The treatment for multilevel noncontiguous spinal fractures

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Received: 9 July 2006 / Accepted: 21 July 2006 / Published online: 17 October 2006
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Abstract We report the outcome of 30 patients with multilevel noncontiguous spinal fractures treated between 2000 and 2005. Ten cases were treated conservatively (group A), eight cases were operated on at only one level (group B), and 12 cases were treated surgically at both levels (group C). All cases were followed up for 14–60 months (mean 32 months). Initial mobilisation with a wheelchair or crutches in group A was 9.2 ± 1.1 weeks, which was significantly longer than groups B and C with 6.8 ± 0.7 weeks and 3.1 ± 0.4 weeks, respectively. Operative time and blood loss in group C were significantly more than group B. The neurological deficit improved in six cases in group A (60%), six in group B (75%) and eight in group C (80%). Correction of kyphotic deformity was significantly superior in groups C and B at the operated level, and increasing deformity occurred in groups A and B at the non-operated level. From the results we believe that three treatment strategies were suitable for multilevel noncontiguous spinal fractures, and individualised treatment should be used in these patients. In the patients treated surgically, the clinical and radiographic outcomes are much better.

Résumé Nous rapportons l'évolution de 30 patients avec des fractures étagées non contiguës du rachis traités entre 2000 et 2005 : 10 cas étaient traités conservativement (groupe A), 8 cas étaient opérés à un seul étage (groupe B), et 12 cas étaient opérés à plusieurs étages. Le suivi était de 14 à 60 mois (moyenne 32 mois). La mobilisation initiale, en chaise roulante ou avec des cannes, était significativement plus

tardive que dans les groupes B et C. La durée opératoire et la perte de sang étaient plus importante dans le groupe C que dans le groupe B. Le déficit neurologique était amélioré dans 6 cas du groupe A (60%), 6 du groupe B (75%) et 8 du groupe C (80%). La correction de la cyphose était meilleure dans le groupe C et au niveau traité du groupe B tandis qu'une aggravation de la déformation était notée dans le groupe A et au niveau non opéré du groupe B. De ces résultats nous concluons que les trois traitements sont possibles mais qu'ils doivent être individualisés selon les patients. Les résultats cliniques et radiologiques sont meilleurs chez les patients opérés.

Introduction

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 [17]. A delayed diagnosis of the second lesion is frequently seen in the literature, ranging from 23.1% to even up to 83.3% [13, 15, 17]. The definition of these injuries is not clear in the literature, resulting in variable incidence from 1.6% to 23.8% [6, 10]. It's previous definition was that at least three intact vertebrae should be included between two injured or fractured vertebrae [11]. However, Iencean [9] suggested that in multilevel noncontiguous spinal fractures there was at least a normal spinal segment between the lesions of the same structural type as the injured segments. In this study, we followed Iencean's definition as multilevel noncontiguous spinal fractures. Therefore, there are 30 of a total 561 patients with spinal fractures in our unit included in this study.

Such lesions were always caused by high-energy trauma and had consequences ranging from minor local pain to

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quadriparaplegia and even death [9, 10]. The optimal approach to the management of these patients has yet to be identified [17]. The purpose of this study is to evaluate the outcomes of three treatments for multilevel noncontiguous spinal fractures; and compare the therapeutic effect.

Patients and methods

From January 2000 to January 2005, 30 patients with multilevel noncontiguous spinal fractures were treated in our unit. There were 19 males and 11 females with mean age of 43.7 years (range, 21–69 years). The causes of injury included a traffic accident in 11 patients, a fall from height in 15 patients, a diving accident in 3 patients and trauma from a heavy blow in 1 patient. Involvement of two vertebra in 24 patients, three vertebra in 5 patients and four vertebra in 1 patient were found. Altogether, 67 vertebral body fractures were diagnosed. The region involved was from C1 to L5, with the highest number found in the

thoracolumbar region (T11–L2). The clinical data is summarised in Table 1.

The symptoms and signs included local symptoms, such as cervical or back pain and restriction of motion, and neurological deficits from radiculopathies to paraplegia. The American Spinal Injury Association (ASIA) scale was used for neurological evaluation [5]. All patients underwent plain radiograph including AP and lateral views, computed tomography scanning (CT) and/or magnetic resonance imaging (MRI). Most critically, there was a mean delay of 5.1 days (range from 1 to 11 days) in establishing the diagnosis of the second fracture site in eight patients (26.7%). Calculation of vertebral body angles was made in a modification of Cobb recommendation [3]. Table 1 also showed the neurological status of the patients.

Concomitant injuries such as head trauma, fracture in rib and chest contusion, abdominal injuries, fracture of clavicle, pelvic fractures and limb fractures were observed in ten patients (33.3%).

Table 1 Summary of clinical data obtained in the 30 patients with multi-level noncontiguous fractures of spine

Groups	No.	Age	Sex	Mode of injury	Lesion sites	Neurological status (ASIA)	
						Initially	1 year later
Group A	1	54	M	Fall from height	T12+L2	C	C
	2	38	M	Traffic accident	C2+T3	C	D
	3	43	F	Traffic accident	T11+L1	B	B
	4	49	M	Traffic accident	T6+L2	A	A
	5	65	F	Fall from height	T9+L3	B	C
	6	50	F	Fall from height	T10+L5	C	D
	7	58	M	Fall from height	L1+L4	D	E
	8	35	M	Traffic accident	T11,12+L2	A	A
	9	28	M	Diving	C1+L1	B	E
	10	69	F	Fall from height	T12+L2	C	E
Group B	11	41	M	Fall from height	C1,2+C6,7	A	A
	12	21	M	Heavy blow	L1+L3	C	D
	13	37	F	Traffic accident	T12+L2	B	E
	14	35	M	Fall from height	L1+L4	C	E
	15	55	M	Traffic accident	C2+T3,4	B	D
	16	45	F	Fall from height	T8+T12	D	E
	17	31	M	Diving	C6,7+L1	B	C
	18	48	F	Fall from height	C3,4+C6	A	A
Group C	19	51	F	Fall from height	L1+L5	C	D
	20	39	M	Traffic accident	C5+L1	A	A
	21	38	M	Traffic accident	L1+L3	C	E
	22	53	M	Fall from height	C2,3+L1	D	E
	23	27	M	Diving	C2+C7	A	A
	24	40	F	Fall from height	T12+L2	B	D
	25	52	M	Traffic accident	T6+L2	B	E
	26	34	F	Traffic accident	T11+L2	C	D
	27	65	M	Fall from height	C6+L1	A	C
	28	42	M	Traffic accident	T12+L3	C	D
	29	23	F	Fall from height	L2+L4	C	E
	30	46	M	Fall from height	T11+L2	B	D

Ten patients were treated conservatively (group A), eight patients were operated for only one lesion (group B) (Fig. 1, case 15) and 12 patients were treated surgically for two lesions (group C) (Fig. 2, case 29). All patients were followed up for 14–60 months (mean 32 months). Follow-up included neurological status and radiographic assessment.

Results

There were no significant differences between groups in age, gender composition, injury mode, and lesion site (Table 1).

Initial mobilisation with a wheelchair or crutches in group A was 9.2 ± 1.1 weeks (range 6–12 weeks), which was significantly longer than groups B and C with 6.8 ± 0.7 weeks (range 4–8 weeks) and 3.1 ± 0.4 weeks (range 1–4 weeks), respectively ($P < 0.001$). Group B was significantly

longer than group C ($P < 0.001$). Group B had significantly shorter mean operative time and required less blood during surgery than group C ($P < 0.001$, Table 2).

In group A, six patients (60%) had improvement of one to three points in the ASIA scale. In group B, six patients (75%) had improvement of at least one point in the ASIA scale. But in these two groups, no improvement could be found in four cases with grade A.

However, in group C, a patient with grade A improved to grade C six months after surgery. And all the other seven patients with incomplete lesions improved at least one point in the ASIA scale. So the total improvement of neurological function in this group was 80% (Table 1). The differences of neurological improvement between three groups were significant ($P < 0.01$).

In group A, the kyphotic deformities were corrected by an average of 4° at the time of mobilisation, and had

Fig. 1 A 55 year-old male was involved in a traffic accident which resulted in C2 and T3–4 fractures (case 15); his neurological deficit corresponding to T3–4 level. **a** Lateral view of cervical spine shows fracture of C2 (arrow). **b** Anterior-posterior view of thoracic spine

showing fractures of T3–4 (arrow). **c** CT scan showing evidence of C2 fracture. **d** CT scan showing evidence of T4 fracture and spinal cord compression (arrow). **e** Post-operative radiograph of T3–4. **f** Lateral view of C2 after conservative treatment showing solid fusion (arrow)

Fig. 2 A 23 year-old female with fractures of L1 and L4 resulting from a fall (case 29). **a** MRI of the lumbar spine showing fractures of L1 and L4. **b** Post-operative radiograph showing that two levels were operated on in a single stage. L4 was operated, posteriorly and L1 anteriorly

progression at the latest follow-up of 6° mean ($P<0.01$). The correction of kyphotic deformities of the surgical vertebral bodies were 7° and the non-operative lesions were 4° within group B. At the latest follow-up, the correction of operative lesions had no significant loss but the non-operative lesions had an average loss of 5° ($P<0.01$). In group C, an average of 13.5° were corrected and no significant losses were found at follow-up.

Complications in group A included a patient who developed pressure sore in the lumbosacral area and a patient who had a urinary tract infection. Within group B, a patient had transient neurological deficit deterioration. In group C, cerebrospinal fluid leakage was found in two cases, pleural effusion in one case, and transient neurological deficit deterioration in two cases.

Discussion

Patients with severe injury, always caused by high-energy trauma, may simultaneously sustain multilevel noncontiguous spinal fractures [10]. There is still conflicting opinion on the definition of multilevel noncontiguous fractures of the spine. In this study, we follow the concept introduced by Iencean that at least one normal spinal segment should intervene between the fractured vertebra [9]. An increase of motor vehicle accidents and amelioration of diagnostic techniques, are attributed to the gradual increase of the reported incidence of these lesions [8, 10].

However, a delayed diagnosis of noncontiguous spine fractures has been frequently seen in the literature. There was a mean of 2.8 days to 52.6 days delay in diagnosis of the secondary lesion [10, 17]. Sometimes, the second injury is not recognised early enough to prevent clinically

significant extension of the neurological deficit, pain pattern, spinal instability and deformity [13]. In this study, the second fracture was diagnosed at a later time of 5.1 days in eight patients (26.7%), which probably resulted from atypical clinical presentations and the accompanying injury such as head trauma and chest contusion. But this did not cause any harm to the patients, because all injuries were detected at a maximum of 11 days after injury and before any mobilisation started. 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 [4, 16]. Especially when the upper fracture was responsible for the neurological deficit, a second fracture located below must be excluded [17].

Because of the complexity of the injury mechanism, there are always some severe concomitant injuries in patients, as seen in 33.3% of this series. Initial management of these injuries should follow the therapeutic principle of multiple injuries, and life support is the most important. In our study, a total of six patients (cases 2, 4, 5, 10, 16, 18) with head, chest and abdomen injury were treated surgically immediately after admission. For the spine injuries, early

Table 2 Data comparison of three groups

	Immobilization time (weeks) ^a	Operating time (min) ^a	Blood loss (ml) ^a
Group A	9.2±1.1	0	0
Group B	6.8±0.7*	150±25	700±90
Group C	3.1±0.4***	330±40**	1,200±110**

^a Value expressed as mean and standard deviation, * $P<0.001$ vs group A, ** $P<0.001$ vs group B

management mainly involves immobilisation of the spine with orthosis or cast, especially during transport. When admitted to hospital within 8 hours of injury, methylprednisolone (MP) was administered according to the results of the second National Acute Spinal Cord Injury Study (NASCI-2) [1, 2].

Treatment for the multilevel noncontiguous spinal fractures must follow the same guidelines for treatment as for the isolated fracture in the majority of circumstances [10]. However, the treatment of multilevel spinal fractures requires particular attention and must be individualised. Certain factors must be taken into account, such as neurological deficit, spine instability and deformity, the number of intact spinal units between the two fractures [11], and even the patient's desire for shorter hospital stay. Special consideration must be given to all lesions in their treatment to avoid conflicting influences of the multiple lesions.

Instability of the spine, deformity and neurological deficit are major factors when selecting treatment for multilevel noncontiguous spinal fractures. If the vertebral fractures with kyphosis of less than 30° is considered stable, conservative treatment should be the first choice [14]. In our series, if the two fractures of the spine are stable, or there is not obvious compression of the spinal cord, conservative treatment was selected for both of the lesions (group A). This group also includes patients with poor general condition or severe concomitant injury that precludes operation. The disadvantage of this selection is that patients must stay in bed longer, resulting in some complications such as pressure sores and urinary tract infections, and correction of deformity may be lost significantly in the long-term.

If one lesion is stable without neurological deficit, and the second is unstable or attributing to neurologic deficit, only the second site was treated surgically (Fig. 1, case 15) and the other conservatively (group B). In the patients that had a spinal cord injury corresponding to the upper level fracture, the lower level was treated non-operatively only if it was stable and no compression of spinal cord was shown in MRI or CT. The surgical treatment in multilevel noncontiguous spinal lesions has the same principles for a single lesion: to decompress the neural elements, to correct the deformity, to restore the alignment and to stabilise the spine [9, 12]. For neurological recovery, mobilisation time and deformity correction, this group is excellent compared with group A, but inferior compared to group C. Because of only one site of operation, the operating time and blood loss in this group was less than group C. Although some authors found that the intra-operative reduction of one spinal injury can affect the alignment at the location of the second injury [7], intra-operative reduction and stabilisation of one lesion in our series didn't affect the alignment at the location of the second injury. But some measures should be taken, such

as skull traction and cervico-thoracic brace, to prevent the second lesion from loss of alignment and deterioration of neurologic function.

Two lesions were treated surgically at a single stage in the patients (group C) in which both fractures were unstable, kyphotic deformity was more than 30°, and neurological involvement was potentially caused by multi-level compressions (Fig. 2, case 29). The clinical and radiographic outcomes were better than the other two groups. However, the longer operating time and greater blood loss were the main disadvantages in these patients. Moreover, some complications relating to surgery can be found in this group and, during the operation on the first fracture, the second fracture should be protected to prevent deterioration of the neurological deficit. In this series, there was no deterioration of neurological function in any of the three groups.

Comparing the radiologic results, similar to other studies [17], the patients in group C showed a more satisfactory deformity correction than group A in the whole follow-up period. And in group B, there was no significant loss of correction of the operated vertebra, but a 5° angle loss in the non-operated vertebra.

In conclusion, in patients with a spine fracture resulting from severe injury, a second fracture at another level must be excluded. Radiographs of good quality from the whole spine must be examined very carefully. Life support is the most important element for initial management. Treatment for multilevel noncontiguous spinal fractures must be individualised; all three methods mentioned above can be used clinically. The clinical and radiographic outcomes are better in the patients treated surgically.

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