Amyotrophic Lateral Sclerosis and Motor Neuron Disease

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Introduction

Motor neuron diseases (MNDs) are a class of progressive neurodegenerative disorders affecting motor neurons resulting in weakness, spasticity, and atrophy of innervated muscles. Most common and familiar of this group is amyotrophic lateral sclerosis (ALS). As a class, MNDs are heterogeneous, occurring at varying rates, ages of onset, and disease severity. Furthermore, most have little to no inheritable contribution, while a minority are genetically linked. Manifestations reflect preferential involvement of upper and/or lower motor neurons and spinal and/or bulbar tracts. Clinical features commonly include limb weakness, poor articulation, swallowing impairment, and breathing derangement. Individualized evaluation and management of MND is important but can be challenging as phenotypes differ among subtypes and invariably fluctuate throughout disease evolution. Because they are uniformly progressive and fatal, early and accurate assessment, open communication, and shared decision-making are imperative.

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Epidemiology

As a class, MNDs are relatively rare, occurring with an incidence of approximately 2 in 100,000 people and affect men slightly more than women, at a ratio of 1.4:1 [1]. The most common MND, ALS, occurs in up to 3 out of 100,000 people, and in some parts of the world, the terms MND and ALS are used interchangeably. Age of onset varies across MND subtypes and also within certain diagnoses. Some features of MND including early age at onset, female gender, and initial presentation with bulbar symptoms (e.g., dysarthria, nasal regurgitation, dysphagia, dysphonia) seem to predict worse disease severity and more rapid progression, particularly in ALS [2, 3]. Awareness of such predictors allows for earlier, prophylactic interventions such as enteral feeding.

The etiology of MND is broad and likely multifactorial. MND may be acquired through environmental exposures, genetic predisposition, or contributions from both. Although no one environmental exposure has been definitively associated with MND, there are several studies associating physical and psychological stress, environmental toxins, cigarette smoking, autoimmune attack, and history of military service with the development of MND [4–6].

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Genetics

MND subtypes can be classified as inherited or largely sporadic (Table 11.1). Inherited forms of MND include spinal and bulbar muscular atrophy (SBMA), spinal muscular atrophy (SMA), and hereditary spastic paraparesis (HSP). Additionally, up to 10% of ALS cases are familial. Sporadic forms of MND include most cases of ALS, primary lateral sclerosis (PLS), progressive muscular atrophy (PMA), and progressive bulbar palsy (PBP).

Pathophysiology

MNDs are a varied group of progressive neurologic disorders characterized by degeneration of upper motor neurons (UMNs), lower motor neurons (LMNs), or a pattern of both. UMNs are either pyramidal or extrapyramidal and originate in the motor region of the cerebrum, specifically along the fifth layer of the cerebral cortex housed in Betz cells [7]. Alternatively, LMNs originate in the alpha motor neurons of the gray matter in the brainstem and spinal cord. UMNs carry out their effect on LMNs, controlling voluntary muscle groups.

Key pathologic features of MND result from involvement of the brain and anterior horn cells of the corticospinal and corticobulbar tracts producing deleterious effects on the neuromuscular skeletal system. Frequently this manifests as unilateral, progressing to bilateral, upper or lower limb dysfunction. The deterioration of corticobulbar pathways to IX, X, XI, and XII cranial nerve nuclei greatly impacts the complex, coordinated control of speech and swallowing. Particularly harmful are impairments of the vagal and glossopharyngeal nerves as they are responsible for the motor and sensory innervation to the larynx and pharynx [8].

Clinical presentation of MND depends on the pattern of motor neuron involvement. When UMNs are affected, muscle spasticity, brisk reflexes, and overall slowing are observed. When LMN involvement predominates, muscle weakness, atrophy, and fasciculations are seen. Many MNDs are characterized by the affliction of both upper and lower motor neurons, thereby manifesting clinical features of both. The most common MNDs and their defining characteristics are detailed in Table 11.1.

Common Motor Neuron Disease

Inherited MND

Spinal and bulbar muscular atrophy (SBMA) or Kennedy disease is an adult-onset X-linked MND affecting bulbar and LMNs. Individuals with SBMA are exclusively male and may present

Table 11.1 Common motor neuron diseases

Motor neuron disease	Classification	Age of onset	UMN	LMN	Bulbar involvement
Spinal and bulbar muscular atrophy (SBMA)	Inherited	15–60 years	–	+	+
Spinal muscular atrophy (SMA)	Inherited	<6 months–30s	–	+	+/–
Hereditary spastic paraparesis (HSP)	Inherited	Across lifespan	+	+/–	+
Primary lateral sclerosis (PLS)	Sporadic	40–60 years	+	–	+
Progressive muscular atrophy (PMA)	Sporadic	Across lifespan	–	+	+
Juvenile amyotrophic lateral sclerosis	Sporadic	<25 years	+	+	+
Progressive bulbar palsy (PBP)	Sporadic	50–80 years	+	+	+
Amyotrophic lateral sclerosis (ALS)	Sporadic 5–10% inherited	40–60 years	+	+	+/–

UMN upper motor neuron, *LMN* lower motor neuron
"+" characteristic; "–" not characteristic; "+/–" sometimes present

with similar phenotypes as their brothers, fathers, or uncles. Common features include slowly progressive bulbar and spinal muscular atrophy resulting in limb and facial weakness, dysphagia, and dysarthria. Less common but a feature unique to Kennedy disease is a propensity for laryngospasm, informally referred to as "dry drowning [9]." The diagnosis of SBMA is confirmed by molecular genetic testing for CAG trinucleotide repeat expansion on the androgen receptor of the X chromosome. Point mutations within the androgen gene receptor confer androgen insensitivity, resulting in infertility, testicular atrophy, and gynecomastia. These features distinguish Kennedy disease from all other MNDs [10].

Spinal muscular atrophy (SMA) is an autosomal recessive LMN disease and is the most common genetic cause of death in children less than 2 years old. The pathogenesis involves the loss of a specific protein, survivor motor neuron 1, which results in poor muscle tone. Proximal muscle weakness is much greater than distal and, in severe cases, results in fatal respiratory failure. There are four types of SMA, defined clinically by age of onset and most advanced motor milestones achieved. The first molecular genetic target for SMA, nusinersen (Spinraza®, Biogen Netherlands, Badhoevedorp, the Netherlands), was approved by the US Food and Drug Administration (FDA) in 2017. Early studies have demonstrated children treated with nusinersen have improved motor strength and manifest a milder disease phenotype. Type I SMA occurs in children less than 6 months old and is also known as Werdnig-Hoffmann disease. Infants with SMA Type I never sit and require gastrostomy tube feeding and tracheostomy to prolong life. SMA Type II, Dubowitz disease, occurs later than SMA Type I, between the ages of 6 and 18 months. These children sit but never stand. SMA Type III is juvenile in onset and known as Kugelberg-Welander disease. These children walk but eventually regress and may require a wheelchair. Type IV is adult-onset SMA, a milder phenotype.

Hereditary spastic paraparesis (HSP) is a primarily UMN disease involving the posterior column of the spinal cord and bladder. The prevalence of HSP is 1.3–9.6 per 100,000, and the inheritance pattern is variable including autosomal dominant, autosomal recessive, or X-linked [11]. Over 15 genes have been associated with HSP; therefore the phenotype can be quite diverse. Key features are progressive lower extremity greater than upper extremity spasticity, weakness, cerebellar ataxia, neurogenic bladder, and peripheral neuropathy [12, 13]. Dysarthria and dysphagia are less common, usually seen in atypical forms of HSP, and the exact mechanism is unknown [14].

Sporadic MND

Sporadic MNDs are a spectrum of mainly adult-onset diseases of which ALS is the most common, accounting for approximately 80% of MNDs [15]. Atypical variants including primary lateral sclerosis (PLS), progressive muscular atrophy (PMA), progressive bulbar palsy (PBP), and juvenile amyotrophic lateral sclerosis are less common and less severe.

Sporadic ALS involves both UMNs and LMNs. It has an incidence of 1–2.6 per 100,000 persons with the average age of onset of 58–60 years [1, 5, 16]. The average survival from symptom onset is 3–5 years with only 20% of patients surviving beyond 5 years and fewer than 10% surviving beyond 10 years [17]. The etiology of ALS is not entirely clear.

The development of ALS is theorized to be multifactorial and acquired through environmental exposures, cellular oxidative stress, excitotoxicity, and mitochondrial dysfunction leading to cell death [5, 16, 18–20]. Up to 10% of ALS cases may have genetic associations. Most commonly, mutations in well-characterized proteins, C9ORF72 and superoxide dismutase 1 or SOD1, are associated with both familial and sporadic forms of ALS. Owing to the increased applications of molecular genetic testing, the genetic influences on sporadic MND will be more transparent in the future.

Symptoms at disease onset include progressive, painless weakness, often with a distinct and predictable spread throughout the body. The initial weakness pattern can be divided into thirds

with approximately one-third bulbar, one-third upper extremity, and one-third lower extremity [21–23]. Bulbar presentation is associated with poorer prognosis [24].

Communication, Swallowing, and Respiratory Findings

Involvement of the corticospinal and corticobulbar tracts, in particular the nuclei of cranial nerves V, VII, IX, X, and XII, yields clinical signs of dysarthria, dysphonia, dysphagia, and dyspnea. Bulbar manifestations may occur in isolation or in combination with limb symptoms. Patients often present to otolaryngologists or other specialists prior to correct disease diagnosis which may result in delayed identification of MND [17]. Diagnosis relies on building a clear clinical impression and may take time, ruling out other possible causes. Ancillary testing including lab work, electromyography (EMG), MRI, and muscle biopsy may confirm a suspected diagnosis. Among MND subtypes, swallowing impairment occurs in up to 100% of patients leading to significant morbidity and mortality [7]. Although dysarthria and dysphonia are also common among MND, the underlying mechanisms are not as clearly defined and are often reticent as compared to respiratory comorbidities. Cognitive abnormalities, depression, and emotional lability commonly coexist with MND with up to 50% of patients demonstrating some degree of impairment which may further contribute to alterations in communication and deglutition [25].

Communication

Communication impairment is a significant source of distress, isolation, and altered quality of life in MND patients. Abnormalities of voice, the sound produced by the larynx, and speech, the sound ultimately modified by the upper airway and oral cavity, are common in MND. In ALS, dysarthria is more common than dysphonia, each occurring in up to 93% and less than 50% of patients, respectively [17]. Table 11.2 highlights features of both dysphonia and dysarthria in MND.

Table 11.2 Features of voice and speech impairment in motor neuron disease

Dysphonia	Dysarthria
Spastic	Slow
Harsh	Labored
Breathy	Disarticulate
Fatiguing	Imprecise
Monotone	Hypernasal

Voice quality varies depending on predominance of the upper vs. lower motor neuron involvement. Spastic dysphonia is a manifestation of UMN involvement with a voice that sounds tight, harsh, and strained which is easily fatigued. LMN disease is accompanied with breathy or weak dysphonia and limited ability for rapid vocal changes resulting in monotonicity or monoloudness [15].

Speech in MND is influenced by both upper and lower motor neuron manifestations. UMN involvement results in stiffening of oral cavity muscles including the tongue and lips. Resultant dysarthria is slowed and hypertonic and lacks precision. LMN involvement may start as unilateral and then progress to bilateral and includes low tone, atrophy, weakness, and fasciculation of oral cavity and oropharyngeal muscles. Tongue fasciculations are one of the most common signs of ALS presenting to otolaryngologists [17]. Dysarthria is characterized by quietness, huskiness, and slurring. Speech may also be hypernasal due to involvement of muscles innervating the soft palate which creates velopalatal insufficiency, though this scenario is not consistent across MND [26].

Swallowing

At onset of most MND, swallowing function is often preserved. However as disease progresses, dysphagia becomes increasingly common, ultimately reported by up to 90% of MND patients [27]. MNDs with initial presentation limited to dysphagia or dysphonia are likely to present first to an otolaryngologist or speech language pathologist. In a large cohort of ALS patients in otolar-

yngology practice, 86% reported dysphagia. In comparison with rates, dysphagia in PBP and PMA were 89% and 45%, respectively [28].

All phases of swallowing are affected by MND. Presenting symptoms may be purely UMN or LMN or a combination of both. With disease progression, both UMNs and LMNs are often affected leading to severe dysphagia, often requiring a gastrostomy tube to meet nutritional needs. Table 11.3 details abnormalities of various components of swallowing observed in MND.

Oral cavity structures affected by MND include the lips, tongue, and masticatory muscles. Muscle atrophy and weakness as well as tongue fasciculations are observed. Oral phase dysfunction may manifest as drooling, difficulty chewing, and mealtime fatigue. Such oral impairments are commonly seen in SBMA but are slowly progressive and may not develop until as late as 10 years after disease onset. In these patients, reduced tongue pressures may be an early indicator of swallowing dysfunction.

Pharyngeal structures involved by MND include the palate, pharyngeal constrictors, and cricopharyngeus muscle (CPM). Clinically, dysphagia to liquids and nasal regurgitation, which are attributed to LMN degeneration, generally arise before difficulty with solids. The typical pharyngeal manifestation of UMN involvement is CPM dysfunction. Pharyngeal phase impairments result in reduced swallowing efficiency and compromised airway protection. In early onset SMA, oropharyngeal weakness leads to dysphagia secondary to impaired pharyngeal clearance evidenced by post-swallow vallecular and hypopharyngeal residue commonly identified during videofluoroscopic swallow study (VFSS). Combined with neck extensor weakness and resultant forward head posture, such patients are predisposed to aspiration pneumonia. Gastrostomy tubes are universally required for these patients to maintain nutrition and mitigate pulmonary disease [29].

Esophageal dysphagia related to MND is less completely described owing to upstream (oral and pharyngeal) deficits which make characterization of esophageal phase impairments challenging. Prolonged esophageal transit has been identified in PBP and PLS and is an isolated finding in patients with PMA [30–32].

Laryngopharyngeal sensory abnormalities, particularly of the supraglottis, magnify the effect motor deficits and have been observed in up to 54% cases of ALS [33]. Undoubtedly such impairment contributes to the well-described and considerable sequalae of swallowing dysfunction in MND including dehydration, malnutrition, pneumonia, social isolation, fear, and anxiety. And for ALS patients, aspiration pneumonia is a leading cause of death [34].

Respiratory

Further compromising lung health is weakening of intercostal and diaphragm muscles leading to respiratory compromise and ineffective cough. For fatal MND, respiratory failure is a frequent cause of demise, and shared discussions surrounding the use of mechanical ventilation or artificial airway (tracheostomy) should take place early in the disease course.

Table 11.3 Features of swallowing impairment in motor neuron disease

Oral phase	Pharyngeal phase	Esophageal phase	Sensation and timing
Drooling	Reduced tongue base retraction	Impaired stripping wave	Delayed swallow trigger
Spillage	Velopharyngeal incompetence	Prolonged transit	Multiple swallows
Poor bolus formation	Decreased hyolaryngeal elevation	Esophageal residue	Orofacial pain
Lingual weakness	Weak pressures		Delayed airway closure
Ineffective chewing	Vallecular residue		Aspiration
Prolonged mastication	CPM dysfunction		Impaired/absent cough
Mandible rigidity	Hypopharyngeal residue		
Oral cavity residue			

CPM Cricopharyngeus muscle

Evaluation and Assessment

Comprehensive evaluation and management of MND patients and the upper aerodigestive manifestations of their disease requires multidisciplinary care. The complete team is comprised of family members or caregivers, physicians (including otolaryngologist, neurologist, pulmonologist), speech language pathologist, dietician, therapist (physical, occupational, respiratory), and mental health professional.

A focused physical exam of MND patients includes a qualitative assessment of voice and speech. Furthermore, attention is paid to the integrity of oral cavity structures and cranial nerve function. Judgement of cognitive impairment is important and factors into decision making throughout the disease course. Indirect laryngoscopy, with stroboscopy when feasible, is performed to evaluate vocal fold motion, contour, and closure as well as laryngopharyngeal sensation, secretion management, and cough strength [15]. Common videostroboscopic findings in patients with MND include incomplete glottic closure, vocal fold bowing, hyperfunction, decreased abduction, pachydermia, and pooling [17]. Aerodynamic and acoustic measurements provide additional information regarding glottic incompetence, subglottic air pressure, velopharyngeal insufficiency, and intelligibility which may help guide appropriate therapies for dysphonia and dysarthria.

Disease- and symptom-specific outcome measures are useful tools for screening MND patients for deficits as well as for disease severity and progression. The most commonly used tool specifically designed for MND is the Amyotrophic Lateral Sclerosis Functional Rating Scale-Revised (ALSFRS-R). It is a four-domain instrument which measures bulbar, fine motor, gross motor, and respiratory function to a maximum score (best function) of 48 [35]. Items assessed include speech, salivation, swallowing, and respiratory insufficiency, and worse scores have been shown to predict laryngeal penetration in patients with ALS [36].

The Eating Assessment Tool-10 (EAT-10) and Swallowing-Related Quality of Life (SR-QOL) are symptom-specific, patient-reported outcomes measuring perceived swallowing function. Among ALS patients, the EAT-10 has high discriminant ability to predict aspiration with reasonable sensitivity and specificity of 86% and 76%, respectively, as well as a superb negative predictive value of 95% [36]. Furthermore, SR-QOL is moderately reduced in patients with ALS with the fatigue and eating duration domains most accurately reflecting degree of swallowing dysfunction [37].

Instrumental tools including VFSS, flexible endoscopic evaluation of swallowing (FEES), and high-resolution manometry (HRM) are well-established, validated methods for assessing swallowing impairment. Each provides valuable information about swallowing anatomy, physiology, efficiency, and safety, but as different assessment modalities, each offers certain advantages and has specific limitations. Table 11.4 reviews the ability of each VFSS, FEES, and HRM to assess swallowing function.

On VFSS, certain features common to MND-related swallowing impairment are well-visualized including incomplete velar closure, reduced tongue base retraction, and post-swallow pharyngeal residue. Furthermore, VFSS is an excellent tool for assessing and measuring hyolaryngeal elevation and its relationship to completeness and timing of laryngeal closure. This is particularly valuable in patients with MND who are at high risk of negative health sequelae related to unsafe swallowing [38, 39].

FEES is uniquely useful for assessing laryngopharyngeal anatomy, sensation, swallow onset, and pooling or residue. In ALS patients, residue on FEES predicts ALS clinical stage as measured by ALSFRS-R [40]. FEES is also a good tool for biofeedback and to evaluate the efficacy of particular swallowing maneuvers or strategies.

HRM, originally used primarily to assess esophageal phase of swallowing, has gained popularity in measuring more proximal, pharyngeal manometric and impedance information. For cases of MND, HRM very accurately detects abnormal pharyngeal pressures and variable CPM tonicity. Furthermore, manometry technology can be used to assess tongue pressure, which, in

Table 11.4 Comparison of instrumental swallowing assessments

Component evaluated	FEES	VFSS	HRM
Vocal fold function and anatomy	++++	++	+
Laryngopharyngeal sensation	++++	+	+
Spillage	++++	++++	+
Aspiration	++++	++++	+
Laryngeal penetration	++++	++++	+
Pharyngeal and vallecular residue	++++	++++	+
Cricopharyngeus muscle function	+	++++	++++
Pooling of secretions	++++	+	+
Objective swallowing parameters	++	++++	+++
Oral cavity	+	+++	+
Laryngohyoid elevation	++	++++	+++
Esophageal phase of deglutition	+	+++[a]	++++

FEES flexible endoscopic evaluation of swallowing, *VFSS* videofluoroscopic swallow study, *HRM* high-resolution manometry

"+" poor ability to evaluate; "++" average ability to evaluate; "+++" good ability to evaluate; "++++" excellent ability to evaluate

[a]with esophageal follow through

MND, shows reduced isometric strength as well as disorganized movement during swallowing.

Electromyography (EMG) and nerve conduction are often used to help confirm the diagnosis of MND. To assess specific components of swallowing or voice, the use of EMG has been largely experimental. EMG in ALS patients has demonstrated longer swallowing duration, variability in cricopharyngeal pause duration, and discoordination between the timing of laryngeal excursion and cricopharyngeal relaxation.

Additional useful tools for assessing the MND patient include spirometry and airflow measures. The finding of irregular voluntary cough airflow and altered respiratory-swallowing coordination predicts aspiration in patients with ALS [41].

Management and Therapies

Presently, there are no cures for MND. Two drugs approved by FDA—riluzole (Rilutek®, Sanofi Aventis, Bridgewater, New Jersey) and edaravone (Radicava®, MT Pharma America, a US subsidiary of Mitsubishi Tanabe Pharma)—have demonstrated small improvements in survival (2–3 months) and reduced clinical decline, respectively. Despite these promising developments, symptomatic management remains the primary focus of treatment for ALS and MND [42]. Because of the degenerative and progressive nature of these conditions, therapeutic approaches focus on patient autonomy and advanced planning toward end of life early in the disease course. Behavioral and lifestyle modifications orchestrated by occupational therapists, speech language pathologists, and respiratory therapists, among others, are mainstays for preserving quality of life and mitigating illness in MND.

Sustaining communication relies on enhancing a patient's own voice and speech or providing an alternative means of expression. Augmentative and alternative communication (AAC) devices are very commonly used in the MND population, and appropriate patients should be referred expeditiously for early integration [43]. On average, patients with ALS use such devices from 25 to 31 months depending on disease subtype. There are a range of devices available including non-keyboard technology (dynamic touch screen, head tracking, and eye tracking) which is often useful in later disease stages. With recent technological advanced, voice banking has emerged as a means to potentially personalize an individual's AAC experience.

In mild or less advanced MND, interventions specifically aimed at improving voice quality may be considered. For predominant UMN manifestations such as harsh voice and spasticity,

voice therapy may be useful for teaching volitional relaxation, breath support, and speech control. However, in LMN involvement and symptoms of hypotonicity, intensive voice therapy may be counterproductive due to increased effort required [26]. In patients who have coexisting glottic insufficiency, vocal fold augmentation may be an appropriate procedural intervention; otolaryngologists should evaluate for candidacy using clinical impression and videostroboscopy.

Appropriate instrumental evaluation of swallowing such as VFSS of FEES should guide interventions for feeding and diet allocation. As previously discussed, these evaluations are critical to establish swallowing safety and efficiency and are the foundation to personalize swallowing care throughout the course of disease. The decision to continue oral diet in patients with MND should be serially reevaluated and based on swallowing function, level of activity, nutritional status, pulmonary clearance, quality of life, and preestablished goals of care.

Commonly recommended diet modifications include mechanically altered foods, limited textures, smaller more frequent meals, supplemental nutrition, and thickened liquids if indicated. Where appropriate, patients are advised to reduce to bolus size, perform multiple swallows, alternate solids and liquids, and avoid distractions during mealtime. For some patients, the addition of enhanced sensory stimuli including thermal, vibratory, and gustatory may be considered. Most patients are recommended a set of compensatory strategies during swallowing to mitigate abnormalities identified during instrumental evaluation. Table 11.5 describes commonly used swallowing maneuvers and positions.

Table 11.5 Swallowing postures and maneuvers

Posture/ maneuver	Description	Therapeutic effect
Chin tuck	Chin is tucked toward the neck during swallow	Narrows entrance to airway by bringing tongue base to posterior pharyngeal wall and arytenoids to the epiglottis
Chin up	Chin is tilted up during the swallow	Facilitates bolus transfer from oral cavity to pharynx
Head turn	Head is turned to either the left or the right side, typically toward the damaged or weak side	Improves glottic closure, diverts bolus away from impaired side
Mendelsohn maneuver	When larynx is maximally elevated during swallow, patient holds larynx in elevated position for 2 seconds and then relaxes	Increases height and duration of hyolaryngeal elevation
Supraglottic swallow	Bolus is held in the oral cavity, and then breath is taken and held, followed by swallowing and then volitional cough	Triggers glottis closure prior to swallow
Super-supraglottic swallow	Similar to supraglottic swallow, except breath is held effortfully with Valsalva prior to initiating swallow	Triggers glottis closure and moves arytenoids anteriorly to close vestibule
Effortful swallow	Patient instructed to swallow as hard as possible, push hard with tongue against hard palate	Improves posterior tongue base movement during swallow

There are several rehabilitative strategies for impaired swallowing in MND. Whereas swallowing exercises are commonly employed across disease states and degrees, use in MND must be cautiously considered and continuously reassessed. In more advanced disease, engaging in effortful, repetitive exercise may hasten fatigue and be counterproductive toward swallowing function. Adjuvant devices (palatal prosthesis) are mainstays of treatment. Strategies aimed at enhancing breathing coordination and cough strength such as expiratory muscle strength training (EMST) have demonstrated improved maximum expiratory pressure, hyoid displacement, and laryngeal penetration and aspiration [44].

Medical and procedural interventions may be appropriate to target specific swallowing impairments. Velopharyngeal insufficiency is common

in ALS and presents a challenge for maintaining pharyngeal competence during swallowing and causes bothersome hypernasality of speech. Palatal interventions such as prostheses (palatal lift) and augmentation procedures improve hypernasality, articulation, and nasopharyngeal regurgitation in most patients with effects lasting longer than 6 months in most cases [45]. For MND patients with excessive drooling or difficulty managing secretions, therapies for saliva management are available. Medical options include anticholinergic drying agents as well as salivary gland botulinum toxin injection. For more severe cases, salivary gland diversion or excision may be considered.

For many with MND, progression of symptoms will render swallowing function unsafe and unable to meet nutritional demands. Enteral nutrition via feeding tube is the most common recommendation across all MND patients [38]. With this in mind, discussions regarding non-oral feeding should take place early so that personal wishes and goals of care may be established [46]. In patients who accept feeding tubes, early prophylactic placement is preferred so that respiratory capacity is maximized at time of surgery. Furthermore, mortality from feeding tube is influenced by degree of weight loss at time of tube placement with those losing >10% of diagnosis weight demonstrating poorer survival. Feeding tube use in MND has been extensively studied. Enteral feeding reduces risk of secondary health consequences, improves and maintains nutritional status, and enhances weight gain [47, 48]. However, whether feeding tubes prolong survival or positively impact quality of life is unknown and controversial [49]. Feeding tube-related complications including leakage, pain, irritation, bleeding, and infection are commonly managed conservatively, and rarely do MND patients undergo feeding tube removal [50].

Similar to the inevitability of enteral feeding for many MND patients, noninvasive ventilation (NIV) and tracheotomy with invasive mechanical ventilation (TMV) are common recommendations and considerations for those with or moving toward advanced disease. NIV improves forced vital capacity (FVC) on pulmonary function testing as well as survival. It may be initiated early (FVC > 80%) and has been demonstrated to offer more benefit to ALS patients without bulbar predominate symptoms [51]. Indications for TMV include respiratory failure (FVC < 50%), improved access for pulmonary clearance, and laryngeal obstruction, most commonly due to bilateral vocal fold immobility [15]. As with feeding tubes in MND, tracheostomy prolongs life and but has equivocal effect on quality of life [52]. Ultimately, fewer than 15% of ALS patients undergo tracheostomy. Morbidity of tracheostomy including mucus plugging, accidental decannulation, bleeding, infection, and airway stenosis dampens enthusiasm for its universal recommendation.

In patients who experience recidivistic aspiration pneumonia despite conservative efforts (enteral feeding, tracheostomy), consideration of functional laryngectomy may be appropriate. In otherwise healthy adults, the procedure is relatively safe, efficient, and completely effective at eliminating aspiration [53]. Appropriateness for laryngectomy should be considered in the context of overall quality of life, future prognosis, post-laryngectomy communication options, and access to psychosocial support.

Conclusion

As a group, MNDs are rare, but because they involve motor neurons of the corticobulbar and spinal tracts, they commonly manifest with disordered communication, deglutition, and respiration. Consequently, clinicians who evaluate and treat upper aerodigestive are anticipated to interface with this population. Symptom severity varies across MND subtype and disease stage with inevitable progression toward complete nutritional and respiratory support in the most advanced cases. Clinical phenotypes reflect the distribution of motor neuron involvement—whether upper or lower, spinal or bulbar. Accurate diagnosis and appropriate assessment rely on a cooperative multidisciplinary team, and it may require multiple evaluations before definitive conclusions can be made. In such cases,

screening tools may be useful in guiding additional testing and workup [54]. It is critical that candid conversations about disease course and expectations take place before significant progression in order to preserve patient autonomy. MND management involves treatment of symptoms when possible, prevention of negative disease sequelae, and, importantly, meeting the psychosocial needs of patients and their caregivers.

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