orphanaesthesia

Anesthesia recommendations for

Amyotrophic lateral sclerosis

Disease name: Amyotrophic lateral sclerosis

ICD 10: G12.2

Synonyms: Charcot disease, Lou Gehrig's disease

Disease summary: Amyotrophic lateral sclerosis (ALS) is a rare progressive, paralytic disorder characterized by degeneration of upper and lower motor neurons in the motor cortex, brainstem, and spinal cord. It represents the most common form of degenerative motor neuron disease [1-4]. Involvement of the upper motor neurons causes weakness, spasticity, hyperreflexia, and Babinski signs, whereas degeneration of the lower motor neurons results in weakness, muscular atrophy, fasciculations, and cramps [4]. Brainstem involvement may lead to bulbar symptoms.

The clinical course varies depending on the initially affected region and presenting symptoms, but respiratory failure is typically the final cause of death [5]. The worldwide incidence is approximately 1/50,000 per year, and the prevalence around 1/20,000. These rates are relatively uniform across Western countries, although higher frequency has been observed in the Western Pacific [6]. Both incidence and prevalence increase with age [1].

The mean age of onset for sporadic ALS is late 50s, while familial cases may present earlier. There is a slight male preponderance in sporadic cases (male to female ratio ~ 1.5-2:1), whereas familial cases show an equal distribution [1, 6]. Approximately 5-10 % of ALS cases are familial (typically autosomal-dominant inheritance), while 90-95 % occur sporadically. However, both forms are clinically indistinguishable [1, 3].

More than 40 genes have been associated with ALS, although the pathogenetic mechanism(s) remain unknown [7]. Interestingly, different mutations can result in distinct phenotypes (e.g., similar age of onset, site of onset, and disease duration), whereas identical gene mutations may lead to multiple phenotypic presentations [3]. Current research focuses on genes involved in cytoskeletal dynamics, protein and RNA homeostasis, and trafficking processes [1].

Environmental factors are believed to influence disease pathogenesis, though their precise roles are not yet clear. Reported risk factors include military service, different kinds of (head) trauma, smoking and exposure to heavy metals and pesticides [1].

ALS displays marked phenotypic heterogeneity with respect to onset, distribution, and neuronal populations affected, resulting in diverse clinical manifestations [1, 3, 8]. "Classical" ALS typically begins with focal limb weakness, progressing within weeks to months to involve most skeletal muscles. Notably, ocular and bladder muscles usually remain spared until late in the disease course [1, 3]. In addition to weakness, muscle atrophy, fasciculations, spasticity and hyperreflexia are common [8].

About one-third of patients initially present with bulbar symptoms such as dysphagia, dysarthria, drooling and slurred speech [1, 9]. Dysphagia may eventually lead to aspiration of liquids and solids [10]. Emotional lability caused by involvement of frontopontine motor neurons can manifest as pseudobulbar palsy, characterized by facial spasticity and inappropriate laughter or crying in response to minor emotional stimuli [1]. Up to 50 % of patients develop behavioral or cognitive changes, 5-15 % meeting the criteria for (frontotemporal) dementia [11].

Beyond “classical” ALS, several related motor neuron disorders within the ALS spectrum (“non-classical” or “atypical forms”) exist, including those with predominant upper or lower motor neuron involvement and slower progression, such as Primary Lateral Sclerosis (PLS) and Progressive Muscular Atrophy (PMA) [7]. ALS shows marked heterogeneity in the degree of upper and lower motor neuron involvement, affected regions, cognitive or behavioral changes, and rate of progression [3, 7].

The average time from symptom onset to diagnosis is approximately 12 months. Diagnosis is primarily clinical, supported by the Gold coast criteria (or the revised El Escorial and Awaji criteria), imaging (head, spine), electromyography, and laboratory testing to exclude alternative causes of paralysis [1, 7]. Disease progression and functional impairment can be monitored using the ALS Functional Rating Scale-Revised (ALSFRS-R) [4].

Currently, no curative therapy exists for ALS. Treatment options are usually palliative and focus on symptom control through interventions such as nasogastric feeding, speech-assistive surgery, cough-assist devices, diaphragmatic pacing, ventilatory support or tracheostomy. Botulinum toxin B, as a supportive symptomatic therapy, can reduce sialorrhea in ALS patients [12]. The survival benefit of gastrostomy remains controversial [13-15]. Discussions about tracheostomy and long-term ventilation are integral to ethical considerations in advanced care planning, as these interventions may prolong life but can lead to a locked-in state with complete paralysis and loss of communication.

Pharmacologic options such as riluzole offer only modest benefit [1]. Edaravone has been approved for ALS in numerous countries, its clinical benefit remains debated, and it has not achieved approval in all regions worldwide [16]. In addition, several new and experimental disease-modifying therapies are currently under development [11].

Given the lack of effective disease-modifying treatments, the overall prognosis is poor [1, 17]. Progressive weakness of the diaphragm and respiratory muscles leads to dyspnea, orthopnea, hypoventilation, pneumonia and finally death from respiratory failure or complications such as dysphagia or immobility within 3-5 years [1, 4, 8]. The mean life expectancy after symptom onset is approximately three years [4]; however, about 20% of patients survive for five to ten years, and around 10% live longer than ten years with a slower disease progression [18].

Find more information on the disease, its centers of reference and patient organizations on Orphanet: www.orpha.net

Emergency information

A	**AIRWAY / ANESTHETIC TECHNIQUE**	Prepare for difficult airway due to spasticity and cramps (mouth opening / neck and jaw mobility?), tracheal constriction / scar after tracheotomy – frequent pulmonary dysfunction with (severe) restrictive pattern – suction availability (bulbar symptoms) – consider glycopyrrolate for premedication – consider synchronization of respirator and diaphragmatic pacing system (if applicable) – no general (dis)advantage for GA (TIVA / balanced) or RA – peripheral / neuraxial RA should be considered as safe and feasible alternative – consider NIV during RA – anticipate increased autonomic dysfunction during neuraxial RA
B	**BLOOD PRODUCTS (COAGULATION)**	No specific recommendations
C	**CIRCULATION**	Treat hypovolemia (malnutrition, dehydration, autonomic dysfunction) – apparent primarily after induction – consider IBP measurement
D	**DRUGS**	No risk for MH – use short acting agents for GA – restrictive use of opioids, NDMR and sedative agents – avoid succinylcholine (hyperkalemia)
E	**EQUIPMENT**	Anesthetic-depth (e.g., BIS) and neuromuscular monitoring recommended – use ultrasound for vessel cannulation / RA – patient positioning with caution (spasticity, muscle weakness) – prefer upper position in PACU / IMC / ICU, anticipate respiratory complications with necessity of airway suctioning and allow disposability for patient's own e.g., ventilator- / cough-assist devices and caregiver

Typical surgery and procedures

Tracheostomy.

Suprapubic bladder catheterization.

Laparoscopic placement of diaphragmatic pacing systems [14, 19].

Gastrostomy: percutaneous endoscopic gastrostomy (PEG)*, percutaneous radiologic gastrostomy (PRG), per-oral image-guided gastrostomy (PIG), surgical gastrostomy (laparotomy and laparoscopy approaches have higher complications and mortality rates and are therefore less common) [10, 13, 20].

Type of anesthesia

Surgical interventions requiring general (GA) or regional (RA) anesthesia may accelerate the progression of ALS, even during minor procedures such as PEG [21, 22]. Direct influence of anesthetic agents, inflammation, and hypoperfusion, among other factors, are discussed as contributing mechanisms. Furthermore, repeated exposure to surgery and anesthesia may considerably increase the risk of respiratory complications in these patients [23].

Each anesthetic technique presents specific challenges in ALS, which must be carefully evaluated [24, 25]. GA with invasive ventilation can lead to complications such as prolonged postoperative ventilation, perioperative worsening of respiratory muscle weakness with ensuing respiratory failure, hypoventilation, an increased aspiration risk due to bulbar symptoms, and weaning difficulties. The use of short acting anesthetic – ideally avoiding muscle relaxants when feasible – may help mitigate some of these risks [9, 14, 26, 27]. Many procedures for which muscle relaxation is typically used have been successfully performed without relaxants in ALS patients, including lung surgery [28]. Furthermore, a restrictive use of opioids, sedatives and neuromuscular blocking agents is advised due to the presumed increased sensitivity of ALS patients these drugs.

Depending on the surgical procedure, RA (peripheral/neuraxial) should be strongly considered as safe and feasible alternative to avoid airway manipulation, invasive ventilation, and the use of sedatives or muscle relaxants [8, 29]. In patients with severe preexisting respiratory weakness, non-invasive ventilation (NIV) during RA may support respiratory function [9, 30]. RA can also provide effective analgesia, thereby reducing the need for systemic analgesics and their associated side effects [10].

The initiation of neuraxial (especially spinal) RA may cause hypotension and bradycardia due to local sympathectomy, as in other patients undergoing neuraxial blockade. In ALS, this may theoretically be exacerbated by varying degrees of autonomic dysfunction. Optimizing fluid balance before spinal anesthesia can help minimize hemodynamic instability. Furthermore, appropriate monitoring – non(invasive) or invasive (e.g., arterial line) – and the availability of vasoactive drugs are recommended for prompt management of hemodynamic changes [8].

Patients with preexisting CNS disorders, including those with ALS, are thought to be at increased risk of postoperative neurologic deterioration (“double-crush” phenomenon), where preexisting neural impairment and demyelination (“first crush”) may predispose to secondary injury through mechanisms such as needle trauma, technical challenges, local anesthetic neurotoxicity, or the use of specific substances (e.g., vasopressors or lidocaine) (“second crush”) [8, 31, 32]. However, there is still discordance among experts regarding the causation or even the existence of this phenomenon [33].

Nevertheless, when the surgical procedure does not require deep muscle relaxation or is confined to the extremities, RA may be preferred over GA to reduce respiratory complications [2, 8]. Various RA techniques have been successfully used in ALS patients without worsening neurological symptoms. Reported examples include epidural, spinal, or combined spinal-epidural (CSE) anesthesia for abdominal and lower limb surgery; paravertebral block for radiologic gastrostomy placement; scalp block for neurosurgery; rectus sheath block for PEG; and sacral / lumbar plexus, sciatic, adductor canal and transversus abdominis plane (TAP) block for abdominal, anorectal and lower limb surgery – even in outpatient settings [2, 10, 24, 29, 34-44]. Bilateral dual TAP block – with injections into the upper intercostal and lateral TAP compartments – may even allow abdominal surgery in ALS patients to be performed without muscle relaxants [39].

Currently, there is no universally accepted or evidence-based recommendation regarding the optimal anesthetic approach – GA vs. RA – for ALS patients. The choice should be individualized on a case-by-case basis, incorporating a thorough risk-benefit assessment, patient preferences, and coordinated multidisciplinary perioperative approach [8].

Necessary additional preoperative testing (beside standard care)

There is no standardized recommendation or protocol for the preoperative assessment of ALS patients. Evaluation should be individualized, taking into account the specific condition of each patient, in close collaboration between the anesthesiologist, neurologist, and other involved clinicians. Depending on comorbidities, preoperative assessment should focus on detecting organ dysfunction, with particular attention to the pulmonary status.

ALS patients frequently undergo pulmonary function testing (e.g., spirometry), and parameters such as SNIP, FVC, FEV 1, FEV 1 / FVC should be reviewed preoperatively as key indicators to determining the need for postoperative monitoring, respiratory support like NIV or possibly prolonged invasive ventilation [4, 45].

If postoperative NIV is anticipated, it is advisable to initiate this therapy before surgery to allow the patient to develop mask tolerance prior to its postoperative use [14]. Additional diagnostic studies (e.g., chest X-ray, ECG, echocardiography, laboratory tests, blood gas analysis) should be performed on an individual basis and clinical findings.

Particular preparation for airway management

Evaluation and preparation for airway management in ALS patients should generally follow standard guidelines for airway management. A thorough airway assessment is essential, with special attention to anatomic and dysmorphic features such as spasticity or tracheal narrowing and scarring after previous tracheostomy. Clinicians should be aware that macroglossia due to denervation-related pseudohypertrophy can rarely occur in ALS, potentially complicating airway management [46, 47].

In tracheotomized patients, the medical history should include details about any complications related to the artificial airway – such as scars, problems during tracheostomy tube changes, and the frequency of suctioning. Anticipation of a difficult airway is crucial, and appropriate backup strategies should be planned in advance.

Because pulmonary dysfunction is common in ALS, adequate preoxygenation is essential. Bag-mask-ventilation may be challenging due to spasticity and the often (severe) restrictive

ventilatory pattern. Therefore, adjunct devices (e.g., oropharyngeal (Guedel) or nasopharyngeal airway) and sufficient trained personnel should be readily available. Laryngoscopy and intubation may also be challenging. Thus, videolaryngoscopy or fiberoptic techniques can be valuable and sometimes necessary [4].

Oral and tracheal suction should be available during intubation because of frequent dysphagia and secretion management issues. Premedication with an antisialagogue such as glycopyrrolate may reduce secretion [5, 19, 48]. Although endotracheal intubation remains the preferred method for airway protection in most non-tracheotomized ALS patients, the use of a laryngeal mask may be a viable option in selected patients [31].

Particular preparation for transfusion or administration of blood products

No specific recommendations. No typical bleeding disorders were reported in ALS patients.

Particular preparation for anticoagulation

There are no specific recommendations for anticoagulation in ALS patients. However, given the frequently limited mobility and the possibility of patients being bedridden, anticoagulation should be considered on an individual basis in accordance with current guidelines, taking into account the surgical procedure and the patient's comorbidities. Furthermore, the use of compression stockings and physiotherapy may be beneficial for the prevention of deep vein thrombosis.

Particular precautions for positioning, transportation and mobilization

Many ALS patients require varying degrees of assistance with daily activities, including positioning and movement, due to physical disability and muscle weakness. Spasticity, muscle cramps, atrophy and weakness necessitate extremely careful positioning and mobilization. Surgery in the prone position (and under spinal anesthesia) has been reported without complications; however, this approach should be carefully considered in awake ALS patients without secured airway [49]. The supine position – such as in the postoperative setting – may also be stressful for ALS patients, as the use of accessory muscles is often required to maintain adequate respiration [9]. An upper or semi-sitting position may therefore help to facilitate breathing and improve respiratory comfort [30, 42].

Interactions of chronic disease and anesthesia medications

The therapeutic ALS drug riluzole has been shown to decrease the MAC of isoflurane in animal studies [50]. However, no data/reports on such interactions are available in humans. In patients receiving chronic riluzole therapy, we recommend the use of anesthetic-depth monitoring (e.g., BIS monitoring) to ensure an adequate level of anesthesia.

Anesthetic procedure

Preoperative evaluation: See details above.

Premedication: Should be administered after weighing the individual risks and benefits. Anesthesiologists must consider the increased sensitivity of ALS patients to sedative agents and their elevated risk of hypoxemia, airway obstruction, and aspiration. Benzodiazepines and gabapentinoids should only be used after careful risk-benefit evaluation [51]. Glycopyrrolate may be used as an antisialagogue to reduce salivary secretion.

Vascular access: May be difficult due to spasticity or muscle cramps. Ultrasound guidance or the use of a vein finder can facilitate successful cannulation.

(Monitored) Sedation: Agents such as fentanyl, midazolam, ketamine, dexmedetomidine, remimazolam and propofol may be used either as a sole technique or in combination with RA. Providers should consider a potential increased sensitivity of ALS patients to opioids and sedatives. Ideally, sedation should allow purposeful response to tactile and verbal stimuli, while avoiding the loss of airway and protective reflexes [8].

Induction of anesthesia: Should take into account patient-specific risk factors, particularly respiratory impairment. Due to dysphagia, malnutrition, and dehydration, hypovolemia should be anticipated. (Severe) Hypotension following induction may occur and should be assessed and anticipated using clinical evaluation, passive leg raising, transthoracic echocardiography, hemodynamic monitoring, or lactate measurement. Autonomic nervous system involvement – particularly sympathetic dysfunction – is under discussion in ALS and may lead to abnormal or inadequate hemodynamic responses, posing a risk of sudden instability [52].

Anesthetic drugs: The use of standard agents for induction and maintenance of anesthesia has generally been reported as uneventful. However, drug selection and dosing should be approached cautiously, as adverse effects may be pronounced and emergency situations more likely than in healthy individuals [52]. Non-depolarizing muscle relaxants (NDMR) should be used sparingly and at the lowest effective dose, ideally guided by quantitative neuromuscular monitoring. Succinylcholine should be avoided whenever possible due to the risk of hyperkalemia [8, 45].
Following reversal of NDMR, anesthesiologists should remain alert for residual or recurrent muscle weakness necessitating continued ventilatory support. Both sugammadex and neostigmine combined with glycopyrrolate have been successfully used to reverse NDMRs in ALS patients [2, 4, 48, 53, 54]. However, neuromuscular recovery may be delayed after the use of sugammadex in ALS [5]. When using cholinesterase inhibitors, the longer duration of action of most NDMRs compared with agents such as neostigmine should be taken into account [53]. The choice of reversal drug and its dosage should be appropriate to the degree of neuromuscular blockade, and adequate reversal must be confirmed through monitoring to prevent residual paralysis [5]. Depending on risk assessment, GA without muscle relaxants may be a viable option [6, 26, 55].
Total intravenous (TIVA) and balanced anesthesia using volatile anesthetics are both considered safe. However, volatile anesthetics have been controversially discussed regarding residual muscle relaxation – despite reversal and normal neuromuscular monitoring – as well as the possible influence on disease progression. Although current evidence does not clearly demonstrate an advantage of TIVA over inhalational anesthesia in ALS, anesthesiologists should remain aware of these considerations. When volatile anesthesia is used, desflurane and sevoflurane are preferred for maintenance due to their low lipid solubility, which allows for rapid titration and emergence [2, 45].

Regional, neuraxial, and infiltration anesthesia: When using standard agents, RA techniques have not been associated with specific complications in ALS patients [4, 29, 49]. Ultrasound guidance aids in identifying target structures, particularly in patients with spasticity, deformities, or muscle atrophy. In cervical or brachial plexus blocks, it also helps to reduce the risk of phrenic or recurrent laryngeal nerve anesthesia, which could worsen respiratory compromise.

Ventilation: Should be as lung protective as possible. In patients with a diaphragmatic pacing system, synchronization of the device with the anesthesia workstation ventilator may facilitate ventilation and postoperative weaning [14]. Preoperative consultation with the patient's referral or neuromuscular center is recommended to optimize perioperative management of such devices.

Particular or additional monitoring

Depending on the severity of pulmonary impairment, an arterial line may be placed peri-operatively for blood gas monitoring [30]. Furthermore, ALS patients may have an increased risk of sudden hemodynamic instability during anesthesia due to involvement of the autonomic nervous system [52].
Despite the presence of cognitive dysfunction or a locked-in state in some patients, bi-spectral index (BIS) monitoring has been reported to provide a reliable estimation of anesthetic depth comparable to that in healthy individuals [56]. Neuromuscular monitoring is indispensable when muscle relaxants are used as a part of GA [2]. However, clinicians should be aware of possible discrepancies between measured neuromuscular response and clinical signs [2, 53, 55]. A Train-of-Four (TOF) ratio > 0.9 should therefore not be considered an absolute criterion for safe extubation or complete recovery from neuromuscular blockade in ALS patients [2, 54].

Possible complications

Patients with ALS are at high anesthetic risk, with pronounced respiratory depression and increased sensitivity to hypnotic agents [38]. They are especially susceptible to respiratory exhaustion and failure after neuromuscular blockade, mechanical ventilation, or aspiration pneumonia, which may necessitate prolonged mechanical ventilation or re-intubation [4, 8, 22, 38]. Weaning from ventilatory support is frequently prolonged and challenging [23, 57]. Bulbar symptoms, especially dysphagia, increase the perioperative risk of aspiration. Additionally, dysregulation or exacerbation of bulbar and autonomic nervous system involvement may contribute to perioperative complications [8].

Postoperative care

Postoperative care should be individualized according to disease severity, surgical procedure, and anesthestic technique. Patients with ALS often show increased sensitivity to muscle relaxants and opioids, predisposing them to postoperative respiratory failure and aspiration pneumonia. Poor nutritional status may cause electrolyte abnormalities and hypovolemia, while surgical stress can further exacerbate neurological symptoms [8].

Admission to an IMC or ICU may be advisable, particularly for patients with severe pre-existing respiratory dysfunction or those requiring intraoperative ventilation. The postoperative availability of NIV devices may facilitate extubation, support weaning, and help prevent secondary respiratory deterioration [58]. However, weakness of facial or upper airway muscles may complicate or even preclude the initiation of NIV [17].

Patients who use NIV preoperatively should resume it postoperatively. Those who routinely employ cough-assist or airway clearance devices should bring their own equipment and continue their usual regimen [14, 45]. In selected cases, NIV may also be successfully applied prophylactically in the postoperative setting to prevent respiratory failure, which may result from respiratory muscle fatigue induced by GA and surgical stress [59].

Involving the patient's primary caregiver in PACU can greatly assist with device handling and communication. Familiar aids such as alphabet boards or computer-based eye-tracking text systems may further facilitate interaction[14, 60].

Routine postoperative oxygen administration is not recommended, as ALS patients often display instability of respiratory control, and their ventilatory drive during sleep depends primarily on oxygen saturation levels [14, 45].

Bulbar symptoms, such as dysphagia or dysarthria, as well as cognitive impairment, may contribute to malnutrition, necessitating intravenous or enteral feeding during prolonged hospital stays. Since ALS is associated with a hypermetabolic state and increased caloric requirements, postoperative nutritional support is particularly important to prevent further weight loss [10, 38].

Adequate postoperative analgesia is essential to promote effective respiration and prevent hypoventilation due to pain. However, opioid use must be approached cautiously, as these agents may cause respiratory depression. Conversely, insufficient pain control may also impair respiratory effort [30]. Nonsteroidal anti-inflammatory drugs (NSAIDs) may be used when not contraindicated.

Early postoperative physical therapy can be beneficial, especially for the chest and breathing [38].

Disease-related acute problems and effect on anesthesia and recovery

Differential diagnosis: Conditions that may mimic or coexist with ALS include peripheral neuropathy, Lyme disease, vitamin B12 deficiency, thyroid disease, and metal toxicity [1].

Emergency-like situations: Potential acute complications include aspiration, pneumonia, respiratory exhaustion or failure, and hypoxemia.

Ambulatory anesthesia

There are no general recommendations regarding outpatient procedures in ALS patients due to limited data available in the literature. However, ambulatory anesthesia may be feasible in institutions with appropriate resources and expertise. Minor procedures requiring only minimal sedation can be performed safely in an outpatient setting [4].

Nevertheless, most perioperative complications in ALS are not related to the procedure itself but arise as consequences of the underlying disease. Therefore, for more extensive surgeries – or when pre-existing respiratory impairment, the intraoperative need for invasive ventilation, or the absence of adequate professional homecare (e.g., monitoring, nursing service, or home oxygen therapy) is anticipated – hospital admission is recommended [4].

Obstetrical anesthesia

The combination of ALS and pregnancy is extremely rare, as the disease predominantly affects men and typically manifests in the fifth or sixth decade of life. Consequently, data on ALS and pregnancy are limited. Nevertheless, women with ALS are generally fertile. The relationship between hormonal changes during pregnancy and a potential increased susceptibility to ALS remains under discussion, and it is still unclear whether pregnancy influences the course of ALS – or vice versa [9, 30].

Depending on disease progression, pregnant women with ALS may require hospital admission for monitoring during pregnancy. The timing and mode of delivery depend largely on the individual course and severity of the disease. Because motor neuron diseases do not affect the sensory or motor innervation of the uterus, vaginal delivery is generally possible (and preferred) [9, 30]. However, complications such as progressive respiratory distress or insufficient oxygen supply during labor due to respiratory muscle weakness may necessitate an (emergency) cesarean section [30].

Respiratory function is typically the most affected system during pregnancy, and deterioration should be anticipated regardless of the delivery mode. The physiologic increase in cardiovascular workload and in tidal and minute ventilation that occur during pregnancy may be impaired in ALS due diaphragmatic and intercostal muscle weakness. During labor, affected parturients may be unable to adequately increase ventilation to meet the oxygen demands. Furthermore, diaphragmatic elevation during the third trimester reduces FRC, which further compromises respiratory reserve [61]. Regular assessment of respiratory and pulmonary function is therefore recommended throughout pregnancy. Notably, lower abdominal procedures such as cesarean section are associated with postoperative lung volume reduction lasting up to two weeks [9, 50, 62].

To mitigate pregnancy-associated risks of difficult airway management and aspiration of gastric content – both of which pose additional challenges in ALS patients – neuraxial anesthesia (epidural, spinal, or CSE) is preferred over GA for delivery. Epidural analgesia during labor may also minimize maternal respiratory efforts [30]. However, neuraxial anesthesia can affect intercostal muscle function and potentially impair spontaneous ventilation [62]. In addition, concerns exist that neuraxial techniques in ALS patients undergoing cesarean section may exacerbate pre-existing disease symptoms [63]. As an alternative, bilateral ultrasound-guided TAP block with incision infiltration before delivery and TIVA by TCI after delivery has been reported as a successful approach for cesarean section [64]. In another report, the combination of TAP block and local infiltration of the incision site was successfully used to avoid neuromuscular blockade, employing ketamine and propofol with a laryngeal mask airway and maintenance with subanesthetic concentrations of sevoflurane [63]. Thus, the optimal anesthetic approach remains under discussion [55].

When significant bulbar dysfunction is assumed, GA may be the only effective means of protecting the airway against aspiration. A reported successful anesthetic approach for cesarean section in such cases included topical anesthesia of the trachea and vocal cords, TIVA (propofol, remifentanil), avoidance of muscle relaxants, and local infiltration of incision site with ropivacaine [55]. Given that succinylcholine is contraindicated and NDMRs are associated with increased risk for both mother and neonate, this combination of short-acting agents may represent a viable alternative.

Riluzole, the standard therapeutic agent for ALS, can be continued during pregnancy [9, 61]. Since motor neuron disease does not directly affect fetal development, neonatal outcomes are generally favorable [9]. Management of pregnant women with ALS requires a multidisciplinary approach involving obstetricians, anesthesiologists, neurologists, neonatologists, nutritionists, and physiotherapists. This team-based strategy supports optimal respiratory function, adequate nutrition, prevention of deep vein thrombosis, and maintenance of mobility [9].

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This recommendation was prepared by:

Authors

Christine Gaik, Anesthesiologist, Department of Anesthesiology and Intensive Care Medicine, University Hospital Giessen and Marburg, Campus Marburg and Philipps University of Marburg, Germany
gaikc@med.uni-marburg.de

Thomas Wiesmann, Anesthesiologist, Department of Anesthesiology and Intensive Care Medicine, Diak Klinikum Landkreis Schwäbisch-Hall, Schwäbisch-Hall, Germany
thomas.wiesmann@diak-klinikum.de

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This recommendation was reviewed by:

Reviewer 1
Toby Weingarten, Anaesthesiologist, Department of Anesthesiology and Perioperative Medicine, Mayo Clinic, Rochester, MN, USA
weingarten.toby@mayo.edu

Reviewer 2
David Czell, Neurologist, Rapperswil, Switzerland
david.czell@hin.ch

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Christine Gaik, Anesthesiologist, Department of Anesthesiology and Intensive Care Medicine, University Hospital Giessen and Marburg, Campus Marburg and Philipps University of Marburg, Germany
gaikc@med.uni-marburg.de

Thomas Wiesmann, Anesthesiologist, Department of Anesthesiology and Intensive Care Medicine, Diak Klinikum Landkreis Schwäbisch-Hall, Schwäbisch-Hall, Germany
thomas.wiesmann@diak-klinikum.de

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Reviewer

Martin Jöhr, Former head of the Division of Pediatric Anaesthesia, Luzcerne Hospital (LUKS) Adligenswil, Switzerland
joehrmartin@bluewin.ch

Editorial Review

Philipp Gude, Specialist in anaesthesia and intensive care medicine,
Ruhr University Bochum, Bochum, Germany
St. Elisabeth-Hospital, Bochum, Germany
philipp.gude@kklbo.de

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