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# Long term clinical outcome following decompressive surgery for Cauda Equina Syndrome. A single centre experience from India

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Keywords
Cauda Equina Syndrome, long term follow-up, surgical decompression, time to surgery

## ABSTRACT

**Study design**: Retrospective study with prospective long-term clinical follow-up.
**Background**: Cauda equina syndrome (CES) is a neurosurgical emergency, mostly caused by herniated lumbar disc for which urgent surgical decompression is indicated. Data on long-term clinical outcome of bladder, bowel & sexual function following decompression are elusive.
**Aim**: To evaluate the effectiveness of surgical decompression on recovery of CES symptoms at long-term follow-up & role of timing of surgery on the outcome.
**Methods**: Records of 35 CES patients who underwent surgical decompression for herniated lumbar disc during a five years period retrospectively analysed & patients called for follow-up visits. Outcome measures comprised of history & clinical examination pertinent to bladder, bowel & sexual function.
**Results**: Twenty-four patients (68.5%) were included for final evaluation who attended follow-up visits, with a minimum follow-up period of one year. Most common complaint at presentation was bladder dysfunction (100%) with urinary retention in 16 patients (66.6%), faecal incontinence in 11 (45.8%), saddle anaesthesia in 22 (91.6%) & erectile dysfunction in 6 patients (out of 15 males). Only four patients underwent surgery within 48 hours of CES symptom onset, rest cases after 48 hours duration. At follow-up, bladder dysfunction present in 33.3% with urinary retention in 16.6%. Faecal incontinence persisted in 4 patients (16.6%) & saddle anaesthesia in 7 (29.1%). Sexual dysfunction was the most persistent complaint.
**Conclusion**: Long-term follow-up shows significant recovery of sphincteric function in CES patients after surgical decompression. Urinary & bowel dysfunction improve significantly. Timing to surgery didn't affect the long-term outcome.

## INTRODUCTION

Cauda equina syndrome (CES) is clinically characterized by varying degree of loss of bladder, bowel & sexual function & is often associated with one or more of features like low back pain, unilateral or bilateral

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sciatica, leg weakness & is caused by compression of lumbar and sacral nerve roots in cauda equina [1, 2, 25, 33, 35].

It is considered a neurosurgical emergency & prompt surgical decompression represents the therapeutic gold standard [1, 18, 28]. The most common cause of CES is herniated lumbar disc (HLD) & CES is considered the only primary absolute indication for surgery in HLD patients [1, 8, 18, 28].

There are differing reports in the literature regarding the optimum time to surgery but because of the rare occurrence of this syndrome, there is a lack of unified criteria for deciding the best timing for surgery and determining factors that positively influence the clinical outcome.

Hence, the influence of timing of surgery on outcome has been a topic of debate in literature and most studies show that decompression within 48 hours yield better outcome [1, 3, 18]. But many others disagree & indicate that timing of surgery does not appear to significantly improve the outcome [4, 14, 25, 26, 28]. Regardless of the disease onset, it is logical to conclude that operating sooner rather than later is better.

Long term follow-up of CES patients is required for evaluation of bladder, bowel & sexual function recovery following surgical decompression and several studies do include individual population with follow-up of several years, however, those patient numbers are small and evaluation of outcome seldom includes defecation and sexual function [20].

Aim of this study was to present our experience at this institute and assess the effectiveness of surgical decompression on functional recovery of CES symptoms after long term follow-up with regards to bladder, bowel as well as sexual dysfunction & evaluate the factors affecting the long-term outcome after surgery following development of CES symptoms, together with a thorough review of literature.

## Materials & methods

### Study design

Medical records & clinical data of consecutive patients operated for lumbar herniated disc at this tertiary care regional Government hospital during a five years period from July 2014 to June 2019 with coded admission diagnosis & clinical presentation of CES were retrospectively reviewed for their baseline characteristics, presenting complaints, pre-operative neurological status, surgical complications, clinical parameters at the time of discharge from the hospital. Then selected patients included in the study were called upon telephonically for follow-up visits arranged in outpatient care clinic. All patients had pre-operative MRI of lumbosacral spine for definitive diagnosis of herniated disc causing clinical cauda equina syndrome. The minimum follow-up period was set to one year with mean follow-up of 28 months and maximum of 5 years. Patients were evaluated for clinical improvement & outcome of micturition, defecation, and sexual function and possible predictors of outcome. The study was approved by Institutional Review Board.

### Inclusion criteria

- Patients with newly diagnosed CES operated within the study period.
- Pre-operative MRI suggestive of herniated lumbar disc causing cauda equina nerve root compression (Figure 3 & 4).
- Follow-up of at least one year.

### Exclusion criteria

- Cause of CES other than HLD, like tumors or degenerative lumbar stenosis.
- Patients with re-operation for persistent symptoms with post-operative MRI suggestive of residual/recurrent disc herniation.
- Didn't attend the follow up clinic.

A total of 35 patients were identified by screening the records of all patients operated by the two experienced senior neurosurgeons for lumbar herniated disc at this institution & out of these, 24 patients were included for the final evaluation. Rest eleven patients didn't meet the inclusion criteria due to various reasons & were excluded.

### Operative procedure

All patients underwent standard laminectomy & removal of herniated lumbar disc causing compression of lumbosacral nerve roots. No patient in this study had spinal fusion or any instrumentation for instability.

### Demographic & clinical data

Baseline parameters like age, sex, level of disc, associated comorbidities, smoking status, presenting symptoms, duration of symptoms of CES

& time to surgery were analyzed (table-1). Limb weakness was graded according to MRC (Medical research council) scale. Symptoms of bladder, bowel & sexual dysfunction were separately measured. Patients who were catheterized at the time of presentation were considered having urinary retention. Incontinence of faeces due to sphincteric dysfunction & saddle anesthesia were included as symptoms of bowel dysfunction relevant to CES & were evaluated. Sexual dysfunction was present in male patients as erectile dysfunction. Post-operative complications were also noted & patient-related clinical data at the time of discharge from the hospital were analyzed.

| Characteristics (n=24) | |
|---|---|
| Median Age (in years) | 40.0 years (Range 30-65) |
| Sex – Male<br>Female | 15<br>09 |
| Level of HLD | L2-3 1 (4.1%)<br>L3-4 5 (20.8%)<br>L4-5 11 (45.8%)<br>L5-S1 9 (37.5%)<br>Two level HLD 2 (8.3%) |
| Comorbidities | DM-2 3<br>HTN 4 |
| Smoking status | Smoker 8<br>Non-smoker 16 |
| (HLD Herniated lumbar disc; DM-2 Diabetes mellitus type-2; HTN Hypertension) | |

**Table 1.** Pre-operative patient related parameters.

### Outcome Measures

A follow-up visit was arranged during a period between July to August 2020 for all screened patients of CES as per their convenience to attend the outpatient care & relevant clinical history was taken regarding present status of pain, limb weakness & improvement in bladder, bowel & sexual function. Thorough neurological examination was performed in all patients including presence of motor deficit, anal tone & perineal sensation. Improvement in limb weakness was considered significant if it upgraded at least two MRC (Medical research council scale) grades from the pre-operative record.

Outcome of individual parameters was assessed & compared between two intergroups of chronological order 1) pre-operative v/s at discharge & 2) at discharge v/s long term follow-up. This comparison was done to evaluate the importance of a long-term follow-up & long recovery time required to see the results of surgical decompression.

### Statistical analysis

The recorded data were analyzed using IBM-SPSS software version 24.0 for windows OS 10 (SPSS Inc. Chicago). Comparing independent groups with categorical variables was done with Chi Square test. For comparisons between paired groups of categorical variables, McNemar's test was done with Yates correction for continuity and validated with a binomial exact test. Binary logistic regression models were used to evaluate predictors for bladder, bowel and sexual dysfunction at long term follow-up, with inclusion of the following variables: age, sex, level of herniated disc at presentation, duration of complaints of CES at presentation & time to decompression. Statistical significance determined by a p value $< 0.05$.

## Results

A total of 594 patients underwent laminectomy with discectomy surgery for herniated lumbar disc during the five years study period at this institution, out of which thirty-five (35) patients were diagnosed having CES. So, the incidence of CES among patients operated for lumbar herniated disc was 5.9% at our center. Out of these 35 patients, eight didn't attend the follow-up visit due to various reasons (three of them couldn't be contacted, five didn't came for follow-up even after several requests made telephonically & so couldn't be examined at follow-up). Three patients demonstrated significant residual or recurrent disc herniation in the follow-up MRI scans and were re-operated, so excluded from the final evaluation. Hence, twenty-four patients (68.5%) with CES were included in our study for evaluation.

Demographic parameters of the patients who were included are summarized in table-1. The median age was 40 years with 15 males & 9 females. The most common level of disc herniation was L4-5 (in 45.8%) followed by L5-S1 (37.5%) & two-level disc herniation in two cases (8.3%), one with L2-3 & L3-4 levels & other one with L3-4 & L4-5 levels, & these

two patients underwent laminectomy & discectomy at both levels simultaneously.

### Pre-operative clinical parameters

The common presenting clinical features are listed in Table-2. The most common presenting symptoms were radicular leg pain (87.5%), urinary dysfunction (100%) & saddle anesthesia (91.6%). Other common complaints were weakness of either or both legs (54.1%) & bowel dysfunction in form of faecal incontinence of varying severity (45.8%). Two patients had partial foot drop at presentation which improved at long term follow-up. The least common complaint reported was sexual dysfunction (25% in whole sample) as 6 male patients having erectile dysfunction (40%). None of the females reported any sexual dysfunction. Sixteen patients (66.6%) were catheterized either at the time of admission or before surgery for urinary retention. Per-rectal examination revealed perineal hypoesthesia in thirteen (54.1%) & decreased anal tone in nineteen (79.2%) patients. Three patients who reported absence of radicular pain, also had bilateral lower limb weakness, complete saddle anesthesia with urinary retention.

| Symptoms/signs | Overall (n=24) |
|---|---|
| Low back pain | 22 (91.6%) |
| Radicular leg pain | 21 (87.5%) |
| - Unilateral | 16 (66.6%) |
| - Bilateral | 5 (20.8%) |
| Motor deficit | 13 (54.1%) |
| - U/l leg weakness | 8 (33.3%) |
| - B/l leg weakness | 3 (12.5%) |
| - Foot drop (U/l & partial) | 2 (8.3%) |
| Bladder dysfunction | 24 (100%) |
| - Urgency/dysuria | 3 (12.5%) |
| - Overflow incontinence | 5 (20.8%) |
| - Retention | 16 (66.6%) |
| Bowel dysfunction | |
| - fecal incontinence | 11 (45.8%) |
| Sexual dysfunction (Male) | |
| - Erectile dysfunction | 6/15 (40.0%) |
| Perineal hypoesthesia | 13 (54.1%) |
| Saddle anesthesia | 22 (91.6%) |
| - Complete | 15 (62.5%) |
| - Partial | 7 (29.1%) |
| Anal tone | |
| - Normal | 5 (20.8%) |
| - Decreased | 19 (79.2%) |

**Table 2.** Pre-operative clinical parameters.

### Disease duration and time to surgery

The duration of complaints related to herniated lumbar disc disease with low backache &/or radicular leg pain are summarized in Table-3. The most important parameter to be measured was the mean duration of onset of cauda equina syndrome symptoms (bladder &/or bowel dysfunction with or without leg weakness) to surgical decompression. For this, the duration of symptoms at admission was added to the duration from admission to surgery. The mean duration was 117 hours (approximately 5 days) with only four patients (16.6%) undergoing surgery within 48 hours from symptom onset. We do not have emergency spine surgery unit at this institution; hence all cases were posted for surgery on urgent priority basis in the elective theatre on the same day or within 48 hours of admission. The time to surgical decompression from onset of CES symptoms of all included patients is shown in Figure-1 & the time to surgery from admission to the hospital in Figure-2. The average duration of hospital stay was 6.5 days. Mean follow-up period was 28 months with range from 12-60 months. The duration of symptoms relevant to herniated disc like low backache and radicular pain with or without limb weakness were also noted from patient's history sheets. Many of these were on conservative approach of management with analgesics alone. Those cases first presented to us with acute involvement of bladder & bowel function. Some cases developed CES without prior symptoms of HLD. The longest duration of CES symptoms recorded was 15 days in two cases (Figure-1).

| | Duration (Range) |
|---|---|
| Mean duration from onset of symptoms of HLD to presentation (in days) | 152.3 (10-730) |
| Mean duration of onset of CES complaints to surgery (in hours) | 117.0 (36-360) |
| Mean duration from admission to surgery (in hours) | 33.5 (12-48) |
| Average duration of hospital stays (in days) | 6.5 (3-13) |

**Table 3.** Duration of symptoms & time to surgical decompression.

### Surgical complications

All patients underwent standard laminectomy & discectomy surgery to decompress the cauda equina

nerve roots, intraoperatively dural tear was encountered in two cases but they were recognized & managed intraoperatively without closure of dura required & they had no post-operative CSF leak. Post-operatively no major complications were reported before discharge except one patient having diabetes developed superficial wound infection on post-operative day-4 which was managed conservatively with antibiotics alone. No worsening of neurological status reported in the post-operative period & at discharge from hospital. All patients were shifted to elective ICU care at least for 24 hours post-operatively, no patient required ventilatory support or prolonged ICU stay. Injectable antibiotics were given routinely to all patients for a minimum of three days post-operatively, no steroid use documented for any patient.

**Clinical outcome at long-term follow up**

At a minimum follow-up period of one year, most of the patients had significant improvement in their pre-operative deficits (Table-4). Age at onset of CES, sex, comorbidities, smoking status & level of disc were not found to influence the outcome (not statistically significant).

The assessment of pain relief was subjective & patient reported & this was not quantified on pain scale. Our study shows that a significant number of patients (37.5%) still complain of radicular leg pain at follow up. Patients who had limb weakness show significant improvement when compared to pre-operative & discharge records, & only 4 patients (16.6%) had reported residual deficits.

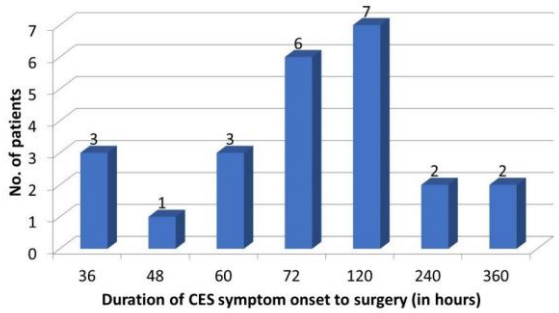


**Figure 1.** Duration from CES symptom onset to surgery of all patients.

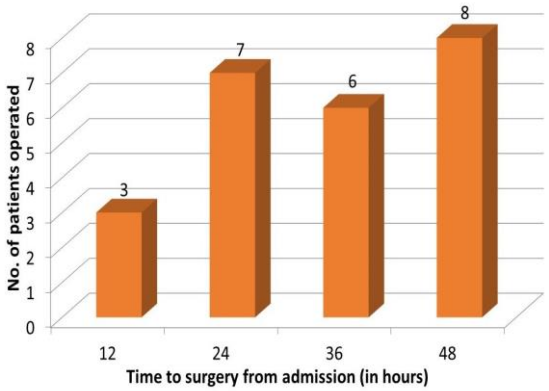


**Figure 2.** Time to surgery after admission of all patients.

| | Pre-operative | At discharge (average 6.5 days) | At long-term follow up | p-value** |
|---|---|---|---|---|
| **Radicular leg pain** | 21 (87.5%) | 15 (62.5%) | 9 (37.5%) | MNY 0.003 |
| **- Unilateral** | 16 (66.6%) | 11 (20.8%) | 6 (25.0%) | BE <0.001 |
| **- Bilateral** | 5 (20.8%) | 4 (8.3%) | 3 (12.5%) | |
| **Motor deficit*** | 13 (54.1%) | 12 (50.0%) | 4 (16.6%) | MNY 0.016 |
| **-U/l leg weakness** | 8 (33.3%) | 8 (33.3%) | 3 (12.5%) | BE <0.001 |
| **-B/l leg weakness** | 3 (12.5%) | 3 (12.5%) | 1 (4.1%) | |
| **-Foot drop** | 2 (8.3%) | 1 (4.1%) | 0 (0.0%) | |

* if no improvement in motor power by at least 2 MRC grades; **outcome at long-term; MNY – McNemar's test with Yates correction; BE – Binomial Exact test

**Table 4.** Long-term outcome of leg pain & motor deficits.

| | Pre-operative | At discharge (average 6.5 days) | At long-term follow up | p-value[#] |
|---|---|---|---|---|
| **Urgency/dysuria** | 3 (12.5%) | 3 (12.5%) | 2 (8.3%) | - |
| **Overflow incontinence** | 5 (20.8%) | 4 (16.6%) | 2 (8.3%) | - |
| **Retention** | 16 (66.6%) | 14 (58.3%) | 4 (16.6%) | - |
| **Total** | **24 (100%)** | **21 (87.5%)** | **8 (33.3%)** | MNY <0.001<br>BE <0.001 |

# outcome at long-term; MNY – McNemar's test with Yates correction; BE – Binomial Exact test

**Table 5.** Long-term outcome of bladder dysfunction.

### Long-term outcome of bladder dysfunction

At follow-up, 33.3% of patients complained of bladder involvement at follow-up & this improvement, when compared with either pre-operative or at discharge data using McNemar's test with Yates correction for continuity, was statistically significant (Table-5). Binomial exact test was used to check the validity of this calculation. Out of 16 patients with retention initially, 12 were free from catheter at long-term & only 16.6% were still dependent on it despite proper bladder training in post-operative period.

Two of the cases who had retention before surgery, however, reported complaints of dysuria or urgency at follow-up but were not catheter-dependent. Out of the four patients operated within 48 hours after CES symptom onset, three had retention & one had incontinence pre-operatively, out of which one patient still had retention at the follow-up visit. When compared with the group of rest of the 20 patients operated >48 hours after CES onset, no statistically significant difference was observed in outcome of bladder function between the two groups.

| | Pre-operative | At discharge (average 6.5 days) | At long-term follow up | p-value[##] |
|---|---|---|---|---|
| Saddle anaesthesia | 22 (91.6%) | 19 (79.1%) | 7 (29.1%) | MNY <0.001 |
| - Complete | 15 (62.5%) | 13 (54.1%) | 4 (16.6%) | BE <0.001 |
| - Partial | 7 (29.1%) | 6 (25.0%) | 3 (12.5%) | |
| Faecal incontinence | 11 (45.8%) | 11 (45.8%) | 4 (16.6%) | MNY 0.046<br>BE 0.004 |
| Perineal hypoaesthesia | 13 (54.1%) | 11 (45.8%) | 8 (33.3%) | MNY 0.131<br>BE 0.016 |
| Anal tone -decreased | 19 (79.2%) | 15 (62.5%) | 7 (29.1%) | MNY 0.005<br>BE <0.001 |
| Sexual dysfunction in males (ED), n=15 | 6 (40.0%) | 6 (40.0%) | 4 (26.6%) | MNY 0.479<br>BE 0.50 |

## outcome at long-term; MNY – McNemar's test with Yates correction; BE – Binomial Exact test

**Table 6.** Long-term outcome of bowel & sexual dysfunction.

### Bowel & sexual dysfunction

Bowel dysfunction was measured with four different parameters (Table-6). Two subjective parameters including saddle anaesthesia & faecal incontinence as reported by the patients. Saddle anesthesia present pre-operatively in 22 cases (91.6%) including 15 complete & 7 partial loss of sensation in saddle region. It improved at follow-up visit to seven (29.1%), four (16.6%) & three (12.5%) respectively. Faecal incontinence with partial or complete loss of control over defecation including either intermittent incontinence or soiling was reported by 11 patients

(45.8%) before surgery which improved significantly at follow-up & prevalent in only 4 cases (16.6%) at follow-up.

Objective parameters of bowel dysfunction included presence or absence of perineal hypoaesthesia & demonstration of anal tone. At presentation, hypoaesthesia was present in 13 patients & decreased anal tone i.e. lax anal sphincter in 19 patients, which improved at follow-up. The association of saddle anaesthesia & decreased anal tone with presence of urinary retention at presentation & follow-up was statistically significant (p-value < 0.05) & all 4 patients with retention at follow-up had saddle anaesthesia, perineal hypoaesthesia & decreased anal tone. Hence, presence of saddle anaesthesia with perineal hypoaesthesia and a lax anal tone was a predictor of urinary dysfunction.

Sexual dysfunction which was prevalent in 25% of the study cohort & reported by 6 male patients (40%) having erectile dysfunction at presentation was still present in 4 of them at follow-up. The lower initial incidence of this complaint as compared to other sphincteric disturbances may be due to response bias, as none of the females complained any form of sexual dysfunction, possibly reflecting some form of barrier on both patient's side as well as on doctor's side regarding the discussion of sexual health.

## Discussion

This study is one rare of its kind to prospectively assess the long-term outcome following surgery for CES secondary to herniated lumbar disc by directly obtaining patient history & performing clinical examination in the outpatient care clinic after a minimum of one year.

The primary aim of this study was to evaluate clinical outcome after a long period following surgery, specifically the outcome of sphincteric function. This long term follow-up is required for neurological recovery which tends to occur many years after decompression [5, 25]. Some previous studies by Korse et al. & Hazelwood et al. have evaluated outcomes at relatively longer duration [13, 20]. Together with highlighting the importance of a long term follow up, we also reviewed the literature to describe other features relevant to the context of cauda equina syndrome and their possible association with the outcome.

The sample size (n=24) in our study was relatively small but considering the rare occurrence of this syndrome [9, 15, 23], number of patients in this study were considerable. We achieved a response rate of 68.5% due to unwillingness of many patients (31.5%) to participate for the follow-up evaluation for various reasons, personal or social. This shows a significant number of patients were lost to follow-up & indicates towards an attrition bias, but it could well be because of dissatisfaction from the delivered care also & must have been a major factor affecting the overall outcome assessment.

The incidence of CES in patients undergoing surgery for lumbar disc herniation in this study was 5.9%, which is slightly higher than previous literature that quotes approximate incidence of 1-3% [8, 9, 14, 16, 19, 23, 25]. Recently Korse et al. quoted a higher incidence of 10.8% in their study on 75 patients [19].

The most common cause of CES is lumbar disc herniation [18, 34]. Others include tumors, spinal stenosis, hematomas, trauma, and iatrogenic causes [21]. The most common level of cauda equina nerve root compression is L4-5 or L5-S1 level [6, 8, 16] and our study population also reflects the same with almost 83.3% (20/24) of cases demonstrating disc at these two levels. We couldn't demonstrate a correlation between the level of disc and long-term outcome.

The exact definition of cauda equina syndrome is not available. It is described by various authors in different terms and there is no agreed definition [32]. There have been attempt to quantify the clinical aspects of Cauda equina syndrome by N. V. Todd based on bladder and bowel dysfunction but has not been validated for clinical practice [2, 35]. The five characteristic features of CES are bilateral neurogenic sciatica, reduced perineal sensation, altered bladder function ultimately to painless urinary retention, loss of anal tone and sexual dysfunction. Not all will be present in any individual patient [8, 32]. Results demonstrated that bladder dysfunction, radicular leg pain, saddle anaesthesia with decreased or loss of anal tone are the most prevalent complaints within this population, while leg weakness & bowel dysfunction being comparatively less common and sexual dysfunction reported least frequently. Bilateral sciatica also, was a less common feature (in 20.8%). Unilateral foot drop is also described as a feature of CES & two patients in this study had partial unilateral foot drop

along with sphincter dysfunction with evidence of disc herniation at L3-4 & L4-5 levels respectively. These two patients recovered at follow-up. Bilateral foot drop can also occur but is an extremely rare condition as described by Mahapatra et al. in a case of CES due to L3-4 prolapsed disc [24]. Low-backache being non-specific, was not assessed as an independent outcome measure, though many cases still had this complaint in post-operative and follow-up period.

There has also been an attempt to classify CES by 'The British Association of Spinal Surgery' into three subgroups as CESS (suspected CES with absence of sphincter dysfunction), CESI (CESS plus dysuria, urgency or altered urinary sensation) and CESR (painless retention with faecal or urinary overflow incontinence) [10, 14]. However, classification into two broad groups of incomplete (CESI) and complete (CESR) cauda equina syndrome seems more realistic for the true evaluation of the clinical outcome, as these two groups represent the definite involvement of sphincter function, specifically the bladder function. We followed the same criteria to describe CES clinically. All the 24 patients in our study cohort had some form of bladder dysfunction and 21 of them fall into CESR subgroup (16 with retention & 5 with overflow incontinence). Thereby, a comparison couldn't be made with the rest of the three patients falling into CESI subgroup due to such skewed distribution of variables.

The long-term outcomes related to bladder, bowel & sexual dysfunction in this study broadly agree with previous literature. However, similar to previous studies, the proportions of patients with residual symptoms differ in individual categories. Our study noted a lower rate of bladder dysfunction (33.3%) at long term follow up than previous studies, with Hazelwood et al. finding 76%, Korse et al finding 36.1% & McCarthy et al finding 43% of patients to have bladder dysfunction at long term follow-up [13, 20, 25]. The higher incidence of bladder dysfunction by Hazelwood et al. may be due to use of the objective USP score (Urinary symptoms profile score) which have a high sensitivity to a range of urological symptoms and patients would often report a symptom-free bladder, only to show dysfunction on the USP [5, 36]. This is likely due to the neural damage sustained in CES that would preferentially affect detrusor innervation and function over pelvic floor strength or urethral patency [10]. Olivero et al. have described an improvement of bladder function in more than 90% of their cases with a sample size of 31 patients [26]. Kaiser et al. noted good outcomes in 70% of their patients with CESR [16]. Similar to these, patients in the retention group also had good recovery patterns in our study with a prevalence of 66.6% reducing to 16.6% at follow-up. This improvement is significant considering the generally described poor outcome in previous studies [18, 20]. Konig et al. found no improvement in bladder dysfunction in any case of a grade-4 CES (based on Shi classification) regardless of the timing of surgery [18, 31]. We did not classify our patients into these grades as described by Shi et al. but the classification seems promising and further prospective studies on its application in prognostication of CES patients are recommended [31].

Two important aspects of bladder dysfunction not sufficiently mentioned in the previous literature are the pre & post-operative urodynamic study (UDS) and electromyography of bladder musculature. Uroflowmetry and post-void residual urine (PVR) are simple objective tests to establish the neurovesical involvement in CES [17]. These can be further confirmed with invasive multichannel UDS to exclude other possible causes responsible for persistent bladder dysfunction in the post-operative period. Yamanishi et al. in their study on urodynamic evaluation of surgical outcome of CES stated that most of the patients could empty their bladder only by straining or changing their voiding postures postoperatively [37]. This adaptation by the CES patients in post-operative period could well be a reason for the subjective improvement of bladder dysfunction in the present study and their catheter-free status at follow-up, despite the presence of a residual bladder dysfunction on objective assessment. Lee et al. have evaluated the role of electromyography as a tool for evaluating the integrity of sacral spinal segments 2 to 4 to predict the outcome of bladder dysfunction in CES & found that results of electrically induced bulbocavernosus reflex (E-BCR) examination seemed to give excellent positive and negative predictive values for the recovery of bladder function in patients with CES [22]. These two factors should be considered relevant predictors of bladder dysfunction and should be evaluated in the follow-up.

Bowel dysfunction is a complex domain of Cauda equina syndrome and includes two subjective and

two objective parameters as previously mentioned. We describe a high prevalence of 91.6% saddle anaesthesia and 45.8% faecal incontinence. This incontinence of varying degree was strongly related to the presence of two objective parameters of perineal sensory loss and decreased anal tone. All patients having some form of faecal incontinence also had both these findings present. Most of the previous studies report poor outcome of bowel disturbances with Korse et al. finding a prevalence of 43% at long term follow-up from 47% at initial follow-up and McCarthy et al. finding 60% bowel disturbance at follow-up & one-third of these having intermittent faecal incontinence or soiling [20, 25]. Our findings correlate with the previous studies but since there is no unified criteria of defining bowel dysfunction or disturbance in different studies [4, 13, 20] we could not compare individual parameters, however, the overall recovery is significant for all these 4 parameters. The role of rectal examination testing the anal tone is described in previous studies. Sphincter disturbance and saddle anaesthesia appear to be the most reliable predictors of outcome after surgery [7, 12, 21, 25]. There are few studies suggesting that early surgery increases the likelihood of an improvement in bowel dysfunction [8, 18, 25]. However, we could not verify this association.

Sexual dysfunction was reported less commonly and complained only by the male population with erectile dysfunction. There was no patient showing any functional recovery at the time of discharge but 33.3% (2 of 6) patients had reported improvement in erection at long term follow-up though it was not statistically significant (p value 0.479). None of the females reported any form of sexual dysfunction, however this doesn't rule out its prevalence in this population considering the under-reported complaints related to sexual dysfunction. McCarthy et al. reported 50% of patients had some degree of sexual dysfunction, and Korse et al. reported dysfunction prevalence of 56% at 2 months, marginally improving to 53% at 13 years [20, 25].

In our study, patients operated before 48 hours fared no better than those operated after 48 hours, specifically the sphincter function. However, since only four cases were operated before 48 hours, this conclusion didn't reach a statistical significance. But, considering the significantly good recovery in those operated after 48 hours, it can be concluded that a more important factor predicting the outcome is 'time factor' post-surgery, thus emphasizing the role of a long-term follow-up of these cases. Four cases presented more than 10 days after the onset of their CES symptoms (figure-1), but had no statistically significant difference between the outcome when compared with those operated early upon. What are the factors then, governing the neurological recovery in such patients remains unanswered.


**Figure 3.** Pre-operative T1-weighted sagittal MRI image of a 36 years old male patient showing a large herniated disc at L5-S1 level (yellow-coloured arrow mark).

Recently, Bydon et al. in their study on 45 patients of CES have stated that determinants of outcome in CES are elusive, similar to the state of the literature on surgical management of acute spinal cord injury, in which the timing of surgery has not been conclusively correlated with outcome [4]. Studies in the porcine model have shown that cauda equina compression can cause injury after as little as 2 hours [4, 27, 29]. They have further postulated that time-dependent cellular and physiologic effects of cauda equina impingement are irreversible well before patients reach surgery, leaving outcome dependent on other factors. This together with the delayed presentation of patients to seek medical help, unavailability of adequate medical facilities in the developing countries and delayed diagnosis by primary care physician leads to a significant delay in time to surgery. Heyes et al. in their recent series of 136 patients, demonstrated that regardless of type of CES and independent of timing of surgical intervention, most patients see a significant improvement in bowel and bladder function following surgical decompression [14]. The majority

of patients in their series also presented with symptom duration of greater than 48 hours. We consider this related to the long time required for natural recovery of damaged nerve fibers after decompression. Nerve injury is not necessarily a direct result of injury to the nerve at the level of the Cauda equina but more a mechanical injury to the bladder wall musculature. Schoenfeld AJ & Bono CM stated in their systematic review of timing on post-operative recovery in Lumbar discectomy, functional outcome was only adversely affected if decompression was carried out 6 months post onset of symptoms [30]. Considering all these facts, outcome in our study were fairly good irrespective of duration of CES symptoms & time to surgery.

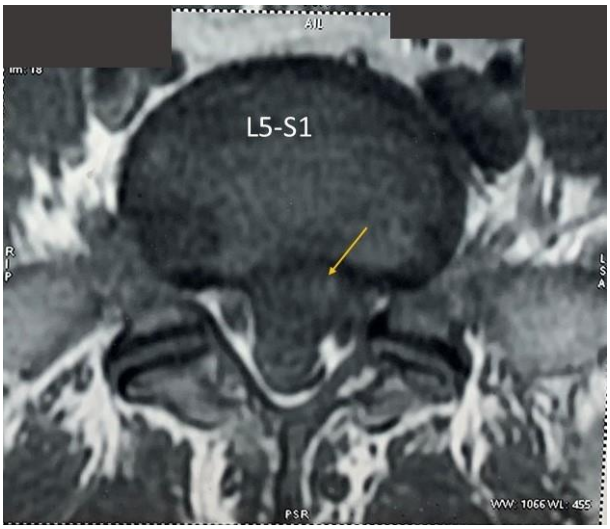


**Figure 4.** Pre-operative axial MRI image of the same patient as in figure-3, showing large postero-central disc herniation at L5-S1 level causing compression over ventral thecal sac (yellow-coloured arrow mark).

We also reviewed the pre & post-operative MRI scans wherever available to evaluate the possible role of MRI findings in clinical outcome (figure-3 to 6). Three of the cases not included in our study cohort but were first operated during the study period, had evidence of significant residual or recurrent disc herniation on post-operative MRI, were re-operated for their persistent sphincteric dysfunction. This role, of ineffective decompression or recurrence of disc herniation, has not been considered in most of the previous studies. Residual disc or recurrent disc herniation can be a cause of long term sphincteric dysfunction in these population of patients and should not be overlooked. Another factor which can influence the outcome is disc herniation size and degree of compression of cauda equina nerve roots. A previous study by Kaiser et al. however, found no significant correlation between the size of disc herniation relative to size of spinal canal and post-operative urinary function in patients with CES [16]. Further research is recommended to evaluate this probable association.

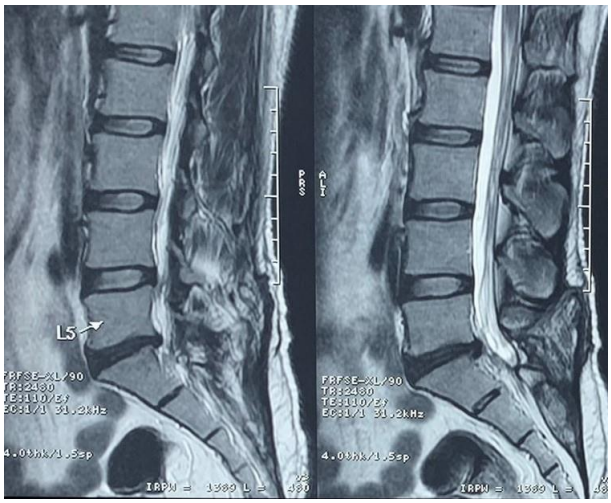


**Figure 5.** Post-operative sagittal MRI image of same patient as in Figure-3.

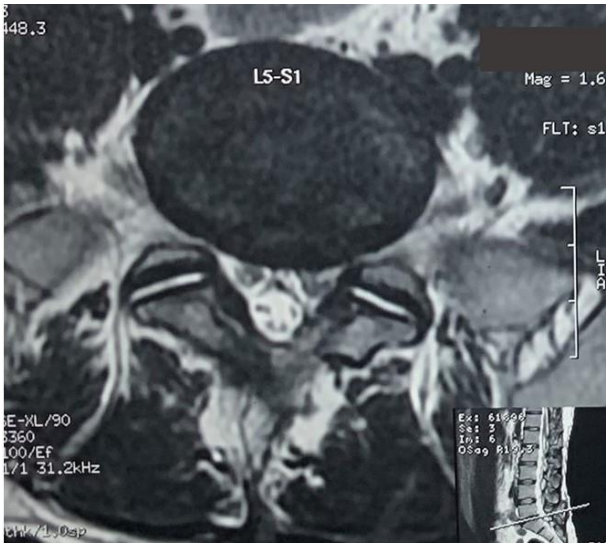


**Figure 6.** Post-operative axial MRI image of same patient as in Figure-4.

We also reviewed the literature for comparison of different surgical techniques and found that most of the previous studies recommend a wider decompression [11]. There is no significant difference with either bilateral laminectomy or

hemilaminectomy or interlaminar fenestration with discectomy, with fusion or without fusion. Dave et al. found patients operated with trans-foraminal lumbar interbody fusion (TLIF) have decreased incidence of surgical complications but similar neurological outcome compared with non-fusion group [6]. All the patients included in current study underwent standard unilateral or bilateral laminectomy with discectomy and without fusion.

Overall, the outcome predictors of CES surgery are difficult to prognosticate. Timing of surgery is the most extensively studied parameter in CES patients but till now no consensus exists for the optimum time window of surgery. However, we still recommend urgent surgical decompression once the patient presents with CES symptoms. We also recommend a strict follow-up schedule for all operated patients of CES till recovery of sphincteric dysfunction achieved so as to further evaluate the other causes responsible for delayed long-term outcomes.

## Limitations

All pre-operative data were obtained retrospectively from the history files of the patients from hospital's medical record section. This implicates an observer's bias & limitation of the data quality. Most of the recorded parameters were patient reported & subject to individual variation.

## Conclusion

This study assesses most of the issues relevant to CES & demonstrated that regardless of timing of surgical intervention, most of the patients see a significant improvement in pain, limb weakness, bowel and bladder function following surgical decompression & this requires a long-term follow-up. Recovery is not complete in all patients but urinary & bowel dysfunction improve significantly. Sexual dysfunction, however, have poor recovery. This long-term outcome after surgery has highlighted the importance of a strict schedule of follow-up of all CES patients. Timing of surgery was not shown to influence the clinical outcome in this study. This doesn't mean surgery should be deferred, but better outcomes are not guaranteed even after earlier surgical decompression. Since it is not always practical for most of the patients of CES to operate within the first 48 hours after symptom onset, especially in the developing countries, we should focus further research on other relevant outcome parameters to prognosticate this rare neurosurgical disease entity.

## References


1. Ahn UM, Ahn NU, Buchowski JM, Garrett ES, Sieber AN, Kostuik JP. Cauda Equina Syndrome Secondary to Lumbar Disc Herniation: A Meta-Analysis of Surgical Outcomes. SPINE 2000;25:1515-22.
2. Angus M, Berg A, Carrasco R, Horner D, Leach J, Siddique I. The Cauda Scale - Validation for Clinical Practice. Br J Neurosurg 2020;34:453-6.
3. Arrigo RT, Kalanithi P, Boakye M. Is cauda equina syndrome being treated within the recommended time frame. Neurosurgery 2011;68:1520-6.
4. Bydon M, Lin JA, Garza-Ramos RDL, Macki M, Kosztowski T, Sciubba DM, et al. Time to Surgery and Outcomes in Cauda Equina Syndrome: An Analysis of 45 Cases. World Neurosurg 2016;87:110-5.
5. Chang HS, Nakagawa H, Mizuno J. Lumbar herniated disc presenting with cauda equina syndrome long term follow-up of four cases. Surg Neurol 2000;53:100–5.
6. Dave BR, Samal P, Sangvi R, Degulmadi D, Patel D, Krishnan A. Does the Surgical Timing and Decompression Alone or Fusion Surgery in Lumbar Stenosis Influence Outcome in Cauda Equina Syndrome? Asian Spine J 2019;13:198-209.
7. Domen PM, Hofman PA, Santbrink HV, Weber WEJ. Predictive value of clinical characteristics in patients with suspected cauda equina syndrome. Eur J Neurol 2009;16:416-9.
8. Fraser S, Roberts L, Murphy E. Cauda equina syndrome: a literature review of its definition and clinical presentation. Arch Phys Med Rehabil 2009;90:1964-8.
9. Gardner A, Gardner E, Morley T. Cauda equina syndrome: a review of the current clinical and medico-legal position. Eur Spine J 2011;20:690-7.
10. Germon T, Ahuja S, Casey ATH, Todd NV, Rai A. British Association of Spine Surgeons standards of care for Cauda equina syndrome. Spine J 2015;15:2-4.
11. Gitelman A, Hishmeh S, Morelli BN, Joseph Jr SA, Casden A, Kuflik P, et al. Cauda equina syndrome: a comprehensive review. Am J Orthop (Belle Mead NJ) 2008;37:556-62.
12. Gooding BWT, Higgins MA, Calthorpe DAD. Does rectal examination have any value in the clinical diagnosis of cauda equina syndrome? Br J Neurosurg 2013;27:156-9.
13. 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;161:1887-94.
14. Heyes G, Jones M, Verzin E, McLorinan G, Darwish N, Eames N. Influence of timing of surgery on Cauda equina syndrome: Outcomes at a national spinal centre. J Orthop 2018;15:210-5.

15. 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;32:832–41.
16. Kaiser R, Nasto LA, Venkatesan M, Waldauf P, Perez B, Stokes OM, 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;83:1193-200.
17. 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;29:1236-47.
18. Konig A, Amelung L, Danne M, Meier U, Lemcke J. Do we know the outcome predictors for cauda equine syndrome (CES)? A retrospective, single-center analysis of 60 patients with CES with a suggestion for a new score to measure severity of symptoms. Eur Spine J 2017;26:2565-72.
19. Korse NS, Pijpers JA, Zwet EV, Elzevier HW, Vleggeert-Lankamp CLA. Cauda Equina Syndrome: presentation, outcome, and predictors with focus on micturition, defecation, and sexual dysfunction. Eur Spine J 2017;26:894-904.
20. Korse NS, Veldman AB, Peul WC, Vleggeert-Lankamp CLA. The long term outcome of micturition, defecation and sexual function after spinal surgery for cauda equina syndrome. PLoS ONE 2017;12.
21. Lavy C, James A, Wilson-MacDonald J, Fairbank J. Cauda equina syndrome. BMJ 2009;338:b936.
22. Lee DG, Kwak SG, Chang MC. Prediction of the outcome of bladder dysfunction based on electrically induced reflex findings in patients with cauda equina syndrome. Medicine (Baltimore) 2017;96:e7014.
23. Long B, Koyfman A, Gottlieb M. Evaluation and management of cauda equina syndrome in the emergency department. Am J Emerg Med 2020;38:143-8.
24. Mahapatra AK, Gupta PK, Pawar SJ, Sharma RR. Sudden bilateral foot drop: an unusual presentation of lumbar disc prolapse. Neurol India 2003;51:71-2.
25. McCarthy MJH, Aylott CEW, Grevitt MP, Hegarty J. Cauda Equina Syndrome: Factors Affecting Long-term Functional and Sphincteric Outcome. SPINE 2007;32:207-16.
26. Olivero WC, Wang H, Hanigan WC, Henderson JP, Tracy PT, Elwood PW, et al. Cauda Equina Syndrome (CES) From Lumbar Disc Herniations. J Spinal Disord Tech 2009;22:202-6.
27. Pedowitz RA, Garfin SA, Massie JB, Hargens AR, Swenson MR, Myers RR, et al. Effects of magnitude and duration of compression on spinal nerve root conduction. Spine 1992;17:194-9.
28. Qureshi A, Sell P. Cauda equina syndrome treated by surgical decompression: the influence of timing on surgical outcome. Eur Spine J 2007;16:2143-51.
29. Rydevik BL, Pedowitz RA, Hargens AR, Swenson MR, Myers RR, Garfin SR. Effects of acute, graded compression on spinal nerve root function and structure. Spine. 1991;16:487-93.
30. Schoenfeld AJ, Bono CM. Does surgical timing influence functional recovery after lumbar discectomy? A systematic review. Clin Orthop Relat Res 2015;473:1963-70.
31. Shi J, Jia L, Yuan W, Shi G, Ma B, Wang B, et al. Clinical classification of cauda equina syndrome for proper treatment. Acta Orthop 2010;81:391-5.
32. Todd NV, Dickson RA. Standards of care in cauda equina syndrome. Br J Neurosurg 2016;30:518-22.
33. Todd NV. Guidelines for cauda equina syndrome: Red flags and white flags, Systematic review and implications for triage. Br J Neurosurg 2017;31:336-9.
34. Todd NV. Letter to the editor concerning "Cauda Equina Syndrome treated by surgical decompression: the influence of timing on surgical outcome" by Qureshi A, Sell P (2007). Eur Spine J 2009;18:1391-3.
35. Todd NV. Quantifying the clinical aspects of the cauda equina syndrome - The Cauda Scale (TCS). Br J Neurosurg 2018;32:260-3.
36. Wakrim B, Kaboré FA, Sebbani M, Sarf I, Amine M, Lakhmichi A, et al. Sensitivity to change of the USP score (Urinary Symptoms Profile) after surgical treatment of benign prostatic hyperplasia (BPH). Prog Urol 2014;24:229–33.
37. Yamanishi T, Yasuda K, Yuki T, Sakakibara R, Uchiyama T, Kamai T, et al. Urodynamic evaluation of surgical outcome in patients with urinary retention due to central lumbar disc prolapse. Neurourol Urodyn 2003;22:670-5.