

Gender Differences in Traumatic Brain Injury : Why Do Males Most Likely Have a Higher Number of Cases?

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Abstract

Traumatic brain injury (TBI) is a leading cause of disability and death, representing a global public health concern. This injury can lead to mild and severe concussion, coma, psychological effects, or even fatality. Apparently, there are some factors that may influence the severity of TBI, one of them is gender. Almost all of the various studies consistently find that the number of cases in males is disproportionately higher across all age categories and research periods than in females. This review article aims to evaluate the specific role of gender in TBI cases based on prior studies.

Keywords: TBI, gender, psychosocial, steroid

1. Introduction

Traumatic brain injury (TBI) is a non-degenerative and non-congenital injury that occurs suddenly due to impact, blow, sudden jolt, or penetrating wound to the head, potentially causing damage and disrupting the function of the brain (National Institute of Neurological Disorders and Stroke, 2018). TBI is a comprehensive term encompassing a wide range of injuries affecting the brain. The damage incurred can be either focal, confined to a specific brain area, or diffuse in multiple areas. The extent of a brain injury varies, spanning from a mild concussion to a severe injury that may lead to coma or in extreme cases, fatality (Johns Hopkins Medicine, 2019). Traumatic brain injury is a leading cause of disability and death, representing a global public health concern.

In 2020, there were around 214,110 hospitalizations related to traumatic brain injury. In 2021, there were 69,473 reported deaths associated with TBI. This translates to over 586 TBI-related hospitalizations and 190 TBI-related deaths per day. It is important to note that these figures do not encompass all TBIs, as some cases may only receive treatment in emergency departments or primary care and others may go untreated altogether. The age group of 75 years and older had the highest numbers and rates of TBI-related hospitalizations and deaths, contributing to approximately 32% of TBI-related hospitalizations and 28% of TBI-related deaths (Centers for Disease Control and Prevention, 2022). Based on data from Riskesdas in 2018, the number of head injuries due to traffic accidents in Indonesia reached 11.9% and the highest was in Gorontalo Province with a percentage of 17.9%. This may be influenced by the percentage of helmet use in Indonesia, which is only 33.7%.

Apparently, there are some risk factors that may correlate with the severity of TBI, such as age, gender, occupation, and alcohol usage (Harding and Robertson, 2013). However, there is some other research that shows that the mechanism of injury, helmet usage, and position in the vehicle also have a relation with the severity of TBI. In preclinical research that has been conducted, there is evidence showing that differences in age influence the pathophysiology and long-term effects in children with head injuries (Serpa et al., 2021). Apart from that, there appears to be a significant difference in the number of cases, with the incidence rate in males being much higher than in females (Prasad, Swank and Ewing-Cobbs, 2017).

2. Anatomical Factors

Basically, the severity of TBI is certainly caused by the mechanism of injury experienced. However, many other causes still need to be known about this, one of which is gender. Differences in intracranial volume and brain size are evident from birth and are considered to be related to the effects of steroid hormones during fetal brain development. On average, males have larger brain sizes compared to females, as indicated by higher intracranial volumes, total brain volume (~8-15% larger volume in males), and a greater number of neurons. However, these brain volume differences tend to diminish with age. Therefore, the observed poorer outcomes in females might be attributed to smaller brain volumes, but these differences may diminish or even reverse with advancing age (Biegon, 2021).

3. Psychosocial Factors

Although falls are more prevalent among girls, the falls experienced by boys tend to be more serious. This observation is reinforced by variations in the mechanics of falls, with boys displaying a higher likelihood of falling from elevated surfaces compared to girls. Likewise, a more significant number of boys admitted with traumatic brain injuries sustained injuries from motor collisions in comparison to girls, and a significantly higher proportion of boys across various age groups did not utilize proper restraints (Morrongiello, Midgett and Stanton, 2000).

A greater percentage of traumatic brain injuries (TBI) in girls is attributed to falls. Regardless of gender, the home emerges as the most common site of injury. Substantial gender variations become apparent early on and persist throughout childhood and adolescence. Boys experience injuries linked to higher energy transfer, such as falls from heights exceeding 2 meters. They are also less inclined to use protective devices and are more prone to intentional injuries. This leads to a distinct injury pattern, potentially resulting in elevated levels of associated harm and mortality (Collins et al., 2013).

Lack of appropriate restraint becomes apparent at an earlier age, a period during which caregivers bear the responsibility of ensuring the safety of child passengers. During adolescence, adherence to rules based on gender differences is largely influenced by perceived gender stereotypes rather than biological sex (Granié, 2009). In daily life, men are more active in activities; they like to do quite dangerous activities, such as climbing. Apart from that, some individuals also don't like to follow the rules for wearing safety equipment when carrying out activities. On the other hand, women were significantly more likely than men to report internal problems, such as depression and anxiety, while men were more likely to report external problems, such as accidents, drug abuse, and criminal behaviour (Scott et al., 2015). This was consistent across age groups.

4. Hormonal Factors

The influence of hormones is also suspected to play a role in the difference in the number of head injury cases between boys and girls, one of which is steroid hormones. Steroid hormones are a primary source of gender differences in the brain. Considerable research in various animal models has revealed five differences modulated by developmental exposure to steroid hormones. These include differences in volume due to cell death and survival, neurogenesis, dendritic morphology, synaptic patterns, and changes in astrocyte and microglia morphology and activation (McCarthy, 2016).

Moreover, endogenous gonadal hormones that act in the brain during critical periods beginning in the womb regulate neural formation differently in males and females. In rodent model studies, the brain maturation process begins with high-level intracerebral exposure to locally synthesized estrogen through the aromatization of fetal male testicular testosterone. Conversely, female rodent ovaries remain inactive, resulting in the development of the female rodent brain in the relative absence of steroid hormones (Weisz and Ward, 1980).

The developing male brain exhibits inflammatory mediators and reactive microglia during the critical period of sexual differentiation. Additionally, steroid hormones mediate morphological changes and microglial activation, with many brain regions in males showing higher microglia after testosterone surges. Males also have more other inflammatory cells, such as mast cells (Lens, Nugent and McCarthy, 2012). Overall, the inclination toward the inflammatory pathway is more prominent in the normally developing male brain, suggesting that there may be a higher level of neural inflammation after traumatic brain injury in young males.

In the biochemical aspect, tryptophan also plays a crucial role in traumatic brain injury. In pathological conditions, such as after a head injury, tryptophan metabolism can shift from producing protective and homeostatic products, such as serotonin, melatonin, and kynurenic acid, to excitotoxic products like quinolinic acid. Furthermore, emerging literature suggests that sex hormones may influence the tryptophan pathway, which can be a significant consideration in adolescents with traumatic brain injury (Barth, Villringer and Sacher, 2015).

5. Conclusions

Several factors can influence the severity of traumatic brain injury; one of them is gender. From prior studies, TBI cases in males are likely higher than in females. Three factors tend to influence this phenomenon: psychosocial influences, hormonal factors, and the brain's anatomy.

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