EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 8
Issue: 1
124-134
Year: 2021

LEVELS OF SPINAL CORD INJURY LEADING TO PARALYSIS AND ASSOCIATED ASIA SCALE

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DOI: https://doi.org/10.17605/OSF.IO/45XMP

Article Received on 06/11/2020 **Article Revised on 26/11/2020** **Article Accepted on 16/12/2020**

ABSTRACT

Introduction: The spinal cord is a long, thin, tubular bundle of nervous tissue and supports cells that extends from the brain (the medulla oblongata specifically). The brain and spinal cord together make up the central nervous system (CNS). A spinal cord injury (SCI) refers to any injury to the spinal cord that is caused by trauma instead of disease. Depending on where the spinal cord and nerve roots are damaged, the symptoms can vary widely, from pain to paralysis to incontinence. Spinal cord injuries are described at various levels of "incomplete", which can vary from having no effect on the patient to a "complete" injury which means a total loss of function. **Purpose of study:** The main purpose of this study was to find the major causes, level of injury, ASIA score, most commonly affected age group and the most affected area by the traumatic spinal cord injury in Pakistan. By finding the common causes and common level of injury in specific area and age group we would be able to develop plans for the management of such injuries. With the help of this study we will also be able to set criteria for the prevention, assessment and intervention plan for the traumatic spinal cord injury patients in Pakistan. **Methodology:** By using descriptive cross sectional methodology a sample of 70 SCI patients was selected from August, 2019 to October, 2019. Data was collected through close ended questionnaire, MRI and physician notes. **Results:** The results have shown that falls are the most common case of SCI (52.9%). In more than half of the subjects (58.6%) the affected area of the spinal cord was T8-T12. The majority (77.1%) of the SCI patients lie within 20-30 years age group. 68.6% of the patients are classified as class A according to the ASIA scoring. **Conclusion:** The study has highlighted the most common cause, area of SCI involved and level of injury in the spinal cord injury patients. On the basis of the findings of this study further work should be done to establish measures that will ensure reduction in these injuries as well as proper handling of injured patients so that spinal cord injuries can be avoided through proper on scene treatment.

KEYWORDS: Spinal Cord injuries, demographics, causes, ASIA scale, level of injury, Pakistan.

INTRODUCTION

The **spinal cord** is a long, thin, tubular bundle of nervous tissue and supports cells that extends from the brain (the medulla oblongata specifically). The brain and spinal cord together make up the central nervous system (CNS). The spinal cord begins at the occipital bone and extends down to the space between the first and second lumbar vertebrae; it does not extend the entire length of the vertebral column. It is around 45 cm (18 in) in men and around 43 cm (17 in) long in women. Also, the spinal cord has a varying width, ranging from 1/2 inch thick in the cervical and lumbar regions to 1/4 inch thick in the thoracic area. The enclosing bony vertebral column protects the relatively shorter spinal cord. The spinal cord functions primarily in the transmission of neural signals between the brain and the rest of the body but also contains neural circuits that can independently control numerous reflexes and central pattern generators. The spinal cord has three major functions: as a conduit for motor information, which travels down the spinal cord, as a conduit for sensory information in the reverse direction, and finally as a center for coordinating certain reflexes.[1]

The anatomy of the spinal cord itself, consists of millions of nerve fibers which transmit electrical information to

and from the limbs, trunk and organs of the body, back to and from the brain. The spinal cord is divided to the cervical, thoracic lumbar and sacral segments. The nerves which exit the cervical and thoracic segments control neck, arm respiratory muscles and thoracic area. The nerves which exit the spinal cord in the mid and lower section of the back, control the trunk and legs, as well as bladder, bowel and sexual function.[2] The nerves which carry information from the brain to muscles are called Motor Neurons. The nerves which carry information from the body back to the brain are called Sensory Neurons. Sensory Neurons carry information to the brain about skin temperature, touch, pain and joint position. The brain and spinal cord are referred to as the Central Nervous System, whilst the nerves connecting the spinal cord to the body are referred to as the Peripheral Nervous System.[2] There are 33 spinal cord nerve segments in a human spinal cord:

Cervical Spine

There are seven cervical bones or vertebrae. The cervical bones are designed to allow flexion, extension, bending, and turning of the head. They are smaller than the other vertebrae, which allows a greater amount of movement. Each cervical vertebra consists of two parts, a body and a protective arch for the spinal cord called the neural arch. Fractures or injuries can occur to the body, pedicles, or processes. Each vertebra articulates with the one above it and the on below it.[3] 8 cervical segments forming 8 pairs of cervical nerves (C1 spinal nerves exit spinal column between occiput and C1 vertebra; C2 nerves exit between posterior arch of C1 vertebra and lamina of C2 vertebra; C3-C8 spinal nerves through IVF above corresponding cervical vertebra, with the exception of C8 pair which exit via IVF between C7 and T1 vertebra).[4]

Thoracic Spine

In the chest region the thoracic spine attaches to the ribs. There are 12 vertebrae in the thoracic region. The spinal canal in the thoracic region is relatively smaller than the cervical or lumbar areas. This makes the thoracic spinal cord at greater risk if there is a fracture. The motion that occurs in the thoracic spine is mostly rotation. The ribs prevent bending to the side. A small amount of movement occurs in bending forward and backward.[3] 12 thoracic segments forming 12 pairs of thoracic nerves (exit spinal column through IVF below corresponding vertebra T1-T12).[4]

Lumbosacral Spine

The lumbar vertebrae are large, wide, and thick. There are five vertebrae in the lumbar spine. The lowest lumbar vertebra, L5, articulates with the sacrum. The sacrum attaches to the pelvis.

Because the vertebral column grows longer than the spinal cord, spinal cord segments do not correspond to vertebral segments in adults, especially in the lower spinal cord. In the fetus, vertebral segments do correspond with spinal cord segments. In the adult, however, the spinal cord ends around the L1/L2 vertebral level, forming a structure known as the conus medullaris. For example, lumbar and sacral spinal cord segments are found between vertebral levels T9 and L2.[1]

Lesions

Upper motor neuron lesion

An upper motor neuron lesion (also known as pyramidal insufficiency) is a lesion of the neural pathway above the anterior horn cell of the spinal cord or motor nuclei of the cranial nerves. This is in contrast to a lower motor neuron lesion, which affects nerve fibers traveling from the anterior horn of the spinal cord to the relevant muscles.[6] Upper motor neuron lesions occur in conditions affecting motor neurons in the brain or spinal cord such as stroke, multiple sclerosis, traumatic brain injury and cerebral palsy.[7] Symptoms also include increase deep tendon reflex (DTR) and pronator drift.[8]

Lower motor neuron lesion

A lower motor neuron lesion is a lesion which affects nerve fibers traveling from the anterior horn of the spinal cord to the relevant muscle(s) – the lower motor neuron.[6]

One major characteristic used to identify a lower motor neuron lesion is flaccid paralysis – paralysis accompanied by muscle loss. This is in contrast to an upper motor neuron lesion, which often presents with spastic paralysis – paralysis accompanied by severe hypertonia.[9]

Spinal Cord Injury

A spinal cord injury (SCI) refers to any injury to the spinal cord that is caused by trauma instead of disease.[10] Depending on where the spinal cord and nerve roots are damaged, the symptoms can vary widely, from pain to paralysis to incontinence.[11,12] Spinal cord injuries are described at various levels of "incomplete", which can vary from having no effect on the patient to a "complete" injury which means a total loss of function.

Classification

The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) is still widely used to document sensory and motor impairments following SCI. It is based on neurological responses, touch and pinprick sensations tested in each dermatome, and strength of ten key muscles on each side of the body, including hip flexion (L2), shoulder shrug (C4), elbow flexion (C5), wrist extension (C6), and elbow extension (C7).[4] Traumatic spinal cord injury is classified into five categories on the ASIA Impairment Scale.[8]

The five categories of the ASIA impairment scale

Category		Description
A	=	No motor or sensory function is preserved in the sacral segments S4-S5
Complete		
B Incomplete	=	Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5
C Incomplete	=	Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade of less than 3
D Incomplete	=	Motor function is preserved below the neurological level, and at least half of the key muscles below the neurological level have a muscle grade of 3 or more
E = Normal		Motor and sensory functions are normal.

Causes of Spinal Cord Injury

The most common causes of spinal cord injury is a broken neck or back neck (causing damage to the bones of the spine that surround the spinal cord). This often results in damage to the nerves of the spinal cord inside the spinal column. This is known as 'traumatic' injury. Traumatic spinal cord injury may be caused by: Road traffic accidents, domestic and work-related accidents, sports injuries, self-harm, assault or complications following surgery e.g., corrective surgery for spinal deformity e.g. scoliosis.[13] SCI can also be caused by so-called 'non-traumatic' cord injury. Examples include: Infection of the spinal nerve cells (bacterial and viral), cysts or tumors pressing on the spinal cord, interruption of the blood supply to the spinal cord (causing cord damage), congenital medical conditions (i.e. present since birth) that affect the structure of the spinal column e.g., spina bifida.[13]

Epidemiological pattern of traumatic spinal cord injuries (SCI) in Pakistan

According to a study conducted in Pakistan there were 68 (81.9%) males and 15 (18.1%) females. Mean age was 28.3 ± 12.4 years. Majority of the patients were in their second decade 43 (51.8%) years. Ambulance evacuation was carried out in only 18 (22.2%) patients and none received any spinal trauma first aid and log roll at the injury site. Most of the patients were paraplegics 49 (71.1%), 48 (57.8%) had complete injury and 43 (51.8%) spinal fixation. Fracture dislocation was the predominant vertebral column injury in 25 patients. Associated injuries and problems were present in 49.4% patients.[14]

Epidemiology of SCI in a developing country has unique epidemiological features and problems, which is different from a developed country. This was to be considered while formulating a plan for SCI management and rehabilitation. There is a dire need to establish a SCI registry in Pakistan, in order to improve the spinal trauma evacuation protocols and develop spinal rehabilitation centers.[14]

Objectives

The objectives of this study are:

1. To find out the most common age group, level of injury and ASIA score for the traumatic SCI in Pakistan
2. To find out the most common causes/risk factors and area for traumatic SCI in Pakistan
3. To gather the evidence so that better measures can be taken in future and to set a criteria for the prevention, assessment and treatment in Pakistan.

MATERIALS AND METHODS

Study Design: Cross Sectional Study
Data Collection: Data collected through close ended questionnaire and also through physician notes
Study Setting: Armed Force Institute of Rehabilitation Medicine (AFIRM) and National Institute of Rehabilitation Medicine (NIRM)
Study Duration: 6 Months
Sample Size: 70
Sampling Technique: Non-Probability. Sample selection will be done on basis of inclusion and exclusion criteria

Inclusion Criteria

- Traumatic spinal cord injury
- Above 20 years and below 60 years

Exclusion Criteria

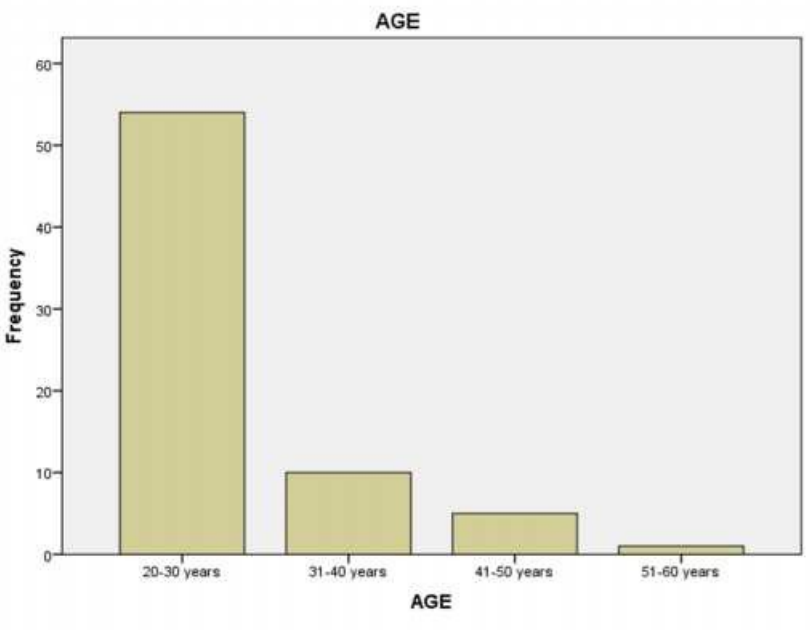
- Non-traumatic Spinal Cord injury
- Below 20 years and above 60 years

Statistical Analysis: Data is analyzed using IBM SPSS Statistics Version 20.0.0 software.

Data Analysis

Table 1: Age.

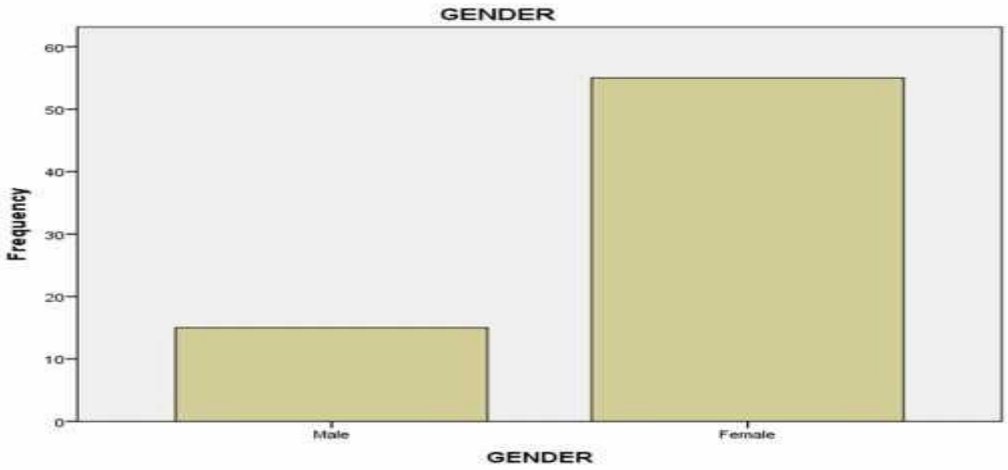
	Frequency	Percent	Valid Percent	Cumulative Percent
20-30 years	54	77.1	77.1	77.1
31-40 years	10	14.3	14.3	91.4
Valid 41-50 years	5	7.1	7.1	98.6
51-60 years	1	1.4	1.4	100.0
Total	70	100.0	100.0	



The frequency Table 1 shows that out of 70 patients, the majority 54 patients i.e. 77.1% were in the age group of the 20-30 years, 10 patients i.e. 14.3% were in the age group of 31-40 years, 5 patients i.e. 7.1% were in the age group of 41-50 years and the remaining 1 patient i.e. 1.4% was in the age group of 51-60 years.

Table 2: Gender.

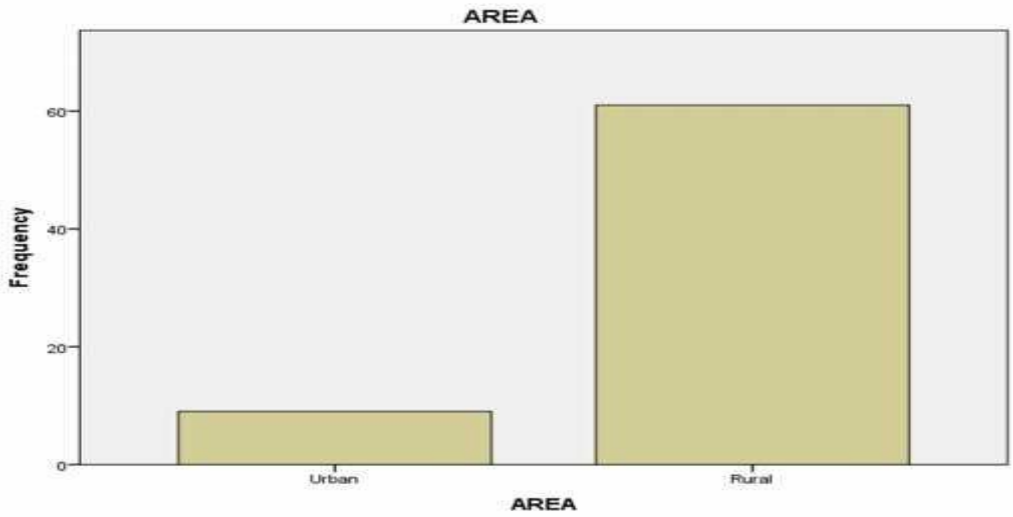
	Frequency	Percent	Valid Percent	Cumulative Percent
Male	15	21.4	21.4	21.4
Valid Female	55	78.6	78.6	100.0
Total	70	100.0	100.0	



The frequency table 2 shows that out of 70 patients, the majority 55 patients i.e. 78.6% were female while the remaining 15 patients i.e. 21.4% were male.

Table 3: Area.

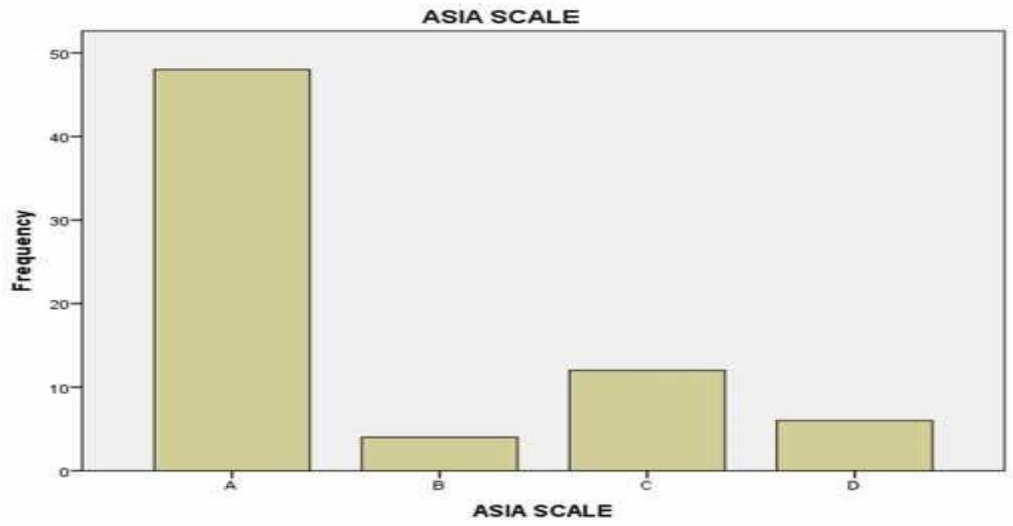
	Frequency	Percent	Valid Percent	Cumulative Percent
Urban	9	12.9	12.9	12.9
Valid Rural	61	87.1	87.1	100.0
Total	70	100.0	100.0	



The frequency table 3 shows that out of 70 patients the majority 61 patients i.e. 87.1% were from rural area while the remaining 9 patients i.e. 12.9% were from urban area.

Table 4: Asia Scale.

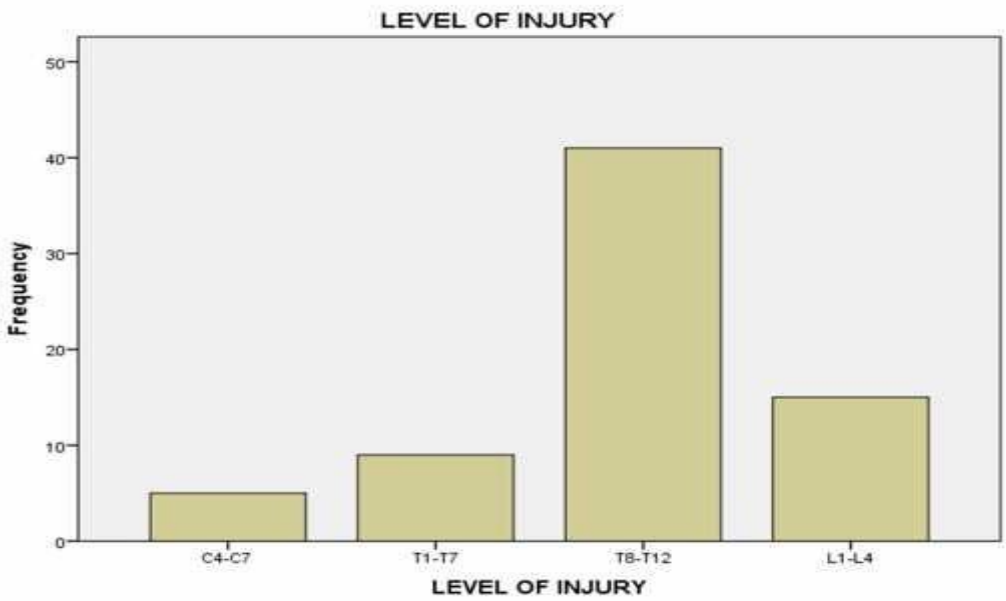
	Frequency	Percent	Valid Percent	Cumulative Percent
A	48	68.6	68.6	68.6
B	4	5.7	5.7	74.3
Valid C	12	17.1	17.1	91.4
D	6	8.6	8.6	100.0
Total	70	100.0	100.0	



The frequency table 4 shows that out of 70 patients the majority 48 patients i.e. 68.6% were scaled "A" on ASIA Scoring system. 12 patients i.e. 17.1% were scaled "B" on ASIA Scoring system. 6 patients i.e. 8.6% were scaled "D" on ASIA Scoring system. 4 patients i.e. 5.7 were scaled "B" on ASIA Scoring system.

Table 5: Level of Injury.

	Frequency	Percent	Valid Percent	Cumulative Percent
C4-C7	5	7.1	7.1	7.1
T1-T7	9	12.9	12.9	20.0
Valid T8-T12	41	58.6	58.6	78.6
L1-L4	15	21.4	21.4	100.0
Total	70	100.0	100.0	



The frequency table 5 shows that out of 70 patients the majority 41 patients i.e. 58.6% had the injury at the level of T8-T12, 15 patients i.e. 21.4% had the injury at the level of L1-L4, 9 patients i.e. 12.9% had the injury at the level of T1-T7 and the remaining 5 patients i.e. 7.1% had the injury at the level of C4-C7.

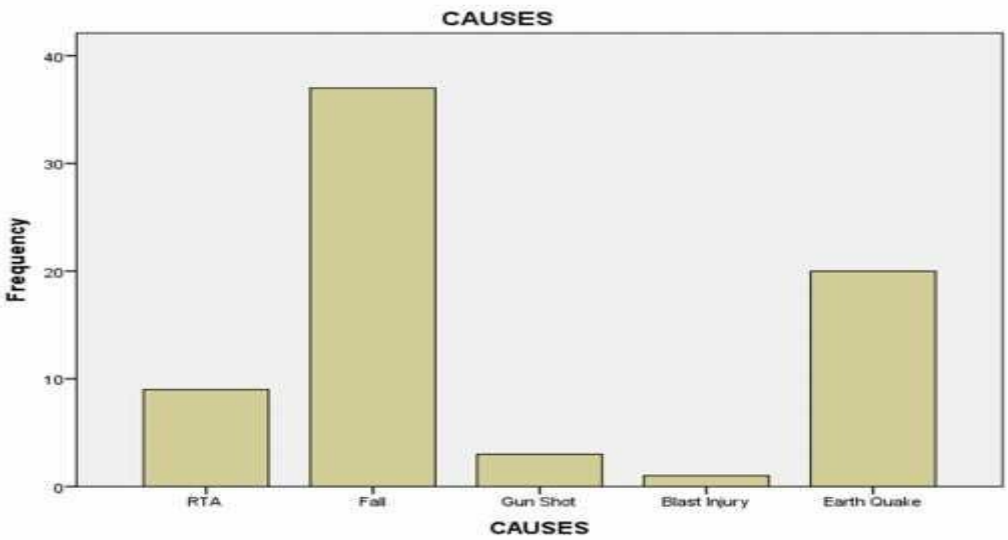
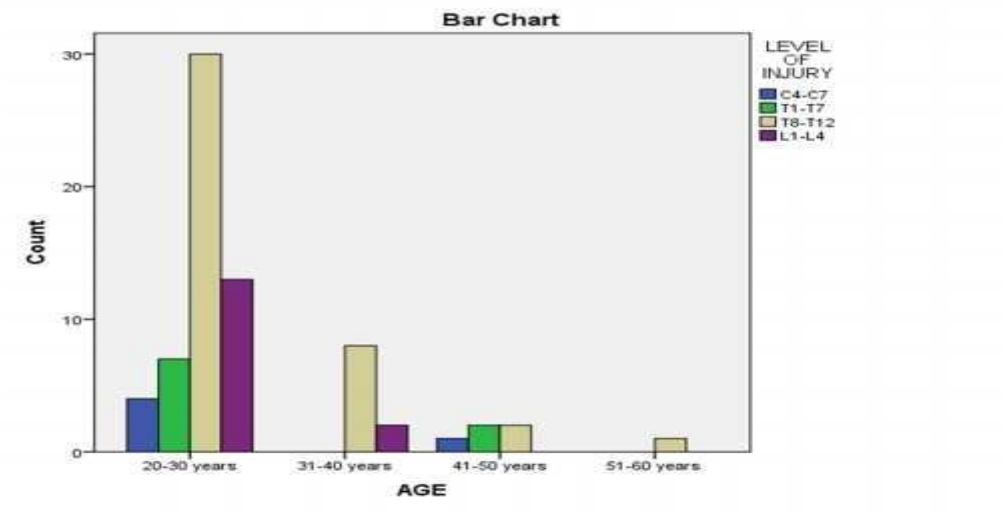


Table 6: Causes.

	Frequency	Percent	Valid Percent	Cumulative Percent
RTA	9	12.9	12.9	12.9
Fall	37	52.9	52.9	65.7
Gun Shot	3	4.3	4.3	70.0
Blast Injury	1	1.4	1.4	71.4
Earth Quake	20	28.6	28.6	100.0
Total	70	100.0	100.0	

The frequency table 6 shows that out of 70 patients the majority 37 patients i.e. 52.9% were injured due to fall from a height, 20 patients i.e. 28.6% were injured due to earth quake, 9 patients i.e. 12.9% were injured due to RTA, 3 patients i.e. 4.3% were injured due to gunshot injury and the remaining 1 patient i.e. 1.4% was injured due to bomb blast injury.



Comparisons between variables

Table 1: Cross tabulation between AGE and LEVEL OF INJURY.

Count AGE	LEVEL OF INJURY				Total
	C4-C7	T1-T7	T8-T12	L1-L4	
20-30 years	4	7	30	13	54
31-40 years	0	0	8	2	10
41-50 years	1	2	2	0	5
51-60 years	0	0	1	0	1
Total	5	9	41	15	70

The cross tabulation table 1 shows that out of 54 patients that were from the age group of 20-30 years, 30 had the injury between the levels of T8-T12.

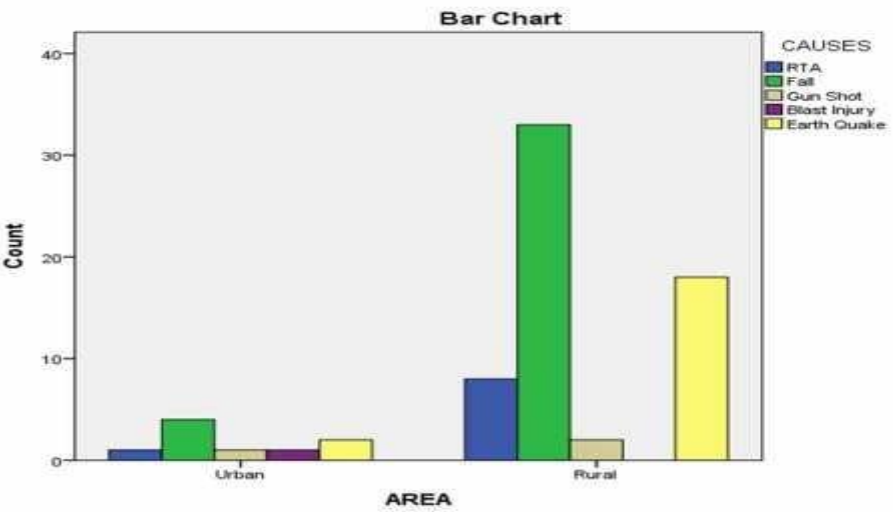
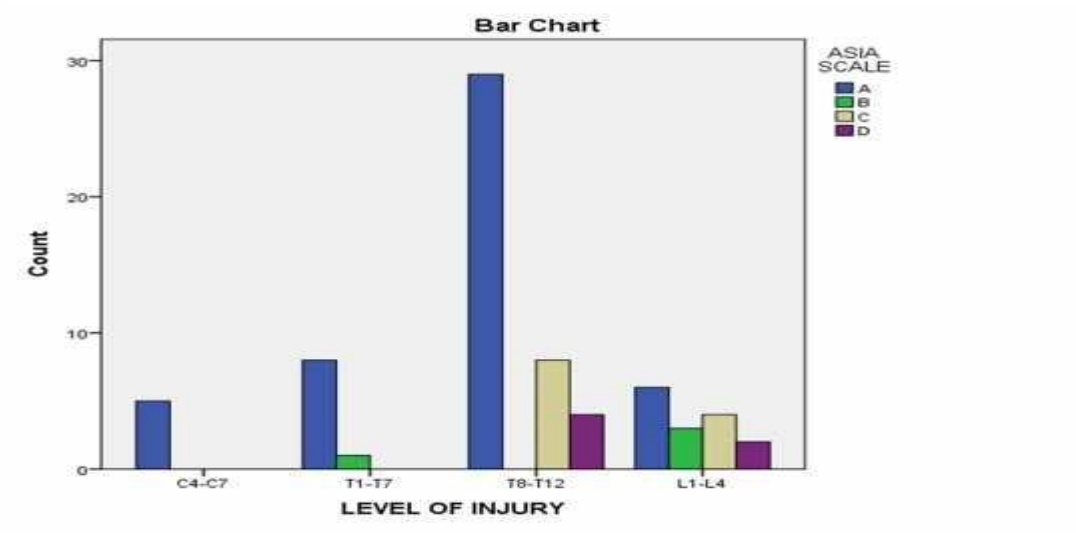


Table 2: Cross tabulation between AREA and CAUSES.

Count AREA	CAUSES					Total
	RTA	Fall	Gun Shot	Blast Injury	Earth Quake	
Urban	1	4	1	1	2	9
Rural	8	33	2	0	18	61
Total	9	37	3	1	20	70



The cross tabulation table 2 shows that out of 61 patients that were from rural area, 33 were injured due to fall from height.

Table 3: Cross tabulation between LEVEL OF INJURY and ASIA SCALE.

Count LEVEL OF INJURY	ASIA SCALE				Total
	A	B	C	D	
C4-C7	5	0	0	0	5
T1-T7	8	1	0	0	9
T8-T12	29	0	8	4	41
L1-L4	6	3	4	2	15
Total	48	4	12	6	70

The cross tabulation table 3 shows that out of 41 patients that were injured between the levels of T8-T12, 29 were scaled ASIA "A".

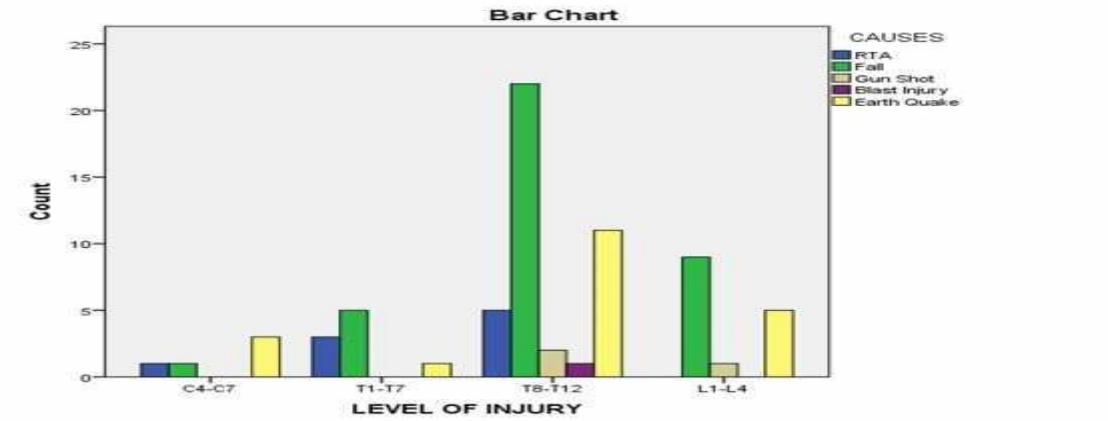


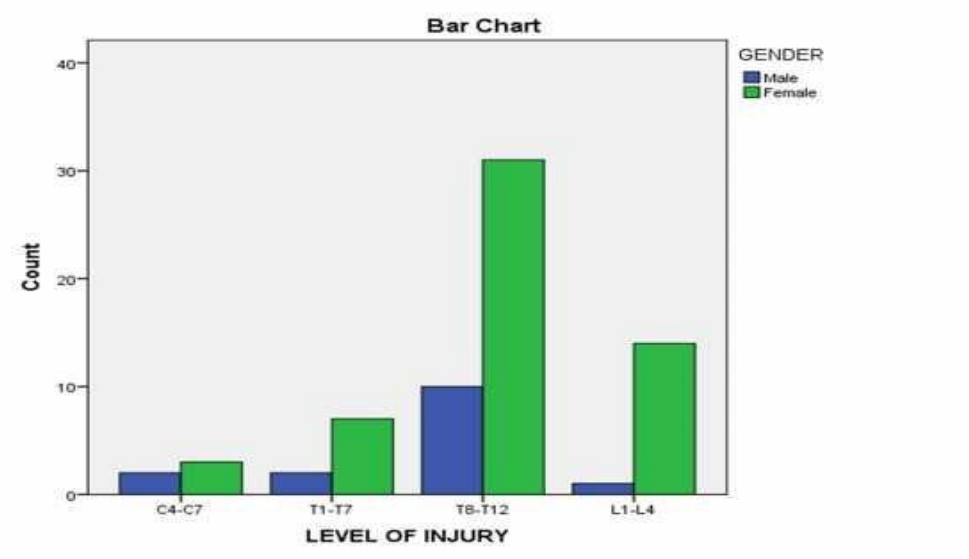
Table 4: Cross tabulation between LEVEL OF INJURY and CAUSES.

Count LEVEL OF INJURY	CAUSES					Total
	RTA	Fall	Gun Shot	Blast Injury	Earth Quake	
C4-C7	1	1	0	0	3	5
T1-T7	3	5	0	0	1	9
T8-T12	5	22	2	1	11	41
L1-L4	0	9	1	0	5	15
Total	9	37	3	1	20	70

The cross tabulation table 4 shows that out of 41 patients that were injured between the levels of T8-T12, 22 patients were injured because of fall from height.

Table 5: Cross tabulation between LEVEL OF INJURY and GENDER.

Count	GENDER		Total
LEVEL OF INJURY	Male	Female	
C4-C7	2	3	5
T1-T7	2	7	9
T8-T12	10	31	41
L1-L4	1	14	15
Total	15	55	70



The cross tabulation table 5 shows that out of 41 patients that were injured between the levels of T8-T12, 31 patients were female.

RESULTS

The results of this descriptive analysis are described in the tabulated and graphical representation. The important descriptions of statistical analysis are given here for evaluation. Out of 70 patients, the majority 54 patients i.e. 77.1% were in the age group of the 20-30 years, 10 patients i.e. 14.3% were in the age group of 31-40 years, 5 patients i.e. 7.1% were in the age group of 41-50 years and the remaining 1 patient i.e. 1.4% was in the age group of 51-60 years. The majority 55 patients i.e. 78.6% were female while the remaining 15 patients i.e. 21.4% were male. The majority 61 patients i.e. 87.1% were from rural area while the remaining 9 patients i.e. 12.9% were from urban area. The majority 48 patients i.e. 68.6% were scaled "A" on ASIA Scoring system. 12 patients i.e. 17.1% were scaled "B" on ASIA Scoring system. 6 patients i.e. 8.6% were scaled "D" on ASIA Scoring system. 4 patients i.e. 5.7 were scaled "B" on ASIA Scoring system. The majority 41 patients i.e. 58.6% had the injury at the level of T8-T12, 15 patients i.e. 21.4% had the injury at the level of L1-L4, 9 patients i.e. 12.9% had the injury at the level of T1-T7 and the remaining 5 patients i.e. 7.1% had the injury at the level of C4-C7. The majority 37 patients i.e. 52.9% were injured due to fall from a height, 20 patients i.e. 28.6% were injured due to earth quake, 9 patients i.e. 12.9% were injured due to RTA, 3 patients i.e. 4.3% were injured due to gunshot injury and the remaining 1 patient i.e. 1.4% was injured due to bomb blast injury.

The cross tabulation tables shows the relationship between "age and level of injury", "Area and Cause", "level of injury and ASIA scale", "level of injury and causes" and between "level of injury and gender" respectively. The result shows that out of 54 patients that were from the age group of 20-30 years, 30 had the injury between the levels of T8-T12, out of 61 patients that were from rural area, 33 were injured due to fall from height, out of 41 patients that were injured between the levels of T8-T12, 29 were scaled ASIA "A" and out of 41 patients that were injured between the levels of T8-T12, 22 patients were injured because of fall from height, out of 41 patients that were injured between the levels of T8-T12, 31 patients were female.

DISCUSSION AND RECOMMENDATION

The demographical study of SCI shows that the most affected age by SCI is the age group of 20- 30 while the literature review shows the mean age of 28.3 which support the results of our study. [14] As the risky tasks and works are done by young people in our society which exposes them to more risk as compared to the people that

fall in the elder age groups. The safety measures should be taken to avoid such injuries during climbing a pole or doing any work related to climbing on height. The safety measures include wearing safety belts, helmets and other safety equipment. Sign boards should be used in hilly area for precaution of hikers and tourists. They should be pre-educated and guided for taking preventive measures to avoid fall form heights. The second major cause of SCI is RTA and it is supported by our study. For the prevention of SCI due to RTA, not just the drivers but also the passengers must be educated to wear seat belt.

As in most of the previous studies a relatively younger population in the second and third decade of life was predominately affected. In this age group life is characterized by high risk activities such as rash driving, climbing on trees and on moving vehicles resulting in an increased risk for SCI. This age group represents the most productive years of one's life, hence the need for a comprehensive spinal rehabilitation program to ensure transition back into mainstream society.[15-22]

In developed countries the male predominance is more than female with the ratio of 4:1[18] to 13.5:1[16,20] in developing countries. While our study reveals the ratio of 1:3.5 Male/Female ratio which contradicts the values of literature review. The difference between the values of our study and the other studies is because of participation of female earth quake victims in the study. Otherwise our society is male dominant and most of the outdoor work is done by males which expose them to more risk of injury during driving or injury at work.

The major cause of SCI was falls in developing countries like Bangladesh.[23] India[20] Turkey,[21] Nigeria[19] and Nepal.[24] While also in the developed countries like Canada[25] and UK,[26] which support the results of our study which shows the major causes of SCI due to fall from height. The subjects participated in our study were mostly from hilly areas and there cause of injury was mostly fall from height i.e. from hill top and fall from trees. The female victims used to climb the walnut trees, which is the leading cause of fall incidents. Proper education of people from such areas should be done and to tell them the consequences for not taking precautions.

The study shows that the majority of SCI patients were injured at T8-T12 level. From such results we concluded that spinal cord injury is most common at the junction of the mobile and the fixed segment. The prevention and management of such injuries should be done accordingly.

Another aspect which has been highlighted by this study is the poor system of spinal trauma evacuation in the country. Ambulance evacuation to hospital was available to only 18 patients. Not even a single patient was provided with spinal board, which is the standard of care of a spinal injured patient in the west.[27] Immobilization of the spine is mandatory in order to avoid inciting secondary neurological damage.[28]

CONCLUSION

In the light of the results obtained from the data it has been shown that the most common age groups affected with SCI is 20-30 years. The most common cause of SCI in the area under study was found to be falls. About the level of injury it was found out that most injuries can be classified as class A according to the ASIA scoring. Also the level of spinal cord that is most susceptible to injury was found to be T8-T12. This data can be very helpful in formulating methods for prevention and minimizing the amount of damage that may occur as a result of any trauma. A properly trained and efficient paramedic staff and well equipped trauma centers can be of crucial importance in reducing the level of lifelong disability that occurs as a result of SCI. Also by educating the general public about the common causes and the essential need to prevent such injuries from occurring will reduce the burden of disabled persons from the community.

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