JIOM Nepal. 2020 Aug;42(2):85-90.

# Multilevel Spinal Injury: Incidence, Distribution and Neurological Patterns

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**Submitted** : Nov 1, 2020
**Accepted** : Dec 4, 2020

## ABSTRACT

**Introduction**

Fractures and dislocation of spine are serious injuries that most commonly occur in young people. Spinal injury at more than one level is not uncommon. Awareness of multilevel injury of the spine and associated neurological patterns is important for the proper initial management of the patient.

**Methods**

This was a prospective observational study carried out in Department of Orthopedics, Maharajgunj Medical Campus, Institute of Medicine, Tribhuvan University, Kathmandu, Nepal from February 2012 to September 2013. Sixty cases of age group between 18 to 63 years of traumatic spinal injury were enrolled. Patients were examined clinically and radiographically.

**Results**

Out of 60 patients, multilevel spinal injury occurred in 26 (43.3%) patients; 10 (16.67%) had contiguous spinal injury and 16 (26.67%) had non-contiguous spinal injury. There were 5 type A pattern spinal injury. Contiguous spinal injury most commonly occurred at level L1/L2 (n=4, 40%) and most had Frankel grade E neurology (n=6, 60%) followed by Frankel grade D (n=2, 20%). Non-contiguous lesions most commonly occurred at thoracic spine and had Frankel grade E neurology in most cases (n=10, 16.67%) followed by grade B and C (n= 2, 2.33% each).

**Conclusion**

Multiple spinal injury was a common pattern of injury, which occurred in 26 (43.3%) patients out of 60 patients enrolled in our study. Multilevel spinal injury is common. We should be aware about its occurrence. We should evaluate for multilevel spinal injuries, so as not to miss them, especialy non-contiguous injuries, in the patients presenting with spinal injury.

**Keywords:** *Contiguous lesion, Frankel grade, multilevel spinal injury, non-contiguous lesion*

## INTRODUCTION

Fractures and dislocation of spine are serious injuries that most commonly occur in young people. Nearly 43% of patients with spinal cord injuries sustain multiple injuries.[1] Spinal injury at more than one level is not uncommon. Awareness of multilevel injury of the spine and associated neurological patterns is important for the proper initial management of the patient. Multiple level non-contiguous lesions at more than two levels have the worst prognosis with 70% of patients suffering complete paraplegia.[2] Noncontiguous spinal fractures are a rare and special type of multilevel spinal injuries, most frequently occurring in a fall from height or a traffic accident. A delayed diagnosis of the second lesion is frequently seen in the literature, ranging from 23.1% to even up to 83.3%.[3,4] Sometimes, the second injury is not recognized early enough to prevent clinically significant extension of the neurological deficit, pain pattern, spinal instability and deformity.[5] To avoid the risk of overlooking a second fracture, the injury pattern should be known, and radiographic assessment of the whole spine in patients with multiple injuries must be taken. The other modalities such as CT scan and MRI are important for the initial diagnosis and planning management.[6]

Especially when the upper fracture was responsible for the neurological deficit, a second fracture located below must be excluded.[3] It is important to be aware of the possibility of multilevel spinal injuries. They occur most commonly as a result of high-speed road traffic accidents or falls from a height. When examining a shocked or unconscious patient a thorough neurological examination is difficult, but serious consequences are possible if a secondary injury is missed.[7] Early recognition is important for assessment and planning treatment. If a spinal fracture is identified at any level, the entire spine should be examined with antero-posterior and lateral views to document the presence or absence of spine fracture at other level.[8]

There were very few studies conducted to determine multilevel spinal injury, its distribution patterns and its relation to neurology in our country. We thought it worthwhile to conduct the study on the topic, the findings of which could increase the awareness about the occurrence of multilevel spinal injury, among the doctors dealing with spine trauma cases, so as not to miss them, especially non-contiguous injuries.

## METHODS

This was a prospective observational study carried out in Department of Orthopedics, Maharajgunj Medical Campus, Institute of Medicine, Tribhuvan University, Kathmandu, Nepal from February 2012 to September 2013. It was commenced after taking approval from institutional Review Board. Written informed consent was taken from the patients who fell into the inclusion criteria of the study. Patients were screened for any exclusion criteria. The inclusion criterion was patient aged 18 years or above, who presented to our hospital with the history of spinal injury. The exclusion criteria were pathological fractures, age less than 18 years, history of previous surgery for bone disorders of spine and old fracture in spine. The study proforma included demographic profile, occupation, mode of injury and duration between time of injury and presentation to the hospital The patients were evaluated for the primary lesion, which was the presenting lesion and seemed to be responsible for the patient's symptoms or neurological signs on first examination. Plain X-rays AP and lateral view of whole spine were sent to look for any secondary vertebral lesion; the secondary vertebral lesion was an injury which would contribute to or have the potential to contribute to the patient's neurological deficit or symptoms. Patient's neurological status was evaluated by using Frankel grading system.

Level of spinal injury was recorded as contiguous when two adjacent vertebrae were injured and non -contiguous when at least one vertebrae had been preserved in between. Further evaluation was done to see specific pattern like patterns A, B and C.[9]

- Pattern A: Primary injury at C5-C7 level and secondary injury at T12 or in lumbar vertebrae
- Pattern B: Primary injury at T2-T4 and secondary injury in upper cervical spine
- Pattern C: Primary injury at T12-L2 and secondary injury in L4-L5.

The data was analyzed with the use of SPSS software program version 17.0. Independent sample t- test was used to analyze the results while comparing this study to other populations.

## RESULTS

Out of 60 patients, 44 (73.3%) were males and 16 (26.7%) were females. Age of the patients ranged between 18 to 63 years with a mean age of 37.15+/- 12.6 years. Fifty four (90%) of the patients were from the capital city and rest from other places. Forty percent of the patients were farmers, 23.3% were housewives, 13.3% were laborers and rest followed other occupations.

More than half (51.7%) of the injuries occurred because of fall form trees, followed by fall from buildings (25%), fall from cliffs (8%), road traffic accidents (6.7%) and rest by other modes like physical abuse and being buried under landslides.

Twenty eight patients (46.7%) arrived to the hospital within 2-3 days of the injury, 26 patients (43.3%) arrived within 4-7 days, 5 patients (8.3%) within a

*Table 1. Distribution of spinal injury at contiguous spinal level patterns and neurological grading*

| Contiguous injury spinal levels | n (%) | Neurological grading | |
|---|---|---|---|
| | | Grade | Number |
| C5/C6/C7 | 1 (10) | E | 1 |
| T4/T5 | 2 (20) | E | 1 |
| | | B | 1 |
| T7/T8/T9/T10 | 1 (10) | D | 1 |
| T12/L1 | 1 (10) | D | 1 |
| L1/L2 | 4 (40) | A | 1 |
| | | E | 3 |
| L3/L4 | 1 (10) | E | 1 |
| Total | 10 (100) | | |

day and one patient arrived later than seven days post-injury.

Thirty four (56.7%) had single level spinal injury and remaining 26 (43.3%) had multiple level spinal injury. Out of the 26 patients with multiple level spinal injuries, 10 (16.67%) were contiguous and 16 (26.67%) were non-contiguous spinal injuries.

Out of the 34 patients with single level spinal injury, most frequently involved level was lumbar (35%), followed by thoracic (11.6%) and cervical (10%). Among all levels, most common level involved was L1 (18.33%) followed by L2 (13.33%). Most of the single level fracture was between T11 to L2 levels. 20% of the patients with single level injury had neurological grading of Frankel grade E, followed by grade A in 15%, grade D in 11.67% and grade B and C 5% each. (Figure 1)

*Table 2. Distribution based on incidence distribution and neurological pattern of non-contiguous multiple level spinal injury*

| Spinal Regions | Contiguous Spinal Injury Levels | n (%) | Neurological grading | | | |
|---|---|---|---|---|---|---|
| | | | A | B | C | D |
| Cervical 1 (1.67) | C5, C6, D8 fracture | 1 (1.67) | 0 | 0 | 0 | 0 |
| Cervico-dorsal 3 (5.00) | C4/C5 subluxation/D12 fracture | 1 (1.67) | 0 | 0 | 0 | 0 |
| | C5/C6 subluxation/D12 fracture | 1 (1.67) | 0 | 0 | 0 | 0 |
| | C6 /C7 subluxation/D10, D11 fracture | 1 (1.67) | 0 | 1 | 0 | 0 |
| Cervico-lumbar 3 (5.00) | C5/C6 subluxtaion/L2 fracture | 1 (1.67) | 1 | 0 | 0 | 0 |
| | C3/L2 fracture | 1 (1.67) | 0 | 0 | 0 | 0 |
| | C5/L4,L5 fracture | 1 (1.67) | 0 | 0 | 1 | 0 |
| Dorsal 6 (10.00) | D4/D6 fracture | 1 (1.67) | 0 | 0 | 0 | 0 |
| | D5/D7 fracture | 2 (2.33) | 0 | 1 | 0 | 0 |
| | D5/D8 fracture | 1 (1.67) | 0 | 0 | 0 | 0 |
| | D10/D12 fracture | 2 (2.33) | 0 | 0 | 0 | 1 |
| Dorso-lumbar 1 (1.67) | D8/D11 and L1 fracture | 1 (1.67) | 0 | 0 | 0 | 0 |
| Lumbar 2 (2.33) | L1/L3 fracture | 1 (1.67) | 0 | 0 | 1 | 0 |
| | L3 /L5 fracture | 1 (1.67) | 0 | 0 | 0 | 0 |
| | Total | 16 (26.67) | 1 (1.67) | 2 (2.33) | 2 (2.33) | 1 (1.67) |

*Table 3: Distribution based on incidence distribution and neurological grading of pattern A spinal injury*

| Pattern A injury spinal levels | n (%) | Neurological grading | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | E |
| C5/C6 subluxation/L2 fracture | 1 (1.67) | 1 (1.67) | 0 | 0 | 0 | 0 |
| C6/C7 subluxation/T11,T12 fracture | 1 (1.67) | 0 | 1 (1.67) | 0 | 0 | 0 |
| C5/L4,L5 fracture | 1 (1.67) | 0 | 0 | 1 (1.67) | 0 | 0 |
| C4/C5 subluxation/T12 fracture | 1 (1.67) | 0 | 0 | 0 | 0 | 1 (1.67) |
| C5/C6/T12 fracture subluxation | 1 (1.67) | 0 | 0 | 0 | 0 | 1 (1.67) |
| Total | 5 (8.35) | 1(1.67) | 1(1.67) | 1(1.67) | 0 | 2 (3.33) |

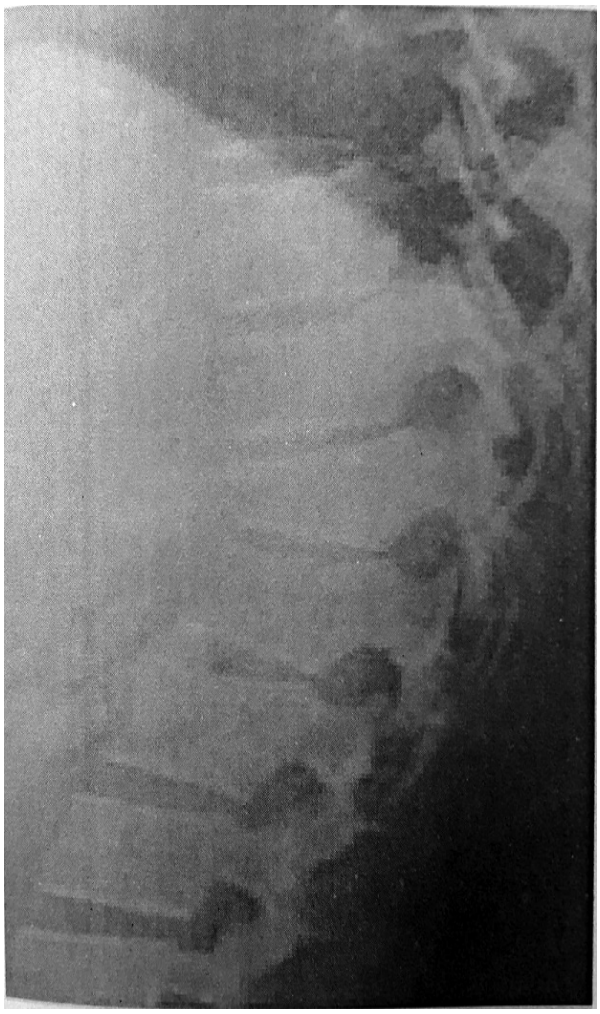

*Fig 1. Single level T12 fracture*

*Fig 2. T6-T9 fracture*

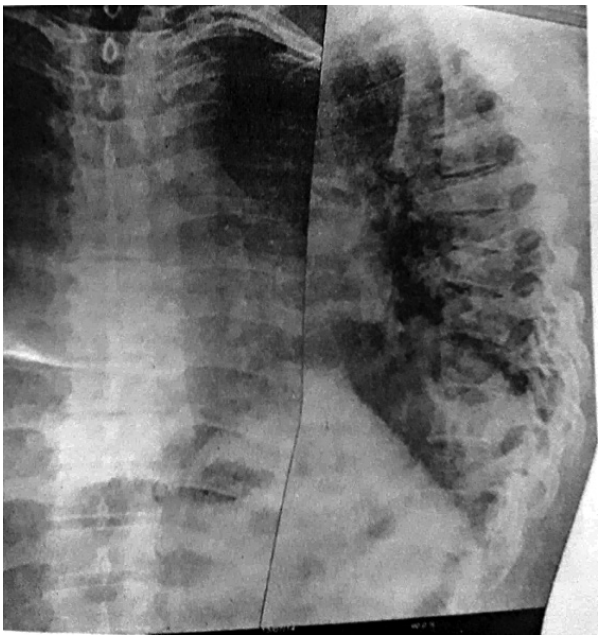

*Fig. 3. C6/C7 fracture with T12 fracture (Type A pattern)*

Out of 10 contiguous spinal injury, most common injury was at level L1/L2 (n=4, 40%) followed by at level T4/T5 (n=2, 20%). Most of the patients had Frankel grade E neurological injury (n=6), followed by Frankel grade D (n=2). (Table 1,Figure 2)

Out of 16 patients with non-contiguous lesions, dorsal spinal region was most common (n=6, 10%), followed by cervical and thoracic, and cervical and lumbar regions (n=3, 5% each) then lumbar region (n=2, 2.33%) and cervical and thoracolumbar regions (n=1, 1.67%). Ten patients with non-contiguous lesions had Frankel grade E neurology, 2 each had grade B and grade C while rest had grade A and D. (Table 2)

Out of 60 cases enrolled in this study, 5 patients (8.35%) had pattern A injury. Among them 2 had Frankel grade E neurological pattern and remaining 3 had A, B and C neurological patterns respectively. (Table 3, Figure 3)

## DISCUSSION

Awareness of multilevel injury of the spine and associated neurological patterns is important for the proper initial management of the patient. Such injuries have worse prognosis and delayed complete diagnosis as well.[2,3]

We reviewed 60 patients ranging from 18 to 65 years of age in our study. Patients less than 18 years of age were excluded because soft tissue injury is more common and end plate of vertebrae are cartilaginous which is not seen on plain X-ray, and age more than 65 were excluded because these patients have increased chance of osteoporotic

fractures.

In this study, 34 (56.7%) patients had single level spinal injury and remaining 26 (43.3%) patients had multiple level spinal injury. Out of 26 (43.3%) multiple level spinal injury cases, 10 (16.67%) were contiguous and 16 (26.67%) were non-contiguous spinal injury. The occurrence of multilevel injury among the spinal injury cases in our study is similar to the finding of the study of GC Velmahos et al.10 The incidence of multilevel injury among spinal injury was less in the study done by A Gupta, W. S. el Masri[2] and by D. S. Korres, A. Katsaros, T. Pantazopoulos et al[11]. Similar smaller proportion of multilevel injury among the spinal injury was found in the studies done by D S Tearse, J S Keene and D S Drummond[12], L Calenoff, JW Chessare et al[9] and AR Vaccaro et al.[13] This difference in occurrence of multiple spinal injuries in our study and other studies might be due to small sample study population and short duration of our study.

In our study, the most common contiguous spinal injury occurred at level L1/L2 (n=4, 40%) followed by at level T4/T5 (n=2, 20%). Most of the patients had Frankel grade E neurological injury (n=6) followed by Frankel grade D (n=2). The most common contiguous injury level was T3/T4 in the study done by D Hugo, RN Dunn[14], C1/2 and C 5/6 in the study done by OP Sharma, MF Oswanski, JS Yazdi et al.[15] and T12/L1 in the study carried out by Riaz-ur-Rehman ,Azmatullah, F Azam et al.[16] Associated neurogical injury in the contiguous injury in study by A Gupta ,W. S. el Masri,[2] was that 10 patients had Frankel grade A neurology followed by B,C and D in each 3 cases and only 1 had grade E neurology among 91 cases. This difference between their and our findings, in distribution and neurology, might be due to small study population in our study

In our study, patients with non-contiguous spinal injury were 16 (26.67%). Thoracic spinal region was most common region involved (n=6, 10.0%) followed by cervicothoracic and cervicolumbar region with equal distribution (n=3, 5.0%), and lumbar region (n=2, 2.33%), Most of the patients had Frankel grade E neurology (n=10, 16.67%) followed by grade B and C (n=2, 2.33% each); the remaining two had neurology grade A and D respectively. In the study conducted by A Gupta, W. S. el Masri[2], 7.6% of patients had non-contiguous injury. Cervicothoracic and cervical spine regions were more involved in non-contiguous multilevel spinal injury in their study. They also had more Frankel A (31 out of 71) neurology among the non-contiguous multilevel spine injury cases. The difference of level of injury in our and their studies might be due to small study population in our study. The mode of injury, which was different in our and their study might also be the cause of the difference. The common mode of injury in our cases was fall from height while motor vehicle accident was the common mode of injury in their cases.

L. Calenoff, J. W. Chessare. et al[9] did the analysis of vertebral level at which primary and secondary injury occurred and yielded 3 definite patterns of injury. They defined patterns A, B and C. In our study, there was only pattern A type of injury and no patterns B and C. In our study, out of 60 cases enrolled,[5] patients (8.35%) had pattern A multilevel injury. This might be due to small study population in this study or relatively less common occurrence of injury patterns of type B and C.

The short-coming of our study was that it was done in a single centre. The sample size was small, larger sample size could have yielded more power to results. Plain radiograph with AP and lateral views were used to identify the fracture site. The use of more advanced imaging like CT scan and MRI would have been more informative regarding bony injury as well as soft tissue injury.

## CONCLUSION

Spinal injury occurred most commonly in male adult population, and the commonest modes of injuries were fall from height and road traffic accident. There was delayed presentation to the hospital. Multiple spinal injury was a common pattern of injury, which occurred in 26 (43.3%) patients out of 60 patients enrolled in our study. 10 (16.67%) had contiguous and 16 (26.67%) had non-contiguous lesion, and most of the patients had an incomplete neurology. As multilevel spinal injury is common, both clinical and radiological examination of the whole spine should be done in all patients with acute spinal injury.

## CONFLICT OF INTEREST

None declared.

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