Nursing Considerations for Post-traumatic Amnesia After a Traumatic Brain Injury

Hannah Grant

A Senior Thesis submitted in partial fulfillment
of the requirements for graduation
in the Honors Program
Liberty University
Fall 2022

Acceptance of Senior Honors Thesis

This Senior Honors Thesis is accepted in partial fulfillment of the requirements for graduation from the Honors Program of Liberty University.

____
Cynthia Goodrich, Ed.D., MSN, RN, CNE
Thesis Chair

____
Jerry Harvey, Ed.D., MSN, RN
Committee Member

____
James H. Nutter, D.A.
Honors Director

____
Date

Abstract

A period known as post-traumatic amnesia (PTA) often follows a traumatic brain injury (TBI). PTA is characterized by anterograde and retrograde amnesia, confusion, disorientation, and agitation. The duration and severity of PTA is a key indicator of the long-term prognosis after a TBI, so proper assessment and nursing care of a PTA patient is crucial. TBIs range from mild to severe, but primarily affect the fronto-temporal lobes. In PTA, both neural lesions and white matter damage within the parahippocampal region can cause PTA. A nurse must perform a thorough assessment of a TBI patient, but, since PTA is a key indicator of a TBI, a nurse must be familiar with the PTA assessment scales, particularly when comparing the Westmead Post-Traumatic Amnesia Scale (WPTAS) and the Galveston Orientation and Amnesia Test (GOAT). Finally, multi-disciplinary care of a TBI patient within PTA patient must include evidence-based pharmacological and nonpharmacological treatments, nursing considerations, nutritional considerations, physical and occupational therapy, and psychosocial implications.

Keywords: traumatic brain injury, post-traumatic amnesia, memory, posttraumatic confusion state, orientation, agitation

Nursing Considerations for Post-traumatic Amnesia After a Traumatic Brain Injury

Traumatic brain injuries (TBI) are one of the most serious health complications, ranking as a leading cause of death, long-term cognitive disability, and financial difficulty (Promlek et al., 2020). Every year in the United States, approximately 2.8 million people are treated for a TBI (Keller, 2020). If the TBI requires hospitalization, 20% of hospitalizations result in death. Patients who are over 65 have an increased likelihood of hospitalization and death (Perrin, 2020). Motor vehicle accidents most commonly cause a TBI, followed by work-related accidents, sport-related injuries, war-related trauma, assaults, firearms, and falls (Keller, 2020; McDonald et al., 2019). Specifically, in one study, 50% of participants received their TBI from a motor vehicle accident (Spiteri et al., 2021). Furthermore, alcohol is involved in 35-50% of TBI patients (Perrin, 2020). Outside of war, TBIs are the most frequent cause of brain damage (McDonald et al., 2019). Following a severe TBI, patients often experience a period of confusion, disorientation, agitation, and amnesia, which is known as post-traumatic amnesia (PTA). The length of PTA indicates the severity of the injury (Spiteri et al., 2021). Given the potential lifelong severity of a TBI, competent, knowledgeable nursing care is crucial.

The severity of a TBI is determined, alongside other assessments, by the Glasgow Coma Scale (GCS) (Perrin, 2020). A mild TBI is classified as a GCS of 13-15. In a mild TBI, a patient may lose consciousness or experience amnesia for less than an hour. A moderate TBI is classified as a GCS of 10-12 and a patient may lose consciousness for up to a day. In a severe TBI, the GCS is less than or equal to 8 and the patient experiences a loss of consciousness for more than 24 hours. This thesis will primarily focus on severe TBI patients who experience PTA. Out of approximately 250-350,000 TBIs each year, severe TBIs consist of only 3-12/100,000 TBIs every year and present with the highest mortality rate (Stålnacke et al., 2019). While a patient can present with a mild, moderate, or severe TBI—largely determined by the GCS—severe TBI patients present with significant neuronal damage.

The neuronal damage from a severe TBI impacts both gray and white matter. Gray matter consists of unmyelinated neurons, whereas white matter consists of myelinated axons, labeled as such due to the pale, white myelin sheath (Silverthorn, 2019). White matter contains less neuron cell bodies than gray matter. Damage to the neural white matter is known as a diffuse axonal injury, which prevents connectivity between the frontal, temporal, and subcortical brain regions (Vakil et al., 2019). Even months after the initial injury occurs, axons can continue to breakdown as the neighboring axons die, further increasing the severity of the diffuse axonal injury (McDonald et al., 2019). Axons that transverse sections within the CNS are known as tracts, similar to nerves within the peripheral nervous system (Silverthorn, 2019). Unfortunately, a diffuse axonal injury may not show up on the initial CT or MRI scans, but the inflammation and axonal damage will continue to manifest over time (Perrin, 2020). The neuronal damage within a TBI damages the cerebral tissue, myelin, cerebral blood flow, and microglia (Vakil et al., 2019). TBIs can vary greatly in the severity of neuronal injury, therefore impacting the severity of PTA.

A severe TBI inflicts considerable injury throughout the brain. During the acceleration-deceleration forces of a trauma, the middle and anterior fossae of the skull compresses and injuries the frontal and temporal brain lobes (McDonald et al., 2019). The acceleration-deceleration forces often create focal lesions, which, when occurring within the frontal and temporal brain lobes, results in executive functioning and memory deficits (Vakil et al., 2019). In one study, severe TBI patients were scanned with a structural MRI and diffusion tensor imaging (McDonald et al., 2019). (Since a traditional MRI often misses white matter injury, diffusion tensor imaging utilizes the movement of water through neural white matter tracts to better depict any injury [Douglas et al., 2015]). The scans revealed alterations within the white matter in the fornix, corpus callosum, cingulum, and hippocampus, among other brain structures (McDonald et al., 2019). The fornix, which conveys messages from the hippocampus to the thalamus, was particularly impacted by a severe TBI. Injury to the thalamus (particularly the ventral and anterior thalamus) was associated with memory loss and impaired social cognition. Injury to the left hippocampus and left mid-temporal gyrus appeared to impact memory, particularly semantic memory and verbal recall. Damage to the brain's neural structures impact a patient's presentation of PTA following a severe TBI.

Pathophysiology of Post-Traumatic Amnesia

In a TBI, after the patient emerges from a coma, he or she often experiences a period known as PTA (Venkatesan et al., 2021). PTA is a period characterized by confusion, disorientation, agitation, irregular sleep patterns, and occasionally aggression, but the hallmark symptom is memory impairment and confusion (Spiteri et al., 2021; Venkatesan et al., 2021). One researcher defined PTA as a triad of disorientation, anterograde amnesia, and retrograde amnesia (McLellan et al., 2017). Anterograde amnesia is the inability to form new memories *after* the incident causing amnesia, which in this case, is the TBI (De Simoni et al., 2016). Retrograde amnesia, meanwhile, is the inability to evoke memories *prior* to the incident (Cleveland Clinic, 2020). While PTA could last only a few minutes in a mild TBI, for a moderate to severe TBIs, the disorientation in PTA could last weeks or months (Perrin, 2020; Spiteri et al., 2021). The length of PTA indicates the severity of the TBI and the subsequent cognitive impairment, so therefore, the length of PTA can determine appropriate therapies and the eventual discharge timeline (Spiteri et al., 2021). Given the degree of confusion found within PTA, a few researchers, including Spiteri et al. (2021) choose to use the term "posttraumatic confusion state" (PTCS)

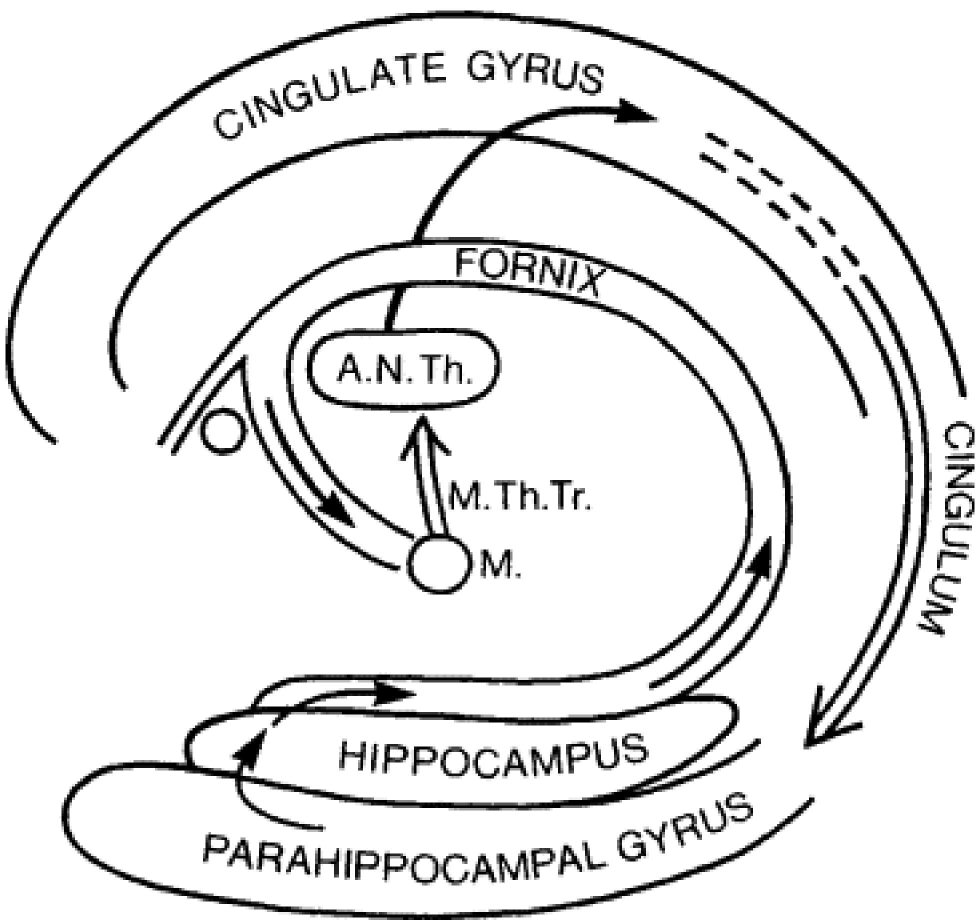
(Spiteri et al., 2021, para. 3). When a patient displays PTCS, this is known as deep PTA, which lengthens their recovery time frame. Proper assessment of PTA at all stages, therefore, is critical.

Impact of PTA on the Hippocampus and the Parahippocampus

Some studies indicated PTA's correlation with neuronal focal lesions, resulting in decreased cerebral perfusion (De Simoni et al., 2016). Lesions primarily occur within the frontal and temporal lobes, thus correlated to the effect on memory. However, De Simoni et al. (2016) indicated the presence of PTA even without lesions, as PTA is present in some patients with a mild TBI. Memory itself largely relies on the hippocampus, parahippocampus, and cingulate cortex, which are all interconnected within the brain (see Figure 1). When the hippocampus is activated, it sends signals to the posterior cingulate cortex. The hippocampus and the parahippocampus are both within a region known as the medial temporal lobe, which is largely responsible for all steps within memory, such as encoding, consolidation, and retrieval. Encoding, consolidation (also known as storage), and retrieval make up the three stages of memory (Cleveland Clinic, 2020). In encoding, when the brain inputs new information, it also forms connections to information already within the brain. Second, in storage, the brain consolidates information so that, in the final stage, retrieval, memories can be recalled when needed.

Figure 1

Relationship between the hippocampus, parahippocampal gyrus, and cingulate gyrus within the brain. Adapted from "Neuroanatomy for Medical Students" (2nd Edition), by Wilkinson, J.L, 1992, pp. 197-205. Used with permission (see Appendix B), copyright 1992 by Butterworth-Heineman.



Electrical signals for memory run within the default mode network of the brain (De Simoni et al., 2016). The parahippocampus sends signals between the medial temporal lobe and the default mode network, especially without external stimulation. If a patient is experiencing a diffuse axonal injury, however, the axonal injury disrupts signals between the various brain regions, which is especially prominent in the cingulum bundle. If a patient has long-term memory deficiencies, therefore, this is primarily due to the axonal injury surrounding the hippocampus. Additionally, a damaged fornix is associated with an associative memory impairment. Associative memory is defined as combining two different senses to remember information (Wang & Cui, 2017). For instance, an individual may smell her grandma's homemade brownies and associate the smell with the brownies, even without any visual or tactile sensory input. Associative memory is also used to connect a person's name with their face. PTA affects various brain structures, but especially structures within the medial temporal lobe—such as the hippocampus and parahippocampus, which then sends signals through the default mode network.

Structural Changes

Within post-traumatic amnesia, one study hypothesized a disconnection of the hippocampus and the parahippocampus from the cingulate cortex, as evidenced by an MRI (De Simoni et al., 2016). A resting state functional magnetic resonance imaging (fMRI) system can be used to detect the interactions within this system. This test surveyed 19 TBI patients, divided into a group of individuals within PTA and the control group of TBI patients without PTA. All patients were screened within 15 days of the TBI, so this information is pertinent to nurses working with patients shortly after their injury. Patients returned within a year to assess any return to memory. For patients in PTA, the study revealed deficiencies in associative memory, spatial working memory, and the speed of information processing. There was also dysfunction between the parahippocampal gyrus and the posterior cingulate cortex. This dysfunction was directly correlated with associative memory and the speed of information processing. Similar to chronic TBI patients, PTA patients displayed dysfunction within the posterior cingulate cortex, particularly within the cingulum bundle, which links the parahippocampal gyrus with the posterior cingulate cortex. The resting state fMRI also uncovered injury on the myelinated axons between the limbic structures. In comparison to the control group of TBI patients outside of PTA, the PTA group displayed greater impairments in memory, reaction time, spatial working memory, and verbal recognition. There were, however, no significant impairments with spatial recognition and memory accuracy, and only minor differences with reaction times. There was no difference with free verbal recall.

Short-Term and Long-Term Impacts

Thankfully, between the initial assessment and the follow-up, which was within a year later, errors within paired associative learning decreased 69%, choice reaction time decreased by about 50%, and spatial recognition memory increased by 50% (De Simoni et al., 2016). The MRIs also displayed damage within the default mode network, but there was not a significant difference between the TBI control group compared to the PTA control group. From the MRIs, however, there was a significant difference in the functional connectivity between the posterior cingulate cortex and the medial temporal lobe for patients in the PTA group compared to the TBI control group. This damaged region was between the anterior and posterior left parahippocampus. There did, not, however, appear to be a significant difference in the hippocampus. Functional connectivity of the parahippocampus, did, however, appear to be stabilizing when the PTA group was reassessed. The degree of damage between the posterior cingulate cortex and the parahippocampus was associated with increasing impairment in associative memory, longer reaction times, spatial working memory performance, and immediate verbal recognition memory. PTA patients also displayed significant changes within the fronto-parietal and executive control networks. The PTA group displayed changes within the executive control network, particularly within the cingulo-opercular and inferior frontal regions. There was also a decrease in connectivity from the executive control network to the hippocampus and cerebellum.

The intensity of the white matter damage within the right parahippocampal region was correlated with memory performance. Once PTA patients were able to encode new memories again, there was a return in functioning to the posterior cingulate cortex's functional connectivity network. Dysfunction between the posterior cingulate cortex and the parahippocampus was associated with memory and information processing impairments. Therefore, deficiencies both in memory and cognitive functioning are related to the same network. This study did not, however, find any changes in the hippocampal network. This may be because the posterior cingulate cortex connects primarily to the parahippocampus rather than the hippocampus. Even connections between the hippocampus and the posterior cingulate cortex flow through the parahippocampus. In summary, De Simoni et al. (2016) discovered a significant amount of white matter damage in PTA patients, specifically within the parahippocampal region that connects the medial temporal lobe to the posterior cingulate cortex.

Assessment of Post-Traumatic Amnesia

To properly assess PTA, a nurse must first know how to assess a severe TBI. In a severe TBI assessment, a nurse assesses the vital signs, the GCS, and a full neurological assessment (Perrin, 2020). A nurse must also identify and account for any factors that affect the assessment and prognosis, such as opioids and alcohol, as well as the patient's comorbidities. When assessing PTA, the two most common assessment scales are the WPTAS and the GOAT (Roberts et al., 2018). The WPTAS assesses for orientation, anterograde memory, and the ability to learn new information (Hennessy et al., 2020; Spiteri et al., 2021). The GOAT primarily assesses for orientation, anterograde memory, and retrograde memory (Spiteri et al., 2021). Other assessment scales include the Confusion Assessment Protocol (CAP), Orientation Log (O-Log), and Rey Auditory Verbal Learning Test (RAVLT). Various studies have been performed to assess the results and implications from these assessment scales. One study found that continuous memory returned at a similar timeframe as orientation, but continuous memory returned prior to the return of anterograde memory according to the WPTAS (Roberts et al., 2019)**.** In another study performed by Spiteri et al. (2021), the CAP defined PTA as the shortest, followed by the GOAT, and finally by the WPTAS. Therefore, the WPTAS best assesses patients with more extended PTA. A third study sought to determine any possible effect of opioids on the WPTAS and the GOAT (Hennessy et al., 2020). They found an effect of opioids on the WPTAS, but not on the GOAT. More significantly, to maximize the specificity and the sensitivity of the WPTAS and the GOAT, Hennessy et al. (2020) recommended combining elements of the WPTAS and the GOAT into a seven-item scale. To properly assess PTA, a nurse must know how to properly assess a TBI and how to properly utilize a PTA assessment scale.

Assessment of a Severe TBI

To assess PTA properly, nurses must know how to properly assess a severe TBI. When assessing a severe TBI, key assessment components include GCS, vital signs, and a full neurological assessment, which includes orientation questions, pupillary reactions, and motor function (Perrin, 2020). If needed, the nurse can also assess the cranial nerves, reflexes, sensation, and brainstem functioning. If the patient presents with a hematoma, swelling, or herniation on their CT scans, intracranial pressure (ICP) monitoring is crucial. Even if a patient has a normal CT scan, however, but they are over the age of 40, have posturing, or have a systolic blood pressure less than 90 mmHg, ICP monitoring is indicated for them as well. In addition, the healthcare team should identify any abnormal axonal markers, glial markers, or neuronal markers (Tenovuo et al., 2021). The nurse is responsible for all steps in the nursing assessment process, utilizing necessary TBI tools such as the GCS and ICP monitoring.

A variety of factors could complicate a nurse's assessment of a TBI. First, sedatives, opiates, and alcohol could all impact the assessment (Tenovuo et al., 2021). Sedatives and opiates could lead to fabricated memories, resulting in psychogenic instead than neurological amnesia. Furthermore, sedatives and opiates can lead to hearing deficits, hypovolemia, and hypoxia. Opioids appear to impact the accuracy of the WPTAS but do not appear to impact the GOAT as significantly, which will be discussed later in further detail (Hennessy et al., 2020). Alcohol and drugs could further impact language deficits and sleep, as well as causing psychic shock, orbital injuries, and seizures (Tenovuo et al., 2021). Perrin (2020), however, states that alcohol does not appear to impact the GCS, so nurses should test the GCS immediately without waiting for any intoxication to wear off. Factors such as opioids, sedatives, alcohol, and drugs can impact the assessment and presentation of PTA.

Patients' various co-morbidities, age, and genetics could also impact the assessment and subsequent prognosis (Tenovuo et al., 2021). If patients are obese and diabetic, for example, they already have an increased level of inflammation, decreasing their immune response and lengthening their healing process. Additionally, if the patient is elderly, he or she has already experienced neural atrophy prior to the TBI (Perrin, 2020). For an elderly patient, the patient will more likely present with mental status changes but may not present with a headache and papilledema. If, however, the patient is on an anticoagulant, he or she may not display any change in level of consciousness or any altered neurological change. According to Perrin (2020), these factors are most likely to impact patient outcomes: age, GCS before sedative medications and intubation, pupillary response, additional extracranial injury, CT or MRI findings, and hypotension. Any additional considerations (such as hypoxia or hypovolemia) and the severity of increased ICP can also indicate the severity of a TBI (Tenovuo et al., 2021). From any CT or

MRI scans, the health care team can attempt to determine the quantity and severity of any neural lesions, which can be a useful tool for the nurse as well. A nurse must also recognize that repeated brain injuries are significantly more detrimental than a one-time incident. Those who experience multiple TBIs, such as from sports, may have permanent neurological damage. Additionally, immediately after the injury, brain physiology is the most important factor for the recovery process. Following the injury, however, other factors such as the socioeconomic setting, psychosocial support, and personality traits become more significant. Patients' previous health status could either positively or negatively affect their prognosis and perhaps their quality of life.

A nurse must also recognize the potential risk factors associated with a TBI, especially if the TBI is not properly assessed. For example, hypotension and hypoxia compound the risk for potential negative impacts (Perrin, 2020). Specifically, a severe TBI increases the risk of respiratory failure. Therefore, a nurse must carefully monitor the patient's PaO_2 and SpO_2. It is also crucial to properly assess the severity of the TBI. If the severity of a TBI is underestimated, the healthcare team may fail to detect a potentially lethal diagnosis, such as an epidural hematoma (Tenovuo et al., 2021). A patient may also return to normal activities prematurely, therefore perpetuating the healing process. From an economic standpoint, the patient might fail to receive proper financial assistance if the TBI is underestimated. If, however, the severity of a TBI is overestimated, a patient may not receive potentially life-saving treatments because of his or her overly pessimistic prognosis. Financially, a patient's hospital stay will be prolonged, and he or she will be unable to work longer than necessary. From a hospital standpoint, the hospital would be unnecessarily depleting their resources if the severity of a TBI is overestimated. It is paramount for a nurse to properly assess the status of the patient's TBI, therefore minimizing risk factors.

Assessment Scales for PTA

Since PTA has been shown to be the best predictor of long-term clinical functioning, proper assessment of the duration and severity of PTA is crucial (Tenovuo et al., 2021). Other than the GCS, these two scales are the most common assessment tools while in PTA: the Westmead Post-Traumatic Amnesia Scale (WPTAS) and the Galveston Orientation and Amnesia Test (GOAT) (Roberts et al., 2019). Traditionally, researchers view the WPTAS as more accurate than the GOAT, realizing that the WPTAS measures a longer duration of PTA when compared to the GOAT. In the WPTAS, the first seven questions assess the patient's orientation by asking his or her age, date of birth, month, time of day, day of the week, year, and location (Department of Psychology, n.d.). The final five questions assess the patient's memory by asking for the name and face of the examiner and then asking him or her to identify three different pictures. On the first day he or she receives a 12/12, the picture cards switch to new pictures. After a patient scores 12/12 on three consecutive days, he or she is considered to have emerged from PTA. The WPTAS, then, emphasizes orientation, anterograde memory, and the ability to learn new information (Hennessy et al., 2020; Spiteri et al., 2021). The WPTAS has excellent validity and reliability ratings (Spiteri et al., 2021). The GOAT, meanwhile, has been standard protocol for PTA and has good validity and reliability ratings, but sometimes underestimates the duration of PTA (Hennessy et al., 2020). In the GOAT, the patient is asked a series of 15 questions, which is scored out of 100 points, assessing orientation, anterograde memory, and retrograde memory (Spiteri et al., 2021). The GOAT asks the patient to remember the first and last memory around the injury, therefore, unlike the WPTAS, incorporating retrograde memory into the assessment. The GOAT does not, however, evaluate for the ability to learn new information. When a patient receives a score greater than 75 out of 100 points, they are considered to have emerged from PTA. The WPTAS and the GOAT are both useful assessment tools, but with differing strengths and weaknesses.

Other additional scales include the Confusion Assessment Protocol (CAP), Orientation Log (O-Log), and Rey Auditory Verbal Learning Test (RAVLT) (Spiteri et al., 2021). First, the CAP primarily tests for the presence of posttraumatic confusion state (PTCS). CAP utilizes several tests used for PTA, assessing for these seven signs: arousal, cognitive impairment, disorientation, fluctuation in presentation, psychotic symptoms, agitation, and nighttime sleep disturbance. To assess for these symptoms, the CAP combines other tests, such as the Delirium Rating Scale to assess for delirium, the GOAT to assess for disorientation, and the Agitated Behavior Scale (ABS) to assess for agitation. To assess for cognition, the CAP utilizes the Toronto Test of Acute Recovery After TBI (TOTART) and Cognitive Test for Delirium (CTD). If a patient is negative for all seven signs of confusion, they receive a score of 0. If, however, the patient displays all the signs of confusion, they receive a maximum score of 7. If they display four or more of the symptoms or, if one symptom is disorientation, then only three symptoms, the patient is considered to have PTCS. While the CAP displays concurrent and predictive validity, less research has been performed on CAP compared to the GOAT and WPTAS. CAP was originally created as a research tool, so the clinical implications are still being tested (Sherer, 2004). Second, the Orientation Log (also known as the O-Log) can be used for a TBI, but this tool primarily assesses orientation and is therefore not specific to a TBI (Novack, 2000). Finally, the RAVLT is used to assess TBI patients. In the RAVLT, the examiner reads a list of 15 words during five separate trials (Roberts et al., 2019). After each trial, the patient is asked to recall as many words as possible, in whatever order. A second list of 15 words is read, and the patient attempts to recall as many of the words from list B as possible. Twenty minutes later, the patient seeks to recall as many words as possible from list A. The CAP, O-Log, and RAVLT are three additional tests used to assess PTA (Spiteri et al., 2021).

Results from Assessment Scales

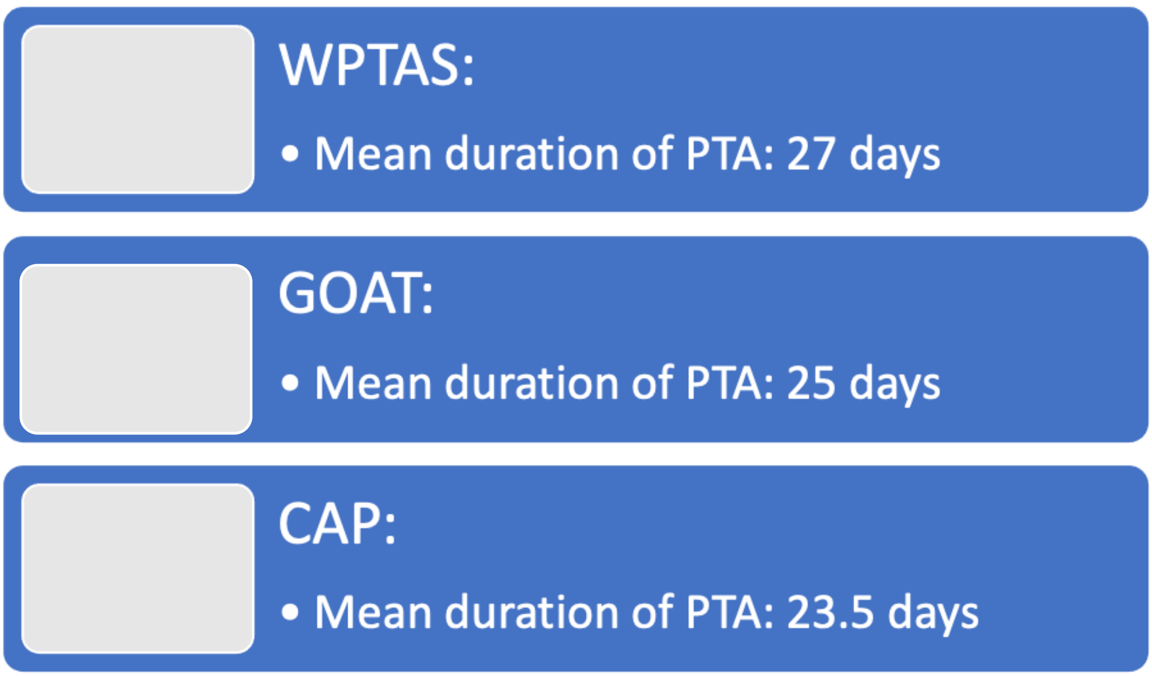
Several studies have been performed to evaluate and compare the results from the various TBI assessment scales. One study assessed 51 moderate-to-severe TBI participants between the ages of 18 to 75 from a rehabilitation facility, if they had PTA of at least seven days according to the WPTAS (Roberts et al., 2019). This study was performed with the purpose of determining the return of continuous memory. In addition to administering the WPTAS daily, this study also asked participants two questions from the GOAT: the first event they can remember after the injury and the last memory they can remember prior to the injury. These two questions from the GOAT assess anterograde and retrograde memory. After emergence from PTA, the researchers followed up with the participants, eliciting additional information about their first and last memories surrounding the injury. These memories were classified as either clear, patchy, or no recall. This was to determine the restoration of continuous memory following the injury. At follow-up, 20 participants were lost, decreasing the sample size to 31, but these 31 participants still had similar proportions in terms of age, education, GCS, PTA duration, and the time of their last memory. In this study, on average, patients received their first score of 12 on the WPTAS 15.71 days after the injury. Immediately upon emerging from PTA, 25.8% (8/51) of the participants could recall their hospitalization. Of this percentage, they could all still remember their hospitalization upon follow-up. Upon emergence from PTA, 54.8% (17/51) of patients described their memory of their hospitalization as patchy, and 4 of the 17 were no longer able to recall their hospitalization at follow-up. The six who could not remember their hospitalization upon emergence from PTA could also not remember it when asked at follow-up. Therefore, in

68% of cases, recall was consistent between PTA emergence and follow-up, while in 32% of cases, recall diminished at follow-up. The mean time in PTA was 5.38 days for patients who were able to report the same memory across consecutive days at their first assessment. In contrast, patients who were unable to report a consistent memory across consecutive days beginning at their first assessment had a mean time in PTA of 11.56 days. This contrast yielded a p value of 0.014. 71% of participants did not change in their memory, either for better or for worst, of the last memory prior to the accident. This study found that continuous memory returned at a similar timeframe as consistent orientation. According to this study, however, continuous memory returned prior to the return of anterograde amnesia according to the WPTAS. On average, continuous memory returned eight days earlier than as defined by the WPTAS. This is most likely because, as a patient recovers from PTA, he or she is still to form a few memories, such as the patient's first and last memories surrounding the accident. These memories may change, however, as evidenced by the 32% of cases that changed from assessment at PTA emergence to the later assessment. The WPTAS, however, defines the return of anterograde memory more objectively, by testing for the examiner's name and face, followed by identification of three pictures. According to the study from Roberts et al. (2018), continuous memory returned prior to the return of anterograde amnesia from the WPTAS.

In another study, 82 moderate-to-severe TBI patients were assessed while within PTA in an inpatient rehabilitation hospital (Spiteri et al., 2021). The purpose of this study was to determine the differences between the WPTAS, the GOAT, and the CAP, primarily in determining how they each define the length of PTA. This study found that PTA resolved earliest according to the CAP, followed by the GOAT, and finally by the WPTAS. The mean duration of PTA was 23.5 days according to the CAP, 25 days according to the GOAT, and 27 days according to the WPTAS. Using this study's modified version of the CAP, they required a pass rate on two consecutive days (which is the pass rate criterion for the GOAT, which is a component of the CAP). With this adjustment, the mean duration of PTA according to the CAP was 24.5 days. The mean GCS in this study was 8.01.

Figure 2

Mean duration of PTA for the WPTAS, GOAT, and CAP



According to Spiteri et al., (2021), two patients never emerged from PTA according to the WPTAS criteria. When patients emerged from PTA according to the CAP and the GOAT criterion, the median score on the WPTAS at the time was 11/12, which is still considered to be within PTA. There was, however, a much greater range for PTA duration according to the WPTAS, so, on average, participants emerged from PTA 12 days later according to the WPTAS when compared to the CAP. The majority of participants (87.8%) emerged from PTA according to the CAP first. The remaining 12.2% of participants emerged from PTA according to the CAP on the same day as the GOAT and/or the WPTAS. No participants emerged from PTA according to the WPTAS or the GOAT prior to the CAP. The CAP and the GOAT classified a patient as emerging from PTA similarly, which is understandable since the GOAT is a component of the CAP. In fact, the CAP and the GOAT agreed 95.12% of the time, while the CAP and the WPTAS were only in agreement 45.12% of the time, and the GOAT and the WPTAS were only in agreement 47.6% of the time. This study found that CAP defined the emergence of PTA first, followed by the GOAT, and finally by the WPTAS.

In conclusion, then, the WPTAS best assesses patients who demonstrate more extended PTA (Spiteri et al., 2021). The WPTAS defines PTA as longer because the WPTAS requires participants to recall pictures witnessed 24 hours previously. This requires the ability to encode new memories, which is more difficult than recalling the first and last memories surrounding the injury (tested on the GOAT) or recognizing pictures from 5 minutes earlier (tested on the CAP). Therefore, the WPTAS best tests the return of anterograde memory, a crucial component of the emergence of PTA. Furthermore, even when a patient was deemed out of PTA according to the CAP and GOAT, they often still demonstrated significant disorientation and confusion, further strengthening the WTAS' reliability. However, upon emergence from PTCS as defined by the CAP, patients within PTA as defined by the WPTAS lack anterograde memory, but now display procedural learning. The CAP, then, may be a useful tool for determining appropriate therapies to strengthen procedural learning.

The Effect of Opioids on the WPTAS and the GOAT

Another key nursing consideration is the potential effects of opioids on the WPTAS and the GOAT. Previous studies indicated drugs' interference of drugs on assessment findings (McLellan et al., 2017). For example, midazolam can lead to anterograde amnesia. This study found anterograde amnesia and disorientation—but not retrograde amnesia—within orthopedic patients taking opioids, primarily oxycodone (McLellan et al., 2017). According to McLellan et al. (2017), then, opioids may impact anterograde amnesia and disorientation, so assessing retrograde amnesia may be more reliable when assessing TBI patients due to the impact of opioids. To further assess this, one study, performed by Hennessy et al. (2020), sought to determine the potential effects of opioids on WPTAS and GOAT assessment by comparing three clinical groups. Group 1 included patients with a moderate-to-severe TBI within PTA; these patients received some form of opioid. Group 2 included moderate-to-severe TBI patients considered to have emerged out of PTA who were not receiving an opioid. Group 3 included patients without a TBI recovering from orthopedic surgery and receiving an opioid. Due to ethical considerations, the study did not include a control group made up of PTA patients not receiving opioids. For TBI patients, nearly all patients experience severe pain in their head and neck, and potentially in other parts of their body depending on the injury. Nearly all TBI patients, then, receive some form of opioid. All three groups were tested using the WPTAS and the GOAT. Opioids, then, may impact assessment, but the study performed by Hennessy et al. (2020) sought to determine the extent of opioid's impact on the WPTAS and the GOAT.

Hennessy et al. (2020) found that opioids impacted the WPTAS but not the GOAT. In this study, 33% of group 1 (PTA patients on opioids) received 12/12 on the WPTAS, compared to 77% in group 2 (moderate-to-severe TBI patients not receiving opioids) and 48% in group 3 (orthopedic patients on opioids). For the GOAT, the median score for group 1 was 89, lower than both group 2 (median score of 100) and group 3 (median score of 99). There was clearly not a significant difference between groups 2 and 3.

Table 1

Scoring on the WPTAS and the GOAT compared with Group 1, Group 2, and Group 3

	Group 1 (PTA patients on opioids)	Group 2 (moderate-to-severe TBI patients not receiving opioids)	Group 3 (orthopedic patients on opioids)
12/12 on the WPTAS	33%	77%	48%
Median GOAT score	89	100	99

For example, in group 1, only 72% correctly answered the “transport medium to the hospital” question on the GOAT, while 100% in both group 2 and group 3 answered this question correctly. Furthermore, in group 1, 44% answered the anterograde amnesia correctly, while 92% of group 2 and 96% of group 3 answered this question correctly. Finally, 39% of group 1 answered the retrograde amnesia question correctly compared to the 92% of group 2 and the 100% of group 3.

Table 2

Percentages that correctly answered the “transport medium to the hospital” question, anterograde amnesia question, and retrograde amnesia question, comparing group 1, group 2, and group 3

	Group 1 (PTA patients on opioids)	Group 2 (moderate-to-severe TBI patients not receiving opioids)	Group 3 (orthopedic patients on opioids)
“Transport medium to hospital” question	72%	100%	100%
Anterograde amnesia question	44%	92%	96%
Retrograde amnesia question	39%	92%	100%

In distinguishing between the various groups, the WPTAS displayed sensitivity of 72%, but specificity of only 40%. In contrast, the GOAT sensitivity was only 0%, but its specificity was 100%. If the GOAT sensitivity was only 0%, then the GOAT failed to correctly identify patients as being within PTA. In fact, since the median GOAT score for group 1 was 89, then the median score fell *above* the GOAT's pass rate cut-off of 75. Since the GOAT's specificity, however, was 100%, then the GOAT was more specific at identifying groups 2 and 3 as falling outside of PTA.

Table 3

Sensitivity and specificity for the WPTAS and the GOAT

	Sensitivity	Specificity
WPTAS	72%	40%
GOAT	0%	100%

Therefore, Hennessy et al. (2020) suggested combining various questions from the WPTAS and the GOAT to best maximize the WPTAS' sensitivity and the GOAT's specificity. After this study ran various combinations, they recommended combining the WPTAS' day of week and the three picture identification questions, along with GOAT's transport medium to hospital, anterograde amnesia, and retrograde amnesia components to yield the best outcome. This combination yielded a sensitivity of 100%, specificity of 85%, positive predictive value of 83%, and negative predictive value (NPV) of 100% in distinguishing between groups 1 and groups 2. Furthermore, this abbreviated version of the WPTAS and the GOAT narrows down the 22 items between the WPTAS and the GOAT to only 7 items. The abbreviated assessment scale would benefit staff's busy time schedule and assist PTA patients with a shortened attention span. This study also did not discover any difference between opiates and opioids, which are synthetic opiates. From this study, Hennessy et al. (2020) recommended a seven-item assessment scale incorporating the strengths of both the WPTAS and the GOAT.

Multi-disciplinary Care for a Severe TBI Patient

Several important components make up a thorough multi-disciplinary treatment plan, including evidence-based pharmacological and nonpharmacological treatment, nursing considerations, nutritional considerations, and psychosocial implications. For pharmacological treatments, sedatives, anti-depressants, anticonvulsants, psychostimulants, and anti-Parkinsonian agents have all been shown to effectively mitigate TBI symptoms (Block et al., 2021). Other non-pharmacological measures, such as decreased sensory input, are also crucial. Other studies have surveyed nurses to assess for pertinent nursing considerations. For example, one survey highlighted the importance of safety due to the impulsive behavior present in TBI patients (Oyesanya et al., 2018). Another study highlighted nursing deficiencies related to the care of a TBI patient (Promlek et al., 2020). A third nursing survey emphasized various nursing treatment modalities, addressing cognitive impairments, communication techniques, patient safety techniques, agitation and behavior management techniques, and education techniques (Oyesanya & Thomas, 2019). As part of the multi-disciplinary care of a TBI patient, nutritional considerations are of key importance. Due to a patient's increased metabolic rate, evidence-based practice recommends a full caloric intake by the ninth day after the injury, while ensuring that patients do not experience gastric residual volume excess, delayed gastric emptying, and aspiration pneumonia (Ohbe et al, 2020; Perrin, 2020). Physical and occupational therapy is another key component of multi-disciplinary care. A study performed by Mortimer et al. (2019) demonstrated that patients who received structured ADL during PTA experienced increased independence, as well as decreasing overall treatment costs (Mortimer et al., 2019). To further assist with occupational therapy, another study identified aids to help with memory retention after a TBI (Brown et al., 2017). When considering psychosocial implications, nurses, patients, and the patients' family must deal with the significant behavioral changes present with a TBI. Evidenced-based pharmacological and non-pharmacological treatment modalities, nursing considerations, nutritional considerations, and psychosocial implications make up the multi-disciplinary care of a TBI patient.

Evidence-Based Practice Treatment Considerations

Evidence-based practice has demonstrated several effective pharmacological and non-pharmacological treatment considerations for patients in PTA. Pharmacologically, sedatives, anti-depressants, anti-convulsants, psychostimulants, and anti-Parkinsonian agents have been shown to effectively address the symptoms and pathophysiology of a TBI (Block et al., 2021). Effective non-pharmacological interventions include any necessary environmental adjustments, regulating sensory input, regular reorientation, and physical restraints. Transcranial magnetic stimulation was shown in five case studies and one case series containing two case studies to alleviate neurobehavioral symptoms. When a patient has experienced a TBI, speedy transportation to a medical facility is crucial (Perrin, 2020). When admitted to the medical facility, rapid intubation, fluid resuscitation, CT scanning, evacuation of an intracranial lesion, and ICP monitoring are all key components for the most positive prognosis. The health care team must be sure to implement these evidence-based practice interventions to ensure the best chance of success for their patient.

Further Nursing Considerations

Researchers have performed several studies to assess nurses' knowledge and potential knowledge deficits related to TBI patients. One study surveyed nurses with an average of 18 years of experience—which included caring for TBI patients (Oyesanya, 2019). In this study, nurses indicated a need for TBI specific training, stating that TBI recovery lasted several years. Another study surveyed 693 nurses across three hospitals within the Midwest (Oyesanya et al., 2018). The nurses were primarily concerned with the acute phase of TBI recovery. Nurses identified these concerns: avoiding physical injury, overlooking change in condition, supplying education, providing support, and allowing for recovery. Due to their short-term memory loss, safety is a special concern for these patients, resulting in impulsive, reckless decisions and significantly increasing the risk for falls. When caring for TBI patients, challenges included the following: insufficient knowledge, insufficient staffing, and lack of resources. A third study identified potential nursing knowledge deficiencies when caring for TBI patients (Promlek et al., 2020). According to Promlek et al. (2020), knowledge deficiencies included monitoring and treating hypercapnia, assessing mean arterial pressure (MAP) and cerebral perfusion pressure, handling sedatives properly, and caring for hyperthermia. Given the potential severity of a TBI, caring for a TBI patient is a significant undertaking, so these studies sought to determine nurses' perception and knowledge deficiencies when caring for TBI patients.

Another study surveyed nurses to identify common treatment modalities for TBI patients. In this study, Oyesanya & Thomas (2019) surveyed 692 nurses from three different hospitals in midwestern America, asking them their typical schedule when caring for a moderate-to-severe TBI patient who also experienced cognitive impairment. For TBI patients, the nurses identified 189 different strategies, categorized by cognitive techniques, communication techniques, patient safety techniques, agitation and behavior management techniques, and education techniques. Cognitively, nurses sought to address memory impairment by writing down information, repeating information (such as frequently reintroducing oneself), providing simple, step-by-step instructions, and regularly re-orienting the patient. Communication techniques included repeating information, speaking to a family member, and, if applicable, asking the patient to repeat information back. To keep the patient safe, nurses recommend frequently assessing the patient and enacting falls risks precautions, such as turning on necessary alarms and placing the patient’s room close to the nurses’ station. To decrease agitation, nurses recommended building a consistent routine, moving slowly, increasing rest, and decreasing stimulation. Commonly utilized teaching methods include incorporating family members, providing education in shorter spurts, and repeating information. The nursing strategies identified by Oyesanya & Thomas (2019) provide invaluable tools while caring for a TBI patient.

Nutritional Considerations

The patient’s health status, particularly while within a coma or PTA, complicates their nutritional considerations. TBI patients have an increased metabolic rate of 120% to 240% compared to their normal metabolic rate (Perrin, 2020). If the patient is sedated or paralyzed, their metabolic rate is 100% to 120% of what it would normally be. The increase in metabolic rate leads to weight loss and the loss of muscle mass, which is further exacerbated by protein catabolism (Ohbe et al., 2020). Of course, the patient's immobility only worsens the loss of muscle mass. Due to these factors, patients who are not fed within five to seven days of a TBI have a two-to-four-fold increase in mortality. By the ninth day after the injury, patients should receive their full caloric intake (Perrin, 2020). Unfortunately, if fed prematurely, patients can experience gastric residual volume excess and delayed gastric emptying, as well as aspiration pneumonia (Ohbe et al., 2020). A patient is typically started on enteral feedings by 72 hours after the injury so they can receive the full caloric intake by the seventh day. If enteral nutrition is started at 25 mL/hr and increased by 25 mL every 12 hours, the patient should not experience excess gastric residual volume. Infection is more common with parenteral nutrition, so enteral nutrition is recommended (Perrin, 2020). One study compared severe TBI patients who received early enteral nutrition compared to those who received delayed enteral nutrition (Ohbe et al., 2020). This study did not show any correlation between early enteral nutrition and mortality reduction, but early enteral nutrition was correlated with a lower rate of nosocomial pneumonia and shorter hospitalization. Nutrition is a key consideration for TBI patients, but more research is need on the impact of early enteral nutrition within PTA.

Physical and Occupational Therapy

Physical therapy (PT) and occupational therapy (OT) are often indicated for TBI patients as rehabilitation for neuromuscular symptoms. Because the brain controls neuromuscular functioning, patients often must relearn motor functioning through physical therapy, occupational therapy, and speech therapy (Mortimer et al., 2019). Through speech therapy, patients relearn how to swallow and communicate. A study conducted by Mortimer et al. (2019) compared functional outcomes for patients during PTA who received structured activities of daily living (ADL) retraining plus treatment as usual (TAU), compared to patients who only received TAU (Mortimer et al., 2019). This study assessed 104 patients who were in rehabilitation and experienced PTA for greater than seven days after a severe TBI. In this study, TAU incorporated physiotherapy and/or speech therapy, as well as ADL retraining *after* the conclusion of PTA. TAU, however, did not include structured ADL retraining from an occupational therapist *during* PTA. According to this study, patients who received structured ADL retraining during PTA experienced increased independence, both at the conclusion of PTA and upon hospital discharge. Independence was defined as various self-care functions such as eating, bathing, grooming, and dressing oneself. Even though most patients in PTA experience agitation for at least one day, ADL retraining does not appear to exacerbate agitation levels. Financially, structured ADL retraining while in PTA was shown to be significantly cost-effective when compared to TAU. The decrease in inpatient rehabilitation time outweighed the costs of structured ADL training while in PTA. If a patient can regain greater independence in ADLs, this significantly increases their employability and psychological well-being, both in the short-term and the long-term. According to Mortimer et al. (2019), structured ADL training during PTA increases independence and decreases the overall cost of treatment.

Patients may also require other supports for the residual effects of PTA, specifically the subsequent memory impairment. One study surveyed eight college students, assessing for the most popular supports to assist with memory retention (Brown et al., 2017). Memory supports would be particularly essential for individuals returning to school after their TBI. According to this study, college students preferred high-tech supports, given their ease of accessibility. They did, however, sometimes combine a high-tech support with a low-tech support. The most preferred electronic support was an electronic calendar, while the most preferred low-tech support was a paper checklist. Four potential low-tech supports options include a paper checklist, sticky notes, a paper calendar, and a daily planner. Four potential high-tech support options include electronic lists, voice memos, a digital calendar with reminders, and a phone scheduling app. Participants were asked to identify what they liked or disliked about each of these aids, and then rank the two they liked the most. Participants expressed a need for reminders when events or tasks were outside the normal routine. Participants preferred electronic assists due to their accessibility—after all, they already use a phone on a regular basis. Portability is another benefit of electronic supports; a small phone is easier to transport than a clunky paper calendar. While this study cannot be extrapolated perfectly for patients uncomfortable with technology, Brown et al. (2017) provides various suggestions for memory supports.

Psychosocial Considerations

Finally, nurses must consider the psychosocial implications of PTA on themselves, patients, and the patients' families. While in PTA, patients experience significant, often unpredictable behavioral changes (Block et al., 2021). A patient may display signs of agitation or aggression (either physical or sexual), apathy, or wandering. Patients often experience akathisia, which is continual inner turmoil. Additionally, 30-70% of TBI patients admitted to an acute rehabilitation facility display post-traumatic agitation. Patients who displayed agitation experience longer hospitalizations and greater negative outcomes. They can have significant psychosocial effects, particularly on the patient's family. The patient's injury dealt a serious blow to the patient's family, forcing the family to consider their loved one's mortality. In PTA, the patient's personality is significantly altered from prior to the injury. If the patient recovers, while the PTA will pass, the patient will most likely never return to their original self. Caring for a PTA patient also carries psychosocial considerations for the nurses. Patients may carry out verbal or physical aggression on the staff, taxing them emotionally. The severity of a TBI, particularly if a patient experiences PTA, carries significant psychosocial considerations.

Conclusion

Proper assessment and treatment for TBIs impart key takeaways for nurses, as well as providing areas for further research. According to evidence-based practice, structured ADL training during PTA allows the patient to regain more independence, therefore assisting with reincorporating outside of the hospital. As an added benefit, structured ADL training decreases the costs of a TBI by decreasing inpatient rehabilitation time. Enteral feedings by 72 hours of the injury, with a goal of full caloric intake by the seventh day, are highly important for TBI patients. Further research is needed to pin down the best type of nutrition, as well as the impact of enteral nutrition on mortality, hospitalization time, and nosocomial infections. As patients begin to recover from their injury, encourage them to find appropriate memory supports—such as electronic supports or low-tech supports like sticky notes. Additionally, more research is needed to investigate a combined GOAT and WPTAS assessment scale. A combined GOAT and WPTAS appears to optimize their respective strengths, maximizing both specificity and sensitivity. However, what would be the results of implementing this scale within the in-patient setting? How would a combined GOAT and WPTAS scale measure the duration of PTA, especially compared to pre-existing GOAT, WPTAS, CAP, and Orientation Log results? Further research is needed to investigate the results of implementing a combined GOAT and WPTAS scale.

In conclusion, TBIs are a weighty diagnosis—to the individual, their family, and the health care team. The patient will most likely deal with the ramifications of a severe TBI for the rest of their life. In a severe TBI, the acceleration-deceleration force injures the frontal and temporal brain lobes, leading to executive functioning and memory impairments. Injury to the gray and white matter can lead to a diffuse axonal injury, the full severity of which may be unknown initially, but the inflammation will continue to negatively influence the patient. In PTA, diffuse axonal injury to the posterior cingulate cortex injures the axons connecting the parahippocampus, hippocampus, and the cingulate cortex, all of which are within the medial temporal lobe. When this region is injured, the patient experiences the amnesia, disorientation, sleep disturbances, and agitation known as PTA. The GCS, WPTAS, and the GOAT are all common assessment tools for PTA, but recent research recommends combining components of the WPTAS and the GOAT to maximize their sensitivity and specificity. Due to the severity of a TBI, it is important to incorporate all members of the health care team, addressing a patient's pharmacological, safety, nutritional, self-care, and psychosocial needs.

References

Block, George, S., Milanese, S., Dizon, J., Bowen-Salter, H., & Jenkinson, F. (2021). Evidence for the management of challenging behaviours in patients with acute traumatic brain injury or post-traumatic amnesia: An Umbrella Review. *Brain Impairment: A Multidisciplinary Journal of the Australian Society for the Study of Brain Impairment.*, *22*(1), 1–19. https://doi.org/10.1017/BrImp.2020.5

Brown, J., Hux, K., Hey, M., & Murphy, M. (2017). Exploring cognitive support use and preference by college students with TBI: A mixed-methods study. *NeuroRehabilitation*, *41*(2), 483–499. https://doi.org/10.3233/NRE-162065

Cleveland Clinic. (2020, July 29). *Amnesia: Types, tests, diagnosis, symptoms, & causes*. https://my.clevelandclinic.org/health/diseases/21455-amnesia

De Simoni, S., Grover, P. J., Jenkins, P. O., Honeyfield, L., Quest, R. A., Ross, E., Scott, G., Wilson, M. H., Majewska, P., Waldman, A. D., Patel, M. C., & Sharp, D. J. (2016). Disconnection between the default mode network and medial temporal lobes in post-traumatic amnesia. *Brain (London, England: 1878)*, *139*(Pt 12), 3137-3150. https://doi.org/10.1093/brain/aww241

Department of Psychology at Macquarie University. (n.d.) *Glasgow coma scale (GCS) and abbreviated westmead pta scale (A-WPTAS)*. https://www.mq.edu.au/about/about-the-university/our-faculties/medicine-and-health-sciences/departments-and-centres/department-of-psychology/glasgow-coma-scale-gcs-and-abbreviated-westmead-pta-scale-a-wptas

Douglas, D. B., Iv, M., Douglas, P. K., Anderson, A., Vos, S. B., Bammer, R., Zeineh, M., & Wintermark, M. (2015). Diffusion tensor imaging of TBI: Potentials and challenges. *Topics in Magnetic Resonance Imaging, 24*(5), 241-251. https://doi.org/10.1097/RMR.0000000000000062

Hennessy, M. J., Marshman, L. A. G., delle Baite, L., & McLellan, J. (2020). Optimizing and simplifying post-traumatic amnesia testing after moderate-severe traumatic brain injury despite common confounders in routine practice. *Journal of Clinical Neuroscience, 81*, 37-42. https://doi.org/10.1016/j.jocn.2020.09.030

Levin, H. S., O'Donnell, V. M., & Grossman, R. G. (1979). The Galveston Orientation and Amnesia Test. A practical scale to assess cognition after head injury. *The Journal of nervous and mental disease*, *167*(11), 675–684. https://doi.org/10.1097/00005053-197911000-00004

McDonald, S., Dalton, K. I., Rushby, J. A., & Landin-Romero, R. (2019). Loss of white matter connections after severe traumatic brain injury (TBI) and its relationship to social cognition. *Brain Imaging and Behavior, 13*(3), 819-829. https://doi.org/10.1007/s11682-018-9906-0

McLellan, J., Marshman, L. A. G., & Hennessy, M. (2017). Anterograde amnesia and disorientation are associated with in-patients without traumatic brain injury taking opioids. retrograde amnesia (RA) is absent. RA assessment should be integral to post-traumatic amnesia testing. *Journal of Clinical Neuroscience, 44*, 184-187. https://doi.org/10.1016/j.jocn.2017.06.027

Mortimer, D., Trevena-Peters, J., McKay, A., & Ponsford, J. (2019). Economic evaluation of activities of daily living retraining during posttraumatic amnesia for inpatient rehabilitation following severe traumatic brain injury. *Archives of Physical Medicine and Rehabilitation, 100*(4), 648-655. https://doi.org/10.1016/j.apmr.2018.08.184

Novack, T. (2000). *The orientation log*. The Center for Outcome Measurement in Brain Injury. http://www.tbims.org/combi/olog

Ohbe, H., Jo, T., Matsui, H., Fushimi, K., & Yasunaga, H. (2020). Early enteral nutrition in patients with severe traumatic brain injury: A propensity score–matched analysis using a nationwide inpatient database in japan. *The American Journal of Clinical Nutrition, 111*(2), 378-384. https://doi.org/10.1093/ajcn/nqz290

Oyesanya, T. O. (2019). Veterans health administration nurses' training and beliefs related to care of patients with traumatic brain injury. *PloS One*, *14*(9), e0222585-e0222585. https://doi.org/10.1371/journal.pone.0222585

Oyesanya, T. O., & Thomas, M. A. (2019). Strategies nurses use when caring for patients with moderate-to-severe traumatic brain injury who have cognitive impairments. *Journal of Clinical Nursing, 28*(21-22), 4098-4109. https://doi.org/10.1111/jocn.14958

Oyesanya, T. O., Bowers, B. J., Royer, H. R., & Turkstra, L. S. (2018). Nurses' concerns about caring for patients with acute and chronic traumatic brain injury. *Journal of Clinical Nursing, 27*(7-8), 1408-1419. https://doi.org/10.1111/jocn.14298

Perrin, K. (2020). Care of the patient experiencing an intracranial dysfunction. In Perrin, K.O. & MacLeod, C.E. (Eds.), *Understanding the Essentials of Critical Care Nursing* (3rd Edition, pp. 237-271). Pearson Education, Inc. https://coursepoint.vitalsource.com/reader/books/9780134146508/epubcfi/6/118%5B%3Bvnd.vst.idref%3DP7001012420000000000000000001AEBC%5D!/4

Promlek, K., Currey, J., Damkliang, J., & Considine, J. (2020). Thai trauma nurses' knowledge of neuroprotective nursing care of traumatic brain injury patients: A survey study. *Nursing & Health Sciences, 22*(3), 787-794. https://doi.org/10.1111/nhs.12730

Roberts, C. M., Spitz, G., Mundy, M., & Ponsford, J. L. (2019). Prospective evaluation of first and last memory reports following moderate to severe traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology, 41*(2), 109-117. https://doi.org/10.1080/13803395.2018.1490392

Sherer, M. (2004). *The confusion assessment protocol*. The Center for Outcome Measurement in Brain Injury. http://www.tbims.org/combi/cap

Silverthorn, D.U. (2019). *Human physiology: An integrated approach*. (8th edition). Pearson Education, Inc.

Spiteri, C., Ponsford, J., Jones, H. & McKay, A. (2021). Comparing the westmead posttraumatic amnesia scale, galveston orientation and amnesia test, and confusion assessment protocol as measures of acute recovery following traumatic brain injury. *Journal of Head Trauma Rehabilitation, 36*(3), 156-163. https://doi.org/10.1097/HTR.0000000000000607

Stålnacke, B., Saveman, B., & Stenberg, M. (2019). Long-term follow-up of disability, cognitive, and emotional impairments after severe traumatic brain injury. *Behavioural Neurology, 2019*, 9216931-7. https://doi.org/10.1155/2019/9216931

Tenovuo, O., Diaz-Arrastia, R., Goldstein, L.E., Sharp, D.J., van der Naalt, J., & Zasler, N.D. (2021). Assessing the severity of traumatic brain injury—Time for a change? *Journal of Clinical Medicine*, *10*(1), 148. doi.org/10.3390/jcm10010148.

Vakil, E., Greenstein, Y., Weiss, I., & Shtein, S. (2019). The effects of moderate-to-severe traumatic brain injury on episodic memory: A meta-analysis. *Neuropsychology Review*, *29*(3), 270–287. https://doi.org/10.1007/s11065-019-09413-8

Venkatesan, U. M., Rabinowitz, A. R., Wolfert, S. P., & Hillary, F. G. (2021). Duration of post-traumatic amnesia is uniquely associated with memory functioning in chronic moderate-to-severe traumatic brain injury. *NeuroRehabilitation (Reading, Mass.)*, *49*(2), 221-233. https://doi.org/10.3233/NRE-218022

Wang, J., & Cui, S. (2017). Associative memory cells: Formation, function and perspective. *F1000 Research*, *6*(1), 283. https://doi.org/10.12688/f1000research.11096.1

Appendix A: Literature Review Matrix

Article	**Purpose**	**Sample**	**Methods & Level of Evidence**	**Major Findings**	**Limitation**	**Gaps**
Block, George, S., Milanese, S., Dizon, J., Bowen-Salter, H., & Jenkinson, F. (2021). Evidence for the management of challenging behaviours in patients with acute traumatic brain injury or post-traumatic amnesia: An Umbrella Review. *Brain Impairment: A Multidisciplinary Journal of the Australian Society for the Study of Brain Impairment.*, *22*(1), 1–19. https://doi.org/10.1017/BrImp.2020.5	To survey the literature on the best pharmacological and nonpharmacological treatments during post-traumatic amnesia.	10 electronic data bases containing systematic reviews published after September 2018, yielding 2916 articles.	Level 1 Umbrella review following the Joanna Briggs Institute (JBI) methodology.	While in PTA, patients experience significant, often unpredictable behavioral changes. A patient may display signs of agitation or aggression (either physical or sexual), apathy, or wandering. Patients often experience akathisia, which is continual inner turmoil. This can have	All potential biases or limitations are contained within the articles reviewed, so this meta-analysis may potentially reflect their biases.	There is currently not significant information regarding dosage for pharmacological treatments. Additionally, there is limited information regarding non-pharmacological treatment after an acute TBI or PTA.

				significant psychosocial effects, particularly on the patient's family. In particular, 30-70% of TBI patients admitted to an acute rehabilitation facility display post-traumatic agitation. Patients who displayed agitation experienced longer hospitalizations and more negative outcomes. Key pharmacological treatments included		

				sedatives, anti-depressants, anti-convulsants, psychostimulants, and anti-Parkinsonian agents. Key non-pharmacological treatments included adjustments to environment, controlling sensory input, reorientation, physical restrains. Transcranial magnetic stimulation was shown in five case studies and		

				one case series containing two case studies to alleviate neurobehavioral symptoms.		
Brown, J., Hux, K., Hey, M., & Murphy, M. (2017). Exploring cognitive support use and preference by college students with TBI: A mixed-methods study. *NeuroRehabilitation*, *41*(2), 483–499. https://doi.org/10.3233/NRE-162065	To determine the support aids utilized by college students with a TBI	8 college students using a triangulation mixed-methods study.	Level III Utilized quantitative (such as participants' cognitive scoring) and qualitative (such as one-on-one interviews with participants) data.	Participants preferred higher-tech supports (such as an electronic calendar) over lower-tech options	This study was performed on college students, so other age groups (such as older adults) may not prefer higher-tech supports.	This study can be reperformed on other age groups.
De Simoni, S., Grover, P. J., Jenkins, P. O., Honeyfield, L., Quest, R. A., Ross, E., Scott, G., Wilson, M. H., Majewska, P., Waldman, A. D., Patel, M. C., & Sharp, D. J. (2016). Disconnection between the default mode network and medial temporal lobes in post-traumatic	To determine the pathophysiology of PTA in the absence of focal lesions	19 patients between the ages of 16 to 80 who had	Level III Neuropsychological testing was performed on all patients and then a	This study did not find any changes in the hippocampal network but did find	Since PTA patients are often receiving opioids or anticonvulsants, their	The authors recommended further research into whether their

amnesia. *Brain (London, England: 1878)*, *139*(Pt 12), 3137-3150. https://doi.org/10.1093/brain/aww241		recently experienced a moderate-to-severe TBI	functional MRI scan was performed.	dysfunction between the posterior cingulate cortex (PCC) and parahippocampus.	cognitive functioning may be further reduced. Other medications could alter the functional MRI results. The sample size is another potential negative factor.	findings were reliant on PTA or a TBI in general. They were unsure whether it is better to view a TBI's severity on a continuum, instead of separating patients into PTA and non-PTA categories.
Hennessy, M. J., Marshman, L. A. G., delle Baite, L., & McLellan, J. (2020). Optimizing and simplifying post-traumatic amnesia testing after moderate-severe traumatic brain injury despite common confounders in routine practice. *Journal of Clinical Neuroscience*, *81*, 37-42. https://doi.org/10.1016/j.jocn.2020.09.030	To determine any possible effects of opioids on the WPTAS or GOAT.	This study compared three clinical groups. Group 1 included patients with a moderate-to-severe TBI who	Level III This study compared the three clinical groups using the WPTAS and GOAT.	This article found that opioids affected the WPTAS, but not the GOAT. The WPTAS and GOAT advantages and disadvantage	The small sample sizes pose a limitation to this study. Due to ethical considerations, a PTA without opioids control	Larger studies could serve to confirm or modify this study. Studies can also be performed on this suggested modified

		were in PTA (total of 18 participants). Group 2 included moderate-to-severe TBI patients who were considered to be out of PTA (total of 13 participants). Group 3 included orthopedic patients without a TBI who were experiencing a surgery (total of 25 partipants		s are opposite. Therefore, this article recommends utilizing the best parts of WPTAS (three out of twelve components) and the best parts of GOAT (three out of ten components) to optimize specificity and sensitivity.	group is impossible, but is a limitation of the study.	WPTAS and GOAT test.

		). Groups 1 and 3 received opioids. Between the three groups, there was a total of 56 participants.				
McDonald, S., Dalton, K. I., Rushby, J. A., & Landin-Romero, R. (2019). Loss of white matter connections after severe traumatic brain injury (TBI) and its relationship to social cognition. *Brain Imaging and Behavior*, *13*(3), 819-829. https://doi.org/10.1007/s11682-018-9906-0	TBI are known to affect the focal temporal and frontal areas, resulting in decreased social cognition. This study sought to investigate the damage to the white matter connects and its impact on social cognition.	17 adults with a chronic, severe TBI and 17 control participants.	Level II study All participants were scanned with a structural MRI and Diffusion Tensor Imaging. They were also assessed with the Awareness of Social Inference Test (TASIT).	Participants with a TBI showed alterations within the white matter in the fornix, corpus callosum, cingulum, along with several other brain structures, including the hippocampus. The fornix in particular appears to have a role in	The group varied in amount of time since the TBI, so that may have impacted the results.	More research is needed to investigate the role of white matter pathology on memory.

				memory.		
McLellan, J., Marshman, L. A. G., & Hennessy, M. (2017). Anterograde amnesia and disorientation are associated with in-patients without traumatic brain injury taking opioids. retrograde amnesia (RA) is absent. RA assessment should be integral to post-traumatic amnesia testing. *Journal of Clinical Neuroscience*, *44*, 184-187. https://doi.org/10.1016/j.jocn.2017.06.027	PTA is made up of anterograde amnesia (AA), retrograde amnesia (RA), and loss of orientation, yet retrograde amnesia is often not assessed. This study sought to investigate the reliability of assessing these three components, under the influence of opioids.	The control group was a convenience sample of 25 orthopedic patients under the influence of opioids.	Level II study The participants were assessed using the WPTAS to assess AA, and the GOAT to assess RA. These tests were performed between 24-36 hours after surgery.	This study found that AA and disorientation, but not RA, were found in orthopedic patients taking opioids (primarily oxycodone). Therefore, AA and disorientation may be impacted by opioids, but the degree of RA may be more reliable when assessing TBI patients.	A primary limitation is the sample size of 25 participants. Additionally, the mean age of these participants is 60, higher than the mean age of TBI patients. Also, given that this study is performed on orthopedic patients, it can be difficult to see how much can be applied to TBI patients.	Further research can be performed on the effect of opioids on RA, particularly for TBI patients.
Mortimer, D., Trevena-Peters, J., McKay, A., & Ponsford, J. (2019).	The purpose was comparing	104 patients	Level I	This study found that	If the patient does	More research

Economic evaluation of activities of daily living retraining during posttraumatic amnesia for inpatient rehabilitation following severe traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *100*(4), 648-655. https://doi.org/10.1016/j.apmr.2018.08.184	functional outcomes for patients during PTA who received structured ADL retraining plus treatment as usual (TAU), compared to patients who only received TAU.	who were in rehabilitation and experienced PTA for greater than 7 days after a sTBI.	The researchers utilized structured ADL retraining during PTA, comparing this to the control group who received TAU, which included physiotherapy and/or speech therapy during PTA, as well as ADL retraining after PTA conclusion.	patients who received structured ADL retraining during PTA experienced increased independence, both at the conclusion of PTA and upon hospital discharge.	not experience significant improvement upon hospitalization discharge, then structured ADL retraining during PTA is actually not any more cost-effective than TAU. However, based on the results conducted in this study, the structured ADL training appears to be cost-effective.	should be conducted on the most effective ADL retraining during PTA.
Ohbe, H., Jo, T., Matsui, H., Fushimi, K., & Yasunaga, H. (2020). Early enteral	To compare TBI patients	Japanese patients	Level II	There did not appear to be	Since this study did	Further studies

nutrition in patients with severe traumatic brain injury: A propensity score–matched analysis using a nationwide inpatient database in japan. *The American Journal of Clinical Nutrition*, *111*(2), 378-384. https://doi.org/10.1093/ajcn/nqz290	who receive early enteral nutrition (EN) with those who receive delayed EN.	with GCS ≤8, with 1100 participants who received early EN and 1980 who received delayed EN.	The researchers surveyed the Japanese Diagnosis Procedure Combination inpatient database between April 2014 to March 2017 and identified TBI patients with GCS ≤8, dividing them into participants who received early EN and those who received delayed EN. The researchers then looked for in-hospital mortality rates and nosocomial pneumonia rates.	any correlation between early EN and mortality reduction, but early EN was correlated with a lower rate of nosocomial pneumonia and shorter hospitalization.	not account for total caloric intake or any adjustments to EN, this could alter the results. This study is also not randomized. Finally, they did not differentiate between nasogastric EN and jejunal EN.	should be conducted to determine the import of EN, utilizing randomization and accounting for a baseline nutritional assessment and caloric advancement.

Oyesanya, T. O. (2019). Veterans health administration nurses' training and beliefs related to care of patients with traumatic brain injury. *PloS One, 14*(9), e0222585-e0222585. https://doi.org/10.1371/journal.pone.0222585	Investigate how nurses at Veterans Health Administration (VHA) care for patients with a TBI	211 VHA nurses	Level III A survey was passed out to the VHA nurses.	This study found that nurses believed that they needed specific training to care for patients with a TBI and that recovery from a TBI lasted several years.	This study was only performed on nurses at VHA, so the findings may not be able to be extrapolated to nurses not caring for veterans	Future studies could investigate the differences in beliefs between nurses who care for patients with TBIs compared with nurses who do not care for patients with TBIs.
Oyesanya, T. O., & Thomas, M. A. (2019). Strategies nurses use when caring for patients with moderate-to-severe traumatic brain injury who have cognitive impairments. *Journal of Clinical Nursing, 28*(21-22), 4098-4109. https://doi.org/10.1111/jocn.14958	Investigate strategies nurses utilize while caring with adults with moderate-to-severe traumatic brain injuries.	692 nurses from three hospitals	Level III The 692 nurses were surveyed with open-ended questions about their strategies for caring for patients with a TBI	Nurses identified 189 different strategies for caring for patients with a TBI, particularly in the categories of cognitive techniques, communication	The response rate of the electronic survey was 17.7%, which not unusual for online surveys, but may not be truly indicative of	It is important to do further research on the effectiveness of treatments used for patients with moderate-to-severe TBIs rather

				techniques, patient safety techniques, agitation and behavior management techniques, and education techniques.	strategies employed by nurses	than just the popularity of techniques utilized.
Oyesanya, T. O., Bowers, B. J., Royer, H. R., & Turkstra, L. S. (2018). Nurses' concerns about caring for patients with acute and chronic traumatic brain injury.*Journal of Clinical Nursing, 27*(7-8), 1408-1419. https://doi.org/10.1111/jocn.14298	The purpose was to investigate nurses' concerns about long-term care of patients with moderate-to-severe brain injury	693 nurses across three hospitals	Level III The nurses were surveyed with a qualitative open-ended question and a cross-sectional study was performed	The nurses were primarily concerned about challenges while caring for a patient in the acute phase. Nurses identified these concerns: avoiding physical injury, overlooking change in condition, supplying education,	The question in the survey did not specify concerns about caring for acute versus chronic TBIs, which allowed the researchers to identify that the majority of the concerns centered on the acute	More research is needed to identify what resources nurses need to adequately care for patients with a TBI.

				providing support, and allowing for recovery. They also stated that challenges included the following: insufficient knowledge, insufficient staffing, and lack of resources. Safety is a special concern for these patients due to their short-term memory loss, leading them to make impulsive, reckless decisions. They are at a very high risk of falling.	phase.	
Promlek, K., Currey, J., Damkliang, J., &	The purpose	22 RNs	Level III	The nurses	The results	Additional

Considine, J. (2020). Thai trauma nurses' knowledge of neuroprotective nursing care of traumatic brain injury patients: A survey study. *Nursing & Health Sciences, 22*(3), 787-794. https://doi.org/10.1111/nhs.12730	was to assess the knowledge that Thai trauma nurses had concerning evidence-based practice care regarding the neuroprotective care for patients with a moderate-to-severe TBI	and 13 nursing assistants (NA) were surveyed from a trauma ward of a Thai hospital, comprising 100% of the RNs and NAs on that floor	The nurses were surveyed with a multiple-choice question survey	were limited in their understanding of CO2 monitoring, hypercapnia, MAP and cerebral perfusion pressure, properly handling sedatives, and caring for hyperthermia.	of this study are limited to the 22 RNs and 13 NAs on that particular trauma floor	research can be performed on the knowledge deficits of other trauma nurses. The difference between nurses who receive specialty neurocognitive training compared to nurses who do not receive neurocognitive training can also be assessed.
Roberts, C. M., Spitz, G., Mundy, M., & Ponsford, J. L. (2019). Prospective evaluation of first and last memory reports following moderate to severe traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology*, *41*(2), 109-117. https://doi.org/10.1080/13803395.20	To study patients' first memories after a TBI and assess how consistent those memories	51 participants with a TBI were recruited from the Head Injury	Level III Participants were asked about their first and last memories surrounding	This study found that the return of continuous memory returned most closely alongside	The follow-up group was only made up of 38 participants, instead of the original	No gaps in the literature were reported in this study.

18.1490392	remain.	Rehabilitation Unit at Epworth Hospital	the injuries and tested using the WPTAS. After they emerged from PTA, researchers performed an interview to determine the return of memory and their last memory prior to the injury. The same interview was performed six months later, as well as the Community Integration Questionnaire and Rey Auditory Verbal Learning Test.	consistent orientation, which occurred prior than assessed according to the WPTAS.	51.	
Spiteri, C., Ponsford, J., Jones, H. & McKay, A. (2021). Comparing the Westmead Posttraumatic Amnesia Scale, Galveston Orientation and Amnesia Test, and Confusion Assessment Protocol as	To compare the recovery time when using the WPTAS,	82 participants with moderate to severe	Level III Patients were assessed daily using the	PTA resolved earliest according to the CAP,	The findings reported on the WPTAS,	Further research should incorporate more

Measures of Acute Recovery Following Traumatic Brain Injury. *Journal of Head Trauma Rehabilitation*, *36*(3), 156-163. https://doi.org/10.1097/HTR.0000000000000607	GOAT, and CAP.	TBIs were studied at an inpatient rehabilitation hospital while in PTA.	WPTAS and ABS. The CAP, which includes the GOAT, was utilized twice a week until the patient was considered to be out of PTCS.	followed by the GOAT, and finally by the WPTAS. Therefore, the WPTAS picks up on more extended PTA.	CAP, and GOAT apply only to moderate-to-severe TBI patients, not to less severe TBI patients. The CAP was also not administered as frequently and may alter the results.	frequent CAP testing.
Stålnacke, B., Saveman, B., & Stenberg, M. (2019). Long-term follow-up of disability, cognitive, and emotional impairments after severe traumatic brain injury. *Behavioural Neurology*, *2019*, 9216931-7. https://doi.org/10.1155/2019/9216931	Assess the levels of impairment in patients who have had a severe TBI (sTBI) from 3 months to up to 7 years afterwards	37 patients with a sTBI from the Neurotrauma Center at Umea University Hospital	Level III study Participants were scored with the Glasgow Coma Outcome Scale Extended (GOSE), the Barrow	The participants scores on the GOSE and the BNIS improved significantly between 3 months to 1 year following the accident.	This study is only performed on individuals with a sTBI who survived past three weeks (when most individuals	More research is needed on the effectiveness of treatment on patients with severe TBI.

			Neurological Institute Screen for Higher Cerebral Functions (BNIS), and the Hospital Anxiety and Depression Scale (HADS)		die from a sTBI).	
Tenovuo, O., Diaz-Arrastia, R., Goldstein, L.E., Sharp, D.J., van der Naalt, J., & Zasler, N.D. (2021). Assessing the severity of traumatic brain injury—Time for a change? *Journal of Clinical Medicine*, *10*(1),148. doi.org/10.3390/jcm10010148.	This paper criticizes current methodology used for categorizing the severity of TBIs.	N/A	Level V The authors study current assessment tools for TBIs and PTA, incorporating relevant evidence. They then suggest, in their opinion, better alternatives.	The authors recommend using multimodal approach using quantifiable dating, such as imaging and biomarkers. They also recommend labeling a TBI as “low-risk”, “medium-risk”, and “high-risk.”	This is not a study, but instead reflects these authors opinions based on their interpretati on of the current data.	According to this article, there is a gap in the literature regarding the reliability of PTA assessment scales. Studies of PTA are often performed after the fact, and are therefore potentially biased by

						inaccurate recall.
Vakil, E., Greenstein, Y., Weiss, I., & Shtein, S. (2019). The effects of moderate-to-severe traumatic brain injury on episodic memory: A meta-analysis. *Neuropsychology Review*, *29*(3), 270–287. https://doi.org/10.1007/s11065-019-09413-8	To determine the effect of a TBI on episodic memory.	Final result yielded 77 studies, all assessing patients with moderate-to-severe TBIs.	Level I A computerized search was performed, including studies prior to May 31, 2019. The key words were "traumatic," "brain," "Injury," "damage," "head," "memory," and "learning." A meta-analysis was performed on the relevant articles.	This study found that verbal memory, particularly verbal recall, is most affected by a moderate-to-severe TBI.	Since this is a meta-analysis, the researchers were unable to divide the various patient groups into homogenous groups. Therefore, it can be difficult to delineate causes of a TBI that lead to visuospatial memory deficits.	This meta-analysis identified a gap in the literature regarding the impact of a TBI on visuospatial memory.
Venkatesan, U. M., Rabinowitz, A. R., Wolfert, S. P., & Hillary, F. G. (2021). Duration of post-traumatic amnesia is uniquely associated with memory functioning in chronic moderate-to-severe traumatic brain injury. *NeuroRehabilitation (Reading,*	To determine the relationship between the duration of PTA and memory	82 individuals with a moderate-to-severe TBI within the	Level II Information was retrieved from the patient's hospitalization	This study found that the duration of PTA was highly correlated to the extent of	The Orientation Log was used to determine the duration of PTA, in	Future studies should utilize a consistent method for determining

Mass.), 49(2), 221-233. https://doi.org/10.3233/NRE-218022	abilities	last year	. The duration of PTA was assessed by a minimum score of 25 on the Orientation Log. For the 17 participants that the Orientation Log was not utilized, an interview was used to determine the duration of PTA. A variety of tests were utilized to assess memory, processing speed, executive functioning, cognitive impairment, and subjective memory.	healthy memory functioning, both at early and long-term stages of recovery.	contrast to the WPTAS and the GOAT utilized in many of the other studies. Additionally, the same test for determining the duration of PTA was not used for all patients.	the duration of PTA.

Appendix B: Permission for Figure 1

ELSEVIER LICENSE
TERMS AND CONDITIONS

Nov 03, 2022

This Agreement between Liberty University -- Hannah Grant ("You") and Elsevier ("Elsevier") consists of your license details and the terms and conditions provided by Elsevier and Copyright Clearance Center.

License Number	5421430838057
License date	Nov 03, 2022
Licensed Content Publisher	Elsevier
Licensed Content Publication	Elsevier Books
Licensed Content Title	Neuroanatomy for Medical Students
Licensed Content Author	J.L. Wilkinson
Licensed Content Date	Jan 1, 1992
Licensed Content Pages	9
Start Page	197
End Page	205
Type of Use	reuse in a thesis/dissertation
Portion	figures/tables/illustrations
Number of figures/tables/illustrations	1
Format	electronic
Are you the author of this Elsevier chapter?	No
Will you be translating?	No
Title	Senior Thesis
Institution name	Liberty University
Expected presentation date	Nov 2022
Order reference number	Figure10.6
Portions	Figure 10.6
Requestor Location	Liberty University 1971 University Blvd LYNCHBURG, VA 24515

	United States Attn: Liberty University
Publisher Tax ID	98-0397604
Total	0.00 USD