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Factors affecting long-term outcome in acute cervical cord injury

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Abstract: Several clinico-imageological factors affect the neurological outcome following cervical cord injury. Studying these factors is essential for predicting the outcome. Thirty-three patients with acute cervical cord injury who were treated at our institute from 2000-2003, were assessed by the American Spinal Injury Association (ASIA) scoring and magnetic resonance imaging (MRI) of cervical spine. MR patterns of cord injury and length of damage were evaluated by senior neuroradiologist . They were followed up with ASIA score at the end of one year. Four factors were analyzed for their possible influence on outcome namely age, initial neurological status, timing of surgery, MR findings. Patients were divided into groups based on the factor studied, and the improvement was compared amongst the groups. Chi Square analysis was done to study the statistical association. All patients with ASIA Grade 'D' improved whereas none improved in ASIA grade 'A'. Patients with cord edema showed good recovery (52%) compared to patients with cord contusion (0%). Among the patients with cord edema, improvement was better in three or less than three segments (84.6%) compared to more than three segments (16.66%). There was no significant difference in improvements between age groups< 40 years (45%) and > 40 years (46.1%) ($p>0.05$). The difference in improvements between early surgery (60%) and delayed surgery (33.33%) was also not significant ($p>0.05$). The single most important factor, which determines the outcome, is the initial neurological status following injury. The age of the patient and the timing of surgery do not seem to influence the outcome. MRI pattern of cord edema with less than three segments has best prognosis for recovery.

Keywords: ASIA scoring; magnetic resonance imaging features; neurological outcome.

INTRODUCTION

The impact of cervical cord injury is enormous from the economic, psychological and social perspectives[1]. Approximately 10,000 new cervical spinal cord injuries occur each year in the US with an estimated prevalence of 300,000 to 500,000 living victims[2].

The information on outcome helps in counseling the anxious relatives, forecasting length of stay and expenditure in the hospital[3]. There are several factors that affect the neurological outcome following cervical spinal cord injury. Age, mode and severity of injury, autonomic disturbances and preexisting diseases are important among them. In the present study we made an attempt to analyze the influence of these factors.

MATERIALS AND METHODS

A prospective study was performed on 33 patients with acute cervical cord injury, who were admitted to the department of Neurosurgery, at Nizam's Institute of Medical Sciences from 2000 to 2003.

The following criteria were used for selection of patients.

Inclusion Criteria : Following patients were included in the study –

- Cervical spinal injury patients with cord damage,
- Those who presented within one week following injury.
- Those who underwent surgery, and
- had a minimum follow-up of one year.

Exclusion Criteria : Following patients were excluded from the study –

- Patients who were managed conservatively
- Patients with penetrating cervical spine injuries,
- Patients with autonomic disturbances, (with bradycardia < 40 beats/min and mean arterial pressure < 90 mm of Hg), and
- With associated thoraco-lumbar or head injuries.

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CLINICAL ASSESSMENT

Each patient was evaluated clinically by using the American Spinal Injury Association (ASIA) standards for assessment of neurological injury[4]. Motor and sensory scores were calculated based on the examination of ten key muscles and 28 key sensory points on both halves of the body. Sensory examination was done using a wisp of cotton for light touch and a sharp needle for pinprick. Patients were graded into five groups from A to E according to ASIA impairment scale.

Magnetic Resonance Evaluation

All these patients underwent magnetic resonance imaging (MRI) cervical spine either at our institute or outside. MRI was conducted on a 1.5-T superconducting unit. Imaging included three series in the sagittal plane. T1- and T2-weighted, spin-echo sequences were obtained using a 22-cm field of view, a four-mm section thickness with a one-mm gap, and a 192 x 256 matrix. The parameters for the T1-weighted images were 550/ 20/4 (TR/TE/excitations); for the T2-weighted images, 2000/ 30,80/1; and for the fast recovery fast spin-echo acquisition images, 2500/85/2 with a 256 x 192 matrix and an echo train length (ETL) of eight. An additional STIR image sequence was performed. The field of view incorporated the lower brainstem, the entire cervical spinal cord, and the upper thoracic region to T3.

Quantification of Injury on Magnetic Resonance Images

The imageological patterns are identified as defined by Silberstein *et al*[5]. The length of the damage to the spinal cord was quantified by locating the longitudinal boundary of the spinal cord hemorrhage or edema relative to the nearest adjacent spinal vertebral landmark on mid-sagittal MRI. Each vertebral body was divided into two parts, the upper half and the lower half, which were denoted as segments one and two, respectively, and the intervertebral disk below each vertebral body as segment three. Using this method, the location of upper and lower limits of pathology was recorded to determine length of pathology. The number of segments between the upper and lower limits represented the length. A senior neuroradiologist did the reporting of these images.

These patients were managed as per the guidelines given by American Association of Spinal Cord injuries. All patients were immobilized with skull traction immediately and put on Stryker beds till the time of surgery. Patients were operated after the stabilization of cardiovascular and respiratory status at the earliest possible time. Surgical stabilization and decompression was performed according to the extent and nature of injury.

All these patients were followed up in the outpatient department at regular intervals with ASIA scoring. Functional grading was done using functional independent measure at admission and at the end of one year and the results was compared. More than or equal to one grade change as per ASIA impairment scale from admission to one year follow-up was taken as improvement.

STATISTICAL METHODS

Chi Square analysis was done to study the statistical association of each factor with outcome. Chi Square values were obtained from which p values were derived. $p<0.05$ was taken as statistically significant.

RESULTS

There were 32 males and one female. The age ranged from 14 to 68 years. The mean age of patients was 37.72 years. The duration of follow-up ranged from one year to 16 months.

Effect of initial neurological status on outcome: patients were classified into five grades as per ASIA impairment scale. We could get only four grades of patients, as none were present in Grade E. The distribution of patients in the ASIA grades is shown in Figure 1. The maximum number of patients was present in ASIA B and minimum in ASIA D.

None of the patients in Grade A improved. In Grade B, out of 11 patients two patients improved to Grade C. In Grade C, out of nine patients, five patients improved to Grade D two patients to Grade E and remaining two did not improve. All the patients

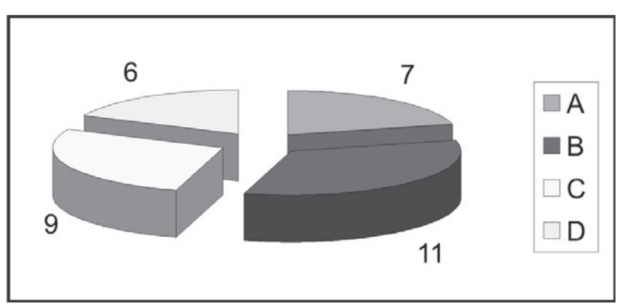

Fig 1: Distribution of Patients in Asia Grades at Admission

of Grade D (six) improved to Grade E (Figure 2). There is significant statistical difference in improvement between the groups, which indicate that initial neurological status is an important factor which determines the recovery.

Effect of age on outcome: The patients were divided into two age groups, above and below 40 years. There were 13 patients in the age group of above 40 years of which 6 improved and 20 patients in age group of below 40 years of which 9 improved. No statistical difference in improvement noted between the groups.

Effect of MRI patterns on outcome: MRI patterns were classified according to the Silberstein *et al* definition. Three types of imageological patterns were observed. The distribution of patients among them is as follows: cord edema - 25, cord contusion (Figs 8 & 9) -5, normal cord-3. When the improvements between the two imageological patterns were compared, 13 out of 25 patients with cord edema improved whereas none improved with cord contusion (Figure 4) showing good statistical difference.

Further, among patients with cord edema, based on length of the edema, there were two groups i.e. more than and less than three segments. In the "more than three segments" group (shown in Fig 10), two out of 12 and in the "less than three segments" group (shown in Fig 11), 11 out 13 patients improved (Figure 5).

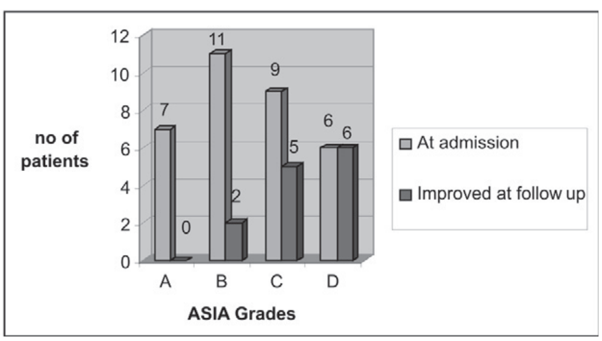

Fig 2: Neurological Improvement in ASIA Groups

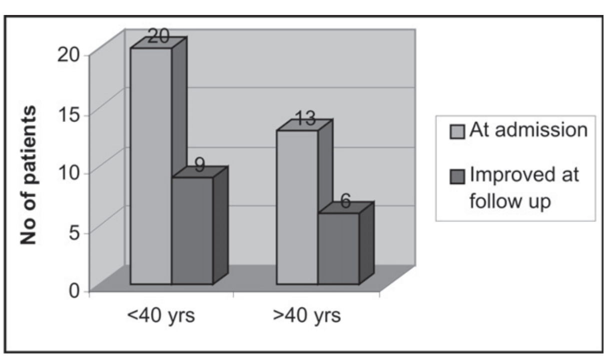

Fig 3: Neurological Improvement in Age Groups

Timing of surgery on outcome: patients were divided into early (surgery done within seven days) and late (surgery done more than seven days) surgery groups. In the late surgery group, 6 out of 18 improved and in the early surgery group, 9 out of 15 patients improved (Figure 6).

DISCUSSION

Neurological Status – Outcome

As reported in literature, a significant statistical association was observed between initial neurological

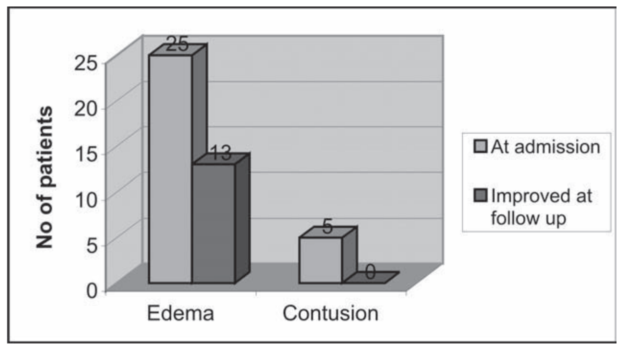

Fig 4: Neurological Improvement in MRI Patterns Studied

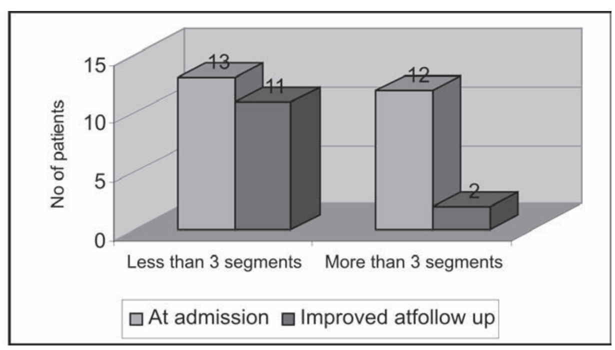

Fig 5: Neurological Improvements in Edema Groups

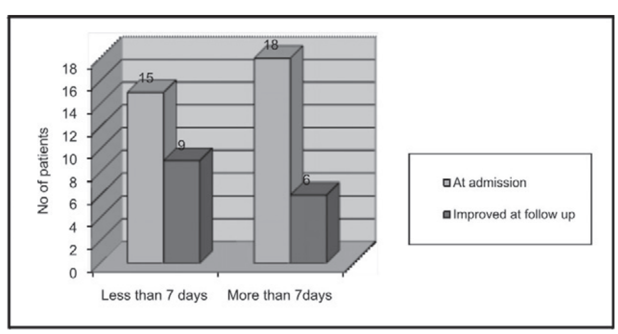

Fig 6: Improvements in Early and Late Surgery Groups

status and improvement (*p<0.05)*. The improvement was best in Grade "D" with 100% and worst in Grade "A" with 0%. Irrespective of grades, only 45% of patients showed neurological recovery. This relative less improvement may be due to more number of patients in grade A&B (18/33). The results of our study were comparable to previous studies. Burney *et a*l reported a significant difference in the improvements between complete and incomplete injuries[6]. He reported 66% of recovery in incomplete and 14% in complete injuries. A similar trend was noted in our series with incomplete injuries showing 57.6% of recovery, and no improvement in complete cord injuries. Ducker *et al* reported 34% mortality at the end of one year in their series of 273 patients with complete cord injuries[7], we noticed mortality of 42.8% at the end of one year in patients with ASIA Grade A. Burns S.P Golding while studying the effect of age and neurological status on the outcome reported that the recovery in patients with ASIA D was independent of age whereas, in patients with Grade C, recovery was influenced by age[8]. A similar trend was observed in our series with 100% improvement in Grade D irrespective of age.

Age-Outcome

It is reported that in elderly patients, injuries are due to trivial falls, which result in incomplete injuries and in young patients, injuries are due to vehicular accidents, which result in complete injuries[9]. A similar pattern of injuries was observed in our series. In the age group above 40 years, 92% were incomplete injuries and 7.6% were complete whereas in the age group below 40 years, 30% were complete, 70% were incomplete. Alander *et al* noticed a similar trend in their study on patients older than 50 years of age[10].

The improvement patterns between the age groups of less than 40 and more than 40 years were 45% and 46.1% respectively. This marginal difference in improvement was not statistically significant showing that age per se does not influence neurological recovery (Figure 3).

Previous studies show that in old age, respiratory complications were high with high mortality, but this trend was not noted in our series. Contrary to this, mortality in age group below 40 years was higher (10%) compared to above 40 years group (7.6%). These findings are to be interpreted cautiously as the difference is only marginal.

MRI – Outcome

Various classifications of imaging patterns have been put forward to associate the degree of neurological deficits and predict motor recovery[11]. Silberstein *et al* classified MR appearances into contusion and edema and compared them with the pathological findings[5]. Kulkarni *et al* classified them into three groups[11] which were broadened by Ramon *et al* into six groups[12]. We followed the classification given by Silberstein *et al*[5] in which they used the terms contusion and edema. The term contusion in our series is similar to that of hemorrhage pattern described by other authors. It is analogous to Type I and III patterns of Kulkarni *et al*[11] and Ramon *et al*[12]. Both the authors used terms hemorrhage/ hematoma for these lesions.

Analysis of the imageological patterns revealed that there were 25 patients with cord edema, 5 patients with contusion, and rest three had normal cords. Edema was the most common imageological finding with incidence of 76%. Kulkarni *et al* noted similar results in their studies[7].

Cord Edema

MR appearance of cord edema has been associated with good recovery of neurological function, more so when it involves a small portion of the spinal cord[13]. In our study we noticed maximum recovery of patients with cord edema less than three segments (84.6%), compared with other patterns of injury. Apart from neurological recovery most of the patients with cord edema presented with incomplete neurological deficits.

Rostrocaudal length of edema was significantly correlated with outcome. Eighty-four per cent of patients showed improvement in less than three segments of edema compared to 16.6% in more than three segments. A similar conclusion was drawn by Selden *et al*[13].

In concordance with other studies, we found that the neurological function at presentation is the single best predictor of long-term neurological outcome. However, a good number of our patients showed recovery despite complete motor injuries at presentation (11.11%). Both the patients who improved had cord edema, which indicates that MRI adds to the clinical examination in predicting the outcome.

Contusion

The results of our study reconfirmed previous authors' findings that have demonstrated the relationship of spinal cord hemorrhage/ contusion and edema to initial neurological deficit. Various studies showed that the identification of hemorrhage in MRI is associated with complete motor injuries (ASIA A and B) and the length of edema is inversely proportional to the motor function[14]. In our study almost all the patients with complete cord injuries either had cord contusion or severe cord edema (>three segments). However, cord contusion was noticed in 4% (1/26) of subjects with incomplete cord injuries also. This shows that the presence of hemorrhage in MRI is not always associated with complete motor injury. A similar result was found by Flanders *et al* in which 21% subjects with incomplete cord injuries had hemorrhage[15]. They attributed this finding to the improved spatial and contrast resolution in the imaging protocol.

In our series none of the patients with cord contusion showed recovery and there is a significant statistical association between cord contusion and lack of neurological recovery $p<0.05$ (Graph 4). This indicates that the presence of hemorrhagic signal is associated with bad prognosis. A similar result was noted by Ramon *et al*[12] and Lucas and Duckers[7].

There is no correlation between the length of the hemorrhage and the motor recovery[15]. All five patients with hemorrhagic signals in our series did not show any improvement irrespective of their lengths. A similar result was noted by Flanders *et al*[15] and Selden *et al*[13].

Timing of Surgery

Timing of surgery for the spinal cord injury is highly controversial. There is strong evidence from the animal models to indicate that decompression of spinal cord improves the recovery after spinal cord injury. However, it is difficult to determine a "time window" for effective application of surgical decompression in the clinical settings[16].

The definitions for early and late surgeries are variable in several studies[16]. We chose the norm as before seven and after seven days because spinal cord injuries are not treated as surgical emergencies at our institute. The reasons for postponement of surgery for more than seven days are variable in each case. The most common reason was the presence of autonomic disturbances, which required stabilization. When the neurological outcome was compared in these two groups, improvement was better in the early surgery group (60%). The improvement in delayed surgery group was 33.3%. The autonomic disturbances might have contributed for less improvement in the delayed surgery group. We could not get any statistical significance between the two groups (Figure 6).

Functional Outcome

Functional independent measure (FIM) scoring system is often practiced to assess the disability at admission and to predict the long-term outcome[17].

No change in FIM was noted in ASIA Grade A as all patients remained in the same grade at follow-up (Figure 7).

In ASIA Grade B, out of 11 patients, two improved to Grade C but did not show improvement in FIM score (Figure 6).

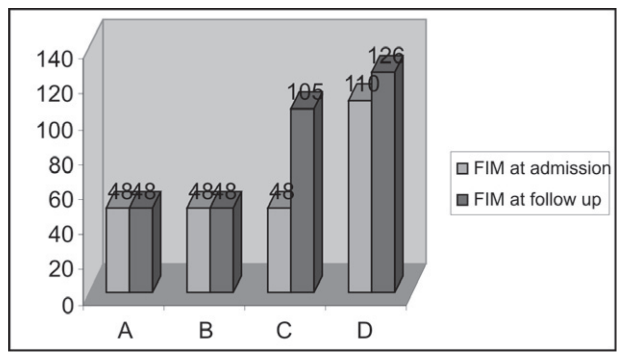

Fig 7: Average Improvement in FIM in each ASIA Grade

Fig 8: Gradient echo image showing cord contusion

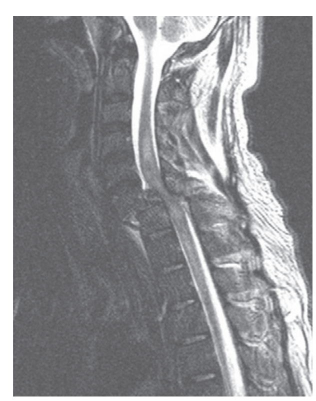

Fig 9: MRI T 2 WI showing cord contusion

Fig 10: MRI T 2 WI showing cord edema more than 3 segments

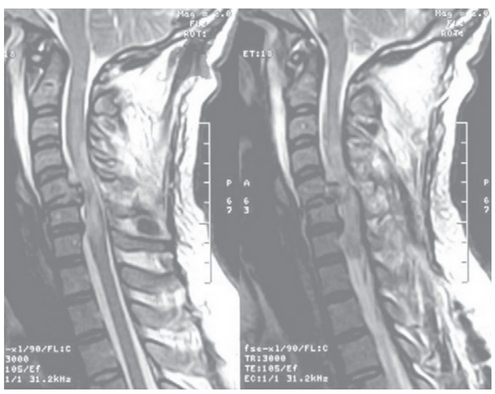

Fig 11: MRI T 2 WI showing cord edema less than 3 segments

Those patients in Grade C who improved to Grade D, showed maximum improvement in various sub-scores of FIM (average improvement of FIM from 48/126 to 105/126). Among them, the FIM sub-score of transfer has shown the best improvement (up to the level of complete independence). The second best improvement was seen in both locomotion and self-care. However, even in this group there was no improvement noted in the sphincter control. This indicates that sphincter control is very sensitive to the trauma and recovery is often delayed.

In ASIA Grade D, there was no impairment in FIM at admission itself, therefore, no further improvement in FIM was expected. A similar conclusion, with maximum improvement of FIM scores in ASIA Grade C, was drawn by Hall *et al*[18].

Another interesting finding that was noticed in our study was, cognition sub-scores did not show any change indicating that they are not of any significance in the spinal cord injury patients. Hall *et al* noted similar findings in their study[18].

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