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Influence of timing of surgery on Cauda equina syndrome: Outcomes at a national spinal centre

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ABSTRACT

Purpose: There is no doubt that the best outcome achieved in Cauda equina syndrome (CES) involves surgical decompression. The controversy regarding outcome lies with timing of surgery. This study reports outcomes on a large population based series. Timing of surgery, Cauda Equina syndrome classification based on British Association of Spine Surgeons (BASS) guidelines and co-morbid illness will be assessed to evaluate influence on outcome.

Materials and methods: A retrospective review of all patients surgically decompressed for CES between 01/01/2008 to 01/08/2014 was conducted. Patients with ongoing symptoms were followed up for a minimum of 2 years. Cauda Equina Syndrome (CES) was classified according to the BASS criteria: CES suspicious (CESS), incomplete (CESI) and painless urinary retention (CESR). Time and symptom resolution were assessed.

Results: A total of 136 patients were treated for CES; 69 CESR, 22 CESI and 45 CESS. There was no statistical difference in age, sex, smoking status and alcohol status with regards to timing of surgery. No correlation between increasing co-morbidity score and poor outcome was demonstrated in any subgroup

All CESR/I patients demonstrated some improvement in bowel and bladder dysfunction post-operatively. No significant difference in improved autonomic dysfunction was demonstrated in relation to timing of surgery. CES subclassification may predict outcome of non-autonomic symptoms. Statistically better outcomes were found in CESS groups with regards to post-operative lower back pain (P 0.049) and saddle paraesthesia (P 0.02).

Conclusion: Surgical Decompression for CES is an effective treatment that significantly improves patient symptoms including bowel and bladder dysfunction Early surgical decompression < 24 h from symptom onset does not appear to significantly improve resolution of bowel or bladder dysfunction.

1. Introduction

Luschka first described lumbar disc protrusion in 1858.[1] It was another 50 years before the first discectomy took place and another 30 years until Mixter and Barr described the syndrome of Cauda Equina compression (CES).[2,3] It is fortunately a rare condition with a reported incidence of approximately 1 per 100 000/year affecting 2–3% of lumbar disc operations.[4,11]

The pathogenesis and natural history of CES is not clearly defined. One hypothesis is that large central or paracentral disc prolapses cause extrinsic compression of the lumbosacral nerve roots below the level of the Conus Medullaris. It is not clear what quantifies significant canal compression leading to CES. CES has been reported with less than 25% canal compromise.[5] Another hypothesis is that CES is chemical mediated with inflamed and oedematous neural structures being found on pathological samples.[6–9]

CES can present with a myriad of symptoms. These include back pain, lower extremity and perineal sensory deficit, leg pain, leg weakness and disturbance of bladder and bowel function.[10,11] Subsequently the clinical diagnosis of CES lacks sensitivity and specificity with no single symptom or sign adequately predicting management or outcome.[12–15]

Regardless of exact aetiology and presentation once identified, the current recommendation in the literature is to treat CES emergently.[5,9,16–20] This is despite there being no clear consensus on the timing of intervention.[4,21–23]

This study represents a population based analysis of all cases of CES in Northern Ireland over a six year period. We present one of the largest series of data in the literature. We aim to describe the typical presentation of CES, predictors of outcome and influence of timing of surgery on bowel and bladder symptoms.

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2. Methods

All patients presenting with suspected or confirmed CES in Northern Ireland are managed at a single spinal unit. According to census data during the study period Northern Ireland's annual population was estimated to be in the region of 1,852,000.[24]

During the study period, four neurosurgeons and eight orthopaedic spinal surgeons provided emergency spinal treatment. All cases of CES underwent surgical decompression as soon as technically feasible after presentation.

The local audit and research department approved this study. A prospective Outcomes Research Database was used to retrospectively search for all emergency referrals to the service with lower back and/or neurological sequelae between the period 01/01/2008 to 01/08/2014. The Northern Ireland Online Electronic Care Records (ECR) and outpatient review system was used for assessment of outcome and follow up.

Data collected included patient gender, past medical history, presenting symptoms, duration of symptoms prior to surgery, timing of surgery and outcomes following surgery. Onset of symptoms was identified from available data sources as accurately as possible, recognizing the limitations of retrospective analysis. For the purpose of this study we defined the onset of symptoms as the time patient first reposts new symptoms or worsening of chronic symptoms that leads them to seek medical attention. The ECR system allowed us to review all documentation of patient's first point of contact for medical attention. This was either at Accident and Emergency or General Practitioner review. All data was collected by one of the authors GH an Orthopaedic Registrar.

Past medical history was evaluated using a Charlson Co-morbidity Index (CCMI). The CCMI is a validated scoring system for predicting excess morbidity and mortality.[30] Scores were stratified in to mild (1–2), moderate (3–4) and high risk (5 +). All patients had compression of Cauda Equina (CE) confirmed by MRI (134 patients) or CT Myelogram (2 patients).

Symptom assessment was classified into the following variables:
Non-Autonomic dysfunction

- Lower Back Pain
- Unilateral Leg Pain
- Bilateral Leg Pain
- Leg Weakness
- Leg weakness was recorded using MRC grading and the use of ankle-foot orthoses.
- Leg Paraesthesia
- Saddle Paraesthesia
- Paraesthesia symptoms include reports of numbness, itch, "pins and needles."

Autonomic dysfunction
Urinary Dysfunction

- Incomplete urinary symptoms (dysuria, frequency, urgency & altered urinary sensation in the absence of infection)
- Complete Urinary symptoms (Painless urinary retention/neurogenic bladder)

Faecal Dysfunction

- Faecal incontinence and no anal tone

The British Association of Spinal Surgery's classification of CES was used in this study.[25]

CESS (suspected CES with absence of sphincter dysfunction)
CESI (CESS plus dysuria, urgency or altered urinary sensation)
CESR (painless retention with faecal or urinary overflow incontinence)

All patients with ongoing symptoms were followed up for at least 24 months. All online patient information systems were interrogated for at least 24 months following surgery to ensure no patient presented elsewhere in the National Healthcare System with problems related to their previous CES.

The primary outcome of this study was to evaluate the influence of BASS CES classification and timing of surgery on clinical outcomes after surgical decompression. Secondary outcomes were to look at any other patient variables that may predict surgical outcome.

Statistical analysis was performed using SPSS software Version 21.0. Statistical significance was evaluated using Chi squared and Fisher's Exact test, when data values were under 5. In order to evaluate more than two variables contingency tables were constructed and serial Chi Squared or Fisher's Exact tests performed. Significance level was set at 0.05. Statistical analysis was performed by an independent medical statistician

3. Results

During the study period a total of 136 patients were confirmed CES and referred for surgical treatment. In every case surgical treatment involved a lumbar discectomy and laminectomy. 69 patients presented with CESR, 22 with CESI and 45 with CESS. No patients were lost to follow up. Based on a mean annual incidence of 30 and population of 1,852,000 this represents an incidence of 1.6 cases per 100,000 each year.

Patients were discharged a minimum of three months following surgery only if symptoms had completely settled. Otherwise patients were followed up a minimum of 24 months. It was noted that post-operative symptoms remained static at 6 months.

There was no statistical difference in secondary outcome measures such as age, sex, smoking status and alcohol status with regards to timing of surgery (All Fisher's Exact test P values were > 0.05). There was no statistically significant correlation between increasing CCMI score and poor outcome in any subgroup. (All Fisher's Exact test Pvalues were > 0.05). Table 1 describes the study population.

Table 2 demonstrates the time to surgery from onset of symptoms and the incidence in each CES classification. The majority of patients underwent surgery after 24 h due to delay in their presentation. All patients operated on within 48 h of symptoms underwent surgery within 24 h of diagnosis. All patients underwent surgical decompression within 48 h of diagnosis regardless of delay in presentation/duration of symptoms.

The incidence of out of hours operating was low, with 3 out of 9 (33%) patients presenting within 24 h of symptom onset having surgery

Table 1
Study population.

	Overall (n = 136)	CESR (n = 69)	CESI (n = 22)	CESS (n = 45)
Age; mean (range)	40.0 (24.7,81.5)	39.9 (26.6,81.5)	38.7 (28.0,59.0)	41.8 (24.7,79.2)
Male	63 (46%)	34 (49%)	8 (36%)	21 (47%)
Smoker status:				
Non Smoker	114 (84%)	56 (81%)	19 (86%)	39 (87%)
Ex- Smoker	4 (3%)	2 (3%)	2 (9%)	0 (0%)
Current Smoker	18 (13%)	11 (16%)	1 (4%)	6 (13%)
Alcohol status:				
Non drinker	29 (21%)	17 (25%)	3 (14%)	9 (20%)
Occasional drinker	66 (48%)	36 (52%)	8 (36%)	22 (49%)
Social drinker	39 (29%)	15 (22%)	11 (50%)	13 (29%)
Alcoholic	2 (2%)	1 (1%)	0 (0%)	1 (2%)
Charlson comorbidity; mode (range)	1 (0,8)	1 (0,8)	1 (0,3)	1 (0,8)

Table 2
Timing to surgery and incidence of CES classification.

	Overall (n = 136)	CESR (n = 69)	CESI (n = 22)	CESS (n = 45)
< 24 h	9 (7%)	7 (10%)	1 (5%)	1 (2%)
24–48 h	27 (20%)	15 (22%)	4 (18%)	8 (18%)
> 48 h	100 (73%)	47 (68%)	17 (77%)	36 (80%)

out of hours compared to 18 out of 127 (14%) patients undergoing out of hours operations over 24 h from onset of symptoms. Chi squared analysis demonstrated no significant difference in out of hours surgery operating within 24 h and after 24 h. (p 0.14).

A total of 11 patients suffered complications as a result of surgery. This included 6 dural tears, 2 patients undergoing re-operation for retained disc fragments and 3 superficial wound infections treated with oral antibiotics.

There was a heterogenous group of presenting symptoms in this study population. Table 3 lists non-autonomic symptoms and their respective prevalence within CES pre- and post-operative subgroups. Post-operative data represents residual symptoms following surgical intervention on final outpatient review. Percentages listed represent frequency of symptoms as they occurred in each CES group.

There was an improvement in all recorded symptoms post operatively. In order of decreasing frequency the most common symptoms were lower back pain, unilateral leg pain, saddle paraesthesia, bilateral leg pain, leg weakness and leg paraesthesia. Symptoms most likely to resolve following surgical intervention were back pain and saddle paraesthesia. Those classified as CESS had a statistically significantly better chance of resolution of lower back pain (Fisher's Exact test P 0.049) and saddle paraesthesia (Fisher's Exact test P 0.02).

There was no statistical difference in leg weakness resolution when comparing the CES subgroups (Fisher's Exact test P 0.64). Numbers were too small to compare foot weakness outcomes within each CES subgroup. In total 4 patients required the use of ankle-foot orthoses as the result of longstanding foot drop. No significant difference in strength was noted past 6 months post operatively. When comparing non-autonomic symptoms with in CES subgroups and timing of surgery no statistical difference was found.

Table 4 reports the rate of incomplete and complete urinary symptoms and faecal incontinence. Note that one patient had incomplete urinary symptoms but was classified as CESR. This was due that patient having faecal incontinence. This highlights the complexities of the classification system. Patients were not moved to different CES subgroups post operatively. This was to assist in reviewing recovery or indeed deterioration following surgery.

There was an overall improvement in bowel and bladder function post operatively for the majority of affected patients. 70% of CESR patients had resolution of painless retention and 59% of CESI patients had full resolution of urinary symptoms postoperatively. CESR patients with either painless retention and/or faecal incontinence showed no overall difference in outcome with both symptoms present versus painless urinary retention alone (Fisher's Exact test p 0.67).

Three patients in the CESR had partial resolution of their urinary symptoms and 13 required long term urinary catheterisation. One patient in the CESI subgroup went on to develop painless urinary retention despite surgical intervention. This patient did not have an iatrogenic complication.

When CESR & CESI groups were combined there was a significant association between timing of operation and residual painless urinary retention. A higher proportion of those operated on within 24 h had residual symptoms compared to those who were operated on later. In contrast timing of surgery did not influence faecal incontinence and incomplete urinary dysfunction.

Table 5 demonstrates the outcomes of timing of surgery on symptoms in the CESR group. A statistically significant difference in the rate of residual urinary symptoms was demonstrated when operated on within 24 hours (highlighted in bold). A higher proportion of those operated earlier had problems compared to those who were operated later. Also of note we found a correlation towards increased out of hours surgical complications although this was not statistically significant (P < 0.12).

4. Discussion

Cauda Equina syndrome is fortunately a rare condition comprising between 2 and 3% of lumbar disc operations.[4] We found an annual incidence of 1.6: 100000 which is in keeping with previous studies of around 1:100 000.[31–33,35] Our experience is that of increasing referrals and investigation for suspected CES without a significant increase in true CES incidence.

The primary aim of this study was to review the associated symptoms of CES and identify predictors of outcome during inpatient treatment for the condition. This study was a retrospective analysis. Although data collection has been undertaken in a systematic manner utilising a prospective outcome database it is dependent on the quality of the admitting doctors documentation. Fortunately we have a robust computerised patient notes system, there was no missing data, however at the time of the study there was no routine use of objective outcome measures of bladder function. Post-void scanning or bladder function tests were not performed routinely in all patients at our unit. Therefore for this study subjective reports of bladder symptoms from patients were used. Identification of patients with resolution of bowel and bladder dysfunction was obtained from history taken at clinic. All patients with static residual bladder dysfunction were referred onward to Urology services for further management.

Our study found that timing does not significantly affect the outcome of those with faecal incontinence and/or incomplete urinary

Table 3
Symptom Prevalence in each CES subgroup.

	Overall (%)[a]		CESR (%)[b]		CESI (%)[c]		CESS (%)[d]	
	Pre-operative	Post-operative	Pre-operative	Post-operative	Pre-operative	Post-operative	Pre-operative	Post-operative
Lower back pain	117 (86%)	34 (25%)	56 (81%)	22 (32%)	19 (86%)	5 (23%)	42 (93%)	7 (16%)
Unilateral leg pain	74 (54%)	19 (14%)	43 (62%)	10 (14%)	12 (54%)	3 (14%)	19 (42%)	6 (13%)
Saddle paraesthesia	56 (41%)	14 (10%)	23 (33%)	10 (14%)	9 (41%)	3 (14%)	24 (53%)	1 (2%)
Bilateral leg pain	42 (31%)	2 (2%)	16 (23%)	0 (0%)	5 (23%)	0 (0%)	21 (47%)	2 (4%)
Leg weakness	35 (26%)	13 (10%)	14 (20%)	3 (4%)	7 (32%)	3 (14%)	14 (31%)	7 (16%)
Foot Drop	9 (7%)	4 (3%)	2 (3%)	1 (1%)	2 (9%)	0	5 (11%)	3 (7%)
Leg paraesthesia	33 (24%)	20 (5%)	16 (23%)	11 (16%)	8 (36%)	3 (14%)	9 (20%)	6 (13%)

[a] % of n = 136.
[b] % of n = 69.
[c] % of n = 22.
[d] % of n = 45.

Table 4
Incomplete and Complete Bladder and Bowel Symptoms.

	Overall (%)[a]		CESR (%)[b]		CESI (%)[c]	
	Pre-operative	Post-operative	Pre-operative	Post-operative	Pre-operative	Post-operative
Incomplete urinary	23 (17%)[a]	13 (10%)	1 (1%)[b]	4 (6%)	22 (100%)[c]	9 (41%)
Painless urinary retention	68 (50%)	14 (10%)	68 (99%)	13 (19%)	0 (0%)	1 (4%)
Faecal incontinence	20 (15%)	3 (2%)	20 (30%)	3 (4%)	0 (0%)	0 (0%)

[a] % of n = 136.
[b] % of n = 69.
[c] % of n = 22.

Table 5
Influence of timing to surgery on Urinary and Faecal Symptoms in CESR group only.

CESR n = 69	Painless urinary retention		Faecal Incontinence		Incomplete urinary symptoms	
	Pre-operative	Post-operative	Pre-operative	Post-operative	Pre-operative	Post-operative
< 24 h	7 (100%)[1]	4 (57%)	1 (14%)[1]	1 (14%)	0 (0%)[1]	0 (0%)
24–48 h	15 (100%)	3 (20%)	4 (27%)	1 (7%)	0 (0%)	1 (7%)
> 48 h	46 (98%)	6 (13%)	15 (32%)	1 (2%)	1 (2%)	3 (6%)
Fisher's Exact test P value	**0.02**		0.30		0.79	

symptoms. We found that there was no further improvement in post-operative residual bladder and bowel symptoms at 6 months despite following these patients up for at least 2 years. We do note however that one study reported continued improvements for up to 3–4 years.[34]

The low numbers of patients operated on within 24 h is worth consideration when compared to other papers.[9,16,18,34,36] A possible explanation is our paper focuses on identifying a time of onset of new or worsening symptoms, rather than using the time of presentation to emergency care.

Most patients presented with back pain (86%) and/or leg pain (85%) with associated disturbance of their bowel or bladder (67%) and/or saddle paraesthesia (41%). In keeping with prior analyses there is no symptom complex that is reliably predictive, sensitive or specific for CES.[13]

There was a significant number of those in the CESR that had significant improvement of symptoms or even resolution of symptoms after surgery and this appeared independent of timing. This is reported elsewhere and it is worth taking into account that CESR does not uniformly lead to poor outcome.[4] Surgery should be performed in optimal conditions and not just as soon as possible, regardless of time of the day.

Defining diagnostic parameters for CES remains a challenge. There are various interpretations of CES in the literature. CES has been described in terms of speed of onset of symptoms[26] or classified according to the clinical picture at time of presentation.[4] It is widely accepted that the critical feature in CES is compression of the Cauda equina with resultant autonomic dysfunction.[27,28]

The type of CES and varied time of onset are two possible confounders present in the literature. Identification of true onset of symptoms remains poorly recorded in the literature and we wonder whether some studies may have recorded time of presentation as onset of symptoms. This was alluded to in Delong et al's meta-analysis.[9] Other confounders include: patient demographics, hospital demographics, definitions of timing of surgical intervention, varied clinical assessments, type of surgical decompression, pathology of CES and the length of follow up and outcome assessment.[22]

The heterogeneity of the syndrome, its assessment, diagnosis, reported management, outcome measures and differences in statistical analysis have made comparison of the literature challenging. Criticisms of early studies into surgical management of CES include unclear definition of the syndrome and a failure to differentiate the degree of bowel and bladder dysfunction in statistical analyses.[9,16,18]

Given the evidence available to determine best practice is insufficient we believe consensus opinion of spinal surgeons represents a valid reference point. For this reason we chose to utilise the British Association of Spinal Surgeon's standard of care document.[25] It is the most up to date consensus statement in publication specifically discussing the syndrome complex, it builds on previous classifications and offers a benchmark on which to focus further research.

This study also assesses the effect of timing of surgery on post-operative outcome. Our series demonstrates 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. The majority of patients in our series presented with symptom duration of greater than 48 h. Following presentation to the spinal service all patients in our case series were operated on within 48 h. We hypothesise a number of reasons that patients may not be operated on within 24 h of onset of symptoms. These include delay in presentation, theatre access, fasting status, availability of diagnostic imaging and diagnostic delay. For those patients suffering incomplete urinary dysfunction or bowel incontinence there was no effect of timing of surgery on outcome.

Following on from numerous case series and *meta*-analyses the CES literature has divided the timing of surgical intervention into 3 categories spanning 48 h.[4,5,9,16,18,22,27–29] The debate as to the most appropriate timing of surgical intervention has created a categorical view of CES. The value of achieving decompression within 12 vs. 24 vs. 48 h confuses the discussion as such distinctions are heuristic in nature and may lead to poor decision-making. We also believe that the recommendation for surgery within 24 h is not always clinically practical. Our experience was that with careful scrutiny of patient presentation the majority present and receive treatment after 24 h from symptom onset.

It may be more appropriate to consider CES as the progression of a continuous process with the end result possible dysfunction of bowel and bladder function.[22] In addition prolonged compression can be associated with further neurologic loss even after CESR.[16,22,25]

Focus should instead centre on identifying other predictors of poor outcome and prolonged duration of recovery. Rydevik's 1984 porcine model may be worth considering, highlighting that whilst increased duration of compression may only increase recovery time rather than final morbidity it is the pressure of compression that may be more critical.[7] Delamater's canine model of cord constriction may further support this demonstrating that bladder function at 6 weeks post decompression recovers irrespective of the degree of cord constriction.[36]

Notwithstanding this once a patient has developed a neurogenic bladder the resulting atonic bladder that results following over-distention and the associated muscular injury to the bladder wall can be catastrophic. This injury however 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. A further consideration is the evidence of effect of timing of discectomy in routine radiculopathies. In Bonos' 2014 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.[37]

Whilst CES classifications allow analysis of group data it is more likely that CES behaves like many biologic systems and deteriorates in a linear not stepwise fashion. Therefore difficulty may lie in identifying limits for subclassification. For example using the CESS subgroup may help pick up earlier CES however it may also pick up lumbar disc prolapses that don't progress to CESI/R. The use of the BASS classification, particularly in retrospective studies, relies upon thorough assessment and documentation of symptoms for accurate classification. All classification systems have limitations, potentially more so in CES, however we believe the BASS classification is a safe system with prognostic benefit.

Despite this our data demonstrates that those patients presenting in the CESS subgroup were likely to have a statistically significantly higher improvement rate in non-autonomic symptoms, namely bilateral leg pain and saddle paraesthesia ($P < 0.05$). This supports the use of the BASS classification as a predictor of outcome.

To further clinical outcomes the focus of future studies should not be solely confined to evaluating timing but also in evaluating classification systems and preoperative symptom complexes. It is there that we believe more sensitive discriminators of outcome could be identified.

This study represents one of the largest reported case series in the literature to date. The population of Northern Ireland is clearly defined and due to its geographic location there is a very high follow-up of all patients cared for by the regional spinal service. Given the large series and complete follow up of patients the findings can be considered robust.

5. Conclusion

CES is a topical issue, it can have a devastating effect on quality of life, place a significant burden on medical services and have considerable medico-legal implications arising from the perceived ramification of delays. As this is one of the largest studies to date and the first to utilise BASS classification we believe it offers a useful contribution to current literature.

This study found no clear evidence that timing of surgery negatively influenced outcome following surgical decompression for CES. CES subclassification also appears to correlate closely with outcome regarding non-autonomic symptoms. Clinical signs offer valuable guide to diagnosis however suspicion should be confirmed with magnetic resonance imaging. We believe our study demonstrates that whilst symptoms remain static patients should be treated in a pragmatic fashion safely on the next planned list. Despite all out of hours operating being performed by consultant surgeons we did see a trend towards excess complications.

We hypothesise that CES may behave in a progressive nature from CESS to CESI then CESR. Although timing does not appear to influence outcome, classification does and therefore upon admission of patients under medical care it should not be the case that they are allowed to progress from CESS onwards.

We believe thought should be given to performing surgery as soon as pragmatically feasible but not at the expense of patient safety.

Conflict of interest

None.

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