ORIGINAL ARTICLE

A correlation of demographic characteristics, preoperative conservative therapy and timing with postoperative outcome in herniated disc-associated cauda equina syndrome: Do they really matter?

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ABSTRACT

Aim To examine a correlation of demographic characteristics of patients, preoperative modality of conservative therapy and timing on the postoperative outcome of patients six months after the operation.

Methods A retrospective, non-randomized, clinical study involved 48 patients of different age and gender with a verified diagnosis of cauda equina syndrome (CES). The inclusion criteria were patients with CES caused by discus hernia. Observed research variables were age, gender, affected vertebral level, conservative modalities of perioperative therapy (nonsteroidal anti-inflammatory drugs - NSAIDs and physiotherapy), duration of symptoms, and outcome parameters (motor and sensory function, sphincter function of the urinary bladder and bowel).

Results A statistically significant negative correlation was found between age and postoperative outcome ($p<0.05$). The affected vertebral level was positively correlated with the motor and sensory outcome ($p<0.05$). A positive correlation between the use of NSAIDs and the outcome was found ($R=0.570$; $p<0.001$), as well as a negative correlation with perioperative physiotherapy ($R=-0.201$; $p= 0.001$). Postponement of surgery was negatively correlated with outcome variables ($p<0.001$).

Conclusion The results of the study bring new conclusions that were not previously observed. Possible new characteristics associated with the outcome of cauda equina syndrome were determined.

Key words: cauda equina syndrome, intervertebral disc degeneration, time

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INTRODUCTION

Cauda equina syndrome (CES) is an infrequent clinical entity with an incidence ranging from 0.3 to 7 per 100,000 population (1). CES is defined as a set of symptoms and neurological outcomes resulting from compression of the cauda equina. It is manifested by a certain complex of symptoms, such as asymmetric radicular pain in the perineum, loss of sensation in the S1, S2 and S3 dermatomes, radicular pain in the extremities, sphincter damage with incontinence or retention of urination and stool, motor weakness in the extremities with hyporeflexia or areflexia (2,3). Although it is a rare disease, it requires early recognition, which is a prerequisite for urgent surgical treatment (4).

Seventy percent of all cases of cauda equina syndrome occur in patients who have had chronic radicular pain, while in thirty percent of cases CES is the first manifestation of a lumbar disc herniation (5). Given that an increase in the incidence of disc herniation, as the most common precursor of CES, has been noticed, there is a need to clarify less well-known factors that can affect a final outcome of the operative treatment of CES. Previous research has confirmed the effectiveness of surgical treatment of this condition (6), but the role of conservative therapy and the influence of demographic characteristics on the postoperative outcome of patients have not been clarified in detail yet. Therefore, the data from this study will facilitate further evaluation of insufficiently clarified factors that could influence the outcome of CES.

The aim of this research was to examine a correlation of demographic characteristics of patients, modality of conservative therapy and timing on the postoperative outcome of CES patients six months after the operation.

SUBJECTS AND METHODS

Patients and study design

A retrospective, non-randomized, clinical study involved 48 patients of different age and gender with a verified diagnosis of CES. All patients were treated surgically at the Department of Neurosurgery, Cantonal Hospital Zenica in the period from the beginning of 2012 to the end of 2022. Inclusion criteria were patients with CES caused by discus hernia. The specific exclusion criteria were patients who experienced CES as a result of spinal fractures, spinal anaesthesia, spinal stenosis without significant herniation, spondylolisthesis, and patients who had undergone revision.

Methods

All patients underwent a detailed medical history and a detailed neurological examination. Demographic variables (gender and age) were determined based on anamnestic data. In addition to demographic characteristics, variables related to conservative therapy were also defined: preoperative use of nonsteroidal anti-inflammatory drugs (NSAIDs) and preoperative use of physical therapy.

The affected vertebral level was determined by computed tomography (CT; Somatom Definition AS, Siemens, Erlangen, Germany) or magnetic resonance imaging (MRI; Magnetom Avanto 1.5 T, Siemens, Erlangen, Germany).

Surgical intervention for cauda equina syndrome was based on reliable neurological indicators, including sphincteric, sensory, and motor dysfunctions. Timing of the surgery at Cantonal Hospital Zenica is considered in terms of symptom duration and severity.

Patients were prioritized for surgery within 12 hours of admission, preferably within 12 hours of symptom onset. Preoperative catheterization is performed for patients with urinary dysfunction, who were not previously catheterized during their hospitalization. Residual urine measurement was not possible for all patients due to prior catheterization in other departments, and these data were excluded from the analysis.

The outcome variables required for the research were defined on the basis of a control neurological examination six months after the operation, and included the assessment of motor and sensitivity function of the lower extremities and assessment of bladder and bowel function. Motor power assessment was evaluated using the Medical Research Council muscle power scale (MRC): 0 – no visible contraction, 1 – visible minimal contraction, 2 – movement without overcoming gravity, 3 – active movement with overcoming gravity, 4 – movement with overcoming some resistance, 5 – normal strength (7). Sensitivity impairment was evaluated using a sensitivity assessment scale (SAS) for L1-S3 dermatomes with the following

values: 0 – absent, 1 – reduced, 2 – normal (8). Evaluation of bladder and bowel function included three different levels of functionality: 0 – complete dysfunction (retention or incontinence), 1 – incomplete dysfunction, and 2 – normal function (3). Postoperative improvement was evaluated based on the cumulative score of the mentioned scales. An increase in the cumulative score compared to the preoperative values was considered indicative of improvement.

Statistical analysis

The Kolgomorov – Smirnov test determined deviations from the normality of the distribution, which is why non-parametric tests were used. The $\chi 2$ test was used to determine statistically significant differences in categorical variables. A correlation analysis was performed with the non-parametric Spearman Rho's correlation coefficient. Statistical significance was set at $p \leq 0.05$.

RESULTS

The total number of patients was 48, of which 38 were males and 10 females (p=0.006). Mean value for age was 50.1±14.3 years. The most represented were patients between 18 and 40 years, 14 (out of 48; 29.2%). The most frequently affected vertebral level was L4/L5, 21 (out of 48; 43.8%), followed by L3/L4, 13 (out of 48; 27.1%) (p=0.001).

The majority of patients used NSAIDs, 40 (out of 48; 83.3%) with a noticeable statistically significant difference (p<0.001). Physical therapy as a preoperative modality of therapy was used in seven (out of 48; 14.6%) patients (p<0.001) (Table 1). The duration of symptoms through two-time determinants (<48 hours and >48 hours), two subgroups was homogeneous (p=0.386). The mean duration of symptoms was 11.7± 22.1 days. Six months after surgery, gross motor power was assessed at the maximum scalar value in 25 (out of 48; 52.1%), making it the most common outcome. The second most common outcome was a value of 3 on the scale, observed in 11 (out of 48; 22.9%) (p<0.001). Regarding sensory impairments, 21 (out of 48; 43.8%) patients did not exhibit any impairments, while milder forms of impairment were present in 16 (out of 48; 33.3%), and complete impairment of sensitivity was confirmed in 11 (out of 48; 22.9%) (p = 0.210).

Table 1. Demographic characteristics, therapy modalities, timing and outcome in patients with cauda equina syndrome

Variable	M±SD (Min-Max) No (%)	p
Age (years)	50.1±14.3 (27-81)	0.006
18-40	14 (29.2)	
41-50	11 (22.9)	
51-60	12 (25.0)	
61-70	4 (8.3)	
71-80	6 (12.5)	
>80	1 (2.1)	
Gender		<0.001
Male	38 (79.2)	
Female	10 (20.8)	
Vertebral level	-	
L2/L3	7 (14.6)	0.012
L3/L4	13 (27.1)	
L4/L5	21 (43.8)	
L5/S1	7 (14.6)	
Conservative therapy		
NSAID	-	<0.001
Yes	40 (83.3)	
No	8 (16.7)	
Physiotherapy	-	<0.001
Yes	7 (14.6)	
No	41 (85.4)	
Timing	-	
Duration (days)	11.7 ± 22.1 (1-120)	0.386
<48h	21 (43.8)	
>48h	27 (56.3)	
Total	48 (100.0)	

M, Mean; SD, standard deviation; Min, minimum; Max, maximum; NSAID, nonsteroidal anti-inflammatory drug

Regarding postoperative evaluation, the majority of patients, 26 (out of 48; 54.2%) had no bladder sphincter dysfunction (p<0.001). Similar prevalence of neurologic sequelae was noted for bowel dysfunction as a consequence of CES (p<0.001). It was found that on the follow-up examination, 31 (out of 48; 64.6%) patients showed significant improvement (p=0.048). No postoperative complications or indications for surgical revision were recorded (Table 2).

A negative correlation was found between age and postoperative motor function (R = -0.416; p=0.003), suggesting that younger patients exhibited a diminished deficit during the follow-up evaluation. Negative correlations were also observed between age and sensitive impairment (R= -0.443; p=0.002), bladder function impairment (R= -0.317; p=0.028), and intestinal motor dysfunction (R= -0.327; p=0.023), indicating that as patients' age increases, they exhibit more pronounced negative values on the assessed scales. The vertebral level affected by cauda equina syndrome (CES) was positively correlated with the motor outcome after six months (R=0.289; p=0.046) and sensory outcomes

Table 2. Outcome-related characteristics of patients with cauda equina syndrome

Variable	M±SD (Min-Max) No (%)	p
Outcome		
Motoric function	4.0 ± 1.3 (0-5)	<0.001
0	1 (2.1)	
1	2 (4.2)	
2	2 (4.2)	
3	11 (22.9)	
4	7 (14.6)	
5	25 (52.1)	
Sensitive function	1.2 ± 0.8 (0-2)	0.210
0	11 (22.9)	
1	16 (33.3)	
2	21 (43.8)	
Urinal retention	-	0.002
Complete	6 (12.5)	
Incomplete	16 (33.3)	
Normal function	26 (54.2)	
Bowel dysfunction	-	0.001
Complete	6 (12.5)	
Incomplete	15 (31.3)	
Normal function	27 (56.3)	
Improvement	-	0.043
No	17 (35.4)	
Yes	31 (64.6)	
Total	48 (100.0)	

M, Mean; SD, standard deviation; Min, minimum; Max, maximum;

(R=0.290; p=0.045), providing evidence that lesions at lower vertebral levels have a better outcome on the follow-up neurological examination. The use of NSAIDs is positively correlated with the outcome of sensory function (R=0.302; p=0.037). A significant indicator was the positive correlation between the use of NSAIDs and the duration of the deficit (R=0.570; p<0.001). The negative correlation of the preoperative physiotherapy modality of therapy with intestinal function was also evident (R=-0.201; p=0.001). Regarding the duration of the deficit, that is, delay of neurosurgical treatment, a statistically significant negative correlation with the postoperative values of motoric function, sensitivity, urinary retention and intestinal dysfunction was determined (p<0.001). Ultimately, the variable "improvement" demonstrated a logical positive association with the outcome of motor, sensory, sphincter, and bowel motor functions (p<0.001). There was a negative correlation observed with the duration of deficit (R=-0.565; p<0.001), confirming its negative correlation with individual outcome parameters (Table 3).

DISCUSSION

The results of the research showed predominance of males among the diagnosed patients with CES, similarly with other authors (9). An equal gender distribution is reported by Ma et al. (10), while opposing observations are presented by Woodfield et al. (11) with a higher prevalence of female patients.

The results of this study show that CES developed most often in patients younger than 40 years of age, which is also confirmed by other authors (11). Comer et al. (12) note that CES most often develops in people under 50 years of age. Almost identical data on the age characteristics were also obtained (13).

CES occurs most often in the area of the L1/L5 vertebral level (14), and the results of this study specified that it most often occurs at the L4/L5 and L3/L4 levels. On the other hand, Brouwers et al. (15) state that the most common cause of neurological deficit is the compressive effect at the levels from L3 to L5, which confirms the previously explained results. Recognizing the involved level is extremely important in a clinical context. Moreover, Borouwers et al. (15) explain that the involvement of a level above L2 causes more serious consequences and worse outcome due to the involvement of the conus medullaris. Korse et al. (16) state L5-S1 as the most frequently affected level of the lesion.

Furthermore, the duration of symptoms is an important determinant in this study. The average duration was 11.7 days, which is shorter than the reported duration of 15.4 days in Sakkar et

Table 3. Correlation of observed variables

Variable	Motoric function		Sensitive function		Urinal retention		Bowel dysfunction		Duration of deficit	
	R	p	R	p	R	p	R	p	R	p
Age	-0.416	0.003	-0.443	0.002	-0.317	0.028	-0.327	0.023	0.141	0.339
Gender	0.101	0.496	-0.085	0.564	0.017	0.911	0.087	0.554	0.058	0.694
Vertebral level	0.289	0.046	0.290	0.045	0.149	0.312	0.167	0.256	0.023	0.879
NSAID	0.257	0.078	0.329	0.022	0.302	0.037	0.286	0.049	0.570	<0.001
Physiotherapy	0.234	0.109	0.261	0.073	0.186	0.207	-0.201	0.17	-0.476	0.001
Duration of deficit	-0.610	<0.001	-0.617	<0.001	-0.659	<0.001	-0.664	<0.001	1	-
Improvement	0.892	<0.001	0.788	<0.001	0.828	<0.001	0.854	<0.001	-0.565	<0.001

R, Spearman's Rho correlation coefficient; NSAID, nonsteroidal anti-inflammatory drug

al. study (17). Developing countries tend to have prolonged symptom duration (17), leading to delayed surgical intervention, as is the case in Zenica-Doboj Canton.

Preoperative conservative therapy modalities were observed, where evidently the majority of patients used NSAIDs, and a smaller number of patients started physical therapy. Surgical treatment of cauda equina syndrome is controversial, but also associated with lower associated mortality (18). The preference over surgical treatment and its effectiveness on postoperative outcome in giant extrusions with consequent CES was also found (19). On the other hand, some authors state that without the development of CES, giant disc herniations tend to resolve the disc material that is identified in the spinal canal (19). The use of NSAIDs for pain caused by CES in the preoperative period reduces painful sensations (20), and thus can affect the quality of life and daily activities of patients. Another extremely important component is the anti-inflammatory effect of NSAIDs, because the compressive effect causes an inflammatory process (21), which can ultimately lead to irreversible changes in nerve structures exposed to the compressive effect. Also, in the etiology of CES there are some inflammatory diseases such as ankylosing spondylitis and spinal arachnoiditis (22). When it comes to the second observed conservative modality – physical therapy, a smaller percentage of patients in this study underwent this form of therapy. The preoperative physiotherapy effect in surgically indicated patients probably has a positive effect in disc herniation (23), and due to the specificity of the cauda equina syndrome, and its time dependence in relation to the outcome (3,5), it cannot be claimed that it is a conservative modality of choice in the preoperative therapy of CES.

Six months after the operation, the motor and sensory functions of the corresponding myotome, i.e. dermatome, and the sphincteric function of the bladder and bowel were observed. The overwhelming majority of respondents had no motor impairments, while 43% had sensory impairment at the follow-up examination. The prevalence of motor and sensory impairment after surgery is also reported by others mentioning bladder dysfunction, bowel and sexual dysfunction as a long-term consequence of CES (24). The results of this research are in agreement with other studies when it comes to the origin of the variable (25-27). Woodfield et al. (28) reported that symptom and sign resolution of CES was observed in 45% of patients, which was 7% lower for motor function, 9% lower for urinary dysfunction, and approximately 11% lower for bowel motor function compared to the findings of this study.

Our results showed an evident negative correlation between age and all initial parameters, which means that as the number of patients increases, the outcome is weaker. Sulla (29) comes to similar data. Disc herniation, as the most common cause of CES development, treated with surgical treatment has a worse outcome in older people compared to younger people (30). On the other hand, a worse outcome can be caused by numerous complications that occur in the elderly when it comes to this clinical entity (31). A statistically significant correlation, despite the more frequent development of CES in males, in relation to the variables of gender and outcome has not been confirmed in this study, similarly with other authors (32).

The affected vertebral level was positively correlated with motor and sensory impairments, which means that the more caudal the nerve roots affected by CES are, the higher the values of the outcome variables are. The precisely affected level has a significant impact on the outcome of cauda equina syndrome, because the involvement of a higher level, for example TH8/L1, can lead to compression of the conus medullaris and consequent motor and sensory damage to the associated myotomes and dermatomes, as well as autonomic sphincteric functions (33).

The positive correlation between preoperative NSAID use and the outcome of cauda equina syndrome (CES) is an intriguing finding. Possible explanations include: NSAIDs being prescribed for pain relief, the anti-inflammatory effects of NSAIDs in CES related to rheumatological diseases (34), and the presence of comorbidities such as depression and anxiety in patients with pronounced pain, which are associated with a worse outcome of surgical treatment of CES (35). Further investigation is needed to explore these explanations and their interrelationship. Previous studies have not specifically addressed the potential impact of NSAIDs on CES outco-

mes. However, the anti-inflammatory effects of dexamethasone have been mentioned in several studies as a pharmacological therapeutic modality associated with the reduction of neurological impairments and pain relief in CES (36).

The negative correlation that was presented between physiotherapy treatment and the duration of symptoms is a logical sequence, because preoperative physiotherapy requires time, which according to the results of this study, is one of the key aspects. A negative correlation was found between the duration of symptoms, i.e. the delay in surgery, and the postoperative outcome of CES. The largest number of studies suggest that the optimal time period for decompression of the cauda equina fibers is within 48 hours of the onset of the neurological deficit (3, 37-39). Consequently, cauda equina syndrome is one of the emergency conditions in spinal surgery, and is one of the rare conditions where the time frame of the intervention determines the outcome. In any case, delayed surgical intervention is not an option in cauda equina syndrome (3). Contrary to the findings of the current study, certain studies challenge the notion of an optimal time period for operative decompression, particularly the conventional 48-hour window for optimal intervention (28,40,41).

The limitations of this study include its retrospective design, small sample size, and limited follow-up period. These limitations can affect the reliability and generalizability of the findings. Future studies with larger sample sizes, prospective designs, and longer follow-up periods are needed to strengthen our understanding of cauda equina syndrome and its outcomes.

In conclusion, cauda equina syndrome is a devastating condition with very high morbidity and permanent complications, if not recognized and treated in time. Therefore, education about the characteristics and specificities of the cauda equina syndrome enables faster recognition, rapid diagnosis and earlier surgical intervention, and thus the prevention of permanent complications.

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