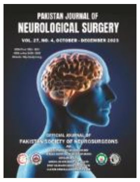

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Original Research

Incidence of Cervical Spine Injuries in Pediatric Patients and Their Outcome in Tertiary Care Hospital

Abbas Khan[1], Sahibzada Haseeb Ahmed[2], Muhammad Kashif Jamal[3], Bahrul Amin Khan[3], Syed Mansoor Shah[3], Adnan Khan[3], Shumaila Gul[3], Maria Nisar[4]

[1] Department of Orthopedics, Police Services Hospital, Peshawar
[2] Department of Neurosurgery Police Services Hospital, Peshawar
[3] Department of Neurosurgery, Lady Reading Hospital, Peshawar
[4] Department of Radiology, Lady Reading Hospital, Peshawar-Pakistan

ABSTRACT

Objective: The incidence of mortality after cervical trauma in the pediatric population is very high. The purpose of this study was to determine the treatment given, morbidity and mortality of patients with cervical spine injuries, and their outcome after 6 months of management which includes both surgical and conservative treatment.

Materials & Methods: A prospective study was conducted at Lady Reading Hospital, Peshawar with a total number of patients n = 187 included in our study. Patients were stratified according to their age, mortality, mechanism of injury (fall, motor vehicle accident, bicycle injuries, &sports-related injuries), level of cervical spine injury, presence of neurologic deficit, presence of bony injury (fractures, &dislocations), ligamentous injuries & SCIWORA. The primary outcome was the functional status at 6 months following treatment.

Results: There were 78 females and 109 males. In comparison to the lower cervical spine (C3 – C7), which was involved in 86 patients (46%), the higher cervical spine level (C0 – C2) was involved in 101 patients (or 54%). The most frequent cause of cervical spine injuries in the older age range was a history of a fall, followed by a motor vehicle accident. Among the treatment groups, mortality was highest in patients who underwent surgery. Mortality was maximum in post-treatment ASIA group A and ASIA group B (post-treatment). The mortality is dependent on the post-treatment neurological status of the patients. There existed a significant difference between patients' pre-op and post-op neurological outcomes concerning the ASIA scale.

Conclusion: Younger age groups, higher cervical spine levels, and mechanisms of injury such as high energy impact trauma were independent risk factors for increased mortality. Compared to incomplete neurological abnormalities, a complete neurological disability increases mortality.

Keywords: Cervical Spine, Neurological Deficit, ASIA Score, Cervical Spine Trauma, SCIWORA (Spinal Cord Injury without Radiographic Abnormality), Atlanto-Axial Rotatory Subluxation.

Corresponding Author: Sahibzada Haseeb Ahmed
Department of Neurosurgery, Police Services Hospital, Peshawar
Email: flaming_ice2@hotmail.com

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INTRODUCTION

Pediatric spine injuries are uncommon among trauma patients yet they are a serious cause of mortality and morbidity.[1] It is suspected when a child presents with neck pain or tenderness or when there are root or cord symptoms. The incidence of cervical spine injuries in the US is 7.41/per 100,000 population.[2] Cervical spine injuries in the pediatric population present differently as compared to adults.[3]

Motor vehicle accidents are the most common cause of pediatric cervical injuries, but obstetrical complications, falls, sports, diving accidents, firearms, and child abuse account for many injuries as well [7]. In children from 6 – 10 years, bicycle injuries are common causes of cervical cord trauma whereas in children more than 10 years of age motor vehicle accidents and sports-related injuries are the most common causes. Birth-related injuries are also responsible for cervical cord injuries and result in flaccid paralysis, apnea, and quadriplegia.

Cervical spine injuries are more common from occiput to C2 at ages less than 9 years and more common in the lower cervical spine at ages more than 9 years due to disparity in the fulcrum of motions in the cervical cord. Facet dislocation is also associated with cord or nerve root injury. Although rare, cervical cord injuries can result in bowel and bladder dysfunction.

Pediatric spines are relatively hypermobile because of ligamentous laxity, the shallow and more horizontal orientation of facet joints, and incomplete ossification of the odontoid and wide neck muscles. These factors predispose them to an unstable cervical spine.[4] Common mechanisms of injuries among the pediatric population include motor vehicle accidents, pedestrians, and inflicted injuries.[5] SCIWORA injuries are also common in the pediatric population because of ligamentous elasticity associated with sports.

In the pediatric population, the outcome of cervical cord injuries is better than as compared with adults. Moreover, incomplete cord lesions have better outcomes than complete cord lesions. Residual deficits may be there after complete spinal cord injuries.[6] In children, 80% of all spinal injuries involve the cervical spine as compared to the lumbar and thoracic spine. In younger children, the level of injury occurs most commonly from OC junction to C3 and it tends to occur low in the cervical spine as the child grows old.[5.]

Radiological findings can be mistaken in Pediatrics, the age group for pseudo subluxation or synchondrosis. X-rays cervical spine with AP, lateral, and open-mouth odontoid view are initially done to rule out cervical cord injuries. Dynamic X-rays are done if the patient is neurologically intact otherwise MR imaging may be used to assess cervical cord injury.[8] CT scans can be used as an adjunct for surgical planning of cervical cord injuries because they can detect bony injuries and not ligamentous injuries in the cervical spine.MR imaging has an important role in cervical spine injury prognosis as it can detect ligamentous and disc injuries.[8]

Pseudo-subluxation is common in children up to 14 years of age. A line drawn from C1 to C3 should pass within 1mm anterior to the posterior cortex of C2.[10] Spinal instability in the pediatric population is more tolerable than in adults due to more ligamentous laxity. In Pediatrics, subluxation of more than 4.5mm and angulation of more than 7 degrees is considered as unstable spine.[11] SCIWORA is another common injury of the cervical spine in the pediatric population. There is traumatic cervical myelopathy with no radiological findings. There are no MR findings in these patients and immobilization for up to 3 months should be done followed by flexion and extension x-rays. It is more common in children due to more profuse blood supply[12] and greater elasticity of the spinal cord in children.

The majority of cervical spine injuries are managed by external immobilization. Traction devices may be used followed by serial imaging to reduce fracture dislocation. Posterior fusion by cable and grafts is recommended in children of 4 years or less age. The above 5 years anterior approach can be considered as well. The choice of approach depends on the site of compression of the cervical cord. Indications of surgery include non-reducible dislocation, progressive deformity, unstable injuries, and decompression of neural structures.[13]

MATERIALS AND METHODS

Study Design and Study Setting

A prospective, observational study was conducted at the Neuro-Trauma Unit of The Lady Reading Hospital, Peshawar from Oct 2021 to Oct 2022 after obtaining approval from the hospital's ethical committee and after obtaining informed consent from the parents.

Inclusion Criteria

Patients were stratified according to their age, mortality, mechanism of injury (fall, motor vehicle accident-MVA, bicycle injuries, sports-related injuries), level of cervical spine injury, presence of neurologic deficit, presence of bony injury (fractures, dislocations), ligamentous injuries & SCIWORA. Our inclusion criteria were age 6 – 17 years, history of trauma, and radiological evidence of cervical spine injury.

Exclusion Criteria

Patients of age more than 18 years, co-morbidities, congenital anomalies, history of Potts disease, or malignancy were excluded from the study.

Patient Groups

The sampling technique was non-probability sampling. A total number of 187 patients were included in our study after identifying 2300 patients with a history of trauma. We divided the patients into two age groups i.e., lower (6-9 years) and higher (10-17 years). Patients were divided into two spinal levels of injury i.e., axial (C0 – C2) and sub axial (C3 – C7). We further classified injuries into fractures, dislocations (traumatic rotatory subluxations, facet dislocations, and subluxations), ligamentous injuries, and SCIWORA.

Clinical Management

Patients were managed according to the type and severity of injuries. Patients with neck pain, normal neurology, and no radiological abnormalities were managed conservatively. We applied traction for cervical trauma patients with the following indications: cervical subluxation, Atlanto-axial rotatory subluxation, Cervical fractures, and incomplete neurology. Traction was applied for 2 – 3 weeks and patients were followed both neurologically and radiologically. If there was any residual instability or progressive neurological deficit, these patients were subjected to surgical intervention.

Surgical Management

A posterior approach was used for surgery in the majority of cases. Intraoperatively reduction was done for facet dislocation under image guidance and fixation was done subsequently. The majority of the patients who underwent surgery had a posterior lateral mass fusion. These patients were then followed up for neurological assessment. We also used odontoid screw fixation for odontoid fractures. The majority of them were for type 2 odontoid fractures however 1 case of type 3 odontoid fracture was fixed. We applied nexus criteria for cervical spine imaging in our patients.

Neurological status was assessed using the ASIA impairment score. Patients were followed for 6 months.

Clinical Assessment Tools

Data was collected on proforma that contained the relevant information including patients age range (6 – 9, 10 – 17 years), mechanism of injury: motor vehicle accident, falls, bicycle injury, sports-related injury, neurological status according to ASIA (American Spinal Injury Association) scale, level of cervical spine injury in CT-scan/X-rays and MRI: C0-C1 & C3 –C7. Moreover, we used nexus criteria (**Table 1)** for imaging recommendations of the patients as follows.

Table 1: Nexus Criteria.

Nexus Criteria	Imaging Recommended
Midline cervical spine tenderness	Yes
Focal neurological deficit	Yes
Not alert or intoxicated	Yes
Distracting injury	Yes

Data Analysis

Data was analyzed by using IBM SPSS version 26. Chi-square test was applied for categorical variables for the outcome analysis in respective groups. A p-value less than 0.05 was considered statistically significant.

RESULTS

Gender Incidence

There was a total of n = 187 patients in the study group. There were 78 females (41.7%) and 109 males (58.3%).

Age Incidence

The patients were 10.6 ± 3.6 years old on average. 72 (38.5%) patients were between the ages of 6 – 9 years, and 115 (61.5%) patients were between the ages of 10 – 17 years.

Incidence of the Level of Injury

In comparison to the lower cervical spine (C3 – C7), which was involved in 86 patients (46%), the higher cervical spine level (C0 – C2) was involved in 101 patients (or 54%). 3.8 ± 1.5 months was the average follow-up period.

Incidence of the Mechanism of Injury According to Age

29 patients in the younger age range (6 to 9 years) experienced cervical spine injuries as a result of car accidents, which were followed by a history of falls (28 patients).

The most frequent cause of cervical spine injuries in the older age range (10 – 17 years) was a history of a fall (49 patients), followed by a motor vehicle accident (41 patients). Injury rates from diving and sports were 12:1 and 5:1 respectively in older age groups. Injuries involving pedestrians occurred in both age groups on an equal basis (7 each respectively).

Level of Injury

Motor vehicle accident (MVA) and history of falls were equal in higher cervical spine levels (40 patients each), however, a history of falls was more common in lower cervical spine levels as compared to MVAs (37 vs. 30 patients). Sports and diving-related injuries involved lower cervical spine levels more commonly (8:5 vs. 4:2 respectively). Pedestrian injuries involved the upper cervical spine in 9 patients as compared to 5 patients in lower spine levels.

ASIA Score at Presentation

29 patients, or 15.5% of the total 187 patients, had preoperative neurology of ASIA grade A. 60 patients (32.1%) had ASIA B neurology at

presentation. There were 74 (39.6%), 19 (10.2%), and 5 (2.7%) patients in ASIA C, D, and E, respectively (**Table 2**). As opposed to older age groups, patients in younger age groups had more patients in ASIA A (14 vs. 11). However, compared to lower age groups, the ASIA B, C, D, and E groups had more patients in higher age groups: 24 vs. 12, 21 vs. 11, 40 vs. 22, and 18 vs. 11 (**Table 3).**

Table 2: ASIA grade At Presentation(A-E)

ASIA Scale	Frequency	Percent
ASIA A	29	15.5
ASIA B	60	32.1
ASIA C	74	39.6
ASIA D	19	10.2
ASIA E	5	2.7
Total	187	100.0

Table 3: ASIA scale (A-E) according to Age groups (6 – 9 vs. 10 – 17 yrs.)

ASIA Scale	06 – 09 Years	10 – 17 Years
ASIA A	14	11
ASIA B	12	24
ASIA C	11	21
ASIA D	22	40
ASIA E	11	18

Post Management & ASIA Scale

After treatment, we had 36 patients with ASIA B neurology (19.3%) and 28 patients in the ASIA A group (15%). Each of the ASIA C, ASIA D, and ASIA E groups contained 30 (16%), 61 (32.6%), and 32 (17.1%) patients, respectively (**Table 4**). This demonstrates an increase in patients in ASIA D and ASIA E following treatment.

Mortality

Patients in the younger age range, 6-9 years, had a greater mortality rate than those in the older range, 10-17 years (p-value 0.0074). 28 children in the age range of 6-9 years and 24 patients in the range of 10-17 years (**Table 5).** In our study, group, 52 patients (27.8%) expired with a mean follow-up of 3.8± 1.5 months. Mortality was more common in males (31 patients) than in females' group (21 patients) (**Table 6).**

Table 4: Post-management neurological status according to ASIA scale (A-E).

ASIA Scale	Frequency	Percent	Cumulative Percent
ASIA A	28	15.0	15.0
ASIA B	36	19.3	34.2
ASIA C	30	16.0	50.3
ASIA D	61	32.6	82.9
ASIA E	32	17.1	100.0
Total	187	100.0	

Table 5: Mortality outcome according to age of individuals.

Age of Patients (Years)	Mortality		Total	Chi-Square Test
	Yes	No		
6-9	28	44	72	χ2 = 7.1616
10-17	24	91	115	p-value=0.0074
Total	52	135	187	(significant result)

Table 6: Mortality outcome following gender of individuals.

Gender of Patients	Mortality		Total	Chi-Square Test
	Yes	No		
Male	31	78		
Female	21	57	78	
Total	52	135	187	

Level of Cervical Injury and Mortality

Mortality was more common in higher cervical spine levels as compared to lower cervical spine levels (p-value: 0.0095). Mortality was present in C0 to C2 levels in (36 patients) and C3 to C7 (16 patients) (**Table 7)**.

Mortality & Mechanism of Cervical Spine Injury

The most frequent cause of death (p-value: 0.052) was motor vehicle accidents, followed by history of falls (27 vs. 17 patients). Injury to pedestrians accounted for 5.7% of fatalities (3 patients). 2 (3.8%) of the deaths were caused by diving-related accidents (**Table 8)**. No deaths from sports-related or other types of injuries were noted.

Mortality & Type of Injury

Out of 52 patients in the mortality group, 24 (46.1%) had fractures, and 14 (26.9%) had dislocations. Twelve patients (12.0%) deaths were caused by ligament injuries, while SCIWORA was to account for two deaths (3.8%) (**Table 9).**

Mortality & Treatment Given

Among the treatment groups, mortality was highest in patients who underwent surgery (28 patients). Among the traction/immobilization group and those who underwent conservative management, 14 patients faced mortality. In patients who underwent combination therapy i.e. both traction/immobilization and surgery 10 patients passed (**Table 10).**

Mortality was maximum in post-treatment ASIA group A and ASIA group B(post-treatment). The mortality seems dependent on the post-treatment neurological status of the patients (p value<0.05) (**Table 11).**

Mortality Outcome Pre-Op Vs. Post Op:

We followed the patients for 6 months and their mortality outcome is

Table 7: Level of cervical spine injury (C0-C2 vs. C3 – C7) and mortality outcome.

Level of Cervical Spine Injury	Mortality Yes	Mortality No	Total	Chi-Square Test
C0 – C2	36	65	101	χ2 = 6.7175
C3 – C7	16	70	86	p value=0.009547
Total	52	135	187	(significant result)

Table 8. Mechanism of cervical spine injury and mortality outcome

Mechanism of Cervical Spine Injury	Mortality Yes	Mortality No	Total	Chi-Square Test
Motor Vehicle Accidents	27	39	66	χ2 = 9.3613 p value=0.0526 (insignificant result)
History of Fall	17	59	76	
Sports-Related Injury	3	13	16	
Diving Injury	2	6	8	
Pedestrian Injury	3	18	21	
Total	52	135	187	

Table 9: Type of cervical spine injury (fracture, dislocation, ligamentous, SCIWORA) vs. mortality outcome.

Type of Bony Injury	Mortality Yes	Mortality No	Total	Chi-Square Test
Fracture	24	60	84	χ2 = 2.90 p value=0.407 (insignificant result)
Dislocation	14	49	63	
Ligamentous Injury	12	20	32	
SCIWORA	2	6	8	
Total	52	135	187	

Table 10: Mortality outcome according to management (conservative, surgery, traction/immobilization).

Management	Mortality Yes	Mortality No	Total	Chi-Square Test
Conservative	5	8	13	χ2 = 5.5011 p-value=0.1385 (insignificant result)
Surgery	28	56	84	
Traction and Immobilization	9	22	31	
Combination	10	49	59	
Total	52	135	187	

Table 11: Mortality outcome according to post-op neurological status (ASIA A-E).

Post-op Neurological Status	Mortality Yes	Mortality No	Total
ASIA A	27	1	28
ASIA B	22	14	36
ASIA C	3	27	30
ASIA D	0	61	61
ASIA E	0	32	32
Total	52	135	187

mentioned in **Table 12.** At 4-months, mortality was observed in 12 patients. At 5 and 6 months, the mortality was seen in 10 patients after 2 months. **Table 13** shows the pre-op vs. post-op neurological outcome of patients having cervical trauma. There existed a significant difference (p-value< 0.00001) between patients' pre-op and post-op neurological outcomes concerning the ASIA scale (A to E).

Table 12: Six months follow-up mortality outcome of patients having cervical spine trauma.

Follow up	Mortality		Total
	Yes	No	
1 month	3	11	14
2 months	10	22	32
3 months	7	20	27
4 months	12	32	44
5 months	10	31	41
6 months	10	19	29
Total	52	135	187

Table 13: Pre-op vs. post-op neurological outcome of patients having cervical trauma.

ASIA Grading	Pre-op Patient's n (%)	Post op Patients n (%)	Chi-Square Test
ASIA A	29 (15.5%)	28 (15.0%)	
ASIA B	60 (32.1%)	36 (19.3%)	$\chi^2 = 66.38$ p-value<0.00001 (significant result)
ASIA C	74 (39.6%)	30 (16.0%)	
ASIA D	19 (10.2%)	61 (32.6%)	
ASIA E	5 (2.7%)	32 (17.1%)	

DISCUSSION

Cervical spine injury is common in patients with a history of trauma. The higher cervical spine level (C0-C2) was implicated in 101 individuals (or 54%) compared to 86 patients (46%) who involved the lower cervical spine (C3 – C7). In the older age group (10 – 17 years), a history of falls was the most common cause of cervical spine injuries, followed by auto accidents. At upper cervical spine levels, motor vehicle accidents (MVAs) and fall history were equally prevalent (40 patients each); however, a history of falls was more common at lower cervical spine levels than at MVAs. Of the 187 individuals, 29 had preoperative neurology of ASIA grade A, or 15.5% of the total. At presentation, ASIA B neurology was present in 60 individuals (32.1%). Patients in younger age groups had more patients in ASIA A compared to those in older age groups. Following therapy, we had 28 patients in the ASIA A group (15%) and 36 patients with ASIA B neurology (19.3%). a rise in ASIA D and ASIA E patients after therapy. Patients between the ages of 6 and 9 died at a higher rate than those between the ages of 10 and 17. Twenty-eight youngsters, aged six to nine, and twenty-four patients, aged ten to seventeen. Our results matched with the study conducted by Patel et al,[14] which showed a 27% mortality rate in the cervical spine with a difference of 0.8%. Mortality was more common in higher cervical levels (i.e., C0 – C2) as compared to lower cervical levels (i.e., C3 – C7).

Higher cervical spine levels were associated with a greater mortality rate than lower cervical spine levels. Compared to C3 to C7 (16 individuals), mortality was more common in C0 to C2 levels (36 patients). Auto accidents were the most common cause of mortality, followed by a history of falls. 26.9% had dislocations and 46.1% had fractures. Patients who underwent surgery had the greatest death rate among the therapy groups. Maximum mortality was seen in ASIA groups A and B following therapy (post-treatment). The patient's neurological condition following therapy appears to have an impact on death. Regarding the ASIA scale, there was a noteworthy distinction in the neurological results of the patients before and after surgery.

According to Finch et al,[15] children under 10 years had cervical spine injuries most commonly due to MVA and involved upper cervical spinal levels more commonly. In children above 10 years, sports-related injuries were the most common cause of cervical spine injury. These findings were similar to our study. Brown et al conducted a study that showed that high-impact traumas like MVAs and a history of falls most commonly caused dislocations and fractures respectively. These findings also matched according to our study population. According to a study by Habib et al,[16] traumatic spinal injury was common in ages 16 to 18 years. MVA consisted of 60.8% of the cases of cervical spine injuries. Pedestrian injuries were common in younger age groups (< 12 years of age). Cervical spine injury was 55.8%, especially in the younger age group (< 12 years of age).in 23.3% of cases, multiple-level cervical spine injuries were found. Neurological deficits in these children were found to be 22.7 % and the overall mortality rate was 8.3%.

Sports-related injuries can result in fractures to the cervical spine and spinal cord injuries (SCI). There are currently insufficient large database studies examining sports-related cervical trauma in the pediatric population. The greatest incidences of upper/lower cervical fracture, dislocation, and SCIWORA were seen in adolescent athletes. In all sports, adolescence, and SCIWORA were highly significant predictors of concomitant TBI. The rising incidence of CSI with age highlights the growing concern for competitive young sports and is consistent with newly revised laws intended to reduce juvenile sports-related injuries.[17] The epidemiology and imaging features of cervical spine injuries in children who have experienced blunt trauma were detailed by Beckmann et al.[18] Upper cervical spine injuries, which are usually distraction injuries and are often linked to avulsion fractures, are common in pediatric patients. Pediatric patients' injury patterns differ greatly depending on their age, with distraction-related injuries being more common in those under three.

Younger children had a much-reduced frequency of cervical spine injuries, according to Yadav et al.[19] Patients who fell from a height were the most prevalent mechanism of injury, followed by those who were in car accidents. In younger children, there was a much larger involvement of the upper cervical spine. Subluxation fractures were the most frequent kind of damage. In younger children, 42% had spinal cord injury without radiographic abnormalities (SCIWORA), compared to 8% in older children. The mortality rate was 20% overall. SCIWORA was observed in both age categories, with younger children showing a noticeably greater occurrence. Children's fusion and instrumentation procedures are safe, however, growing juvenile spines require extra care. Children's cervical trauma differs from adult cervical injuries mostly because of anatomical variances. An ideal course of diagnosis and treatment is essential, especially in circumstances where standardized standards for the handling of such illnesses are lacking. A review examined many facets of SCIWORA and modern pediatric cervical trauma decision-making and therapy. The primary stay of care for SCIWORA patients involves immobilization and avoiding high-risk activities. The early neurological state and magnetic resonance imaging are major factors in determining prognosis. Future randomized controlled trials are required to help provide standardized methods because there is a substantial amount of variance in the literature about diagnosis and therapy.[20]

CONCLUSION

Patients with cervical spine fractures had 27.8% mortality. Independent risk factors for raised mortality were younger age groups, higher cervical spine levels, mechanism of injury including high energy impact trauma like MVAs had raised mortality, bony injuries like fractures and dislocations had raised mortality than SCIWORA, and ligamentous injuries. Surgical intentions included posterior and anterior fusions and decompression. Complete neurological deficits had raised mortality as compared to incomplete neurological deficits.

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Additional Information

Disclosures: Authors report no conflict of interest.

Ethical Review Board Approval: The study conformed to the ethical review board requirements.

Human Subjects: Consent was obtained by all patients/participants in this study.

Conflicts of Interest:

In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.

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AUTHORS CONTRIBUTION

S #	Authors full name	Intellectual Contribution to Paper in Terms of:
1.	Abbas Khan	Study design and methodology.
2.	Sahibzada Haseeb Ahmed	Literature review and referencing.
3.	Muhammad Kashif Jamal	Final review and approval.
4.	Shumaila Gul, & Bahrul Amin Khan	Data collection and calculations.
5.	Syed Mansoor Shah	Interpretation of results.
6.	Maria Nisar	Analysis of data.