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Evaluation and management of cauda equina syndrome in the emergency department

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ABSTRACT

Background: Cauda equina syndrome (CES) may be a devastating disease with the potential for significant patient morbidity. It is essential for emergency clinicians to be aware of how to effectively diagnose and manage this condition.
Objective: This article provides a narrative review of the diagnosis and management of CES for the emergency clinician.
Discussion: Cauda equina syndrome is a rare but emergent condition associated with back pain. It can result in severe morbidity and can be due to a variety of causes, most commonly vertebral disc protrusion. Diagnosis is often delayed, which may result in a poor prognosis. Red flags and findings consistent with CES include bilateral neurogenic sciatica, reduced perineal sensation, altered bladder function leading to painless urinary retention, loss of anal tone, and loss of sexual function. In isolation, history and examination findings demonstrate poor sensitivity. Symptoms may occur either suddenly or gradually, and most patients do not present with all of these symptoms. Postvoid bladder volume assessments can assist in the evaluation, but the diagnosis typically involves magnetic resonance imaging (MRI) or computed tomography myelography if MRI is not available. Treatment relies upon surgical consultation and operative intervention for decompression.
Conclusion: Cauda equina syndrome can be a difficult diagnosis. However, knowledge of the history and examination findings, imaging, and treatment can assist the emergency clinician in optimizing management of this condition.

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1. Introduction

Back pain affects up to 75% patients during their lifetime and is a leading cause of disability, with 15–20% of persons within the United States experiencing back pain at any one time [1-4]. While many cases of back pain are relatively benign, cauda equina syndrome (CES) is a potentially devastating cause with the potential for significant morbidity and long-term neurologic deficits. Cauda equina syndrome is a rare but emergent condition associated with back pain and other symptoms resulting from compression of the cauda equina [1,5-10]. The cauda equina is comprised of the second through fifth lumbar nerves, sacral nerves, and coccygeal nerve and begins in the medullary cone. The incidence of CES varies depending upon the etiology, with an overall prevalence ranging from 1 in 33,000 to 1 in 100,000 persons [5,6,11-15]. While CES can present at any age, most patients with CES are diagnosed around 40 years of age [14,15]. Additional risk factors include obesity and female gender [13,15-17]. A retrospective study found CES from a disc prolapse occurred in 1.8 patients per million, while a different registry study found an incidence of 7 per 100,000 person-years [5,6,13,15]. Of those presenting with a chief complaint of back pain, CES may be present in 0.04% of cases [6,18-20]. Unfortunately, CES is also associated with significant medico-legal consequences, most commonly due to failure to diagnose CES, inadequate examination, failure of communication, failure of testing, and delays to surgery [4,6,18-20]. The literature suggests that damages are paid in approximately half of all cases, with an average settlement of several hundred thousands of dollars per person [4,6].

While back pain is the most common symptom in CES, other symptoms include unilateral or bilateral sciatica, decreased perianal region sensation, fecal and bladder disruption, lower extremity

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weakness, and reduced sexual function [4,6,11,19-29]. However, many patients do not present with all of these symptoms, and they may occur either suddenly or gradually [4,6,11,19]. Moreover, there are at least 17 distinct definitions of CES present in the literature [1,5,21]. Due to these factors and the variety of etiologies, diagnosis can be challenging and may be delayed, resulting in significant morbidity and mortality. Unfortunately, there is a relatively paucity of evidence in the emergency medicine literature regarding the presentation, evaluation, and management of patients with cauda equina. This narrative review provides emergency clinicians with an evidence-based overview of the current evidence for CES.

2. Methods

The authors searched PubMed and Google Scholar for articles using the keyword "cauda equina syndrome". Authors included case reports, case series, retrospective studies, prospective studies, systematic reviews and meta-analyses, clinical guidelines, and narrative reviews. The literature search was restricted to studies published in English. Emergency physicians with experience in critical appraisal of the literature reviewed all of the articles and decided which studies to include for the review by consensus, with a focus on emergency medicine-relevant articles. A total of 80 resources were selected for inclusion in this review.

3. Discussion

3.1. Anatomy and pathophysiology

The spinal cord ends with the conus medullaris at the L1/L2 vertebral level, which then travels further as nerve roots [9,30-32] (Fig. 1). These lumbosacral and coccygeal nerve roots are similar in appearance to a horse's tail, which led to their name as the cauda equina. These nerve roots include the ascending and descending nerve roots from L2 through the coccygeal segments [5,6,9,10,30-32]. These nerves control lower limb movement (L2-S2), lower limb sensation (L2-S3), bladder control (S2-S4), external anal sphincter control (S2-S4), external genitalia and perianal sensation (S2-S4), and coccygeal sensation (S4, S5, and the coccygeal nerve). The nerve roots travel within the vertebral canal and are surrounded by the neural arches, the vertebral bodies and discs, spinous processes, ligamentum flavum, posterior longitudinal ligaments, and facet joints, all of which house and protect the nerve roots. CES results from any compression of these cauda equina nerve roots along their course within the vertebral canal, including direct compression, inflammation, venous congestion, or ischemia [5,6,9-11].

Urination, defecation, and sexual function are key components of normal function affected in CES [5-7,9-11]. The bladder's innervation is via the pelvic splanchnic nerves (S2-S4), with sensory input from the hypogastric, pelvic, and pudendal nerves, while the autonomic control is primarily via the parasympathetic system [7-9]. Stimulation of these nerves causes bladder emptying through stimulation of the detrusor muscle and inhibition of the urethral sphincter [5,6,8]. Damage to these nerves results in bladder atony with urinary retention and absence of voluntary control [5-9]. Defecation is controlled by the internal (involuntary) and external (voluntary) anal sphincters. Stimulation of the rectum from stool triggers the pudendal nerve (S2-S4) to increase peristalsis and relax the sphincters. Damage to these nerves can result in aperistalsis and failure of sphincter activity. Constipation is generally the first sign, followed by failure to voluntarily retain stool [5-10]. Sexual function can also be affected by CES. In males, erection is controlled by the parasympathetic system, while ejaculation is controlled by the sympathetic and somatic systems [7-9]. Consequently, damage to the parasympathetic innervation from CES will result in erectile dysfunction [5,6,8].

Fig. 1. Caudal spinal cord with 1) conus medullaris, 2) filum terminale, and 3) cauda equina. From https://commons.wikimedia.org/wiki/File:Human_caudal_spinal_cord_anterior_view_description.jpg.

3.2. Etiologies

CES is most commonly the result of a large central disc herniation or prolapse at the L4/L5 or L5/S1 level, which accounts for over 45% of cases [1,5,11,24,33-40]. While disc herniation is the most common cause of CES, only 1–2% of all disc herniations will result in CES [1,4-6,33,41-43]. The degree of herniation resulting in CES varies. One study found that 75% of herniations occupy at least one-third of the spinal canal diameter, while a different study

Table 1
Etiologies of cauda equina [4-6,44-55].

Ankylosing spondylitis
Chemotherapy
Congenital spinal cord disorder
Constipation
Disc herniation
Epidural anesthesia
Infection - osteomyelitis, spinal epidural abscess, arachnoiditis
Multiple sclerosis
Neoplasm - primary or metastatic
Radiation
Spinal stenosis
Vascular lesion – hematoma, arteriovenous malformation, inferior vena cava thrombosis
Trauma

found that 45% of herniations occupy greater than three-quarters of the canal [4-6,43]. Other etiologies of CES are shown in Table 1 [4-6,24,33,44-55]. Preexisting spinal disease such as spinal stenosis or thickening of the ligamentum flavum is a major risk factor for development of CES, as even small disc protrusions can result in significant compression in these patients [4-6,8-11].

3.3. History and physical examination

Given the myriad of potential presentations, a thorough history and physical examination are important. However, the literature suggests a significant delay in time to diagnosis, with a median of 11 days from onset of CES symptoms to diagnosis [14]. Tandon and Sankaran described three common presentations of CES based on the history and physical examination: 1) rapid onset in the absence of prior back problems, 2) acute bladder dysfunction with a history of low back pain with or without sciatica, and 3) chronic back pain and sciatica with gradually worsening pain combined with bladder and bowel dysfunction [5,6,56]. Approximately 70% of patients have a history of chronic back pain [4,35,57]. However, CES may present acutely or gradually over weeks to months [4-6,8-11]. One study suggested that 89% of patients with CES experience an acute worsening of symptoms within 24 h [5,6,9,58]. It is important to determine the time of onset, as more rapid onset of symptoms is associated with worse outcomes [39,58-62]. Other definitions have divided CES into two categories [5,6,9,58,63]. Complete CES includes painless urinary retention with incontinence, while incomplete CES can include reduced urinary sensation, decreased desire to void, or reduced urinary stream with pain [5-9,58,63]. This distinction is important, as those with complete CES require more emergent therapy and may have a worse prognosis [63]. The most recent definition relies on five clinical features and four stages (Table 2) [63]. This table depicts stages of CES, which play a role in determining prognosis. CES with retention is associated with poor prognosis, while suspected CES with bilateral radicular pain is associated with better prognosis if the condition is appropriately diagnosed and managed [5-9,11,63].

Classic red flag symptoms for CES including severe low back pain, bilateral sciatica, saddle anesthesia or genital sensory changes, bladder or bowel incontinence, and sexual dysfunction [5-8,63]. These findings suggest a central cause of canal compression [5-8,63]. The history and examination should focus on these findings, as well as predisposing risk factors (Table 3). While chronology of pain is vital to obtain, other important factors include changes in pain, pre-existing weakness or sensory changes in the lower extremities, any new weakness or sensory changes, prior interventions (including lumbar punctures, spinal or epidural anesthesia, or spinal surgeries), and past medical history [8,11,63]. Back pain in CES is typically more severe than that expected with compression of a single nerve root [5-9,11,63]. The pain typically worsens when in the supine position because this increases pressure on the affected nerve roots [5,6,46]. Lumbosacral radicular pain results from nerve root impingement, though the specific distribution of the radiculopathy depends upon the affected nerves [5,6,9]. Lesions more cranial in location typically result in more severe, widespread pain [5,6,8,9]. Unilateral sciatica is more common than bilateral sciatica in confirmed cases of CES [5,6,64,65]. While bilateral sciatica is classically associated with CES, it has not been found to be a statistically significant indicator of CES [5-11,66]. Lower extremity weakness occurs when there is compression of lumbosacral nerve roots in the L4-S2 distribution [5,6,9,10]. Perineal sensory changes can occur, but patients often fail to spontaneously report them unless specifically queried [5,6,9,10]. Clinicians should inquire about changes in sensation with sitting, during defecation, or during hygiene activities (e.g., wiping with toilet paper) [67]. Changes in perineal sensation can be unilateral, mild, or patchy [5,6,67]. The distribution of the sensory loss worsens as the compression of the sacral and coccygeal nerves progresses [5,6,9,10,67].

Bladder dysfunction can include retention, incontinence, or decreased urethral sensation during urination [5,6,63,67,68]. Urinary retention in the absence of back pain may be the sole feature of CES, though this is rare [5,6,68]. Retention typically precedes incontinence; therefore, patients may not present with incontinence until late in the disease process [4,5,35,39,66]. Rather than inquiring about incontinence, clinicians should ask about retention and difficulty passing urine [67,69]. Unfortunately, difficulty passing urine can be associated with severe pain or chronic illness

Table 2
CES features and stages [63].

Features and stages	Specifics
CES characteristic features	1. Bilateral neurogenic sciatica 2. Reduced perineal sensation 3. Altered bladder function leading to painless urinary retention 4. Loss of anal tone 5. Loss of sexual function
CES stages	1. CES Suspected – Bilateral radicular pain 2. CES Incomplete – Urinary difficulties of neurogenic origin (e.g., altered urinary sensation, loss of desire to void, poor urinary stream, need to strain to micturate) 3. CES Retention – Neurogenic urine retention (defined as painless urinary retention with overflow incontinence) 4. CES Complete – Objective loss of cauda equina function, absent perineal sensation, patulous anus, paralyzed and insensate bladder/bowel

CES, cauda equina syndrome.

Table 3
Features suggesting CES.

Evaluation	Findings (decreasing order of impact on prognosis)
History	Bladder dysfunction (urinary retention, incontinence)
	Defecatory dysfunction
	Sexual dysfunction
	Perineal anesthesia or hypoesthesia
	Severe back pain that suddenly worsened
	Lower extremity motor or sensory changes
	Bilateral sciatica
	Unilateral sciatica
Examination	Decreased perineal/urinary sensation
	Decreased anal tone
	Motor weakness in lower extremities
	Sensory deficit in lower extremities
	Depressed patellar and Achilles reflexes

[7-10]. Other common causes of urinary retention include anticholinergic medications and benign prostatic hyperplasia; therefore, it is essential to ask about these risk factors. Fecal incontinence is not as commonly reported as urinary retention and incontinence [5-11,67]. This may be due to decreased patient reporting, as patients urinate more frequently than they defecate, or that bowel transit issues may take longer to become apparent [4-9,11,67]. CES can also result in urination during intercourse, dyspareunia, and erectile dysfunction [4-9,11,67]. However, the literature suggests that clinicians fail to inquire about and document sexual function in their assessment of patients with suspected CES [1,64,67,70]. This may be due to discomfort in asking about sexual function, as patients may be more reluctant to report sexual symptoms [4-6,67,70]. Therefore, it is important for clinicians to specifically inquire about these issues.

The physical examination may be challenging in these patients, particularly if they are in severe pain. Therefore, it is important to treat pain early to ensure that a reliable examination can be performed. Examination should focus on assessing strength and sensation of the lower extremities (L2-S3), perianal region sensation (S2-S4), patellar reflex (L4), the Achilles tendon reflex (S1), anal wink reflex, and the bulbocavernosus reflex (S2-4) [4-11]. Clinicians may find unilateral or bilateral weakness in the L2-S2 distribution. The Achilles and patellar reflexes are typically reduced in CES. Hyperreflexia may be present when the compression is multifocal or superior to the cauda equina [4-11]. Sensation in the lumbosacral dermatomal distribution should be assessed, especially in the perineal region [4-11]. Clinicians should test the anal wink reflex, which can be assessed by gently stroking the skin around the anus with a cotton swab or applicator. An intact reflex results in contraction of the external anal sphincter [9,11]. An absent anal wink reflex is associated with dysfunction of the sacral nerve roots. The bulbocavernosus reflex occurs when the anal sphincter contracts in response to squeezing the glans penis or pulling on a urinary catheter [4-9,11]. This is also typically absent in CES. While a rectal examination was traditionally recommended for the diagnosis, the literature suggests rectal tone findings do not correlate with CES and vary among providers [63,71,72]. Table 3 contains a list of features suggestive of CES.

While these signs and symptoms may suggest CES, no single finding or combination of findings is sufficient to exclude CES in isolation [64-66,69,73]. While back pain is the most common presenting symptom, followed by bladder dysfunction and saddle hypoesthesia [64,66], a recent systematic review evaluating red flag findings in the history or physical examination when compared with MRI-confirmed CES found that bowel incontinence, perineal anesthesia, and reduced anal tone were the most specific, but that most findings had low sensitivity (Table 4) [74]. While many of the individual studies had significant limitations, clinicians should suspect CES in patients with acute or chronic low back pain with at least one of the following: urinary retention, urinary incontinence, fecal retention, fecal incontinence, loss of anal sphincter tone, sexual dysfunction, or saddle hypoesthesia or anesthesia [4-11,67,74].

3.4. Diagnostic testing

There are no laboratory studies which are diagnostic of CES. However, pre-operative laboratory testing should be considered if there is significant concern for CES. This often includes a complete blood count, basic metabolic panel, prothrombin time, activated partial thromboplastin time, and a type and screen, but may vary depending upon the hospital.

A point-of-care ultrasound examination may be performed to assess for the bladder volume. It is important to assess this immediately after a patient voids. One study found that a post-void volume >500 mL had an odds ratio of 4.0 for diagnosing CES [66]. However, the odds ratio increased to 48.0 when this was combined with two of the following three symptoms: bilateral sciatica, subjective complaints of urinary retention, or rectal incontinence symptoms [66].

Plain radiographs are of low utility in CES [4-6,10,11]. While they may demonstrate an associated fracture or other injury, advanced imaging remains necessary, and plain radiographs are unlikely to significantly alter the initial management [4-6,10,11]. The gold standard for diagnosis is magnetic resonance imaging (MRI) [5,6,9,10]. While there are no studies directly assessing the diagnostic accuracy of MRI for CES, a recent systematic review and meta-analysis on imaging for disc herniation found that MRI was 81% sensitive and 81% specific [75]. Given that many cases of CES have much greater degrees of herniation than in the aforementioned study, it is likely that the diagnostic accuracy would be greater in this population. Importantly, MRI is contraindicated in the presence of pacemakers, aneurysmal clips, or when metal fragments are near vital structures (e.g., eyes, heart) [76]. When MRI cannot be performed, clinicians should consider a computed tomographic (CT) myelogram [76]. CT myelography is more invasive than MRI and involves placing a needle into the spinal canal followed by injection of contrast dye [76]. One recent study found that a CT of the lumbar spine with <50% thecal sac effacement was able to rule out CES in 96 out of 97 cases (98% sensitivity), while a thecal sac effacement $\geq$50% was suggestive of CES (86% specificity) [77].

3.5. Treatment

Treatment involves immediate neurosurgical consultation for operative management [5,6,9,10]. The literature suggests that surgery should be performed within 48 h of symptoms with abrupt onset, as delays beyond 48 h are associated with a greater risk of permanent dysfunction [1,5,6,11,23,35,45,78,79]. While the exact timing for surgical management is controversial, those with rapid onset of symptoms (defined as occurring within 24 h) or evolving bladder dysfunction are considered particularly high risk, and

Table 4
Reliability of history and examination in CES [74].

Feature	Sensitivity (95% CI)	Specificity (95% CI)	LR+ (95% CI)	LR− (95% CI)
Back pain	34% (26–42%)	62% (51–72%)	1.98 (1.52–2.58)	0.64 (0.26–1.60)
Sciatica	43% (30–56%)	66% (59–73%)	1.50 (0.80–2.80)	0.90 (0.61–1.30)
Perineal anesthesia	38% (28–49%)	85% (81–89%)	2.00 (0.92–4.33)	0.80 (0.61–1.05)
Urinary retention	25% (17–35%)	72% (65–79%)	0.84 (0.53–1.32)	0.99 (0.82–1.20)
Urinary incontinence	24% (16–33%)	70% (61–77%)	0.76 (0.50–1.13)	1.05 (0.92–1.20)
Bowel incontinence	19% (9–33%)	86% (80–91%)	1.60 (0.66–3.89)	0.97 (0.78–1.20)
Reduced anal tone	30% (16–49%)	83% (76–88%)	1.83 (1.00–3.33)	0.90 (0.73–1.12)

CI, confidence interval; LR+, positive likelihood ratio; LR−, negative likelihood ratio.

experts recommend that these patients undergo surgery within 24 h of presentation [58-63,80].

3.6. Disposition

Patients with cauda equina syndrome require operative intervention. As such, these patients will typically be admitted to the hospital following their surgery [4-11]. The majority of patients will be admitted to an intensive care unit prior to their surgery given the need for frequent neurologic assessments.

4. Conclusions

Cauda equina syndrome is a rare but devastating disease with the potential for significant morbidity. While it can be due to a variety of causes, the most common is vertebral disc protrusion. Findings consistent with CES include bilateral neurogenic sciatica, reduced perineal sensation, altered bladder function leading to painless urinary retention, loss of anal tone, and altered sexual function. While in isolation these findings have limited sensitivity, clinicians should consider CES in patients with these symptoms. Several stages of CES based on history and examination findings include suspected, incomplete, retention, and complete. In the ED, a focused history and physical examination combined with a postvoid assessment of bladder volume can assist with identifying cases. Recommended imaging involves MRI or CT myelography. Treatment relies upon surgical consultation and operative intervention for decompression.

Declaration of competing interest

None.

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