Turk J Phys Med Rehab 2019;65(x):i-vi
DOI: 10.5606/tftrd.2019.3169

Original Article

Urgent operation improves weakness in cauda equina syndrome due to lumbar disc herniation

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Received: May 18, 2018 **Accepted:** October 01, 2018 **Published online:** February 01, 2019

ABSTRACT

Objectives: This study aims to examine the effect of surgical timing on the sphincter function and improvement of motor function in patients with cauda equine syndrome (CES) due to lumbar disc herniation (LDH).

Patients and methods: Between January 2005 and December 2013, a total of 33 patients (18 males, 15 females; mean age 48.6±2.2 years, range, 24 to 73 years) who underwent lumbar spinal surgery and were diagnosed with CES due to LDH were retrospectively analyzed. Data including demographics, muscle weakness, sensory deficit, sphincter control, LDH level, time from the initiation of symptoms to admission, and time to surgery were documented. The latest muscle weakness, sensory deficits, and sphincter control were also recorded. The patients were divided into two groups according to the rate of muscle strength improvement and data including age, gender, and operation time were compared.

Results: The weakness remained unchanged in 11 (33.3%), improved in 13 (39.4%), and returned to normal in nine (27.3%) patients. Sphincter control resolved in five patients. Sensory loss resolved in two patients. While admission duration was shorter in the group with improved muscle strength (p=0.02), there was no significant difference in the time to surgery (p=0.63). Logistic regression analyses revealed that only the admission within 0 to 24 hours was significant for the muscle strength improvement (regression coeeficient [B]=2.83, standard error [SE]=0.86, p=0.006).

Conclusion: A significant improvement in the motor strength can be achieved in patients with CES who are operated within 24 hours. On the other hand, patients with CES should be received surgery immediately when first seen, regardless of the time, since the muscle strength is slightly improved.

Keywords: Cauda equina syndrome; lumbar disc herniation; muscle strength spinal column.

Cauda equina syndrome (CES) is a rare, but dramatic condition occurring due to compression of fibers of the cauda equina. Clinical signs and symptoms include saddle-type anesthesia, urinary and anal incontinence, sexual dysfunction, and severe weakness such as drop foot. It has been reported to occur primarily as a consequence of lumbar disc herniation (LDH), thoracolumbar fractures, and tumors. Hematomas and infections, which are uncommon etiological factors, may be also the cause of CES.[1]

Nearly 95% of LDH cases are improved by conservative treatment methods without progression.[1] Of note, LDH is the most common pathology, leading to CES. About 45% of all CES cases are caused by LDH, and about 1 to 6% of all LDH cases manifest with CES.[1-3] The incidence of CES has been reported between 1/33,000-100,000.[4] In addition, CES with LDH must be treated surgically as an absolute indication.

There is no controversy regarding the indications for surgical management of LDH with CES, although the spine surgeons have not agreed upon a consensus for timing of surgery, yet. It is well-known that surgical treatment is appropriate immediately after the diagnosis of CES, while early surgery may not alter the natural course of CES in all cases.[5-7] Tragic impairments, such as loss of sphincter control or foot drop, may lead to medico-legal problems, due to misdiagnosis and/or delayed therapeutic procedures.[2,8] Impaired urinary

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Cite this article as:
Uçkun ÖM, Alagöz F, Polat Ö, Divanlıoğlu D, Dağlıoğlu E, Belen AD, et al. Urgent operation improves weakness in cauda equina syndrome due to lumbar disc herniation. Turk J Phys Med Rehab 2019;65(x):i-vi.

and/or anal sphincter functions are considered for the diagnosis of CES by many authors.[1,3] On the other hand, some authors have suggested that CES must initiate with urinary and/or anal dysfunction.[6,7,9] Therefore, prognostic studies on CES have focused on sphincter functions, and the timing of surgery is often based on the improvement of these functions.

It is of utmost importance to recover from CES caused by LDH with minor damages as possible, as sphincter dysfunction, weakness or drop foot findings would affect all of the living conditions and quality of life. In this study, we aimed to examine the effect of surgical timing on the sphincter function and improvement of motor function in patients with CES due to LDH.

PATIENTS AND METHODS

This retrospective study was conducted at the neurosurgery clinic between January 2005 and December 2013, and patients who had lumbar spinal surgery in our clinic were screened. A total of 3,486 patients were identified. Pathologies such as trauma, tumor, epidural hematoma or abscess were excluded. Charts of operated patients were reviewed and only patients diagnosed with CES due to LDH were included. Patients with missing preoperative examination findings and those who were unable to be reached after surgery were also excluded. Finally, a total of 33 patients (18 males, 15 females; mean age 48.6±2.2 years, range, 24 to 73 years) who underwent lumbar spinal surgery and were diagnosed with CES due to LDH were included. The study flow chart is shown in Figure 1.

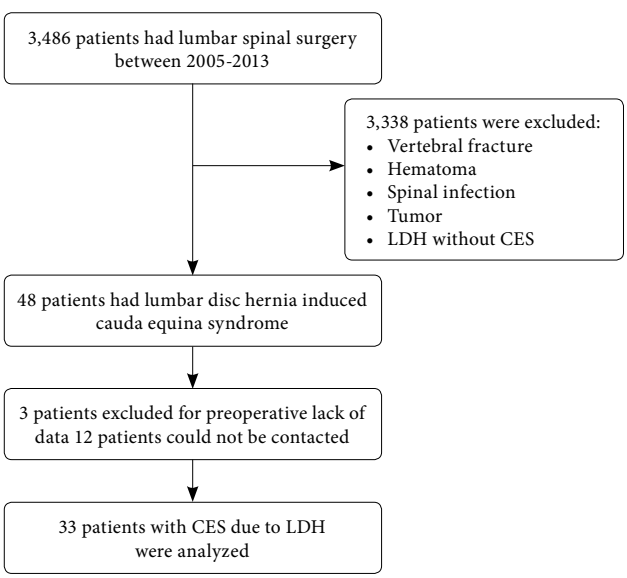

Figure 1. Patients' study flowchart. LDH: Lumbar disc herniation; CES: Cauda equine syndrome.

Data including demographics, muscle weakness, sensory deficit, sphincter control, LDH level, time from the initiation of symptoms to admission, and time to surgery were documented. The latest muscle weakness, sensory deficits, and sphincter control were also recorded. The patients were interviewed via phone call and scheduled for a follow-up visit.

Pre- and postoperative muscle strength were recorded. The patients were, then, divided into two groups according to the rate of muscle strength improvement: *(i)* loss of strength unchanged (those with no improvement in the muscle strength after surgery); and *(ii)* improved muscle strength after surgery, compared to baseline.

In addition, preoperative anal sphincter tone was examined in all patients. The presence of urinary catheter was also assessed. Pre- and postoperative muscle strength, sensory deficit, and sphincter control were compared. The effects of demographic characteristics and operation time on the muscle strength improvement were investigated.

A written informed consent was obtained from each patient. The study protocol was approved by the Ankara Numune Training and Research Hospital Local Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical analysis

Statistical analysis was performed using the PASW for Windows version 18.0 software (SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test was used to test normality. Descriptive statistics were expressed in mean ± standard deviation (SD) or median (min-max) for continuous variables and in number and percentage for categorical variables. The Mann-Whitney U and chi-square tests were used to compare continuous and nominal variables between the groups. The Wilcoxon and McNemar's tests were used to analyze pre- and postoperative results. Binary logistic regression analyses were used to evaluate predictors for muscle strength improvement. A p value of <0.05 was considered statistically significant.

RESULTS

Of a total of 3,486 patients screened at baseline, 48 were diagnosed with CES based on their symptoms and signs. However, 33 of these patients were included

Table 1. Demographic and clinical characteristics of patients

Clinical characteristics	n	%	Mean±SD	Median	Min-Max
Age (year)			48.6±2.2	48	24-73
Gender					
Female	15				
Male	18				
Lumbar disc herniation level					
L2-L3	4	12.1			
L3-L4	4	12.1			
L4-L5	16	48.5			
L5-S1	9	27.3			
Muscle weakness +					
0/5 motor strength	30	90.9			
2/5 motor strength	1	3.03			
3/5 motor strength	1	3.03			
4/5 motor strength	1	3.03			
Incontinence +	27	81.8			
Sensory deficit +	31	93.9			
Time from initation of symptoms to admission			48.5±45.5	24	3-150
Time from admission to surgery			7.6±5.2	8	1-24

SD: Standard deviation; Min: Minimum; Max: Maximum.

in the study. At baseline, all patients had low back and/or leg pain during admission. Muscle weakness was present in all patients, and 30 patients had 0/5 muscle strength. Although one patient had 4/5 motor strength, she was diagnosed with CES based on incontinence and sphincter control loss. Twelve of the patients were referred to our hospital with urine catheter; incontinence was found in 15 patients at the initial examination. The remaining six patients had no incontinence. About half of the patients (48.5%) were found to have L4-L5 level LDH. The mean time from the initiation of symptoms to admission was 48.5±45.5 hours. All patients were considered emergent and operated as soon as possible, irrespective of the time of admission and time from symptom onset. All patients underwent hemilaminectomy in which the selection of side was decided according to side of the previous sciatica and magnetic resonance imaging (MRI). The mean time from admission to surgery was 7.6±5.2 hours. Demographic and clinical characteristics of the patients are shown in Table 1.

The patients were mobilized on the first day of surgery, and passive range of motion exercises for feet were initiated in the early period. All patients continued a physiotherapy schedule and rehabilitation sessions.

The mean follow-up was 16 (range, 2 to 54) months. The muscle weakness remained unchanged in 11 (33.3%), improved in 13 (39.4%), and returned to normal in nine (27.3%) patients. Sphincter control resolved in five patients. Sensory loss resolved in two patients, but remained unchanged in 29 patients, which was the least satisfactory sign and symptom (Table 2).

Table 2. Pre- and postoperative clinical assessments

	Preoperative evaluation					Postoperative evaluation					
Clinical characteristics	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median	Min-Max	*p*
Motor strength			0.27±0.91	0.00	0.00-4.00			2.51±2.01	2.50	0.00-5.00	<0.001*
Muscle strength											
0/5 motor strength	30	90.9				11	33.3				
2/5 motor strength	1	3.03				5	15.2				
3/5 motor strength	1	3.03				5	15.2				
4/5 motor strength	1	3.03				3	9.1				
5/5 motor strength	-	-				9	27.3				
Sphincter control loss	27	81.8				22	66.7				0.06**
Sensory deficit	31	93.9				29	87.9				0.25**

SD: Standard deviation; Min: Minimum; Max: Maximum; * Wilcoxon analyses; ** McNemar's test.

Table 3. Clinical variables, admission, pre-operation and operation time in patients with improved and non improved muscle strength

	Patients with same muscle strength (n=11)					Patients with improved muscle strength (n=22)					
Clinical characteristics	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median	Min-Max	*p*
Age (year)			53.5±12.0	52	37-73			46.0±11.7	47	24-63	0.14*
Gender											
Female	6	54.5				9	40.9				0.45**
Time from initation of symptoms to admission			76.4±53.3	78	8-150			33.5±33.1	24	3-120	0.02*
Time from admission to surgery			7.5±3.8	8	2-15			7.5±5.8	7	1-24	0.63*
Time from initation to surgery			83.8±11.0	80	13-165			41.0±22.0	27	7-144	0.037*

SD: Standard deviation; Min: Minimum; Max: Maximum; * Mann Whitney U test, ** Chi-Square test.

Table 4. Association between muscle strength improvement, clinical variables and surgery duration

Muscle strength 2** (improved muscle strength)	B	SE	*p**	Exp(B)	95%CI
Constant	5.07	2.73	0.004		
Age	-0.74	0.044	0.094	0.928	0.851-1.013
Gender	0.565	0.892	0.526	1.759	0.306-10.103
Time from initation of symptoms to admission	-0.24	0.010	0.019	0.977	0.957-0.996
Time from initation to surgery	0.231	0.142	0.104	1.260	0.953-1.666

B: Regression coefficient; SE: Standard error; Exp (B): Odds ratio; Cl: Confidence interval.

The time from initation of symptoms to surgery was defined as the operation time (OPT). The time from the initiation of symptoms to admission and duration of surgery were shorter in the patients with improved muscle strength, while there was no significant difference in the time from admission to surgery between the patients with and without improvement (Table 3).

Binary logistic regression analyses were used to evaluate predictors for muscle strength improvement and only time from the initiation of symptoms to admission was found to be a significant predictor (Table 4). This variable was evaluated in four subgroups, as 0-24 hours; 25-48 hours; 49-72 hours, and >72 hours. Logistic regression analyses indicated that only the admission within 0-24 hours was significant for muscle strength improvement (regression coeeficient [B]=2.83, standard error [SE]=0.86, p=0.006).

DISCUSSION

Cauda equina syndrome is a dramatic condition which is commonly caused by LDH.[1-3] Although it is a widely accepted rule that a herniated disc should be removed at once when it causes CES, there is no consensus about the timing of surgery. In the present study, we evaluated the effect of demographic features and operation time on the sphincter function and muscle strength. Our study results showed that the OPT was effective in improving the muscle strength.

Incontinence and muscle weakness are the main components affecting functional capacity and quality of life in patients with CES. The importance of early (within the first 24 and 48 hours) operation has been shown to be associated with improved sphincter functions.[10-13] Nielsen et al.[10] reported a significant improvement in the detrusor functions of patients undergoing decompression within 48 hours after the first attack. Hellstrome et al.[11] also reported improvements in the sexual potential following early surgery. Dinning and Schaffer[12] showed a substantial improvement in urinary complaints of patients operated with decompression within 24 hours. Similarly, Shapiro[3] reported an improvement rate of 100% for urinary symptoms, when decompression surgery was performed within 48 hours and 33%, when surgery was performed after 48 hours. Kostuik[2] and Kostuik et al.[13] also recommended surgery to be performed within 48 or 24 hours, if possible. In a meta-analysis, however, Kohles et al.[14] reported that there was no significant difference between an early surgery (within 24 hours) and a longer period (between 24 and 48 hours) after CES onset. Although early surgery has

been conventionally recommended for CES, previous studies reported in 2000s have highlighted that early surgery is not effective on treatment outcomes. Chang et al.[15] reported that incontinence persisted during a mean follow-up of 6.4 years and some authors found that early surgery did not affect prognosis of bladder functions.[6,15] In addition, McCarthy et al.[4] reported that early surgical decompression did not affect improvement rates at two years. Similarly, Dhatt et al.[16] reported that 39 of 50 patients operated within a mean of 12.2 days showed improvement and delayed surgery did not adversely affect prognosis, as expected. In our study, consistent with the aforementioned studies, we found no positive effect of surgical timing on the sphincter functions.

Sphincter dysfunction, which is a more dramatic sign, has been more commonly evaluated in the literature as a prognostic criterion in such patient groups with heterogeneous demographic features, complaints, and symptoms. Although a significant muscle weakness has not been as often studied as sphincter dysfunction, it is a significant sign which can affect the function and quality of life of patients. Loss of strength is mainly expected in severe and advanced stage of CES. Kostuik et al.[13] reported loss of strength in all 31 patients, Choudhury and Taylor[17] in 24 patients (n=42, 57%), McCarthy[4] in 23 patients (n=42, 55%), and Shapiro[3] in 37 patients (n=44, 84%). In a meta-analysis published by Ahn et al.,[1] resolution of sensory and motor deficits was founded in the patients treated within 48 hours. Similarly, in the present study, all patients had motor deficit and motor strength significantly improved in those undergoing surgical decompression within 0-24 hours. As seen in many studies in the literature, we highlighted the importance of the first 24-hour surgery in our study. On the other hand, we also found improvement in motor weakness following surgery in the patients who were admitted to hospital after 24 hours. Therefore, patients with CES should be received surgery immediately when first seen, regardless of the time of admission.

Both pain and neurological signs leading to the loss of strength and sphincter dysfunction result from compression of the nerve roots in the cauda equina by herniated disc. There are two main opinions regarding this pathological process involving the nerve roots: *(i)* chemical exposure due to chemical chain reactions caused by herniated nucleus pulposus;[9,18] and *(ii)* compression of the cauda equina by herniated nucleus pulposus.[4,8] First, it should be emphasized that the cauda equina fibers are, unlike peripheral nerves, unmyelinated preganglionic fibers and has a lower chance of regeneration after Wallerian degeneration.[19] Compressive effects and chemical exposure start a vicious cycle including progressive edema, impaired venous return, and impaired vascular supply/hypoxia, resulting in an irreversible damage, and this process takes four to six hours.[8] Sacral fibers related to the sphincter control and sensory innervations of the perianal region are more centrally located in the cauda equina, whereas motor fibers in the sciatic nerve are more proximally and laterally located, while leaving the foramen.[8,20] Therefore, it is possible that motor fibers escape compressive effects. On the other hand, the thick nerve fibers carrying motor strength conduction are less affected by compression and ischemia, compared to smaller-caliber nerve fibers carrying sensory conduction.[19,20] These data may help explain the postoperative motor recovery in our study. Although we diagnosed CES in a short period of time, completing radiological examinations (e.g., MRI) indicating that CES due to LDH and performing surgery would not be always an easy task. A favorable prognosis can be achieved by removing the culprit disc causing the chemical process and, thus, eliminating compression at once with early surgery.

It has been reported that sphincter functions improve at a rate of 70% following surgery. Although theories related to nerve regeneration, detrusor muscle reinnervation, and improved motor function have been proposed,[7] they are not objective theories based on urodynamic examinations. Being able to micturate only via increasing intraabdominal pressure, multiparity, and altered bladder functions due to diabetic polyneuropathy complicate accurate evaluation of the sphincter control.[21-24] Moreover, sphincter functions return over an extended period of time. In a meta-analysis by Korse et al.,[25] sphincter dysfunction persisted in 55.3% of the patients for a follow-up less than 12 months and in 28.1% at a longer follow-up. Chang et al.[15] also reported that the improvement process could last for months to years. Therefore, while motor improvement starts earlier and allows prediction of prognosis, we may need to wait longer to evaluate the improvement in sphincter functions.

In this study, valuable results were obtained in terms of screening records for about a decade in an experienced center. However, relatively small patient population and retrospective study design can be deemed as the limitations of the study. Although studies and meta-analyses with CES mainly consist of retrospectively evaluated patient groups and it does not seem possible to analyze patients with CES

in a prospective-controlled studies due to the widely adopted concept of early surgery and medico-legal issues, further large-scale studies may be useful to confirm our preliminary findings.

In conclusion, sphincter control and perianal sensory fibers may be more dramatically affected than motor fibers due to their more central localization and histologically being more sensitive. Sphincter dysfunction which is already widely present in LDH patients complicates distinguishing complete from incomplete CES. Motor strength examination should be a tool for the differentiation of complete CES. A significant improvement in the motor strength can be achieved in patients with CES who are operated within 24 hours. On the other hand, patients with CES should be received surgery immediately when first seen, regardless of the time, since the muscle strength is slightly improved. Although sphincter dysfunction appears to be independent of the timing of surgery, further large-scale studies with long-term follow-up are needed to draw a conclusion.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

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