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Epidemiological Characteristics and Respiratory Impairments in Patients with Traumatic Spinal Cord injury

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KEYWORDS

Abstract

Background: Spinal cord injury (SCI) is a debilitating condition that can lead to various secondary complications, including significant respiratory impairments. Understanding the epidemiological characteristics of SCI patients and the nature of their respiratory challenges is crucial for improving patient care and outcomes.

Study design and subjects: Descriptive analysis of data of patients with SCI admitted to Pravara Rural Hospital, Loni, Maharashtra. from Jan 2020 to Dec 2023.

Objectives: To identify the epidemiological characteristics of Cervical and Thoracic SCI and respiratory impairments in patients with SCI.

Setting: Smt.Sindhutai E.Vikhe Patil SCI Rehab Centre, Pravara Rural Hospital, Loni, Maharashtra.

Methods: A total of 43 patients with traumatic spinal injuries were included in the study. The patient characteristics that were included were age groups, Height, Weight, BMI, Cause of injury, neurological level of injury and Respiratory impairments.

Results: The maximum number of patients was in the age range of 20 to 40 years. There were 43 patients with neurological deficit. Mechanisms of injury recorded were fall from height (4.60%), motor vehicle accidents (95%).The different levels of spine that sustained injuries were High tetraplegics (20.9%) , Low tetraplegics (18.6%) High paraplegics (41.8%), Low paraplegics (18.6%).

Conclusion: This study gives a preliminary overview of the characteristics of patients and common respiratory impairments in patients with SCI.

Introduction:

Traumatic spinal cord injury (TSCI) is a life changing neurological condition with substantial socioeconomic implications for patients and their care-givers. TSCI usually occurs suddenly due to an accident and it causes momentous permanent damage, leading to significant changes in people's quality of life.[1]

Various epidemiological studies have been carried out in different parts of the world. The incidence of TSCI varies from 9.2 to 56.1 per million, which is influenced not only by research methodology but also by social, economic, geographical, demographic and political characteristics of the region. In the Indian setup, as in most developing countries, very little is known about the exact incidence of SCI. Approximate 20,000 new cases of SCI are added every year.[2]

After SCI, there is important limitation in activities, and restriction in participation such as transfers and locomotion, selfcare activities, difficulties in regaining employment, and in sexual life, leading to serious complications regarding the adaptation of affected patients. As the level of injury increases, the functional loss in SCI becomes even greater. The more rostral the level of injury, the more likely the injury will affect ventilation. In fact, respiratory insufficiency is the number one cause of mortality and morbidity in tetraplegic patients. People with SCI are at increased risk of chronic respiratory symptoms, added disability, and early death from respiratory complications where

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respiratory function following a SCI is primarily associated with injury level. Patients may lose up to one level of injury within the first few days of injury as a result of cord swelling or bleeding, making this an especially high-risk period.[3]

A patient with a complete injury above C5 will typically have impaired diaphragm function and is likely to require a period of endotracheal intubation and mechanical ventilation. A C5 injury level may also involve diaphragm weakness but is associated with the ability to breathe independently. Impaired inspiration, lack of cough strength, and no movement of the hands, trunk and lower limbs are seen. A patient with a complete T12 classification will have no observable inspiratory or expiratory impairment, full upper body strength, good trunk strength and balance but no movement of the lower limbs. [4] An understanding of this classification allows the clinician to predict the likely needs and respiratory management of their patient.

Neurological Level	Dysfunctions in Acute stage [5]
C1–C3	Likely full time, ventilator dependent secondary to severe diaphragm weakness (paralysis) May be able to come off ventilation for brief period if able to adequately self-ventilate using frog/ Potential candidate for diaphragm pacing
C3–C4	Diaphragm function will be impaired, reducing tidal volume and vital capacity Periods of unassisted ventilation (ventilator-free time) are likely and may be adequately supported with nocturnal ventilation alone Domiciliary ventilatory support may be noninvasive, particularly if lung volumes are high enough during day while seated
C5	Independent respiration possible long term although initial ventilatory support common Diaphragm function intact but intercostal and abdominal muscle paralysis results in decreased lung volumes, cough strength and effectiveness
C6–8	Independent breathing People with lesions caudal to C7 typically can augment inspiration and cough with accessory muscles, particularly pectoralis major and minor
T1–T4	Inspiratory capacity and forced expiration supported by intercostal activity; however, cough efficacy remains reduced secondary to abdominal (expiratory) weakness
T5–T12	Progressive relative improvement in muscle strength at descending lesion levels Minimal disruption to autonomic dysfunction affecting the cardiovascular system below T6

Secondary complications of the respiratory system occur in 50% of persons during the acute postinjury period, and they rival urinary tract dysfunction in terms of severity and frequency, among persons with complete tetraplegia especially with high level and among the elderly.

Conditions associated with SCI that contribute to increased respiratory dysfunction with increased risk of specific complications such as pneumonia and respiratory failure involve mechanical problems due to loss of neural control mechanisms, respiratory muscle paralysis, impaired cough, decreased inspiratory capacity, hypoventilation, less effective mucociliary clearance of secretions, aspiration, apnea, exaggerated bronchospasm, atelectasis, and skeletal deformities of the spine and chest. [5]

Jackson and Groomes reported that 67% of persons hospitalized with recent SCI experienced 544 respiratory complications, with atelectasis being the most common (36.4%), followed by pneumonia (31.4%) and ventilatory failure (22.6%). Another recent study of persons hospitalized for acute traumatic cervical SCI showed that respiratory complications, specifically the requirement for mechanical ventilation, occurrence of pneumonia, or use of tracheostomy, were more important in determining length of hospitalization and hospital costs than the level of injury.[6]

SCI represents a life threatening event triggering a profound stress response mirrored by hypercortisolism indicating a stress response capable of mobilizing the body's energy, which can decrease lean body and muscle mass. As the recent studies have determined the association of body mass with mortality risk.[7]

This epidemiological study provides information regarding the magnitude of respiratory problems after

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SCI and resultant demands on medical and social resources. Additionally, it strives to assist in identifying the risk factors involved in SCI. It may also help to formulate preventive measures which may modify or eliminate the risk factors and may decrease the incidence of this incapacitating injury.

Objectives:

1. To identify the epidemiological characteristics of cervical and thoracic spinal cord injury.
2. To see the common respiratory impairments in spinal cord injury patients.

Methodology

In the Present Study, 43 patients with traumatic spinal injuries from Jan 2020 to Dec 2023 were included from the Smt. Sindhutai E.Vikhe Patil SCI Rehab Centre, Pravara Rural Hospital and reviewed. Data that were recorded consisted of age, gender, height, weight, BMI, neurological level of injury, cause of injury and respiratory impairments. Neurological level and extent of injury were defined using the international standards set forth by the American Spinal Injury Association (ASIA). The neurological level of injury was defined as the most caudal segment of the spinal cord with normal sensory and motor function on both sides of the body. They were categorized as having high tetraplegia (injury level C2-C5 impairment of diaphragm function expected) , low tetraplegia (C6-C8, normal diaphragm function expected), high paraplegia (T1-T7, sympathetic impairment expected), low paraplegia (T8-L5, normal sympathetic function expected). Completeness was categorized as complete, incomplete. Etiology of injury was categorized into two groups. Motor vehicle accidents (MVA) included accidents that occurred while the subject was traveling in a vehicle as well as pedestrians hit by vehicles. Fall from a height included falls from buildings and trees and leading to spinal injuries.

Results and findings

Table 1. Epidemiological Patients Data

Patients Particulars	**No of Patients**
Total Cancer patients included in the study	43
Gender	
Male	40
Female	03
Body Mass Index	
< 18	03
18-24	28
25-29	12
Cause of Spinal cord Injury	
Fall from Height	2 (4.6%)
Road Traffic Accident	41 (95.4%)
Neurological Level of SCI	
High Tetraplegia	9 (20.9)
Low Tetraplegia	8 (18.6)
High Paraplegia	26 (60.4)
Completeness of SCI	
AIS A	27 (62%)
AIS B	8 (18.60%)
AIS C	4 (9.30%)
AIS D	4 (9.30%)
Time from injury to admission to Rehab centre	
0 to 6 months	17
7 to 12months	23

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1 year or >1 year	03

Table 2. Respiratory impairments for people admitted with acute SCI.

Level of Injury	Pulmonary functions Interpretation	Peak cough flow Range
High tetraplegia (C2-5)	Severely Reduced	80-120 L/Min
Low tetraplegia (C6-C8)	Moderately Reduced	150-250 L/Min
High paraplegia (T1-T7)	Mildly reduced	250-350 L/min

Discussion

The abrupt onset of SCI is tragic and has a profound impact on the individuals and their families. Knowledge of epidemiology of SCI in a given country is important not only for planning of resources, but also for adequate treatment and rehabilitation. Most of the studies in medical literature are from advanced countries where the problem and presentations are different with respect to mode of injury, sex, incidence etc. Though this study may not be a true representation of epidemiology of all spinal injuries in the society, as it is restricted only to one institute, it can best be taken as the trend, as we receive patients from a vast area, the institute being the only medical college in the state.

The age distribution of patients is comparable with studies from the other parts of the India and other parts of the world. Most common affected age group being 20-40 years signifying higher incidence in young, active, and productive population of the society. Higher incidence in males can be explained by examination of etiological factors, men being more exposed to risk factors since they are more active on account of occupation. Road traffic accident (RTA), fall from tree, were commoner in males.

The mean age at injury of 36.2 years in our study is more or less similar to that in studies from Turkey,[7] and other studies from India, less than that in the studies from the USA (37.6 years). A closer look reveals that studies in which mean age was lower (as in our study) are older studies. Other study conducted by N Mathur.et.al supports our study and stats that out of 2716 cases seventy-one percent SCI patients were in the age range of 20–49 years. This is an alarming condition where the most active human resource is becoming severely disabled resulting in loss of family earning in nuclear families. This affects their day-today life, including medical treatment due to financial constraints and non-availability of care taker. Joint families overcome this problem to some extent where other members of the family are likely to support the patient and his family. However, it is a universal fact that SCI affects the most productive age group of society and ultimately affected family is in a precarious position.[8]

SCI Patients are predominantly male, though the ratio varies considerably within developed and developing countries. This lower predisposition of Indian females to Traumatic SCI may be due to the fact that most Indian females are housewives. India has one of the lowest percentage of female professional and technical workers (20.5%).However, as witnessed in developed countries, the incidence in women is likely to increase with time.[9]

In the current study, the mean range of BMI was 19-24 kg/m^2 with in normal limits. BMI is important findings which suggest that the metabolic impact observed with the increasing probability of developing a Non-alcoholic fatty liver disease (NAFLD) diagnosed by detecting BMI thresholds.[10]

BMI assessment after SCI is associated with change in the risk of mortality rate a study conducted by Fallah N.et.al gives information about the effect of BMI on survival after SCI, in this cohort study 742 patients were included and result showed being underweight at admission was significant risk factor for mortality up to 7.7 years after SCI and concluded that mortality risk (1 month to 7.7 years after SCI) was associated with difference in BMI at admission.[11]

Falls and RTA comprise two major causes of SCI in the present study. However, falls were found to least cause of SCI in keeping with findings of other studies in the country (Hoque et al, 1999; Islam et al, 2011; Razzak et al, 2011).Similar increased trends of SCI caused by RTA have also been noticed recently in Jammu (Manjeet et al, 2009) and other places in India (Chhabra and Arora, 2012). A few factors that could be responsible for the increase in transport accidents in recent years are:

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increased urbanisation and the number of motorised vehicles, less public awareness, insufficient number of roads and highways, and poor road infrastructure, unskilled drivers, incompetent traffic systems, weak legislation, rise in number of faulty and non-standard vehicles on the road.[12,13,14]

The WHO report on SCI (World Health Organization, 2013) stated that spinal cord injury is preventable. Since falls and RTA are the two major causes of SCI, preventive measures should be employed. The government and the concerned international non-government organizations should initiate such preventive programmes immediately.[15]

The time from injury to admission to the Rehabilitation centre was also considered in our study which will give a rough idea about the status of patient we received for the rehabilitation. The duration or Time to admission (TTA) was considered from 0 – 6months we received 17 patients, 7-12 months we received 23 patients and 12 or more than 12 moths we received 3 patients. The time from injury to admission to rehabilitation was considered as it may help in improving the ASIA impairment scale (motor recovery). A study conducted by Scivoletto G. et.al gives idea about the importance of early versus delayed inpatient spinal cord injury rehabilitation, in their multicentre retrospective study they found an average TTA of 55 days for traumatic SCI and reported that, in all cases TTA exceeded 30 days. In our study we TTA for rehabilitation exceeded more than 6 months.[16]

Respiratory complications remain the most common cause of mortality following SCI. Patients are most vulnerable to respiratory illness in the first year after injury but continue to suffer from respiratory complications throughout life. The most important determinants of the extent of respiratory compromise after SCI are the patterns and level of motor, sensory and autonomic neurological impairment.[17]

Respiratory Impairments

Cough:

In this study, there was severe reduction in peak cough flow in high tetraplegic, low tetraplegics patients, moderate reduction in peak cough flow in high paraplegic patients and mild reduction in peak cough flow in low paraplegic patients. Hence above findings indicate that ability to produce an effective cough is severely impaired in patients with cervical Level.[18]

Patients who have loss of innervation to the abdominal muscles and the internal intercostals lose the ability to produce a forced expiration. De Troyer and Estenne[19] have shown that patients with injuries at C5–C8 can utilise the clavicular portion of pectoralis major to generate an expulsive force, although the extent to which this is clinically important is unclear. Linn et al. found that in a group of patients with high tetraplegia, peak expiratory flow rate was <50% of predicted normal values. The most effective peak cough flows can be achieved with a positive pressure-supported inspiration followed by expiration augmented by negative pressure or an assisted cough.[20]

A similar study conducted by Kwan-Hwa L.et.al supports our study that spinal cord injury is contributing factor for reducing the cough threshold. The unopposed vagal efferent in the subjects with SCI increased their discharge to augment cough sensitivity. The influence for lower thoracic injuries would be less. People with chronic SCI may have morphological or osmolality changes in the airway epithelium to increase the exposure of the receptor to chemical irritant, thus increasing the vagal afferent or efferent activities and hence reduces the cough threshold.[21]

Pulmonary Functions:

The present study showed that Pulmonary Functions are severely reduced in High Tetraplegic patients, moderately reduced in Low tetraplegic patients and mildly reduced in high and low paraplegic patients. Hence the above findings suggest that pulmonary functions are severely reduced in High level injury patients.

In SCI injuries, there is flaccid paralysis of the intercostal and abdominal muscles, with marked paradoxical abdominal and thoracic movement, and a reduction in vital capacity to approximately 60% of the predicted value in tetraplegia and 40 % in paraplegia.[22,23]

The paradoxical breathing pattern is due to the diaphragm contracting against an unstable rib cage and is more marked following cervical injuries. Truncal and intercostal tone increase with time, stabilising the rib cage and returning the vital capacity to approximately 60% of the pre-injury level.[24] A progressive reduction in the functional residual capacity also occurs during this time, associated with atelectasis and basal pulmonary fibrosis.[25]

Expiratory muscle function is more compromised than inspiratory muscle function among subjects with tetraplegia and high paraplegia, which can result in ineffective cough and propensity to mucus retention and atelectasis. Thus disruption in the inspiratory and expiratory muscles function, is reflected by reduction in spirometric and lung volume parameters.[26]

Hence, this study gives a preliminary overview of the characteristics of patients and common respiratory impairments in patients with spinal cord injury.

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References

[1] Nas K, Yazmalar L, Şah V, Aydın A, & Öneş K. Rehabilitation of spinal cord injuries. World J Orthop. 2015 Jan 18; 6(1): 8–16.

[2] Mathur N, Jain S, Kumar N, Srivastava A, Purohit N & A Patni. Spinal Cord Injury: Scenario in an Indian State. Spinal Cord 53, 349–352 (2015).

[3] Como JJ, Sutton ERH, McCunn M. Characterizing the need for mechanical ventilation following cervical spinal cord injury with neurologic deficit. J Trauma Acute Care Surg 2005; 59: 912–916

[4] Hassid VJ, Schinco MA, Tepas JJ. Definitive establishment of airway control is critical for optimal outcome in lower cervical spinal cord injury. J Trauma 2008; 65: 1328–1332

[5] Berlowitz DJ, Wadsworth B, Ros J. Respiratory problems and management in people with spinal cord injury. Breathe 2016;12:328-340

[6] Lucke KT. Pulmonary management following acute SCI. J Neurosci Nurs. 1998;30:91–104

[7] Wen H, Devivo MJ, T,Kaur Baidwan N & ChenY. The impact of body mass index on one year mortality after spinal cord injury. J Spinal cord Med.(2021)44:563-71

[8] Burke DA, Linden RD, Zhang YP, Maiste AC, Shields CB. Incidence rates and populations at risk for spinal cord injury: a regional study. Spinal Cord 2001;39:274-278.

[9] Biering-Sørensen F, Pedersen V, Clausen S. Epidemiology of spinal cord lesions in Denmark. Paraplegia 1990; 28: 115–118.

[10] Loomis AK, Kabadi S. Body mass index and risk of non-alcoholic fatty liver disease:two electronic health record prospective studies.J Clin Endorinol Metabol.2016;101(3):945-952

[11] Nader F, Noonan VK, Thorogood NP, Kwon BK. Effect of body mass index on survival after spinal cord injury. Front.Neurol.Jan 2024;14:645-51

[12] Hoque M. Spinal cord lesions in Bangladesh: an epidemiological study. International Medical society of Paraplegia.1999;37:858-861.

[13] 13.Manjeet S, Siddhartha S, Iftikhar WH, Agnivesh T. Spine injuries in a tertiary health care hospital in Jammu- A clinic-epidemiological study. The Internet Journal of Neurosurgery.2008;5:1-5

[14] Chhabra HS, Arora M. Demographic profile of traumatic spinal cord injuries cetntre with special emphasis on mode of injury: a retrospective study.2012;10;745-754.

[15] Jagnoor. Road traffic injury prevention: a public health challenge. Indian J Community Med 2006;31:129-131.

[16] Scivoletto G, Morganti B, Molinari M. Early versus delay inpatient spinal cord injury rehabilitation: an Italian study. Arch.Phys Med Rehabil March 2005;86;512-516

[17] Roth EJ, Lu A, Primack S. Ventilatory function in cervical and high thoracic spinal cord injury: relationship to level of injury and tone. Am J Phys Med Rehabil 1997; 76: 262–267.

[18] Wang AY, Jaeger RJ, Yarkony GM. Cough in spinal cord injured patients: the relationship between motor level and peak expiratory flow. Spinal Cord 1997; 35: 299–302.

[19] De Troyer A, Estenne M. The expiratory muscles in tetraplegia. Paraplegia 1991; 29: 359–363.

[20] Linn WS, Adkins RH, Gong H Jr. Pulmonary function in chronic spinal cord injury: a cross-sectional survey of 222 southern California adult

outpatients. Arch Phys Med Rehabil 2000; 81: 757–763

[21] Kwan- Hwa L, Yih Loong L, Huey Dong W, Tyng Quey W, Yen Ho W. Cough threshold in people with spinal cord injuries. Physical Therapy1999;79(11):1026-1031

[22] Ledsome JR, Sharp JM. Pulmonary function in acute cervical cord injury. Am Rev Respir Dis 1981; 124: 41–44.

[23] Baydur A, Adkins RH, Milic-Emili J. Lung mechanics in individuals with spinal cord injury: effects of injury level and posture. J Appl Physiol 2001; 90: 405–411.

[24] Morgan MD, Gourlay AR, Silver JR. Contribution of the rib cage to breathing in tetraplegia. Thorax 1985; 40: 613–617.

[25] Haas F, Axen K, Pineda H. Temporal pulmonary function changes in cervical cord injury. Arch Phys Med Rehabil 1985; 66: 139–144.

[26] Gregory J, Lesser M, Ann M. Pulmonary function and spinal cord injury. Respiratory Physiology and Neurobiology 2009: (3):129-141