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Review Article

Post-Operative Cauda Equina Syndrome: A Comprehensive Overview

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Abstract:

Postoperative cauda equina syndrome can be defined as a rare but serious complication that can occur typically after spinal surgery. It involves the compression and/or ischemic changes to the cauda equina which can lead to severe neurological deficits.

This is a comprehensive review aiming to identify what current literature concluded regarding common and uncommon causes of postoperative CES, commonly used treatment methods, and the outcome of postoperative cauda equina syndrome in addition to the role of early detection and management of CES and whether there are intraoperative predictors for post-operative CES or not.

Thirty-one studies were included in this review. aiming to comprehensively analyse this devastating postoperative complication.

Introduction:

Definition

Cauda Equina Syndrome (CES) is a serious condition caused by the compression of the nerve roots at the lower end of the spinal cord. These nerves, known as the cauda equina, are responsible for motor and sensory functions in the lower body, including the legs and bladder. (1) CES can lead to severe symptoms such as lower back pain, leg weakness, and loss of bladder or bowel control.(1)

Post operative cauda equina syndrome can be defined as a rare but serious complication that can occur typically after spinal surgery. It involves the compression and/or ischemic changes to the cauda equina which can lead to severe neurological deficits.

Signs and Symptoms of Cauda Equina Syndrome

1. **Severe Lower Back Pain**: This is often the first symptom and can radiate down the legs.
2. **Leg Weakness**: Patients may experience weakness or numbness in one or both legs.
3. **Saddle Anesthesia**: Loss of sensation in the areas where you would sit on a saddle (inner thighs, back of legs, and around the rectum).
4. **Bladder and Bowel Dysfunction**: Difficulty in starting urination, frequent urination, inability to feel when the bladder is full, or loss of bowel control.
5. **Sexual Dysfunction**: Difficulty achieving or maintaining an erection in men, and sexual dysfunction in women.
6. **Foot Drop**: Difficulty lifting the front part of the foot, leading to a high steppage gait.
7. **Sensory Loss**: Loss of sensation in the lower extremities, including the feet.
8. **Motor Weakness**: Weakness in the muscles of the lower extremities, which can lead to difficulty walking. (1)

Etiology

The primary causes of CES include:

- **Disc herniation**: The most common cause, where the intervertebral disc material (nucleus polposus) herniates and compresses the nerve roots. And usually affects the L4-L5 and L5-S1 levels (2)
- **Spinal stenosis**: A narrowing of the spinal canal that compresses the cauda equina. Which is usually caused by hypertrophied ligamentum flavum, facet joints osteophytes and facet cysts. (2)
- **Trauma**: Accidents or injuries that damage the spine either by direct damage or compression by bony or soft tissue elements. (2)
- **Tumors**: Both primary spinal tumors and metastatic cancers can compress the nerves.
- **Infections**: Such as epidural abscesses or spinal infections can cause direct pressure in addition to local inflammatory response. (2)
- **Epidural hematoma**: Blood accumulation in the epidural space can cause direct pressure effect contributing to CES. (2)

- **Autoimmune disorders**: various autoimmune disorders can cause progressive stiffness and stenosis causing compression of the cauda equina such as ankylosing spondylitis and rheumatoid arthritis. (2)
- **severe scoliosis**: : In severe scoliosis, the abnormal spinal curvature can cause narrowing of the spinal canal (spinal stenosis), which in turn compresses the cauda equina nerves. (3)
- **Pregnancy:** During pregnancy, the body undergoes significant changes, including weight gain and shifts in the center of gravity. These changes can put additional pressure on the spine, particularly the lumbar region. The increased weight and altered posture can lead to conditions such as disc herniation or spinal

stenosis, which can compress the cauda equina nerves. (1)

Diagnosis

Diagnosing CES involves a combination of clinical evaluation and imaging studies:

- **Medical history and physical examination**: Assessing symptoms such as severe back pain, leg weakness, and bladder or bowel dysfunction.
- **Imaging studies**: MRI (Magnetic Resonance Imaging) is the preferred method to visualize the compression of the cauda equina. CT (Computed Tomography) scans can also be used4.
- **Urodynamic tests**: To evaluate bladder function.
- **Digital rectal examination**: To assess bowel function. (4)

Treatment

The primary treatment for CES is **surgical decompression**:

- **Laminectomy**: Removal of part of the vertebral bone called the lamina to relieve pressure on the nerves.
- **Discectomy**: Removal of the herniated disc material compressing the nerves.
- **Epidural hematoma evacuation**: Removal of accumulated blood in the epidural space.
- **Antibiotic therapy**: If an infection is the cause, appropriate antibiotics are administered.
- **Supportive care**: Includes pain management, physical therapy, and bladder/bowel management. (2)

Prognosis

The prognosis for CES varies depending on the severity and duration of the compression: (1)

- **Early intervention**: Prompt surgical treatment can significantly improve outcomes and reduce the risk of permanent damage.(1)
- **Delayed treatment**: Can lead to permanent neurological deficits, including paralysis, incontinence, and sexual dysfunction. (2)
- **Overall outcomes**: Approximately 20% of patients may experience poor outcomes despite treatment. (2)

Summary

Cauda Equina Syndrome is a medical emergency requiring immediate attention.(1) Early diagnosis and surgical intervention are crucial to prevent permanent damage and improve outcomes (1). Patients at higher risk include those with lumbar disc herniation, spinal stenosis, trauma, tumors and infections. (5) Treatment primarily involves surgical decompression, and the prognosis depends on the timeliness of intervention. (2) However, current literature discussing Causes, treatment, timing of the intervention and the prognosis of postoperative CES will be further analyzed in this systematic review.

Methods

This is a comprehensive review aiming to identify what current literature concluded regarding common and uncommon causes of post operative CES, commonly used treatment methods, and the outcome of post operative cauda equina syndrome in addition to the role of early detection and management of CES and whether there are intraoperative predictors for post-operative CES or not.
Thirty-one studies were included in this review and retrieved from pubmed and research gate databases.

The studies that were included in this review were categorized as the following:

1- Studies discussing causes of CES.
2- Studies discussing different management strategies
3- Studies discussing the timing of intervention
4- Studies discussing outcome.
5- Studies Discussing the intraoperative findings that predicts possible post-operative cauda equina syndrome

The data were arranged in tables concerning each of the above categories and were discussed individually.

Table 1: Causes of post-operative cauda equina syndrome

No	Author	Article title	Results and conclusion
1.	Shields LBE, Iyer VG, Zhang YP, Shields CB. (6)	Acute cauda equina syndrome following orthopedic procedures as a result of epidural anesthesia	Acute CES should be considered in patients undergoing spinal or epidural anesthesia for joint replacement surgery. Prompt evaluation with MRI studies may lead to appropriate medical/surgical measures to reverse the deficit.
2.	Jain M, Das SS, Behera S, Tirpude A. (7)	Non-compressive postoperative cauda equina syndrome following decompression and transforaminal interbody fusion surgery	Aetiology of postoperative CES can be attributed to compressive and non-compressive causes such as nuero-ischaemia as demonstrated in this study

3.	Deburge A, Bitan F, Lassale B, Vaquin G (8)	Cauda equina syndrome caused by migration of a fat graft after laminoarthrectomy	In a case of partial laminoarthrectomy for lateral recess stenosis cauda equina compression occurred post-operatively, and was caused by migration of a fat graft. Recovery was complete within six months.
4.	Maki Y, Takayama M, Hayashi H, Yokoyama Y, Agawa Y. (9)	Cauda Equina Syndrome Due To Dural Sac Shift with Engorgement of the Epidural Venous Plexus: Rare Complication After Lumbar Microdiscectomy.	They reported a rare case of postoperative cauda equina syndrome due to dural sac shift and proposed laminoplasty as an option to treat dural sac shift with engorgement of the epidural venous plexus.
5.	Kebaish KM, Awad JN. (10)	Spinal epidural hematoma causing acute cauda equina syndrome	Spinal epidural hematoma (SEH) is an uncommon cause of acute cauda equina syndrome. Most of these hematomas are caused by trauma, anticoagulation therapy, and vascular anomalies or occur following spinal epidural procedures and, rarely, spinal surgery. Spontaneous SEH is an extremely rare occurrence.
6.	Takayama M, Maki Y, Kawasaki T. (11)	Cauda equina syndrome after L5-S1 posterior decompression surgery showing a "convexity sign" caused by engorgement of the ventral epidural venous plexus: A case series	Postoperative CES occurred in four patients undergoing L5-S1 lumbar surgery. This deficit was attributed to marked engorgement of the ventral epidural plexus (i.e., yielding the "convexity sign" on MRI) that resolved spontaneously in three patients, but warranted a laminoplasty in the fourth.
7.	Kakuta, Y., Iizuka, Y., Mieda, T., Sonoda, H. (12)	Transdural cauda equina herniation after uneventful lumbar surgery: A case report and review of the literature	Clinicians should be aware that transdural nerve root herniation can occur, even if no dural tear is identified intraoperatively.
8.	Badra, M. I., Rahal, M. H. J., Najjar, E., & Natout, N. Y. (13)	Acute cauda equina syndrome after percutaneous transforaminal endoscopic discectomy	rare case of acute recurrence of disc herniation after a successful PELD done at L4-5 level causing acute cauda equina syndrome. Surgeons performing endoscopic discectomy should be aware of such complication.
9.	Aslantaş, Hüseyin & Kutlay, Sehim & Gunes, Secilay & Genç, Aysun & Ünal, Sena & Peker, Elif & Özaydın Aksun, Zerin (14)	Elsberg Syndrome: One of the Causes of Cauda Equina Syndrome - A Case Series and Review of the Literature.	ES is a rare diagnosis that is not generally considered in the differential diagnosis and therefore can be missed. Low back pain and accompanying cauda equina syndrome are among the red flags for low back pain. It is important to make the differential diagnosis appropriately in order not to make unnecessary interventions to the patients. The fact that CSF analysis could not be performed in the presented cases is a limitation, but their clinical and radiological features are sufficient for diagnosis.

Table 2: Management strategies for Cauda equina syndrome

No	Author	Article title	Results and conclusion
1.	Ashour, A., Mousa, A., Elshamy, W., Elsayed, A (15)	Minimally Invasive Microscopic Lumbar Discectomy for Treatment of Cauda Equina Syndrome, Is It Effective?	MIS-LD is effective and efficient procedure for treatment of CES caused by huge/ruptured LDH with approximately good recovery of motor power, full control of urinary, bowel and sexual functions, and normal saddle sensation without surgical side effects.
2.	Fokmare P., Medhavi E., Pratik A. (16)	Cauda Equina syndrome rehabilitation strategies post decompression- Discectomy – A case report.	Post-operative physiotherapy treatment showed significant improvement and used to prevent secondary complications.

3.	Kuris O., McDonald C., Palumbo M., Daniels A. (17)	**Evaluation and Management of Cauda Equina Syndrome**	Even with expeditious surgery, improvements remain inconsistent. However, early decompression has been shown to portend greater chance of neurologic recovery. All providers in clinical practice must understand the severity of this condition. Providers can optimize long-term patient outcomes and minimize the risk of litigation by open communication, good clinical practice, thorough documentation, and expeditious care.
4.	Hur JW, Park D-H, Lee J-B, Cho T-H, Park J-Y. (18)	Guidelines for Cauda Equina Syndrome Management	surgery should be performed immediately.
5.	Dubuc E., Décary S., Grenier J., Pépin K., Blanchette M. (19)	Conservative Management of Cauda Equina Syndrome: A Case Report	A case report of a patient with CES treated conservatively, the patient reported a self-perceived percentage of improvement of 80%, a verbal numeric pain-rating scale at 2/10 and a 22% Oswestry score. Her bowel dysfunction, sexual dysfunction, and perineal numbness were resolved.
6.	John A. , Simjian T. , Lamba N., Yuxin Y., Carosella C. , Song J., Trinh S., (20)	**A comparison of the safety and efficacy of minimally invasive surgery versus open surgery in treating cauda equina syndrome: A systematic review and meta-analysis**	MIS for CES was associated with reduced operative time, length of stay, and blood loss, compared to OS. MIS was also associated with better post-operative lumbar/back and leg VAS scores and complete motor and bladder recovery rates. MIS and OS produced an equal average percentage of "excellent" patient outcomes.
7.	Yankang L, Leiming Z, Lewandrowski KU, Xiangyu T, Zexing Z, Jianbiao X, Lin Z, Heng Y, Xifeng (21)	Full Endoscopic Lumbar Discectomy Versus Laminectomy for Cauda Equina Syndrome.	CES clinical symptom resolution was equal with endoscopy and laminectomy both in short-term and midterm follow-up. However, endoscopic treatment was advantageous by reducing the amount of bleeding, duration of surgery, and hospitalization days when compared to laminectomy.

Table 3: Timing of intervention for cauda equina syndrome

No	Author	Article title	Results and conclusion
1.	Hogan W., Kuris E. , Durand W., Eltorai A. , Daniels A.(22)	Timing of Surgical Decompression for Cauda Equina Syndrome	Patients receiving decompression within 0 or 1 day after admission are associated with improved inpatient outcomes, including lower complication and mortality rates.
2.	Chau A., Xu L., Pelzer N., Gragnaniello C. (23)	Timing of Surgical Intervention in Cauda Equina Syndrome: A Systematic Critical Review	There is no strong basis to support 48 hours as a blanket safe time point to delay surgery. Both early and delayed surgery may result in improved neurological outcomes. However, it is likely that the earlier the surgical intervention, the more beneficial the effects for compressed nerves, especially with acute neurological compromise.
3.	**Thakur J., Storey C., Kalakoti P., Ahmed O. (24)**	**Early intervention in cauda equina syndrome associated with better outcomes: a myth or reality? Insights from the Nationwide Inpatient Sample database (2005-2011)**	**Early intervention in CES, regardless of the subtype (complete or incomplete), has higher likelihood of improved inpatient outcomes. The odds of getting better were higher, however, with incomplete CES. The timing of intervention did not seem to matter in traumatic CES as compared with degenerative etiology.**
4.	Shah R, Thapa B., Magar S., (25)	**Evaluation of Outcome of Timing of Surgical Intervention on Cauda Equina Syndrome**	Timing of surgery may not be the most important determining factor for the outcome of the CES. Surgical decompression in delayed presentation have good clinical outcome in CES.

5.	Heyes G., Jones M., Verzin E. (26)	Influence of timing of surgery on Cauda equina syndrome: Outcomes at a national spinal centre	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.
6.	Qureshi A, Sell P. (27)	Cauda equina syndrome treated by surgical decompression: the influence of timing on surgical outcome	There was no statistically significant difference in outcome between three groups of patients with respect to length of time from symptom onset to surgery- <24, 24-48 and >48 h.

Table 4: The outcome of cauda equina syndrome.

No	Author	Article title	Results and conclusion
1.	Hazelwood JE, Hoeritzauer I, Pronin S, Demetriades AK. (28)	An assessment of patient-reported long-term outcomes following surgery for cauda equina syndrome	With a mean follow-up time of 43 months, findings confirm the high prevalence of long-term bladder, sexual and physical dysfunction in CES patients and that a diagnosis of CES-R confers poorer outcomes.
2.	Srikandarajah N, Wilby M, Clark S, Noble A, Williamson P, Marson T. (29)	Outcomes Reported After Surgery for Cauda Equina Syndrome: A Systematic Literature Review.	There is significant heterogeneity in outcomes reported for studies after surgery for CES patients.
3.	Lee KY, Lim YH, Kim SH. (30)	Prognostic Factors of Clinical Outcome of Postoperative Cauda Equina Syndrome	The less the motor loss and voiding difficulty before the secondary decompression and the faster diagnosis and surgical decompression, the better the prognosis. In particular, as voiding difficulty showed the lowest recovery rate, it is considered to affect prognosis and satisfaction most seriously
4.	Barker T., Steele N., Swamy G., Cook A., Rai A., Crawford R., Lutchman L. (31)	Long-term core outcomes in cauda equina syndrome	This study reports the long-term outcome of patients with CES and is the first to use validated patient-reported outcome measures to assess the CES Core Outcome Set. Persistent severe back pain and on-going autonomic dysfunction were frequently reported at a mean follow-up of five years.
5.	Tamburrelli F., Genitiempo M., Bochicchio M., Donisi L., Ratto C. (32)	Cauda equina syndrome: evaluation of the clinical outcome	Results show that a long-term follow-up is mandatory to evaluate the real outcome of surgical managed cauda equine syndrome because short-term evaluation could be misleading about the residual capacity of late neurologic improving.
6.	Kennedy J., K Soffe K., McGrath A., Stephens M., Walsh M., McManus F.(33)	Predictors of outcome in cauda equina syndrome	The most important factors identified in this series as predictors of a favourable outcome in CES were early diagnosis and early decompression.
7.	Hussain S., Gullan R., Chitnavis B.(34)	Cauda equina syndrome: outcome and implications for management	Emergency decompressive surgery did no significantly improve outcome in CES compared with a delayed approach.
8.	Kumar V., Baburaj V., Rajnish R., Dhatt S. (35)	Outcomes of cauda equina syndrome due to lumbar disc herniation after surgical management and the factors affecting it: a systematic review and meta-analysis of 22 studies with 852 cases	Decompression within 48 hours of the onset of symptoms appears to result in fewer patients with persistent bladder dysfunction. However, a randomized controlled trial is required to conclusively determine whether early decompression leads to better outcomes.

Table 5: Intraoperative predictors for possible post-operative cauda equina syndrome occurrence.

No	Author	Article title	Results and conclusion
1.	Dimopoulos V, Fountas KN, Machinis TG, Feltes C, Chung I, Johnston K, Robinson JS, Grigorian A.(36)	Postoperative cauda equina syndrome in patients undergoing single-level lumbar microdiscectomy. Report of two cases.	The authors' findings support the proposition that intraoperative SSEP monitoring may be useful in predicting the development of cauda equina syndrome in patients undergoing lumbar microdiscectomy. Nevertheless, further prospective clinical studies are necessary for validation of these findings.

Results:

Thirty-one studies were included in this systematic review discussing different aspects of post-operative cauda equina syndrome, including causes, treatment measures, the timing of the intervention, the outcome in addition to intraoperative predictors for post-operative cauda equina syndrome these studies can be categorized and broken down as the following:

1- Causes of post-operative cauda equina syndrome:

Nine studies were included in this category suggesting different causes for postoperative cauda equina syndrome.

Shields (6) mentioned a very important cause for post-operative cauda equina syndrome which is the epidural anesthesia she included patients who underwent joint replacement surgeries and proposed that CES can be caused by mechanical root injury from the spinal needles.

Jain (7) could not identify any mechanical cause for CES via imaging studies therefore proposed the ischemia as a cause for cauda equina syndrome and also suggested that nonoperative management for these cases would yield good outcome.

Deburge (8) was able to identify fat graft migration following partial laminoarthrectomy for lateral recess stenosis causing postoperative cauda equina syndrome.

Maki (9) reported a case of dural sac shift through microdiscectomy window with engorgement of the epidural venous plexus. He was able to reverse the pathology by performing laminoplasty to help reduce the dural sac back in to the spinal canal.

Kebaish (10) focused in his study on epidural hematoma as a cause for CES he discussed that it can be spontaneous, post-traumatic, post epidural anesthesia or following spine surgery. However, he suggested that the latter is rare.

Takayama (11) reported in a case series of 4 patients that post operative CES can be caused by engorgement of the ventral epidural venous plexus following decompressive surgeries and can be detected by MRI (convexity sign). He also suggested that it has resolved spontaneously in three patients but required surgical intervention in the fourth patient.

Kakuta (12) reported a rare case of transdural nerve root herniation following spinal decompression and fixation for a case of spondylolisthesis. Even though there was no actual dural tear during the procedure but the patient developed post-operative cauda equina syndrome and MRI confirmed intrdural root herniation with pseudomenegiocele for which he performed re-exploration and dural repair and the patient experienced immediate relieve afterwards.

Badra (13) presented a case report of disc recurrence following Percutaneous Endoscopic Lumbar discectomy emphasizing on the necessity of being aware of this cause of post operative cauda equina syndrome.

Aslantaş (14) described Elsberge syndrome (post viral radiculitis) as one of the causes of CES stressing on the fact it is actually a rare condition and frequently not considered as one of the differential diagnosis and eventually missed. They also mentioned that even though CSF analysis which is necessary for the diagnosis of this condition may not always be feasible however, MRI study is sufficient for the diagnosis.

2- Management strategies for cauda equina syndrome:

Seven studies were included in this category discussing and comparing different treatment strategies for CES

Ashour (15) Proposed that minimally invasive surgery is a safe option for the treatment of cauda equina syndrome caused by ruptured intervertebral disc even if the disc was large, resulting in approximately good recovery of motor power, full control of urinary, bowel and sexual functions, and normal saddle sensation without surgical side effects.

Fokmare (16) suggested that physiotherapy following decompression for CES facilitates significant improvement and prevents secondary complications.

Kuris (17) stressed on the fact that even with expeditious surgery for CES, recovery may remain inconsistent. However, early decompression can help achieve a better recovery. Therefore, Surgeons can optimize long-term patient outcomes and minimize the risk of litigation by open communication, good clinical practice, thorough documentation, and expeditious care.

Hur (18) mentioned that Meticulous diagnosis is most important for the treatment planning. Clinical symptoms should be concerned for the first step and then, MRI finding should match the symptoms. EMG could be helpful in the diagnosis and once the diagnosis is confirmed, surgery should be performed immediately.

Dubuc (19) Reported a case of CES that was referred to a chiropractic clinic and after 22 treatment sessions. the patient reported a self-perceived percentage of improvement of 80%, a verbal numeric pain-rating scale at 2/10 and a 22% Oswestry score. Her bowel dysfunction, sexual dysfunction, and perineal numbness were resolved. They also suggested that further studies should be directed towards identification of cases that may benefit from non-surgical treatment when surgery is not considered an immediate option.

John (20) conducted a systematic review to compare between

minimally invasive and open surgery for the treatment of CES, and they found that the outcome was equal for both modalities. However, minimally invasive surgery was associated with less bleeding, reduced surgical time and reduced hospital stay.

Yankang (21) Compared endoscopic and open laminectomy for treatment of CES and found that symptom resolution was equal with endoscopy and laminectomy both in short-term and midterm follow-up. However, endoscopic treatment was advantageous by reducing the amount of bleeding, duration of surgery, and hospitalization days when compared to laminectomy.

3- Timing of Intervention for cauda equina syndrome:

Six studies were included in this category.

Hogan (22) proposed that early intervention with in 0-1 day would improve patients outcome and decrease morbidity and mortality.

Chau (23) conducted a systematic review regarding the timing for the intervention and found that there was no clear cut point for the optimum timing of the intervention and both early and late intervention can achieve good outcome. However, it is likely that the earlier the surgical intervention, the more beneficial the effects for compressed nerves, especially with acute neurological compromise.

Thakur (24) found that Early intervention in CES, regardless of the subtype (complete or incomplete), has higher likelihood of improved inpatient outcomes. The odds of getting better were higher, however, with incomplete CES. The timing of intervention did not seem to matter in traumatic CES as compared with degenerative etiology.

Shah (25) conducted a study on 10 patients of CES that underwent surgical decompression within mean time of 142 hours from the onset of symptoms only 2 patients ended up with sexual dysfunction while 8 patients had complete recovery. Therefore, he suggested that timing of the intervention may not be the most important determining factor for the outcome of the CES. Surgical decompression in delayed presentation has good clinical outcome in CES.

Heyes (26) suggested that even though surgical decompression improves patient's outcome and helps in resolution of the symptoms. However, early surgical decompression <24 h from symptom onset does not appear to significantly improve resolution of bowel or bladder dysfunction.

Qureishi (27) divided his patients into 3 groups according to the time of intervention (A-less than 24 hours B- 24-48 hours C- more than 48 hours) and he found that the timing of the intervention has no significant effect on the outcome of CES.

4- The outcome of cauda equina syndrome:

Eight studies were included in this category.

Hazelwood (28) compared the outcome between incomplete and complete CES with urinary retention after following up their patients for up to 43 months they found that there was a high prevalence of physical, bladder and sexual dysfunction in patients with complete CES. Therefore, suggested that CES with urinary retention carries poorer prognosis than incomplete CES.

Srikandarajah (29) conducted a systematic review to find out the outcome of CES and they discovered a broad heterogenicity between studies as different measuring scores and different terms were used to present the findings. Therefore, they suggested using a common unified scoring system for the recovery and outcome of cauda equina syndrome.

Lee (30) included 10 patients in their study and discovered that the outcome is better with faster diagnosis, faster decompression and less neurological involvement.

Barker (31) used the (CES Core Outcome Set) to assess the outcome and found that persistent severe back pain and ongoing autonomic dysfunction were frequently reported at mean follow-up period of five years.

Tamburrelli (32) emphasizes that long term follow-up is essential to determine the true outcome of CES and early follow-up maybe misleading as many neurological symptoms are liable to improvement on the long run.

Kennedy (33) stated that early diagnosis and early decompression are the most important predictors for improved patients outcome following CES which was inconsistent with Hussain (34) who found that early decompression did not significantly improve patients outcome as compared to late decompression.

Kumar (35) conducted a meta-analysis of 22 studies and found that decompression within 48 hours is associated with better bladder function recovery.

5- Intraoperative predictors for possible post-operative cauda equina syndrome occurrence.

The only one that discussed this matter was Dimopoulos (36) who proposed that intraoperative somato sensory evoked potential (SSEP) monitoring may be useful in predicting the development of cauda equina syndrome in patients undergoing lumbar microdiscectomy. Nevertheless, further prospective clinical studies are necessary for validation of these findings as they used SSEP monitoring in 2 patients only.

Conclusion:

Postoperative cauda equina syndrome is not an uncommon condition and frequently complicates the patients' outcome. Several common causes have been reported in the literature like recurrence of disc prolapse or hematoma formation. However, special attention should be paid towards the uncommon causes like dural sac shift through microdiscectomy window with engorgement of the epidural venous plexus as reported by Maki (9) or Elsberge syndrome (Aslantaş) (14) or even engorgement of the ventral epidural venous plexus following decompressive surgeries as reported by Takayama. (11)

Therefore, high index of suspicion of the surgeons is crucial for early diagnosis and treatment to reverse the causative factor/ factors.

Even though the majority agreed that adequate decompression once the diagnosis is made is essential to achieve the best possible outcome. There has been some debate regarding whether to perform open surgery or minimally invasive (endoscopic surgery). However, both have been reported to be equally effective according to Yangkang (21) in treating the condition in mid-term and long-term follow-up.

Other authors like Dubuc (19) suggested that physiotherapy might be enough to treat some cases of CES but they stressed on the need to perform further investigation to identify which cases might benefit from non-operative treatment.

Chau conducted a systematic review to define the best time to do the intervention and they failed to identify a clear cut point. However they found that early intervention is associated with better patient's outcome and this is supported by Hogan (10) who proposed that early intervention within 24 hours would improve the patient outcome and decrease morbidity and mortality which goes with common knowledge about this issue. However, interestingly many other authors like Shah (25), Heyes (26) and Qureishi (27) did not find significant difference between early and delayed intervention in terms of patients' outcome.

Some authors like Hazelwood (28) stated that the prognosis of CES depends the type whether it was complete or incomplete CES and found that complete types have poorer prognosis, Others like Kennedy (33) stated that early diagnosis and early decompression are the most important predictors for improved patients outcome.

However, there has been many discrepancies in the literature regarding the outcome as there was no single scoring system used by all surgeons to assess the outcome and this supported by Srikandarajah (29) who conducted a systematic review to find out the outcome of CES and they discovered a broad heterogenicity between studies as different measuring scores and different terms were used to present the findings. Therefore, they suggested using (CES Core Outcome Set) to assess the outcome and helps to better understand the outcome and prognostic factors.

During our journey though the literature we have encountered an interesting article by Dimopoulos (35) who proposed the ability to intraoperatively predict the possibility of postoperative cauda equina syndrome by using intraoperative somato-sensory evoked potentials monitoring. However, he reported this in two cases only and emphasized on the need to further investigate this matter.

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