

Original Article



Acute Traumatic Sub-Axial Cervical Spine Injuries: Pattern and Permanent Disability

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ABSTRACT:

Introduction: Traumatic cervical spine injuries is one of the most common causes of spinal cord injury. Life-long disability and death are common devastating consequences of trauma to the cervical spine, leading to numerous physical, functional disabilities with social and economic burdens. **Study aim:** To describe pattern of acute traumatic

sub-axial cervical spine injuries and the probable permanent disability resulting from it. **Patients and methods:** A descriptive cross-sectional study was conducted upon 60 patients of acute traumatic sub-axial cervical spine injuries (C3-C7) attending the Emergency Department, Suez Canal University Hospital from January 2020 to December 2020. Pattern of sub-axial cervical spine injuries was determined from clinical findings and imaging studies. Level and extent of the injuries were identified using the American Spinal Injury Association (ASIA) scoring and grading system at admission time. Outcome was assessed after 12 months follow-up period. **Result:** Most participants were males (81.7%). The mean age was 23.3 ± 4.8 years with a majority in age group (20– <30 years) representing (40%). Sixty percent of participants were from rural areas. All the study participants were subjected to cervical spine injury accidentally, the most frequent mechanisms of trauma were diving in shallow water (46.7%), followed by road traffic accident (41.7%), there is 10% mortality rate. At the end of 12 months follow-up period; 28% of the participants were neurologically free, about 32% of the participants suffer from severe life-long motor disability (ASIA grades A, B and C). **Conclusion:** The most frequent mechanisms of cervical spine injuries in Suez Canal region is diving in shallow water followed by road traffic accident. About one third of the participants suffer from life-long motor disability. There is minor change in neurological state of the patients from admission time to the end of the 12-months follow up period according to ASIA scoring and grading system.

KEYWORD: Cervical spine injuries, Pattern, Permanent disability, Diving in shallow water

I. INTRODUCTION:

Trauma is of great importance in the forensic context as it may result in morbidity and mortality. Spine is one of the body parts that is commonly subjected to trauma (Omran et al., 2019). Traumatic cervical spine injuries (CSI) are one of the most devastating types of spine injuries worldwide, it may end in dramatic neurologic impairment and even death (Grauer et al., 2009). More than 13 million patients are assessed each year in emergency departments across the United States; of these, 30,000 (0.2%) have CSI (Grossman et al., 1999).

In Egypt, CSI associated morbidity and mortality is a significant problem that may end in litigations (Omran et al., 2019), the incidence of these injuries is unknown as the national registry system is not covering this data (El-Beshbeshy et al., 2020).

Sub-axial cervical spine injuries are defined as fractures, dislocations or ligamentous disruption of the C3 to C7 vertebral levels (Patel et al., 2008, Silva et al., 2016). These injuries represent a common injury pattern in young age group because they have an active lifestyle (Abdelgawaad et al., 2021). These injuries may end in varying degrees of physical, functional, sexual disabilities and permanent infirmities with a significant economic and social impact (Silva et al., 2016). Permanent infirmity is a major sequel of CSI, it is considered as a legal as well as a medical problem. Physician should be oriented about the legal issues of compensation to help them in saving patients' rights (Omran et al., 2019).

Because of the high risk associated with CSI; immediate and definitive treatment is the key to successful management to optimize patients' outcome (Srinivas et al., 2017).

The epidemiologic patterns and clinical features of CSI can help in analyzing the mechanism of trauma in the forensic context which help the forensic authority in determining compensation (Vazquez et al., 2008, Refaat, 2019)

As there is no sufficient national data registry about cervical spine injuries, the present study aims to describe the pattern of acute traumatic sub-axial cervical spine injuries and the probable permanent disability resulting from it.

II. PATIENTS AND METHODS:

A descriptive cross-sectional study was conducted upon patients of acute traumatic sub-axial cervical spinal injuries (C3-C7) attending the Emergency Department, Suez Canal University Hospital from January 2020 to December 2020. Patients with associated head trauma, thoracic, lumbar spine injuries and those who were admitted after 7 days of trauma were excluded from the study.

Demographic data, pattern of cervical spine injuries, manner of injuries, mechanism of injuries, type and level of injuries, associated injuries, neurological status at admission and during follow-up visits were assessed.

Initial management was started according to Advanced Trauma Life Support guidelines (Kortbeek et al., 2008) then all participants were evaluated by an expert neurosurgeon. Evaluation included: clinical assessment, neurological assessment (motor, sensory, autonomic deficits) and radiological assessment (X ray, computed tomography [CT], magnetic resonance imaging [MRI]) that were performed according to the patients' clinical findings. Treatment measures included: surgical intervention; conservative treatment (mega-dose of

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methyl-prednisolone) with /without cervical traction either in inpatient or in intensive care unit.

Cervical spine injuries were classified into diagnostic categories according to the pattern of injuries by using AOSpine (AO: Arbeitsgemeinschaft für Osteosynthesefragen) classification system which is a comprehensive but simple classification system for spinal trauma and one of the most popular CSI classification systems. In the sub-axial cervical spine; this system is based on five injury morphology types: compression injuries, tension band injuries, translational injuries, facet injuries and Bilateral injuries (Kreitz et al., 2017, Hitti et al., 2019).

Neurological status including level and extent of injuries were determined by using

the American Spinal Injury Association (ASIA) scoring and grading system (figure 1 &table 1) at time of admission and after 6 , 12 months from injury (ASIA, 2019, Physiopedia, 2021). It is known as “ASIA Impairment Scale”, it is a universal classification tool for spinal cord injuries based on a standardized sensory and motor assessment. It involves both a motor and sensory examination to determine the sensory level and motor level for each side of the body (Right and Left), the single neurological level of injury (NLI) and whether the injury is Complete or Incomplete (ASIA, 2019). According to ASIA scale; the neurological level was defined as "the most caudal segment with motor function (at least 3 out of 5) with present pain and sensation (ASIA, 2019).

ASIA INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY (ISNCSCI)

Patient Name _____ Date/Time of Exam _____
 Examiner Name _____ Signature _____

RIGHT MOTOR KEY MUSCLES
 UER (Upper Extremity Right): C5 Elbow flexors, C6 Wrist extensors, C7 Elbow extensors, C8 Finger flexors, T1 Finger abductors (little finger)
 LER (Lower Extremity Right): L2 Hip flexors, L3 Knee extensors, L4 Ankle dorsiflexors, L5 Long toe extensors, S1 Ankle plantar flexors
 (VAC) Voluntary Anal Contraction (Yes/No)

RIGHT SENSORY KEY SENSORY POINTS
 Light Touch (LTR) (50) Pin Prick (PPR) (56)

LEFT MOTOR KEY MUSCLES
 UEL (Upper Extremity Left): C5 Elbow flexors, C6 Wrist extensors, C7 Elbow extensors, C8 Finger flexors, T1 Finger abductors (little finger)
 LEL (Lower Extremity Left): L2 Hip flexors, L3 Knee extensors, L4 Ankle dorsiflexors, L5 Long toe extensors, S1 Ankle plantar flexors
 (DAP) Deep Anal Pressure (Yes/No)

LEFT SENSORY KEY SENSORY POINTS
 Light Touch (LTL) (50) Pin Prick (PPL) (56)

MOTOR SUBSCORES
 UER + UEL = UEMS TOTAL (50) LER + LEL = LEMS TOTAL (50)
 MAX (25) (25)

SENSORY SUBSCORES
 LTR + LTL = LT TOTAL (112) PPR + PPL = PP TOTAL (112)
 MAX (56) (56)

NEUROLOGICAL LEVELS
 Steps 1-5 for classification as on reverse

1. SENSORY R L
2. MOTOR R L

3. NEUROLOGICAL LEVEL OF INJURY (NLI)

4. COMPLETE OR INCOMPLETE? (In injuries with absent motor OR sensory function in S4-5 only)
 Incomplete = Any sensory or motor function in S4-5

5. ASIA IMPAIRMENT SCALE (AIS)

6. ZONE OF PARTIAL PRESERVATION R L
 Most caudal levels with any sensation

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Figure 1: American Spinal Injury Association Scale (ASIA) impairment scale for level of injury (ASIA, 2019).

Table 1: American Spinal Injury Association Scale (ASIA) for extent of injury (ASIA, 2019) :

Grade	Type of Injury	Description of Injury
A	Complete	No Sensory or motor function is preserved in the sacral segments S4-S5
B	Sensory Incomplete	Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5, and no motor function is preserved more than three levels below the motor level on either side of the body
C	Motor Incomplete	Motor function is preserved below the neurological level and more than half of key muscle functions below the neurological level of injury have a muscle grade less than 3 (Grades 0-2)
D	Motor Incomplete	Motor function is preserved below the neurological level and at least half (half or more) of key muscle functions below the neurological level of injury have a muscle grade ≥ 3
E	Normal	Sensation and motor function are normal in all segments.

Muscle function grading was considered as follows: **0:** Total paralysis, **1:** Palpable/visible contraction, **2:** Active movement, full range of motion with gravity eliminated, **3:** Active movement, full range of motion against gravity, **4:** Active movement, full range of motion against gravity and moderate resistance in a muscle specific position, **5:** Normal (Active movement)

Follow up was conducted at the outpatient clinic (after 1 month, 3 months; 6 months and 12 months). More than or equal to 1 grade change in ASIA grade from time of admission to 12 months follow up was considered as improvement.

Outcome of CSI at the end of the 12 months follow-up period was assessed; either dead, neurologically free (ASIA grade E) and life-long motor disability (ASIA grade A, B, C) as illustrated in Figure 1.

Ethical considerations: Administrative approval was obtained from head of Neurosurgery department, Suez Canal University hospital. Ethical approval was obtained from the Research Ethics Committee, faculty of Medicine, Suez Canal

University, reference code: # 4777. Written informed consent was obtained from all enrolled patients.

Statistical Analysis: Descriptive analysis of all variables was done where; categorical variables were expressed as frequency and percentages and continuous variables were expressed as mean and standard deviation (Mean, SD). IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp. was used for statistical analysis.

III. RESULT:

A total of 60 patients were enrolled during the study period. The majority (81.7%) of them were males. The mean age for all patients was 23.3 ± 4.8 years (ranging from 16-48 years)

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with a maximum number of patients in age group (20 - <30 years) representing (40%) of the total sample. Over half (60%) of patients were from rural areas. About half of the

patients had completed their high school education (46.7%) and 21.7% had a bachelor's degree (table 2).

Table 2: Demographic data of patients with acute traumatic sub-axial cervical spine injuries attending Suez Canal University Hospital from January 2020 to December 2020 (N=60)

Demographic data		Frequency (N=60)	%
Gender	Male	49	81.7%
	Female	11	18.3%
Age (in years)	Mean± SD	23.3±4.8	
	Range	16-48	
	10 - < 20	9	15%
	20 - < 30	24	40%
	30 - < 40	19	31.7%
Residence	40 - < 50	8	13.3%
	Rural	36	60%
Work status	Urban	24	40%
	Employed	28	46.7%
Marital state	Unemployed	15	25%
	Irregular work	17	28.3%
	Single	25	41.7%
Education	Married	32	53.3%
	Divorced/widows	3	5%
	Illiterate	2	3.3%
	Less than high school	17	28.3%
Education	High school graduate	28	46.7%
	Bachelor's degree/higher	13	21.7%

SD: standard deviation

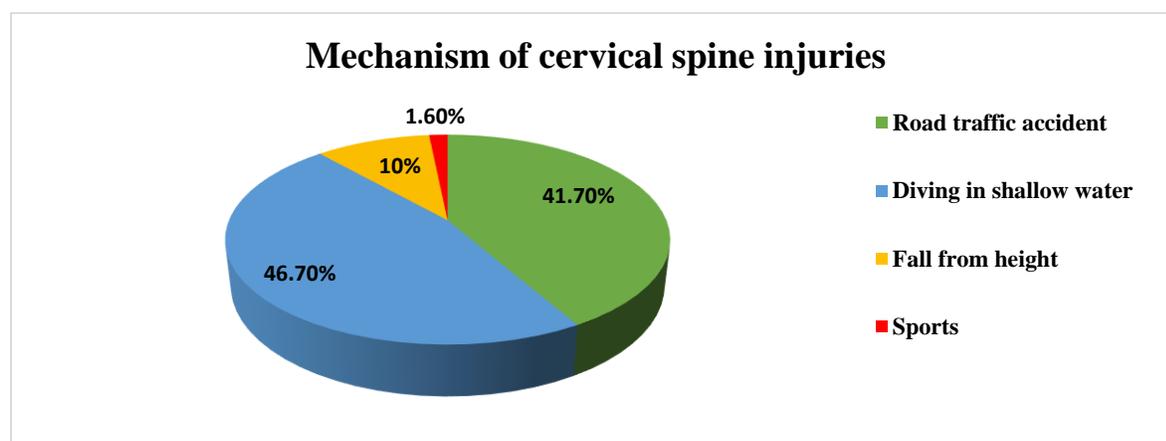


Figure 2: Mechanism of acute traumatic sub-axial cervical spine injuries among patients admitted Suez Canal University Hospital from January 2020 to December 2020. (N=60)

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Table 3: Characteristics of acute traumatic sub-axial cervical spine injuries in patients attending Suez Canal University Hospital from January 2020 to December 2020 (N=60)

Injury characteristics		Frequency (N=60)	%
Level of cervical spine injuries	C3	1	1.6%
	C4	11	18.4%
	C5	23	38.3%
	C6	21	35%
	C7	4	6.7%
Type of sub-axial cervical spine injuries*	Compression injuries	21	35%
	Tension band injuries	3	5%
	Bilateral injuries	1	1.6%
	Translation injuries	11	18.4%
	Facet injuries	24	40%
Associated injuries	Facial injuries	4	6.7%
	Chest injuries	7	11.7
	Abdominal injuries	5	8.3%
	Pelvic fracture	1	1.6%
	Long bone fracture	4	6.7%

*According to AOSpine classification system. C: cervical vertebra

Table 4: Treatment measures of acute traumatic sub-axial cervical spine injuries patients attending Suez Canal University Hospital from January 2020 to December 2020 (N=60)

Treatment measures *	Frequency (N=60)	%
Medical treatment (methylprednisolone)	50	83.3%
Cervical traction	53	88.3%
Surgical intervention	49	81.6%
Inpatient admission	59	98.3%
Intensive care unit admission	41	68.3%
Duration of hospitalization (in days)	Range: 3-30 Average: 10	

*More than one choice is allowed

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Table 5: American spine injury association (ASIA) grade changes at admission time, after 6 and 12 months follow up of patients with acute traumatic sub-axial cervical spine injuries attending Suez Canal University Hospital from January 2020 to December 2020 (N=60)

ASIA grade	At time of admission (N=60)	After 6 months follow up (N = 54)	After 12 months follow up (N=52)
A	17 (28.3%)	12 (20%) ^{4D}	9 (15%)
B	4 (6.7)	3 (5%) ^{2D}	4 (6.7%)
C	9 (15%)	8 (13.3%)	6 (10%)
D	14 (23.3)	15 (25%)	16 (26.7%) ^{1LF}
E	16 (26.7)	16 (26.7)	17 (28.3%) ^{1LF}

D: Deaths

LF: lost to follow up

All the study participants were subjected to CSI accidentally. The most frequent mechanism of acute sub-axial cervical spine injuries was diving in shallow water representing 46.7%, followed by road traffic accident representing 41.7% (figure 2).

The sub-axial cervical spine fractures were found mostly in the fifth cervical vertebrae (38.3%). Radiological assessment of the patients shows that the most common types of fracture are facet injuries (40%) followed by compression injuries and translation injuries (35%;18.4%) respectively (table 3). In addition, 65% of patients had solitary injuries in the cervical region, while 35% had concomitant injuries/fractures in different body parts (6.7% had facial injuries, 11.7% had chest injuries, 8.3% had abdominal injuries and 6.7% had long bone fractures) (table 3).

Treatment measures of acute sub-axial cervical spine injuries showed that 50 patients (83.3%) were given medical treatment (mega-dose methylprednisolone), 53 patients (88.3%) were subjected to cervical traction while surgical intervention was the treatment of choice for 49 patients (81.6%), about two third (68.3%) of the studied patients admitted to intensive care unit (table 4).

Assessment of neurological status of the studied patients using ASIA grade at time of admission, at 6 months and 12 months follow-up periods was labeled in table 5 taking in consideration that more than/equal to 1 change in neurological status from time of admission to 12 months follow-up was considered as improvement. Distribution of patients according to grades of ASIA scale was: 17 patients (28.3%) ASIA grade A; 4 patients (6.7%) ASIA grade B; 9 patients (15%) ASIA grade C; 14 patients (23.3%) ASIA grade D and 16 patients (28.3%) ASIA grade E.

Concerning the outcome of CSI; current study shows that after six months follow-up period; there were 6 deaths (ASIA grade A; 4 deaths; ASIA grade B; 2 deaths) representing 10 % mortality rate.

The study did not record any neurological deterioration among survived patients after 12-months follow-up period. However, there are few neurological improvements in many ASIA grades. They were explained as the following: Out of the 17 patients admitted with ASIA A: 4 were died; 4 patients showed neurological improvement (3 patients improved to ASIA B; 1 improved to ASIA C); out of the 4 patients admitted with (ASIA B): 2 were died; 2 patients showed neurological

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improvement to ASIA C; out of the 9 patients admitted with (ASIA C): 4 patients showed neurological improvement to ASIA D and one patient lost to follow up; finally out of the 14 patients admitted with (ASIA D): only one patients showed neurological improvement to normal (ASIA E) and one patient lost to follow up.

IV. DISCUSSION

Traumatic cervical spine injury (CSI) may lead to severe life-long disabilities, which may require assessment for judicial reasons. As there are considerable variations in the structure and function of C1, C2 from the sub-axial spine (C3- C7), they are considered separately when investigating CSI (Hitti et al., 2019). Current study was conducted to describe pattern of acute traumatic sub-axial cervical spine injuries and the probable permanent disability resulting from it.

Intent to improve the neurological and functional status has led to numerous studies regarding acute traumatic cervical spine injuries, evaluating various factors such as demographic data, mechanism of injuries, level of injuries and ASIA grading from the forensic point of view.

The study shows that the age of the enrolled patients ranged from 16-48 years, which were in agreement with previous studies (El-Beshbeshy et al., 2020). However it is inconsistent with the report of the National Spinal Cord Injury Statistical Center that reported the average age of injury is 41 years (National Spinal Cord Injury Statistical, 2013). About 55% of the studied patients aged less than 30 years as CSI commonly affects the young in their productive ages. These results are in contrast with another study reported that the most frequent age of

CSI (39%) is from 20 to < 40 years (El-Beshbeshy et al., 2020). This difference may be explained by that the most frequent mechanism of CSI in the current research is diving in shallow water, which is more common in younger age groups in the Suez Canal area.

The majority of the enrolled patients in current study were males. This result is similar to many previous studies which reported male predominance among victims of CSI (Asemota et al., 2018, El-Beshbeshy et al., 2020, Baxter et al., 2021, Lowery et al., 2001). This predominance of males can be explained by the fact that males are more physically active than females, they engaged in many high risk activities, thus being more vulnerable to trauma as well as they don't appreciate consequences (Hemalatha and GambhirSingh, 2013). They are also more likely to involve in sports and fights. In addition, they are more exposed to many outdoor activities, traveling on a regular base between home and their workplace, while females usually take good care of themselves and don't involve in dangerous acts (Yadav et al., 2008).

About 80% of cervical spine fractures among the studied patients were at the level of C5-C7 vertebrae which is due to the mobility of these vertebrae (Borius et al., 2010).

The most frequent mechanism of acute sub-axial CSI among the studied patients was diving in shallow water (46.7%), which is not described as a major cause in similar studies. This may be attributed to by the special nature of the current study sitting (Suez Canal University hospital) which is considered the main tertiary care hospital in Suez Canal area. As this area includes many resorts and

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beaches, special type of spine injuries secondary to diving activities was referred to this hospital. This type of injury may result from misjudgments of the depth of water; reckless diving and little experience about diving in shallow water. One of its most dramatic sequels is quadriplegia which may occur secondary to cervical hyperflexion with or without compression as a result of head hitting the bottom of the sea (Awad and Elqazaz, 2014).

The 2nd most frequent mechanism of CSI is road traffic accident (RTA) (41.7%). This result is in line with similar studies that reported RTA (62.2%) and falls (32.6%) to be the most frequent mechanisms of CSI injury (Tian et al., 2009, El-Beshbeshy et al., 2020). This result is contradicted with another studies that reported falls as the most frequent cause of CSI (Asemota et al., 2018); others reported that most of the CSI were due to different types of sports (football, gymnastics, rugby and diving) (Bárbara-Bataller et al., 2017). This high rate of RTA in our country is highly expected as it is considered as one of the densely populated countries with poorly planned and congested highways, increase in the number of cars, reckless driving and ignoring speed limits/traffic rules (Yadav et al., 2008, Refaat, 2019).

The present study shows that 35% of the patients have concomitant injuries and fractures in different body parts with the predominance of chest injuries (11.7%). This small prevalence of associated injuries can be explained by that diving accidents represent about 50% of the mechanisms of injuries, this mechanism of injury is not usually associated with other injuries (Borius et al., 2010), the

2nd most frequent mechanism of CSI is RTA which is usually associated with other injuries, as skeletal and chest injuries.

The outcome of cervical spine injury was assessed after 12 months follow up period, this one year follow up period was based on a previous study that documented that one year after injury is the time period needed to detect significant neurological improvement as any improvement after this time is considered minimal (Vazquez et al., 2008). The present study revealed that by the end of the 12 months follow-up period; the mortality rate was (10%), these results are likewise El-Beshbeshy et al and Baxter et al as they reported (15.3%), (8–14%) mortality rate respectively (El-Beshbeshy et al., 2020, Baxter et al., 2021). The study also revealed that about (32%) of the patients had severe life-long motor disability (ASIA grades A, B and C). These results are inconsistent with previous studies that found that more than half of CSI (60%) end in neurological deficits with its associated disabilities (Baxter et al., 2021).

Concerning good outcome; current research showed that about (28%) of the participants were neurologically free (ASIA grade E), this result is in the same line with a previous study which reported that 40% of CSI patients were neurologically free (El-Beshbeshy et al., 2020).

The study revealed that there is minor improvement regarding the neurological state of CSI patients at the end of the 12 months follow-up period even after receiving their proper management. This indicates that CSI patients with motor disability (poor ASIA grade) at the time of admission will probably suffer from severe life-long major

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consequences leading to permanent disabilities. This permanent disability is considered as more burden of CSI than mortality, this highlights the need for prevention of CSI (Hall et al., 2019).

V. CONCLUSION

The study revealed that CSI are more predominant among males, the majority were in age group (20–<30 years). All the study participants were subjected to cervical spine injury accidentally, the most frequent mechanisms of trauma were diving in shallow water, followed by road traffic accidents. The study reported 10% mortality rate, about 32% of the participants suffer from severe life-long motor disabilities. There is minor improvement in neurological state of the patients from admission time to the end of the 12-months follow up period according to ASIA scoring and grading system.

Limitations

Similar to other cross-sectional studies; the current study included a relatively small number of patients with cervical spine injuries. It was conducted at certain hospital located in an area of special nature that had specific criteria of referred patients, this limits the generalizability.

Conflict of interest

There are no conflicts of interest.

VI. RECOMMENDATIONS

Further studies with larger sample size are recommended to ensure the validity of the results.

Vehicle safety measures must be practiced to decrease road traffic accidents related injuries. Preventive measures in roads must be practiced to avoid consequences for individuals, societies and economic

resources.

Raise public awareness about the mortality and severe disabilities that may result from careless and reckless diving.

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إصابات الفقرات العنقية الحادة : نمط الإصابة والعجز الدائم

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مقدمة: تعد إصابات الفقرات العنقية من أكثر الأسباب شيوعاً لإصابات الحبل الشوكي. هذا وتعد الإعاقة المستديمة والموت من النتائج المدمرة الأكثر حدوثاً من إصابات الفقرات العنقية، وقد تسبب هذه الإصابات الكثير من الإعاقات الجسدية و العواقب النفسية و الاجتماعية والاقتصادية.

الهدف من الدراسة: وصف نمط إصابات الفقرات العنقية الحادة و ما قد ينتج عنها من إعاقات مستديمة.

طريقة الدراسة: تشتمل هذه الدراسة الإكلينيكية على 60 مريضاً ممن عانوا من إصابات الفقرات العنقية الحادة و الذين توجهوا لقسم الطوارئ، بمستشفى جامعة قناة السويس خلال الفترة الزمنية من يناير 2020 حتى ديسمبر 2020. تم إجراء تقييم لنمط الإصابة من خلال الفحوصات السريرية والإشعاعية للمرضى. تم تحديد مستوى ومدى الإصابات باستخدام نظام التصنيف التابع لجمعية إصابات العمود الفقري الأمريكية (ASIA) في وقت دخول المستشفى، و بعد فترات متابعة ستة أشهر و اثني عشر شهراً

النتائج: هذا و قد كانت النسبة العظمي من المصابين من الذكور بنسبة (81.7%) و قد كان متوسط اعمارهم (4.8 ± 23.3) عاماً مع تواجد الأغلبية في الفئة العمرية (من 20- إلى أقل من 30) عاماً ممثلة بنسبة (40%)، كما وجد أن (60%) من المصابين من قاطنى المناطق الريفية. وكانت الآلية الأكثر شيوعاً للإصابة هي الغوص في المياه الضحلة بنسبة (46.7%) يليها الحوادث المرورية على الطرق بنسبة (41.7%). جميع المشاركين في الدراسة تعرضوا لإصابة عرضية للفقرات العنقية. و قد بلغ معدل الوفيات 10% من المشاركين في الدراسة، كما أوضحت الدراسة أن 32% من المشاركين يعانون من إعاقة حركية مستديمة.

الخلاصة: أوضحت الدراسة أن أكثر الآليات شيوعاً لإحداث إصابات الفقرات العنقية هي الغوص في المياه الضحلة، يليها الحوادث المرورية على الطرق. كما أوضحت أن حوالي ثلث المشاركين سوف يعانون من إعاقة حركية مدي الحياه. كما أسفرت الدراسة علي أن هناك تحسن طفيف في الحالة العصبية للمرضى من وقت الدخول للمستشفى إلى نهاية فترة المتابعة البالغة اثني عشر شهراً وفقاً لنظام (ASIA).

هذا و توصي الدراسة باتخاذ تدابير سلامة المركبات وذلك لتقليل معدل الإصابات المرتبطة بالحوادث المرورية. كما توصي باتخاذ إجراءات مرورية صارمة علي الطرق لتجنب حدوث الحوادث المرورية وما يعقبها من إصابات. كما توصي الدراسة برفع مستوى الوعي العام حول العواقب الصحية الناجمة عن الرعونة و التهور عند ممارسة رياضة الغوص.