Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6, 5438-5445
2024
Publisher: Learning Gate
DOI: 10.55214/25768484.v8i6.3208

Analysis of factors affecting the incidence of Pneumonia, length of stay in intensive care unit (ICU), and mortality in traumatic cervical spinal cord injury (tCSCI) patients after surgery

Wahyu Wiswa Wardhana[1,2*], Bambang Pujo Semedi[1,2], Dhania Anindita Santosa[1,2], Hamzah[1,2], Christrijogo Sumartono W.[1,2]
[1]Departement of Anesthesiology and Intensive Care, Dr Soetomo General Academic Hospital, Surabaya; wahyuwwardhana@gmail.com (W.W.W.).
[2]Departement of Anesthesiology and Intensive Care, Faculty of Medicine – UNIVERSITAS AIRLANGGA, Surabaya;

Abstract: Spinal cord injury is a condition that has a catastrophic impact on the clinical, social, and economic well-being. It has a poor prognosis as it leads to neurologic impairments, as well as disruption of the diaphragmatic muscles. This condition is one of the risk factors associated with increased morbidity and mortality. All ICU patients who met the inclusion and exclusion criteria at Dr. Soetomo Hospital between January 2023 and January 2024 had their Electronic Medical Records (EMR) data used in this retrospective analytical study. The 38 patients in the sample were collected. All of the samples were male, and their average age was 45 years. Of these, 11 patients (29%), had 30-day mortality, while 21 patients (55%), had pneumonia. The majority of patients (n = 16; 42%) were classified as AIS A, and the lower cervical area was the most often affected lesion site (16; 42%). The most frequent mode of injury was falling from a height including 24 patients (63%). Fifteen patients (39%) underwent tracheotomies. Tracheostomy was the risk factor that affected the duration of ICU hospitalization ($p<0.001$) and the incidence of 30-day mortality ($p=0.012$; OR 7.61). The multivariate logistic regression analysis revealed no correlation between any of the covariates and the incidence of pneumonia. In other hand, tracheostomy is one factor that affects 30-day mortality and length of stay in the intensive care unit.

Keywords: *Cervical spinal cord injury, Length of hospitalization, Mortality, Pneumonia, Trauma.*

1. Introduction

The clinical, social, and financial well-being of the patient and their family is severely impacted by spinal cord injury. Autonomic, motor, and sensory abilities are all compromised as a result of this injury. The prognosis is typically poorer for injuries to the cervical spine. The phrenic nerve, which controls diaphragm function, is damaged by traumatic cervical spinal cord injury (tCSCI). Sixty five percent of respiratory function is attributed to the diaphragm muscle. This illness is thought to be one of the main risk factors for both morbidity and mortality [1,2,3]. According to a meta-analysis of 47 research from 23 developing nations, the highest prevalence of cervical spinal cord injury (tSCI) was 43.4% [4], while the highest mortality rate was found in patients with ASIA A, at 20.57% [5]. According to estimates, hospital mortality rates vary from 4% to 17%. Following hospital discharge, the average mortality rate is 3.8% for the first year, 1.6% for the second year, and 1.2% for the subsequent years. Patients with cervical lesions, multiple trauma, sepsis, elderly, and severe injury mechanisms are at a higher risk of death [1].

Reduced respiratory function results from neurological deficits in CSCI, such as paralysis of the neck, chest wall, and abdominal muscles, including the diaphragm and intercostal muscles. This causes the tidal volume to decrease, which causes atelectasis and hypoventilation, which are frequently accompanied by an increase in mucus secretion. Respiratory failure may result from inadequate mucus

* Correspondence: wahyuwwardhana@gmail.com

clearing. According to earlier research, patients with high cervical lesions are more likely to require mechanical ventilation for this illness. Long-term use of mechanical ventilation, however, makes weaning more difficult and raises the risk of ventilator-associated pneumonia (VAP), which lengthens hospital stays in intensive care units and raises medical expenses [3]. The number of comorbidities, trauma mechanism, concurrent injuries, need for mechanical ventilation, tracheostomy, degree of cervical lesion, AIS classification, length of surgery, length of surgery, amount of bleeding, and surgical position are some of the risk factors found in earlier studies. The investigator sought to examine the correlation between these risk factors and 30-day mortality, ICU length of stay, and pneumonia incidence.

2. Method

Analytical retrospective methodology was used in this study, and secondary data from Dr. Soetomo Hospital's intensive care unit patients' electronic medical records from January 2023 to January 2024 were used. There were 89 patients in the study's total sample. A final sample size of 38 participants was obtained by excluding 50 patients for non-trauma reasons, 4 patients with conservative management, and classifying 2 patients as dropouts because of readmission.

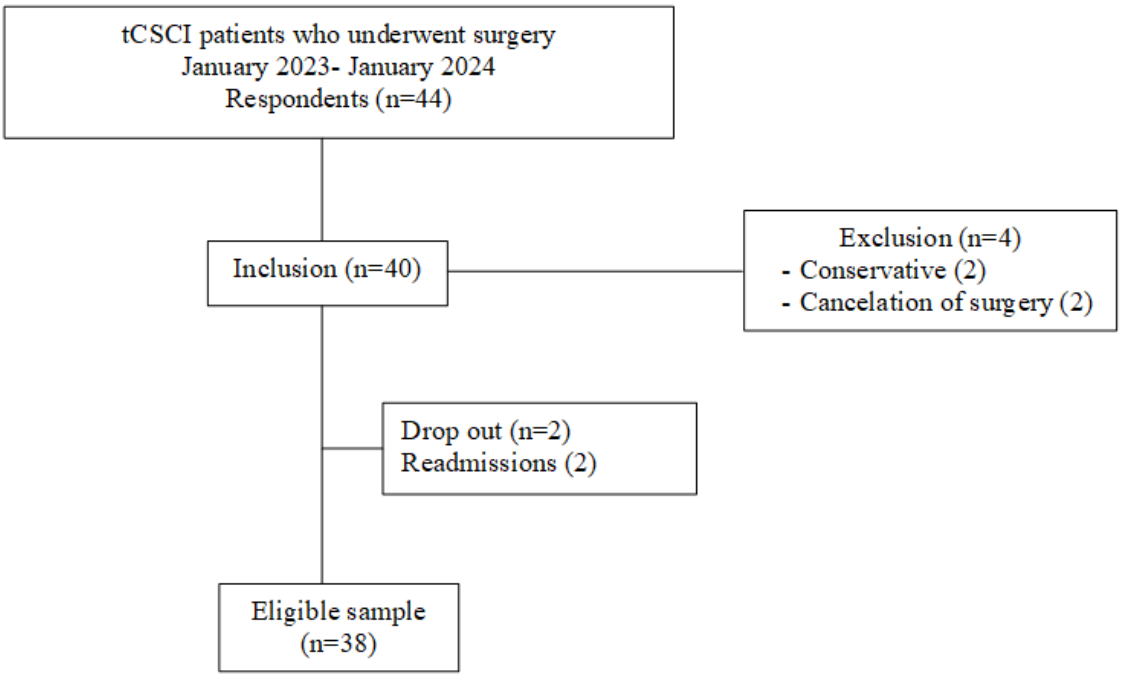

Figure 1.
Research sample recruitment process.

The study's inclusion criteria were age more than 18, post-operative cervical trauma with posterior stabilization, and ICU hospitalization at Dr. Soetomo General Hospital. Previously diagnosed sepsis, conservative treatment, significant brain injury, spinal surgical history, and inadequate data were among the exclusion criteria. If a patient was readmitted to the intensive care unit or had an unanticipated extubation during the post-operative care period during the same observation period after posterior stabilization surgery, they were classified as dropouts.

3. Result

The average age of the 38 patients in this study was 45.67 years, and they were all male. At Dr.Soetomo hospital, TCSCI patients spent an average of 10 days in the ICU and 29.82 days overall. Pneumonia was identified in 21 out of 38 individuals (55%) of the total. Of the patients in the 30-day

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6: 5438-5445, 2024
DOI: 10.55214/25768484.v8i6.3208

mortality variable, 11 (29%) died. In terms of patient characteristics, AIS A had the highest percentage (16 patients, 42%), followed by AIS C (13 patients, 34%). There were lower portion of cervical lesions (16 patients, 42%) than upper and lower cervical lesions (13 patients, 34%). Falls from a height accounted for 24 cases (63%) was the most frequent mechanism of damage, while vehicle collision occurring in 13 patients (34%). Out of the 38 patients, 15 (39%) had a tracheotomy, and 9 (60%) had a tracheostomy after 7 days. With 29 patients (76%), the majority of patients who were scheduled for surgery had procedures that lasted longer than 48 hours.

Table 1.
Demographic characteristics of the study subjects.

Sample characteristics (n=38)	**f (%) mean± SD median (Min.-Max.)**	
Sex		
Male	38	100%
Female	0	0%
Age	45,67 ± 14,18	
	44 (15-72)	
Occupation		
Farmer	13	34%
Self-employed	16	42%
Day laborers	2	5%
Student	3	8%
Construction worker	2	5%
Others	2	5%
Identity address		
Surabaya	3	8%
Luar Surabaya	35	92%
Weight	63,95 ± 7,88	
	65 (45-80)	
Height	164 ± 4,54	
	165 (155-174)	
BMI	24 ± 2,40	
	24 (18,49-28,68)	
EBV	4476 ± 551,41	
	4550 (3150-5600)	
Previous treatment room		
Low care	3	8%
High care	24	63%
Intensive care	11	29%
Physical stase based on ASA classification		
4	9	24%
3	29	76%

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6: 5438-5445, 2024
DOI: 10.55214/25768484.v8i6.3208

Table 2.
Distribution of study outcome.

Sample characteristics (n=38)	f (%) mean±SD median (min-max)	
Total length of hospital stay (days)	29,82 ± 17,78	
	28 (8-80)	
Total length of ICU hospitalization (Days)	10 ± 14,07	
	3 (1-67)	
≤ 7 hari	24	63%
>7 hari	14	37%
Pneumonia		
Yes	21	55%
No	17	45%
Mortality in 30 days		
Yes	11	29%
No	27	71%

Among the six factors that satisfied the requirements for bivariate analysis, tracheostomy procedures were found to have a significant impact on the duration of ICU stay (p-value < 0.001). Furthermore, tracheostomy was found to be a factor impacting the 30-day mortality incidence in multivariate analysis, with a p-value of 0.012 (OR 7.61), among the four independent variables that passed bivariate analysis.

Table 3.
Characteristics of the independent variables.

Sample characteristics (n=38)	f (%) mean SD (Min.-Max.)	
AIS		
A	16	42%
B	6	16%
C	13	34%
D	0	0%
E	3	8%
Level of cervical injury		
High cervical	9	24%
Low cervical	16	42%
Multiple segment	13	34%
Comorbid		
0	6	16%
1-2	22	58%
≥3	10	26%
Associated Injury		
0	14	37%
1	12	32%
≥2	12	32%
MOI		
Fall from height	24	63%
Vehicle Collision	13	34%
Others	1	3%

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6: 5438-5445, 2024
DOI: 10.55214/25768484.v8i6.3208

Sample characteristics (n=38)	f (%) mean SD (Min.-Max.)	
Preceding infection		
Yes	12	32%
No	26	68%
Postoperative ventilator use		
Yes	35	92%
No	3	8%
Tracheostomy		
Yes	15	39%
No	23	63%
Trakeostomy (n=15)		
Early	6	40%
Late	9	60%
Operating position		
Supine	9	24%
Prone	27	71%
Combine	2	5%
Amount of hemorrhage	394,08 ± 354,48	
	275 (50-1500)	
Duration of surgery (minutes)	323,82 ± 127,18	
	300 (160-660)	
Waiting time for surgery (days)	10,73 ± 10,69	
	7 (1-53)	
<24 hour	0	0%
24-48 hour	9	24%
>48 hour	29	76%

4. Discussion

All of the participants in this study are predominantly self-employed in vocations, as the primary sector having the largest percentage at 42% (16 patients). Other occupations have lesser numbers, each below 5%, whereas farmers have the second-highest percentage at 34% (13 patients). This proportion is consistent with earlier studies showing that 75% of participants are men [6]. The ratio of female tCSCI patients to male patients is 4:1 [7], according to another Chinese study. Another research, however, claims a female-to-male ratio of 3:1, which is more than twice the earlier number [8]. Male and female lifestyle variations could be the cause of this disparity. Women are more inclined to work in lower-risk industries like housekeeping, whereas men are more likely to work in high-risk fields like construction because of their great desire to serve others [7,9]. The study sample's average age was 45 years, with the youngest participant being 15 and the oldest being 72 in age. According to a prior study, the average age of CSCI cases was 50 years old [10]. According to a different study, TCSCI usually strikes people between the ages of 45 and 65, with an average age of 54 [8]. A peak incidence age of 37 years, within the most common age range of 20-39 years, and a younger average age of 29.1 years, with an age range of 15-30 years were identified in two more investigations [11]. According to the studies, this age group in particular, those between the ages of 25 and 49 represents an active demographic in Brazil [8].

According to a number of additional research [12,13,14], farming is the occupation most frequently linked to TSCI. Low educational backgrounds are the main cause of this finding since they restrict access to formal career possibilities and raise the risk of SCI [14]. Spinal shock was the most frequent complication in the High Care Unit (HCU), where the majority of patients in this study received treatment. In more severe situations, however, patients required intensive care unit (ICU) admission due to bradycardia, severe hypotension, a history of cardiac arrest, and frequently respiratory problems such hypoventilation and CO_2 retention. Three of the 43 patients study died of cardiac arrest in the intensive

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6: 5438-5445, 2024
DOI: 10.55214/25768484.v8i6.3208

care unit (ICU) for serious injuries or complicated sequelae [13]. The probability of people with ASIA C, ASIA D, and ASIA E arriving at a spinal trauma center within 24 hours progressively declined, whereas 91.9% of people with ASIA A and 94.4% of people with ASIA B were able to do so. Additionally, the findings indicate that individuals with lower neurological function were more likely to need surgery, had more associated injuries, and have been injured by high-energy mechanisms [13].

However, falls from height are more frequently correlated to upper cervical injuries. Younger patients are more likely to sustain lower-level cervical injuries, whereas elderly patients who are more prone to falls are more likely to sustain upper-level cervical injuries. Because of its smaller diameter at this level, the lower cervical spinal cord is anatomically more susceptible to damage after high-velocity trauma, like that which occurs in sports. The spinal canal is substantially narrower at the C6 level than it is at the C1 and C3 levels, according to studies. Furthermore, C3's canal diameter is narrower than C1's. Additionally, aging is linked to a reduced canal diameter. Regardless of the cause of the accident, individuals 65 to 75 years of age and older are more prone to sustain upper cervical spine injuries, as do patients who fall from a height at any age [10]. The diaphragm is the most significant respiratory muscle, as is well known, and its action is triggered by the phrenic nerve, which emerges from the anterior branches of C3-5. Cervical injury causes more severe respiratory system impairment because the degree of cervical injury enhances the loss of diaphragm and intercostal muscle function [15]. With the highest proportion in the lower cervical lesions (16 patients, 42%) at C5-C7 and several segments (13 patients, 34%) at C1-C7, the study's categorization boundaries were set at C4 for the upper limit and C5 for the lower limit, which also influenced the results. Twenty-one patients (55%) had respiratory problems of pneumonia.

Nineteen patients (31%) with upper cervical SCI (C1-C5) experienced neurogenic shock, according to a trauma center's retrospective analysis. Reduced heart filling from vascular dilatation in the lower limbs brought on by a drop in sympathetic tone results in hypotension and shock. The first line of treatment is intravenous fluid resuscitation. When euvolemia is reached but hypotension still occurs, second-line treatment involves the use of vasopressors and inotropes. To maximize spinal cord perfusion, the mean arterial pressure should be kept between 85 and 90 mmHg for the first seven days. When utilizing vasopressors, care should be taken because their vasoconstrictive effects can make pre-existing injuries worse [16]. Dopamine inhibits pyroptosis, stops NLRP3 inflammasomes from activating, and lowers the production of pro-inflammatory cytokines after SCI. After SCI, dopamine helps to lessen nerve inflammation. Inflammatory cytokines linked to pyroptosis include interleukin (IL-1β) and IL-18. Reduced levels of IL-1β and IL-18 were linked to systemic dopamine administration following SCI in one study, indicating that dopamine regulates nerve inflammation after SCI. Cell death through pyroptosis is reliant on caspase activation (caspase-1, 4, 5, and 11). One cellular multiprotein complex that acts as a platform for caspase-1 activation is the NLRP3 inflammasome [17]. This disturbance of pro-inflammatory immunity could also account for CSCI patients' vulnerability to infections, such as pneumonia.

Weaning off of artificial ventilation earlier is made possible by early tracheostomy, which is associated to decreased respiratory strain and airway resistance. Additionally, this makes managing the airway easier. Furthermore, tracheostomy lowers the risk of aspiration, promotes oral nutrition, and protects against laryngeal damage. In patients who exhibit improved physiological status and better damage patterns, tracheostomy may be delayed in favor of a possible extubation trial[3]. This is in line with recent research showing that there are no clear guidelines about the best time to perform a tracheostomy. The patient's condition and the expense of care are factors in the decision to perform a tracheostomy. A higher prevalence of VAP and slower weaning processes can arise from delayed tracheostomy [18,22]. There are currently no established standard procedures for the ideal time to perform a tracheostomy. Additionally, in patients who may be candidates for extubation and have less severe AIS scores or brain impairment, doctors may choose to postpone tracheostomy. Other research, however, casts doubt on this clinical judgment's veracity. Overall, a large body of research suggests that early tracheostomy has two primary advantages: first, it shortens the time needed for adequate spontaneous breathing, which cuts down on both the amount of time spent on a ventilator and the amount of time needed for decannulation. Second, it reduces the length of stay in the intensive care unit,

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6: 5438-5445, 2024
DOI: 10.55214/25768484.v8i6.3208

as seen by lower 90-day readmission and mortality rates. This suggests that early tracheostomy improves patient safety and fosters clinical improvement [19].

For hospitalized tCSCI patients, respiratory failure is the primary cause of death (36–83%). Up to 80% of early in-hospital mortality in individuals exhibiting tetraplegia symptoms are caused by pulmonary problems. Respiratory problems are the leading cause of death (41.8%) [20]. The effectiveness of proper respiratory care in enhancing respiratory function is now widely known. Acute tCSCI mortality is also influenced by cardiovascular problems. In contrast to other criteria such clinical signs of injury, lesions above C5, and atelectasis. High secretion production was the strongest predictor of intubation, with a p-value of 0.0144 and an OR of 7.19. 32.5% of CSCI patients in a study who needed intubation later had an empiric tracheostomy, or early tracheostomy, without attempting extubation [21].

5. Conclusion

Multivariate logistic regression analysis revealed no factors were found to significantly influence the occurrence of pneumonia among the parameters studied. Tracheostomy, however, was found to be a factor linked to 30-day mortality and the length of stay in the intensive care unit. The effect of tracheostomy timing on the incidence of pneumonia, length of stay in the intensive care unit, and mortality with a larger sample size might be investigated further as there is no established recommendation about the timing of early versus late tracheostomy. It is expected that this study would provide a basic information evaluating of implementation and management for patients with tCSCI in Dr. Soetomo hospital, Surabaya.

Acknowledge:

We would like to thank the hospital, the Department of Anesthesiology and Intensive Care at, Dr Soetomo General Academic Hospital, Surabaya, and all of the advisers for their help, support, and revisions. This study was carried out without any special support from any source in order to complete the requirements for the educational program. There are no conflicts of interest in this study, according to the research team. Every author contributed to the planning, execution, assessment, and preparation of the manuscript. The ethics committee of Dr. Soetomo Surabaya Hospital obtained ethical permission with certificate number 1714/LOE/301.4.2/VII/2024.

References

[1] Ahuja, C.S., Wilson, J.R., Nori, S., Kotter, M.R.N., Druschel, C., Curt, A. and Fehlings, M.G. 2017. Traumatic spinal cord injury. *Nature Reviews Disease Primers* 3. doi: 10.1038/nrdp.2017.18.

[2] Apriawan, T., Wicaksono, P., Meizikri, R. and Subagio, E.A. 2021. Emergency surgery for traumatic spinal cord injury in a secondary hospital: A case report. *Surgical Neurology International* 12. doi: 10.25259/SNI_333_2021.

[3] Anand, T. et al. 2020. Time to tracheostomy impacts overall outcomes in patients with cervical spinal cord injury. In: *Journal of Trauma and Acute Care Surgery*. Lippincott Williams and Wilkins, pp. 358–364. doi: 10.1097/TA.0000000000002758.

[4] Golestani, A. et al. 2022. Epidemiology of Traumatic Spinal Cord Injury in Developing Countries from 2009 to 2020: A Systematic Review and Meta-Analysis. *Neuroepidemiology* 56(4), pp. 219–239. doi: 10.1159/000524867.

[5] Sadeghi-Naini, M. et al. 2023. In-hospital mortality rate in subaxial cervical spinal cord injury patients: a systematic review and meta-analysis. *Acta Neurochirurgica* 165(9), pp. 2675–2688. doi: 10.1007/s00701-023-05720-5.

[6] Hlwatika, P. and Hardcastle, T.C. 2022. Concurrent cranial and cervical spine injuries by associated injury mechanisms in traumatic brain injury patients. Available at: https://doi.org/10.4102/sajr.

[7] Chen, R. et al. 2017. Current epidemiological profile and features of traumatic spinal cord injury in Heilongjiang province, Northeast China: Implications for monitoring and control. *Spinal Cord* 55(4), pp. 399–404. doi: 10.1038/sc.2016.92.

[8] Lomaz, M.B., Netto, L.A.F.S., Filho, M.S.G., Alves, A.P. and De Tavares Canto, F.R. 2017. Epidemiological profile of patients with traumatic spinal fracture. *Coluna/ Columna* 16(3), pp. 224–227. doi: 10.1590/S1808-185120171603176399.

[9] Li, H.L. et al. 2019. Epidemiology of traumatic spinal cord injury in Tianjin, China: An 18-year retrospective study of 735 cases. *Journal of Spinal Cord Medicine* 42(6), pp. 778–785. doi: 10.1080/10790268.2017.1415418.
[10] Futch, B.G. et al. 2023. Demographics, Mechanism of Injury, and Outcomes for Acute Upper and Lower Cervical Spinal Cord Injuries: An Analysis of 470 Patients in the Prospective, Multi-Center, North American Clinical Trials Network Registry. *Journal of Neurotrauma* 40(17–18), pp. 1918–1927. doi: 10.1089/neu.2022.0407.
[11] Derakhshanrad, N., Yekaninejad, M.S., Vosoughi, F., Sadeghi Fazel, F. and Saberi, H. 2016. Epidemiological study of traumatic spinal cord injuries: Experience from a specialized spine center in Iran. *Spinal Cord* 54(10), pp. 901–907. doi: 10.1038/sc.2016.10.
[12] Yuan, S., Shi, Z., Cao, F., Li, J. and Feng, S. 2018. Epidemiological features of spinal cord injury in China: A systematic review. *Frontiers in Neurology* 9(AUG). doi: 10.3389/fneur.2018.00683
[13] Feng, H., Xu, H., Zhang, H., Ji, C., Luo, D., Hao, Z. and Li, K. 2022. Epidemiological profile of 338 traumatic spinal cord injury cases in Shandong province, China. *Spinal Cord* 60(7), pp. 635–640. doi: 10.1038/s41393-021-00709-2.
[14] Khadour, F.A., khadour, Y.A., Meng, L., XinLi, C. and Xu, T. 2024. Epidemiology features of traumatic and non-traumatic spinal cord injury in China, Wuhan. *Scientific Reports* 14(1). doi: 10.1038/s41598-024-52210-4.
[15] Sun, D. and Zhang, Z. 2021. Epidemiological characteristics of traumatic cervical spinal cord injury in Chongqing, China, from 2009 to 2018. *Spinal Cord Series and Cases* 7(1). doi: 10.1038/s41394-021-00434-1.
[16] Sagar Dave, A., Dahlstrom, J.J. and Weisbrod Affiliations, L.J. 2024. Neurogenic Shock. StatPearls Publishing.
[17] Jiang, W., He, F., Ding, G. and Wu, J. 2023. Dopamine inhibits pyroptosis and attenuates secondary damage after spinal cord injury in female mice. *Neuroscience Letters* 792. doi: 10.1016/j.neulet.2022.136935.
[18] Tanaka, A. et al. 2022. Association between early tracheostomy and patient outcomes in critically ill patients on mechanical ventilation: a multicenter cohort study. *Journal of Intensive Care* 10(1). doi: 10.1186/s40560-022-00610-x.
[19] Flanagan, C.D., Childs, B.R., Moore, T.A. and Vallier, H.A. 2018. Early tracheostomy in patients with traumatic cervical spinal cord injury appears safe and may improve outcomes. *Spine* 43(16), pp. 1110–1116. doi: 10.1097/BRS.0000000000002537.
[20] Chhabra, H.S., Sharawat, R. and Vishwakarma, G. 2022. In-hospital mortality in people with complete acute traumatic spinal cord injury at a tertiary care center in India—a retrospective analysis. *Spinal Cord* 60(3), pp. 210–215. doi: 10.1038/s41393-021-00657-x.
[21] Yonemitsu, T., Kinoshita, A., Nagata, K., Morishita, M., Yamaguchi, T. and Kato, S. 2021. Timely intubation with early prediction of respiratory exacerbation in acute traumatic cervical spinal cord injury. *BMC Emergency Medicine* 21(1). doi: 10.1186/s12873-021-00530-3.
[22] Foran, S.J., Taran, S., Singh, J.M., Kutsogiannis, D.J. and McCredie, V. 2022. Timing of tracheostomy in acute traumatic spinal cord injury: A systematic review and meta-analysis. *Journal of Trauma and Acute Care Surgery* 92(1), pp. 223–231. doi: 10.1097/TA.0000000000003394.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6: 5438-5445, 2024
DOI: 10.55214/25768484.v8i6.3208