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Research Article

Comparison of Frankel Scale with Apache-II Scale in the Prediction of Early Stage Mortality of Cervical Spinal Cord Injury

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ABSTRACT: Cervical spinal cord injury (CSCI) is a devastating event that can cause not only motor and sensory impairments but also autonomic dysfunction. Functional and morphological changes in the autonomic nervous system can also affect the respiratory, cardiovascular, renal and gastrointestinal systems. In our study, APACHE-II and Frankel Scale were used. The revised acute physiology and chronic health assessment system (APACHE-II) is a physiologically-based scale that includes 12 physiological parameters. The Frankel Scale was developed in 1969 by Dr. Frankel and is considered to be the pioneer of the ASIA scale for staging of Spinal Cord Injury. In this study, 47 patients who had cervical spinal cord injury between 2016 and 2020 were retrospectively analyzed. The patients were treated within 24 hours of their admission to the emergency department. Each patients APACHE-II and Frankel scores were measured and analyzed with SPSS in terms of sensitivity, specificity, and mortality prediction.

Cervical spinal cord injury is a devastating event that can cause not only motor and sensory impairments, but also autonomic dysfunction. Functional and morphological changes in the sympathetic nervous system can also affect the respiratory, cardiovascular, renal, hematological and gastrointestinal systems. These systems can be affected more than lower level spinal traumas. Therefore, patients with cervical spinal cord injury were evaluated according to both Frankel and APACHE-II classification systems in terms of mortality prediction.

KEYWORDS: APACHE II, Frankel Scale, Cervical Spinal Cord Injury, Classification, Mortality

1. INTRODUCTION

Cervical spinal cord injury (CSCI) is a devastating event that can cause not only motor and sensory impairments but also autonomic dysfunction. Functional and morphological changes in the autonomic nervous system can also affect the respiratory, cardiovascular, renal and gastrointestinal systems. The predictability of mortality that may result from autonomic nervous system damage in patients from the onset of trauma, which we will consider as the early stage of CSCI, to the first moment of surgery, is of vital importance in the correct planning of the surgery to be performed and postoperative follow-ups. The early phase of CSCI covers a very limited time frame due to the possibility of worsening the clinical picture and the need for appropriate treatment as soon as possible. The initial neurological examination is the most important tool to assess the severity and level of the injury. For optimum reliability of the initial exam, the patient must be able to cooperate and follow the examiner's instructions. Since its introduction in 1969, the Frankel scale, a 5-point severity scale, has been widely used to determine injury severity. Therefore, the prediction of mortality at this stage is of vital importance and must be done immediately.

In our study, it was aimed to show that the Frankel scale can be a method that can be performed in a much shorter time compared to the APACHE-II scale in the early stage after CSCI, easy to communicate between the emergency doctor and neurosurgeon, and has a high mortality predictive value.

2. MATERIALS AND METHODS

In our study, APACHE-II and Frankel Scale were used. The adjusted acute physiological and chronic health evaluation system (APACHE-II) is a physiological-based scale with 12 physiological parameters. Frankel Scale, on the other hand, was developed by Dr. Frankel in 1969 and is considered to be the pioneer of the ASIA scale in Spinal Cord Injury staging. In this study, 47 patients who had cervical spinal cord injury between 2016 and 2020 were retrospectively analyzed. This study was approved by the Institutional Review Board (TUEK E1-22-2953), and written informed consent was obtained for each patient. The patients were treated within 24 hours of their admission to the emergency department.

2.1. Patient Selection

In this study, 47 patients who had cervical spinal cord injury between 2016 and 2020 were reviewed retrospectively. The patients were treated within 24 hours of their admission to the emergency department. Patients who stayed in the intensive care unit for less than 24 hours, patients younger than 16 years of age, and patients whose records lacked data to calculate scores were excluded from the study. APACHE II and Frankel scores were calculated for each patient. All physiological measurements were scored over the value that deviated the most from normal in the first 24 hours. In addition to all these variables, the patient's diagnosis, duration of intensive care and hospital stay, and 6-month mortality were learned from the patient files. The SPSS statistical program was used to evaluate the sensitivity, specificity, and mortality prediction.

2.2. Data Analysis

Table 1: Patient characteristics and clinical presentations

		n	%
Sex	Female	13	27,6
	Male	34	72,4
Age (years)*			45,7 (21– 82)
Age of patients who died			57.81±14.36
Length of stay in ICU			9.00 ±13
Frankel Score	A	10	21,2
	B	2	4,2
	C	3	6,3
	D	14	29,7
	E	18	38,2
Death		9	19,1
APACHE II Score			13,1±15,59
ROC Analysis for APACHE II			0,82

*: Mean ± Standard Deviation / Median (Min – Max)

SPSS statistical program was used for statistical evaluation. Mana-Whitney U, Wilcoxon, Kruskal Wallis test was used for statistical analysis. $p<0.05$ was considered significant.

3. RESULTS

The study included 34 male and 13 female patients. The ages of the patients ranged from 21 to 82 (Mean 45,7). There was no statistically significant difference in terms of gender distribution between discharged and deceased patients ($p>0.05$). The mean age of patients who died is 57.81±14.36. The length of stay in the intensive care unit was 9.00 ±13 (1-175) in those who were discharged, and 6±9 (1-280) in those who died. Ten patients were Frankel A, 2 patients B, 3 patients C, 14 patients D, and 18 patients E. Nine patients died, 38 patients were discharged after treatment. The average Apache II score was 13,1±15,59. The Apache II score in deceased patients was 41±12,7. The efficacy of scoring systems in determining ICU mortality was investigated using the "receiver operating characteristic curve" (ROC curve). In comparison of scores, the area under the curve in the ROC analysis was calculated (the value must be between 0,5-1,0 for it to be significant; 1,0 indicates the most significant relationship). An APACHE II score above 13,5 (the threshold value determined by ROC analysis) had a sensitivity of 81,5% and a specificity of 75,9% in determining mortality. The area under the curve in the ROC analysis for the APACHE II score was calculated as 0,82 (95% CI: 0,778-0,845). All 9 patients who died were Frankel grade E. When evaluated with the Pearson correlation test, it was found that the scoring systems did not have a relationship with the length of stay in the intensive care unit, but the relationship between the length of hospital stay and the APACHE II and Frankel Scoring was significant. Frankel scale as well as APACHE-II were found to be successful in predicting mortality.

4. DISCUSSION

Evaluating cervical spinal cord injuries not only as neural tissue damage but also as a systemic disease is important for the prognosis of the patient. In the acute phase, atelectasis, pneumonia, deep vein thrombosis, cardiac arrhythmias, pulmonary embolism, autonomic dysreflexia, orthostatic hypotension, bladder and bowel problems are important causes of morbidity and mortality. Especially in elderly patients and patients with chronic diseases, morbidity and mortality rates due to systemic complications are observed at higher levels in cervical spinal cord injuries. Ischemic heart disease, hypertension, heart failure, diabetes mellitus, Parkinson's disease, hypothyroidism, cerebrovascular diseases, motor neuron disease, osteoporosis and osteomalacia are diseases that are more common in elderly patients. It is obvious that the presence of these diseases before trauma will lead to serious post-traumatic complications and systemic disorders, leading to an increase in mortality and morbidity rates.

Mortality scoring systems have been developed and used for various purposes in intensive care patients. Their primary aim is to discriminate patients according to their probability of mortality. In addition, the observed mortality rate versus the expected mortality rate is frequently used in the evaluation of the clinical performance of intensive care units.

In the presence of a neurological deficit, the expression of the neurological status is usually made according to the Frankel scale. According to this classification, A: Complete motor and sensory loss (Muscle strength: 0), B: Complete motor loss - sensory normal (Muscle strength: 0), C: Useless motor activity (Severe paresis)-sensory normal (Muscle strength: 1 -2), D: Functional motor activity (Mild paresis)- normal sensation (Muscle strength: 3-4), E: Normal motor activity and sensory function (Muscle strength: 5). The prognosis is considered poor in Frankel A and B and good in C and D and E. However, ignoring the pre-existing diseases that may affect the prognosis of the patient will cause deficiencies in patient follow-up and treatment to be overlooked.

The revised acute physiology and chronic health assessment system (APACHE-II) is a physiological-based scale that includes 12 physiological parameters, was first defined by Knaus and has been used in intensive care units since 1985 (Knaus et al., 1985). The overall evaluation score of APACHE II is 71. The acute physiology score consists of 3 parts: age and chronic health assessment. The sum of the acute physiology score, which includes parameters such as blood pressure, blood pH value, Glasgow coma score (GCS), varies between 0-60. Scoring includes the same parameters of chronic health assessment with scoring from 0 to 5 (Knaus et al., 1985; Cho et al., 1999).

It has been determined that respiratory, cardiovascular, renal and gastrointestinal complications and, in the last period, hyponatremia and hematological disorders contribute to the poor prognosis after cervical spinal cord injury (Frankel et al.,1969).

Respiratory complications are the most common cause of mortality and morbidity in cervical spinal cord injury, with an incidence ranging from 36% to 83%. 80% of deaths in hospitalized patients are secondary to pulmonary dysfunction, and pneumonia is the cause in 50% of these cases. The 4 main reasons that contribute to 60% of hospital costs are the use of mechanical ventilation, the occurrence of pneumonia, the application of surgery and the need for tracheotomy (Carter et al., 1987; Lemons et al.,1994; Kiwerski et al.,1992).

The most common complications in the first 5 days after cervical spinal cord injury are atelectasis (36,4%), pneumonia (31,4%) and respiratory failure (22,6%). Respiratory failure is the earliest complication that occurs after an average of 4,5 days after injury and ends in an average of 5 weeks (Jackson et al., 1994). In the study of Claxton et al., which included 72 patients with traumatic cervical spinal cord injury, the need for mechanical ventilation due to respiratory failure was found at a rate of 36%, and the need for mechanical ventilation was found in 90% of them within the first 3 days after the injury(Claxton et al., 1998). In the retrospective study of Waters et al. including 941 cases with spinal cord injury, the incidence of pneumonia and atelectasis in tetraplegic cases was found to be 45% (Waters et al., 1999).

The rate and type of respiratory complications vary with the level of injury and motor grade. The incidence of respiratory complications was 84% in injuries at the C1-C4 level and 60% at the C5-C8 level. While pneumonia and atelectasis were the second most common in C1-C4 level injuries, atelectasis was the 2nd and 3rd most frequent, respectively, pneumonia and respiratory failure were seen in C5-C8 level injuries (Jackson et al.,1994).

One of the important complications developing in spinal cord injuries is gastrointestinal system problems. The most important complication that can be seen in the first 48 hours is paralytic ileus and it manifests itself with abdominal distention and dehydration. In cord injuries above the thoracic 6 segment, unlocalized abdominal discomfort, increased spasticity, and autonomic dysreflexia are observed (Clinton et al.,2005).

Other symptoms seen in cervical spinal cord injuries include dysphagia, gastric hypersecretion and dilatation, gastrointestinal stasis, anal incontinence and constipation. In addition, fluid electrolyte imbalances occur due to deterioration in intestinal motility and permeability, and the rehabilitation process and quality of life are adversely affected (Tong et al., 2009).

Basal gastric motility and esophageal-gastric relaxation reflex decrease after spinal cord injury independent of damage to sympathetic innervation. As a result, gastric stasis and reflux occur. This increases the risk of aspiration of gastric contents. Influence of spinosoliter afferent fibers is effective in the occurrence of gastric stasis. The vago-vagal reflex pathways are active from the oral cavity to the proximal 1/3 of the colon. In general, gastric and intestinal reflexes are under the control of vago-vagal reflexes via the medulla (Tong et al., 2009).

The parasympathetic innervation of the distal colon and rectum is provided by the S2-S4 spinal segments, and the sympathetic innervation is from the lumbar spinal segments, and these extrinsic neural pathways are necessary for colonic motility. However, in studies on gastrointestinal reflexes, although no changes were detected in colorectal, rectocolic and gastrorectal reflexes compared to healthy people, a delay was found in the gastrocolonic reflex. Providing colorectal, rectocolic and gastrorectal reflexes by intrinsic (local) neural pathways, as well as vagal and neurohormonal (for gastrocolonic reflex) pathways have an effect on the protection of these reflexes. The decrease in the gastrocolonic reflex is thought to be secondary to gastroparesis, although unlikely. Although colorectal activity is preserved, it has been reported that anorectal dysfunction has a small share in the resulting constipation. It has been reported that digitization has a potential effect on the initiation of defecation (Suttor et al., 2009).

Another complication that may affect the prognosis in cervical spinal cord injuries is cardiovascular problems. Cardiovascular complications that can be seen in the acute phase are sinus bradycardia, loss of vascular tone, supraventricular-ventricular ectopic beats, arterial hypotension, increased vasovagal reflex sensitivity, vasodilation, and venous stasis.

Parasympathetic innervation of the cardiac region is provided from the brain stem region via the vagus, while sympathetic innervation is provided from the T1-5 segments. Acute loss of sympathetic stimulation causes bradycardia and arterial hypotension (neurogenic shock). Hypersensitivity in the vagus ends in approximately 2-3 weeks. It is important to avoid vagus stimulation during this period. Hypoxia, nasogastric and endotracheal tubes can also cause vagal reflexes to start. In emerging bradycardia, atropine is the drug of choice (Hagen et al.,2012).

Autonomic dysreflexia occurs in injuries above the T6 level. This occurs with the induction of sensory stimulation under the injury site and develops within the first 2-4 months. Paroxysmal hypertension often occurs accompanied by baroreflex-mediated bradycardia. In 85% of the patients, the reason is full bladder due to retention or catheter blockage. A 20-40 mm Hg increase in systolic pressure should be considered as a sign of autonomic dysreflexia. Nifedipine and captopril are effective in its treatment (Hagen et al.,2012).

Deep vein thrombosis and related pulmonary thromboembolism are also important in mortality and morbidity. Therefore, patients should be started on low molecular weight heparin therapy for the first 3 months (Chung et al.,2011).

In the long term, decreased physical activity and autonomic dysreflexia predispose to coronary artery disease. Cardiac arrhythmias such as orthostatic hypotension, bradycardia and A-V block are among the common causes of mortality and morbidity. Decreased high-density lipoprotein, high total cholesterol and low-density lipoprotein, increased C-reactive protein, obesity, smoking, diabetes, and insulin resistance are predisposing factors for cardiac complications (Myers et al.,2007).

Two active pathways have been defined between the immune system and the central nervous system: the hypothalamus-pituitary-adrenal pathway and the autonomic nervous system. Sympathetic-noradrenergic and, to a lesser extent, sympathetic-neuropeptide-Y innervation is effective on primary and secondary lymphoid tissues. The loss of control of the autonomic sympathetic system over the lymphoid organs also causes hematological changes. Decreased hemoglobin concentration, leukocytosis, lymphopenia, and thrombocytopenia in the first 1 week post-traumatic are frequently seen after isolated cervical spinal injury. As the degree of spinal cord damage increases, the decrease in hemoglobin concentration and lymphopenia become more pronounced. In addition, when the cases with methylprednisolone use are compared with those who do not, there is no significant difference in the occurrence of leukocytosis, but it is stated that lymphopenia is more pronounced in cases where methylprednisolone is used (Furlan et al.,2006).

Hyponatremia is the most common electrolyte imbalance in the first 2 weeks after cervical spinal cord injury. The reason for this is hypotension secondary to vasodilation, increasing the release of antidiuretic hormone from the paraventricular nuclei in the hypothalamus and disruption of the integrity of the descending renal sympathetic pathway (Furlan et al.,2006). In addition, spinal cord damage causes a decrease in glomerular filtration rate, leading to deterioration in renal functions. This decrease is more evident in complete cord injuries in the cervical and thoracic regions (Pettersson-hammerstad et al.,2008). In addition, there is a risk of developing vesicoureteral reflux and hydronephrosis in patients who empty their bladders with Valsalva or Crede maneuvers (Subramanian et al., 2012).

It should be taken into account that these complications, which may develop due to spinal cord injury in patients with pre-traumatic chronic disease or in advanced age, may develop at more frequent rates and/or in more severe degrees.

Frankel scale is an evaluation method that should be applied in terms of expressing the degree of cord damage in a simple language. However, since the APACHE II scale gives more detailed information about the general condition of the patient, it is an undoubted fact that it will provide more detailed information about the prognosis of the patients. Our study showed that the communication between the emergency physician and the neurosurgeon is as reliable as the APACHE II, with its predictability of mortality in the early stage and the more practicality of the Frankel scale in the planning of patient treatment without wasting time. In addition, the evaluation of APACHE II parameters by the team that will follow and treat the patient after the early stage is also necessary in order to determine possible complications that may develop.

5. CONCLUSION

Damage to the autonomic system causes respiratory, cardiovascular, renal and gastrointestinal complications, and these systems are thought to be the most commonly affected after cervical spinal cord injury. Recently, hyponatremia and hematological disorders have also been found to contribute to poor prognosis after cervical spinal cord injury. Although APACHE-II, which includes 12 physiological parameters, is thought to be effective in predicting mortality due to mutlisystemic dysfunction after cervical spinal cord injury, we found that the Frankel scale, which is cheaper and easier to apply, is at least as valuable as it. The small number of cases and the fact that only one APACHE-II measurement was made at the time of admission are the weaknesses of this study. More detailed studies on this subject should include hospital follow-up values, so we think that comparison with other scales will be more valuable in the evaluation of mortality and prognosis. Because the Frankel scale is simple and functional, it is still a common language between the emergency doctor and the clinician.

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