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INCOMPLETE TRAUMATIC SPINAL CORD INJURIES: TREATMENT OUTCOME AND RELATIONSHIP TO NEUROPLASTICITY OF BRAIN AND SPINAL CORD

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ABSTRACT
Summary: I am not unrewarding as my brother complete says incomplete spinal cord injury. The knowledge, careful handling and proper care of incomplete spinal injury is rewarding in neurological recovery. Neurological recovery is being attributed to neuroplasticity of the brain and the spinal cord. **Objectives:** To determine the treatment outcomes in incomplete traumatic spinal cord injury patients managed in our center. The effect of injury type on neurological outcome and its relationship to neuroplasticity of brain and the cord. **Methods:** It was a prospective study on incomplete traumatic spinal cord injury patients managed in our center from 1st August 2010 to 30th April 2016. Patients were managed in accident and emergency using Advance Trauma Life Support protocols. The injury site was splinted and stabilized using Philadelphia collar or corset. Injury type was determined clinically using American Spinal Injury Association impairment scale grading. Patients were managed conservatively. Structured proforma was used to collect data which were analyzed using Environmental Performance Index 7 software. **Results:** Ninety three patients were studied. Males were 64. The age range was 19-74 years. The most common etiology was vehicular trauma. At discharge forty nine patients achieved ASIA grade E. ASIA grade at presentation significantly affected the neurological outcome but injury type did not. **Conclusion:** There was good neurologic recovery among various types of incomplete spinal cord injury. There was no significant difference in neurologic recovery among the various types of injury. Neuroplasticity must have been involved in the neurologic recovery of all the types.

KEYWORDS: incomplete spinal injury, neurological recovery, neuroplasticity.

INTRODUCTION
'Doctor I failed to attend the clinic because I went home to show those who said I would not walk again that I am walking. I have started my taxi work'. 'Doctor let me tell you the truth. My father told me to discharge against medical advice. He said I was attacked in the forest by spirit and only herbalist can handle it with herbs and massaging. I want to stay and be treated here, help me please'. The first quotation was at surgical out-patient clinic by a taxi driver who sustained central cord syndrome, ASIA B, from car crash. He had ASIA grade D on discharge. The second quotation was in the ward by a logger who branch of falling tree hit on the neck and he sustained Brown-Sèquard syndrome ASIA B. The confession was when he learnt that by the time he reached home through pot-hole laden roads, cord edema might paralyze his diaphragm and threatened his life. On discharge he had ASIA D. The first patient showed level of satisfaction he had for his recovery. The advice of the father of the second patient portrays what some spinal injured patients pass through due to lack of knowledge. Awareness and proper handling of incomplete spinal cord injury, a common problem with us, cannot be overemphasized. The proportion of patients with incomplete spinal cord injuries, according to European and American databases, were 52..8% and 44.3% respectively.[1] The primary cord injury is at the moment of impact, but secondary injuries follow the primary injury.[2] Cortical and spinal circuitries are said to undergo plastic changes and reorganization to improve functional recovery in spinal cord injuries.[3,4] We studied incomplete spinal cord injured patients we managed in our center checking the outcomes of types of injuries and their possible relationships to neuroplasticity of the brain and spinal cord.

PATIENTS AND METHODS
Setting
It was a prospective, descriptive and cross-sectional study of incomplete traumatic spinal cord injury patients managed non-operatively in a poor resource neurosurgical center in a developing country from1st August 2010 to 31st July 2016.

Inclusion criteria

All patients who had incomplete traumatic spinal cord injury that were managed conservatively in our center from admission to discharge within the study period. They included patients with anterior cord syndrome, central cord syndrome and Brown-Sèquard syndrome. Patients with American Spinal Injury Association (ASIA) impairment scale grades B to D. Those with associated traumatic brain injuries whose Glasgow Coma Scale (GCS) scores were 13-15.

Exclusion criteria

Patients with complete spinal cord injuries, whiplash injuries and cauda equina syndromes were excluded. Those with ASIA grades A and E or had associated traumatic brain injuries with Glasgow Coma Scale (GCS) scores <13 were excluded. Patients who left against medical advice or who could not afford radiological investigations were also excluded.

Methods

Patients were managed in accident and emergency using Advanced Trauma Life Support protocols. We aimed at euvolemia and normotension using normal saline or 5% Dextrose/saline. Oxygen saturation of ≥95% was ensured either in room air or by augmenting with oxygen via face masks, nasal prongs, or endotracheal tubes. The injured site was splinted with Philadelphia collar for neck and corset for trunk. Adequate analgesia was ensured using intramuscular (i.m.) Paracetamol 900mg 8 hourly, which was augmented with i.m. Diclofenac 75mg 12 hourly depending on the extent of the injuries sustained. We catheterized some patients to monitor urine output, depending on the extent of injuries. Full history and physical examinations were done. The ASIA impairment scale was used to grade the patients and their GCS scores were determined. The clinical type of incomplete injury was assigned after physical examinations. Those with open wounds had i.m. Tetanus Toxoid 0.5ml stat and intravenous (i.v.) Ceftriaxone 1gm daily. Those with other system injuries were co-managed with appropriate specialist units. Radiological investigations, full blood count, serum electrolytes and creatinine and random/fasting blood sugar were done. Patients were admitted in the wards or intensive care unit (when functional) and further care continued. We used water mattress (depending on affordability) or air ring with two hourly turning to prevent pressure sores. We gave them high energy/high protein diet as full diet or for supplementation. The diet was constituted thus: 500ml pap, two tablespoonful powdered milk, two tablespoonful soya bean powder, one tablespoonful crayfish powder and one tablespoonful red oil. Multivitamin, Vitamin C, Vitamin B-complex, one tablet each three times daily were given to them. Vitamin E 1000 I.U. was given two times daily. We gave Bisacodyl suppository, two stat, then one alternate days for those who failed to open bowel after 48 hours. Low dose Aspirin 75mg once daily and subcutaneous Clexane 40mg once daily (for those who could afford Clexane) were given to patients. Infusions and i.m./i.v. injections were stopped once adequate enteral feeding was achieved. Oral antibiotics were then commenced for those with wounds. Physiotherapy was started once the injured site was splinted. Psychotherapy was commenced in the wards. Check X-rays of injured sites were done at 6 weeks post-injury to check for fusion. Then, patients were mobilized on bed gradually till 90 degree sitting position was achieved. They were then mobilized out of bed on wheel chair, walking frame, or walking on their own when power of lower limbs were ≥4. Patients were then discharged to surgical out-patient department for follow up. Some were referred to occupational therapists since we do not have any in our hospital.

Data were collected using structured proforma which was component of our prospective data bank that was approved by our ethics and research committee. The biodata, history and physical findings, including GCS scores, ASIA grading at presentation and radiological findings were documented in accident and emergency. The progress of the patients, ASIA grading at discharge and length of hospital stay were documented in the wards. Data were analyzed using Environmental Performance Index (EPI) info 7 software (Center for Disease Control and Prevention, Atlanta, Georgia USA). We used add analysis gadget of the visual dashboard. Frequency/charts components were used for frequencies of some variables like etiology. Mean component was used for continuous variables such as age and length of hospital say. We recoded age using 'defined variables' before dividing them into age groups using frequency. Univariate analysis was done using MXN/2X2 and its advanced component for multivariate analysis. At 95% confidence interval, P <0.05 was considered significant.

RESULTS

Ninety three patients were studied. There were sixty four males and twenty nine females. The average age was 36.61 years with a range of 19 - 74 years. The most common age group involved was 30 – 40 years, table 1.

Table 1: Age group frequency

Age group	Number	Percent (%)
10 - <20	3	3.23
20 - <30	24	25.81
30 - <40	31	33.33
40 - <50	20	21.51
50 - <60	13	13.98
60 - <70	1	1.08

70 - < 80	1	1.08
Total	93	100

Fifty six patients were involved in motor vehicular accident, table 2.

Table 2: Etiology frequency

Etiology	Number	Percent (%)
Assault	4	4.03
Fall	11	11.83
Motorcycle	10	10.75
Others	2	2.15
Sports	2	2.15
Something fell on patient	6	6.45
Tricycle	2	2.15
Vehicle	56	60.22
Total	93	100

Eighty one patients had cervical spinal cord injury, fig 1.

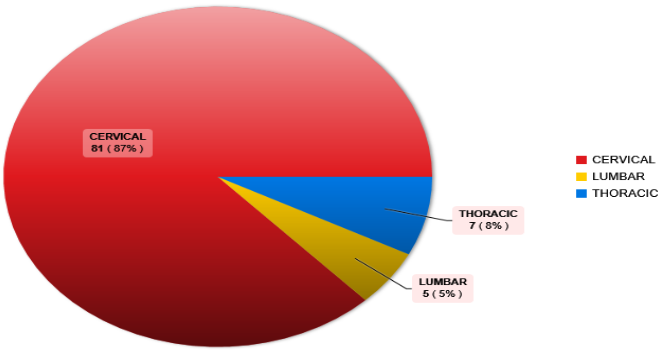

Fig 1: Site of injury

Anterior cord syndrome was seen in 51 patients, fig 2.

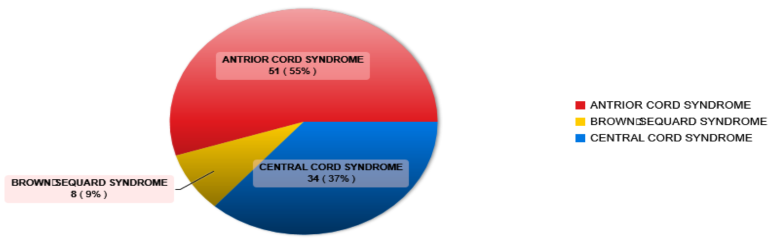

Fig 2: Type of injury

Clinically, ASIA Impairment Scale grade D was the most common at presentation, table 3.

Table 3: ASIA grade at presentation

ASIA grade at presentation	Number	Percent (%)
B	18	19.35
C	36	38.71
D	39	41.94
Total	93	100

Seven patients were hypertensive, one diabetic and two asthmatic. Spondylolisthesis was the most common radiological finding, table 4.

Table 4: Radiology findings

Radiology findings	Number	Percent (%)
Burst fractures	6	6.45
Multiple compression fractures	9	9.68
Multiple fracture patterns	12	12.90
No abnormality	10	10.75
Others	4	4.30
Single compression fracture	14	15.05
Spondylolisthesis	38	40.86
Total	93	100

At discharge, the patients with ASIA grade E were 49, while three patients died, table 5.

Table 5: ASIA grade at discharge

ASIA grade at discharge	Number	Percent (%)
B	1	1.08
C	5	5.38
D	35	37.63
Died	3	3.23
E	49	52.69
Total	93	100

There was no significant effect of age on ASIA grade at discharge, $P = 0.7712$. There was also no significant relationship between type of injury and ASIA grade at discharge, $P = 0.2746$, table 6.

Table 6: Type of injury vs ASIA grade at discharge

Type of injury	ASIA grade at discharge					
	B (%)	C (%)	D (%)	Died (%)	E (%)	Total (%)
ACS	1 (1.96)	1 (1.96)	17 (33.33)	2 (3.92)	30 (58.82)	51 (100)
BSS	0 (0)	1 (12.50)	6 (75)	0 (0)	1 (12.50)	8 (100)
CCS	0 (0)	3 (8.82)	12 (35.29)	1 (2.94)	18 (52.94)	34 (100)
Total	1 (1.08)	5 (5.38)	35 (37.63)	3 (3.23)	49 (52.69)	93 (100)
$P = 0.2746$						

(ACS = Anterior Cord Syndrome, BSS = Brown-Sèquard Syndrome, CSS = Central Cord Syndrome).

No significant relationship between comorbidity and ASIA grade at discharge, $P = 0.9889$. The relationship between radiological findings and ASIA grade at discharge was not significant, $P = 0.8394$. However, there was significant relationship between ASIA grade at presentation and ASIA grade at discharge, $P = 0.00$, table 7.

Table 7: ASIA grade at presentation versus ASIA grade at discharge

ASIA at presentation	ASIA grade at discharge					
	B (%)	C (%)	D (%)	Died (%)	E (%)	Total (%)
B	1 (5.56)	5 (27.78)	9 (50.00)	2 (11.11)	1 (5.56)	18 (100)
C	0 (0)	0 (0)	23 (63.89)	1 (2.78)	12 (33.33)	36 (100)
D	0 (0)	0 (0)	3 (7.69)	0 (0)	36 (92.31)	39 (100)
Total	1 (1.08)	5 (5.38)	35 (37.63)	3 (3.23)	49 (52.69)	93 (100)
$P = 0.00$						

Nine patients had multiple complications, table 8.

Table 8: Complications

Complications	Number	Percent (%)
Depression	2	2.15
Fecal impaction	5	5.38
None	73	78.49
Orthostatic pneumonia	1	1.08
Multiple	9	9.68
Pressure sore	1	1.08
Urine retention	2	2.15
Total	93	100

The average hospital stay was 56.59 days with a range of 12 - 157 days.

DISCUSSION

There were more males than females in our study and those 20 – 50 years formed the bulk of the patients, 75. Vehicular accident, fall and motorcycle accidents were the most common etiologies, 77 patients. In our environment, males engage in many occupations to put food on the table for their families and these occupations predispose them to trauma. Most patients from falls were carpenters who fell while roofing houses and wine tappers who fell from palm trees. These occupations are exclusive of males in our environment. Many of those something fell on were loggers. They cut down trees in the forest. Branch of falling tree hit the logger on the neck or back with resultant spinal cord injury. Logging is also exclusive of males. Due to high rate of unemployment, many young men had embraced commercial motorcycle, tricycle and vehicle driving to help them sustained themselves and their families, and many of them got involved in accident. In Turkey, Çeliker et al[5] in their study of patients with traumatic spinal injuries, found that 75.68% were males. Road traffic accidents and falls were the most common etiologies, 64.92%. Kato et al[6] in 63 patients they studied found that 52 were males. Twenty nine patients were involved in road traffic accident, while 16 were from falls. Miyanji et al[7] in 100 patients with traumatic cervical spinal cord injuries they studied found that 79 were males; road traffic accident and fall were the most common etiologies, 76 patients.

The cervical spinal cord was mostly involved, 81 patients. As noted by Ropper et al[8] the cervical spine is most vulnerable to injury due to the relative axial alignment of their facet joints which require less force to dislocate compared with thoracic or lumbar spine. They also noted that the neck has relatively less external support compared with thoracic spine which has rib cage for stabilization. The lumbar spinal cord was least involved due to termination of the cord at lower part of first or upper part of second lumbar vertebra.

There was significant relationship between ASIA grade at presentation and ASIA grade at discharge. ASIA impairment grading at presentation depicts the clinical manifestation of the extent of the injury. It follows that the more the injury the worse the clinical manifestation and the more difficulty in repairing the damage.

Pollard et al[9] in their study of factors associated with improved neurologic outcomes in patients with incomplete tetraplegia found that neurological recovery was not related to gender, race or mechanism of injury. They also found that neurologic recovery was also not related to high dose steroid, early definitive surgery, or early anterior decompression. They found that patients with either central cord syndrome or Brown-Sēquard syndrome had improved neurologic outcome. Donovan et al[10] in their study of cervical spinal cord injury found that surgery, conservative care, canal stenosis and vertebral alignment did not have effect on neurological recovery. Tator et al[11] found no difference in neurologic recovery and hospital stay for acute spinal cord injury managed operatively or non-operatively. Courtine et al[12] in their study of recovery of supraspinal control of stepping via indirect propriospinal relay connections after spinal cord injury found that propriospinal pathway was used as detour route for supraspinal circumvention of lesioned site. There was axonal sprouting above the lesioned site to contralateral side and subsequent sprouting below the lesioned site from contralateral side to ipsilateral side to restore neurological function. Other studies had shown that axotomized neurons sprouted over a short distance to make a new local synaptic connections with short and long propriospinal circuits, thus circumventing lesion sites.[12,13,14] Sprouting of intact axons within the spinal cord and within motor centers of brain stem can utilize the same detour mechanism to either drive activity within original denervated targets or utilize remaining intrinsic propriospinal circuitry to bridge structures across lesioned areas.[15,16] Fink and Cafferty[17] in their review of reorganization of intact descending motor circuits to replace lost connections after spinal cord injury found that in supraspinal reorganization, rubrospinal tract,[16] reticulospinal tract,[18] and raphespinal tract[19,20] were involved in neurological recovery. They concluded that in addition to utilizing the propriospinal pathway, the plasticity of intact fibers that arborize into the denervated territories are now established to have significant functional benefits.[12-14] Nishimura and Isa[21] in their review of cortical and subcortical compensatory mechanisms after spinal cord injury in monkeys found that bilateral primary motor areas play major role in early stage (less than one month) of recovery,[22,23] whereas bilateral ventral premotor area are the prominent contributors to the later stages (3-4 months).[23] From above findings, the lack of significant difference in functional outcome from the various types of incomplete spinal injuries in our study was likely due to the common method of recovery by neuroplasticity of the brain and spinal cord.

CONCLUSION

There was good recovery among the various types of incomplete spinal cord injuries. The functional recovery (ASIA grade at discharge) was significantly affected by extent of injury (ASIA grade at presentation). There was no significant difference in functional recovery among the different types of incomplete spinal cord injuries. Thus the neurological recovery in incomplete spinal cord injuries in our study centered likely on a common pathway of neuroplasticity of brain and spinal cord. We believe that the controversies of surgical and nonsurgical treatment should be left behind us. Avoidance of secondary injuries and stabilization of the injured site should be the goal of treatment. It could be achieved by conservative as well as by surgical method. The reparative processes are taken care of by neuroplasticity of the brain and spinal cord. The future research should be centered on how to further support the reparative process, especially in bridging the complete transection in complete spinal cord injury.

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