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AAST Critical Care Committee clinical consensus: ECMO, nutrition

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ABSTRACT

The American Association for the Surgery of Trauma Critical Care Committee has developed clinical consensus guides to help with practical answers based on the best evidence available. These are focused in areas in which the levels of evidence may not be that strong and are based on a combination of expert consensus and research. Overall, quality of the research is mixed, with many studies suffering from small numbers and issues with bias. The first two of these focus on the use of extracorporeal membrane oxygenation in trauma patients and nutrition for the critically ill surgical/trauma patient.

EXTRACORPOREAL MEMBRANE OXYGENATION (ECMO)

Background

When is ECMO use appropriate in trauma patients?

Recommendation: ECMO can be considered for partial or full support in cases of potentially reversible post-traumatic cardiopulmonary failure.

Discussion: Although in cardiac surgery, venoarterial (VA) ECMO is often used to support the function of both the heart and lungs, in trauma patients, venovenous (VV) ECMO is most commonly used to support acute respiratory distress syndrome (ARDS) or acute respiratory failure due to traumatic processes (although use of VA ECMO for post-traumatic shock states has also been described).

The recently published EOLIA (ECMO to Rescue Lung Injury in severe ARDS) trial of ECMO support for severe respiratory failure failed to demonstrate mortality reduction with the use of early ECMO. Nevertheless, substantial crossover between the control and ECMO arms yielded a significantly advantaged secondary outcome for the combined outcome of mortality and crossover. As such, the overall role of ECMO support remains controversial; we examine the specific considerations for ECMO use in trauma patients.

Technique

Which method of ECMO, VV or VA is more appropriate for trauma patients?

Recommendation: Mode of ECMO should be based on the patient disease process. Those with only respiratory failure, or shock reasonably thought to be caused by severe hypoxia should be candidates for VV ECMO. Those with refractory cardiac dysfunction/cardiogenic shock should be placed on VA ECMO.

Discussion: In trauma, VV cannulation is the most common modality of ECMO[1] and is used for refractory hypoxemia or severe ARDS. VV ECMO can be used to oxygenate and ventilate in place of or to augment native pulmonary function when the patient cannot be appropriately supported via conventional ventilation, evidence-based and rescue modalities (prone position, paralytics, inhaled nitric oxide).

VA ECMO removes venous blood from the vena cava, circulates it extracorporeally through the membrane oxygenator and returns it under pressure to the arterial system via the aorta, functionally providing cardiac and respiratory support. Different from cardiac surgery, trauma patients are often cannulated peripherally for ECMO with access through the femoral vein and artery. Cannulae are guided to the vena cava and distal aorta/proximal iliac, respectively. For those with depressed left ventricular function, care must be taken to avoid blood stasis with increased afterload from the ECMO circuit or risk of complete left heart failure. Another device (Impella/intra-aortic balloon pump) is often required to unload ('vent') the left ventricle to avoid thrombosis.

Is single-lumen cannulation or dual-lumen cannulation appropriate for trauma patients requiring VV ECMO?

Recommendation: Either cannulation technique is appropriate and should be based on the clinical comfort of the cannulator and the ECMO team goal.

Discussion: Cannulation for VV ECMO can be accomplished by either a dual-lumen single cannula or by two separate cannulae. A single dual-lumen cannula is placed in the right internal jugular vein. Dual cannulae are typically placed in the jugular and femoral veins, with the jugular cannula typically used as the patient return line. In either case, ultrasound, echocardiographic or other image guidance should be used to position the cannulae. For single dual-lumen cannulation, the return port should be guided in the right atrium toward the tricuspid valve, whereas for dual cannulation, both cannulae should be placed in the vena cava. The cannulae should be far enough apart to avoid recirculation (oxygenated returned blood directly entering the extracorporeal circuit rather than returning to the patient).

There is little guidance on which method is more appropriate and the choice of cannulation should be made based on the clinical judgement of

the cannulator and ECMO team. In one study, 6 of 24 trauma patients were placed on VV ECMO using a dual-lumen cannula (all survived).[2] Advantages to the dual-lumen single cannula technique include less sedation and easier mobility. Disadvantages include need for more precise placement with higher potential for malposition, need for higher anticoagulation goals, and flow limitation.[2]

Indications/outcomes

Which traumatic diagnoses can be considered for ECMO therapy?

Recommendation: In trauma patients, no specific diagnoses are absolute indications or contraindications to ECMO therapy, *other than irreversible injury*. Individual decisions regarding anatomy, physiology, and risk/benefit of ECMO need to be taken into account.

Discussion: Thoracic trauma leading to pulmonary dysfunction is the most common indication for ECMO reported. In the largest study of the Extracorporeal Life Support Organization (ELSO) registry, thoracic injury as the index trauma diagnosis leading to ECMO was most common followed by spine fractures and abdominal injury. In this study, ARDS/pulmonary failure was the most common indication followed by trauma diagnosis, not otherwise specified and extremity fracture.[3] In patients with blunt thoracic trauma, survival rates of up to 75% have been reported.[4] Patients intolerant of traumatic pneumonectomy (hemodynamic collapse or profound hypoxemia) can be immediately placed on ECMO support during their index operation.[1 5]

Massive transfusion does not seem to be a contraindication to successful ECMO use,[6] Patients who present with massive acute pulmonary emboli may benefit from ECMO support. In most cases, VA support is required for hemodynamic collapse secondary to right ventricular failure.[7 8] In trauma patients, ECMO to rescue cardiac arrest (extracorporeal cardiopulmonary resuscitation (ECPR)) has been described with a survival rate of approximately 25%, but too few patients have been studied to make any broad recommendations regarding ECPR.

Traumatic brain injury (TBI) has often been considered a contraindication to ECMO due to need for anticoagulation. Nevertheless, given advances in circuit technology and reports of successful ECMO use for up to several days without systemic anticoagulation, TBI should no longer be an automatic exclusion. Although no systematic long-term follow-up exists for these cases, the literature confirms that patients with brain injury may successfully be managed acutely with ECMO.[3 9–11]

What are inclusion and exclusion criteria for ECMO?

Recommendation: Individual ECMO centers should develop criteria for initiation of ECMO as well as exclusion criteria. Criteria include the presence of severe ARDS or respiratory failure, with severe hypoxemia or inability to ventilate refractory to conventional therapy.

Discussion: For ECMO inclusion criteria, various levels of severity of hypoxia and hypercapnia exist in the literature. Current definitions of severe ARDS (arterial oxygen pressure:fractional inspired oxygen (FiO_2) <100) seem to be most common and the inclusion and exclusion criteria used in the CESAR (Conventional ventilatory upport vs Extracorporeal memberane oxygenation for Severe Adult Respiratory failure) and EOLIA trials can be considered. Prespecified pathways of ARDS care including trials of paralytics and prone positioning should be attempted prior to initiation of ECMO.

Absolute contraindications include unrecoverable injury or comorbid condition (such as terminal malignancy) and vascular disease or injury precluding successful deployment of ECMO. Relative contraindications include mechanical ventilation of over 7 days duration prior to initiation of therapy, chronic end-stage organ dysfunction without transplant candidacy, advanced age or severe frailty. Brain injury, hemorrhage, and intolerance of anticoagulation may remain relative contraindications.

We recommend each institution develop and adhere to their own guidelines to minimize variability in patient care and optimize outcomes. Whether an institution decides to exclude hemorrhage, TBI, or contraindications to heparin should be based on available technology and institutional expertise.

When should trauma patients be placed on ECMO?

Recommendation: Timing for initiating ECMO appears to favor early (<7 days of mechanical ventilation) initiation. Conventional management of pulmonary failure includes prone positioning, paralytics, and advanced ventilatory modes should be tried prior to initiating ECMO; however, ECMO should not be delayed as a therapy of last resort. Similarly for VA ECMO, attempts at pressor/volume/hemorrhage resuscitation should be attempted rapidly, but therapy should be initiated prior to premortal state.

Discussion: In one study of the ELSO registry, 80 patients receiving ECMO demonstrated no differences in survival related to time to initiation of ECMO from emergency department admission or differences in survival comparing those who had ECMO initiated in the first 24 hours compared with those cannulated after 100 hours in the hospital.[5] In an older study, patients started on ECMO within 5 days of onset of mechanical ventilation had an improved mortality.[12] Although not first-line therapy, ECMO should be considered early if advanced therapies appear to be inadequate.

What should the expected survival be for trauma patients supported by ECMO?

Recommendation: Individual centers should have process improvement strategies in place to ensure this high-risk patient population receives optimal care.

Discussion: In evaluating the literature on ECMO, survival rates for trauma patients range from 28% to 74.1% in small cohort studies.[4 6 13–15] In the largest analysis of the ELSO registry focused on trauma patients, survival to discharge was 61% in a cohort of 279 patients. This compared favorably to non-trauma indications for ECMO.[1] In one study of 80 trauma patients, Injury Severity Score (ISS) was the only significant difference between survivors and non-survivors (ISS 24 (10–30) vs 29 (21–38)).[15] Another study in a more severely ill cohort demonstrated similar findings (ISS 46.5±16.3 vs 65±9.6),[16] suggesting that the severity of the underlying traumatic injury remains an important determinant of survival after ECMO.

ECMO management

What is the appropriate anticoagulation strategy for ECMO in the trauma population?

Recommendation: The minimal amount of anticoagulation should be used to support the trauma patient on ECMO.

Discussion: Despite modern circuit coatings, the blood-prosthetic interface of the ECMO circuit remains a prothrombotic environment. Systemic anticoagulation is routinely used during VV ECMO, with wide variation between centers in choice of monitoring test (partial thromboplastin time, activated clotting time, anti-Xa) and therapeutic targets. On ECMO, bleeding complications range from minor (oozing around cannulae and

lines) to major (devastating intracranial hemorrhage). Although the major intracranial event rate on ECMO has historically been 10%–15%, this was markedly lower in the most recent EOLIA trial at 5%.[16] For patients with acute concomitant TBI, therapeutic anticoagulation can be safely withheld until bleeding is stabilized. Anticoagulation may be held from 5 days to an entire run so long as there is minimal evidence of oxygenator clot formation.[17 18]

What is the recommended ventilator strategy on ECMO?

Recommendation: Low volume lung rest strategies are appropriate for both VA and VV ECMO support of the trauma patient.

Discussion: During ECMO support, patients who were dependent on high pressure mechanical ventilation can have ventilator support reduced. Most recently, lung protective ventilation has been recommended. Other strategies, including ultra-low tidal volume, open lung, high support spontaneous ventilation, and even extubation have all been proposed; however, little randomized data exists to support a specific mode.

When should ECMO support be weaned?

Recommendation: Once objective evidence of lung and/or heart recovery presents, ECMO weaning should immediately commence.

Discussion: As ECMO is support for reversible pulmonary failure, it stands to reason that once the underlying process is resolving, ECMO support should be weaned. One strategy is to wait for aeration to return on chest X-ray, then perform a recruitment trial (Cilley test) to check for increased arterial oxygen saturation when the ventilator FiO_2 is raised to 1.0 (using patient's own lungs). The oxygen support can be weaned by either decreasing flow or by using a blender to decrease the percentage of oxygen delivered in the sweep gas. The sweep can be weaned to maintain normal partial pressure of carbon $dioxide_2$.

What types of complications should the acute care surgeon expect for ECMO patients?

Recommendation: Acute care surgeons should anticipate ECMO-related complications during the patient's critical illness, including arrhythmia and, paradoxically, both hemorrhage and thrombosis. Daily rounds and circuit evaluation should be the norm.

Discussion: ECMO-related complications are common in this critically ill population. Approximately 80% of traumatically injured patients requiring ECMO will develop at least one complication. More than half develop a cardiovascular complication, typically a self-limiting arrhythmia. Less than one-third of patients developed bleeding complications. When they do occur, it is often at the percutaneous cannulation site (10%), but serious intracranial or gastrointestinal (GI) hemorrhage may ensue.[3] For patients undergoing VA ECMO, the potential for arterial limb ischemia is of great concern. Most centers will use an antegrade arterial catheter to provide distal perfusion as a preventive measure.

Daily circuit evaluation includes radiographic evaluation of cannulae position and direct inspection for identification of early fibrin deposition in the oxygenator, tubing, and cannulae. Identification of oxygenator clots should alert the surgeon that anticoagulation strategies should be adjusted and the possibility that oxygenator exchange may soon be required.

Competency/credentialling

Who should be managing the trauma patient when on ECMO?

Recommendation: A multidisciplinary team that includes the trauma service and ECMO team should care for the trauma patient.

Discussion: There are several models of ECMO care. In some centers, ECMO care is managed in the cardiac intensive care unit (ICU). The acute care surgeon may continue to care for the patient and use the ECMO team as a consultant analogous to patients requiring renal replacement therapy. In other cases, care may be transferred when on ECMO support and returned to the trauma service after decannulation. Service structure should be established with clear lines of responsibility in the care of these complex patients.[19 20] Daily multidisciplinary rounds with the ECMO service, surgical team, pharmacist, respiratory therapist, and nursing should occur. The model of ECMO specialist care in nursing has been similarly utilized for other advanced mechanical circulatory devices and renal replacement. Finally, given the high-risk nature of this procedure and the severe illness of this patient cohort, routine palliative care consultation should be strongly encouraged.[21]

What is the role of the acute care surgeon in providing ECMO?

Recommendation: The surgeon's role will be analyzed in conjunction with the ECMO director. It may only involve cannulation and initiation only or may be fully involved in the critical care/ECMO management of the patient. This may further delineate whether it involve VV, VA, or access for both.

Discussion: The role of the surgeon will vary by the structure of the ECMO programme. In a fully integrated programme, the surgeon may cannulate and manage the patient in the ICU. In other programmes, the surgeon may have the responsibility for cannulation and initial support as a bridge to long-term medical management by an ECMO specialist team.

What (skills) do I need to participate in ECMO care?

Recommendation: A postgraduate didactic course that includes simulation is a minimal requirement for consideration of credentialing. Quarterly simulation training, participation in quality improvement, and annual clinical updates should be required.

Discussion: Although adult ECMO volume has rapidly increased during the past several years, at present, there are no national or international certifications for ECMO management and cannulation. Credentialling is ultimately at the discretion of the hospital and ECMO director.[22] The ECMO director typically sets educational requirements and a minimum number of proctored cases to attain ECMO credentials. There is currently no agreed on minimum case benchmark for competency and is an active area of educational investigation.

A recent study of critical care programme directors confirmed that although ECMO management was a desired skill set, the majority of programme directors did not think that graduating fellows were competent to manage ECMO independently.[23]

In the absence of explicit guidance, we recommend a 3–5 day didactic and simulation-based course as an initial entry point. Further training (ie, cannulation, initiation, management) should be based on the role the surgeon will play in ECMO care.

What is the right number of patients to care for to maintain competency?

Recommendation: A minimum number of patient hours should be established by the ECMO director for ECMO management.

Discussion: Although the number of adult ECMO cases is increasing, the majority of patients treated by ACS surgeons

will likely be for respiratory failure (VV). To maintain competency, ACS surgeons should actively and continuously participate in ECMO care. The number of patients or number of ECMO contact hours is established by the ECMO director. Although cannulation, positioning, and decannulation are based on patient volume, actual number of patients may be less practical (or important) than number of hours of patient contact time for ECMO medical management. If they have not cared for a patient quarterly, they should participate in simulation training. Annual didactic updates are typically required in most ECMO programmes.

Should ECMO care in the trauma patient be regionalized? Do I need to send my patient out of my trauma center?

Recommendation: ECMO care for trauma patients should be regionalized to trauma centers that offer higher volume ECMO care. If ECMO is unavailable, an established transfer policy should exist.

Discussion: Retrospective studies and analyses from the ELSO registry indicated that higher volume centers are associated with better outcomes. Among adult ECMO patients, hospitals with more than 30 cases had significantly lower odds of mortality (adjusted OR 0.61, 95% CI 0.46 to 0.80) compared with hospitals with less than six annual cases.[24] Although recent trends for ECMO in trauma patients is on the rise, there are limited trauma center-specific data. Several high volume trauma centers that offer ECMO demonstrate improved outcomes.[6 13 25–27] If ECMO capability is not present in the trauma center, an established transfer agreement with an ECMO center should be available. Withholding ECMO therapy for lack of capability may not be in the patient's best interest.

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NUTRITION

Nutritional assessment

How should nutritional status be evaluated?

Recommendation: Clinicians must incorporate routine assessment of nutritional status into the daily care of their patients. The Nutrition Risk in Critically Ill (NUTRIC) score is a nutrition

risk assessment tool that has been validated in ICU patients. The components of the NUTRIC score include markers of critical illness such as Acute Physiology and Chronic Health Evaluation II and Sequential Organ Failure Assessment scores, as well as the presence of comorbidities. The score helps to identify those patients likely to benefit most from early and aggressive nutritional intervention.[1]

Discussion: Although there are many questions related to the optimal timing and amount of nutritional support to be provided, it is clear that critically ill patients face significant nutritional compromise during their ICU admission. Malnutrition may be present at admission or may occur rapidly in patients with critical illness or injury. Recent evidence suggests that greater amounts of nutritional intake in the first week of ICU admission are associated with improved survival and more rapid physical recovery.

How should adequacy of nutrition be monitored?

Recommendation: Serum protein markers, such as albumin, prealbumin, and transferrin should not be used to analyze nutrition status, as they are acute phase reactants and do not accurately reflect nutrition status in critically ill patients.[2]

Discussion: Patients receiving nutritional therapy should be monitored closely. Electrolytes and blood glucose should be monitored serially until the nutritional regimen is at goal. Daily weight and intake/outputs should also be monitored. Micronutrient levels, such as iron studies, should be considered. Urinary urea nitrogen can be used to calculate nitrogen balance to assess if patients are receiving adequate protein. Indirect calorimetry is the gold standard to optimize total calories. More subjective measures such as wound healing rates have also been described.[2 3]

Timing

When should nutrition should be started?

Recommendation: Nutrition should be started within 24–48 hours of ICU admission.[4]

Discussion: Although the exact amount and timing of nutrition is unclear, the evidence supports the beneficial effects of early enteral feeding after ICU admission in patients unable to sustain oral intake on their own.

In shock states, redistribution of blood flow and vasopressor use can lead to a 'steal' phenomenon predisposing to complications of non-occlusive mesenteric ischemia and non-occlusive bowel necrosis. Enteral nutrition (EN) may exacerbate these events. There are no specific guidelines regarding EN with vasopressor use; however, in patients who are hemodynamically unstable, we recommend holding EN until vasopressor dose is decreasing or stable.[1 4 5]

Amount

How should energy requirements be calculated?

Recommendation: Complex predictive equations have not been shown to have a beneficial clinical outcome when compared with weight-based calorie goals. The important factor is delivery of energy.[6 7]

Discussion: The gold standard for energy assessment is to measure indirect calorimetry in all patients. This can be logistically challenging in a critically ill population. Alternately, multiple predictive equations are available and may be useful in ICU populations. However, routine provision of 25–30 kcal/kg/day achieves nutritional requirements in most critically ill patients. Volume-based feeding protocols, rather than rate-based protocols, often achieve nutrient goals more effectively, particularly when EN is suspended for procedures or traveling outside of the ICU. These have not become incorporated into American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines yet but can be calculated based on the total daily volume expected with a rate-based nutritional requirement.[6–8]

How should energy requirements be altered for obesity?

Recommendation: In the subgroup of patients with a body mass index (BMI) of 30–50, 11–14 kcal/kg of ACTUAL body weight should be used, whereas if the BMI is greater than 50, the use of 22–25 kcal/kg IDEAL body weight is recommended. In addition to hypocaloric feeds, high protein is recommended for these patients due to the underlying sarcopenia. Protein content of 1.2 g/kg ACTUAL body weight, or 2–2.5 g/kg IDEAL body weight is recommended.[9]

Discussion: Malnutrition occurs in obese patients but is often overlooked in this population. In addition, obese patients may have a significant degree of underlying sarcopenia. Due to hormonal changes and insulin resistance, obese patients will break down their muscle stores as an energy source at a much higher percentage than non-obese individuals. Nutrition support should be initiated within the same time frame as other critically ill patients, as there is not a protective effect in obesity.[2 9 10]

How much protein is needed during critical illness?

Recommendation: Typically, the non-obese ICU patient will require 1.2–2 g protein per kg of actual weight. Obese patients are more difficult to analyze protein needs and current recommendations are to provide 2–2.5 g/kg ideal body weight.[2 10]

Discussion: Considerations in determining protein needs include disease severity, comorbid conditions, and insensible losses such as ascites, wound output, fistulas, and burns. The basis of protein provision should take weight status into consideration. The gold standard for determining protein needs is considered the 24 hours urine for urea nitrogen collection which provides actual 24 hours urinary nitrogen losses and provides a measure of the patient's nitrogen retention.[2 10]

Enteral versus parenteral

What route should be used?

Recommendation: EN, even at low rates, provides physiologic benefits by promoting the structural and functional integrity of the GI tract.[1]

Discussion: Changes in gut permeability can be seen within hours after critical illness or injury. These changes in gut permeability are suspected to play a role in infectious complications in ICU patients and may lead to a higher risk of multiorgan dysfunction syndrome. Initiation of enteral feeding has been shown to decrease infectious morbidities, reduce mortality and may reduce organ failure and length of stay.[1 4]

Gastric or jejunal tubes for enteral nutrition?

Recommendation: The 2016 Critical Care Nutrition Guidelines do not advocate regular assessment of gastric residual volume.[2]

Discussion: Gastric feeding may be feasible in many ICU patients and tends to result in earlier initiation of nutrition. Evidence suggests a lower risk for pneumonia in patients fed into the small bowel; however, no difference in mortality or ventilator time has been found between gastric versus small bowel feeding. If small bowel access will delay EN initiation, a trial of gastric feeds is reasonable unless a patient has a clear contraindication to gastric feeding.[2 11–14]

In patients at high risk for aspiration (eg, inability to protect airway, age >70 years, reduced level of consciousness), small bowel feedings or continuous EN should be considered. Gastric residual volumes are generally lower with prokinetic agents.[11–14]

How should tube placement for EN be confirmed?

Recommendation: Radiographic confirmation of enteric feeding tubes is strongly recommended prior to the initiation of nutrition.[15 16]

Discussion: Tube placement can be confirmed by several methods including serial films during advancement, endoscopic assistance, or via various commercial methodologies. A meta-analysis showed accuracy of capnography or colorimetric capnometry to ensure adequate enteral feeding tube placement into the esophagus with high sensitivity (0.99) and specificity (0.99). In comparison to obtaining a chest X-ray at 35 cm, these methods prevent pneumothorax, improve a nurse's organization of care, save time, and decrease costs and patients' irradiation. Radiographic confirmation of nasogastric or orogastric tubes when used for EN is strongly recommended for high-risk patients (eg, comatose, neurologically impaired, prior gastric surgery, morbidly obese, abnormal anatomy, etc). Feeding tubes placed under direct visualization, endoscopically, or flouroscopically do not require further radiographic confirmation.[15 16]

What are the indications for parenteral nutrition (PN)?

Recommendation: PN should be initiated as soon as possible in patients who are at high nutrition risk and have a contraindication for EN.[17]

Discussion: PN is also indicated for patients who are predicted to be NPO for >7 days and unable to receive EN. Supplemental PN, receiving PN along with some EN, can be considered for patients who are unable to meet >60% of nutrition goals after 7–10 days. Hypocaloric (80% goal), high protein PN should be considered with initiation.[2 17 18]

Hypophosphatemia and refeeding syndrome

Recommendation: Early correction of hypophosphatemia prior to initiation of EN or diet averts this condition.[19]

Discussion: Patients presenting with critical illness and with associated chronic malnutrition are at particularly high risk of the development of refeeding syndrome. Electrolyte abnormalities, most prominently hypophosphatemia, are attributed to the administration of glucose which stimulates endogenous insulin release causing the extracellular to intracellular shift of phosphate to provide inorganic phosphate for ATP production.[19 20]

Nutrition in special populations

Recommendation: These guidelines are applicable to the pediatric population (<18 years of age) excluding neonates.[21]

Discussion: Nutritional support in patients with severe acute pancreatitis, TBI and open abdomens has consistently favored patients who receive early (<48 hours) feeding initiation. Goal caloric requirements, preference for EN over PN and equivalency of gastric and small bowel feeding are similar to the standard critically ill population. Trophic feeding (the EDEN (Early vs Delayed Enteral Nutrition) trial defined trophic feeding as 10 mL/hour (10–20 kcal/hour)) has been shown to increase fascial closure rates, decreased complications, and decreased mortality in the open abdomen patient with intestinal continuity.

Patients with severe trauma including TBI may benefit from immune enhancing supplementation including arginine and eicosapentanoic acid and docosahexanoic acid.[22–25]

For detailed guidelines for nutrition support therapy in the pediatric critically ill patient, the reader is referred to the 2017 ASPEN guidelines for the provision and assessment of nutrition support therapy in the pediatric critically ill patient.[21]

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