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Guideline on positioning and early mobilisation in the critically ill by an expert panel

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Abstract

A scientific panel was created consisting of 23 interdisciplinary and interprofessional experts in intensive care medicine, physiotherapy, nursing care, surgery, rehabilitative medicine, and pneumology delegated from scientific societies together with a patient representative and a delegate from the Association of the Scientific Medical Societies who advised methodological implementation. The guideline was created according to the German Association of the Scientific Medical Societies (AWMF), based on The Appraisal of Guidelines for Research and Evaluation (AGREE) II. The topics of (early) mobilisation, neuromuscular electrical stimulation, assist devices for mobilisation, and positioning, including prone positioning, were identified as areas to be addressed and assigned to specialist expert groups, taking conflicts of interest into account. The panel formulated PICO questions (addressing the population, intervention, comparison or control group as well as the resulting outcomes), conducted a systematic literature review with abstract screening and full-text analysis and created summary tables. This was followed by grading the evidence according to the Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence and a risk of bias assessment. The recommendations were finalized according to GRADE and voted using an online Delphi process followed by a final hybrid consensus conference. The German long version of the guideline was approved by the professional associations. For this English version an update of the systematic review was conducted until April 2024 and recommendation adapted based on new evidence in systematic reviews and randomized controlled trials. In total, 46 recommendations were developed and research gaps addressed.

Keywords: Guideline, Patient positioning, Early mobilisation, Physical therapy modalities, Critical illness, Critical care

Introduction

In adult critically ill patients in intensive care units (ICU), prolonged immobility is associated with several short- and long-term sequelae such as intensive care unit-acquired weakness (ICUAW) [1], loss of muscle mass [2, 3] and functionality [4], delirium [5–8], cognitive decline [9, 10], and reduced quality of life [10] which may be minimised by early mobilisation. There is increasing evidence that electrophysiological changes in the neuromuscular system occur as early as 48 h after admission

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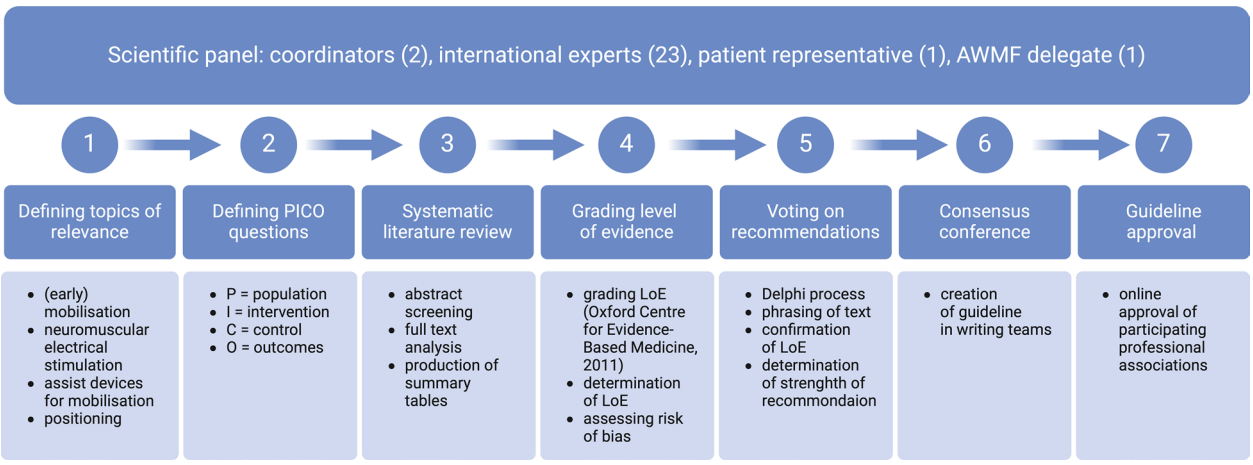

Fig. 1 Guideline process overview. The scientific panel comprised 23 interdisciplinary and interprofessional experts in intensive care medicine, physiotherapy, nursing care, surgery, rehabilitative medicine, and pneumology from Germany and Austria (details in ESM 1, Table S1). In addition, a patient representative and a delegate from the Association of the Scientific Medical Societies who advised methodological implementation were part of the interprofessional and interdisciplinary panel. (1) The topics of (early) mobilisation, neuromuscular electrical stimulation, assist devices for mobilisation, and positioning, including prone positioning, were identified as areas to be addressed and assigned to specialist expert groups, taking conflicts of interest into account. The following steps included (2) the formulation of PICO questions (addressing the population, intervention, comparison or control group as well the resulting outcomes, see ESM 1, Table S3), (3) a systematic literature review with abstract screening and full-text analysis and the subsequent creation of summary tables, (4) the grading of evidence according to Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence [18] and risk-of-bias assessment, and (5) a Delphi-lead process for the voting on recommendations, followed by a final hybrid consensus conference. The final steps were (6) the consensus conference and (7) the final guideline approval by the professional associations. The guideline was created according to the German Association of the Scientific Medical Societies (AWMF), based on The Appraisal of Guidelines for Research and Evaluation (AGREE) II [17]. *AWMF* Association of the Scientific Medical Societies, *LoE* level of evidence

[11]. The complex pathophysiological changes within neuromuscular pathways promote the upregulation of muscle-wasting systems, leading to ICUAW [11]. This results in a loss of muscle mass and, importantly, in a loss of functionality and insulin resistance [12]. Inflammation, a common coexisting condition in critically ill patients, amplifies these effects [13–15].

An interdisciplinary and interprofessional panel of experts from Germany and Austria formulated clinical key questions, conducted a systematic literature review, and developed a guideline to support healthcare providers in implementing positioning and early mobilisation for critically ill adult patients in the ICU. Early mobilisation was defined as mobilisation commencing within 72 h of ICU admission.

Methods

Panel composition

This interdisciplinary and interprofessional guideline, an update from [16], was formulated by experts representing scientific societies in Austria and Germany [electronic supplementary material (ESM) 1, Table S1], following a more rigorous methodology than the previous version, which adhered to the Manual for Guidelines of the Association of the Scientific Medical Societies in Germany (AWMF) [17].

Literature review and evidence preparation

A systematic literature search on Pubmed, Cochrane Library, PEDro (Physiotherapy Evidence Database) and Cinahl (Cumulative Index to Nursing and Allied Health Literature) was conducted in April 2021, with another update in June 2022. Search terms are provided in ESM 1, Table S2. Two reviewers independently screened titles and abstracts for each chapter and graded full texts based on the Oxford Centre of Evidence-Based Medicine Level of Evidence (version 2011) [18]. The risk of bias was assessed using the Cochrane Risk of Bias Tool (RoB2) [19], the Robis tool [20] or the Agree-2 tool [21], depending on the study type. This was followed by level of evidence (LoE) modification of the studies (see ESM 2). Discrepancies between reviewers were resolved through independent third-party expert review at each step and subsequently assessed by the guideline members.

Clinical recommendations and structured consensus

In three online Delphi rounds, the phrasing, referenced studies in the recommendation, including their LoE, and strength of recommendation using GRADE (strong (recommend) and weak (suggest) recommendations) [22] were voted (and commented) on (Fig. 1). In the final hybrid structured consensus meeting, the recommendations that had not yet achieved 100% agreement in the previous Delphi rounds

were finally discussed and voted on. Only recommendations with more than 75% agreement were included in the guideline; firm agreement was defined as > 95%. Details on the regulation of conflicts can be found in ESM 1, Methods.

Table 1 Recommendations on positioning

#	Recommendation	LoE
1.1	We recommend elevation of the upper body ≥ 40° in intubated patients, considering possible haemodynamic side effects and an increased risk of pressure ulcers	1
1.2	We suggest performing upper body elevation in patients with increased ICP to achieve the most favourable effect on cerebral perfusion pressure	4 and guideline adaptation
1.3	We suggest avoiding upper body elevation with flexion of the knees and hips in patients with elevated intraabdominal pressure or at its risk and suggest favouring the anti-Trendelenburg position for upper body elevation	3 and guideline adaptation
1.4	We are unable to make a recommendation for or against lateral positioning for the prevention of pulmonary complications without lung injury	3
1.5	We suggest performing a lateral position of about 90° with the healthy side down (good lung down) when ventilating patients with unilateral lung damage to improve gas exchange	3
1.6	We recommend regular modification of positioning to avoid the flat supine position as an inappropriate form of positioning	5, expert consensus
1.7	We suggest not to use continuous lateral rotation therapy	2
2.1	We recommend prone positioning in invasively ventilated patients with ARDS and impaired arterial oxygenation ($PaO_2/FiO_2 < 150$ mmHg)	1
2.2	We recommend considering prone positioning at an early stage and implementing it as soon as it is indicated	1
2.3	We recommend prone positioning for at least 12, preferably 16 h	1
2.4	We recommend applying the generally recommended principles of optimised ventilation for ventilation in the prone position, including the limitation of tidal volumes, prevention of derecruitment and integration of spontaneous breathing components	1
2.5	We suggest stabilising the patient haemodynamically and optimising volume status prior to prone positioning. The use of catecholamines is not a contraindication for prone positioning	5, expert consensus
2.6	We suggest considering prone positioning in patients following abdominal surgery, patients with abdominal pathologies, or patients with abdominal obesity after individual consideration of benefits (improvement in oxygenation) and risks (increase in intraabdominal pressure with risk of surgical complication, acute renal failure, or hypoxic hepatitis)	4
2.7	We recommend that patients at risk of increased ICP are monitored continuously or closely during prone positioning. The head should be positioned in a centred position and lateral rotation should be avoided	5, expert consensus
2.8	We suggest that prone positioning should only be carried out in individual cases after considering risks and benefits in an interdisciplinary fashion involved when the following contraindications exist: - open abdomen - spinal instability - increased ICP - cardiac arrhythmias with haemodynamic consequences - shock [23]	5, expert consensus
2.9	We suggest terminating prone positioning if improvement in supine oxygenation persists (4 h after repositioning: $PaO_2/FiO_2 \geq 150$ with a PEEP ≤ 10 cm H_2O and a $FiO_2 \leq 0.6$)	2
2.10	We suggest that prone positioning therapy should be discontinued if at least two positioning attempts have been unsuccessful	5, expert consensus
2.11	We recommend complete (180°) rather than incomplete prone positioning as there is no evidence to improve clinical outcomes for incomplete prone positioning and complete prone positioning has a stronger effect on oxygenation	2
2.12	We recommend to carefully examine the areas at risk for pressure ulcers during prone positioning to minimise the risk of development	1
2.13	We recommend awake proning in non-invasively ventilated patients with COVID-19 and acute hypoxic respiratory failure	1
2.14	We are unable to make a recommendation for or against awake proning in non-invasively ventilated patients without COVID-19	5, expert consensus
2.15	We are unable to make a recommendation for the duration of awake proning	5, expert consensus
2.16	We suggest performing prone positioning in ARDS patients with veno-venous ECMO therapy	2

COVID-19 coronavirus disease 2019, *ECMO* extracorporeal membrane oxygenation, *FiO_2* fraction of inspired oxygen, *ICP* intracranial pressure, *PaO_2* partial pressure of oxygen, *PEEP* positive end-expiratory pressure

Additional literature update and adaptions of recommendations

An additional literature update from 1 June 2022 until 4 April 2024 was conducted during the review process. Methodological details and results are presented in ESM 1, Literature search update and modification. Changed recommendations based on the update are marked with an asterisk (*) in the manuscript.

Recommendations for clinical questions

After reviewing 14,258 titles and abstracts since 2014, 446 studies were included (details in ESM 1, Fig. S1). A translation of the German full-text version, including links to evidence tables, is provided in ESM 3.

We developed 46 recommendations: 23 for positioning, 17 for mobilisation, 4 for devices and robotics, and 2 for neuromuscular electrical stimulations (NMES).

Positioning of critically ill patients

For recommendations on positioning of critically ill patients see then Table 1.

Should ICU patients receive upper body elevation?

Upper body elevation reduces the incidence of ventilator-associated pneumonia (VAP) and duration of ventilation compared with the supine position but does not influence ICU or hospital length of stay (LOS) and mortality [24]. An elevation of 30–60° versus 0–10° had significant benefits concerning clinically suspected VAP but no difference for microbiologically confirmed VAP, LOS and duration of ventilation. In another meta-analysis comparing 45° with 30° upper body elevation, the 45° group had a lower incidence of VAP and gastric reflux compared with 30° elevation with an increased risk of developing decubitus ulcers (Recommendation 1.1) [25].

Furthermore, upper body elevation in patients with brain injury should be individualised, including regular cerebral perfusion pressure (CPP) and intracranial pressure (ICP) monitoring at 0°, 15°, and 30° to capture gravity-dependent effects. In all positions, the head should be positioned straight to ensure venous return (Recommendation 1.2) [26].

Notably, observational studies consistently show an association between higher degrees of upper body elevation and increased intraabdominal pressure (Recommendation 1.3) [27–29].

Most studies on upper body elevation were performed in ventilated patients. Therefore, generalisability may be limited for non-ventilated patients, where the positive effects of upper body elevation due to a higher level of consciousness and lower aspiration risk may be less pronounced.

Should ICU patients be placed in the lateral position to prevent VAP?

A randomised controlled trial (RCT) investigating lateral 5–10° head-down position (lateral Trendelenburg positioning with side changes every 6 h) versus upper body elevation to prevent VAP was terminated early due to a low VAP incidence, lack of benefits in secondary outcomes, and six serious adverse events intervention group. Although patients with lateral positioning had a lower incidence of VAP, no significant difference in 28-day mortality occurred (Recommendation 1.4) [30].

In a Cochrane Review on the effect of lateral positioning, only two studies with a very low sample size investigated the effect in ICU patients with unilateral lung injury [31]. The mean difference in oxygenation between good lung down versus bad lung down was approximately 50 mmHg (Recommendation 1.5). Immobilisation in the same position poses many risks, and the flat supine position should be strictly limited to interventions that require it (Recommendation 1.6) [32].

Should ICU patients receive continuous lateral rotation therapy?

In an RCT of ventilated ICU patients comparing continuous lateral rotation therapy (CLRT), a continuous rotation of the patient along the longitudinal axis, with usual care, there was no difference in microbiologically confirmed VAP between groups. Importantly, 39% of patients showed intolerance to CLRT during the weaning phase [33, 34], reflected by a deeper sedation level in the intervention group [35]. A meta-analysis in trauma patients showed a reduction in nosocomial pneumonia for prophylactic CLRT versus usual care but no effect on existing pneumonia or mortality (Recommendation 1.7) [36].

How should prone positioning be conducted?

Prone positioning of 16 h daily for patients affected with acute respiratory distress syndrome (ARDS) with a duration of ventilation < 36 h and a PaO_2/FiO_2 < 150 mmHg showed a significant survival benefit for 28-day mortality (Recommendation 2.1) [37]. Meta-regressions of continuous predictors indicated threshold values for a significant position effect at ≥ 12 prone h/day, ≤ 8.5 mL/kg tidal volume, and $PaO_2/FiO_2 \leq 130$ [38].

Duration of prone positioning Most subgroup analyses within meta-analyses [38–40] have found a significant sur-

vival benefit using a cutoff value of 12 h of prone positioning. In contrast, Sud et al. [41] and Lee et al. [42] defined 16 and 10 h as the minimum duration, respectively, and found a survival advantage with a more extended period of prone positioning aligning with the frequently used 12 h cutoff. According to available evidence, a minimum duration of 12 h seems necessary for a positive effect of prone positioning, with each additional hour improving it (Recommendation 2.3). However, a period longer than 16 h has yet to be studied [37].

Start of prone positioning In a Cochrane review, a subgroup analysis revealed a positive effect on mortality if patients were placed in prone position ≤ 48 h of the start of mechanical ventilation [43]. These are congruent with the time frames in another meta-analysis and the PROSEVA trial [37, 40].

No studies explicitly analyse the optimal time to start the prone positioning. However, all available studies and the positive physiological effects indicate that it is optimal to start immediately after its indication (Recommendation 2.2).

End of prone positioning It has not yet been investigated when therapy in the prone position can be terminated. Based on the survival benefit in the PROSEVA trial, prone positioning should be performed until there is an improvement in oxygenation ($PaO_2/FiO_2 \geq 150$) under de-escalated ventilation (positive end-expiratory pressure (PEEP) ≤ 10 cmH_20 and $FiO_2 \leq 0.6$) 4 h after supine positioning [37] (Recommendation 2.9).

Due to the lack of evidence as to whether and for how long prone positioning should be performed in non-responders, the pragmatic expert recommendation is that prone positioning therapy should be terminated after two unsuccessful attempts (lack of improvement in oxygenation) (Recommendation 2.10).

Ventilator parameters be set during prone positioning Subgroup analyses of meta-analyses suggest that the limitation of tidal volume is necessary for the mortality benefit from prone positioning [44]. While most of the meta-analyses have used a cutoff of 8 ml/kg predicted body weight, evidence suggests that lowering this cutoff has a beneficial effect [44].

Gainnier et al. showed that prone positioning and PEEP have an additive effect on improving oxygenation [45]. Specific evidence on the optimal PEEP setting in the prone position is lacking.

Although deep sedation and analgesia are commonly used in the prone position to avoid discomfort, spontaneous breathing is also possible during prone positioning (Recommendation 2.4) [44].

Preparation of prone positioning The studies on the haemodynamic effects of prone positioning in patients with ARDS showed that the intervention was haemodynamically well tolerated and may also positively affect right ventricular load [46–49]. The volume status of patients should be optimised prior to positioning. Studies on the relevance of vasopressor therapy in the context of prone positioning are lacking. Due to the lack of negative haemodynamic effects of prone positioning, ongoing vasopressor therapy is not a contraindication (Recommendation 2.5).

Prone positioning and intraabdominal pressure During prone position, the intraabdominal pressure increased from 12 ± 4 mmHg to 14 ± 5 mmHg [49]. In obese patients undergoing prone positioning, an increased rate of hypoxic hepatitis and renal failure was present, without a mortality difference [50]. According to a case–control study, obese patients did not experience more complications, and the oxygenation improved more compared with non-obese patients [51]. Due to lacking evidence, the possible positive effects of prone positioning in obese patients or patients who underwent abdominal surgery should be critically evaluated (Recommendation 2.6).

Prone positioning and intracerebral lesions In an RCT, six patients (24%) with continuous ICP monitoring had a significant ICP increase from 11 to 24 mmHg during prone positioning [52]. Two studies confirmed these findings, which found a higher frequency of ICP > 20 mmHg and decreased CPP in neuro-ICU ARDS patients receiving prone positioning [53, 54]. However, patients benefited from prone positioning regarding oxygenation [53–55]. In contrast, others did not report ICP changes in prone position [56].

Based on the available evidence, a recommendation concerning patients with acute cerebral lesions and prone positioning in ARDS is currently not possible [57], and it is required to weigh the potential harms and benefits individually (Recommendation 2.7).

Prone positioning and extracorporeal membrane oxygenation In a systematic review including 13 trials, prone positioning additive to veno-venous (VV-) extracorporeal membrane oxygenation (ECMO) showed a significant survival benefit [58], which was not confirmed in a similar review [59].

Based on the available literature, including current evidence in patients affected with coronavirus disease 2019 (COVID-19) and the safe applicability, we recommend prone positioning of ARDS patients with VV-ECMO in experienced centres (Recommendation 2.16) [58, 60–64].

Further considerations for prone positioning Prone positioning is recommended for moderate to severe ARDS, but individual assessment is crucial due to potential comorbidities. A multi-professional and interdisciplinary consensus should balance potential benefits and risks in cases of an open abdomen, unstable spine, increased intracranial pressure, haemodynamically effective cardiac arrhythmias, or shock (Recommendation 2.8).

Incomplete prone position Scientific studies on incomplete prone positioning are scarce [65, 66]. Based on the magnified effect on oxygenation of complete vs. incomplete prone position [66] and evidence for a reduction in mortality for prone vs. supine position [37], the complete prone position seems superior (Recommendation 2.11).

Risks and side effects Prone positioning causes a weight redistribution to body parts not typically exposed in healthy individuals. Meta-analysis and RCTs have repeatedly shown that prone positioning significantly increases the risk of pressure ulcers [41, 43, 66–73]. Therefore, it is recommended to regularly conduct thorough inspection of the vulnerable locations (Recommendation 2.12).

Should ICU patients receive awake proning during non-invasive ventilation?

In multiple meta-analyses and a meta-analysis of meta-analyses, there was a significant reduction in the need for intubation [74, 75] and a reduced mortality [75–77] when awake prone positioning was used in critically ill COVID-19 patients.

Accordingly, it is recommended that this measure be performed in this patient population (Recommendation 2.13). A recommendation concerning other causes of hypoxic lung failure is currently not possible (Recommendation 2.14).

Duration of awake prone positioning Very heterogeneous protocols were applied in the published trials with conflicting results regarding dose–response relationships [77–84]. Due to the heterogeneity of results, no recommendation can be made regarding the duration and frequency of prone positioning while awake (Recommendation 2.15).

Mobilisation

For recommendations on mobilisation see then Table 2.

When should (early) mobilisation be started in the ICU?

In RCTs, an early start of mobilisation within 72 h of mechanical ventilation had a beneficial effect on functional independence, mobility, ICU LOS, hospital LOS, delirium-free days, ventilation-free days, discharge home and long-term cognitive and functional benefits [4, 10, 85]. On the contrary, other studies with delayed start of mobilisation after five and seven days, respectively, found no effect on outcomes [86, 87]. In addition, a network meta-analysis demonstrated a decreased risk of ICUAW and shortened ventilation duration when mobilisation was started within 72–96 h or 48–72 h of ventilation, respectively [88]. Given the available evidence from meta-analyses [89–93], early mobilisation should be started within 72 h of ICU admission (Recommendation 3.1).

How should (early) mobilisation be performed?

Mobilisation protocol Protocols are known to increase the feasibility, safety, duration, and level of mobilisation [94, 95]. Most mobilisation protocols include passive and active mobilisation elements, ranging from passive mobilisation to walking independently [96–101]. The various mobilisation protocols differ in terms of initiation criteria, patient cohort, and levels of mobilisation [99, 100, 102–107].

The ICU mobility scale (IMS), which is commonly used, includes only active mobilisation, and its protocol aims to mobilise the patient to the highest possible level at the beginning of the mobilisation session [108]. This leads to higher mobilisation levels and longer mobilisation duration than the control group [109–111]. However, this early active mobilisation concept was not superior to standard of care with early mobilisation [112].

Similarly, by applying the surgical optimisation mobilisation score (SOMS) protocol, patients achieved the highest level of mobilisation at ICU discharge compared to the control group [4]. However, the SOMS algorithm consists of passive and active components, ranging from no mobilisation to ambulation. Passive mobilisation represents the lowest level in most mobilisation protocols. It is applied when the patient's consciousness, cognition or haemodynamics are impaired so that active mobilisation cannot be performed [102–104, 113]. Passive mobilisation benefits patients with impaired consciousness and stroke patients [105, 113–115] but has not yet been compared with active mobilisation.

The benefits of mobilisation protocols that combine passive and active mobilisation have been shown [4, 95, 115] (Recommendations 3.11, 3.14). Due to the robust

Table 2 Recommendations on mobilisation

#	Recommendations	LoE
3.1	We recommend starting early mobilisation of ICU patients within 72 h of ICU admission	1
3.2	We recommend that the hospital management provides the personnel and material conditions to enable (early) mobilisation in line with these recommendations	5
3.3	We recommend the implementation of early mobilisation in all critically ill patients who were previously functionally independent and for whom there are no contraindications	1
3.4	We suggest performing early mobilisation in critically ill patients who were functionally dependent prior to ICU admission and for whom there are no contraindications	3
3.5* 3.7*	We recommend mobilising patients on CRRT or ECMO therapy after consultation with the interprofessional team and if there are no contraindications	CRRT: 2; ECMO: 3
3.6	We suggest mobilising patients with subarachnoid haemorrhage or external ventricular drainage after interdisciplinary consultation, considering potential risks and benefits	3
3.8	We recommend an explicit prescription of medically required immobilisation	5, expert consensus
3.9	We recommend mobilisation in patients with adequate respiratory and cardiovascular reserve. However, we are currently unable to make an evidence-based recommendation on absolute values that are considered a contraindication to mobilisation	5, expert consensus
3.10*	We suggest discontinuing a mobilisation session if according to clinical judgement, it poses a risk to the patient. These criteria may be: - desaturation < 86% - heart rate increase > 30% from baseline - systolic blood pressure rise ≥ 40 mmHg from baseline - diastolic blood pressure rise ≥ 20 mmHg from baseline - mean arterial pressure < 60 mmHg - new onset or worsened cardiac arrhythmia requiring treatment - deterioration of the level of consciousness compared to the start - pain that cannot be treated with adequate pain therapy	5, expert consensus
3.11 3.14	We recommend a protocol-based approach for implementing mobilisation with active and passive components	Protocol: 1 Components: 2
3.12	We suggest integrating safety criteria (e.g. pulmonary or cardiovascular conditions) into the mobilisation protocol	2
3.13	For preparing a mobilisation session, we suggest - informing the patient, - providing sufficient staff, and - securing/extending artificial airways, intravenous lines, or other drains	5, expert consensus
3.15*	We are unable to make a recommendation on the daily mobilisation duration	5, expert consensus
3.16*	We recommend stepwise mobilisation to the highest possible level	1
3.17*	We recommend the integration of (early) mobilisation into a treatment bundle covering the management of pain, anxiety, agitation, delirium, and conduction of spontaneous breathing trials in ventilated patients (e.g. ABCDEF bundle)	2
3.18	We are unable to make a recommendation for or against the combination of mobilisation with increased protein intake	5, expert consensus
3.19	We are unable to make a recommendation for or against the involvement of relatives in (early) mobilisation	5, expert consensus

ABCDEF, Assess, prevent, and manage pain, Both Spontaneous Awakening Trials (SAT) and Spontaneous Breathing Trials (SBT), Choice of analgesia and sedation, Delirium: assess, prevent, and manage, Early mobility and exercise, and Family engagement and empowerment

CRRT continuous renal replacement therapy, *ECMO* extracorporeal membrane oxygenation, *ICU* intensive care unit, *IMS* ICU Mobility Scale, *LoE* level of evidence, *SOMS* Surgical ICU Optimal Mobilisation Score

*Recommendation changed after the consensus conference due to literature search update. Original consented wording and explanation of the change is presented in ESM 1, Literature search update and modification

data available on the superiority of mobilisation, immobilisation should be the exception (Recommendation 3.8).

Level and duration of mobilisation The effect of the level of mobilisation on patient outcomes was investigated in an observational study, whereby a higher level of mobilisation was associated with a better state of health [109]. Active mobilisation, measured by IMS ≥ 4 (standing), reduced the risk of developing ICUAW [110]. Similarly, a retrospective analysis indicated that achieving an IMS ≥ 4 within 5 days of ICU admission increased the likelihood of being discharged home [111]. The TEAM trial, however, which initiated active mobilisation at the highest possible level and aimed to achieve the maximum level of activity, demonstrated no benefit [112]. A recent meta-analysis demonstrated positive effects on duration of ventilation, especially by progressive mobilisation programmes [116]. Consequently, a stepwise approach without overburdening the patients is recommended (Recommendation 3.16*).

There is evidence that the duration of mobilisation influences the effectiveness of mobilisation on patient outcomes. A higher dose reduced the risk of unfavourable discharge disposition and mortality and led to shorter ICU and hospital LOS [117, 118]. In a meta-analysis, a pre-defined subgroup analysis of three studies indicated that a higher dose of mobilisation (≥ 30 min/day) led to improved quality of life at 6 months [2]. A recent observational study further confirmed this, demonstrating that a mobilisation duration of more than 40 min positively impacts functional outcomes at ICU discharge [119]. The individual mobilisation dose for each patient may depend on the baseline physical criteria and the underlying disease (Recommendation 3.15*). Further studies in this area are required.

Which patients should receive early mobilisation?

Functional status The evidence for the effects of early mobilisation differs between specific patient groups based on the inclusion and exclusion criteria used; most studies enrolled critically ill patients who had been functionally independent prior to ICU admission. In these patients, the beneficial effect of early mobilisation is pronounced in outcomes such as duration of ventilation, ICU LOS, muscle strength, and ICUAW (see ESM 1, Table S4) [120–122] (Recommendation 3.3).

Currently, no studies specifically investigate the effect of (early) mobilisation in patients with functional dependence prior to ICU admission. However, some studies do not explicitly exclude these patients. Two RCTs, including patients ≥ 60 years after cardiac surgery or septic shock, demonstrated that mobilisation reduces the hospital LOS and improves health-related quality of life [123, 124]. Another non-randomised controlled study showed that mobilisation increased the level of mobilisation on the last day of rehabilitation, even in previously functionally dependent patients [125]. In a multivariate analysis within a matched cohort, frail patients did not exhibit functional deterioration more frequently than non-frail patients, suggesting that efforts should be made to at least maintain the functional status in this patient group (Recommendation 3.4) [126].

Renal replacement therapy and ECMO Concerns about catheter and tube dislocation are a common barrier to mobilisation. In patients who were mobilised during continuous renal replacement therapy (CRRT), only 1.8% of 436 patients experienced an adverse event [127] (Recommendation 3.5). In a prospective observational study including patients receiving ECMO, mobilisation was conducted on 24.9% of 1242 ECMO days. Low blood flow alarms occurred in 3.4% of mobilisations. All adverse events were self-limiting or resolved by the treatment team [128]. Another observational study had a similar rate of 3.6% of adverse events [129]. One accidental femoral cannula displacement during one mobilisation episode, with immediate and effective recannulation, is reported [128]. Therefore, only centres with the necessary expertise in ECMO therapy should perform mobilisation in this high-risk cohort, following consultation with the interprofessional team and thorough evaluation of contraindications (Recommendation 3.7).

Neurocritical ICU patients Neurocritical care patients commonly have bed rest due to concerns about alterations in intracranial pressure and vasospasm [130]. In a pre-post-study in neurocritical ICU patients diagnosed with subarachnoid haemorrhage, cerebral malignancy, or stroke, (early) mobilisation following a progressive protocol was safe, increased mobility, and reduced VAP rates and ICU and hospital LOS [131]. These effects were confirmed in patients with severe brain injury [132]. In contrast, data derived from stroke patients in stroke units (i.e. not in an ICU) indicate that very early mobilisation (< 24 h) may be harmful [133] (Recommendation 3.6).

When should a mobilisation session be discontinued, and what are the contraindications for mobilisation?

Adverse events occur in 2.6–3.9% of cases, which makes close monitoring a critical tool for recognising a deterioration in vital signs at an early stage [134, 135]. To date, there have been no studies comparing different discontinuation criteria. Thus, the clinical symptoms used in the literature were adopted [101, 136, 137], which are considered reference values without general validity (Recommendation 3.10*).

Assessing respiratory and cardiovascular reserves before mobilisation to adjust intensity appropriately is necessary (Recommendation 3.9). No evidence supports absolute parameters as safety criteria for mobilisation initiation, emphasising the importance of the patient's overall clinical presentation. Values in ESM 1, Table S8, are expert-based, aiding individual risk–benefit assessment. We recommend integrating ICU-specific safety criteria into mobilisation protocols (Recommendation 3.12). If mobilisation is not possible during the assessment, implementing therapeutic measures for improvement, followed by a re-evaluation, is warranted [136].

What are the requirements to perform (early) mobilisation?

Early mobilisation therapy must overcome structural barriers to mobilisation such as insufficient personnel and financial support and a lack of equipment [138, 139]. The hospital management is responsible for creating the conditions for implementing this guideline's recommendations (Recommendation 3.2).

Table 3 Recommendations for mobilisation assist devices and robotics

#	Recommendation	LoE
4.1	We are unable to make a recommendation for or against the use of supine cycling in combination with (early) mobilisation	2
4.2	We suggest considering supine cycling as part of (early) mobilisation only when functional training is not sufficiently possible	1
4.3	We recommend monitoring intracranial pressure in patients at risk of intracranial pressure elevations when using a supine cycling	2
4.4	We are unable to make a recommendation for or against the use of assist devices (e.g. tilt tables, treadmills with body weight support) or robotics	5, expert consensus

How should mobilisation be implemented in intensive care?

Implementing bundles that include (early) mobilisation consistently improve patient outcomes [6, 7, 140, 141]. In a multicentre cohort study, ABCDEF bundle implementation correlated with a reduced likelihood of severe outcomes [142]. Recommendations from other guidelines and the implied synergistic effect of accompanying elements support a coordinated bundle approach (Recommendation 3.17*).

How should a mobilisation session be prepared?

Before mobilisation, the treatment team and the patient should be informed. Therapeutic measures, such as line or tube extensions, should be adjusted for safe continuation during mobilisation. Alarm limits should be modified for safety and additional staff support should be considered. These aspects should be planned individually within the interprofessional team based on the patient's clinical background. The patient's status, consciousness, and vital signs should be closely monitored during mobilisation. In ventilated patients, essential ventilation parameters should be continuously monitored (Recommendation 3.13).

How can nutrition supplement (early) mobilisation?

The interaction between exercise, energy consumption, and diet in critically ill patients remains unclear. Active transfer to the chair for 20 minutes required less than five additional kilocalories in ventilated patients [143]. A meta-analysis of 19 studies comparing high versus low protein intake showed no impact on mortality, ventilation duration, or ICU/hospital length of stay but significantly reduced muscle atrophy [144], while the EFFORT trial showed no benefit and a signal of harm in patients with acute kidney injury and high organ failure scores [145]. Increased protein intake with NMES [146] or supine cycling [147] has been associated with reduced muscle atrophy. However, current evidence is insufficient for a recommendation (Recommendation 3.18).

How should relatives be involved in critically ill patients' (early) mobilisation?

The burden on ICU patients' relatives has garnered recent scientific attention. Involvement in care, including mobilisation therapy, has been well-received by the treatment team, patients, and their families [148]. The ABCDE bundle has expanded to ABCDEF (F for family) to acknowledge this aspect. Limited evidence prevents a recommendation on caregiver involvement in mobilisation currently (Recommendation 3.19).

Mobilisation assist devices and robotics

For recommendations on assist devices and robotics see then Table 3.

Background

Assist devices include equipment-assisted (e.g. supine cycling, treadmill, and tilt table) and robotic-assisted measures (e.g. automated stepping device) for passive, assisted-active or active mobilisation. Assist devices represent an opportunity to overcome barriers to (early) mobilisation, such as staff shortages while adapting to the patient's individual rehabilitation needs.

Do mobilisation assist devices or robotics have a beneficial effect?

Supine cycling is the most studied assist device; however, it is often evaluated as part of heterogeneous study protocols concerning intervention, control group, and outcomes. The combination of bed cycling with mobilisation showed no improvement in functionality or quality of life [149–151].

In eight of nine RCTs and meta-analyses [149, 152–159], the duration of ventilation was not influenced by the additional use of cycling in the supine position. Similarly, in seven of nine RCTs and meta-analyses [73, 75–80, 82, 83], cycling in bed did not reduce ICU or hospital LOS. In patients with acute respiratory failure, cycling in the supine position led to improved functionality, a shorter duration of mechanical ventilation and a shorter ICU LOS [154] (Recommendations 4.1, 4.2).

Table 4 Recommendations on NMES

#	Recommendation	LoE
5.1	We suggest considering neuromuscular electrical stimulation for (early) mobilisation of critically ill patients	1
5.2	We recommend continuously monitoring intracranial pressure in patients with already established intracranial pressure monitoring when using neuromuscular electrical stimulation	2

Cycling in the supine position is safe [151, 152, 154, 160]. Only one RCT showed increased intracranial pressure elevations in the intervention group who received a progressive mobility programme, including functional electrical stimulation and bed cycling. In the subgroup of patients with intracranial pressure monitoring, the combination of early mobilisation, NMES and supine cycling led to an increase in intracranial pressure compared to early mobilisation alone (Recommendation 4.3) [149].

There are only a few studies that investigate assistive devices. Kwakman et al. trained patients on a treadmill using their body weight until they could walk with walking aids. The authors found a significantly shorter hospital LOS compared to supervised physiotherapy sessions [161]. In a pilot RCT, stepping verticalization was evaluated in addition to physiotherapy sessions. In patients with impaired consciousness, the intervention led to a longer ICU LOS but improved Disability Rating Scale and the Coma Recovery Scale (Recommendation 4.4) [162].

Neuromuscular electrical stimulation

For recommendations on NMES see then Table 4.

Background

NMES is the non-invasive, transcutaneous application of electrical stimuli that leads to active muscle contraction independent of the patient's cooperation. This therapeutic option can be particularly beneficial in the early phase of a critical illness when patients are often sedated but pathophysiological catabolic processes are already taking place at the muscular level [11].

Should NMES be used in the early mobilisation of intensive care patients?

Several systematic reviews and meta-analyses reported beneficial effects of NMES on physical function [137, 163], muscle strength [163, 164], duration of mechanical ventilation [164, 165], extubation success rate [166], and ICU and hospital LOS [164]. In contrast, others showed no differences in these outcomes (Recommendation 5.1) [153, 167].

NMES is generally a safe intervention [165, 168]. However, in a monocentric RCT, the intervention group that received protocol-based physiotherapy with functional electrical stimulation (combination of NMES and in-bed cycling) showed significantly more ICP elevations and poorer health-related quality of life in the cognitive domain [149]. Therefore, assessing ICP information is recommended for patients with already established ICP monitoring (Recommendation 5.2).

Conclusion and outlook

The beneficial effect of mobilisation in critically ill patients is evident. Still, it is necessary to determine which dose of mobilisation (frequency, duration, level, exertion) is appropriate for which group of patients to achieve the best possible outcome.

The same applies to positioning, where the optimal dosage (frequency and duration), especially for prone positioning, needs to be clarified.

Further evidence will most likely lead us down the path of individualised positioning and mobilisation therapy, similar to other areas of medicine. Despite technological progress, (early) mobilisation and positioning remain a (physical) effort that should be a collective responsibility of the whole intensive care team. This guideline should make a useful contribution to this effort.

Supplementary Information
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Data availability
The authors confirm that all information supporting the recommendations is available within the article and its supplemental information.

Declarations

Conflicts of interest
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