Original Article

Delayed decompression for cauda equina syndrome secondary to lumbar disc herniation: long-term follow-up results

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Abstract: ***Objective*** To assess the impact of delayed decompression on long-term neurological and bladder function recovery in patients with cauda equina syndrome (CES) secondary to lumbar disc herniation (LDH). **Methods** The clinical data of 35 patients receiving delayed decompression surgery for CES secondary to LDH were reviewed. The bladder empty function, bowel control, sexual ability and neurological functions of the lower limbs were evaluated after the operation, and the urodynamic changes were assessed in 6 patients with urodynamic data before and after the operation. **Results** Surgical decompression was performed at 4.1±3.9 weeks in 12 patients with complete CES and at 5.5±7.6 weeks in 23 patients with incomplete CES after the onset of symptoms. The patients were followed up for a mean of 43.0±28.9 months (3-110 months). In the 23 patients with incomplete CES, 19 obtained full recovery, 4 had slight sensory alterations in the saddle area or the lower limbs. In the 12 patients with complete CES, 2 had full recovery, 4 reported slight sensory alterations in the saddle area or the lower limbs (including 2 with occasional constipation); 6 still had sense deficit in the saddle area and difficulties in bladder or bowl emptying, but they all reported significant improvements compared to the condition before operation. Urodynamic analysis in the 6 patients with pre- and postoperative urodynamic data showed increased abdominal pressure when voiding with significantly reduced residual urine in all the 6 patients; 4 patients with abnormal first desire volume before operation reported recovery after the operation. **Conclusion** Patients with LDH-induced CES who missed the chance of early decompression can still expect favorable functional recovery in the long term. The improvement of bladder function following decompression is probably a result of recovery of bladder sensation and the compensation by increased intra-abdominal pressure. The key strategy to promote bladder function recovery in these patients is to promote the detrusor recovery.

Keywords: cauda equina syndrome; lumbar disc protrusion; bladder function; urodynamics

INTRODUCTION

Cauda equina syndrome (CES) is a rare condition arising from severe compression of the cauda equina to cause such symptoms as saddle and/or genital sensory disturbance and/or sexual, bladder and bowel dysfunctions [1]. Around 50%-70% of patients have urinary retention (CES-R), and 30%-50% have an incomplete syndrome [2]. In complete CES is characterized by partial urinary difficulties including weak urinary sensation, loss of desire to void and poor urinary stream, and the patients often have unilateral or partial saddle and genital sensory deficits with retained trigone sensation. CES-R (or complete CES) is characterized as painless urinary retention and overflow incontinence with extensive saddle and genital sensory deficits and deficiency of trigone sensation[2].

Lumbar disc herniation (LDH) is a common cause of compression of the lumbar nerve root or cauda equine, resulting in such symptoms as low back pain, sciatica, leg weakness and sensory alteration. For patients with CES caused by LDH, prompt decompression is required to avoid permanent function loss, and 48 h or even 24 h after the onset of CES is thought to be the golden time for surgical intervention [3, 4]. But according to some reports, delayed decompression (mean 3.7 days) after the onset of CES also achieved good outcomes [5-7]. The consequences of further delayed decompression (by weeks or even months) remain undefined. In this study, we analyzed the long-term outcomes of 35 patients with CES secondary to LDH who underwent delayed surgical decompression and evaluated the long-term consequences of delayed surgical intervention.

PATIENTS AND METHODS

We reviewed the data of consecutive patients with CES secondary to LDH (CES-LDH) treated in Nanfang Hospital from 2001 to 2015. The diagnosis of CES-LDH was established based on the following criteria: (a) presence of symptoms of the bladder with or without sexual or bowel dysfunctions; (b) abnormal muscle strength and sensation related to the compressed nerve, alterations of saddle sensation and anal squeeze pressure, and decreased penilo-cavernosus reflexes (in men); (c) sexual dysfunction in men in terms of morning erection revealed by questionnaire; and (d) severe disc herniation or spinal canal stenosis confirmed by magnetic resonance imaging (MRI) or computed tomography (CT).

In this study, we made the diagnosis of complete

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CES when the patients had any of the following symptoms: urine retention or incontinence, uncontrolled defecation, and penile erectile dysfunction. Incomplete CES was defined as partial loss of functions of the bladder, bowel or sexual activities.

The follow-up interviews were conducted in a cross-sectional manner, in which the patients were surveyed for their current general life, motor and sensory functions of the lower limbs, and urinary, bowel and sexual functions. Six patients with complete CES before operation received urodynamic analysis both before and after operation.

RESULTS

Out of 42 interviewed patients with the diagnosis of LDH-CES, 35 responded to the survey, including 18 patients who completed the survey in the physician's office and 17 patients receiving the interview on the phone. The 35 patients had a mean age of 42.8 years (ranging from 18 to 60 years) at the time of operation and the mean follow-up time was 43.0 ± 28.9 months (3-110 months).

A diagnosis of complete CES was established in 12 of the patients, including 4 patients requiring catheterization for urine drainage and 8 patients with loss of control of urination or defecation, or both; 5 patients did not have morning erection and could not finish sexual intercourse. Physical examination of the patients revealed multiple positive signs (Tab.1). Eleven of the patients had the history of low back pain. In 5 patients, CES symptoms occurred immediately after chiropractic manipulations (type II CES according to Tandon and Sankaran)[8], and in 1 patient, uncontrollable urination and defecation occurred after a long motor-cycle ride on rough roads. Eleven patients had LDH at the level of $L_{4/5}$, including 1 patient with also L_5/S_1 LDH; LDH at L_5/S_1 was found in 1 patient.

Tab.1 Results of functional examinations in 12 patients with complete CES before operation

Patient No.	Age (year)	Perineal sense	Bladder empty	Bowel control	Penile erection	Spinal level	Motor (M) and sense (S) in legs*	Time of operation
1	35	Lost	Catheterized	Incontinence	Null	$L_{4/5}$	Complete Loss	2 months
2	35	Lost	Catheterized	Constipation	Null	$L_{4/5}$	Intact	9 days
3	37	↓↓↓	Incontinence	Incontinence	Null	$L_{4/5}$	↓↓	3 months
4	40	Normal	Incontinence	Incontinence	Null	$L_{4/5}$	↓↓↓	2 weeks
5	35	↓↓↓	Catheterized	Constipation	Null	$L_{4/5}$	↓↓	3 weeks
6	41	Lost	Incontinence	Incontinence	NA	$L_{4/5}$	M: IV; S: Lost	6 weeks 3 days
7	49	↓↓	Incontinence	Incontinence	NR	$L_{4/5}$	M: I; S: ↓↓	7 days
8	50	↓↓	Incontinence	Constipation	NR	$L_{4/5}$	M: Normal; S:↓↓	11 days
9	60	↓↓↓	Incontinence	Incontinence	NA	$L_{4/5}$	M: IV; S:↓↓↓	1 months 5 days
10	49	Lost	Catheterized	Constipation	NR	$L_{4/5}$, L_5/S_1	M: III; S: ↓↓↓	3 days
11	45	lost	Incontinence	Incontinence	NR	$L_{4/5}$, L_5/S_1	M: Normal; S:↓↓↓	2 days
12	38	↓↓↓	Incontinence	Constipation	NA	L_5/S_1	Normal	2 months 6 days

↓, ↓↓, and ↓↓↓ indicate slight, moderate and severe reduction, respectively. *The roman numbers indicate the grade of muscle strength. NR: Not recorded; NA: Not applicable.

The 12 patients with complete CES received delayed surgical decompression from 2 days to 3 months (mean 4.1 weeks) after the onset of symptoms. Full surgical decompression was performed in 11 cases in our department by senior surgeons specialized in spinal surgery; 1 patient was transferred to our department after operation in a local hospital with poor recovery, but the decompression was satisfactory as confirmed by MRI scan. The patients reported good recovery or significant improvement from 3 days to 20 months after operation (Tab.2). In this group, 6 (50%) patients reported good recovery (2 with full recovery and 4 only had sensory alterations in the saddle area or lower limbs), and 6 patients still had sense deficits in the saddle area and difficulties in bladder or bowl empty or both, but none of them required catheterization in spite of occasional incontinence of defecation or urination.

Twenty-three of the 35 patients were diagnosed to have incomplete CES before surgery. Full decompression was performed at 2 days to 7 months (mean 5.5 weeks) after the onset of symptoms (including numbness or tingling in the saddle area, reduced erectile time or sexual desire, slow start and prolonged void time of urination, constipation, and reduced pressure for defecation). Thirteen of the patients had $L_{4/5}$ LDH, 8 patients had L_5 or S1 disc herniation, 1 patient had herniation at both levels, and 1 patient had herniation at $L_{3/4}$ and $L_{4/5}$. In all the 23 patients, the condition did not evolve into complete CES before operation (Tab.3). Nine of the patients received chiropractic manipulation before the onset of CES. In follow-up, 19 (83%) patients had full recovery, and 4 (17%) patients still had mild sensory abnormalities in the saddle area or the lower limbs (Tab.4).

Tab.2 Results of functional examinations in 12 patients with complete CES after decompression

Patient No.	Time after operation (month)	Perineal sense	Bladder empty	Bowel empty	Penile erection	Motor (M) and sense (S) in legs*
1	96	↓↓↓	Often incontinence	occ. incontinence	Normal	M: IV; S: ↓↓
2	28	↓↓	Normal	Normal	Normal	S: ↓
3	14	Normal	Normal	Normal	Normal	Normal
4	12	Tingling	Normal	Normal	Normal	Normal
5	50	Normal	Normal	Normal	Normal	Normal
6	33	↓↓	occ. incontinence	occ. incontinence	NA	M: III; S:Tingling
7	33	Normal	occ. incontinence	Constipation	Normal	M: III; S: Normal
8	23	Tingling	Normal	Constipation	Normal	M:Normal; S: ↓
9	3	↓	Incontinence	Incontinence	NA	M:IV; S:↓↓
10	25	↓↓	occ. incontinence	occ. incontinence	Normal	M:III; S: ↓
11	30	↓↓	occ. incontinence	constipation	Normal	M:Normal; S:↓↓↓
12	96	↓	Normal	occ. constipation	NA	Normal

↓, ↓↓, and ↓↓↓ indicate slight, moderate and severe reduction, respectively. Occ: Occasional; NA: Not applicable.

Tab.3 Results of functional examinations in 23 patients with incomplete CES before operation

Patient No.	Age (year)	Perineal sense	Bladder empty	Bowel empty	Penile erection	Spinal level	Motor (M) and sense (S) in legs*	Timing of operation
1	41	Tingling	↓	↓↓	↓	L_5/S_1	M: Normal; S: ↓↓	5 days
2	56	Normal	↓↓	↓	↓	$L_{4/5}$	M: L I; S: ↓	1 month
3	47	Tingling	↓	Normal	NR	$L_{4/5}/S_1$	M: L III; S: ↓↓	10 days
4	48	↓	↓	↓	Normal	$L_{4/5}$	M: Normal; S: ↓↓	2 days
5	53	↓↓	NR	NR	Normal	L_5/S_1	M: Normal; S: ↓↓↓	1 month
6	32	↓	Normal	Normal	NR	L_5/S_1	M: Normal; S: ↓	2 weeks
7	41	↓	↓	↓	↓	$L_{4/5}$	M: Normal; S: ↓↓	7 months
8	45	↓	↓↓	Normal	NR	$L_{4/5}$	M: Normal; S: ↓	3 months
9	59	↓↓	↓	Constipation	↓↓	L_5/S_1	M: Normal; S: ↓	3 months
10	33	↓	↓	↓	↓	L_5/S_1	M: Normal; S: ↓↓↓	3 days
11	54	↓	↓↓	Constipation	↓	$L_{4/5}$	M: Normal; S: ↓↓	2 months
12	42	Normal	Normal	Constipation	NR	$L_{4/5}$	M: Normal; S: ↓↓	15 days
13	56	Tingling	↓	NR	Normal	$L_{4/5}$	M: Normal; S: ↓	6 months
14	45	Tingling	↓↓	NR	NR	$L_{4/5}$	M: Normal; S: ↓	4 days
15	29	↓↓	↓	Constipation	NR	L_5/S_1	M: Normal; S: ↓↓	12 days
16	51	↓	↓↓	↓	↓	$L_{4/5}$	M: Normal; S: ↓	1 month
17	50	↓↓	↓↓	Constipation	NR	$L_{4/5}$	M:III; S: ↓↓	1 month 3 days
18	26	↓	↓	↓	↓↓	$L_{4/5}$	M:IV; S: ↓↓	8 days
19	35	↓↓	↓	↓	NA	L_5/S_1	Normal	4 days
20	41	↓↓	↓↓	Constipation	NA	$L_{4/5}$	M:Normal; S: Tingling	2 days
21	40	Normal	↓	Normal	NR	L_5/S_1	M:Normal; S: ↓	6 days
22	43	↓↓	Normal	Normal	↓↓↓	$L_{3/4/5}$	M:II; S: ↓↓	5 days
23	18	Normal	Normal	Normal	↓↓↓	$L_{4/5}$	M:IV; S: Normal	3 months 3 days

Urodynamic analysis was performed in 6 patients with complete CES (Tab.5). At 3 to 96 (36.7 ± 31.18) months after the operation, residual volume reduced significantly in all the 6 patients and to the normal level in 5 patients. The peak flow rate increased in 4 patients. Contractions of intra-urethral sphincter demonstrated by urethral pressure were normal or reduced before operation, and became normal in the follow-up in all the 6 cases. The most significant finding was the sensory function of the bladder, as we found that the first-desire volume was in the normal range in all the patients after the operation. But the detrusor contraction still remained paralyzed except in one patient who showed weak contraction during voiding. The non-inhibitory contraction collaborated by the detrusor and autonomic nerves were absent in all the patients. Strong intra-

Tab.4 Results of functional examinations in 23 patients with incomplete CES after decompression.

Patient No.	Time after operation (month)	Age (year)	Perineal sense	Bladder empty	Bowel empty	Penile erection	Motor (M) and sense (S) in legs
1	28	41	Normal	Normal	Normal	Normal	M: ↓; S: ↓
2	80	56	Normal	Normal	Normal	Normal	Normal
3	45	47	Normal	Normal	Normal	Normal	Normal
4	71	48	tingling	Normal	Normal	Normal	ND
5	93	53	Normal	Normal	Normal	Normal	ND
6	42	32	Normal	Normal	Normal	Normal	ND
7	35	41	Normal	Normal	Normal	Normal	Normal
8	91	45	Normal	Normal	Normal	Normal	ND
9	42	59	Normal	Normal	Normal	Normal	Normal
10	3	33	Normal	Normal	Normal	Normal	Normal
11	55	54	↓	Normal	Normal	Normal	ND
12	41	42	Normal	Normal	Normal	Normal	Normal
13	47	56	Normal	Normal	Normal	Normal	ND
14	45	45	Normal	Normal	Normal	Normal	ND
15	110	29	Normal	Normal	Normal	Normal	Normal
16	78	51	Normal	Normal	Normal	Normal	Normal
17	27	50	Normal	Normal	Normal	Normal	Normal
18	29	26	Normal	Normal	Normal	Normal	Normal
19	22	35	Normal	Normal	Normal	NA	M: Normal; S: Numbness
20	24	41	Normal	Normal	Normal	NA	Normal
21	19	40	Normal	Normal	Normal	Normal	Normal
22	13	43	Normal	Normal	Normal	Normal	Normal
23	21	18	Normal	Normal	Normal	Normal	Normal

ND: Not detected (because the patients answered the phone call only without showing up personally).

abdominal pressure was detected in all the 6 patients during voiding.

DISCUSSION

The occurrence of CES caused by LDH can be either gradual or sudden. In slowly developing CES, the symptoms evolve progressively and sustain over a long period of time as in the case of incomplete CES, whereas in the acute type, complete CES can occur in seconds. In our study, 11 out of the 12 patients with complete CES reported a history of low back pain, 4 patients developed complete CES shortly after chiropractic manipulation, 1 patient developed complete CES in 2 days after chiropractic manipulation, and 1 developed complete CES after a long motorcycle ride. In the 23 patients with incomplete CES, progression of the condition was gradual, and 9 patients reported worsening of the condition after chiropractic manipulation. As a common therapy for back pain associated with muscle strain, chiropractic manipulation should be performed with caution after careful examination to exclude such contraindications as LDH, tuberculosis, and tumors.

In patients with CES, neurological deterioration occurs in a progressive manner [10, 11]. If the patients' condition allows, surgery should be performed as soon as possible to prevent neurological deterioration [12-19] and promote recovery of the neural functions. According to Ahn et al[18], decompression within 48 h after the onset of CES could achieve favorable outcomes, but sooner (within 24 h) surgical intervention did not significantly improve the patients' outcomes; Kohles et al [3] and Delong et al [19], however, believed that surgical intervention of CES within 24 h could bring further benefit. In our case, all the patients received much delayed decompression (mean 4.1 weeks for complete CES and 5.5 weeks for incomplete CES). Six (50%) of the patients with complete CES achieved good recovery and the other 6 also reported significant improvement after surgery, and 23 patients with incomplete CES all had normal life after delayed decompression.

Several reasons might explain the functional recovery of the patients after delayed decompression for CES. Firstly, in slowly developing CES, the compressed nerve roots may slowly develop tolerance to hypoxic conditions and still retain the potential of functional recovery after delayed compression; secondly, as peripheral nerves, the cauda equina nerves possess regeneration ability and may recover from reversible injuries caused by compression, which also explains the better results of early decompression than delayed decompression, especially in terms of bladder and bowel functions. During the surgery, we found that the cauda equina roots were swollen with a reddish purple color, but it could be difficult to accurately assess the damages without histopathological evidence. The injury of the cauda equine roots is not necessarily irreversible when

Tab.5 Comparison of urodynamic findings in 6 patients with complete CES before (Pre) and after (Post) the operation

Findings		No.1	No.6	No.7	No.9	No.10	No.11
Gender		M	F	M	F	M	M
Age of diagnosis (year)		35	41	49	60	49	45
Peak flow rate (mL/s)	Pre	4	5	10	3	0	3
	Post	13	10	25	5	14	4
Residual volume (ml)	Pre	350	30	120	220	400	150
	Post	240	10	35	50	65	20
Urethral pressure	Pre	↓	Normal	↓	Normal	↓	Normal
	Post	Normal	Normal	Normal	Normal	Normal	Normal
Bladder filling first sensation (mL)	Pre	202	500	58	478	495	530
	Post	196	137	135	411	161	329
First desire (mL)	Pre	330	508	136	490	510	680
	Post	315	218	184	411	216	377
Urination urgency (mL)	Pre	839	509	169	501	512	689
	Post	442	267	223	412	369	448
Maximum bladder volume (mL)	Pre	1202	511	198	505	525	690
	Post	489	300	255	412	456	588
Intra-abdominal pressure (cm H_2O)	Pre	12	2	15	10	7	6
	Post	36	31	44	23	35	20
Urethremphraxis	Pre	None	None	None	None	None	None
	Post	None	None	None	None	None	None
Detrusor contraction	Pre	Null	Null	Null	Null	Null	Null
During voiding	Post	↓↓↓	Null	Null	Null	Null	Null
Non-inhibitory contraction	Pre	Null	Null	Null	Null	Null	Null
	Post	Null	Null	Null	Null	Null	Null

The case No. assigned to the individual patients in Tab.1 and 2 is used consistently this table. ↓, ↓↓, and ↓↓↓ indicate slight, moderate and severe reduction, respectively.

patients receive late decompression. In addition, progression of incomplete CES into complete CES occurred in none of our cases even after months' delay of decompression. Thirdly, this long-term follow-up study allowed assessment of neural functional recovery of the patients long after the operation. Chang et al[20]followed 4 patients with CES for 6.4 years and found that the long-term outcome of the patients was not necessarily poor in cases of poor short-term recovery of bladder function[20], which was also supported by the results of similar studies[7, 21].

An important finding of this study is that in patients who reported recovery of urination, their recovery was far from good as indicated by the results of urodynamic analysis. This discrepancy had been noticed before, and the bladder function can be disturbed seriously even in the patients without symptoms[22]. Our results of urodynamic analysis indicate that although the detrusor remained paralyzed, the recovered sensation of the bladder and the compensation by increased intra-abdominal pressure allowed the patients to finish urination. This highlights the importance of training the patients to practice the skills of increasing the intra-abdominal pressure (Valsalva maneuver), which serves as one of the rehabilitation strategies for these patients.

Although the patients with CES can have favorable motor function recovery of the lower limbs[5, 23, 24] (as we also found in our patients) and achieve significant regeneration of the neuromuscular junctions even after denervation for up to one year[25], the recovery of detrusor function remained poor in these patients. The relations among the recovery of bladder sensation, motor function of the extremities and detrusor remain so far unclear, but this might point the direction of further study.

In conclusion, we believe that patients with LDH-CES who missed the chance of early decompression can still expect favorable functional recovery in the long term. The improvement of bladder function following decompression is probably a result of recovery of bladder sensation and the compensation by increased

intra-abdominal pressure. The key strategy to promote bladder function recovery in these patients is to promote the detrusor recovery, and long-term follow-up of the patients is of critical importance. Nevertheless, we could not accurately evaluate the benefit of delayed decompression surgery for ethical reasons, and further study is warranted to address this issue.

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腰椎间盘突出伴马尾神经综合征患者延迟手术减压的长期随访分析

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摘要:目的 分析腰椎间盘突出伴马尾神经综合征患者接受延迟手术减压后神经系统及排尿功能恢复的长期随访结果。**方法** 将35例符合腰椎间盘突出伴马尾神经综合征患者纳入此次随访,着重关注患者术前及术后的膀胱排空功能、排便功能、性功能、鞍区感觉及下肢神经功能恢复情况;6例患者术前术后均接受尿动力学检查。**结果** 35例患者中,12例完全性马尾神经综合征患者平均延迟手术减压时间为4.1+3.9周,23例不完全性马尾神经综合征患者平均延迟减压时间为5.5+7.6周;所有患者随访3~110月(平均43.0+28.9月)。23例不完全性马尾神经综合征患者中,19例完全恢复,4例存在轻微的鞍区或下肢感觉功能改变;12例完全性马尾神经综合征患者中,2例患者完全恢复,4例患者存在轻微鞍区或下肢感觉障碍且其中2例存在偶发便秘,其余6例患者存在不同程度的鞍区感觉障碍、排尿及排便功能障碍。6例有完整术前及术后尿动力学结果的患者中,随访尿动力学检查提示排尿时腹压明显上升,残余尿量较术前明显减少,其中4例患者初次排尿感觉时膀胱容量恢复正常。**结论** 对接受延迟手术的腰椎间盘突出伴马尾神经综合征患者,长期随访结果显示多数患者预后良好,神经功能均有不同程度恢复。尿动力学检查提示膀胱排空功能恢复可能为膀胱感觉恢复引发的排尿时腹内压代偿升高所致。膀胱功能恢复的关键策略为促进膀胱逼尿肌收缩功能的恢复。

关键词:马尾神经综合征;腰椎间盘突出;膀胱功能;尿动力学

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