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OUTCOME OF NON-OPERATIVE TREATMENT OF TRAUMATIC CERVICAL SPINE INJURIES; CONTROVERSIES OF CARE AND FUTURE DIRECTION

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ABSTRACT

Traumatic spinal injury is a devastating neurosurgical condition. The cervical region is the most involved region. Morbidities arising from the complications are common. We prospectively studied the outcome of patients with traumatic cervical spinal injuries managed in our center over a four and half year period. **Objective:** The objective was to evaluate the outcome of non-operative treatment of the patients using American Spinal Injury Association (ASIA) impairment scale. **Methods:** It was a prospective study on patients managed non-operatively for traumatic cervical spine injuries in our center from August 2010 to January 2015. Patients were managed in accident and emergency using Advanced Trauma Life Support protocols, ensuring stabilized neck, normotension, euvolemia and oxygen saturation of ≥95%. History and physical examinations were carried out. Patients were admitted to the wards or intensive care unit and their treatment continued until discharged. Data were collected using structured proforma which was component of our prospective data bank that was approved by our ethics and research committee. Data were analyzed using Environmental Performance Index Info 7 software. **Results :** There were 81 patients. Males were 53. Mean age was 37.11 years. Forty seven patients had vehicular accident. Patients with incomplete injury recovered better. ASIA grade at presentation and comorbidity significantly affected the outcome. **Conclusions:** Males were more affected by the lesion, while majority had vehicular accident. ASIA grade at presentation significantly affected neurological recovery. From literature, central nervous system plasticity and reorganization appeared to be the key factors in recovery.

KEYWORDS: cervical spine injury, neurological recovery, trauma.

INTRODUCTION

Traumatic spinal injury leaves on its trail mortalities and morbidities. It imposes lots of challenges to the patients, the relatives, and the society. More than175000 spinal injuries occur globally every year.[1] In United States of America 12000 individuals suffer spinal cord injuries each year, mostly from motor vehicular accident and falls[2] and approximately 57-75% of spinal cord injuries in USA are cervical.[3,4] The incidence of traumatic cervical spinal cord injury varies globally from 10.4-83.0 per million population per year.[5-7] Management of these patients have been challenging. As noted by Ropper et al,[8] the ability to treat the injuries surgically has advanced in recent years from a standpoint of spinal column stabilization, the overall motor and sensory recovery in patients with severe spinal cord injuries have not changed. Emerging medical and surgical therapies have not been rewarding in changing the outlook of these patients.[9] Controversies between timing of surgical care and effects on neurological recovery[10] and between surgical and non-surgical care[11] have been going on for a while. However, it appears that nature has the key and needs assistance from us to unlock its potentials. With the current understanding of secondary injuries[12,13] and functional reorganization of somatosensory-motor cortical topography[14] and plasticity in spinal circuitry,[15] the ability to reduce secondary injuries and assist the central nervous system to quickly reorganize itself may hold the key to improved neurological recovery. We prospectively studied non-operative treatment of traumatic cervical spinal injuries in our neurosurgical center where there was no equipment for surgical care of these patients.

PATIENTS AND METHODS

Design

A prospective and observational study.

Institution credited with the research

University of Calabar Teaching Hospital, Calabar, Cross River State, Nigeria.

Setting
A young neurosurgical center located in rural area of a developing country that started in 2010 with no equipment for spine surgery and no functional intensive care unit (ICU). The ICU became functional in 2012, then became epileptic and stopped working in 2014. There is no functional computerized tomography scan or magnetic resonance imaging in our center.

Inclusion criteria
All traumatic cervical spine injury patients managed by our center from 1st August 2010 to 31st January 2015. Patients with Glasgow Coma Scale (GCS) score ≥13.

Exclusion criteria
Patients who could not afford cervical spine x-rays. Those discharged against medical advice. Patients referred to other centers. Those with ASIA Impairment Scale E, and patients with GCS score <13. Whiplash injury patients were excluded.

METHODS
It was a prospective, observational and cross-sectional study of traumatic cervical spinal injury patients managed in our center from 1st August 2010 to 31st January 2015. Patients were managed in accident and emergency unit using ATLS protocols. The neck was immobilized with Philadelphia cervical collar. The patient was given Normal saline 1liter 8 hourly ensuring euvolaemia and normotension. Oxygen was given using face mask, nasal catheter/prongs, through endotracheal tube or ventilated (when ICU was functional), ensuring saturation of ≥95%. Intramuscular/intravenous (i.m/i.v.) Paracetamol 900mg/1gm (depending on availability) was given 8hourly for analgesia. It was augmented with i.m. Diclofenac 75mg 12hourly depending on the severity of pain. Foley's catheter size 14 was passed to monitor urine output. Intravenous Ceftriaxone 1gm daily was given to those with open wounds. History and physical examinations were done. Patients' were assessed using ASIA impairment scale and Glasgow Coma Scale. Cervical spine x-rays were done and the site of injury checked. Full blood count, urinalysis and other investigations were done. Patients with associated injuries were co-managed with appropriate specialist units. Patients were admitted in the wards or ICU and further treatment continued. We used water mattress or air ring depending on affordability. We commenced oral feeding once patient opened bowel. If they failed to open bowel after 48hours, we used Bisacodyl suppository one alternate days. We gave them high energy/high protein diet constituted thus: 500ml pap, two tablespoonful powdered milk, two tablespoonful soya bean powder, one tablespoonful cray fish powder and one tablespoonful red oil. They were given 5-6 times daily. The infusions and i.v. drugs were then discontinued. We gave Vitamin E 1000IU twice daily, Vitamin C and Multivitamin tablets one three times daily each, and Aspirin 75mg once daily. We gave subcutaneous (s.c.) Heparin (Clexane) 40mg once daily (for those who afforded them). Physiotherapy, psychotherapy and two hourly turning were commenced once the neck was immobilized. Check cervical x-rays were done 6 weeks post-splinting of the neck. Once there was callous bridge, we commence mobilization on and then off the bed, on wheel chair or walking frame, then on feet once the power in lower limbs were minimum of four. Patients were then discharged to be followed up on surgical outpatient clinic. We referred some to occupational therapist on discharge since we are yet to have occupational therapist in our center.

Data were collected using structured proforma which was component of our prospective data bank that was approved by our ethics and research committee. Biodata, history and physical findings, including ASIA grades and GCS scores, and x-ray findings were documented in accident and emergency. The progress of the patients 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 the analytical gadget of the Visual dashboard to analyze the data. We used the frequency or chart components to check frequency of some variables, the mean component for continuous variables, and MXN/2X2 and its advanced component for univariate and multivariate analysis. At 95% confidence interval P <0.05 was considered significant.

RESULTS
There were eighty one patients in the study. Males were fifty three (65.43%), while females were twenty eight (34.57%). Twenty seven patients (33.33%) came to our center direct from the trauma scene, while fifty four patients (66.67%) were referred to our center by other health facilities. Fifty one patients presented within 24 hours of injury, sixteen patients presented between 24hours and 48 hours of injury, while fourteen patients presented after 48 hours of injury. The mean age was 37.11years with age range of 15-74 years. The most common age group affected was 20-29 years, while 20-49 years formed 76.55%, table 1.

Table 1: Age group frequency

Age group	Number	Percent (%)
10 - <20	4	4.94
20 - <30	23	28.40
30 - <40	19	23.46
40 - <50	20	24.69
50 - <60	12	14.81

60 - <70	2	2.47
70 - <80	1	1.23
Total	81	100

The most common etiology was vehicular accident, fig 1.

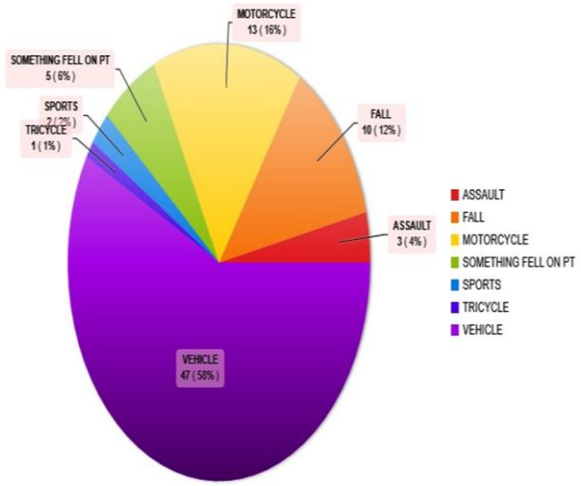

Fig 1: Etiology

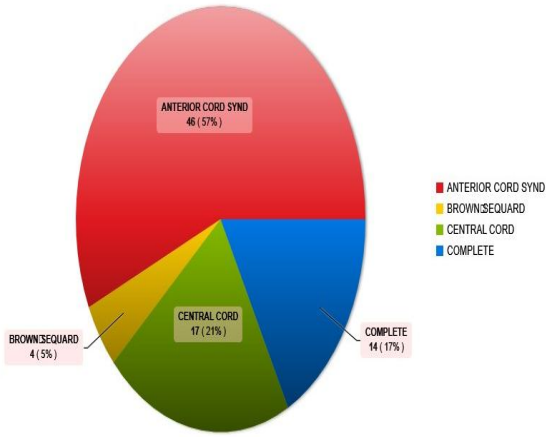

Fig 2: Type of injury

ASIA grade D was most common at presentation, table 2.

Table 2: ASIA grade at presentation

ASIA grade at presentation	Number	Percent (%)
A	14	17.28
B	16	19.75
C	22	27.16
D	29	35.80
Total	81	100

ASIA grade E was most common at discharge, table 3.

Table 3: ASIA grade at discharge

ASIA grade at discharge	Number	Percent (%)
A	8	9.88
B	1	1.23
C	5	6.17
D	23	28.40
E	38	46.91
Died	6	7.41
Total	81	100

The site most involved was C5/C6, fig 3.

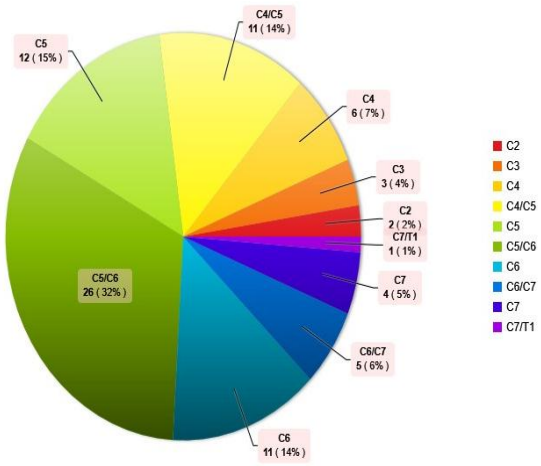

Fig 3: Site of injury

On the x-rays, there were 40 spondylolisthesis, 18 single compression fractures, 10 multiple compression fractures, 5 burst fractures, 4 other forms of fractures, while x-ray appeared normal in 4 patients. Associated injuries were musculoskeletal 12, mild traumatic brain injuries 10, cardiothoracic injuries 4, ophthalmological injuries 3, maxillofacial injuries 2, gastrointestinal injury 1, while 49 patients did not have associated injuries.

ASIA grade at presentation significantly affected the ASIA grade at discharge, $P = 0.00$, table 4.

Table 4: ASIA grade at presentation vs ASIA grade at discharge

ASIA grade at presentation	ASIA grade at discharge (%)						
	A	B	C	D	E	Died	Total
A	8(57.14)	0(0)	1(7.14)	1(7.14)	0(0)	4(28.57)	14(100)
B	0(0)	1(6.25)	4(25.00)	9(56.25)	1(6.25)	1(6.25)	16(100)
C	0(0)	0(0)	0(0)	11(50.00)	10(45.45)	1(4.55)	22(100)
D	0(0)	0(0)	0(0)	2(6.90)	27(93.10)	0(0)	29(100)
Total	8(9.88)	1(1.23)	5(6.17)	23(28.40)	38(46.91)	6(7.41)	81(100)
$P = 0.000$							

The type of injury significantly affected the ASIA grade at discharge (outcome), $P = 0.00$, table 5.

Table 5: Type of injury vs ASIA grade at discharge

Type of injury	ASIA grade at discharge (%)						
	A	B	C	D	E	Died	Total
ACS	0(0)	1(2.17)	4(8.70)	14(30.3)	25(54.35)	2(4.35)	46(100)
BSS	0(0)	0(0)	0(0)	3(75.00)	1(25.00)	0(0)	4(100)
CCS	0(0)	0(0)	0(0)	5(29.41)	12(70.59)	0(0)	17(100)
Complete	8(57.14)	0(0)	1(7.14)	1(7.14)	0(0)	4(28.57)	14(100)
Total	8(9.88)	1(1.23)	5(6.17)	23(28.40)	38(46.91)	6(7.41)	81(100)
$P = 0.000$							

ACS (anterior cord syndrome), BSS (Brown-Sequard syndrome), CCS (central cord syndrome).

Comorbidity significantly affected the outcome, $P = 0.0481$, table 6.

Table 6: Comorbidity vs ASIA grade at discharge

Comorbidity	ASIA grade at discharge (%)						
	A	B	C	D	E	Died	Total
Asthma	0(0)	0(0)	0(0)	0(0)	2(100)	0(0)	2(100)
Diabetes M	0(0)	0(0)	0(0)	0(0)	0(0)	2(100)	2(100)
Hypertension	1(14.29)	0(0)	0(0)	3(42.86)	2(28.57)	1(14.29)	7(100)
None	7(10.14)	1(1.45)	5(7.25)	20(28.99)	33(47.83)	3(4.35)	69(100)
Others	0(0)	0(0)	0(0)	0(0)	1(100)	0(0)	1(100)
Total	8(9.88)	1(1.23)	5(6.17)	23(28.40)	38(46.91)	6(7.41)	81(100)
$P = 0.0481$							

The time of presentation did not affect the outcome, $P = 0.6015$. The mode of presentation (direct or referred) did not affect the outcome, $P = 0.2472$. Associated injuries did not have significant effect on the outcome, $P = 0.2563$.

Complications developed were significantly related to ASIA grade at presentation, $P = 0.0024$, table 7.

Table 7: ASIA at presentation vs complications

ASIA at presentation	Complications							
	DP	DVT/E	FI	None	Multiple	PS	UR	Total
A	1	0	1	4	4	3	1	14
B	0	1	0	9	4	2	0	16
C	1	1	3	16	1	0	0	22
D	0	0	0	28	0	1	0	29
Total	2	2	4	57	9	6	1	81
$P = 0.0024$								

DP (depression), DVT/E (deep vein thrombosis/ embolism), FI (fecal impaction), PS (pressure sore), UR (urine retention).

The mean hospital stay was 54.83days with a range of 2-131 days.

DISCUSSION

We had more males that females in our study. This is related to males engaging in different types of occupations to sustain their families. The etiologies were mainly related to occupations. The most common etiology was vehicular accidents, followed by motorcycle accidents. Due to high rate of unemployment in our country, as in many developing countries, many young men have resorted to commercial vehicle and motorcycle driving to make ends meet. This had been reported by many authors. [16, 17] Many of the falls were carpenters who fell from the roof of houses. In our environment, carpentry is almost exclusive of males. Only three females fell. While two fell at home, the third was a 20 year old girl returning from farm who hit her foot against stone and fell with a basket of cassava tubers

on her head. Five people something fell on were involved in logging. When they cut a tree, while falling the tree fell on another tree and the branch of the second falling tree hit the logger on the neck. Logging in our environment is exclusive of males. One of the two patients in sports was involved in traditional wresting. He was lifted and thrown to the ground and became paralyzed. Local wresting is during festivals and it is exclusive of men. The fact that majority were 20-49 years showed the effect of spinal injury on the work force of our nation. Koji et al [18] in Japan reported 130 males and 45 females in their study. Fehlings et al[19] in their study involving USA and Canadian hospitals found 75.4% males and 24.6% females. These showed world-wide high male involvement and calls for more global action.

Two-third (66.67%) of our patients were referred to us from other health facilities. Many factors were likely involved. First, lecture given by the first author on management of spinal injuries in 2013 as part of continuing education by our medical council that was organized by Nigerian Medical Association for doctors in our state and its environ. It created awareness on the management of the disease and the presence of neurosurgical center in their environment. Second, the fear of complications of spinal injuries make the condition scary for private practitioners. Three, the far coverage of our center that is over 400km makes direct transfer difficult in these areas, hence they went to the nearest hospital where they were subsequently referred to us. One of the three women from falls came from neighboring country by canoe and it took the relatives three days to canoe her to our town and then to our center. Four, the local belief that evil people were involved, especially those involved in logging, make them visit herbalists first, before the nearest hospital where they were subsequently referred to us. Fifth, poverty in our environment. The girl that fell with basket of cassava lost the father years before the incidence, leaving the mother alone to cater for her and her siblings. They first went to native bone setter where they could afford. The bone setter massaged the neck for two weeks with no improvement. She was then taken to general hospital by her aunt where she was referred to us. The aunt died two weeks before her discharge on walking frame. The mother could not pay the hospital bill and the management could not wave her bill. We eventually learnt the patient 'ran away'. It had been documented that cost consideration in a society where health costs are borne by the individual and their families encourage primary recourse to the cheapest option and not necessarily the best available care, at least in the first instance.[20]

The most common site involved was C5/C6 disc space. This is where typical cervical vertebra start to transit towards thoracic vertebra with long spines of C6 and C7 resembling thoracic spines. It serves as an imaginary fulcrum for the head with upper cervical spine, hence the most common site of injury. Mezue et al[21] in Nigeria found C5/C6 involvement in 77.9% of their patients. Miyanji et al[22] in Canada found C5/C6 the most common site involved. The most common type was anterior cord syndrome. This is in keeping with high number of spondylolisthesis with the anterior part of the cord and anterior spinal artery being hinged against the lower vertebra. The anterior part of cervical spine is less protected than the posterior part. The posterior elements with many ligaments and muscles fortify the bones better than anterior longitudinal ligaments and two hollow structures, esophagus and airway. As noted by Ropper et al[8] the cervical spine is especially vulnerable to injury given the relative axial alignment of the facet joints which require less force to dislocate compared with the thoracic or lumbar spine.

ASIA grading at discharge showed that patients with complete injuries (grade A) had 14.28% improvement, while the rest had over 60% improvement. The significant relationship between ASIA grade at presentation and ASIA grade at discharge corroborated the findings of Pollard et al[23] study where they concluded that the most important variable relating to neurological recovery is the completeness of the lesion. This also reflects the effect of type of injury. Complete injury type has poor neurological outcome compared to incomplete types. Raslan et al[10] in their review of controversies in the surgical management of spinal cord injuries noted the frustrating nature of poor neurological recovery in complete injuries. Some authors had noted patients with incomplete injuries had chances of neurological recoveries, but prognosis was far less optimistic for patients with complete injuries.[24] Comorbidity affected neurological recovery significantly. The diabetic patients in this study died. The effect of diabetes in traumatic patients is compounded by hormones such as cortisol and growth hormones that are produced in response to trauma.[25] These ant-insulin hormones not only worsens hyperglycemia but also reduce the glucose uptake by glucose-dependent neurons.

In our study, the complications were significantly related to ASIA grades at presentation. Over 70% of patients with ASIA grade A had complications, while complications was less than 40% in all other grades. Lack of pain sensation is the most significant factor in developing pressure sores. Due to lack of sensation, they do not feel ischemic pain. Most of the patients with pressure sores presented with them. In the study ASIA grade A patients had highest number of pressure sores. Three had pressure sores as the only complication, while 4 had pressure sores in addition to other complications (multiple group). The thought that they might not walk on their feet was the main cause of depression. During psychotherapy we reminded them that no able-bodied Nigerian won medal in 2012 London Olympics; that medals won were from Paralympics and the country rewarded them with millions of Naira; that their lives might change for the better by ensuring ability in

disability which might pull them out of poverty they were experiencing when they were able-bodied.

CONTROVERSIES

Consensus

There is agreement between operative and non-operative groups on negative consequences of hypotension on central nervous system, [26] and that ensuring normotension and avoiding hypoxia improve neurological recovery and decrease mortality. [27] There are also agreement that secondary injuries occur from cascade of events initiated by body's metabolic response to trauma, and attenuating them improves outcome.[12,13]

Surgical timing and neurological improvement

Some authors indicated that 'early' spinal decompression had potential neurological benefits.[28,29] Fehlings et al[19] in their study of early versus late surgery between 2002 and 2009, using 24 hours mark, found early decompression better than late surgery. However, the authors queried how we define 'early'. They also noted that of 22 studies attempting to define optimal timing for surgery in spinal cord injuries, 9 used 24hours to define early[30-38] 8 used 72hours[39-46] while 4 used other bench marks such as 8hours, 48hours, or 4days.[47-50] If we want to use pathophysiology of trauma, the inflammatory phase is the early event and lasts about 48 hours. They based their indication for surgery on MRI diagnosed cord compression which they felt would increase secondary injury.

Doubts or no better benefits from surgery

For many years, surgeons were reluctant to operate acutely owing to consensus that perioperative hemodynamic changes would compromise cord perfusion.[51] Donovan et al [52] in their study of neurological and skeletal outcome in 113 patients with closed injuries to the cervical spinal cord found that the extent of neurological recovery did not depend on surgical versus non-surgical management, vertebral displacement or spinal stenosis. Heiden et al [53] reviewed 356 patients with incomplete myelopathies due to trauma managed operatively or non-operatively and found it difficult to see any effect of surgery on neurological recovery. Those with improvement was similar to those who did not have surgery. Tator et al[54] found no difference between operated and non-operated patients in terms of hospital stay or neurological recovery. A Toronto group of investigators reviewed data that included all human spinal cord injury trials conducted between 1996 and 1998, and those conducted between 2000 and 2005 and concluded that despite strong experimental evidence there was no clear consensus as to the appropriate timing of surgical intervention and that there was no compelling evidence that early surgical decompression influences patient neurological outcome.[55-57] Vaccaro et al[58] showed that there was no significant difference in the length of stay between operated and non-operated groups or between early and late surgery groups. Many other studies failed to demonstrate any neurological advantage of surgical decompression and/or stabilization over conservative management[52,54] Katos et al[11] managed 63 patients with incomplete cervical spine injuries conservatively and recorded good outcome. Rahimi-Movagher et al [59] found conservative management superior to surgical treatment, though the sample size was small. Many other studies on conservative treatment had been done by many authors with good results.[60] The fact that none of our patients deteriorated on conservative management did not support the notion that without decompression secondary injury would worsen.

FUTURE

Nature appears to have the key to neurological recovery.

After spinal cord injury, the spinal cord circuitry had been shown to undergo plastic changes which may include growth of sensory fibers, all in effort to overcome the effects of the injury.[61-63] The brain cortical circuitry also shows plastic changes and reorganization in humans with spinal cord injuries.[64-67] Adult humans and animals with partial injuries often undergo spontaneous recovery that can progress over long times after the initial injury and part of this recovery may be due to collateral sprouting of non-injured axons. Retrograde tracing studies showed collateral sprouting distal to an injury months after spinal cord hemisection in adult monkey.[68] In the same vein, after transection of the dorsal corticospinal tract in adult rats, the uninjured ventral corticospinal tract sprouted and contributed to improve motor recovery.[69] Also collateral sprouting can occur from spared corticospinal fibers on the denervated side in the lumbar cord after partial transection of both corticospinal tracts at the level of the pyramids.[70] After a transection of the hind limb corticospinal tract in adult rats, it was demonstrated that the injured axons sprouted in the cervical gray matter to contact propriospinal neurons which in turn bridged the injured site and contacted lower motor neurons.[71] Reorganization after spinal cord injury also occurs in the somatosensory cortex of monkeys.[72] Courtine et al[73] used kinematic, physiological and anatomical analyses to evaluate mice with various combinations of spatially and temporally lateral hemisections with or without the excitotoxic ablation of intrinsic spinal cord neurons and showed that propriospinal relay connections that bypass one or more injury sites were able to mediate functional recovery and supraspinal control of stepping even when there had been essentially total and irreversible interruption of long descending supraspinal pathways. Rosenzweig et al[74] showed that after cervical unilateral hemisection of the spinal cord in rodents and primates, the spared corticospinal tract system showed substantial spontaneous compensatory sprouting over the spinal midline, targeting the denervated hemicord and the compensatory fiber growth induced significant restoration of skilled fine motor movement and locomotion. Compensatory mechanisms including functional recovery upon incomplete spinal lesions had

been demonstrated for descending rubrospinal tract[75] and reticulospinal projections.[76,77] It had been found that neural plasticity including molecular and structural changes at the synapses, sprouting of axons and dendrites up to representational map shifts can spontaneously occur after CNS injury and these plastic processes were the basic substrate mediating spontaneous or training-enhanced functional recovery after different kinds of CNS damage.[78-80] Corbetta et al[14] in 2002 used functional MRI to study functional reorganization and stability of somatosensory-motor cortical topography in a tetraplegic patient with late recovery. They studied a 50 year old man who sustained a displaced C_2 type II odontoid fracture from equestrian accident in 1995 at the age of 42 years. Motor and sensory functions were absent below the lesion level for 5 years except for spotty sensation in the left hemitorso. He was ventilator dependent. He had a rare recovery of motor function 6-8 years after intense and sustained rehabilitation therapies. When compared with normal subject, his brain showed wide reorganization in response to motor activities. MRI at the site of injury showed continuity with associated myelomalacia but they could not confirm whether normal tract passed through lesion site. In their review of lesion-induced plastic changes in propriospinal pathways, Filli and Schwab[81] noted that formation or strengthening of spinal detour pathways bypassing supraspinal commands around the lesion site to the denervated spinal cord were identified as prominent neural substrate inducing substantial motor recovery in different species from mice to primates and that existence of propriospinal pathways had been found in humans after cortical stroke. They advocated for the novel strategies targeting the remarkable plastic potential of propriospinal circuits to maximize functional recovery after spinal cord injury.

CONCLUSION

Our study showed that in traumatic cervical spinal injury males were more affected and vehicular accident was the most common etiology. The site most involved was C5/C6 and anterior cord syndrome was most common type of injury. ASIA grade at presentation significantly determined ASIA grade at discharge as well as complications seen. Comorbidity was a significant factor in determining outcome. Complete injury fared worst while incomplete injuries had substantial recovery.

We looked at operative and non-operative treatment vis-à-vis the current finding of CNS plasticity and reorganization. We are of the opinion that the human body has innate ability to repair injuries. Avoiding secondary injuries by ensuring normotension, euvolemia and adequate oxygenation were the major supportive measures that must have helped neurological recovery in our patients. Surgical procedures should be left for rare conditions such as traumatic spondylothosis. More researches on CNS plasticity and reorganization are necessary to assist the body repair incomplete injuries faster, and to assist the body bridge completely transected spinal cord.

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