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SYSTEMATIC REVIEW

Long-term complications of prone position ventilation with relevance for acute and postacute rehabilitation: a systematic review of the literature

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ABSTRACT

INTRODUCTION: Prone positioning ventilation (PPV) is an effective treatment for patients with moderate to severe acute respiratory distress syndrome (ARDS). Despite the benefits of PPV, different kinds of short and long-term consequences have been noted. This review summarizes long-term complications of PPV that impact treatment strategies and outcomes in acute and postacute rehabilitation.

EVIDENCE ACQUISITION: PubMed/Medline, Cochrane Library, Cochrane COVID-19 Study Register databases and the Google Scholar search engine were systematically searched for studies investigating long-term complications of PPV. The final search date for all sources/databases was January 31, 2022. For our methodological appraisal, we conducted a systematic review of articles without any restrictions on types of articles or publication dates. Only articles published in English and available as full texts were eligible for inclusion. After the screening process, data of interest were extracted from eligible sources: PPV sequelae and conclusions (*i.e.* possible effects on the course of rehabilitation and therapy strategies).

EVIDENCE SYNTHESIS: A total of 59 studies are included in this review. Long-term consequences are mainly pressure ulcers and nerve lesions that exist after discharge from the Intensive Care Unit (ICU). Publications rarely recommend treatment strategies for long-term complications after PPV. Due to the quality of the included studies, no robust conclusions as to effective strategies can be drawn.

CONCLUSIONS: Further high-quality research is required, considering the different long-term complications after PPV and their impact on rehabilitation in order to draw conclusions about viable physical therapies. Crucially, however, prone positioning (PP) sequelae pose new challenges to physicians and therapists in acute and postacute rehabilitation medicine as well as follow-up care.

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KEY WORDS: COVID-19; Respiratory distress syndrome; Critical illness; Prone position; Follow-up studies.

Introduction

The Proning Severe ARDS Patients (PROSEVA) Trial from 2013 has established prone positioning (PP) as a recommended treatment to help improve respiratory function and oxygenation in critically ill patients with acute respiratory distress syndrome (ARDS) by showing a survival benefit.[1, 2] First recognized in the 1960s, ARDS is caused by diffuse lung damage and manifests by acute, severe shortness of breath, hypoxemia and bilateral diffuse pulmonary infiltrates; it leads to respiratory failure.[3, 4] As it is widely known by now, an infection with SARS-CoV-2 affects the respiratory system, frequently causing ARDS, which can require extended periods of invasive mechanical ventilation.[5] As a consequence, implementation of the PP recommendation in ARDS has increased significantly during the COVID-19 pandemic.[2] At the same time, there has been an increased number of reports of adverse events and complications associated with prone positioning ventilation (PPV).[6] Specifically, PPV sequelae have been posing new challenges to physicians and therapists in acute and postacute rehabilitation medicine as well as follow-up care.[7] An effective breathing support strategy is crucial in treating both COVID-19 ARDS and typical ARDS caused by other pathogens.[8, 9] PPV is an effective treatment for patients with moderate to severe ARDS which can improve oxygenation and reduce mortality.[8] PP has been used since the 1970s to treat severe hypoxemia in patients with ARDS because of its effectiveness in improving gas exchange. Compared with the supine position (SP), placing patients in PP effects a more even tidal volume distribution through improved ventilation of dorsobasal parts of the lungs.[10] PPV appears to be also beneficial in COVID-19-related ARDS.[11] While PPV is used in only about 16% of patients with typical ARDS, its use in COVID-19-related ARDS has been more pervasive and has been shown to be successful earlier in the course of ARDS, with a suggested duration of use for more than 12 hours per day.[12, 13] In the treatment of severe COVID-19 patients, PP has also been applied in awake patients receiving high flow oxygen therapy, especially in patients with moderate ARDS, for an improvement in the mismatch of ventilation-perfusion and for opening the atelectatic lungs by adequate sputum drainage.[11, 14] Despite the benefits of PPV, different kinds of sequelae have been noted, which can be directly attributed to prone ventilation sessions.[15-17] Some side effect risks seem to correlate with the number of days under mechanical ventilation and the daily duration of PP.[17] The sheer number of critical COVID-19 cases during the pandemic has resulted in an increase in ARDS patients being treated in PP, and thus an increase in patients presenting with different kinds of PP sequelae in acute and postacute rehabilitation.[18] A growing number of papers capture typical consequences of PPV. In addition, several reviews offer synopses of these PPV sequelae.[19, 20] However, from an acute and postacute rehabilitation medicine perspective these numerous studies with their disparate scopes and perspectives make it difficult to gain a focused understanding of the sequelae that affect follow-up care. It is crucial to understand how PPV sequelae impact treatment strategies and outcomes in acute rehabilitation and follow-up care. With a view to helping elicit prompter and more specific responses to these challenges in follow-up care, this review aimed to provide an overview of publications on PPV in ARDS, with a focus on their long-term sequelae.[21] In a second step, we aggregate the findings on each sequela with an identified relevance for follow-up care across all publications.

Evidence acquisition

Study design

The literature search was performed based on the Preferred Reporting Items for Systematic Reviews.[22]

Information sources

We relied on the following sources to identify pertinent publications: 1) database search (performed on the 31 January 2022) – PubMed, Cochrane Library, Cochrane COVID-19 Study Register; 2) screening of references from included articles; and 3) search on the internet (*via* Google Scholar) to identify potential sources in the grey literature.

Search strategy

The systematic database search and article selection were performed by two independent investigators, blinded to each other. We followed three search strategies to identify pertinent publications, with a final search date of January 31, 2022. The search strategy was developed by combining search terms related to the intervention ("prone position" OR "prone" AND "position") and the key words related to PP effects ("complication" OR "side effects" OR "sequelae") and related to the cause of PPV ("ARDS" OR "acute respiratory distress syndrome"). The detailed search strategy is reported in Table I.

Data collection process and data items

The data items of interest were extracted by two reviewers. The results were double-checked and completed by one other author. From each individual study, the following information was extracted: study design, patient characteristics (sample size), ventilation position, PP sequelae and the conclusions of the authors. Only outcomes of PP sequelae relevant for acute and postacute rehabilitation were included in the data extraction form. Other outcome measures, which do not influence follow-up rehabilitation, were displayed, yet disregarded in the aggregated analysis.

Table I.—*Search strategy.*

Database	Search strategy
Medline (PubMed)	"Prone position" OR "prone" AND "position" AND "complication" OR "side effects" OR "sequelae" AND "ARDS" OR "acute respiratory distress syndrome" AND "humans"
Cochrane Library	"Pron*" AND "complicat*" OR "side effect" OR "sequelae" AND "ARDS" OR "acute respiratory distress syndrome" in Title Abstract Keyword – in Trials (word variations have been searched)
Cochrane COVID-19 Study Register	"Pron*" AND "complication" OR "side effect" OR "sequelae" AND "ARDS" OR "acute respiratory distress syndrome" in Select All (word variations have been searched)
Google Scholar	"Prone position" OR "prone" AND "position" AND "complication" OR "side effects" OR "sequelae" AND "ARDS" OR "acute respiratory distress syndrome"

Eligibility criteria

Studies were included in this review if they met the following inclusion criteria: 1) type of participants – articles dealing with PP in patients suffering from ARDS (>18 years old); 2) type of intervention – studies investigating prone positioning-associated sequelae; 3) type of outcome – articles including data from prone positioning-associated sequelae that impact treatment strategies and prognoses/outcomes in acute and postacute rehabilitation, and follow-up care (ulcers and wounds, nerve injuries, edema, health-related quality of life); and 4) type of study design – no restrictions on the type of article were imposed. We included all relevant articles from reports of single cases to prospective randomized trials. We applied no publication date constraints. Studies had to be published in English language.

Exclusion criteria

Excluding criteria were: 1) additional diagnoses – articles investigating other diagnoses besides ARDS in PPV; 2) pregnancy – articles on ARDS in pregnant patients; 3) pediatric – articles on ARDS in pediatric patients; and 4) type of outcome – articles were excluded if they focused only on short-term effects that did not persist after discharge from ICU, such as improvement of respiratory and oxygenation parameters, physiological effects, selective intubation, displaced intravenous accesses, endotracheal tube obstruction, tracheal tube displacement, bleeding, and mortality outcome.

Screening process

After excluding duplicates, titles and abstracts of the remaining publications were screened to identify relevant studies. The searches were carried out in titles, abstracts and key terms without restrictions regarding publication dates. For both, studies considered relevant and cases of doubt, full paper copies were retrieved to check their eligibility. If the full text was not available, the study was excluded.

Evidence synthesis

Study selection

Two reviewers (C.V., N.E.) independently reviewed the records identified in the search and assessed the full

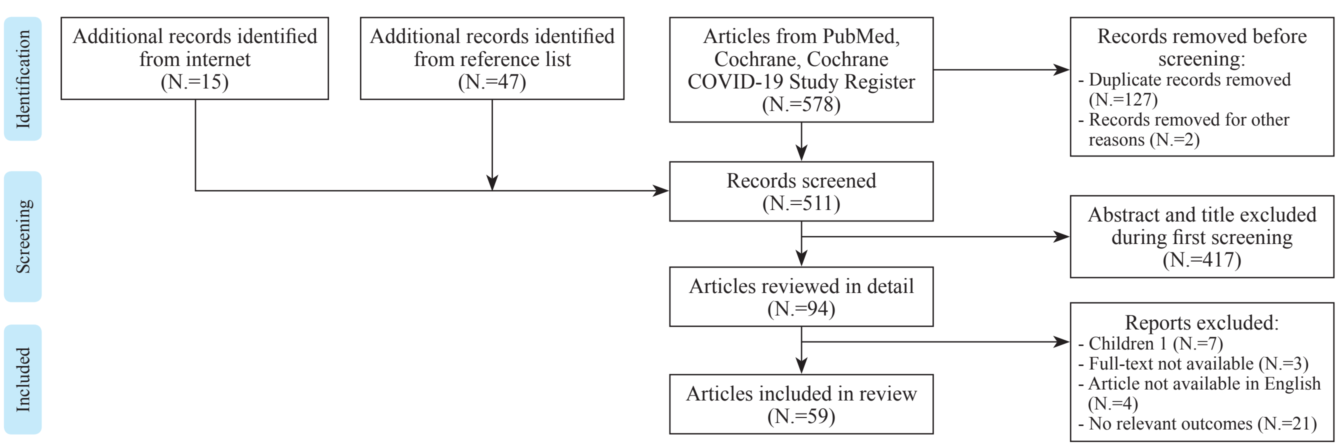

Figure 1.—Flow diagram of the literature selection process.

texts. The database search resulted in a total of 449 hits after removal of duplicates (27) and animal studies (2). A further 62 articles were obtained by screening reference lists and a grey literature search (Figure 1). Of these 511 articles, 417 (81.6%) were excluded during the screening of titles and abstracts. The remaining 94 articles were screened in full text for inclusion criteria. Of these, a further 35 (37.2% of articles screened in full) were excluded (7 pediatric articles, 3 articles not available in full text, 4 not available in English, 21 articles without relevant PP outcomes). Table I provides a systematic overview of all included articles and the side effects of PP they discuss.

Study characteristics

Supplementary Digital Material 1 (Supplementary Table I)[2, 6, 15-17, 21, 23-75] lists the characteristics of all reviewed studies in detail (reference, study design, sample size, PPV associated sequelae, and conclusion of the article).

PPV complications

While the reviewed studies (Supplementary Digital Material 1: Supplementary Table I[2, 6, 15-17, 21, 23-75]) address PP sequelae in ARDS patients, almost all of them (especially case reports) are limited to individual outcomes and their impacts. This review aimed to focus on long-term consequences of PPV (persisting after discharge from ICU and beyond) and discuss potential treatment options that follow. To this end, publications were evaluated with a focus on the findings they provide on the individual PP sequelae.

Pressure sores/pressure injury

PS are defined as damaged skin and tissue due to pressure-induced ischemia.[76] In 2016, the National Pressure Injury Advisory Panel published the Revised NPUAP Pressure Injury Staging System which categorizes pressure injuries (PI) in 4 stages.[77] Stage 1 is described as an intact skin with a localized non-blanchable erythema; attention must be paid in patients with darkly pigmented skin. In stage 2, the skin shows loss of partial thickness with exposed dermis. In stage 3, because of full-thickness skin loss, adipose tissue is visible in the ulcer, the granulation tissue and the epibole.[77] PIs in which a full-thickness tissue damage can be seen, and fascia, muscle, tendon, ligament, cartilage, or bone is exposed or directly palpable in the ulcer, are categorized as Stage 4 pressure injuries.[77] Locations differ depending on patient positioning but skin over bony protrusions is particularly affected.[76] As PP puts anterior body parts in contact with the surface, it seems logical that the incidence of PS involving the face, the abdomen and the anterior part of the thorax is higher in patients in PP than in SP. This conjecture was confirmed by Girard R. *et al.*: at ICU discharge, 41 out of 223 patients that had been treated in PP had facial PS and 14 out of 219 showed PS involving the anterior part of the thorax, whilst in the SP group, the number was only 3 out of 216 and 2 out 216.[39] Also, the appearance of PS on ears,[44] eyelids,[44] cheekbones,[15, 44] chin,[15, 36, 44] scapular waist[29, 44] thorax[15, 36, 40] abdomen,[36, 51, 64] genitals,[44, 46] trochanter,[15] and other sites[37, 39] were described in various studies. Some only mentioned stages of recorded PS but not location.[2, 24, 29, 53, 55] Risk factors for the development of PS in ICU patients are: age, emergency admission, use of norepinephrine, cardiovascular comorbidity, respiratory comorbidity, Sequential Organ Failure Assessment Score (SOFA), length of stay in the ICU, duration of invasive ventilation, winter ICU admission and immobilization.[2] In their multicenter retrospective cohort study, L'Her *et al.* found that the occurrence of clinically significant PS (stage 3 or 4) was directly related to the required number of PP-sessions but not to their duration.[53]

Nerve injuries (upper/lower extremity)

Nerve injuries are uncommon following prone positioning. Yet, in the two months of SARS-CoV-2 peak pandemic in northern Italy, 7 cases of compression injuries across 135 patients who underwent PPV were observed.[26] All of the 7 patients were male. Prevalence of the condition among patients with SARS-CoV-2 discharged from ICU thus amounted to about 5%. Several factors may account for such complications.[26] SARS-CoV-2 infection in combination with IV in PP seems to increase the risk of developing compression nerve injuries.[26] PP procedures require expert skills. Extracare must be taken with arm positioning and motion while patients are prone. Peroneal nerve palsy is the most frequently observed compression neuropathy in lower extremities.[78] Terlemez *et al.* observe patients with unilateral peroneal nerve entrapment. External compression of the peroneal nerve, usually followed by anesthesia, prolonged hospitalization, casting, tight bracing, compression wrapping, and pneumatic compression device use, often causes peroneal nerve entrapment.[71]

Prone position plexopathy

In a case report from 2002, Goettler *et al.* described two cases of brachial plexopathy after the patients were treated in PP.[41] The first case involved a 34-year-old woman who was treated in PP for 12 hours a day as a part of ARDS treatment.[41] During her stay in the ICU, the patient described numbness and presented weakness in her entire left hand and paresthesias of her radial forearm.[41] Thanks to aggressive physical therapy, she showed a complete recovery of functional activity in the left arm.[41] The superficial location of the upper trunk of the brachial plexus in the supraclavicular area renders it susceptible to compression or traction injuries.[67]

Meralgia paresthetica

Meralgia paresthetica (MP) is caused by compression of the lateral femoris cutaneous nerve (LFCN) in the inguinal ligament region in front of the spina iliaca anterior superior,[79] resulting in dysesthesia, paresthesia, anesthesia, or hypoesthesia over the region innervated by the LFCN, the anterolateral thigh.[80] Juhl *et al.* presented the case of a 57-year-old male who received PPV in ARDS treatment. He was positioned with his forehead and chin on a head rest while two supporting pads were placed under the upper thorax and the hips, leaving the abdomen hanging free, without pressure on the genitalia.[45] A third supporting pad was placed under the lower legs.[45] From the time of waking up in the intensive care unit and more than six months later, the patient noticed numbness on the lateral side of both thighs (24). A bilateral meralgia paraesthetica was suspected and later confirmed.[45] The authors assume MP to be an underdiagnosed condition in patients who receive mechanical ventilation in PP.[56, 63, 74]

Lower cranial nerves paralysis

Trejo-Gabriel-Galan *et al.* reported on a 48-year-old male who complained about dysphagia after PPV over a period of two days for 18 hours per day.[72] During a neurological examination the patient presented no movement of the right palate pillar due to right glossopharyngeal/vagus paralysis (IX, X cranial nerves) and atrophy of the right trapezius and sternocleidomastoid.[72] The authors assume that the cranial nerves IX to XII were damaged in the mandibular retrocondylar-peripharyngeal space due to accidental sliding back of the *U*-shaped soft padding around the face intended to protect it from skin ulcerations or, alternatively, because of neck hyperextension during neck repositioning every 2 hours as per protocol.[72] Decavel *et al.* assume that mechanical compression linked to PPV therapy appears to be the major factor for lower cranial nerve palsies.[35]

Edema

Edema is defined as a pathological accumulation of fluid in the interstitium. The etiology is manifold. Edema described in the reviewed studies are facial edema,[24, 44, 53, 55, 58] conjunctival edema (chemosis),[44] limb edema, and thorax edema.[55] In addition, Chan *et al.* noted a swelling of the face, eye and knee.[29] Again, the locations of these sequelae are coherent with parts of the body exposed to PP-induced increased pressure. According to Chan *et al.*,[15] L'Her *et al.*[53] and Mancebo *et al.*,[55] edema rapidly improves after the patient is turned back to SP.

Health related quality of life

The Short Form-36 Questionnaire (SF-36) combines physical and mental components into its scoring as it relates to vitality, physical functioning, bodily pain, perceptions of health, physical role functioning, emotional role functioning, social role functioning and mental health.[81] The score ranges from 0 to 100, with higher scores indicating lower levels of disability. Similarly to SF-36, the Saint George Respiratory Questionnaire (SGRQ) is a health related quality of life questionnaire but specifically designed for patients suffering from pulmonary disease. It covers three domains: symptoms, activity and impact on daily life.[32] While the score again ranges from 0 to 100, here it is lower scores that indicate better pulmonary-specific health-related quality of life.[32] In a 12-month follow-up observational prospective study Chiumello *et al.* studied which effect the application of PP in patients with ARDS had on health-related quality of life compared to patients treated in supine position (SP). No differences in pulmonary function or health-related quality of life between the PP-group and SP-group could be found. However, ARDS survivors, whether treated in PP or SP, reach significantly lower SF-36 scores at 1 year compared to comparably critically ill patients who did not experience ARDS.[32, 34] Davidson *et al.* reported statistically significant reductions in 7 of 8 SF-36 domains, which were physical functioning, role-physical, bodily pain, general health, vitality, social functioning, and mental health, with a difference in scores ranging from 6 to 24 points per domain.[43] These reductions seem to be related to alterations in pulmonary function, impairment of muscle function, and duration of mechanical ventilation.[32]

Impaired mobility and work ability

Kiekens *et al.* in "'Instant paper from the field' on rehabilitation answers to the COVID-19 emergency" reported several mobility impairments in COVID-19-related ARDS survivors, such as: muscle weakness, critical myopathy (and neuropathy), reduced joint mobility, neck and shoulder pain, difficulty in verticalization, impaired balance and gait.[48] Herridge *et al.* evaluated ARDS survivors 3, 6 and 12 months after their ICU discharge, at each stage submitting patients to a physical examination and a standardized 6-minute walk test with continuous oximetry as well as having them complete the SF-36.[82] At the time of discharge from the ICU, patients who survived ARDS were severely wasted and had lost 18% of their base-line body weight. 71% of patients (59 of 83) returned to their base-line weight by one year.[82] All patients reported poor function, which the authors attributed to the loss of muscle bulk, proximal weakness and fatigue; 12% suffered marked and persistent pain at the sites of insertion of chest tubes; 7% showed entrapment neuropathies; 5% sustained enlargement and immobility of large joints as a result of heterotopic ossification; 4% experienced contractured fingers or frozen shoulders due to immobility during their stay in the ICU.[82] Exercise limitations were attributed to global muscle wasting and weakness, foot drop due to entrapment syndromes that began in the ICU, immobility of large joints as a result of heterotopic ossification, and dyspnea.[82] 12 months after ICU discharge, only 49 percent of the evaluated ARDS survivors had returned to work. Patients who had not returned to work stated the following reasons: persistent fatigue and weakness, poor functional status as a result of foot drop and immobility of large joints, work-related stress, voluntary retirement, and job retraining.[82]

Ocular complications

Whilst PP is known to improve ventilation-perfusion mismatch, it may also cause or potentiate an array of devastating ocular complications, including ocular injury, exposure keratopathy, conjunctival chemosis, acute angle closure, ischemic optic neuropathy, orbital compartment syndrome and vascular occlusions.[83] Some studies describe ocular complications like conjunctival hemorrhage[2, 55] and an increase in intraocular pressure (IOP).[68] Subconjunctival hemorrhage emerges due to ruptured small blood vessels in the space between episcleral and conjunctiva, resulting in ocular redness but not in visual impairment.[84] During PP, direct pressure on orbits can result in trauma which is a possible cause for the development of conjunctival hemorrhage.[85] The development of chemosis in patients treated in prone position can be explained on the one hand by gravitational causes of increased hydrostatic pressure and, on the other, by compromised venous return from the ocular structures as a result of positive pressure ventilation escalating positive end expiratory pressure, or of tight endotrachial tube taping.[86] An IOP between 11 and 21 mmHg is considered normal.[87] Saran *et al.* found a significant increase in IOP in ARDS patients treated in PP.[68] In two case reports listed in Table I, an increase in intraocular pressure potentially led to acute ischemic optic neuropathy (ION) and thus to loss of vision.[58, 61] A possible explanation for the development of vision loss in ION could be an increase in IOP that leads to a decline in ocular perfusion pressure – defined as mean arterial pressure (MAP) minus IOP in mmHg – which may ultimately result in insufficient blood supply to the optic nerve.[83]

Short-term complications during PPV-treatment/adverse events

Numerous short-term PP sequelae appear in the reviewed publications. Vomiting,[15, 29, 53] nasogastric pump infusion,[29] endotracheal tube related complications,[2] hypoxemia,[2, 53] transient blood pressure decrease in patients under vasoactive drugs,[53] central venous catheter dislodgement,[53] selective endotracheal intubation and barotrauma,[53] endotracheal extubation,[53] sinus drain dislodgement,[53] enteral nutrition discontinuation,[53] displacement of the respiratory device,[53] increase in gastric residue,[53] cardiac arrest,[55] displacement of urinary bladder catheter and nasogastric feeding tube,[55] kinking of endotracheal tube,[55] kinking of thoracic drain.[55] In the lying patient, an intracranial pressure between 10 mmHg and 15 mmHg is physiological.[88] Guerin *et al.* and L'Her *et al.* both reported a possible transient intracranial pressure increase (ICP) during treatment in PP.[2, 53]

Discussion

Especially in the last two years, during the COVID-19 pandemic, many articles have focused on sequelae after PPV. Our review confirms that 31 of the 59 included studies have emerged since 2020. Our research has shown that the majority of existing studies addressing long-term complications of PP are case reports (32), with one additional interview and retrospective studies (9). By virtue of their designs, these studies are valuable in demonstrating the relevance, variance and frequency of PP sequelae. However, (given the nature of their data), it is hardly possible to derive any therapeutic standards from them, *i.e.*, to determine the viability/efficacy of therapeutic measures, their (required) frequency, and their importance in the follow-up of long-term PP complications. This review provides a comprehensive overview of all long-term consequences after PP. PS and nerve lesions are particularly frequently observed. Luchnini *et al.* also focus on PS and peripheral nerve injuries as long-term complications caused by PPV.[21] Considering the consequences, the question arises what impact these have on rehabilitation and what knowledge can be gained for follow-up care. PS after PP are particularly common and identified in 33 of the included studies. Specialties caring for COVID-19 survivors having undergone PP should be vigilant in the inspection of face and anterior body skin, as well as in the examination of the upper and lower extremities, to identify and treat potential pressure and nerve injuries. Neurologic symptoms (mainly peripheral nerve lesions) were identified as sequelae in 17 of the included studies. PS treatment consists in suppressing the pressure point on the wound due to mobilization, debridement of necrotic tissue, and secondary wound healing with paraffin gauze dressing or alginate in case of abundant wound exudate.[14] PS can be a reservoir for bacteremia and should therefore be managed with care if wound healing is impaired.[89] Over time, facial PS can be responsible for unsightly scars, hyperpigmentation or keloid scars, and may require additional procedures. Furthermore, their long-term consequences need to be evaluated.[29] PS are already important in intensive care treatment but may persist and require continuing care in rehabilitation. Low-grade PS have less serious consequences, and only few patients may need special care or treatment. In the event of PU-related complications, early treatment can contribute to full skin recovery.[21, 65] Neurological symptoms (mainly peripheral nerve lesions) are identified in 17 of the included studies. Thus, peripheral nerve injury appears to be a relevant disabling complication of PP. Therapeutic measures should be implemented as early as possible.[41] Compressive neuropathies can be debilitating and achieving maximal healing may be a long process. PP complications should not be underestimated, particularly regarding their long-term effects. Thus, the possibility of a change in health condition caused by prone positioning-related consequences should be included in treatment planning. Early recording of a patient's health condition after PP may be fundamental to assess the need for rehabilitation (according to the International Classification of Functioning, Disability and Health [ICF]). Numerous possible functional disorders can lead to a change in body structures and/or body functions and are a prerequisite for the use of the ICF and assessment for follow-up care.[90] Davidson *et al.* reported statistically significant reductions in 7 of 8 SF-36 domains following PP, which were mainly physical functioning, role-physical, general health, social functioning and mental health.[34] This recording of limitations in the sense of the ICF can be particularly useful in determining a need for rehabilitation. Generally, ocular complications do not directly impact acute or postacute rehabilitation. Nevertheless, they may frustrate the discharge from acute hospital, for example due to a need for ophthalmological care. Due to the number and frequency of long-term PP sequelae reported in the reviewed studies, the following points are important in follow-up care:

- in any stage of treatment after PP, a head-to-toe examination by the supervising staff should identify possible sequelae to integrate them into treatment planning;
- providing "feedback" on PP consequences to the treating staff (physicians, therapists, nurses) of the prestation/ICU for improvement of positioning techniques, treatment optimization and prophylaxis (regular training and retraining);

Table II.—*Learning points for treating PP sequelae.*

PP-sequelae that can already be treated in ICU	PP-Sequelae that may persist and are relevant in follow-up care (rehabilitation)
Edema. Pressure sores/pressure injury. Nerve injuries (upper/lower extremity). Ocular complications. Lower cranial nerves paralysis.	Pressure sores/pressure injury. Nerve injuries (upper/lower extremity). Plexopathy. Meralgia paresthetica. Lower cranial nerves paralysis. Ocular complications. Health-related quality of life reduction. Impaired mobility and work ability.
Treatment options	Treatment options
Early mobilization. Physical therapies. Manual lymphatic drainage (*e.g.*, head/face/neck edema). Speech and swallowing therapy. Nutritional counseling.	Early mobilization. Physical therapies. Manual lymphatic drainage (edema-induced headaches). Compression bandaging. Falls prophylaxis (*e.g.* vision loss, nerve lesion). Speech and swallowing therapy. Nutritional counseling. Occupational therapy. Aid supply (supplying testing and fitting of aids).

• PP sequelae are not uncommon and can cause long-term complications;
• PU and nerve lesions are particularly common;
• therapeutic measures should be implemented as early as possible.

So far, early physiotherapy mobilization has been recommended to prevent muscles weakness and limit further sequelae potentially due to PP.[44] Table II summarizes the authors' treatment recommendations for prone positioning-associated sequelae. As short-term sequelae are seldomly relevant for follow-up and rehabilitation, this review only mentions them if a study evaluated them in addition to relevant long-term sequelae.

Limitations of the study

The limitations of this review are mostly related to the heterogeneity of the studies regarding [such aspects as] patient characteristics, study design, methods, and variety of PPV long term consequences. Most of the studies lack a detailed description of their methods/criteria. The long-term sequelae of PPV that we extracted from the included studies are not always based on guidelines, but PPV sequelae are still difficult to assess accurately, both in grading them but also in identifying them accurately. We included some case reports to obtain more comprehensive information, thus further adding to the heterogeneity of the material. However, our aim was to maximize the number of studies addressing long-term effects of PPV. However, when interpreting the results, the moderate to poor methodological quality of the included studies must be taken into account. In addition, any risk of bias in the included studies was disregarded. Further limitations of the study include the following: the search may not be comprehensive because no controlled vocabulary such as MeSH was used in the search strategies, the review was not registered, and a protocol was not prepared. The study might have a language bias as only papers written in English were included in the analysis. None of the studies refer to the role of PPV long-term effects in rehabilitation, so that only indirect conclusions can be drawn. This review is the first to discuss the influence of PP-associated sequelae on the course of rehabilitation.

Conclusions

Complications due to prone position ventilation should be monitored at each stage of the treatment by the supervising staff. In the follow-up, special attention should be paid to PP associated sequelae in physical examinations. PP associated sequelae can influence the course of rehabilitation and play an important role in diagnosis, treatment and therapeutic measures.

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