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Literature review: risk factors for neurogenic shock

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ABSTRACT

Spinal cord injury is most often associated as a contributing factor in causing neurogenic shock. Mostly associated with cervical and thoracic spine injuries. However, there are many factors that can cause neurogenic shock. This study explains the risk factors for trauma and non-trauma that can cause neurogenic shock. This type of study is a literature review using a narrative review design by collecting information through various sources related to risk factors for neurogenic shock. The results of article scoping found 15 study articles that could be used to provide answers to the problem formulation for this study. 6 study articles state that accidents are the biggest risk factor for neurogenic shock, spinal cord injuries tend to be influenced by accidents while driving which cause a loss of sensory and motor abilities. Apart from that, several other articles also state that violence, anesthesia, brain damage, tumors, infections, fractures and developmental abnormalities can be risk factors for neurogenic shock. Based on the findings of a review from various sources, it can be concluded that incidents of neurogenic shock are most often caused by risk factors for trauma due to traumatic injury to the spine.

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INTRODUCTION

Shock is a condition of systemic reduction in tissue perfusion which is characterized by a decrease in the use of oxygen at the cellular level and a decrease in the disposal of metabolic products. One type of distributive shock, neurogenic shock occurs when the vasomotor center fails due to a sudden decrease in vascular tone throughout the body (Wardhana, 2022).

The epidemiology of neurogenic shock is difficult to assess because it remains unknown how hemorrhagic shock and other injuries impact the hemodynamic effects of spinal cord injury. Worldwide, neurogenic shock occurs between fifteen and fifty-two events per million people annually. Only approximately five percent of patients are young, and the majority are men between fifteen and thirty-five years of age (Dave, 2021).

The incidence of neurogenic shock is higher in cervical Spinal Cord Injury (SCI) (29%) compared to thoracic (19%). Neurological functional disorders that tend to appear, and

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those that often appear are tetraplegia (53%) and paraplegia (42%). Spinal cord injury is most often associated as a contributing factor in causing neurogenic shock (Ruiz, 2018).

METHOD

The form of study that will be made in this research is a literature review or literature review using the narrative review method with a method of obtaining information or literature related to a topic. The information or literature mentioned comes from journals, books and other libraries.

RESULTS

The results of this research were obtained using a literature study method in the form of calculating information through official information to answer the objectives of this research.

Table 1. Incidence of Neurogenic Shock

Research title	Author	Method	Result
Neurogenic Shock	Sagar Dave; Julia J. Cho-Hoon Kim	Bookshelf	Other, much rarer causes of neurogenic shock include spinal anesthesia, Guillain-Barre syndrome, autonomic nervous system toxins, transverse myelitis, as well as other neuropathies. The pediatric population reports neurogenic shock in children with trisomy 21, skeletal dysplasia, and tonsillopharyngitis.
Presentation of neurogenic shock within the emergency department.	Matthew Pritam Taylor Paul Wrenn Andrew David O'Donnell	Literature Review	In 3069 trauma cases, 15 patients experienced neurogenic shock. As many as 87% of patients experience neurogenic shock within approximately 2 hours after spinal injury. The fastest time for neurogenic shock to occur is 13 minutes after injury and the longest time for neurogenic shock to occur is 263 minutes after injury.
Incidence and natural progression of neurogenic shock	Ian A Ruiz, Jordan W Squair, Aaron A Phillips,	Cross Sectional	Research on 84 cases of spinal cord injury with 56 cases of cervical trauma (C1-C7), 8

following traumatic spinal cord injury	Christine D Lukac, Dayan Huang,		cases of superior thoracic trauma (T1-T5), and 20 cases of inferior thoracic trauma (T6-T12). A total of 38 cases (45%) were spinal cord injuries that were not accompanied by other injuries, 55% of cases had other related injuries (25% fractures, 12% lacerations, 7% pneumothorax, 5% vertebral artery dissection, 3% subarachnoid hemorrhage, 4% abrasion).
Neurogenic shock in a patient with cervical myelopathy from severe cervical kyphoscoliosis	Kim Phan, Naveen Eipe, Philippe Phan	Case Study	A 20-year-old patient with neurofibromatosis (NF) type 1 with a history of traumatic injury. This case represents a severely compromised cervical spine injury with preoperative neurogenic shock. Cervical spine injuries can present with cardiovascular compromise at any time after injury and this can contribute significantly to morbidity and mortality
Neurogenic Shock: A Case Report	Nicholas North, Amber Adams	Case Study	This case describes a 65-year-old man who suffered a cervical spine fracture following a motorcycle accident
Neurogenic Shock Immediately following Posterior Lumbar Interbody Fusion: Report of Two Cases	Tomiya Matsumoto, Shinya Okuda, Takamitsu Haku, Kazuya Maeda, Takafumi Maeno, Tomoya Yamashita, Ryoji Yamasaki, Shigeyuki, Kuratsu, Motoki Iwasaki	Case Study	Reported 2 cases of neurogenic shock that developed rapidly after posterior lumbar interbody fusion (PLIF) apparently caused by a vasovagal reflex following dural injury and cauda equina incarceration.

Metastatic esophageal cancer presenting as shock by injury of vagus nerve mimicking baroreceptor reflex: A case report	Kenji Tsuchihashi, Tomoyasu Yoshihiro, Tomomi Aikawa, Kenta Nio, Kotoe Takayoshi, Taku Yokoyama, Mitsuhiro Fukata, Shuji Arita, Hiroshi Ariyama, Yukiko Shimizu, Yuichiro Yoshida,	Case Study	Case of neurogenic shock caused by pathological baroreceptor reflex through disruption of the vagus nerve which supplies the aortic arch baroreceptors due to large metastatic left cervical lymph nodes due to esophageal cancer.
Traumatic Basilar Artery Entrapment without Longitudinal Clivus Fracture: A Case Report and Review of the Literature	Ayumu Yamaoka, Kei Miyata, Naofumi Bunya, Hirotoshi Mizuno, Hideto Irifune, Naoya Yama.	Case Study, Literature Review	A case of neurogenic shock with quadriplegia occurred in a 67 year old man with a history of treatment for an intracranial aneurysm who received traumatic injury at C4-C6 and Th2-3.
Instantaneous death due to transorbital reverse penetration of a screw in an accidental fall: unusual autopsy case report and review of the literature	Sara Gioia, Mauro Bacci, Massimo Lancia, Luigi Carlini, Fabio Suadoni	Case Study	Death due to neurogenic shock caused by injury to the brainstem and right hemisphere due to transorbital penetration.
Spinal epidural empyema extending from a pleural empyema: case description and anatomical overview	Gabriel Torrealba Acosta, Sylvia Josephy Hernández, Gabriel Castro Ulloa, and Greivin Rodríguez Rojas	Case Study	The patient is a 66-year-old man with a chronic condition such as diabetes that can cause severe infections that are widespread and localized in the form of abscesses and empyema. He was found to have pleural empyema associated with thoracic pyomyositis, which then extended to the spinal canal originating from the epidural empyema. Expansion of this empyema causes spinal neurogenic shock.
Trigemino-cardiac reflex as lethal mechanism in	Riccardo Rossi , Maria Lodise,	Case Study	The incidence of neurogenic shock due to the trigemino-

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a suicidal fire death case	Massimo Lancia, Mauro Bacci, Fabio De-Giorgio, Fidelia Cascini		cardiac reflex in death due to fire burns.
Ruptured spinal arteriovenous malformation: Presenting as stunned myocardium and neurogenic shock	Tasneem H. Mehesry, Nissar Shaikh, Mohammad F. Malmstrom, Marco A. E. Marcus, and Adnan Khan	Case Study	The occurrence of rupture of the cervical arteriovenous malformation of the spine that presents as neurogenic shock.
Neurogenic Shock	Elizabeth H. Mack	Studi Literature	The most common cause (41-56%) of spinal cord injury is motor vehicle accidents. Other causes include spinal anesthesia, Guillain-Barre syndrome, neuropathy, and autonomic nervous system toxins. Unique impacts of SCI in the pediatric population include birth-related injuries, lap-belt injuries, transverse myelitis. Cervical subluxation can cause cervical SCI in children with Trisomy 21, juvenile idiopathic arthritis, skeletal dysplasia, and tonsillopharyngitis.
Osteoporosis and Spinal Cord Injury.	David Weiss, MD; Stephen Kishner, MD, MHA	Bookshelf	One of the complications of spinal cord injury is osteoporosis. A longitudinal cohort study by Rodriguez et al found the 4-year incidence of musculoskeletal morbidity (such as osteoporosis, sarcopenia, osteoarthritis, and fracture) was 82.4% in adults with traumatic spinal cord injury, compared with 47.5% in adults without the injury.
Perioperative management of airway	Kyu Nam Kim, Ji Hee Chang,	Case Study	Penetrating Neck Injury is associated with damage to the

and neurogenic shock in patients with penetrating neck injury : a case report	Hyung Jun Cho	structure of the airway and large blood vessels. We report a case of penetrating neck injury with complete transection of the spinal cord and hemodynamic instability due to neurogenic shock.

Discussion

In the literature written by Sagar Dave and Julia J. Co entitled Neurogenic Shock, it is stated that neurogenic shock is the result of autonomic dysregulation which generally occurs after spinal cord injury, usually due to trauma. A review of trauma databases showed the incidence of neurogenic shock in 19.3% of cervical spine injuries and 7% of thoracic spine injuries (Damiani, 2018).

Other research that supports this is research written by Elizabeth H. Mack entitled Neurogenic Shock which cites that the most common cause of 41%–56% of spinal injuries in children is motor accidents. Other causes include spinal anesthesia, Guillain-Barre syndrome, other neuropathies, and systemic autonomic nervous system toxins. Unique causes of spinal cord injury in the pediatric population include birth-related injuries, lap-belt injuries and transverse myelitis. Cervical subluxation has also been found to cause cervical spine injuries in children with Trisomy 21, juvenile idiopathic arthritis, skeletal dysplasia, and tonsillopharyngitis. Due to physical differences between the sexes, such as children's smaller neck muscles and larger heads, cervical SCI is more common in children than in adults (Mack, 2018).

Both studies have results that neurogenic shock can also be caused by conditions other than spinal traumatic events. Because it is rare for non-traumatic conditions to lead to neurogenic shock, the literature discussing this is limited so that the exact mechanism for the occurrence of neurogenic shock outside of traumatic spinal conditions cannot yet be explained in detail. However, these two studies are also supported by Riccardo Rossi's research in Trigemino-cardiac reflex as lethal mechanism in a suicidal fire death case which found a death due to neurogenic shock which occurred due to the trigemino-cardiac reflex in a case of fire burning (Rossi).

The trigemino-cardiac reflex (or trigemino-vagal reflex) belongs to a large series of vagal reflexes that arise as a reaction to thermal or chemical irritation. This is a brainstem reflex, well known to surgeons and anesthesiologists because it is observed in invasive surgical procedures involving the head and neck region. Other risk factors for developing this reflex may include hypercapnia, hypoxemia, light general anesthesia, young age, strong narcotics, and use of certain b-blockers or calcium channel blockers. It is clinically characterized by bradycardia, dysrhythmia, asystole, arterial hypotension, apnea, and acutely occurring gastric hypermobility (Taylor, 2018).

In the study described by Kenji Tsuchihashi, et al with the title Metastatic esophageal cancer presenting as shock by injury of vagus nerve mimicking baroreceptor reflex: A case report, there was a case of neurogenic shock caused by a pathological baroreceptor reflex

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through disruption of the vagus nerve which supplies the aortic arch baroreceptors due to large metastatic disease. left cervical lymph node due to esophageal cancer. This is in accordance with our literature review (Spinal Cord Compression Due to Metastasis) which states that both primary tumors and metastatic tumors can cause compression of the spinal cord. Problems like this arise when the medulla becomes compressed and displaced within the spinal canal due to injury or cancer. Hypotension and bradycardia, which can then lead to shock, can be caused by reflexes that activate the parasympathetic nervous system and depress the sympathetic nervous system (Yamaoka, 2018).

Sara Gioia et al, reported a case of death with the title Instantaneous death due to transorbital reverse penetration of a screw in an accidental fall: unusual autopsy case report and review of the literature which talks about neurogenic shock caused by injury to the brain stem and right hemisphere due to transorbital penetration. Injury resulting from transorbital penetration in this case is fatal because it injures the brain stem which is the center of the cardiorespiratory system and penetrates to the right hemisphere of the brain. Based on our literature review, injuries that arise due to brain damage tend to affect vasomotor paralysis due to brain ischemia that lasts for a long time (5 - 10 minutes) giving rise to a contradictory effect, namely the lack of full life of vasomotor neurons in the brain stem, which results in a decrease in blood pressure and the occurrence of severe neurogenic shock (Gioia, 2014).

The study entitled Spinal epidural empyema extending from a pleural empyema: case description and anatomical overview written by Gabriel Torrealba et al, reported an incident of neurogenic shock that occurred due to the extension of the epidural empyema towards the spine. This incident occurred in a 66 year old male patient with a chronic condition such as diabetes which allows severe infections to spread and be localized in the form of abscesses and empyema. He was found to have pleural empyema associated with thoracic pyomyositis, which then extended to the spinal canal originating from the epidural empyema. Expansion of empyema originating from epidural empyema can facilitate the spread of bacteria, one of which is through the spinal arteries which will lead to the spinal canal. Bacteria can easily spread and cause inflammation in the spine which, according to our literature, causes spinal cord damage (Matsumoto, 2018).

In contrast to neurogenic shock resulting from non-traumatic events, neurogenic shock which occurs due to traumatic spinal cord injury is the most reported case. A case report compiled by Nicholas North entitled Neurogenic Shock: A Case Report describes neurogenic shock in a 65-year-old man who suffered a cervical spine fracture after a motorbike accident. One of the most common traumatic causes of brain and spinal cord injuries in our literature is accidents. Unfortunately, the majority of these incidents involve vehicles, The National Of Spinal Cord Injury Data Research Center motor vehicle accidents are the leading cause of spinal cord injury (SCI), causing 10,000 new cases each year in the United States. The incidence of SCI varies from 10.4 to 83 incidents per million population per year, with 82% of cases occurring in men (David, 2021).

Research conducted by Matthew Pritam Taylor entitled Presentation of neurogenic shock within the emergency department stated that in 3069 trauma cases, 15 patients experienced neurogenic shock. As many as 87% of patients experience neurogenic shock

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within approximately 2 hours after spinal injury. The fastest time for neurogenic shock to occur is 13 minutes after injury and the longest time for neurogenic shock to occur is 263 minutes after injury (Mack, 2018).

Research by Ian A Ruiz, et al entitled Incidence and natural progression of neurogenic shock following traumatic spinal cord injury found that in 84 cases of spinal cord injury, 56 cases were cervical trauma (C1-C7), 8 cases were superior thoracic trauma (T1-T5) , and 20 cases of inferior thoracic trauma (T6-T12). A total of 38 cases (45%) were spinal cord injuries that were not accompanied by other injuries, 55% of cases had other related injuries (25% fractures, 12% lacerations, 7% pneumothorax, 5% vertebral artery dissection, 3% subarachnoid hemorrhage, 4% abrasion). This research was supported by Ayumu Yamaoka in Traumatic Basilar Artery Entrapment without Longitudinal Clivus Fracture: A Case Report and Review of the Literature which reported a case of neurogenic shock with quadriplegia in a 67 year old man with a history of treatment for an intracranial aneurysm who received traumatic injury at C4-C6 and Th2-3 (Acosta, 2019).

The case report prepared by Kim Phan entitled Neurogenic shock in a patient with cervical myelopathy from severe cervical kyphoscoliosis describes a case of cervical spine injury that was severely disturbed by preoperative neurogenic shock. Cervical spine injuries can present with cardiovascular compromise at any time after injury and this can contribute significantly to morbidity and mortality. In the case reported by Tomiya Matsumoto, et al in the title Neurogenic Shock Immediately Following Posterior Lumbar Interbody Fusion: Report of Two Cases, 2 cases of neurogenic shock that appeared quickly after posterior lumbar interbody fusion (PLIF) were described, apparently caused by a vasovagal reflex after dural injury. and incarceration of the cauda equina (Taylor, 2018).

Another study by Tasnem H. Mehesry, et al entitled Ruptured spinal arteriovenous malformation: Presenting as stunned myocardium and neurogenic shock reported the incidence of rupture of the cervical spinal arteriovenous malformation which appeared as neurogenic shock. The anatomic level of spinal injury impacts the likelihood and severity of neurogenic shock. The injury in this case triggers decentralization of the sympathetic nervous system which results in reduced sympathetic activity, while parasympathetic nervous control remains intact via the vagus nerve. This then causes a response in the form of bradycardia and heart attack (Dave, 2021).

In the literature written by David Weiss and Stephen Kishner entitled Osteoporosis and Spinal Cord Injury, it is stated that a complication of osteoporosis after spinal cord injury is pathological fracture. The historical incidence of fractures in the population with spinal cord injuries is 1.45-6% while the prevalence of fractures is reported to be 25-46%, however the low incidence may be deceptive because most patients with similar injuries who later experience trauma and fractures are not treated in hospital. spinal cord injury center (Acosta, 2019).

A case report prepared by Kyu Nim Kim, et al with the title Perioperative management of airway and neurogenic shock in patients with penetrating neck injury: A case report reports an 85 year old female patient found with a knife stuck in her neck and a penetrating neck injury and complete spinal transection. On CT the patient showed a stab wound involving the T1 vertebra and spinal cord. The patient received intensive care and

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adequate fluid treatment, but cardiovascular collapse occurred due to neurogenic shock and resulted in death. The author concluded that neurogenic shock was caused by disruption of the sympathetic pathway due to spinal cord injury so that the patient died due to irreversible autonomic system disorders (Matsumoto, 2018).

Neurogenic shock, also known as vasogenic shock, is a disturbing consequence following spinal cord injury. Spinal cord injury causes sudden dysfunction of sympathetic outflow and autonomic instability manifested by significant hypotension, bradycardia, and even temperature dysregulation. These hemodynamic changes are a direct result of impaired sympathetic excitatory input to sympathetic preganglionic neurons. The incidence of neurogenic shock is higher when the spinal cord injury is above the first thoracic vertebra. In recent years, the reported incidence of neurogenic shock varies, namely around 29% in cervical spinal cord injuries, and 19% in thoracic spinal cord injuries (Rossi).

CONCLUSIONS

Based on the findings of a review from various sources, it can be concluded that the risk influence for the emergence of neurogenic shock in general and frequently occurs is traumatic injury to the spine, but other risk factors such as tumor metastasis, infection, brain damage, anesthesia, developmental abnormalities, and fractures are factors. Others can also cause neurogenic shock. There are several results that have not answered the literature review, especially on non-traumatic risks, so further research needs to be carried out, which, although very rare, is worth researching considering the fatal impact that can be caused by neurogenic shock..

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