Spine surgery in neurological lesions of the cervicothoracic junction: multicentric experience on 33 consecutive cases

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Received: 2 March 2011 / Published online: 15 March 2011
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Abstract Surgical treatment of the cervico-thoracic junction (CTJ) in the spine require special evaluation due to the anatomical and biomechanical characteristics of this spinal section. The transitional zone between the mobile cervical and the relatively rigid thoracic spine can be the site of serious unstable traumas or neoplastic lesions. Frequently, injury is associated with neurological impairment due to the small caliber of the spinal canal and/or spinal cord vascular insufficiency. The authors considered 33 neurologic lesions of the CTJ (21 traumas, 10 tumors, 2 infections) treated by means of decompression, fixation, and fusion by different type of instrumentation. Surgical procedure was posterior in 26 cases, anterior in 1 and combined in 6. Major general complications were not found in patients undergoing anterior approach. Biomechanical failure was found in two patients operated by T1 body replacement and C7-T2 anterior plate. Serious cardio-respiratory complications were related to 2 polytrauma patients who underwent posterior surgery. Follow-up evaluation showed spinal stability and fusion in 88% of cases, improvement of the neurological deficits in 42%

(19% improved to ASIA E), no or only occasional pain in 75% of patients. In the experience, recovery of spinal realignment and stability is essential to avoid disability due to back pain in trauma patients. In spinal tumors, back pain was related to local recurrence. Neurological outcomes can be unsatisfactory due to the initial serious impairment. There is no type of instrumentation more effective than other. In each single lesion, the most suitable type of instrumentation should be employed, considering morphology, biomechanics, and familiarity of the spinal surgeon with different implants and constructs. Therefore, we prefer to use posterior cervicothoracic fixation in T1 lesions with involvement of the vertebral body and subsequently replace the body with cage without anterior stabilization.

Keywords Spine · Cervicothoracic junction · Instability · Operative treatment

Introduction

Disorders of the cervicothoracic junction (CTJ) are quite rare [38]. Nevertheless, they often produce unstable lesions, because of anatomic and biomechanical characteristics in that particular region of the spine [3, 5, 11, 31]. Traumas, neoplasms, or infections often require surgical procedures, including decompression and stabilization [1, 2, 4, 8, 9, 12, 19, 25, 26, 28, 37]. In a recently published biomechanical study [18], posterior fixation in CTJ has been shown to provide sound stability in flexion-distraction, lateral bending, and axial rotation injuries, while complex lesions involving the anterior column require a combined anterior/posterior technique. Anterior approach to CTJ is technically demanding and some risks and

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complications may arise [7]. Many surgical modifications have been described [16, 22, 23, 30, 33, 36] and some authors suggest to perform this kind of surgery with the help of a general, thoracic or heart surgeon [35].

This is a multicentric study conducted on 33 consecutive patients undergoing decompression, instrumentation, and fusion for CTJ neurological lesions (C7-T3) with different etiology. End-points in this article included early and late complications, fixation soundness, and neuro-motor function recovery.

Materials and methods

Relevant clinical data of 33 patients with CTJ disorders who consecutively underwent surgery between 1998 and 2007 are shown in Table 1 for trauma patients and Table 2, including tumors and infections. Patients were 18 males and 15 females meanly aged 49.5 (range 15–71). Diagnosis included 21 traumas, 10 neoplasms (primary or secondary), and 2 infections. All patients underwent a complete pre-operative diagnostic work-up, by means of X-ray, CT, and MRI. The authors used thoracic trauma classification by Magerl et al. [24] and McCormack et al. [27], and neoplastic classification by Weinstein [39], and Kostuik [17], in order to assess lesion pathomorphology and evaluate

spinal instability (Tables 1, 2). Four primary cancers included aggressive osteoblastoma, leiomyosarcoma, myeloma, and chordoma. Six metastatic tumors originated from breast, thyroid, and kidney and two *S. aureus* infections were included as well. All tumors were classified as extra-compartmental, as they all had invaded epidural space. Eight patients showed anterior instability, including staphylococcal patients in whom more than 50% of each involved vertebral body was eroded.

Neurologic status was evaluated by means of the ASIA score system [10] at hospital admission, as well as at follow-up. ASIA score at hospital admission was A in 8 patients, B in 4 patients, C in 10 patients, and D in 11 patients. Moreover, Prolo functional scale [32] was used to assess final outcome: F4-F5 indicated, respectively, occasional or no pain, F1-F2 constant and inabilitating pain, while F3 an intermediate condition.

Posterior decompression and fusion was performed in 26 patients (Fig. 1a, b), while 1 patient underwent an anterior approach and 6 were submitted to combined (anterior-posterior) surgery (Fig. 2a, b).

In posterior procedures, it was used three different implants with long constructs, variably combining cervical lateral mass screws, thoracic pedicular screws and/or hooks, and pediatric hooks. Connection between segmental screws or hooks was achieved by rods of different caliber

Table 1 Records in 21 patients with neurological traumatic disorders of the CTJ

Case	Age/sex	Level/type/instability	ASIA pre-op	Treatment	F.U. (months)	ASIA post-op	Pain
1	18/M	T1-T3/B1.1.3/post.	A	PFF	60	A	F5
2	55/M	T2/B1.2.1./comb.	C	PFF/ABR	36	C	F4
3	44/F	C7/B1.2.2/comb.	C	PFF/ABR + P	50	D	F4
4	47/M	C7/B1.2.1/comb.	B	ABR + P	44	B	F4
5	57/M	T1/A3.2.1/ant.	C	PFF	36	D	F4
6	32/F	C7/T1/B1.1.2/post.	A	PFF	40	A	F5
7	56/F	C7/T1/B1.1.2/post.	D	PFF	60	E	F3
8	56/M	C7/T1/B1.1.2/post.	D	PFF	50	D	F5
9	69/F	C7/T1/B1.1.1/post.	A	PFF	36	A	F5
10	65/M	C7/T1/B1.1.2/post.	B	PFF	50	B	F4
11	33/M	C7/T1/B1.1.3/post.	A	PFF	18	A	F4
12	23/F	T1/B1.2.1/comb.	C	ABR/PFF*	36	D	F4
13	70/M	T2/B1.2.1/comb.	A	PFF/ABR	48	A	F4
14	28/M	C7/T1/B1.1.2/post.	A	PFF	28	A	F4
15	71/M	C7-T1/B1.1.2/post.	A	PFF	Death	/	/
16	40/M	T2/B1.1.3/post.	A	PFF	30	A	F4
17	37/F	C7-T1/B1.1.2/post.	D	PFF	45	E	F5
18	48/M	T1/A3.2.1/ant.	D	PFF	50	E	F5
19	51/F	C7/T1/B1.1.2/post.	D	PFF	33	E	F5
20	65/F	C7/T1/B1.1.2/post.	C	PFF	48	E	F4
21	35/M	T1-T2/B1.1.3/post.	C	PFF	42	C	F4

PFF posterior fixation and fusion, ABR anterior body replacement, P plate, * PFF performed after failure of the anterior construct

Table 2 Records in 12 neurological patients with tumors and infections of the CTJ

Case	Age/sex	Level/type/instability	ASIA pre-op	Treatment	F.U. (months)	ASIA post-op	Pain
22	67/F	T1-T2/myeloma/post.	D	PFF	36	E	F4
23	15/M	T3/osteoblastoma/post.	D	PFF	42	E	F5
24	56/F	T1/Breast/post.	C	PFF	11	D	F3
25	60/F	T1/thyroid/post.	D	PFF	18	E	F2
26	68/M	C7/T1/LMS/comb.	C	PFF	8	D	F2
27	63/M	T1/kidney/comb.	C	PFF	36	C	F2
28	47/F	T2/breast/ant.	D	PFF	24	D	F2
29	57/F	T1/kidney/ant.	B	PFF	18	B	F3
30	71/F	C7/T1/thyroid/ant.	B	PFF	12	B	F4
31	65/M	T1/chordoma/comb.	D	ABR/PFF*	30	D	F2
32	35/F	T1/infection/comb.	C	PFF	46	E	F4
33	30/M	T2/infection/comb.	D	PFF	32	D	F4

PFF posterior fixation and fusion, *ABR* anterior body replacement, *P* plate

LMS leiomyosarcoma, * *PFF* performed after failure of the anterior construct

Fig. 1 a, b (Case 1): T1–T3 B1.1.3 fracture treated by C6–T6 posterior fixation and fusion with the combination of lateral mass screws, pedicular screws and thoracic sublaminae hooks

Fig. 2 a, b (Case 2): T2 B1.2.1 fracture operated by two-stage combined procedure (C6–T5 posterior fixation and fusion, vertebral body replacement). Note the sternotomic approach

(dual-diameter rods, or longitudinal cross-link connecting the cranial rod to the caudal one). The standard instrumentation spreaded between C6–C7 and T3–T4. Exceptions were represented by 1 patient with a C5 instrumentation cranially, and other 2 patients with a T6 instrumentation caudally. Vertebral body replacement was always achieved by Harms cage. Anterior C6–T1 plate was used in a patients with C7 burst fractures, while C7–T2 plate in two patients with T1 lesion. When a type B1 fracture-dislocation was found, decompression was performed, followed by reduction achieving by soft and gentle traction and distraction forces, whereas definitive fixation was performed in the compression mode according to Benzel [6]. This allowed for restoring of the posterior tension band described by Harms [15] (Fig. 3a, b) Autologous bone graft and/or hydroxyapatite were used for fusion.

Anterior approach, as described by Fielding and Stillwell [14], was used in patients with C7 fractures, whilst sternotomic approach, as described by Fang et al. [13], was used by the thoracic surgeon when thoracic injuries had to be addressed. One-step combined surgery was performed in two patients. Other two patients underwent delayed combined approach, with anterior following posterior surgery 2–3 weeks later. This time lapse was mandatory in order to stabilize patients' cardiac and respiratory status. Remaining two patients underwent posterior surgery after failure of the anterior construct.

In some instances, such as the leiomyosarcoma, 4 metastasis and 2 spondylodiscitis, anterior surgery was not performed even though it would be pathomorphologically indicated. This was due to poor patients' life expectancy, or good response to adjuvant or antibiotic therapies, which were followed by vertebral body reconstruction or spontaneous anterior fusion.

Results

Follow-up ranged from 5 to 60 months with an average of 30.5 months. One polytrauma patient died in the seventh post-operative day due to serious brain injuries. Follow-up in patients with secondary cancers ranged from 11 to 36 months. Leiomyosarcoma patient died during the eighth post-operative month, with evidence of local recurrence, even though his neurological function was good (ASIA D).

Peri-operative complications were found in eight patients (24%). Two patients (6%) had cardio-respiratory worsening following posterior surgery, while two patients (6%) experienced deep wound infections which was successfully treated by surgical debridement. Finally, three patients (9%) had liquoral fistulae whereas one patient (3%) had transient Bernard-Horner syndrome.

Spinal stability and fusion were actually achieved in 29 patients (88%), whilst two posterior surgery patients with

Fig. 3 a, b (Case 6): **a** MRI shows C7–T1 fracture-dislocation type B1.1.2 without vertebral body comminution; **b** Post-operative CT scan shows the good spinal alignment achieved after C6–T2 posterior fixation and fusion

spondylodiscitis had progressive kyphosis with subsequent spontaneous anterior fusion.

Two patients with T1 lesions showed biomechanical failure of the anterior construct (Tables 1, 2) and subsequently underwent posterior fixation.

A 15 year old patient, with an aggressive T3 osteoblastoma, showed signs of hyatrogenic spine instability after posterior en-bloc resection, with T3–T4 dislocation, progressive kyphosis and acute medullary compression (ASIA D). Treatment included posterior T1–T6 hooks fixation, which allowed for good sagittal alignment and restoring of neurological functional status to ASIA E. The myeloma patient showed local progression of the disease to T1–T2 level and previous T3–T8 instrumentation has been extended to C6–C7 by means of lateral mass screws and longitudinal rod connectors.

No patient showed post-operative neurological worsening: ASIA C and D patients showed substantial clinical stability or recovery to ASIA E in 9 cases (27%), whereas ASIA A and B patients did not change their score (Tables 1, 2).

Back pain in trauma patients was absent (F5) or only occasional (F4), except for one patient with C7–T1 dislocation reporting continuous pain during daytime (F3). Roentgenograms from that patient showed that vertebral dislocation was not completely reduced. Worst pain (F2) was found in three patients with metastases, and in leiomyosarcoma and chordoma patients. Remaining patients, including those with spondylodiscitis, were all scored as F4.

Discussion

Spine instability in CTJ injuries is due to different factors [5, 31] and is a challenging condition [9]. Severe damages in this insidious region often occur due to its peculiar anatomical and biomechanical characteristics, with a relatively high risk of neurological impairment [21]. Post-traumatic injuries frequently affect the posterior column, whereas complex anterior-posterior disruptions are less commonly observed [9]. The experience included 21 cervicothoracic fractures, mostly B.1 type, with or without dislocation and without severe body comminution. These lesions all showed only posterior instability. Anterior or combined anterior-posterior instability was found in 7 patients, 2 of whom had A3 burst fractures and 5 a B1 fracture with anterior split.

Modern posterior instrumentation systems are now dedicated to CTJ and show many technical solutions improving implant versatility [38]. In the opinion, and according to recent clinical and biomechanical studies [1, 18], association of posterior instrumentation with fusion

may restore spinal stability in the most of CTJ traumatic type B, but also in type A, injuries. Posterior instrumentation in distraction-mode was used when kyphosis deformity had to be treated, whereas reduction by slight distraction followed by definitive compression-mode construct was achieved in patients with vertebral dislocations. Sagittal alignment was restored in all but one patient with this technique.

For T1 lesions, anterior stabilization alone, by cage and plate, showed no satisfactory results in all but one patient with C7 fracture type A3. Anterior C7–T2 fixation failed and required further posterior surgery. The authors therefore prefer to perform anterior body replacement in the presence of a higher degrees of T1 body disruption, always in association to posterior fixation [17, 27], in order to restore posterior tension band and anterior load-sharing [18]. Indeed, three trauma patients (1 cervical, 2 thoracic), all classified as B1.2 with body split, were operated by posterior decompression and fixation, anterior decompression, and body replacement.

Combined anterior-posterior approach is indicated in most neoplastic lesions involving the vertebral body [17, 19, 25, 27]. In the neoplastic series, however, surgical procedure was only posterior, because of patients' general status and life expectancy. Notably, adjuvant therapy often limited local recurrence, achieving bone reconstruction and consequently acceptable fixation survival rate. In infection patients, response to antibiotic treatment allowed to reach, fortunately, spontaneous anterior fusion.

Anterior approach, specially to the cranial region of the thoracic spine, is technically demanding and not risk-free. Original procedures and some modifications have been proposed [16, 22, 23, 30, 33, 36]. An endoscopic-aided procedure has also recently been described [20]. The authors perform the anterior approach as proposed by Fielding and Stillwell [14] for C7–T1 procedures and by Fang et al. [13] for T1–T4 levels. These approaches are always performed with the aid of the thoracic surgeon.

Major complications, reported in other series [7, 29], were not found in the five patients undergoing anterior approach. Serious complications were related to two patients who underwent posterior surgery. They post-operatively showed cardio-respiratory worsening and they all had sustained polytrauma associated with abdominal and thoracic injuries. One patient with post-traumatic brain injuries died 7 days after posterior surgery.

Neurologic impairment in CTJ disorders is favored by narrowing of the spinal canal and/or vascular damage of the spinal cord [3]. Outcomes of surgical decompression depend on different series in literature [9, 21, 25]. The series showed that 14 (42%) patients undergoing decompression improved. Nine patients (27%), initially classified as ASIA C or D, improved to ASIA E. Overall, 19 patients

(57%) showed no post-operative modifications of their functional status. Of these patients, 12 (36%) were initially classified as ASIA A or B.

No (F5) or occasional (F4) pain was reported in 24 patients (75%). Highest pain levels (F2–F3) were found in patients with local recurrence, secondary malignant tumors and in one trauma patient. In metastatic patients, pain only tended to improve immediately after surgery, whereas late follow-ups showed pain recurrence. This was probably due to biological reasons, as the authors did not observe mechanical failure, in contrast with the results reported by Sapkas et al. [34].

Conclusions

Surgical treatment for CTJ injuries is mandatory, especially when some degree of neurological impairment is associated. Early decompression and fixation should be performed in order to improve functional status and pain. Also paraplegic patients with solid spinal fixation may be early nursed.

Posterior internal fixation and fusion may be useful in most patients with trauma, whereas only few of them need combined anterior-posterior approach. In tumors, the anterior approach may be contraindicated in relation to clinical status and/or life expectancy. In the opinion, anterior surgery should be performed with the help of the general surgeon.

Pathomorphology and instability classification of each particular lesion, together with surgeon's familiarity of each fixation system, should guide in deciding instrumentation type and fixation modality.

Unsatisfactory functional outcome seems to be mainly related to the poor initial neurological condition.

Conflict of interest None.

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