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Original Article

Cauda Equina Syndrome: Prognostic Factors and Surgical Outcome

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BACKGROUND: Cauda equina syndrome (CES) is a neurosurgical emergency resulting in one or more of the following; bladder, bowel, and/or sexual dysfunction, decreased saddle area sensation, and motor and/or sensory neurological deficit in the lower limbs.

OBJECTIVE: This study was performed to assess the clinical outcome following surgery for CES syndrome and to detect the prognostic factors.

METHODS: This study was conducted on 30 patients admitted to Qena University Hospitals. Patients over 18 years old with clinical and radiological evidence of CES were included. Patients must have urinary and/or anal dysfunction, the cause of CES is herniated lumbar disc with or without canal stenosis, and the affected levels are lumbar (L)3-4 or lower, either single or multiple.

RESULTS: The mean age was 43.2 years. Seventeen cases were males. Twenty-one cases had American Society of Anesthesiologists (ASA) grade I. The mean visual analogue scale (VAS) was 2.27±2.16. Urological symptoms were evident among the studied population. Saddle area sensation was normal in 10 cases. The British Medical Research Council (BMRC) scale was of grade 4 in most cases. Lumbar level 4/5 (L4/5) was the most affected level. The mean spinal canal area was 2.03±0.31 cm2, and the time from onset of symptoms till operation was 63.97±6.8 hours. Postoperatively, most cases had 0 VAS, with 56.67% having normal sensation. Most cases had BMRC grade 5. BMRC and ASA were associated with quality of life (QOL).

CONCLUSION: Cauda equina syndrome is a neurosurgical emergency with outcomes indicated by features such as sciatic pain, bladder function, and surgery performed within 24 hours of bladder dysfunction onset. Recovery of neurological deficits may take months to years, particularly for micturition dysfunction, emphasizing the need for longer-term follow-up.

KEYWORDS: Bladder and bowel function, Cauda equina, Intervertebral disc, Laminectomies.

INTRODUCTION

Cauda equina syndrome (CES) is a rare but serious disorder marked by neurological symptoms and signs caused by cauda equina compression, usually by a massive herniated intervertebral disc in the lower back, mainly at lumbar level 4/5 (L4-5).[1] CES accounts for 1-2% of disc herniation lumbar laminectomies. It is most frequent in adults aged 31–50 years.[2]

CES is caused by mechanical compression and chemical irritation of cauda equina nerve roots. Acute and substantial nucleus pulposus herniation causes mechanical compression and chemical discomfort from inflammatory mediators.[3,4] This simultaneous attack or insult may be better reduces neural tissue blood supply, increasing neurological deficits. Lumbar canal stenosis, especially in older people, and other disorders such as tumors, cysts, infections, and bone abnormalities can restrict the spinal canal and compress the cauda equina.[5]

CES symptoms vary according to the affected nerve roots. However, saddle anesthesia and dysfunctions of the bladder and the bowel, such as urine retention or incontinence and fecal incontinence, are significant features. These symptoms indicate a major nervous system issue that requires rapid medical attention.[6,7]

CES must be detected and treated early to prevent nerve damage. However, therapy delays are common, and the best time for surgery is disputed.[8] Some studies suggest early decompression reduces long-term deficits, but others believe that the date of operation has a little effect.[9] Retrospective studies with limited patient populations and different follow-up lengths dominate CES research. This caused findings and recommendations to be inconsistent.[10,11]

The prognosis for CES patients may vary. The length of time symptoms were experienced before seeking medical attention, the extent of initial neurological impairment, the timing of the surgical decompression procedure, and any additional medical disorders all affect neurological function after surgery.[12,13] Neurological function may take months or years to be restored.[14] Unfortunately, 100% recovery is not always possible. CES restrictions can cause physical, social, and economic challenges, emphasizing the need for effective management.[15,16]

In this research, our objective is to assess prognostic factors and surgical outcomes associated with cauda equina syndrome.

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PATIENTS AND METHODS

This is a hospital-based observational study that was conducted at the Neurosurgery Department of Qena University Hospitals, after obtaining approval from the Ethics Committee of Faculty of Medicine, South Valley University, Qena, Egypt (SVU, MED, NES014,4,23,8,714). Data was collected from the database of 30 patients admitted to the Neurosurgery Department at Qena University Hospitals, South Valley University, between March 2015 and March 2022.

We included patients who were 18 years old or older, exhibiting clinical symptoms of CES with corresponding radiological evidence of cauda equina compression on magnetic resonance imaging (MRI). Patients must present with urinary and/or anal dysfunction. The CES must be attributable to herniated lumbar disc, with or without concomitant lumbar canal stenosis, and the affected levels must be at L3-4 or lower, involving either single or multiple levels. On the other hand, we excluded patients younger than 18 years, patients without urinary or anal dysfunction, CES resulting from causes other than herniated lumbar disc (e.g., tumors, infections, trauma, congenital abnormalities, or systemic diseases), history of urinary bladder, sexual, or bowel dysfunction unrelated to CES, or history of lumbar spine surgery or any other spine-related interventions.

The preoperative assessment included demographic, clinical, and radiological evaluation. Demographic assessment included age, sex, and body mass index (BMI). Clinical evaluation included detailed history of low back pain, lower limb radicular pain and numbness, onset and progression of muscle weakness, bladder and bowel pain and numbness, (urinary retention, incontinence, or bowel incontinence), and sexual dysfunction in addition to pain evaluation and neurological examination. Time elapsed since symptom onset was categorized into acute (<48 hours), subacute (48 hours - 1 week), and chronic (>1 week). Sensory examination included detailed assessment of perineal (saddle) area sensation, graded as normal, hypoesthesia, or anesthesia using standardized dermatome maps. Pain evaluation was performed using the visual analogue scale (VAS), with scores ranging from 0 (no pain) to 10 (worst imaginable pain). Motor examination was categorized using the British Medical Research Council (BMRC) scale as Grade 5 when full motor power, Grade 4 when movement against resistance but less than normal strength, Grade 3 when movement against gravity but not against resistance, Grade 2 when movement with gravity eliminated, Grade 1 when visible or palpable muscle contraction with no limb movement, and Grade 0 when no muscle contraction. Bladder dysfunction was classified as incomplete with urinary difficulties, such as hesitancy, decreased urinary stream, straining to void, or increased frequency without retention and as complete when urinary retention requires catheterization, the onset categorized as within 24 hours or longer. Bowel dysfunction was categorized as normal when there was no change in bowel habits, partial dysfunction with symptoms such as constipation or fecal incontinence, or complete dysfunction if there was loss of anal sphincter control. Sexual dysfunction assessment in males included erectile dysfunction and decreased genital sensation, while sexual assessment in females was limited due to sociocultural constraints, but general inquiries were made.

Radiological evaluation included magnetic resonance imaging (MRI) of lumbar spine, which was done for all patients to specify the level of disc herniation, degree of spinal canal stenosis, and presence of any additional abnormalities such as spondylolisthesis or facet joint hypertrophy. Lumbar canal stenosis was graded using standardized criteria (mild, moderate, severe).

All patients underwent emergency surgery within a few hours of admission. During surgery, the patient was placed in the prone position on a radiolucent operating table, a midline skin incision was made, followed by paraspinal muscle dissection to expose the affected level, complete laminectomy was performed at the affected level(s) to decompress the spinal canal, bilateral foraminotomy to relieve pressure on the exiting nerve roots, removal of the herniated disc material with meticulous separation from the neural elements, pedicle screw fixation was performed in cases with instability, and layered closure of the surgical wound with placement of a drain, which was typically removed after 48 hours.

Initiation of a structured physical rehabilitation program starting from the first postoperative day.

Patients were followed-up for one year postoperatively, with outcomes assessed at regular intervals (1 month, 3 months, 6 months, and 1 year).

Outcome measures included assessment of pain relief, bladder function, bowel function, saddle area sensation, motor function, and sexual function recovery in addition to Macnab criteria. Pain relief was assessed using the VAS, with postoperative scores compared to preoperative levels. Post-operative bladder function recovery was classified as full recovery when normal bladder function was restored, partial recovery when improvement from complete retention to incomplete dysfunction, and no improvement when persistent preoperative bladder dysfunction. Bowel function recovery was assessed similarly with categories of normal, partial recovery, and no improvement. Saddle area sensation was evaluated for recovery of sensation, noting changes from anesthesia to hypoesthesia or normal sensation. Motor function is re-assessed using the BMRC scale, documenting improvements or any persistent deficits. Follow-up of sexual function was conducted through inquiries for males regarding improvements in erectile dysfunction or genital sensation.

Macnab criteria, the patient is asked to rate the level of well-being after surgery, the patient chooses one of the four: excellent, good, satisfactory, or unsatisfactory. Excellent: No pain and no restriction of activity. Good:

relief of presenting symptoms, patients could return to modified work. Satisfactory: Improved functional capacity, but handicapped by intermittent pain of sufficient severity. Unsatisfactory: no improvement or insufficient improvement to enable an increase in activities.

RESULTS

The study evaluated 30 patients with cauda equina syndrome. The average age was 43.2 years with a standard deviation (SD) of 9.17 years. The cohort consisted of 17 males (56.67%) and 13 females (43.33%). Twenty-one cases (70%) had ASA grade I and 9 cases (30%) had ASA grade II.

Pain evaluation revealed that 29 patients (96.67%) experienced back pain with a mean VAS of 2.27 (SD = 2.16). Pain severity was classified as mild in 24 patients (80%), moderate in 3 patients (10%), severe in 2 patients (6.67%), and extreme in none. Sciatica was present in 25 patients (83.33%), with 9 patients (30%) experienced unilateral and 16 patients (53.33%) experienced bilateral sciatica **(Table 1).**

Urological symptoms were reported as follows: loss of urinary sensation in 6 patients (20%), urinary incontinence in 17 patients (56.67%), urine retention in 8 patients (26.67%) and absent anal tone in 12 patients (40%). Saddle area sensation was normal in 10 patients (33.33%), while 9 patients (30%) had saddle hypoesthesia, and 11 patients (36.67%) had saddle anesthesia. Motor examination, based on BMRC scale, showed the following grades among patients; grade 0 in 1 patient (3.33%), grade 1 in 3 patients (10%), grade 2 in 4 patients (13.33%), grade 3 in 6 patients (20%), grade 4 in 9 patients (30%), and grade 5 in 7 patients (23.33%). Three (10%) cases had the pathology at L3/4 level, 16 (53.33%) had at L4/5 level, and 11 (36.67%) had at L5/S1 level. The mean spinal canal area was 2.03 ± 0.31 cm2, and the time till operation was 63.97 ± 6.8 hours **(Table 2, Fig. 1).**

Postoperatively, the mean VAS score was 0.43 (SD = 0.62). Pain levels were reported as 0 in 19 patients (63.33%), 1 in 9 patients (30%), and 2 in 2 patients (6.67%). Sensory examination post-surgery revealed normal sensation in 17 patients (56.67%), saddle hypoesthesia in 3 patients (10%), and saddle anesthesia in 10 patients (33.33%). Motor examination results showed: grade 0 in 1 patient (3.33%), grade 1 in 3 patients (10%), grade 2 in 1 patient (3.33%), grade 3 in 3 patients (10%), grade 4 in 1 patient (3.33%), and grade 5 in 21 patients (70%). Sixteen patients (53.33%) achieved excellent Macnab criteria, 6 (20%) achieved good, 4 (13.33%) achieved satisfactory criteria, and 4 (13.33%) achieved unsatisfactory criteria. The quality-of-life score was 29.53 (SD = 5.73) **(Table 3).**

According to regression analysis between QOL and preoperative data, only BMRC and ASA Grade were significantly associated with postoperative QOL **(Table 4).**

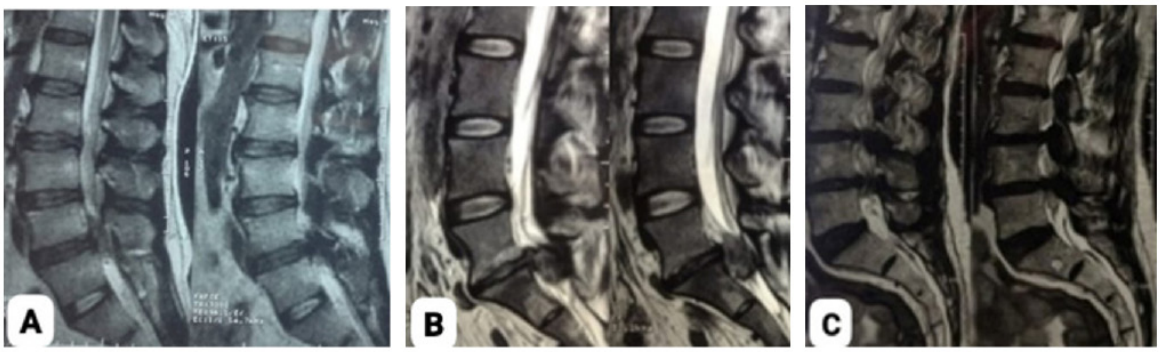

Fig 1: Different MRI T2 -weighted images, sagittal views showing different pathological levels for CES patients, (A): Shows L4-5 disc prolapse, (B): Shows L5- S1 disc prolapse with caudal migration, (C): Shows multiple levels of lumber disc prolapse associated with lumber canal stenosis.

Table 1: Preoperative pain evaluation in patients with cauda equina syndrome

Pain evaluation	Value (N = 30)
Back pain	29 (96.67%)
VAS	2.27 ± 2.16
Pain severity	
• Mild	24 (80%)
• Moderate	3 (10%)
• Severe	2 (6.67%)
• Extreme	0 (0%)
Sciatica	25 (83.33%)
• Unilateral	9 (30%)
• Bilateral	16 (53.33%)

Table 2: Preoperative urological symptoms, saddle area sensation, motor examination using the BMRC, level of pathology, area of spinal canal, and time to operation in patients with CES

Urological symptoms		Saddle area sensation		Motor examination		Pathological data	
Presentation	**Value (N=30)**	**Presentation**	**Value (N=30)**	**BMRC**	**Value (N=30)**	**Level of pathology**	**Value (N=30)**
Loss of urinary sensation	6 (20%)	Normal	10 (33.33%)	0	1 (3.33%)	L3/4	3 (10%)
Urinary incontinence	17 (56.67%)	Saddle hypothesis	9 (30%)	1	3 (10%)	L4/5	16 (53.33%)
Urine retention	8 (26.67%)	Saddle anesthesia	11 (36.67%)	2	4 (13.33%)	L5/S1	11 (36.67%)
Absent anal tone	12 (40%)			3	6 (20%)	Area of spinal canal (cm^2)	2.03±0.31
				4	9 (30%)	Time to operation (up to 72hrs)	63.97±6.8
				5	7 (23.33%)		

Table 3: Postoperative outcomes in patients with cauda equina syndrome

Postoperative	**Value (N=30)**
VAS	0.43±0.62
• 0	19 (63.33%)
• 1	9 (30%)
• 2	2 (6.67%)
Sensory examination	
• Normal	17 (56.67%)
• Saddle hypothesis	3 (10%)
• Saddle anesthesia	10 (33.33%)
Motor examination	
• 0	1 (3.33%)
• 1	3 (10%)
• 2	1 (3.33%)
• 3	3 (10%)
• 4	1 (3.33%)
• 5	21 (70%)
Macnab criteria	
• Excellent	16 (53.33%)
• Good	6 (20%)
• Satisfactory	4 (13.33%)
• Unsatisfactory	4 (13.33%)
QOL	29.53±5.73

Table 4: Regression analysis between QOL and preoperative data

	Unstandardized Coefficients		OR	Test Value	p Value	95.0% Confidence Interval for B	
	B	Std. Error				Lower Bound	Upper Bound
(Constant)	25.8719	9.838579				5.566063	46.17772
ASA	9.9117	1.9247	20.164	5.1497	<0.0001*	5.9554	13.868
VAS	-0.05678	0.424893	0.9448	-0.13363	0.8948	-0.93371	0.820159
Saddle area Sensation	0.561605	1.037407	1.7535	0.541355	0.5933	-1.5795	2.702709
BMRC Grade	2.999397	0.568798	20.0734	5.273221	<0.0001*	1.825456	4.173337
Level of pathology	-1.1233	1.407781	0.3252	-0.79792	0.4327	-4.02882	1.782219
Area of spinal canal	0.58	2.3182	1.786	0.2502	0.8044	-4.1851	5.3451
Time to operation	-0.0751	0.134093	0.9277	-0.56003	0.5807	-0.35185	0.201659

DISCUSSION

In our study, the average age of patients with cauda equina syndrome was 43.2 years, and the distribution between genders was more balanced, with males representing 56.67% (17 cases) and females 43.33% (13 cases). This is similar to the study by Kumar, et al. as the males were predominant, [7] but this contrasts with the study by Buell, et al. as the females were predominant and had an average age of 47 years.[18]

Sciatica was a common symptom among our patients, reported in 25 cases (83.33%); unilateral in 30% and bilateral in 53.33%. Our results also showed that a significant majority of patients experienced back pain (96.67%), with varying degrees of severity, primarily mild (80%). These findings align with the study by Kennedy, et al.where sciatica was consistently a presenting symptom.[1] In contrast, Katzouraki, et al.reported a much lower prevalence of sciatica (32.4%) in their cohort.[19]

Additionally, our study found a substantial history of low back pain in 96.67% of patients, which is a marked contrast to the earlier reported with an average duration of two years. Furthermore, the long-term history of claudication pain was less commonly reported, contrasting with previous data where 52.4% of patients had an average duration of one year.

Regarding postoperative improvement in sciatic pain, measured using the visual analogue scale (VAS), our results indicated substantial pain relief. Postoperatively, the mean VAS score decreased to 0.43 (SD=0.62), with 63.33% of patients (19 patients) reporting complete absence of pain and 30% (9 patients) experiencing minimal pain. This rapid alleviation of pain was notably observed within a few days following surgery. Additionally, our findings indicate that all patients who suffered from preoperative low back pain reported significant relief after surgery.

This aligned with the study by Hazelwood, et al. which reported that about 70% of patients experienced persistent pain upon follow-up.[10] Benko, et al. noted that the prevalence of residual sciatica was 48% during a long postoperative follow-up.[20] Kennedy, et al. observed that patients with unilateral sciatica generally had more favorable outcomes than those with bilateral sciatica.[1] However, they also highlighted that severe residual dysfunction could persist in the absence of pre-existing lower extremity pain. Katzouraki, et al. reported that bilateral sciatica had a predictive value of 32.4% for the outcome of cauda equina compression.[19]

As regards bladder dysfunction, our study noted significant urological symptoms, with 20% of patients (6 patients) experiencing loss of urinary sensation and 56.67% (17 patients) reported urinary incontinence. Additionally, 26.67% of patients (8 patients) had urine retention, and 40% (12 patients) displayed an absent anal tone, indicating various levels of bladder and sphincter dysfunction. This presented a slightly different profile from that reported by Hazelwood, et al.who found that the majority of bladder dysfunction (72%) manifested as retention with overflow, contrasting with the lower incidence of such symptoms in our cohort.[10]

The diagnostic discrepancies noted by Katzouraki, et al. who considered a post-voiding residual volume ≥ 200 ml as indicative of clinical cauda equina syndrome (CES), might explain some variation between studies; however, this method risked missing cases of cauda equina syndrome incomplete (CESI).[19] Kalidindi, et al. highlighted that clinical diagnosis alone tended to have a high false-positive rate, advocating for urodynamic studies to provide more objective information on the lower urinary tract symptoms.[21] These studies served as a crucial diagnostic tool to confirm neurovesical deficits in CES.

In our study, the absence of urodynamic studies-due to their unavailability and the urgent nature of surgical interventions-might have influenced the diagnosis and management of bladder dysfunction. Mauffrey, et al. attributed bladder dysfunction to the autonomic control of the bladder, with sympathetic supply from T12 to L3 and parasympathetic supply from S2 to S3.[11] These nerves supply the detrusor muscle and the internal sphincter, coordinating bladder emptying; their dysfunction can result in an atonic bladder.

In our study, all 8 patients with preoperative urine retention exhibited no postoperative improvement. Conversely, 56.67% of patients (17 patients) with preoperative incomplete urinary dysfunction showed improvement, notably all of whom presented in the emergency room within 48 hours of the onset of bladder symptoms. This observation was consistent with Kennedy, et al. where 75% of patients continued to experience micturition dysfunction postoperatively, indicating a persistent challenge in managing bladder dysfunction in CES patients.[1]

This contrasts with findings from Radulović, et al. who reported only 11% poor outcome,[22] and Hazelwood, et al. who achieved good outcome regarding postoperative bladder dysfunction.[10] The variations in these outcomes could be attributed to the duration of follow-up, which was substantially longer in the studies by Radulović, et al. and Hazelwood, et al. as it was about five years,[22,10] compared to our one-year follow-up and the variable follow-up period that may last for only three months in the Kennedy, et al. study.[1]

The bladder recovery rate in our cohort was calculated using the formula proposed by KrishnanA, et al. [Bladder recovery rate = ({Number of patients with complete bladder recovery} / {Number of patients with pre-operative bladder dysfunction}) * 100%].[9] Long-term follow-up studies by Uçkun ÖM, et al. emphasized that significant recovery in urinary dysfunction can manifest over extended periods, suggesting that assessments based solely on short-term postoperative outcomes may underestimate the potential for recovery.[5]

Gleave JR and Macfarlane R24 supported this perspective, proposing that recovery of bladder and sexual function could continue for several years post-insult due to neural regeneration. This view aligned with Hazelwood, et al. who attributed micturition dysfunction to neural damage affecting detrusor innervation and pelvic floor control.[10] Permanent damage to the lumbosacral plexus results in cauda equina syndrome retention (CESR), whereas cauda equina syndrome incomplete (CESI) with incontinence indicates some residual function of the nerve plexus.

Buell, et al. and Gardner, et al. observed significant differences in outcomes between patients presenting with retention versus those with incontinence.[18,23] Gardner, et al. noted that the prognosis for patients suffering from CESR might not be as time-sensitive as for those with CESI, emphasizing the urgent need for surgery to prevent ongoing damage to the more robust and laterally placed sciatic nerve roots confined in the foramina.[24]

According to the British Medical Research Council scale, post-operative motor power analysis revealed varied improvements. One patient (3.33%) had grade 0, 3 patients (10%) had grade 1, 4 patients (13.33%) had grade 2, 6 patients (20%) had grade 3, 9 patients (30%) had grade 4 and 7 patients (23.33%) had grade 5.

The motor recovery rate, calculated using the formula from Krishnan, et al. is defined as: Motor recovery rate = (Number of patients with motor recovery/Number of patients with preoperative motor weakness)×100%.[9] This quantitative measure highlighted the extent of recovery observed. Kaiser, et al. suggested that motor power tends to improve earlier than sphincter functions, potentially offering a predictive indicator of overall neurological recovery.[25]

Regarding sensory outcomes, pre-operative examination revealed that 30% of patients (9 patients) had saddle area hypoesthesia, while 36.67% (11 patients) lacked saddle area sensation entirely. Post-operatively, no improvement was observed in patients with pre-operative saddle area anesthesia. However, 66.67% (6 patients) of those with pre-operative hypoesthesia reported normal saddle area sensation after surgery, all of whom presented within the first 48 hours of bladder dysfunction onset. This finding emphasizes the critical importance of timely intervention in CES cases. Gardner A, et al. regard the presence of saddle area sensory disturbances as valid and reliable evidence of CES, underscoring the diagnostic significance of these symptoms.[24]

Regarding bowel dysfunction, the prevalence and management were critical aspects of our study. Loss of anal tone was reported in 12 patients (40%) while the others had incomplete dysfunction (constipation and incontinence). On follow up, there was no improvement for any one of the patients who had pre-operative loss of anal tone, although some of them came in the first 48 hours of CES onset; however, we reported improvement in two patients out of 18 patients who presented with an incomplete bowel disorder, both patients came within 48 hours of CES onset. The defecation dysfunction percent in Benko, et al. study was 74% preoperatively and 42% postoperatively. The variable postoperative defecation dysfunction percent is an indicator of persistent challenges in managing bowel function post-CES.[20]

In our cohort, MRI imaging played a pivotal role in diagnosing CES, particularly in distinguishing between different levels of lumbar disc prolapse and stenosis. The majority of disc prolapses occurred at the L4-5 level, a common site for such injuries. The presence of lumbar canal stenosis was a significant factor affecting outcomes, where presence of preoperative canal stenosis was a more crucial outcome predictor than the size of the herniated disc. This finding contrasted with Kennedy, et al. who reported no significant postoperative differences.[1]

In our study, patients who underwent surgical decompression along with facet removal and pedicular screw fixation exhibited greater satisfaction regarding the outcomes of postoperative sciatica. Despite these positive results, there was no significant difference in the outcomes of postoperative bladder or bowel dysfunction when comparing patients who underwent only laminectomies to those who received additional facet removal and pedicular screw fixation. This aligned with findings from other studies, which emphasized the significant impact of the extent of surgical decompression, whether limited

or extensive, on overall outcomes advocating for a full laminectomy in patients with cauda equina syndrome (CES), even if the pathology is solely discogenic.

The timing of the surgical intervention proved critical in our study. Operations that were conducted within 24 to 48 hours post-presentation were most beneficial. Specifically, of the total patient cohort, surgeries performed within 24 hours accounted for 13.33%, while those conducted between 24 and 48 hours represented 36.67%, and surgeries after 48 hours constituted about 50%. Notably, improvements in urinary and bowel dysfunctions, as well as saddle area sensation, were predominantly observed in patients who underwent surgery within the first 48 hours. All patients with urinary dysfunction improvements and the majority showing motor power enhancements were operated on within this crucial window.

This critical window for surgery is supported by findings from Kennedy, et al. where 78% of patients without post-operative residual impairment had undergone surgery within 24 hours of CES onset, highlighting early intervention as a predictor of favorable outcomes. Conversely, other studies have observed clinical improvements across varying surgical timings, though full resolution of bowel and bladder symptoms was not always achieved, even with early surgery.[1] This suggested the complex interplay of factors influencing recovery in CES, including the timing of surgical intervention and the inherent variability in patient responses to treatment.

Overall, our findings and the corroborated literature underscored the importance of prompt surgical intervention in CES, ideally within 24 to 48 hours of symptom onset, to optimize neurological recovery and improve patient outcomes across various functions.

Regarding sexual function, it was difficult to assess sexual function in females (13 patients) due to our conservative society and culture associated with that issue; however, no improvement was noted in any patient whom we were able to assess. Comer, et al.[3] reported that urinary tract dysfunction in men is commonly accompanied by erectile dysfunction, coexisting erectile dysfunction had been reported as high as 79-100% in men, especially that age-related diseases such as diabetes mellitus, hypertension, and cardiovascular pathologies also affect erectile function.

Benko, et al. and Korse et al. reported sexual dysfunction outcomes for 53% of their patients.[20,26] This differs from Hazelwood, et al.[10] who demonstrated a lower prevalence of dysfunction (39%); they referred that to the method of measurement as they used the Arizona sexual experiences scale. In Korse et al. study, the outcome was subjectively assessed, and 11/19 were coded as 'dysaesthesia of genital region', which did not imply dysfunction and may lead to inaccurate results.[26] Gardner, et al. study also reported that recovery of sexual function may need many years after an insult.[24]

Study limitations

This study was limited by the duration of the follow-up, which was only one year following surgery. Further assessment of the neurological state on subsequent dates is needed. Additionally, the number of patients included in this study is still small. In addition, the study was retrospective.

CONCLUSION

The cauda equina syndrome is a neurosurgical emergency, where early surgical decompression is an absolute indication. There are many factors affecting postoperative neurological outcome. The following features suggest favorable outcomes; presence of sciatic pain, partially preserved bladder function (CESI), the pathology is due to pure disc prolapse without canal stenosis, the prolapsed disc is L5-S1 level, surgery done within 24 hours of bladder dysfunction. The recovery of the neurological deficit may take months to years, so we should not rely on short-term postoperative follow-up, especially for micturition dysfunction, which needs a longer time for recovery than motor weakness.

List of abbreviations

ASA: American Society of Anesthesiologists.
BMRC: British Medical Research Council.
CES: Cauda equine syndrome.
CESI: Cauda equine syndrome incomplete.
CESR: Cauda equine syndrome complete with urinary retention.
MRI: Magnetic resonance imaging.
QOL: Quality of life.
VAS: Visual analogue scale.

Disclosure

The authors report no conflict of interest in the materials or methods used in this study or the findings specified in this paper.

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REFERENCES

1. Kennedy JG, Soffe KE, McGrath A, Stephens MM, Walsh MG, McManus F. Predictors of outcome in cauda equina syndrome. *Eur Spine J.* 1999;8(4):317-322.

2. Hoeritzauer I, Wood M, Copley PC, Demetriades

AK, Woodfield J. What is the incidence of cauda equina syndrome? A systematic review. *J Neurosurg Spine.* 2020;32(6):832-841.

3. Comer C, Finucane L, Mercer C, Greenhalgh S. Shades of grey - The challenge of 'grumbling' cauda equina symptoms in older adults with lumbar spinal stenosis. *Musculoskelet Sci Pract.* 2020;45:102049.

4. Sangondimath G, Mallepally AR, Mascharenhas A, Chhabra HS. Sexual and bladder dysfunction in cauda equina syndrome: Correlation with clinical and urodynamic studies. *Asian Spine J*. 2020;14(6):782-789.

5. Uçkun ÖM, Alagöz F, Polat Ö, et al. Urgent operation improves weakness in cauda equina syndrome due to lumbar disc herniation. *Turk J Phys Med Rehabil.* 2019;65(3):222-227.

6. Srikandarajah N, Noble A, Clark S, et al. Cauda equina syndrome core outcome set (CESCOS): An international patient and healthcare professional consensus for research studies. *PLoS One.* 2020;15(1):e0225907.

7. Greenhalgh S, Finucane L, Mercer C, Selfe J. Assessment and management of cauda equina syndrome. *Musculoskelet Sci Pract.* 2018;37:69-74.

8. Kohles SS, Kohles DA, Karp AP, Erlich VM, Polissar NL. Time-dependent surgical outcomes following cauda equina syndrome diagnosis: Comments on a meta-analysis. *Spine (Phila Pa 1976).* 2004;29(11):1281-1287.

9. Krishnan A, Kohli R, Degulmadi D, Mayi S, Ranjan R, Dave B. Cauda equina syndrome: A Review of 15 patients who underwent percutaneous transforaminal endoscopic lumbar discectomy (PTELD) under local anaesthesia. *Malays Orthop J.* 2020;14(2):101-110.

10. Hazelwood JE, Hoeritzauer I, Pronin S, Demetriades AK. An assessment of patient-reported long-term outcomes following surgery for cauda equina syndrome. *Acta Neurochir (Wien).* 2019;161(9):1887-1894.

11. Mauffrey C, Randhawa K, Lewis C, Brewster M, Dabke H. Cauda equina syndrome: An anatomically driven review. *Br J Hosp Med (Lond).* 2008;69(6):344-347.

12. Finucane LM, Downie A, Mercer C, et al. International framework for red flags for potential serious spinal pathologies. *J Orthop Sports Phys Ther.* 2020;50(7):350-372.

13. Bulloch L, Thompson K, Spector L. Cauda equina syndrome. *Orthop Clin North Am.* 2022;53(2):247-254.

14. Pronin S, Koh CH, Bulovaite E, Macleod MR, Statham PF. Compressive pressure versus time in cauda equina syndrome: A systematic review and meta-analysis of experimental studies. *Spine (Phila Pa 1976).* 2019;44(17):1238-1247.

15. Kalidindi KKV, Sath S, Vishwakarma G, Chhabra HS. Magnetic resonance imaging findings in intervertebral disc herniation: Comparison of canal compromise and canal size in patients with and without cauda equina syndrome. *Surg Neurol Int.* 2020;11:171.

16. Woodfield J, Hoeritzauer I, Jamjoom AAB, et al. Understanding cauda equina syndrome: Protocol for a UK multicentre prospective observational cohort study. *BMJ Open.* 2018;8(12):e025230.

17. Kumar V, Baburaj V, Rajnish RK, Dhatt SS. Outcomes of cauda equina syndrome due to lumbar disc herniation after surgical management and the factors affecting it: A systematic review and meta-analysis of 22 studies with 852 cases. *Eur Spine J.* 2022;31(2):353-363.

18. Buell KG, Sivasubramaniyam S, Sykes M, Zafar K, Bingham L, Mitra A. Expediting the management of cauda equina syndrome in the emergency department through clinical pathway design. *BMJ Open Qual.* 2019;8(4):e000597.

19. Katzouraki G, Zubairi AJ, Hershkovich O, Grevitt MP. A prospective study of the role of bladder scanning and post-void residual volume measurement in improving diagnostic accuracy of cauda equina syndrome. *Bone Joint J.* 2020;102-B(6):677-682.

20. Benko MJ, Danison AP, Marvin EA, Saway BF. Distal cauda equina syndrome: A case report of lumbosacral disc pathology and review of literature. *Surg Neurol Int.* 2019;10:84.

21. Kalidindi KKV, Chhabra HS, Suman D, Mannem A, Bhat MR. Cauda equina syndrome: False-positive diagnosis of neurogenic bladder can be reduced by multichannel urodynamic study. *Eur Spine J.* 2020;29(6):1236-1247.

22. Radulović D, Tasić G, Joković M, Nikolić I. The role of surgical decompression of cauda equina in lumbar disc herniation and recovery of bladder function [Article in Serbian]. *Med Pregl.* 2004;57(7-8):327-330.

23. Gleave JR, Macfarlane R. Cauda equina syndrome: What is the relationship between timing of surgery and outcome? *Br J Neurosurg.* 2002 ;16(4):325-328.

24. Gardner A, Gardner E, Morley T. Cauda equina syndrome: A review of the current clinical and medico-legal position. *Eur Spine J.* 2011;20(5):690-697.

25. Kaiser R, Nasto LA, Venkatesan M, et al. Time factor and disc herniation size: Are they really predictive for outcome of urinary dysfunction in patients with cauda equina syndrome? *Neurosurgery.* 2018;83(6):1193-1200.

26. Korse NS, Pijpers JA, van Zwet E, Elzevier HW, Vleggeert-Lankamp CLA. Cauda equina syndrome: Presentation, outcome, and predictors with focus on micturition, defecation, and sexual dysfunction. *Eur Spine J.* 2017;26(3):894-904.