Management of Cervical Myelopathy

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Abstract

Conservative management has limited role in established cases of cervical myelopathy. However intervention during early stages of the disease when there are minimal symptoms is still controversial. Conservative management in CSM has poor prognostic factors such as presence of myelopathy for more than 6 months, compression ratio of more than 0.4 (dividing sagittal diameter by transverse diameter) indicating severe compression of spinal cord and transverse area of cord less than 40mm2. Conservative treatment is aimed to prevent further neurological deterioration. As observed in the natural history studies, regression of myelopathy is highly unlikely. Surgical intervention is often pursued during the course of CSM depending on the progression of the condition. The degree of neurological recovery depends on pre-operative duration of symptoms. This review provides an overview of cervical myelopathy and focusses on the management and decision making aspect

Keywords: cervical myelopathy, surgical management, natural history

Introduction

Cervical spondylotic myelopathy (CSM) is a commonly encountered spinal disorder often requiring surgical intervention. It is a chronic condition affecting middle to elderly aged people but as an acute disorder can be seen at any age group. The true incidence of CSM is difficult to assess due to minimal findings in the early stages of the disease and findings observed in CSM can be ascribed to old age. However according to New et al, degenerative disease of spine contribute about 59% of non-traumatic spinal cord injuries in Japan, 54% in United States, 22% in Australia, 30% in Africa and 31% in European Continent. The prevalence of cervical myelopathy leading to spinal cord injury was observed to be 605 per million in North America, 1120 per million in Canada and 2310 per million in Kashmir region of India.

Natural Course: Does duration of symptoms has an impact on neurological recovery?

Onset of symptoms in the condition is usually insidious leading to static disability and episodic worsening of events. In an attempt to describe the natural course of CSM, Clark et al followed up 120 patients of CSM and observed 5% showed rapid progression of disease, 20% showed insidious decline in functional status without any periodic exacerbations and 75% showed stepwise deterioration in neurological status with episodic worsening of events. Similarly Lees and Turner stated that CSM has a protracted symptomatic course comprising of stable symptoms for a longer duration followed by periodic exacerbations. They also observed that presence of myelopathy for more than six months has poor neurological prognosis even after surgical intervention. Once affected, reversal of symptoms or return to normal neurological condition is uncommon. Hence delay in diagnosis may cause irreversible damage to the spinal cord. In a retrospective study by Nurick et al, concluded that disability in spondylotic myelopathy tended to progress in people above 60 years. The natural history of myelopathy is not completely explored even in the modern literature since surgical intervention is necessarily a part of the treatment to improve the neurological prognosis. Also strong evidence exists regarding the timing of the surgical intervention where surgery within six months from onset of symptoms greatly improves prognosis in CSM.

Clinical Features:

Clinical diagnosis of CSM can be difficult because of variations in clinical presentation.

Symptoms of CSM can be divided into two categories:

1. Caused due to focal compression i.e. radiating pain and neurological deficit limited to single nerve root.
2. Long-tract symptoms i.e. pathological reflexes, bowel and

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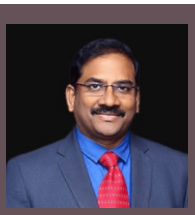

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Table 1: Genes correlating with development of CSM		
1.	Hormonal	Vitamin D receptor
2.	Structural	Collagen IX
3.	Other	Apolipoprotien E

Table 2: Poor Prognostic factors for conservative treatment in CSM	
1	Presence of myelopathy for more than 6 months
2	Compression ratio of more than 0.4
3	Transverse area of cord less than 40mm ^{2}

bladder dysfunction.
Clinical findings vary depending upon the region of the cord primarily involved. Sensory symptoms may arise due to compression either at spinothalamic tract (affecting contralateral pain and temperature) or posterior column (affecting ipsilateral position and vibration sense causing gait disturbances) or dorsal root compression (affecting individual dermatomal sensation). The condition typically shows lower motor neuron signs at the involved cervical region causing hyporeflexia with weakness in upper extremities and upper motor neuron signs below the affected cervical region causing hyperreflexia with spasticity of upper extremities.
Genetics: Does genes predispose to development of cervical myelopathy? Although much literature exists on genetic basis of degenerative disc disease (DDD) and ossified posterior longitudinal ligament (OPLL), focus on CSM is relatively little when compared to the above two [Table 1]. Also most of the studies conducted on genetic association of CSM belong to the Asia region thereby limiting global speculation on the subject.
According to Wang et al, vitamin D receptor (VDR) gene polymorphism is closely related to presence and progression of CSM in Chinese individuals(1). In a study by Setzer et al, apolipoprotein E (APOE) allele E4 is an independent predictor for occurence of CSM in patients with canal compromise(2). Erwin and Fehlings studied and summarised the association of various genes with CSM. They concluded that genes related to VDR and collagen IX have been associated with both CSM and DDD, indicating their importance in natural course of CSM development (6). In contrast many genes are associated with OPLL which includes collagen 11A2 (COL11A2), BMP-4, nucleotide pyrophosphatase (NPPS), TGF-1, TGF-3 ESR1, IL-1B, and retinoic X receptor (3-5).

Management of CSM:
Conservative management has limited role in established cases of cervical myelopathy. However intervention during early stages of the disease when there are minimal symptoms is still controversial (7). Conservative management in CSM has poor prognostic factors such as presence of myelopathy for more than 6 months, compression ratio of more than 0.4 (dividing sagittal diameter by transverse diameter) indicating severe compression of spinal cord and transverse area of cord less than 40mm2 (Table 2)(13). Conservative treatment is aimed to prevent further neurological deterioration. As observed in the natural history studies, regression of myelopathy is highly unlikely. Surgical intervention is often pursued during the course of CSM depending on the progression of the condition (8-12). Goals of surgical intervention in CSM is widening of spinal canal through decompression, stabilisation of spinal column and realignment of sagittal balance.

Factors influencing surgical outcome:
The degree of neurological recovery depends on pre-operative duration of symptoms. Tanaka et al observed this association and concluded that pre-operative duration of symptoms strongly influenced functional recovery after surgical management (15). Suri et al noted similar observation in patients with symptoms of duration less than 1 year had greater neurological recovery (16). Severity of symptoms also plays a major role in predicting outcomes following surgery. According to Bernard et al patients with severe disability and longer duration of pre-operative symptoms had poor outcomes following decompression (17). The degree of neurological recovery is also influenced by age of the patient at the time of onset since elderly patients have higher incidence of new neurological dysfunction arising from other sources (18). Favourable surgical outcomes include duration of symptoms less than 6 months, positive Lhermitte sign, pathological involvement of single vertebral segment, and presence of unilateral symptoms (Table 3) (14).

Table 3: Clinical factors for successful surgical outcomes in CSM	
1.	Presence of myelopathy for less than 6 months
2.	Presence of Lhermitte sign
3.	Pathological involvement limited to single vertebral segment
4.	Presence of unilateral symptoms

Table 4: Radiological factors affecting surgical outcome	
1.	Hyperintensity on T2 WI
2.	Hypointensity on T1 WI
3.	Combined signal changes on T1 & T2 WI
4.	Number of segments with high signal intensity on T2 WI
5.	Presence of Myelomalacia

Table 5: Factors which may influence the choice of approach	
1.	Sagittal alignment of spinal column
2.	Number of vertebral segments involved
3.	Presence of axial neck pain
4.	Location of compression
5.	Presence of previous surgeries

Table 6: Indications for Posterior approach in management of CSM	
1.	Congenital Cervical Stenosis
2.	Presence of OPLL
3.	Multi-level cervical degeneration
4.	Compression caused due to ligamnetum flavum

Radiological factors also influence the post-operative functional recovery. Patients with narrowing of spinal canal to less than 10mm are considered to be suffering from absolute stenosis. T2 weighted image (T2WI) is of high value in myelopathy since the area of maximum cord compression may be manifested by high signal intensities. These hyperintense signals represent presence of intraspinal edema which is referred to as myelomalacia. Presence of myelomalacia is associated with greater degree of disability and poor neurological recovery after decompression. According to Uchida et al, low signal intensity on pre-operative T1 WI but not in T2 sequence is associated with poor neurological recovery after surgery. They also stated that decreased signal intensity in T1WI and increased signal changes in T2WI were predictors of poor neurological outcome (19). Similar observation was reported by Al-Habib et al where less defined T2WI and wider spinal canal were regarded as good prognostic factors for regaining independent walking (20). In a retrospective study by Aria Nouri et al, T1 WI signal hypointensity and degree of maximum canal compromise were strong predictors of postsurgical outcome at 6 months. Another statistical review study was done recently by the same group based on AOSpine data. They reported that C5-C6 is the most commonly involved and most frequent compressed site in degenerative CSM followed by C4-5, C3-4 and C6-7. However maximum number of compression levels was three corresponding to the findings of Northover et al. Lindsay et al based on systematic review concluded that number of high signal intensity changes in T2 WI, combined T1 and T2 signal changes and signal intensity ratio were negative predictors of surgical outcome(Table 4). Takehiro Uda et al analysed the quantitative diffusion parameters of mean diffusivity (MD) and fractional anisotropy (FA) using diffusion tensor imaging (DTI). They concluded that presence of myelopathy can be strongly predicted using DTI with MD z score at maximum compressed level. In a series on 26 CSM patients, MD z score of 1.40 was considered to be the best diagnostic cut off value with 100% sensitivity and 75% specificity.

Early versus Late decompression in CSM – Delayed surgical decompression in CSM results in increased cytokine production followed by sustained astrogliosis and sustained increase in ratio of inflammatory/patrolling blood monocytes. These pathological changes were believed to result in poor neurological recovery of the patient.

Type of OPLL affecting surgical outcome – OPLL is categorised into continuous type, segmental type, mixed type and complex type. Few authors believe that segmental type of ossification is associated with poor functional and neurological outcome. According to Nakashima et al, hill shaped OPLL have worse postoperative JOA score when compared with plateau shaped OPLL after laminoplasty.

Indications for surgical intervention – Okada et al used gait disturbances as primary indication for operative management. Wada et al recommended constellation of clinical symptoms like gait disturbances and loss of fine motor control along with JOA score of less than 13 for determining need for operative intervention. Post-operative functional outcomes of CSM were also assessed by JOA myelopathy scale with score of 17 reflecting normal function.

Operative treatment starts with choice of approach either anterior or posterior or combined. Widening of spinal canal by decompression should be the primary goal of the intervention regardless of the approach chosen. Adequate decompression leads lo expansion of spinal canal which results in increased blood flow to the cord.

Surgical Approach: surgical approach is affected by various factors as mentioned in table 5. Following are the approaches used

Anterior Approach:

Sagittal alignment is an important factor when deciding on anterior versus posterior approach. Cervical kyphosis with or without instability is an absolute indication for anterior approach. Few authors observe pre-operative axial neck pain as relative indication for the approach. In a patient with cervical kyphosis, decompression through posterior approach will destabilise the entire cervical spine leading to progression of the deformity. Yonenobu et al suggested that anterior approach should be the approach of choice if number of pathological vertebral segments is limited to three and

posterior approach should be considered when more than four levels are involved. Two surgical techniques are described with this approach:

1. Anterior Cervical Decompression and Fusion (ACDF) – ACDF is regarded as one of the safest procedures for ventral cervical pathologies. Acute disc herniation and degenerative spondylotic changes limited to disc level are an absolute indication for this procedure. Presence of osteophytes will raise a discussion on its removal during surgery. Robison et al reported that osteophytes will resorb and remodel once solid fusion is taken place. Bohlman et al observed similar findings with 16 of 17 patients experiencing improvement in functional status. In contrast to the above studies, Stevens et al reviewed 12 year follow up CT myelograms of patients who underwent ACDF and concluded that no patient had any osteophyte resorption. They recommended removal of all osteophytes to improve the functional status of the individual.

Zhang et al observed more than 90% improvement in neurological outcome following ACDF. Difference in fusion rates were attributed to the type of graft used in the surgery. They reported that 85% fusion rates were observed with usage of autograft whereas only 50% fusion rates were observed with allograft. Yang et al reported similar observation with 37% pseudoarthrosis rate with usage of allograft but at final follow up, improved functional status was noted in 90% of patients (n=214). In a retrospective evaluation by Irvine et al 78% of the patients who underwent ACDF for CSM had improved ability to ambulate while 9% experienced deterioration of symptoms.

Bohlman et al compared the arthrodesis rate after ACDF without instrumentation. They reported 89% fusion in single level pathology, 73% fusion in double and three level pathologies. Lower fusion rates in the series were attributed to the increase in number of fusion levels. In a series by Emery et al, 13 of 45 patients who underwent ACDF for CSM developed non-union. Similar to conclusion of Bohlman and colleagues, lower fusion were observed when the number of fusion interfaces increased. Other approach related complications are dysphagia, injury to recurrent laryngeal nerve, esophageal injury and injury to cervical sympathetic ganglion leading to Horner syndrome.

2. Anterior Cervical Corpectomy and Fusion (ACCF) - Corpectomy has been described as a hybrid decompression which refers to removal of vertebral body along with its adjacent discs thereby facilitating complete removal of osteophytes. Indications for ACCF include compression behind the vertebral body, cervical kyphosis and CSM associated with OPLL. ACCF can be said as the choice of procedure when multi-level cervical decompression (more than 3 levels) is required. In a series by Bernard et al, 76% had improved functional status with no reported pseudoarthrosis after three years of ACCF. Jamjoom et al had similar results with 96% fusion rate and 84% of improved functional outcome. Both the series had complications of 1 and 3 graft dislodgements respectively. Emery et al performed ACCF in 58 of 108 cases with CSM and reported only 5% rate of pseudoarthrosis at final follow up. According to Zdeblick et al. ACCF is safe and effective procedure in patients affected from multi-level CSM with cervical kyphosis.

Vaccaro et al reviewed cases of instrumented ACCF with autologous strut graft and noted 9% pseudoarthrosis in two level corpectomies which increased to 50% in three level corpectomies. Similarly, Sasso et al reported 6% failure of fusion in two level corpectomies and 71% failure rate in three level corpectomies. In comparative analysis by Hilibrand et al, fusion rates were 93% in ACCF group whereas 66% in ACDF group. Swank et al compared the results between two level ACDF and single level subtotal corpectomy groups where a midline trough is created in the vertebral body with removal of adjacent discs. Two level ACDF groups had 64% fusion rate whereas single level corpectomy groups had 90% union rate. Similarly three level discectomy group had 46% fusion rate whereas two level corpectomy group had 56% fusion rate. All these studies imply the same statement that increase in the number of fusion levels increase the rates of failed fusion.

Graft dislodgment is a commonly reported complication with ACCF. To reduce the incidence of this complication, additional support through anterior plate fixation is suggested. This additional anterior instrumentation may act as a buttress in avoiding graft dislodgement. However it does not completely avoid the graft dislodgment. In a series by Sasso et al, five of seven patients who underwent ACCF with anterior plate fixation had migration of graft anteriorly. Other reported complications of ACCF are injury to vertebral arteries, fractures of autologous strut graft, post-operative neurological deficit, adjacent segment ossification and post-operative C5 palsy.

Posterior Approach:

Posterior approach has been described as a safe and effective option in the management of CSM (Table 6). Posterior approach results in spinal canal decompression through two different mechanisms – direct and indirect. When the structures causing compression is on the dorsal aspect it results in direct decompression but when the causative structure is in the ventral aspect, decompressing through posterior approach causes widening of the spinal canal through indirect mechanism. One of the pre requisite for deciding on posterior approach is maintenance of normal cervical lordosis or neutral sagittal alignment. In kyphotic cervical spine the degenerative bony elements do not allow the spinal cord to fall back into lordosis. Hence even after posterior decompression, spinal cord remains hanging around the anterior compressive structures. Average adult lordotic curvature from C2 to C7 is 14.4 degrees. Maintenance of at least 10 degrees of cervical lordosis is required for considering posterior approach in CSM. Laminectomy and Laminoplasty are the two techniques of decompression performed through posterior approach.

1. Laminectomy with/without fusion- Decompressive laminectomy is performed in patients with multi-level cervical myelopathy. It results in posterior backward shift of spinal cord thereby providing indirect decompression. When associated radicular symptoms are present, cervical foraminotomy can be performed to decompress the involved nerve root. Any adjacent segment with radiographic evidence of stenosis should be included in decompression. According to Kato et al progression of disease at adjacent segments not involved in decompression lead to recurrence of symptoms. Kaptain et al stated that limiting the number of decompressive segments did not influence the development of post laminectomy kyphosis or instability. Any associated instability warrants additional posterior cervical fixation to provide stability for spinal column. Supplementation with instrumentation was found to be beneficial in terms of maintaining cervical lordosis. With introduction of lateral mass screws, wiring technique has become obsolete as they are biomechanically superior to the latter technique. Snow et al reported 77% improvement in neurological outcome following laminectomy in 90 patients. Huang et al reported similar observations with 22 of 32 patients experiencing improvement in functional status after laminectomy and lateral mass fixation. In a post-operative MRI analysis by Sekhon et al absence of compression at operative levels was observed in 100% of the cases. Laminectomy in cervical lordosis versus kyphosis – Few authors state that maintenance of cervical lordosis is a pre-requisite for performing laminectomy, but of late different opinions have been raised creating a controversial matter of discussion (21-26). Akshay jain et al in a retrospective analysis, compared results of laminectomy for CSM in patients with lordotic curvature and with those with segmental kyphosis (27). Laminectomy was performed in 32 CSM patients with cervical kyphosis and in 36 CSM patients with cervical lordosis. They concluded that laminectomy performed in CSM patients with apical kyphosis (kyphosis between C2-C7 in middle of overall lordosis) has good functional and radiological outcomes after long term final follow up. Kaptain et al studied the outcomes of laminectomy in lordotic and neutral or kyphotic cervical spine. They reported 14% of lordotic patients and 30% of neutral/kyphotic patients developed progressive kyphosis, however none of the patients had any impact on functional outcome (28). Development of new onset neurological deficit following laminectomy is not uncommon. It may result due to iatrogenic injury to nerve root or to the spinal cord itself. Yonenobu et al in a series of 85 patients observed 3.5% incidence of new onset post-operative neurological deficit. Dai et al reported 13% incidence of new onset post-operative radiculopathy. Decompression often requires removal of important static and dynamic stabilisers of spinal column. This in turn leads to instability followed by post-operative development of sagittal imbalance. To avoid this complication few authors recommend performing concurrent instrumented fusion along with laminectomy.

2. Laminoplasty – Laminoplasty is also a well suited option for multi-level CSM. Goal of the procedure is to permit expansion of spinal canal with maintenance of cervical sagittal alignment through preservation of posterior elements. Indications for the procedure include congenital stenosis, multi-level CSM, OPLL in lordotic cervical spine. According to Pal et al 36% of load transmission is through anterior column and 64% of load transmission is through posterior column. This observation shows the importance of maintaining posterior column integrity. Instability is very rarely reported after laminoplasty as all the static and dynamic restraints are well preserved during the procedure.

Open door laminoplasty was first described by Hirabayashi et al where

a bone hinge is developed on one side and lamina is detached on the other side thereby allowing expansion of spinal canal at multiple levels. As canal is entered from lateral most part of the cord, injury to the cord tends to be least. However the procedure has its own set of disadvantages comprising of premature closure of the hinge causing further neurological deterioration (spring back phenomenon). To avoid this phenomenon various techniques have been described such as suturing of spinous process to facet capsule on hinge side, placing contoured strut graft on the detached side, maintaining canal patency through specialised plates and screws. French door laminoplasty was described by Kurokawa et al where spinous process is split in the midline before hinging bilaterally at lamina lateral mass junction. To maintain the patency of expanded spinal canal, strut grafts are placed in the gap between the expanded hemilamina. Few authors reported decreased blood loss for french door laminoplasty attributed to paucity of blood vessels in the midline. Complications of the procedure include spring back phenomenon, post-operative motor root palsy due to strut graft dislodgement and C5 root palsy.

Hirabayashi et al reported 54% improvement rate at 3 year follow up after open door laminoplasty whereas 61% recovery rate was observed by Satomi et al over an 8 year follow up after French door laminoplasty. Multiple studies have reported an increase of JOA myelopathy score from 8.7±0.4 to 12.7±1.0.

Focal decompression versus long posterior decompression – The hypothesis that "backward shifting of spinal cord after posterior decompression has a positive impact on surgical outcome" remains controversial. Shiraishi et al developed several minimally invasive procedures for CSM such as skip laminectomy, selective laminoplasty and interlaminar decompression. These procedures were developed based on the pathogenesis that compressions in the spinal cord in CSM takes place at intervertebral level and structures responsible for these compressions are hypertrophied ligamentum flavum and upper edge of bony lamina. These procedures have been reported to have resulted in satisfactory neurological recovery 2years after surgery. Similarly, Yoichiro Hatta et al concluded that limited and selective decompression of spinal canal in CSM is a beneficial alternative to extensive decompression. According to Nader et al, minimally invasive endoscopically assisted decompression of stenosis is a viable

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References of this article are available in the online version of the article

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