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“Nutritional Interventions for Critical Care Patients Receiving Specialized Therapies”

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At the end of the session the participant will be able to:

1) Describe risks of overfeeding and methods to provide adequate nutritional therapy for patients sedated with propofol
2) Identify the key nutritional needs for critically ill patients with acute renal injury on CRRT
3) List nutritional therapy considerations for the patient on ECMO

Nutritional Therapy of Critically Ill

Want to meet patient’s needs and avoid excessive physiologic demands or tissue breakdown

Overfeeding is harmful - even in short term
- Causes lipogenesis and increased CO₂ production
- Increases minute ventilation and work of breathing
- Metabolic derangements (hyperglycemia, hypertriglyceridemia, hepatic steatosis, and elevated liver function tests)
- Coagulopathies
- Cytokine stimulation
Provision of Nutrients

- EN and/or PN formulas

- Other Contributions:
  - IV fluids may contain dextrose
  - IV albumin
  - Modular supplements (e.g., protein)
  - Propofol

Audience Survey Question

- On an average day, what is your best estimate of the percentage of your ventilated ICU patients that are sedated with propofol?
  - A) Less than 20%
  - B) 20-40%
  - C) 40-60%
  - D) More than 60%
Audience Survey Question

A critically ill pt on EN and a ventilator is sedated with propofol for agitation. Which best describes your typical strategy?

A) No change  
B) ↓ EN volume delivered  
C) Change to a lower cal:nitrogen product  
D) ↓ EN only if propofol >500 mL/d

Propofol

Sedative hypnotic for general anesthesia and monitored sedation  
Used for continuous sedation in ICU pts on vent  
Short and predictable half-life: good for ‘wake-ups’  
Side effects include:  
- Respiratory depression  
- Hypotension  
- Bradycardia  
- ‘Propofol infusion syndrome’
Propofol – Practical Nutrition Details

- 1.1 kcal/mL (in 10% lipid emulsion)
- Infusion is dosed in mcg/kg/min and titrated to effect
- Check hourly infusion rate
- Determine ‘average rate’ and use to estimate daily propofol calories then adjust nutrition therapy
- Can be challenge to deliver adequate protein

<table>
<thead>
<tr>
<th>Rate (mL/hr)</th>
<th>Kcal/hr</th>
<th>Kcal/d</th>
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<tr>
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<td>11</td>
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Nutrition and Acute Kidney Injury

- Acute Renal Failure (ARF) occurs in 5% of all hospitalized pts and has associated mortality of 40%
- Renal dysfunction increases the severity and duration of the catabolic state
- Metabolic derangements due to:
  - Metabolic response to stress/organ dysfunction
  - Lack of normal kidney function
  - Effects of Renal Replacement Therapies (RRTs)
Acute Renal Failure (ARF)

- Commonly defined as an abrupt decline in renal function, manifested by acute elevation in plasma blood urea nitrogen (BUN) and serum creatinine (Cr), occurring in hours to days to weeks and which is usually reversible.

- Lack of consensus regarding the actual degree of elevation in serum Cr that defines the syndrome has posed a major limitation to epidemiologic studies.

RIFLE Classification: Acute Kidney Injury

- Proposed by International Consensus Group

- 3 Injury Levels
  - Risk
  - Injury
  - Failure

- 2 Outcomes
  - Loss (persists > 4 weeks)
  - ESRD (persists > 3 months)

RIFLE Classification of Acute Kidney Injury

<table>
<thead>
<tr>
<th>Stage</th>
<th>GFR Criteria</th>
<th>Urine Output Criteria</th>
</tr>
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<tbody>
<tr>
<td>Risk</td>
<td>Cr incr 1.5X or GFR decr 25%</td>
<td>UO &lt; 0.5 ml/kg/hr for 6 hrs</td>
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<tr>
<td>Injury</td>
<td>Cr incr 2X or GFR decr by 50%</td>
<td>UO &lt; 0.5 ml/kg/hr for 12 hrs</td>
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<tr>
<td>Failure</td>
<td>Cr incr 3X or GFR decr by 75%</td>
<td>UO &lt; 0.3 ml/kg/hr for 24 hrs,</td>
</tr>
<tr>
<td></td>
<td>Cr &gt; 4mg/dL; acute rise</td>
<td>Or Anuria &gt; 12 hrs</td>
</tr>
<tr>
<td></td>
<td>&gt; 0.5mg/dL</td>
<td></td>
</tr>
<tr>
<td>Loss</td>
<td>Failure persists &gt; 4 weeks</td>
<td></td>
</tr>
<tr>
<td>ESRD</td>
<td>Failure persists &gt; 3 months</td>
<td></td>
</tr>
</tbody>
</table>


Renal Replacement Therapies

- Hemodialysis (HD)
- Hemofiltration (HF)
- Ultrafiltration (UF)
- Peritoneal dialysis (PD)

Continuous modalities may use venovenous or arterial/venous methodology (ex: CVVHD, CAVHD)
Metabolism and Acute Renal Failure

- EE may be only 20-30% above non-stressed
- For a given illness severity, the increase of EE is higher in pts without ARF
- Intermittent dialysis increases EE by 10-15%
- Protein turnover is increased:
  - Large N\textsubscript{2} losses and negative N\textsubscript{2} balance
  - Or Buildup of nitrogenous wastes

Audience Survey Question

Does your ICU use replacement fluid with CRRT patients that provides a source of calories?

- A) yes
- B) no
- C) use both- with & without carbohydrate
- D) not sure
Nutrition and RRTs

- Dialysis membranes can induce cytokines
- Glucose is lost in HD and HF, but glucose in replacement fluids may provide counterbalance and can be excessive
- AA are lost in HD and HF and need to be accounted for in protein requirements
- 40-60 g AA/d lost in PD

Once RRT is instituted, sufficient quantities of nutrients should be well tolerated

Audience Survey Question

How much daily protein do you typically recommend for a critically ill patient on the ventilator and also on CRRT?

- A) 1.0 g/kg IBW
- B) 1.5 g/kg IBW
- C) 2.0 g/kg IBW
- D) 2.5 g/kg IBW
Animal Studies in AKI

- Survival (78 vs 35%) with early EN vs fluids
  - Preserved GFR and RPF with early EN
- Improved recovery from ischemic AKI with EN vs TPN
- EN improved Renal Blood Flow in animals receiving vasoconstrictors
- No human clinical studies have assessed efficacy of EN in ARF

Anuric, Ventilated Patients on CRRT


- Prospective Randomized Trial to assess caloric and protein needs in 50 patients on CRRT and vent
- EN ± PN to provide predicted energy needs
- Indirect Calorimetry during 3 isocaloric 2 day feeding regimens for 40 subjects (1.5, 2.0 and 2.5 g protein/kg/d) and 10 controls were on 2.0 throughout
- \( N_2 \) balance studies used dialysate ± urine samples for total \( N_2 \) loss measurement

- Schofield mean predicted caloric requirement was 2101 ± 410 kcal/d
- Measured EE was 2153 ± 380 kcal/d and increased by 56 ± 24 kcal/d thru the 6 d study period
- Pts rec'd 99% of predicted energy requirements
- But mean EE was 11% higher at 2336 ± 482 kcal/d
- This difference varied among pts

EE was 2153 ± 380 kcal/d and increased by 56 ± 24 kcal/d thru the 6 d study period

- If predicted EE was < 2500, the measured EE exceeded it by an average of 19%
- If predicted EE was > 2500, the EE on average was 6% lower than predicted

This relationship was statistically significant
Nitrogen balance was:
- Inversely related to EE
- Positively related to protein intake
- Significantly more likely to be attained if protein intake was 2.5 g/kg/d
- Became positive in the study group but not controls
- Directly associated with hospital and ICU outcome

Indirect calorimetry could only be done in 68% of cases due to ventilatory issues but could improve accuracy of EE
- EN had a significant benefit on pt outcome, even after adjusting for predicted risk of death
- Study suggests high protein intake needed in these pts for best outcomes
Audience Survey Question

Which best describes your team’s use of indirect calorimetry for your critically ill patients?

- A) 0-1 time/yr
- B) Occasionally
- C) Often for pts on vents
- D) Routinely

Indirect Calorimetry – Energy Needs

- Some consider this gold standard for ICU patient
- But need steady state in patient at ‘rest’

- Steady state condition is aimed at obtaining gas exchange measure at respiratory level of metabolic cellular events
- Steady state conditions altered by CRRT:
  - Body Temperature
  - Acid-base status
  - Bicarbonate containing IVF may alter pCO₂
  - Extracorporeal removal of CO₂
Indirect Calorimetry – Energy Needs

- Other challenges of indirect calorimetry in ICU patients:
  - Must measure all exhaled gas – leaks cause errors
  - If on FiO₂ > 0.60, thermodynamic equation assumptions will be erroneous
  - Other problematic treatments include inhaled nitric oxide, high frequency oscillatory ventilation, and ECMO
  - ‘Period of rest’ for test is even difficult as patient’s other treatments so frequent
  - As result, we often use predictive equations

Nutrition and AKI/CRRTs

- Critically ill patients are usually very catabolic in contrast to most ESRD patients
- Underlying illness dictates the protein requirements
- Challenge becomes a utilization issue
- Nitrogen balance often remains negative and is tricky to measure
- Protein restriction to ‘hold off on need for dialysis’ is no longer believed valid
Energy Recommendations for AKI and ARF

- Provide 25-35 kcal/kg IBW/d
- Acute renal failure alone is not the key factor
- Underlying critical illness of patient is the main issue
- Slightly higher needs recommended with CRRT due to both glucose and amino acid losses

Nutrition Recommendations in AKI and ARF

- Use early EN
- Monitor electrolytes
- Protein
  - Minimum of 1.0 g/kg/d
  - 1.2-2.5 g pro/kg/d with wounds or on CRRTs
  - CRRTs vs intermittent HD allow high protein intake and better metabolic support
- No proven advantage of specific AA formulations
Extracorporeal Membrane Oxygenation (ECMO)

- Technique to provide both cardiac and respiratory support if pt’s heart or lungs can no longer serve their function

Used for:
- Severe respiratory failure
- Refractory cardiogenic shock
- Cardiac arrest
- Failure to wean from cardiopulmonary bypass after cardiac surgery
- As a bridge to cardiac transplant or placement of a ventricular assist device

Most patients are fluid overloaded when ECMO initiated and diuresis or ultrafiltration can be done while on ECMO

Complications include:
- Sepsis
- Neurologic injury
- Bleeding (as anticoagulation required)
Extracorporeal Membrane Oxygenation (ECMO)


- Retrospective Chart Review 1991-1995
- Consecutive Pediatric Patients on ECMO
- Gp A 14 given TPN; Gp B 13 pts given EN
- No complications with EN
- 100% of EN vs 79% of TPN survived (not significant)
- Savings with EN estimated at $170/day

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Extracorporeal Membrane Oxygenation (ECMO)

**Scott, LK et al. JPEN 2004; 28: 295**

- Retrospective Chart Review 27 pts on V-V ECMO and EN
- Average time on ECMO was 8.7 ± 3.6 d
- 26/27 pts received EN via gastric tube alone or with TPN
- 18 received only EN; remainder rec'd partial PN
- HOB > 15 degrees unless prone (feeds continued prone)
- Prokinetic med (erythromycin) used in first 24 hrs in 75%; within 48 hrs in 95% of pts
- No intestinal ischemia, GI bleeding, or other complications were noted from early EN
Extracorporeal Membrane Oxygenation (ECMO)


- Retrospective Chart Review 2005-2007
- 48 Patients treated with ECMO
- 35 had V-A ECMO; 13 had V-V ECMO
- Mean nutritional adequacy for all was 62% (SD 19%)
- Nutritional adequacy was 55% during and 71% after ECMO removal

- Survivors did not achieve better nutritional adequacy than nonsurvivors

Extracorporeal Membrane Oxygenation (ECMO)


- Prospective Observational Study over 1 yr
- All seven adult pts receiving V-A ECMO for severe hemodynamic failure included
- EN with energy target of 25 kcal/kg/d to be reached over 4 days
- More than 70% nutrition tolerance achieved in first week for all pts
- No serious adverse events attributed to EN
Extracorporeal Membrane Oxygenation (ECMO)

- EN appears well tolerated for pts on ECMO
- Care should be taken to monitor for tolerance
- Prokinetics may help
- Prospective randomized trials of EN vs PN, or other parameters not done, maybe in future
- Quantities of nutrients, value of immune-modulating nutrients needs to be determined

Conclusions/ Recommendations

- Enteral Nutrition is expected to lead to better outcomes than Parenteral Nutrition in these specialized patients. “The gut works, so use it!” still applies.
- Start EN within 12-48 h of ICU admission, usually with a peptide-based or immune-modulating high protein formula
- Consider protein dose of ≥2 g/kg/d. (Found more successful in achieving N₂ equilibrium in critically ill trauma pts, Dickerson R et al. J Trauma Acute Care Surg 2012)
Key Points

- Overfeeding is deleterious
- Propofol sedation may necessitate a change in nutritional plan to avoid overfeeding
- Patients on CRRT likely benefit from higher protein than commonly provided
- Patients on ECMO can be safely treated with enteral nutrition therapies

Questions?
Thank you!

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