

# ERABI

EVIDENCE-BASED REVIEW  
of moderate to severe  
ACQUIRED BRAIN INJURY

## 18. Traumatic Brain Injury and Older Age

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### Abbreviations

ABI	Acquired Brain Injury
CPP	Cerebral Perfusion Pressure
FIM	Functional Independence Measure
GCS	Glasgow Coma Scale
GOS	Glasgow Outcome Score
TBI	Traumatic Brain Injury

## 18. Aging with a Traumatic Brain Injury

### 18.1 Introduction

The term “aging” is often used in the literature to describe how an adult progresses developmentally to an older state of being. However, the meaning of aging in the current context is used to describe individuals that have already reached the age of 65 years and are living out their remaining years according to Canada’s life expectancy estimate. Although the differences are subtle, the point is to highlight the aging process as normal physical, cognitive and psychosocial decline in later years, beyond the age of 65, and not simply a chronological progression. These normal functional declines are commonly referred to as senescence (Comfort, 1964).

Traumatic brain injury (TBI) is a leading cause of death in the elderly and often has devastating long-term effects (Frankel et al., 2006). Not only does TBI have consequences for the individual, but also for the public health system and caregivers. Clinical research has demonstrated that TBI can seriously hinder physical, cognitive, and psychosocial functioning, regardless of whether the head injury is mild, moderate, or severe (Services, 1998).

Statistics regarding TBI in Canada were collected by the Canadian Institute for Health Information (CIHI). In the fiscal year 2003-2004, 29% of all head injury hospitalizations in Canada were elderly individuals (age 60+ years)(Canadian Institute for Health Information [CIHI], 2006). This corresponds to 4,902 hospital admissions in older adults alone. The prevalence of head injury is alarming given that the elderly population made up only 12% of the total Canadian population in 2004. More alarming is that many head injuries go unreported by family physicians and outpatient healthcare settings, and more remain undiagnosed in individuals that do not seek medical help. In 2004, 1,368 individuals who had experienced a head injury died in the hospital as a result of their injuries, the majority of which were elderly (59%). The number of deaths reported in hospitals does not include individuals who died at the scene of an accident or shortly before arriving to the hospital; therefore, it is estimated that the number of fatalities is higher than reported (Canadian Institute for Health Information [CIHI], 2006).

This module provides an overview of the incidence and etiology of brain injury in individuals over the age of 65. Relevant interventions for this demographic are presented throughout the module and are discussed critically to help evaluate their efficacy.

#### 18.1.1 Mechanism of Injury

In 2004 the predominant mode of injury for older Canadian adults was unintentional falls and represented 76% of all head injury admissions. Further, 82% of all injury related admissions of Canadian older adults were the result of a fall (Canadian Institute for Health Information [CIHI], 2006). Individuals who have fallen previously are at a high risk of subsequent falls (Teno et al., 1990). In 2004, the second and third leading causes of head injury in older Canadian adults were motor vehicle collisions and assaults at 17% and 1.1%, respectively (Canadian Institute for Health Information [CIHI], 2006). The rates due to motor vehicle collisions are particularly worrisome given that older adults drive considerably less than younger adults. The rate of death resulting from motor vehicle collisions in those 65 years and older was 13.2 per 100,000, yet for those aged 45 to 64 years, the rate was only 8.2 per 100,000 (Ramage-Morin, 2008). Head injuries caused by falls produce a greater number of focal brain

lesions than those produced by other mechanisms such as motor vehicle accidents (Alberico et al., 1987).

### 18.1.2 Head Injury Incidence by Age and Gender

In 2004, the average age of Canadian seniors sustaining a head injury was 75 years, and on average 57% of all admissions were males. This overrepresentation by males is observed in all other age brackets for TBI as well (Zygun et al., 2005). However, American studies have shown that gender differences regarding TBI incidence disappear over the age of 65 (Tieves et al., 2005). Pentland et al. (1986) reported a slightly higher number of head injuries in women over 75 years of age, resulting mostly from falls, in part because of the large number of women in this age group.

### 18.2 Post-Traumatic Mortality

It is widely accepted that individuals over 65 experience differences in recovery. Key research has shown that individuals 56 years of age and older also experience very different outcomes following major trauma compared to those who are younger. Several studies have demonstrated that older individuals (those 56 years of age or older) have higher mortality rates (up to 62%) at discharge from acute care regardless of injury severity (Bouras et al., 2007; Kuhne et al., 2005; Mosenthal et al., 2002; Spaniolas et al., 2010; Susman et al., 2002). While the literature generally lumps all individuals over 65 years of age as one group, studies have shown that there may in fact be key differences in recovery and outcomes. Bouras et al. (2007) examined mortality rates of older adults with TBI who were stratified into age groups (14-64, 65-74, and 75 or more years of age) and found that mortality rates were significantly different between the two oldest age brackets, with the oldest seniors faring worse than the younger seniors. Further, Kuhne et al. (2005) found that mortality peaked at the age of 75. One explanation for higher mortality rates from brain injuries or secondary shock in older adults may be due to the vulnerability of brain vessels with advancing age (Marxheimer, 1998).

It has been consistently shown that age, Glasgow Coma Scale (GCS), and injury severity are three independent predictors of mortality following a TBI. Table 18.1 presents key research that demonstrates the effect of age and GCS on mortality following an acquired brain injury (ABI).

**Table 18.1 Mortality Rates Post TBI based on Age and Severity of Injury**

Author/ Year/ Country/ Study Design/ N	Time Point	Study Findings	
<i>Mortality at Discharge</i>			
<a href="#">Lilley et al.</a> (2016) United States Case Series N=90	Mortality rate at discharge	GCS ≤8=79% GCS>8=6.2%	Mortality >65 yr
<a href="#">Utomo et al.</a> (2009) The Netherlands Case Series N=428	Mortality rate at discharge	GCS 3-8=83.3% GCS 9-12=47.8% GCS 13-15=14%	Mortality >65 yr
<a href="#">Bouras et al.</a> (2007) Greece Case Series	Mortality rate at discharge	Mortality 65-74 yr GCS 3-4=94% GCS 5-8=71% GCS 9-13=37%	Mortality >75 yr GCS 3-4=92% GCS 5-8=93% GCS 9-13=51%

N=1,926		GCS 14-15=6%	GCS 14-15=13%
<a href="#">Kuhne et al.</a> (2005) Germany Case Series N=5375	Mortality rate at discharge	ISS 16-24 15-35 yr=3.4% 36-65 yr=8.4% 66-75 yr=22.4% >76 yr=37.0%	ISS 50-75 15-35 yr =51.4% 36-65 yr=70.3% 66-75 yr=90% >76 yr=100%
<a href="#">Mosenthal et al.</a> (2002) Case Series N=694	Mortality rate at discharge	Mortality <64 yr GCS 3-8=30% GCS 9-13=1% GCS 14-15=1%	Mortality >64 yr GCS 3-8=61% GCS 9-13=42% GCS 14-15=5%
<a href="#">Susman et al.</a> (2002) USA Case Series N=11,722	Mortality rate at discharge	Mortality <65 yr GCS <6=62% GCS 6-9=12% GCS 10-12=8% GCS 13-15=2%	Mortality >65 yr GCS <6=86% GCS 6-9=52% GCS 10-12=33% GCS 13-15=12%
<b>Mortality at 1-6 Months Post Injury</b>			
<a href="#">Patel et al.</a> (2010) United Kingdom Case Series N=669	Mortality rate 3 mo post injury	Mortality GCS 3-5 65-70 yr=79.6% 70-75 yr=85.9% 75-80 yr=92.0% >80 yr=92.6%	Mortality GCS 6-8 65-70 yr=47.1% 70-75 yr=56.4% 75-80 yr=73.3% >80 yr=78.8%
<a href="#">Mohindra et al.</a> (2008) India Case Series N=1071	Mortality rate 6 mo post surgery	Mortality 20-40 yr GCS 3-8= 39.2% GCS 9-12=19.0% GCS 13-15=5.7%	Mortality >70 yr GCS 3-8=72.7% GCS 9-12=71.4% GCS 13-15=0.0%
<a href="#">Tokutomi et al.</a> (2008) Japan Case Series N=797	Mortality rate at 6 mo post injury	Mortality (Prior Disease) 6-39 yr=17% 40-69 yr=51% >70 yr=65%	Mortality (No Prior Disease) 6-39 yr=34% 40-69 yr=53% >70 yr=75%
<a href="#">Grossman et al.</a> (2002) USA Case Series N=33,781	Mortality rate 1 mo post injury	Mortality >65 yr ISS <15=3% ISS 15-30=18% ISS >30=50%	
<b>Mortality 1-5 Years Post Injury</b>			
<a href="#">Lilley et al.</a> (2016) United States Case Series N=90	Mortality rate at 1 yr post injury	GCS≤8=87.9% GCS>8=40.6%	Mortality
<a href="#">Colantonio et al.</a> (2008) Canada Case Series N=2,721	Mortality rate 1-9 yr post injury	15-34 yr=3.2% 35-64 yr=16.3% >65 yr=55.0%	Mortality
<a href="#">Selassie et al.</a> (2005) USA Case Series N=3,679	Mortality rate 15 mo post injury	15-34 yr=1% 35-54 yr=5% 55-74 yr=11% ≥75 yr=30%	Mortality
<b>Mortality &gt;5 Years Post Injury</b>			

<a href="#">Ratcliff et al.</a> (2005) USA Case Series N=640	Mortality rate 8-24 yr post-injury	Mortality 14-24 yr=7% 25-39 yr=9% 40-59yr=31% >60 yr=74%
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Note: GCS=Glasgow Coma Scale, ISS=Injury Severity Score

In general, older age is a predictor of mortality following a TBI, independent of GCS or injury severity. Additionally, for older individuals with a GCS below eight, higher mortality rates are reported compared to older individuals with a GCS above eight. Mortality rates are consistently seen between 61% and 94% (Bouras et al., 2007; Mosenthal et al., 2002; Utomo et al., 2009). For these reasons, many authors suggest that the best way to reduce the risk of mortality post ABI is to mitigate risk factors and focus efforts on the prevention of injury (Cetty et al., 2017; Yang et al., 2017), as well as using factors predictive of mortality to determine the most appropriate individually-tailored treatment plans (Gardner et al., 2017; Lilley et al., 2016; Okazaki et al., 2016).

### 18.3 Functional Outcomes

Over the course of a lifetime, a variable degree of normal physical and cognitive change occurs. As individuals age, many report these changes as health-related issues. Individuals who have sustained a TBI and live to older adult years, or who sustain a TBI during late adulthood, experience unique and often accelerated declines in physical and mental health. The combination of both brain injury and aging can have serious implications for the patient, their family, and the community.

Older adults with brain injury have been found to have poor GOS functional outcomes compared to younger individuals (Born et al., 1985; Kakarieka et al., 1994; Katz & Alexander, 1994; Ritchie et al., 2000). Only 4% of the older adults with an incoming GCS of less than 8 experienced a good outcome (GOS 4-5), while 91% experienced a poor outcome (GOS 1-3) (Kotwica & Jakubowski, 1992). Further, only 5-20% experienced a moderate-to-good recovery one year later (Alberico et al., 1987; Brazinova et al., 2010; Dikmen et al., 1995). Kilaru et al. (1996) reported that lower GCS is a strong independent predictor of poor long-term functional outcomes in older adults. Ultimately, the research literature has shown that older adults have poorer outcomes at all time points, regardless of the severity of injury (Frankel et al., 2006; Hukkelhoven et al., 2003; Katz & Alexander, 1994; LeBlanc et al., 2006; Mosenthal et al., 2002; Rothweiler et al., 1998; Susman et al., 2002; Vollmer et al., 1991).

**Table 18.2 Functional Outcomes Post TBI based on Age and Severity of Injury**

Author/ Year/ Country/ Study Design/ N	Sample Characteristics	Study Findings	
<i>Outcome at Discharge</i>			
<a href="#">Ritchie et al.</a> (2000) Australia Case Series N=191	Patients >66 yr old, CGS 3-15 incoming, recovery at discharge by GOS	GOS 4-5 GCS 3-8=0.0% GCS 9-12=27.5% GCS 13-15=73.5%	GOS 1-2 GCS 3-8=87.8% GCS 9-12=31% GCS 13-15=13.3%
<a href="#">Pennings et al.</a> (1993) USA Observational N=169	Patients 20-40 and >60 yr old, GCS <5 incoming, recovery at discharge by GOS	GOS 4-5 <40 yr=38% >60 yr=2%	GOS 1-2 <40 yr=44% >60 yr=93%



<a href="#">Kotwica &amp; Jakubowski</a> (1992) Poland Case Series N=136	Patients >70 yr old, GCS 3-15 incoming, recovery at discharge by GOS	GOS 4-5 GCS 3-8=4% GCS 9-12=28% GCS 13-15=80%	GOS 1-2 GCS 3-8=91% GCS 9-12=40% GCS 13-15=20%
<a href="#">Pentland et al.</a> (1986) Scotland Cohort N=2,019	Patients <65 and >65 yr old, GCS scores 3-14 incoming, recovery at 1 mo post injury by GOS	GOS 4-5 GCS 3-7 <65 yr=22% >65 yr=4%  GCS 8-12 <65 yr=86% >65 yr=46%  GCS 13-14 <65 yr=99% >65 yr=96%	GOS 1-3 GCS 3-7 <65 yr=78% >65 yr=96%  GCS 8-12 <65 yr=14% >65 yr=55%  GCS 13-14 <65 yr=1% >65 yr=4%
<b>Outcome at 6 Months Post Injury</b>			
<a href="#">Utomo et al.</a> (2009) The Netherlands Case Series N=310	Patients >65 yr old, AIS 4-5 incoming, recovery at 6 mo post injury by GOS	AIS 4-5 GOS 1-2=8% GOS 3=49.5% GOS 4=11% GOS 5=31.5%	
<a href="#">Mohindra et al.</a> (2008) India Case Series N=1,071	Patients 20-40 and >70 yr old, GCS 3-15 pre-operative, recovery at 6 mo post surgery	GOS 4-5 GCS 3-8 20-40 yr=42.1% >70 yr=3.0%  GCS 9-12 20-40 yr=72.5% >70 yr=14.3%  GCS 13-15 20-40 yr=90.0% >70 yr=80%	GOS 1-2 GCS 3-8 20-40 yr=42.6% >70 yr=96.9%  GCS 9-12 20-40 yr=21.1% >70 yr=85.7%  GCS 13-15 20-40 yr=7.6% >70 yr=0%
<a href="#">Gomez et al.</a> (2000) Spain Case Study N=810	Patients 14-64 and >65 yr old, GCS <8 incoming, recovery at 6 mo post injury	GOS 1-2 15-35 yr=45% 36-45 yr=57% 46-64 yr=54% >65 yr=88%	GOS 4-5 15-35 yr=44% 36-45 yr=30% 46-64 yr=24% >65 yr=8%
<a href="#">Ross et al.</a> (1992) USA Observational N=195	Patients >65 yr old, GCS 3-15 incoming, recovery at 6 mo post injury by GOS	GOS 4-5 GCS 3-8=4% GCS 9-12=12% GCS 13-15=27%	GOS 1-2 GCS 3-8=91% GCS 9-12=71% GCS 13-15=55%
<a href="#">Vollmer et al.</a> (1991) USA Case Series N=661	Patients 15-55 and >56 yr old, GCS 3-15 incoming, recovery 6mo post injury by GOS	GOS 4-5 16-35 yr=49% 36-45 yr=33% 46-55 yr=22% >56 yr=9%	GOS 1-3 16-35 yr=51% 36-45 yr=66% 46-55 yr=77% >56 yr=91%
<b>Outcome at 12 Months Post Injury</b>			
<a href="#">Brazinova et al.</a> (2010) Austria	Patients ≥66 yr old, GCS 3-4 incoming, mortality	GOS 1-3 GCS 3-4=91%	GOS 4-5 GCS 3-4=9%

Case Series N=100	rate/recovery by GOS 1 yr post injury		
<a href="#">Dikmen et al.</a> (1995) USA Observational N=466	Patients <70 and >70 yr old, GCS 3-15 incoming, recovery 1yr post injury by GOS	GOS 4-5 20-29 yr=>75% 30-39 yr=70% 40-49 yr=60% 50 – 59 yr=30% 60-69 yr=25% >70 yr=20%	
<a href="#">Katz &amp; Alexander</a> (1994) USA Observational N=243	Patients <60 and >60 yr old, PTA <3 mo, LOC <2 wk incoming, recovery at 1 yr post injury by GOS	GOS 4 <20 yr=93% 20-39 yr=90% 40-59 yr=88% >60 yr=53%	GOS 2-3 <20 yr=8% 20-39 yr=10% 40-59 yr=10% >60 yr=43%
<a href="#">Alberico et al.</a> (1987) USA Case Series N=330	Patients <60 and >60 yr old, GCS ≤7 incoming, recovery at 1 yr post injury by GOS	GOS 4 0-20 yr=45% 2-40 yr=35% 41-59 yr=15% >60 yr=5%	GOS 1 0-20 yr=25% 20-40 yr=32% 41-59 yr=50% >60 yr=70%

Note: GCS=Glasgow Coma Scale, GOS=Glasgow Outcome Scale, LOC=Length of Coma, AIS=Abbreviated Injury Score

Overall, older adults admitted to acute care with a severe brain injury have a poor prognosis, with few being discharged with a good functional outcome (Kotwica & Jakubowski, 1992; Ritchie et al., 2000). In addition to injury severity being a significant predictor of functional outcome, age as well as GCS predict lower functional outcomes (Brazinova et al., 2010; Kilaru et al., 1996).

Some studies have measured how disability rating scale scores change over time in older individuals with an ABI (Cifu et al., 1996; Frankel et al., 2006; Livingston et al., 2005). All studies compared older adults to younger individuals at admission to and discharge from an inpatient rehabilitation center. Despite that patients had the same injury severity on admission to rehabilitation, the younger group had greater recovery per day, as measured by disability rating scale scores, compared to the older group (Cifu et al., 1996; Frankel et al., 2006). Thus, while recovery in older adults following TBI is apparent, the process is slower. Conversely, Livingston et al. (2005) found that rates of improvement based on the disability rating scale during the first year are similar in both young and old individuals; however, the rates plateaued/declined over time in older adults while they continued to improve for younger individuals.

### 18.3.1 Functional Outcomes as measured by the Functional Independence Measure

Many studies have been conducted to measure functional changes over time in individuals with TBI. Graham et al. (2010) studied admission and discharge Functional Independence Measure (FIM) scores and found that older women made similar functional gains as men from admission to discharge, even though they were approximately two years older and were twice as likely to be living at home prior to the brain injury. Younger adults with TBI improved at a greater rate per day on the FIM compared to older adults from admission to discharge (Frankel et al., 2006). Upon analysis of FIM subscales during acute care, younger and older adults were similar on physical functioning, but the younger group surpassed the older group in terms of behaviour and cognitive function at almost twice the rate (Cifu et al., 1996).

A significant age effect on overall functional outcome was found (GOS); the older a patient was at the time of injury, the poorer the discharge FIM scores were, despite better admission scores than the

younger group (Graham et al., 2010). It should be noted, however, that the authors were unsure how clinically meaningful these differences were (Graham et al., 2010). A side-by-side comparison of admission GCS to discharge FIM revealed that despite the same injury severity in both young and old groups, the older patients with a TBI were discharged with a poorer FIM score for each moderate and severe brain injury sustained (LeBlanc et al., 2006). At one-year post discharge, younger adults recovered significantly better than the older group, even after accounting for pre-morbid conditions (Livingston et al., 2005).

Reeder et al. (1996) did not find that age was a significant predictor of functional gain during rehabilitation, even after controlling for injury etiology, injury severity, and demographic information. The authors suggest that with sufficient rehabilitation lengths of stay, pre-injury functional status is possible in older adults. Given that the lengths of stay in rehabilitation units have decreased over time, the amount of time given to recover to pre-morbid status may not be adequate for patients (Canadian Institute for Health Information [CIHI], 2006). In addition to slower recovery in older adults, there is a clear relationship between increased injury severity and decreased overall function over time (Cifu et al., 1996).

#### 18.4 Cognitive Outcomes

The combination of age-related cognitive decline and neurological damage sustained during a brain injury has a cumulative effect and produces profound deficits in older adults. The literature on cognitive decline following TBI in older adults is limited. In studies directly assessing older adults following a TBI, cognitive impairments have been found including delayed recall (Gupta & Ghai, 1991) and word fluency (Aharon-Peretz et al., 1997).

Short-term and long-term cognitive decline has been shown to be a risk factor for older adults who have sustained a TBI; however, many older individuals experience a decline in cognitive functioning as a result of normal aging or pathology. Such pathology may include dementia, a progressive neurodegenerative disease whereby memory and thinking become impaired. There are currently 564,000 Canadians living with dementia, the majority of these individuals are over the age of 65, therefore, teasing apart the relationship between aging, TBI and dementia can be a difficult task for primary health providers (Chambers, 2016). Quite often dementia (un-related to a TBI) and TBI-related cognitive decline exist as co-morbid conditions. Typically individuals post TBI recover to some degree over time or plateau, whereas patients with dementia experience a progressive decline (Kersel et al., 2001). For example, compared to individuals with Alzheimer's disease, individuals with TBI were able to learn new information and retain it over time with practice (Bigler et al., 1989) and perform better on both verbal and visual memory tests (Bigler et al., 1989; Goldstein et al., 1996). Determining whether dementia is the underlying problem as opposed to TBI sequela is made even more challenging by the fact that a brain injury is a risk factor for developing Alzheimer's disease and other dementias (Fleminger et al., 2003; Guo et al., 2000; Mayeux et al., 1995; Mortimer et al., 1991; Plassman et al., 2000; Roberts et al., 1991; van Duijn et al., 1992). Starkstein & Jorge (2005) claimed that the changes in the brain following a TBI may lower the threshold for the manifestation of Alzheimer's disease in predisposed individuals.

Protein upregulation and genetic factors may both contribute to neurodegeneration following a brain injury. Evidence has been accumulating over the past decade that the genetic polymorphism Apolipoprotein E (apoE, protein; *APOE*, gene) protein may play a role in cognitive outcomes after brain injury. In individuals post injury, the *APOE4* allele has become an excellent predictor for poor clinical

outcome, both physically and cognitively (Blacker et al., 2007; Friedman et al., 1999; Jordan et al., 1997; Liaquat et al., 2002; Lynch et al., 2002; Nicoll et al., 1996; Starkstein & Jorge, 2005; Swan et al., 2005; Teasdale et al., 1997).

### 18.5 Psychological Outcomes

Despite the significant amount of literature on psychosocial issues following brain injury in the younger population, very little is known about how older adults fare. Older adults with brain injuries suffered from significantly more psychosocial dysfunction, psychological distress, and post-concussive symptoms than the controls (Goldstein & Levin, 1995). Additionally, neurobehavioural/emotional disorders have been found in older adults following TBI (Goldstein & Levin, 1995; Goldstein & Levin, 2001; Goldstein et al., 1999; Levin et al., 1997). However, one study found that younger individuals did not differ significantly from the older brain injury population in levels of anxiety and depressive disorders (Whelan-Goodinson et al., 2010). While many of the cognitive changes have been noted five months post injury in the brain injury older population, psychosocial distress only becomes apparent several years post injury (Oddy et al., 1978). This might indicate a delayed onset of depression in the older adult TBI population.

Recent evidence suggests that the location of a given lesion may also influence the psychological well-being of an individual in addition to pre-existing factors. A study by Kim et al. (2017) examined comorbidity between depressed mood and TBI and found that patients with bilateral and left hemispheric brain lesions were more likely to also be depressed than those with right hemispheric lesions. When comparing those who were diagnosed as depressed to non-depressed TBI patients, those who were depressed also exhibited significantly lower FIM cognitive scores at discharge (Kim et al., 2017). This research supports the increasingly holistic approach to rehabilitation medicine, particularly with older populations, as many factors can influence psychological and physical outcomes.

Psychosocial rehabilitation within older adult populations should be considered, as quite often inpatient rehabilitation focuses on physical and cognitive gains. Rehabilitation efforts focusing on the psychosocial dimension are two-fold, those which guide the patient, and those which guide the family and/or caregiver. One of the most troublesome psychological conditions afflicting those with TBI is major depression. Issues related to spousal relationships and family functioning is common among older individuals post TBI. Additionally, caregivers should be a part of the planning process for future treatments and services (Dikmen et al., 1995). Family and caregiving assistance is crucial for all individuals during rehabilitation, but perhaps more so for older adults. As individuals age their social network diminishes and family members or friends must endure a greater burden. Thus, rehabilitation efforts and support services should be available to both the TBI patient and their support network (Uomoto, 2008).

### 18.6 Models of Care

Following a head injury, it is typical that an individual remains in acute care long enough to monitor and manage basic systems (e.g., respiration), undergo surgery, and/or complete a hospital-based rehabilitation program (Stroke., 2002). Following acute care, individuals may be required to complete further rehabilitation in a hospital-based or community setting. Depending on the severity of the injury, individuals may be discharged home or to a long-term facility (Kim et al., 2006).

In acute care, older patients should be aggressively triaged (Kuhne et al., 2005), monitored closely (Selassie et al., 2005), and referred to senior medical staff (Zietlow et al., 1994). Mitra et al. (2008) emphasize that transitioning to intensive care units is extremely beneficial for optimizing good outcomes. Older adults who experience a head injury experience a greater number of medical complications compared to younger individuals (Thompson et al., 2006) and typically have poorer long-term prognoses (Mosenthal et al., 2002). According to the Center for Disease Control and Prevention (2007), 79.1% of all individuals over the age of 65 years, who had sustained a severe head injury, had at least one co-morbid disease. Physicians should be wary of the overlap in symptoms between cognitive impairment and TBI to eliminate the potential for misdiagnosis (Flanagan et al., 2006). Seniors may be more at risk for further complications because of co-morbidities, frailty, previous head traumas, and medication interactions. Given the costs/resources required to care for older adults with TBI, the current demographic trends are concerning. It is important that treatments are unique and shifted towards older adults who have sustained a TBI, particularly due to the large number of older adults with TBI in the population (Cekic & Stein, 2010; Kuhne et al., 2005).

Recent trends in literature have shifted towards compassion-based care (Lilley et al., 2016), meaning that the quality of life and end-of-death experience is taken into consideration when choosing what level of care to provide. As more research is demonstrating age itself to be a predictor of poorer outcomes (Kuhne et al., 2005; Ritchie et al., 2000), end of life decisions are being increasingly approached by a team of individuals (e.g., social worker, family members, and physicians) with the intent of prioritizing the minimization of suffering and not necessarily achieving a functional outcome (Lilley et al., 2016; Schumacher et al., 2017).

### **18.6.1 Acute Care**

#### **18.6.1.1 Length of Stay**

After a brain injury occurs, a patient may transition through a typical care pathway consisting of acute care, intensive care unit management, inpatient rehabilitation, and outpatient rehabilitation or another support service (Khan et al., 2002). In Ontario in 2006, approximately 1-5% of all emergency department visits by individuals 60 years or older were for TBI. Additionally, 4-16% of all acute care inpatient hospital admissions by individuals 60 years or older were for a diagnosis of TBI (Colantonio et al., 2009). Length of stay in acute care varies widely depending on a multitude of factors including but not limited to injury severity, age at injury, geographical status, and discharge disposition. Based on Canadian data, older adults stayed, on average, 15 days in acute care in 2004. In comparison, those aged 0-19 years stayed for 5 days, those aged 20-39 years stayed for 11 days, and those aged 40-59 years stayed for 13 days (Canadian Institute for Health Information [CIHI], 2006).

#### **18.6.1.2 Intensive versus Conservative Treatment**

There is much controversy as to whether older adults should be treated aggressively or conservatively in the acute care setting, especially for older individuals who have sustained very serious head injuries. For ethical reasons researchers have not specifically withheld acute care treatment to compare outcomes. Some studies have found that older patients that have sustained a TBI tend to receive more conservative acute care compared to younger patients (Lane et al., 2003; Thompson et al., 2008). Thompson et al. (2008) found that as age increased, a lower intensity of care was provided to older adults (e.g., transportation to a designated trauma center, intracranial pressure monitoring, specialty care assessments, surgical/medical specialty care, intensive care unit admission, etc.). Additionally, older individuals were more likely to have died at discharge compared to younger adults, after accounting for

injury severity, co-morbidities, and gender. Higher mortality rates could be explained by less aggressive care or a greater number of do-not-resuscitate orders (Thompson et al., 2008). In an observational study, Lilley et al. (2016) recently reported that 72% of families had chosen to withdraw or withhold life-sustaining treatments if the individual's status had declined post intake. A multitude of studies have shown that older adults sustaining a brain injury are given a lower intensity of care which ultimately results in higher than expected mortality rates (Grant et al., 2000; Lane et al., 2003; Thompson et al., 2008).

#### **18.6.1.3 Neurosurgical Care**

After a particularly serious head injury, cerebral perfusion pressure (CPP) can build. Following brain trauma, it is important to maintain stable CPP to allow proper oxygen perfusion, waste removal, and glucose delivery (Rao, 2007). However, there is a general lack of studies assessing whether CPP guidelines are appropriate for elderly individuals. Age-specific factors such as co-morbid conditions including hypertension or diabetes mellitus and multiple medications may affect the cerebral response to injury and thus CPP (Thompson et al., 2006).

When CPP increases to dangerous levels, decompressive craniotomy is a procedure used to relieve pressure in the brain and results in significantly better management of uncontrollable intracranial hypertension (Aarabi et al., 2006; Jiang et al., 2005; Meier et al., 2005; Ucar et al., 2005). While good outcomes can be achieved in young trauma patients, whether the same outcomes could be obtained for older adults is controversial. A suggested age limit for performing decompressive craniotomy has been said to be 40-50 years of age (Aarabi et al., 2006; Meier et al., 2006; Skoglund & Nellgard, 2005). However, surgery should still be recommended for patients with mild injuries who are only recently identified as elderly (Bouras et al., 2007; Jamjoom, 1992). Mohindra et al. (2008) examined 45 older (70+ years) and 1,026 younger (20-40 years) individuals with TBI for outcomes after advanced trauma care, including surgery. The elderly consistently show greater rates of disability and mortality post-surgery (Kinoshita et al., 2016). Taken together, decompressive craniotomies are not typically performed on patients older than 50 years, as the usual risks of surgery combined with the risks of older age typically result in poorer outcomes compared to those under the age of 50.

#### **18.6.1.4 Discharge Disposition**

After an individual has stabilized in acute care and is well enough to leave, they may be discharged to a variety of settings based on their likelihood of improvement. Such settings may include inpatient rehabilitation, personal home with or without outpatient support services, long-term care, or supportive housing. While Livingston et al. (2005) did not find any age-related differences in discharge disposition among their study sample, several researchers have found a discrepancy. Several studies have shown that older adults were less likely to return to their former living status (Mosenthal et al., 2002; Rothweiler et al., 1998; Utomo et al., 2009). Frankel et al. (2006) reported that only 80.8% of the older patients (55 years) with a TBI were discharged to the community as opposed to an institutional setting compared to 94.3% of the younger patients with a TBI (<55 years). Ultimately there appears to be a discrepancy in discharge destination between older and younger individuals post injury; a greater number of older adults are discharged to long term care facilities or nursing homes while younger adults tend to return home.

#### **18.6.2 Rehabilitation**

Goldstein (2005) wrote a special section on rehabilitation for TBI in the older adult population. Unlike the significant focus on rehabilitative efforts in children and young adults, very little has been done

regarding the rehabilitative needs of older adults. A concern is whether a “good” outcome is even possible in older adults. As indicated previously, overall there is a linear relationship between severity of injury and outcome (Mosenthal et al., 2002).

In 2011, the Netherlands implemented a targeted Geriatric Rehabilitation Program, which proposes a framework to improve the rehabilitative care of seniors (Holstege et al., 2015). The program focuses on four areas of care; the alignment of care with the patient’s needs, quality of care, coordination of care, and coordination of care with care team members. A study examining the effects of this Geriatric Rehabilitation Program (Holstege et al., 2015) determined that seniors with a TBI were more likely to experience successful rehabilitation outcomes compared to seniors who have suffered a stroke. Compared to a retrospective control group, TBI individuals who participated in the rehabilitation program had significantly greater independence in activities of daily living, decreased length of hospital stay, and improved functional improvement. However, the majority of rehabilitation efforts that are being used with elderly individuals have resulted from studies solely investigating a younger population. Age-related differences may interact to generate a very different set of circumstances requiring unique rehabilitative efforts. Extra-injury factors including depression and a deterioration of social functioning may exacerbate these differences, supporting the need for a continued focus on developing evidence-based medicine knowledge for specific populations.

#### **18.6.2.1 Length of Stay**

Older adults stay significantly longer in rehabilitation compared to younger patients; studies have reported length of stays ranging from 27 to 56 days among older adults (40+ years), and 22 to 33 days among young patients (<40 years) (Cifu et al., 1996; Frankel et al., 2006; Marquez de la Plata et al., 2008). However, despite longer stays, and therefore greater total costs, there was no notable difference between age groups in terms of daily rehabilitation costs.

#### **18.7 Conclusions**

Falls are the number one cause of injury-related deaths in seniors in Canada (Canadian, 2017; Canadian Fall Prevention Education Collaborative, 2017; Curriculum, 2017; Curriculum, 2017). Overall, there is limited research which has specifically examined older adults post TBI. The health care team must assess the individual to decide which choice of setting will be most beneficial (e.g., inpatient, outpatient, or home therapy). Rehabilitation goals should be set in conjunction with the patient, caregiver, and therapeutic team. While the ultimate goal is to return the patient to pre-morbid functioning, this may not always be possible and therefore goals should be realistic and centered around independence. As a result of this, recent patient care trends have also shifted to incorporate the end-of-life experience and suffering as a factor when deciding whether to continue care and at what intensity. Overall, patients, caregivers and the support network should be aware that regardless of outcome, rehabilitation and recovery require extensive community support (Scherer, 2000).

## 18.8 References

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