Nutritional Support of the TBI Patient

Part 1: Critical care

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Traumatic brain injury (TBI) is damage to the brain tissue caused by direct or indirect trauma to the head.[1] The majority of brain injuries are caused by road traffic accidents. Other causes include falls, trips and slips, physical assaults and high impact sports. It is the most common cause of death and disability in people under the age of 40 in the UK, with 1 million people living with the effects of long-term brain injury.[2] There were 356,699 UK admissions to hospital with acquired brain injury (ABI) in 2019-2020, which represents a 12% increase since 2005-2006. In 2019-2020, males were 1.5 times more likely than women to be admitted to hospital with a head injury, but there had been a 28% rise in female head injury admission since 2005-2006.[3]

TBI has a dynamic pathophysiology, consisting not only of the primary injury but also the secondary injury cascade. The primary injury typically occurs due to direct injury to the brain and can cause tissue destruction. Much of the treatment for primary injury focuses on reducing intracranial hypertension. The secondary injury is identified by brain swelling and cell death due to the inflammatory process that follows.

Effective nutritional intervention and management can play a major role in attenuating this inflammatory process and avoiding the potentially harmful effects of prolonged hypermetabolism.

Metabolic changes

It is well known that critical illness is associated with increased energy expenditure and catabolism.[4] Furthermore, it has been demonstrated that patients with TBI have increased catabolic changes compared to other critically unwell patients, with some estimates suggesting an increased metabolic rate of 87-200%.[5] Protein catabolism appears to peak 8-14 days after injury and is related to the severity of the injury.[6] Little is known about how long this anticipated period of hypermetabolism could last, but evidence suggests at least 30 days post injury.[7] These metabolic changes are associated with increased length of stay and significant lean mass loss.[8] As a result, levels of malnutrition reported in critically ill patients with a TBI admitted for >7 days can be as high as 92%.[9]

Nutritional assessment

There is no gold standard test for the assessment of nutritional status in critically ill patients. ESPEN disputes the use of the critical care specific screening tools Nutrition Risk Screening (2002) and Nutrition Risk in Critically Ill (NUTRIC), and states a definition of acute critical illness-associated malnutrition still needs to be developed. However, they do recommend that any critically ill patient admitted for more than 48 hours should be considered at high nutritional risk.[10]

Nutritional assessment should include clinical, biochemical and anthropometric parameters. However, fluid shifts, oedema, rapid wasting of lean tissue and difficulty obtaining weight history are common in critical illness and can hinder accurate nutritional assessments. With the TBI patient there can be additional barriers, as often patients need to be nursed in a specific position with the patient's head elevated to help control intracranial pressures (ICPs), making weighing with hoist or PATSLIDE difficult. As a result, alternative anthropometric measurements can be a helpful tool to monitor changes to body composition in TBI patients, with mid-upper arm circumference (MUAC) often being easier to obtain than accurate height and weight. Repeated anthropometric measurements, such as MUAC and calf circumference, are also a reliable tool to monitor weight changes and malnutrition risk in the TBI patient.[11]

Energy & protein requirements

As with most clinical conditions, there is no clear consensus on how to best predict energy and protein needs. The use of predictive equations has drawn criticism for being inaccurate due to the homogenous population in which they were developed and validated, often excluding the acutely unwell, with few TBI patients included.

A review by Vasileiou *et al.* highlighted poor accuracy of Harris-Benedict equation and 25-30 kcal/kg when compared against indirect calorimetry (IC).[12] This review included 47 patients with a TBI and 8 burns patients and observed that Harris-Benedict and 30 kcal/Kg over estimated energy requirements on average by 7% and 14% respectively, whilst using 25 kcal/Kg underestimated by 5%.[12] Additionally, a recent small single-centre prospective study highlighted that in severe TBI use of Penn State 2003b equation is inaccurate.[13] However, this study only had 23 patients included, and repeated IC measurements were made on 12 patients only. IC remains the gold standard for measuring energy expenditure,[14] however, it is rarely used due to cost and availability in many ICUs in the UK. Whilst not perfect, the Penn state equations are validated for use on ICUs and have good accuracy when compared with IC for this population.[15, 16] Therefore, for many ICUs this may be the equation of choice in lieu of IC. Regardless of how energy requirements are calculated, clinical judgement, alongside regular monitoring of anthropometrics and biochemistry, is recommended.

There is also limited evidence looking specifically at protein requirements in TBI, with recommendations cited in the literature ranging between 1-3 g/kg body weight. To these authors' knowledge, only 1 systematic review of protein requirements in TBI exists.[17] This review found that protein provision of 2-2.5 g/Kg may improve nitrogen balance, anthropometry, neurology and reduce incidence of infection, but there is limited evidence to suggest benefit of exceeding 3 g/Kg.[17] However, the authors of this review acknowledge the heterogenous and often poor design of the studies included.[17] Only 1 randomised control trial (RCT) was included and several studies had elements of bias or poorly defined inclusion criteria. As a result, the only systematic review looking at protein requirements in TBI concludes that further research is needed before definitive recommendations can be made, and clinicians should use clinical judgement when calculating protein requirements.[17]

A summary of equations for estimating energy and protein requirements in TBI and evidence supporting their use can be found in **Table 1**.

There are no specific recommendations for supplementing micronutrients during critical illness with TBI. There is some evidence to suggest that zinc and vitamin E supplementation can improve protein metabolism and neurological outcome at 1-month post injury.[21, 22] However, these were small studies and further evidence is needed before specific recommendations can be made. Therefore, as most critically unwell TBI patients are likely to have a prolonged hospital stay, routine supplementation with a complete multivitamin could be considered during the first 2 weeks of illness. This is particularly important if high levels of sedation or issues with feed tolerance prevent full rates of feed or nutritionally complete volumes from being delivered.

Timing of feed & nutritional targets

The majority of evidence supports early enteral feeding in critically ill patients. Specifically, within the TBI population delaying feeding for 5-7 days has been shown to more than double the risk of mortality.[18] In comparison, starting feeding within 72 hours of injury can improve neurological and clinical outcomes at 3 months.[9] A systematic review of 15 studies (13 of which were RCTs) looking at nutritional support in TBI found that early enteral nutrition (EN) reduces mortality, improves functional outcomes and reduces infectious complications.[23] Furthermore, aiming to meet energy and protein requirements early (>60% of requirements within 7 days) can improve neurological outcomes and reduce complications.[24] However, the need to meet requirements early should be balanced against the risks of overfeeding, with evidence suggesting that meeting 70-80% of energy and 100% protein requirements in initial phases of critical illness are associated with improved mortality.[25, 26]

Table 1: Predictive Equations

Requirement	Reference	Rationale
Energy		
25 kcal/kg	Hartl, *et al.* (2008)18	• Prospectively collected data from 22 centres USA • 1261 patients included, all severe TBI • No comparison with IC • Recommendation based on rates of feed with lowest mortality
25-30 kcal/kg	Kurtz & Rocha (2020)[8]	• Literature review and expert opinion recommendation
Penn state ventilated equation	Frankenfield, *et al.* (2009)[15]	• 202 ventilated ICU patients included • Mostly trauma and surgical patients • Unclear number TBI patients
Penn state non ventilated equation	Frankenfield & Ashcroft (2016)[16]	• 55 acutely unwell, spontaneously breathing patients • Recommended use in BMI >20.5 • Mostly trauma and surgical patients, unclear number of TBI patients included
Protein		
2-2.5 g/kg	Young, *et al.* (1985)[19]	• 16 patients included • 15 men • All TBI patients on ventilator • Unclear if fed during IC
1-1.5 g/kg	Bistrian, *et al.* (2011)[20]	• Literature review and expert opinion • Literature review included 2 studies: 1 experimental design of 6 burns patients and 1 retrospective study 23 ICU patients
1.5-3 g/kg	Matters, *et al.* (2014)[17]	• Systematic review • 14 studies included (only 1 RCT) • Poor study design and bias in some of studies included.

Barriers to optimising nutrition

The main barrier to enteral feeding and meeting nutritional goals is delayed gastric emptying – up to 60% of all critical care patients are likely to experience this.[27] Delayed gastric emptying is likely to be more common in the TBI population, secondary to high ICPs and often high levels of sedation and/or paralysis used to control ICPs. It's crucial that all possible means to overcome enteral feeding intolerance are considered, given the hypermetabolic clinical state of TBI patients. Prokinetics (metoclopramide +/- erythromycin) should be used first line or as per Trust guidelines, but if these fail, nasojejunal (NJ) feeding should be considered if available. Our ICU unit is fortunate to have a dietetic-led bedside NJ service and, in 2021, 25% (n=34) of NJs inserted on our unit were in TBI patients. For units that do not have access to an NJ service, then the use of supplementary parenteral nutrition (sPN) could be considered to help overcome enteral feeding intolerance and to meet feeding goals.

Evidence supporting the use of sPN in TBI is limited. However, a small retrospective observational study (n=61), in China, demonstrated sPN can improve GCS and long-term quality of life scores in TBI.[28] Although, this was a small study with no information provided on how quality of life was measured and limited information on the volume of enteral and parenteral nutrition provided. Additionally, in their randomised trial, Meirelle and Nascimento found that except for increased risk of hyperglycaemia with parenteral nutrition (PN), there was no difference in clinical outcomes between TBI patients who received sole PN and those who received sole EN.[29] This group also found that patients in the PN group received significantly higher nitrogen when compared to the EN, but this did not correlate to improved nitrogen balance, likely due to the catabolic nature of TBI. Differences in energy provision were similar. Whilst this was a very small study (n=22), it was powered to be able to detect statistical difference, so the findings do support the argument that sPN is safe in TBI patients and can help to meet nutritional targets.

Other barriers that commonly prevent nutritional targets being met are inadvertent tube loss and interruptions to feeds for interventions, such as surgery, intubation and scans. Accidental tube loss can be particularly common with TBI patients when sedation is being weaned, as often patients can be agitated and confused. The use of nasal bridles can be helpful to prevent accidental tube loss[30] and can improve nutritional delivery when compared with tubes secured with tape.[31]

Monitoring

Several electrolytes and micronutrients become severely deranged during the inflammatory response. This may be exacerbated in TBI secondary to the important role they play in maintaining cerebral prefusion pressure and intracranial pressure. Polderman *et al.* found that patients with severe TBI are at risk of developing hypomagnesaemia, hypophosphataemia, and hypokalaemia, which may be attributed to an increase in urinary losses of electrolytes caused by neurologic trauma.[32] Close monitoring and appropriate supplementation are recommended.[32] There is limited evidence recommending micronutrient monitoring, however, given the oxidative stress cell damage that occurs in critical illness, the appropriate supplementation of trace elements is common practice.[33] In our Trust, we routinely check selenium, zinc and copper levels for all patients who have been on ICU for 2 weeks and supplement as needed.

The future

Several new areas of research are emerging in the field of TBI. A recent meta-analysis highlighted that probiotics were shown to reduce mortality, infection, delayed gastric emptying and ICU length of stay in TBI patients.[34] There is also emerging evidence in animal studies suggesting that a ketogenic diet can be neuroprotective in the early stage of TBI.[35] However, the only human trials have been small, observational studies, and whilst they demonstrate no adverse effects, further research in this area is indicated.[36] There are also animal studies to suggest benefits of intermittent fasting, anti-oxidants, branched-chain amino acids, and omega-3 polyunsaturated fatty acids in the emerging stages of TBI.[37, 38] More RCTs are needed to aid further research and development of these areas.

Conclusion

The incidence of TBI is growing and represents a significant burden to the health service. It is associated with hypercatabolism and high rates of malnutrition. Nutritional assessment is challenging within this cohort. The use of predictive weight-based equations can be inaccurate but the gold standard indirectly calorimetry is not widely available for use.

Commencing early enteral nutrition is essential to improve outcomes and aiming for 70-80% energy target and 100% protein target within the first 7-10 days is recommended. Barriers to this can include delayed gastric emptying, inadvertent tube removal and feed interruptions. The most common of these within the TBI population being delayed gastric emptying. NJ feeding or supplementary PN are often required to overcome this.

There have been many new potential developments within this area over recent years, including the use of probiotics, ketogenic diets and intermittent fasting. More research is needed for new feeding ideas in the future.

Part 2 of Nutritional Support of the TBI Patient will follow in the November issue of CN and will cover rehabilitation.

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