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Original Article

Surgical outcomes in thoracolumbar fractures with pure conus medullaris syndrome

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ABSTRACT

Background: Pure conus medullaris syndrome is defined as a combination of signs and symptoms of bladder/bowel incontinence and impotence without the presence of lower limbs weakness. The purpose of the study is to assess the recovery of voiding, sexual, and sensory function in patients with isolated conus medullaris syndrome after surgical treatments.

Methods: From January 2005 to December 2012, patients with a single level burst fracture with pure conus medullaris syndrome were assessed. Level of injury, use of steroid, surgical time, surgical approach, preoperative radiographic parameters, and types of neurogenic bladder were recorded. Bladder function was evaluated using urodynamic study; sexual function was assessed by self-report questionnaire. The final outcomes were focused on the recovery of voiding, sexual, and sensory function.

Results: Eight patients met the criteria of pure conus medullaris syndrome with thoracolumbar burst fracture. The injury level were all located at L1 vertebra. There were 6 males and 2 females. Four patients had overactive neurogenic bladder, and the other 4 patients had underactive type. At final, five patients regained self-voiding function, and three required intermittent catheterization. Two male patients were sexually active, and four male patients had some sexual dysfunction. Two female patients could have normal sexual intercourse but the frequency decreased. One female patients had prolonged perineum numbness at final follow-up.

Conclusions: Although extremely rare, pure conus medullaris syndrome may occur with L1 burst fracture. Despite surgical treatment, only one half of the patients regained normal bladder and sexual function.

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At a glance commentary

Scientific background of the subject

Pure conus medullaris syndrome presents bladder/bowel incontinence and impotence without lower limbs weakness. The incidence of pure conus medullaris syndrome in thoracolumbar burst fractures is extremely rare. The main goal of treatment is to restore the voiding and sexual function, which contributes greatly to a patient's life quality.

What this study adds to the field

We shared our surgical experiences for pure conus medullaris syndrome in thoracolumbar burst fractures and found improved urinary recovery was seen in patients with overactive neurogenic bladders. Recovery of normal bladder function was more likely the shorter the time between injury and the receiving of medical services.

Conus medullaris is usually located at the L1 vertebra level [1]. Conus medullaris syndrome is an ailment that affects the lower sacral segments of the spinal cord. The symptoms of conus medullaris syndrome include bowel and bladder dysfunction, sexual dysfunction, perianal numbness, and lower limb motor weakness [2]. Pure conus medullaris syndrome is defined as signs of bladder incontinence, bowel incontinence, impotence, and absence of lower limbs weakness. Many pathological conditions can cause conus medullaris syndrome such as tumors, vascular lesions, diabetic neuropathy, and trauma [3–6]. Fifty percent of thoracolumbar burst fractures have neurologic deficit. Among these cases, 40% are complete spinal cord injury; 40% sustain incomplete spinal cord injury; and the other 20% have some degree of nerve root injury [7]. Thoracolumbar fracture-related pure conus medullaris syndrome is rare. There are few publications about the condition. For patients with pure conus medullaris syndrome, the main goal of treatment is to restore the voiding function, which contributes greatly to a patient's life quality. Sexual function was also important because sexual dysfunction might affect the patient's psychological state, especially in men. In this retrospective study, we reported our surgical experiences, and clinical outcomes in thoracolumbar burst fracture patients with pure conus medullaris syndrome.

Materials and methods

With the approval of our Institutional Review Board (IRB), we retrospectively reviewed the medical records of patients with thoracolumbar fractures treated surgically in Chang Guan Memorial Hospital's orthopedic department from January 2005 to December 2012. Patients with abnormal voiding

function requiring intermittent catheterization or the use of Foley catheter preoperatively, but with intact lower-extremity motor function were assessed. All cases in the study must be received at least once urodynamic study to determine the types of neurogenic bladder. We recorded patients' demographic data, including gender, age, injury level, and injury mechanism. Factors that might affect clinical outcome such as the use of steroid, surgical time, types of surgical approach, preoperative radiographic parameters (percentage of canal encroachment, local kyphotic angle, percentage of anterior body height loss), and the types of neurogenic bladder were assessed. We recorded motor, bladder, sex, anal function, and sensation distribution of all enrolled patients according to medical records or questionnaires survey by an assistant at out-patient clinic. The final clinical outcomes were reported mainly according to the recovery of bladder function and sexual function. A recovered bladder function is defined that the patient is able to self-void, without assisted urination such as intermittent catheterization or the use of Foley catheter, and the residual urine volume was less than 100 ml. For male patients, the sexual function was measured at the final follow-up, using the 5-item version of the International Index of Erectile Function (IIFE-5) [8]. Each item scores from 1 to 5. Results can be categorized as no erectile dysfunction (ED) (22–25), mild ED (17–21), mild to moderate ED (12–16), moderate ED (8–11) and severe ED (5–7). For female patients, the sexual function was measured at the final follow-up, using Female Sexual Function Index (FSFI) [9]. The FSFI is a self-report, 19-item questionnaire. Full scale score ranges from 1.2 to 36, and female sexual dysfunction is classified for those with score less than 26.65.

Results

Between January 2005 and December 2012, there were 1323 cases with thoracolumbar fractures underwent surgical treatment at our department. Only eight patients met the criteria of pure conus medullaris syndrome with thoracolumbar fractures. The injury level was all at L1 vertebra. There were 6 males and 2 females. Age at surgery ranged from 32 to 68 years old. All patients had a falling accident from height as injury mechanism. The average preoperative anterior body height was $53.4\% \pm 13.0\%$ (35.6%–71.4%), and the local kyphotic angle was $18.0^\circ \pm 7.9^\circ$ (11.3°–31.1°). The average spinal canal encroachment evaluated by computed tomography was $72.8\% \pm 9.6\%$ (55.1%–81.3%). Only five patients were administrated steroids preoperatively. The mean duration from injury to emergency room was 6.1 ± 7.8 h (1–25 h); the mean duration from injury to surgery was 40.8 ± 32.9 h (4–88 h).

According to the urodynamic studies, four patients were classified as overactive neurogenic bladders, the other four patients as underactive neurogenic bladder. Two patients had associated injuries (one had a tibia open fracture, the other was an ankle fracture). Six patients received posterior instrumented surgery, and the other two patients underwent posterior and anterior surgery. Perioperative details of these patients were summarized below:

Case presentation

Case 1

History. A 32-year-old male landed on his buttock from 3 m height when he was working. He was sent to our emergency room three hours later. Upon examination, the patient had Grade 5/5 muscle strength. The anal tone was intact but he complained of inguinal numbness. Plain radiographs revealed an L1 burst fracture. The anterior body height of L1 was 50.6%, and local kyphosis angle was 20.1°. The canal encroachment was 80.3% revealed by CT scan. A Foley catheter was inserted due to a distended bladder. Solumedrol was administered preoperatively.

Operation. Three days later, posterior instrumentation (T12-L2), indirect reduction by distraction, L1 body augmentation with PRODENSE (Wright Medical Technology, Arlington, Tennessee, USA) was performed for this patient.

Follow-up. Three days after surgery, the Foley catheter was removed and intermittent catheterization training began. Urodynamic study was done 5 days after surgery, overactive neurogenic bladder was impressed. According to bladder echo study 9 months after injury, the residual volume of urine was 67 ml. This patient could void freely at his last follow-up (two years after surgery). He complained of an increase of time to full erection and frequent sensation, but could return to sex-life as before injury. The IIFE-5 questionnaire at the final follow-up was 22. There was no abnormal sensation around perineum or medial thigh.

Case 2

History. This 49-year-old female fell from a height of three meters. She was sent to our emergency room five hours later. Initial examination indicated intact lower-extremity movement, but slight left anterior thigh numbness. Urination and anal tone were normal. T-L radiographs revealed L1 burst fracture; the percentage of L1 body height was 50.8%; and local kyphosis angle was 24.3°. Ten hours after admission, this patient began to report urination difficulty. Post-void Foley catheterization showed 500 ml urine retention, Solumedrol was administered.

Operation. Seventeen hours after admission, emergency surgery was performed on this patient. The surgical method consisted of posterior instrumentation (T11-T12-L2-L3), direct decompression by left transpedicular removal of L1 fractured fragment, and right T12-L2 posterior fusion.

Follow-up. The Foley catheter was removed 1 week after surgery. Urine retention was observed and therefore intermittent catheterization training began. Urodynamic study was performed for this patient 1 week after injury, and overactive neurogenic bladder was impressed. 2 years after injury, the final bladder echo study showed the residual volume of urine was 80 ml. At the latest follow up (three years after surgery), this lady could void herself without intermittent catheterization support. She ambulated well but complained of constipation. The sex-life was almost stopped in first-year after injury; however, she could tolerate intercourse now with a decrease of frequency of sex-life. The FSFI questionnaire at final follow-up was 24.1. No abnormal sensation was noted.

Case 3

History. This 68-years-old male fell into a hole of 2-m height when he was walking. He was sent to our emergency room six hours later. Initial impressions included an L1 compression fracture and left tibia open fracture. Emergent surgery with wound debridement and left leg fixation via external skeletal fixator was performed. The Foley catheter was inserted at operation. Three days after first surgery, the Foley catheter was removed, but urinary retention was observed. Post-void catheterization collected 600 ml of urine. Spine CT showed percentage of canal encroachment at L1 was 71.4%.

Operation. 4 days after admission, anterior L1 corpectomy decompression, reconstruction with iliac bone graft, and posterior instrumentation (T11-T12-L2-L3) were performed. One week later, the external fixator was changed to an internal fixator for left tibia fracture.

Follow-up. This patient underwent urodynamic study 47 days after injury, and underactive neurogenic bladder was impressed. This patient ambulated well after his left tibia healed. However, he still suffered from urine retention with 500 ml residual urine and needed intermittent catheterization for urination at the latest follow up (two years after surgery); he also complained of intermittent anal incontinence and sexual dysfunction because of inability of erectile. The IIEF-5 questionnaire at final follow-up was 10. His sensation of perineum and lower limbs were normal.

Case 4

History. This 52-year-old female fell from a 2-m height. She was sent to our emergency room 2 h later. Initial examination indicated intact lower-extremity movement, but slight perianal and bilateral anterior thigh numbness. T-L radiographs revealed L1 burst fracture; percentage of L1 body height was 35.6%; and local kyphosis angle was 20.9°. Spine CT demonstrated percentage of L1 canal encroachment was 73.5%. After admission, she complained of voiding difficulty. Post-void Foley catheterization collected 480 ml of residual urine.

Operation. 3 days after hospital admittance, she received posterior instrumentation, indirect reduction by distraction, and T12-L1 posterior fusion.

Follow up. The Foley catheter was removed three days after surgery. She still suffered from urine retention, and intermittent catheterization began. Urodynamic study was done for her 10 days after injury, and the underactive neurogenic bladder was diagnosed. Four months later in a follow-up visit, 60 mL of residual urine was collected after postvoiding catheterization. At the latest follow-up (four years after surgery), she ambulated well without any abnormal sensation; she could void freely with a little urinary frequency sensation. The FSFI questionnaire at final follow-up was 28 the sex-life was almost returned normally [Fig. 1]).

Case 5

History. This 35-year-old male fell down a flight of stairs three meters long. He was diagnosed with an L1 burst fracture at a local hospital, and was transferred to our emergency room 5 h



Fig. 1 A 49-year-old female with L1 burst fracture complicated with peri-anal numbness and difficult voiding. (A) Preoperative radiograph showed 24.30 local kyphosis and 49% anterior height collapse. (B) Preoperative CT revealed 62% canal encroachment. (C) The patient was underwent posterior instrumentation (T11-T12-L2-L3), direct decompression by left transpedicular removal of L1 fractured fragment. At final, this lady regained voiding function.

after the injury. Initial examination showed intact lower-extremity movement but scrotum and perianal numbness. Loss of anal tone was observed. A Foley catheter was inserted because of bladder distention and urination difficulty. T-L spine radiographs showed L1 burst fracture, percentage of L1 anterior body height was 40.9%, and local kyphosis angle was 31.1°. Spine CT revealed percentage of L1 canal encroachment was 81.3%. Solumedrol was administrated.

Operation. Six hours after the ER arrival, emergency surgery with posterior instrumentation (T11-T12-L2), indirect reduction by distraction, posterior fusion with iliac bone graft was performed. Staged surgery with anterior L1 corpectomy, fusion with iliac tricortical bone graft was done two days later.

Follow up. The Foley was removed 3 days after the second surgery. This patient ambulated well with brace protection. Post-voiding urine retention was still observed. Intermittent catheterization training began. Unfortunately, this patient reported severe back pain again two weeks later. The radiograph revealed anterior bone graft was broken. This patient underwent anterior revision surgery with a strut allograft. Two weeks after the anterior revision surgery, urodynamic study was performed and underactive neurogenic bladder was impressed. At the latest follow up (two years after surgery), this patient ambulated well, but still depended on intermittent catheterization to void completely. Urodynamic study at this follow-up visit showed the residual urine was 500 ml. Perineum and medial thigh numbness was noted. He complained of sexual dysfunction because of prolonged time to full erection and early ejaculation. The IIEF-5 questionnaire at final follow-up was 13 [Fig. 2].

Case 6

History. This 55-year-old male fell down from a height of 5 m. He arrived at our emergency room two hours later.

Examination revealed this patient had Grade 5/5 muscle strength and no sensory changes in his lower extremities. Anal tone was normal but the bladder was distended. Post-voiding residual catheterization showed 500 ml of retained urine. Then the Foley was inserted. T-L spine radiographs revealed L1 burst fracture; percentage of L1 anterior body height was 70.0%; and local kyphosis angle was 13.2°. The percentage of L1 canal encroachment was 55.1% on CT. Solumedrol was administered.

Operation. One day after admission, posterior instrumentation (T11-T12-L2-L3), indirect reduction by distraction, and L1 augmentation with Prodense were performed.

Follow up. 28 days after injury, urodynamic study was arranged for this patient, and overactive neurogenic bladder was impressed. At 3- year follow up, this patient can completely void without catheterization assistance. The bladder echo revealed only 35 ml of residual urine. He has full muscle strength in his lower-extremities and can ambulate without any support, but complained of sexual dysfunction because of early ejaculation. The IIEF-5 questionnaire at final follow-up was 11.

Case 7

History. This 41-year-old male rolled down a flight of stairs two meters long, and was immediately sent to our emergency room. Examination revealed full muscle strength of lower extremities, but the patient sustained a left ankle fracture. T-L radiographs showed L1 burst fracture; percentage of L1 anterior body height was 61.1%; and local kyphosis angle was 11.3°. The percentage of L1 canal encroachment was 78.3% on spine CT. Progressive perianal numbness and urination difficulty were observed. Emergency spine surgery was performed six hours after hospital arrival.



Fig. 2 A 35-year-old male with L1 burst fracture. (A) Preoperative radiograph showed 31.10 local kyphosis and 60% anterior height collapse. (B) Preoperative CT revealed spinal canal was encroached by fractured fragment. (C) Posterior reduction and fixation, followed by anterior decompression and fusion with iliac autograft were performed for this patient. (D) Unfortunately, iliac bone graft was broken 2 weeks later. (E) Revision surgery with humeral allograft for anterior bone graft was performed. At final follow up, this patient still need intermittent catheterization for voiding.

Operation. This patient underwent posterior instrumentation (T12-L2), indirect reduction by distraction, and posterior fusion (T12-L1) for spine fracture. We applied an external fixator for the patient's left ankle fracture.

Follow up. The Foley was removed one week after surgery. 500 ml of retained urine was observed after the first post-void residual catheterization. Urodynamic study revealed overactive neurogenic bladder. The patient underwent intermittent catheterization training for ten months; the final urodynamic study revealed 30 ml of residual urine. At the latest follow up (2.5 years after surgery), his spine and ankle fractures healed. The patient ambulated well and could void completely. He complained of anal constipation sometimes with an increased time to full erection, but could return sex-life as before injury. The IIEF-5 questionnaire at final follow-up was 19 [Fig. 3].

Case 8

History. This 56-year-old male fell down from a height of six meters. An L1 burst fracture was diagnosed at an external institute and steroid was administered there. He was transferred to our emergency room 25 h after injury. Examination at our ER revealed Grade 5/5 muscle strength of lower extremities. A Foley catheter was inserted. This patient complained of severe back pain, perianal anal, scrotum, and bilateral anterior thigh numbness. T-L radiographs showed L1 burst fracture; the percentage of L1 anterior body height was 46.8%; and local kyphosis angle was 17.3°. The spine CT showed the percentage of L1 canal encroachment by bony fragment was 80.5%. Emergency surgery was performed 4 h after hospital arrival.



Fig. 3 A 41-year-old male with L1 burst fracture. (A) Preoperative radiograph showed 11.3.0 local kyphosis and 40% anterior height collapse. (B) Preoperative CT revealed 78% canal encroachment. (C) This patient was underwent indirectly posterior reduction, a four-screw construct and T12-L1 posterior fusion; the voiding function was regained finally.

Operation. The patient underwent posterior instrumentation (T12-L2), indirect reduction by distraction, and L1 body augmentation with PRODENSE.

Follow up. Spine CT and MRI were performed for this patient one day after surgery. The fractured fragment was reduced, and spinal canal showed no encroachment. The Foley catheter was removed one week after surgery. Urination difficulty with residual urine was observed. Urodynamic study demonstrated underactive neurogenic bladder, and the patient began intermittent catheterization training. His final visit to our out-patient clinic was six months after surgery; the bladder echo revealed 397 ml of residual urine. This patient ambulated well, but still depended on intermittent catheterization for urination. At this study period (one and half year after surgery), this patient accepted our telephone interview but refused to return to our out-patient clinic citing as his reason that he started an experimental spinal cord regeneration regimen at another medical center. Besides, he also claimed sexual dysfunction. The IIEF-5 questionnaire at final follow-up was 11.

These patients' demographic data, radiographic parameters, and final outcomes were illustrated at [Table 1] and [Table 2].

At final follow up, five patients could void freely, but the remaining three patients required intermittent catheterization for urination. The overactivity type of neurogenic bladder had a higher percentage of patients who returned to self-void function (100% vs. 25%). Four patients could return to a satisfied sex-life, but the other four patients claimed their sex abilities were dis-satisfied. Compared to male, the female patients had a tendency to satisfy their sex function after treatment (100% vs. 33%). Only 2 of the 6 male patients had no or mild erectile dysfunction.

Discussion

The first recorded case of pure conus medullaris syndrome was in 1993 by Tanaka et al. [10]. His patient with L-1 compression fracture experienced urinary incontinence without lower limb motor function deficit, and the patient's vesicorectal function recovered one year after surgical decompression. There is only one case series from Arizona, United States, consisting of 4 patients, reporting L1 burst fracture with pure conus medullaris syndrome [6]. Three of the four patients underwent surgical decompression and fixation (two with L1 corpectomy and expandable cage, one with transpedicle screw fixation). The fourth patient underwent a conservative treatment. Only the fourth patient regained voiding function. However, these case studies did not discuss about the factors that affect urinary function recovery.

In the present study, the injury levels were all at L1 vertebra. The diagnosis of pure conus medullaris syndrome was made clinically by urinary dysfunction without lower limbs weakness. All of the patients in our series underwent surgical treatment; two underwent combined anterior and posterior surgery; and the other 6 received posterior surgery. Five patients regained voiding function, while the other 3 patients required self-intermittent catheterization for voiding. Among the factors affecting the clinical outcome, we

Table 1 Clinical characteristics of the patients.

Age (years)	Gender	Mechanism Of Trauma	Injury Level	Injury ER Internal (hours)	Injury Surgery Internal (hours)	Steroid Use (Y/ N)	Neurogenic Bladder	Associated Injury	Anterior Body Height (%)	Local Kyphosis (degree)	Canal Encroachment (%)	Surgical Method (A or P)	Complication	Final Void Function
32	M	fall	L1	3	74	Y	overactive	nil	50.6	20.1	80.3	P	nil	Free void
49	F	fall	L1	5	22	Y	overactive	nil	50.8	24.3	62.1	P	nil	Free void
68	M	fall	L1	6	88	N	underactive	Left tibia fracture	71.4	6.1	71.4	P + A	nil	IC
52	F	fall	L1	2	76	N	underactive	nil	35.6	20.9	73.5	P	nil	Free void
35	M	fall	L1	5	11	Y	underactive	nil	40.9	31.1	81.3	P + A	Graft broken	IC
55	M	fall	L1	2	19	Y	overactive	nil	70.0	13.2	55.1	P	nil	Free void
41	M	fall	L1	1	7	N	overactive	Left ankle fracture	61.1	11.3	78.3	P	nil	Free void
56	M	fall	L1	25	29	Y	underactive	nil	46.8	17.3	80.5	P	nil	IC

Abbreviations used: F: female; M: male; ER: emergency room; OR: operation room; Y: yes; N: no; P: posterior approach; A: anterior approach; IC: intermittent catheterization.

Table 2 Comparisons between different type of neurogenic bladder (overactive versus underactive).

	Overactive (n = 4)	Underactive (n = 4)	p- value
Age (years)	44.3 ± 10.0	52.8 ± 13.6	0.248
Sex (F/M)	1/3	1/3	1.000
Injury to ER interval (hours)	2.8 ± 1.7	9.5 ± 10.5	0.144
Injury to OR interval (hours)	30.5 ± 29.7	51.0 ± 36.9	0.248
Steroid use (Y/N)	3/1	2/2	0.465
Surgical method			0.102
P	4	2	
P + A	0	2	
A	0	0	
IC at final			0.028
Yes	0	3	
No	4	1	
Anterior body height (%)	58.1 ± 9.3	48.7 ± 15.8	0.248
Local kyphosis (degree)	17.2 ± 6.0	18.9 ± 10.3	0.773
Canal encroachment (%)	68.9 ± 12.3	76.7 ± 5.0	0.248

Abbreviations: used. F: female; M: male; ER: emergency room; OR: operation room; Y: yes; N: no; P: posterior approach; A: anterior approach; IC: intermittent catheterization.

found that the earlier the patient was admitted to the emergency department, the greater chance for the voiding function to recover. It is reasonable to infer that initial injury management, such as bed rest and pain relief, would prevent further injuries to the conus medullaris. However, neurological recovery was not related to timing of surgical intervention. Our finding was similar to previous studies by Kingwell et al. and McAfee et al. [11,12]. We believed that the injury occurred at the time of trauma rather than resulting from pressure caused by fragments in the spinal canal. Early protection could prevent further injury; this was why early arrival at the hospital improved the final outcome.

In the current study, the initial canal encroachment, anterior body height decrease, or degree of local kyphosis is not correlated to the clinical outcome. These results are also compatible with the previous study by Dai et al. and Limb et al. [13,14]. Although a high dose of steroid administration for spinal cord injury was advocated by The National Acute Spinal Cord Injury Study [15], recent studies demonstrated that steroid had little effect on neurological recovery but caused notable side effects on these patients [16,17]. Now, the use of steroids in patients with spinal cord injury became a controversial issue. In our study, even though steroid was also not found to have a better effect on the final bladder function, our principle was to recommend administering steroids if there was no contraindication.

In the current study, all eight patients underwent posterior decompression and fixation first. There were two patients who received subsequent anterior decompression surgeries days later due to residual canal encroachment. We were not able to find which surgical approach was better to obtain final results in this series. McAfee et al. advocated anterior

decompression and fusion for thoracolumbar burst fractures [11]. Other investigators revealed that posterior and anterior approach method had similar neurological improvement in patients with thoracic or lumbar fractures [12,18]. Our general approach to thoracolumbar fracture was by posterior decompression and stabilization first. Delayed anterior decompression was an option depending on the residual canal compromise or stability. Our philosophy of the surgical approach for thoracolumbar burst fractures was similar to Boriani et al. [19].

Chen et al. examined 52 patients with vertebral fracture at thoracolumbar junction (T11-T12-L1-L2); spastic neurogenic bladder dysfunction was most seen at T11, T12 lesion, flaccid neurogenic bladder dysfunction was most seen at L2 level [20]. The conus medullaris, the terminal segment of the adult spinal cord, usually lies at L1 vertebra of most adults. The segment above the conus medullaris is termed the epiconus and consists of spinal cord segments L4 through S1; conus medullaris lesions affect neural segments S2 and below; injuries of cauda equina affect lumbar and sacral roots. Injuries at epiconus lesion result in upper motor neuron deficits of bladder sphincter, but injuries at conus medullaris and cauda equina can cause lower motor neuron deficits of bladder dysfunction [21]. All eight cases in this study were injured at L1 level. Four of them demonstrated overactive neurogenic bladder, the other four showed underactive neurogenic bladder. This phenomenon represented diversity of spinal cord injury even though the lesion was at the same level. A possible cause might be that the position of cord termination varies in adult population (mostly in L1, but extending from T11 to L3) [22].

From literature review, only two-thirds patients with spinal cord injury could achieve balanced voiding after treatment in both upper motor neuron lesion and lower motor neuron lesion [23]. Similarly, five cases in our series could demonstrate free voiding (5/8, 62%). Comparing to patients with underactive neurogenic bladder, a higher percentage of patients with overactive neurogenic bladder returned to freely void function at final follow up (100% versus 25%). However, we could not conclude that overactive neurogenic bladder was a positive factor in achieving free voiding. Our explanation was that earlier medical treatment was obtained (injury to emergency room interval: 2.8 h versus 9.5 h) and earlier surgical fixation was applied (30.5 h versus 51.0 h) in the patients with overactive neurogenic bladder, which might have prevented further damage of the nerve tissue and provided an improved chance for bladder function recovery.

Sexual function in male patients with thoracolumbar fracture was seldom discussed in the literature. Kim et al. reported 11 of 43 patients with paraparesis after lumbar burst fracture reported sexual dysfunction on the self-administrated questionnaire [24]. In the current study, up to two third of the male patient had erectile dysfunction, and they also felt unsatisfied for not returning to the sexual function before injury. Kim discusses lumbar burst fracture with paraparesis, instead of pure conus medullaris syndrome, and the average age was younger. The innervation of male reproductive system includes the sacral pathway (S2-4) and thoracolumbar pathway (T11-L2) [25]. It has been shown that in the absence of sacral pathway, the thoracolumbar

pathway can convey penile responses from higher CNS level. The neural circuit and age factor may explain the different sexual function outcome in male patients between the current study and Kim's group.

Although our case number is small, it is the largest series discussing pure conus medullaris syndrome. All of our patients underwent urodynamic study, and the possible prognostic factors were also discussed. However, there is still not enough recorded information to make widespread healthcare recommendations that encourage void function recovery from orthopedic injuries. Further case enrollment and prognostic assessment are needed.

Conclusion

The incidence of pure conus medullaris syndrome associated with thoracolumbar burst fracture was extremely rare (0.6%, 8/1323). Improved urinary recovery was seen in patients with overactive neurogenic bladders. Recovery of normal bladder function was more likely the shorter the time between injury and the receiving of medical services.

Conflicts of interest

The authors declare no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.bj.2019.02.004>.

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