feeding – Flow Rates

For gravity feeding, the formula flow rate will be ___________ drops or __________ mL per __________ seconds.

- To determine the number of drops per hour, divide the dose by the feeding time (hours) and multiply it by the drip factor (based on the assumption of 14 drops = 1 mL of formula).
- To determine the number of drops per hour divide the number of drops per minute by 60.
- Watch the drip chamber and time the drops according to the following examples:

<table>
<thead>
<tr>
<th>If goal rate per hour is:</th>
<th>Drops per minute (approximately):</th>
<th>Drops per 15 seconds (approximately):</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 mL</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>80 mL</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>100 mL</td>
<td>23</td>
<td>6</td>
</tr>
<tr>
<td>120 mL</td>
<td>28</td>
<td>7</td>
</tr>
<tr>
<td>140 mL</td>
<td>33</td>
<td>8</td>
</tr>
</tbody>
</table>

Note: The example above is based on 14 drops = 1 mL of formula. Depending on the viscosity of the enteral formula, the drops/mL may vary (10 drops = 1 mL; 14 drops = 1 mL; 20 drops = 1 mL). High viscosity will result in fewer drops; low viscosity will result in more drops.


How We Can Help: Products & Support
Specialized Therapeutic Nutrition

For immune support, to promote GI tolerance, and to help manage inflammation

<table>
<thead>
<tr>
<th></th>
<th>Pivot® 1.5 Cal</th>
<th>Vital® AF 1.2 Cal</th>
<th>Vital® High Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arginine, g/L</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(supplemental)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glutamine, g/L</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(inherent)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamins C and E</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Beta-carotene</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCT/Fish Oil</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Structured Lipids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peptide-based</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>scFOS®</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EPA</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>DHA</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cal/mL</td>
<td>1.5</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>% Protein Cal</td>
<td>25.0</td>
<td>25.0</td>
<td>35.0</td>
</tr>
</tbody>
</table>

Use under medical supervision.
NutraFlora® and scFOS® are not registered trademarks of Abbott Laboratories.
### Vital® AF 1.2 Cal

<table>
<thead>
<tr>
<th>Vitamin and Nutrient</th>
<th>Vital® AF 1.2 Cal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arginine, g/L (supplemental)</td>
<td></td>
</tr>
<tr>
<td>Glutamine, g/L (inherent)</td>
<td>✓</td>
</tr>
<tr>
<td>Vitamins C and E</td>
<td>✓</td>
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<tr>
<td>Beta-carotene</td>
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<tr>
<td>MCT/Fish Oil</td>
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<td>scFOS®</td>
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<td>DHA</td>
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<td>Cal/mL</td>
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<tr>
<td>% Protein Cal</td>
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### Vital® HP

<table>
<thead>
<tr>
<th>Vitamin and Nutrient</th>
<th>Vital® High Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arginine, g/L (supplemental)</td>
<td></td>
</tr>
<tr>
<td>Glutamine, g/L (inherent)</td>
<td>✓</td>
</tr>
<tr>
<td>Vitamins C and E</td>
<td>✓</td>
</tr>
<tr>
<td>Beta-carotene</td>
<td></td>
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<tr>
<td>MCT/Fish Oil</td>
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<tr>
<td>Structured Lipids</td>
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</tr>
<tr>
<td>Peptide-based</td>
<td>✓</td>
</tr>
<tr>
<td>scFOS®</td>
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<tr>
<td>EPA</td>
<td>✓</td>
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<td>DHA</td>
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</tr>
<tr>
<td>Cal/mL</td>
<td>1.0</td>
</tr>
<tr>
<td>% Protein Cal</td>
<td>35.0</td>
</tr>
</tbody>
</table>
Abbott Nutrition – Product Portfolio

Marketing / Inventory Update
Questions?

Thank you