



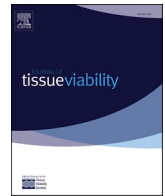
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Skin damage prevention in the prone ventilated critically ill patient: A comprehensive review and gap analysis (PRONect study)

Anika Fourie^a, Maarit Ahtiala^b, Joyce Black^c, Heidi Hevia^d, Fiona Coyer^{e,f}, Amit Gefen^g, Kim LeBlanc^{h,i}, Steven Smet^a, Kathleen Vollman^j, Yolanda Walsh^k, Dimitri Beeckman^{a,l,m,*}

^a Skin Integrity Research Group (SKINT), University Centre for Nursing and Midwifery (UCVV), Department of Public Health and Primary Care, Ghent University, Ghent, Belgium

^b Service Division, Perioperative Services, Intensive Care Medicine and Pain Management, Turku University Hospital, Turku, Finland

^c Niefteft Professor of Nursing, University of Nebraska Medical Center, College of Nursing, Omaha NE, USA

^d Nursing School, Nursing Department, Andres Bello University, Viña del Mar, Chile

^e Intensive Care Services, Royal Brisbane and Women's Hospital, Brisbane, Australia

^f School of Nursing, Queensland University of Technology, Brisbane, Australia

^g The Herbert J. Berman Chair in Vascular Bioengineering, Department of Biomedical Engineering, Faculty of Engineering, Tel Aviv University, Israel

^h School of Physical Therapy, Faculty of Health Sciences, Western University, London, ON, Canada

ⁱ Wound Ostomy Continence Institute/Association of Nurses Specialized in Wound Ostomy Continence, Ottawa, ON, Canada

^j Advancing Nursing LLC, Adjunct faculty Michigan State University, Northville MI, USA

^k YL Walsh (Pty) Ltd, Adjunct Lecturer Stellenbosch University, Western Cape, South Africa

^l Swedish Centre for Skin and Wound Research, School of Health Sciences, Örebro University, Örebro, Sweden

^m Research Unit of Plastic Surgery, Department of Clinical Research, Faculty of Health Sciences, Odense, Denmark

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ABSTRACT

Background: Ventilating critically ill patients with acute respiratory distress syndrome in the prone position is a life-saving strategy, but it is associated with adverse consequences such as skin damage.

Aim: To identify, review and evaluate international proning and skin care guidelines and make an inventory of commonly used equipment and training resources.

Design: A gap analysis methodology was applied.

Methods: 1) Comprehensive search and evaluation of proning and skin care guidelines, 2) extensive search and listing equipment and educational resources, and 3) international consultation with 11 experts (8 countries).

Data sources: A variety of sources researched through July 2021 were used to identify relevant literature: (1) scientific literature databases and clinical trials registries, (2) intensive care and wound care associations, (3) healthcare organisations, (4) guideline development organisations, and (5) the Google search engine. Eleven international experts reviewed the literature and provided insights in two, 2-h online sessions.

Findings: The search yielded 24 guidelines. One clinical practice guideline had high methodological quality. Twenty-five devices/equipment and sixteen teaching materials were identified and discussed with the expert panel. The gap analysis identified a lack of concise, accessible, evidence-based guidelines and educational materials of short duration.

Conclusion: This analysis forms the basis for designing a competency-based education and training intervention for an interdisciplinary team caring for the skin of critically ill patients in the prone position.

Impact: The results can assist the multidisciplinary team to review their current protocol for prone positioning. This is a first step in developing a training package for clinicians.

* Corresponding author. UZ Gent, 5K3, Corneel Heymanslaan 10 9000 Ghent, Belgium.

E-mail addresses: anika.fourie@ugent.be (A. Fourie), Maarit.Ahtiala@tyks.fi (M. Ahtiala), JBlack@unmc.edu (J. Black), hhevia@unab.cl (H. Hevia), fcoyer@qut.edu.au (F. Coyer), gefen@tauex.tau.ac.il (A. Gefen), kleblanc@wocinstitute.ca (K. LeBlanc), steven.smet@ugent.be (S. Smet), kvollman@comcast.net (K. Vollman), Yolanda.Walsh@gmail.com (Y. Walsh), dimitri.beeckman@ugent.be, dimitri.beeckman@ugent.be (D. Beeckman).

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1. Introduction

The prone position, also referred to as ‘ventral recumbent’ [1], has been utilized in patients with acute respiratory distress syndrome (ARDS) - an acute inflammatory lung injury [2] - since the late 1970s, when Piehl and Brown (1976) first published on its effectiveness[3]. The efficacy of prone ventilation is due in part to the reversal of atelectasis, increased homogeneous pulmonary aeration, alveolar recruitment, minimisation of ventilator-induced barotrauma, drainage of pulmonary secretions – all leading to improved gas exchange[4,5]. The Prone Severe ARDS Patients (PROSEVA) multicentre randomised control trial [4] showed that early and prolonged prone positioning - more than 16 h/day - of the patient with severe ARDS also decreased their mortality at 28-days and 90-days. At 28-days the prone position group’s mortality was 16% versus 32.8% in the supine position group, and at 90-days, the prone position group’s mortality was significantly lower ($P < 0.001$) with 23.6% versus 41% in the supine group with a hazard ratio of 0.44 (95% CI, 0.29 to 0.67). A consequent systematic review and meta-analysis by Sud and colleagues [6] concluded from six trials ($n = 1016$) that when using lung protective ventilation in patients with moderate to severe ARDS, and early prone positioning, mortality significantly decreases (risk ratio 0.74, 95% CI 0.59 to 0.95; $I^2 = 29\%$).

The rapid spread of SARS-CoV-2, a novel coronavirus (COVID-19) [7], has resulted in an increased number of patients presenting with typical ARDS-type pathological lung changes, prompting intensive care units to adopt prone positioning without necessarily having all the resources, staff and, protocols in place to guide management of the patient to preserve tissue viability.

Not all patients with COVID-19 infections have severe symptoms; however, approximately 19% of the infected patients present with severe or critical symptoms according to a large descriptive, exploratory analysis of more than 72,000 patient records in China where the outbreak originated[8]. Most of these critically ill patients develop severe ARDS (67%), require mechanical ventilation (71%) and prolonged repositioning in the prone position (11.5%)[8].

Although prone ventilation is a lifesaving strategy, this postural therapy is not free from harm; adverse events such as endotracheal tube obstruction, unplanned extubations, tachy- and bradyarrhythmias, loss of venous and arterial access, cardiac arrests, and pressure ulcer (PU) development [6] on the anterior body surface areas may ensue, with major airway complications and PUs the most prevalent[9]. Mora-Arteaga and colleagues [10] reviewed seven randomised trials (2119 patients) and found that PU development in prone position was the most frequently observed adverse event at 34% (OR: 2.19; 95% CI 1.55–3.09; $p < 0.0001$; $I^2 0\%$). The 2017 meta-analyses and systematic review by Munshi and colleagues[11], reviewing three studies [4,12,13] with a total of 1,109 participants concluded that prone position poses a higher risk for the development of PUs compared to the supine position (RR 1.22, 95% CI 1.06–1.41, $I^2 0\%$).

In prone position, there is an increased risk of developing a PU because the patient remains in this position for up to 16 h or longer (up to 24 h) without the ability to turn the patient sideways as easily as a patient in the supine position. More bony areas and thinner, soft tissue masses (e.g., at the forehead and chin) are exposed to the sustained weight of the body whilst in prone position versus lying dorsally[14]. In

a 2021 study by Shearer et al. [15] of the 143 prone ventilated patients, 47.6% ($n = 68$) developed facial PUs with 84% ($n = 57$) on the cheeks and 50% on the ears. A recent study in a population of COVID-19 patients, reported 34.6% of the PUs being of the peri-oral area related to medical devices[16].

Much of the current biomechanical understanding concerning tissue loading conditions has been developed prior to the COVID-19 pandemic, in the context of prone surgeries such as spinal procedures. This published research has highlighted the unusual localised (focal) deformations and stress concentrations that form in soft tissue structures exposed to the bodyweight forces associated with prone positioning, which cannot be relieved during surgery, similarly to the critical care circumstances that apply during prone ventilation[17]. Like in the surgical arena, the life-support instrumentation may induce additional localised compressive, tensile and shear forces on the surface of the body.

Other threats to skin integrity include moisture-associated skin damage (MASD) due to the increased drainage of respiratory secretions and skin tears due to mechanical trauma of positioning/repositioning of the patient. Adverse events increase when the complexity of care increases, as seen in the case of critical care units[18]. Pressure ulcers are adverse events that can lead to increased costs for treatment, length of hospitalisation, in addition to increasing emotional stress to the patient’s family members in the intensive care unit[19].

Amidst the current pandemic, where there is a dramatic increased adoption of prone positioning with critically ill patients affected by severe COVID-19, it was timely and relevant to conduct a gap analysis to review and evaluate international proning and skin care guidelines which might assist the multidisciplinary team in the preservation of patients’ skin integrity in the prone position, and to make an inventory of commonly used equipment and training resources. Secondly, to discuss the results of the review with the international expert panel to identify where gaps exist and the differences between the current situation and what should be in place.

2. Methods

2.1. Design

A gap analysis methodology was applied during this study. A gap analysis is a useful tool to examine the current state of a health care challenge (prone positioning) and identify areas where the existing reality is different from the ideal situation (guidelines/protocols)[20].

1) Comprehensive search of international proning and skin care guidelines was done using electronic literature databases and clinical trials registries. Intensive care and wound care associations, health-care organisations and guideline development organisations were searched using the Google browser. Those guidelines which could be evaluated by a validated tool, was appraised using the AGREEII instrument[21]. If equipment/devices (used for prone ventilated patients) or educational resources were found during the search, they were listed (Tables 3 and 4).

Table 1

Published records of guidance/protocols/recommendations for skin damage prevention for the prone ventilated patient.

Author(s)	Year	Place	Comments
Douglas et al. [23]	2021	Denver Health Medical Center, Colorado, USA.	Safety and Outcomes of Prolonged Usual Care Prone Position Mechanical Ventilation to Treat Acute Coronavirus Disease 2019 Hypoxemic Respiratory Failure* . Unit standard and trained provider teams. Best practice of proning (B-POP) multi-stakeholder policy . Curriculum chapters, education, recommendations, and video instructions. [some materials available in supplemental document]
Klaiman et al. [24]	2021	Penn Medicine Health System, University of Pennsylvania, Philadelphia, Pennsylvania, USA.	Improving prone positioning for severe acute respiratory distress syndrome during the COVID-19 pandemic. Menu of implementation strategies (educational outreach, learning collaborative, clinical protocol, prone-positioning team, and automated alerting - addressing five themes of knowledge, resources, alternative therapies, team culture and patient factors. [no link to material])
Miguel et al. [25]	2021	Massachusetts General Hospital, Boston, USA.	Development of a Prone Team and Exploration of Staff Perceptions. New curriculum “proning intubated patients in the Intensive Care Unit”. Training and step-by-step procedure video with prone/supine safety checklist. [YouTube video available: “Prone positioning in severe acute respiratory distress syndrome. Massachusetts Medical Society 2013 https://www.youtube.com/watch?v=E_6jT9R7WJs&t=42s]
Mitchell & Seckel [26]	2018	Christiana Care Health Service, Wilmington Hospital, Delaware and Christiana Hospital, Newark, Delaware, USA.	Acute respiratory distress syndrome and prone positioning. New Inaugural Interprofessional Clinical Practice Guideline . [described in article] Implementation strategies include face-to-face education sessions, a video a quick reference sheet and web-based education. [no link to material]
Montanaro [27]	2021	Mount Sinai Morningside Hospital, New York, USA.	Using In Situ Simulation to Develop a Prone Positioning Protocol for Patients With ARDS. Prone position protocol and educational program [described in article] with skin care considerations and formal simulation training. [YouTube video: https://www.youtube.com/watch?v=ECdxhNFLwVo&t=765s] Refer to Mitchell & Seckel 2018 (B5).
Oliveira et al. [28]	2016	Hospital de Clinicas de Porto Alegre, RS, Brazil.	Good practices for prone positioning at the bedside: Construction of a care protocol. Good practices protocol addressing nutritional and nursing care after a literature review was done. [described in article]
Santos et al. [29]	2021	Brazil (São Paulo, Rio Grande do Sul, state of Rio de Janeiro and state of Goiás.) Author: Universidade Federal de São Paulo.	COVID-19 patients in prone position: validation of instructional materials for pressure injury prevention. Content and face validation of a checklist and banner named “6 Steps to Prevent Pressure Injury in Patients with COVID-19 in Prone Position” [described in article]

2) An international expert panel was established in November 2020. The 11 experts from 8 countries reviewed the literature and provided insights in two, 2-h recorded online sessions.

2.2. Search methods

These electronic databases were searched up to July 2021 for relevant literature: Medline on the PubMed interface, Embase, Web of Science, Cumulative Index to Nursing and Allied Health Literature (CINAHL) (EBSCO interface), Cochrane Database of Systematic reviews and The Cochrane Central Register of Controlled Trials. The clinical trials registry (www.clinicaltrials.gov) was searched to include prospective or ongoing studies. Grey literature using Open Grey (www.opengrey.eu) was searched and reference lists of included studies were

scanned.

All records with mechanically ventilated adults (>18 years old) in critical care units were included. ‘Covid-19’ or synonyms were not utilized as a keyword to include all ventilated adults regardless of respiratory disease/lung injury requiring prone positioning. Keywords for ‘guideline’ were not used to avoid missing any mentioned equipment, applicable to skin damage prevention. Studies were limited to English language and full text, but no limitation to year of publication.

The concepts of “prone position” and “skin damage/pressure ulcer” and their synonyms were searched and then combined (**example of search strategy in Supplement A**).

Supplement A: The search strategy for MEDLINE (using the PubMed

Table 2

Intensive care and wound care associations, healthcare organisations and guideline development organisations searched – to provide skin damage prevention strategies for the management of patients during prone ventilation.

Name of Organisation (n = 21)	Abbr.	Skin preservation strategies (n = 16)	Year	Website	Guideline/comment
American Association of critical-care nurses	AACN	Yes (x2)	Apr 2020 2017	https://www.aacn.org/blog/ards-covid-19-and-pronation-therapy https://www.aacn.org/clinical-resources/covid-19/procedure-manual-covid-19-resources	Blog, prone procedure training video, recorded sessions, and prone position articles. Vollman K, Dickinson S & Powers J. Procedural manual on Pronation therapy. Discuss physiology, patient preparation, step by step procedure and frequency of body and head positioning to reduce PUs.
Association of Air Medical Services	AAMS	Yes	Apr 2020	https://aams.org/wp-content/uploads/2020/04/Manual-Prone-Positioning-Guide-RN_RT.pdf https://aams.org/wp-content/uploads/2020/04/UMPC-STAT-MedEvac-Prone-Positioning_Tranport-3_2020.pdf	Mechanical Ventilation Prone Positioning Guidelines IPMS life changing medicine. Guidelines extrapolated from Guerin C, Reignier J, Richard JC et al. Prone positioning in severe acute respiratory distress syndrome. N Engl J Med 2013; 368:2159–2168
Australian and New Zealand Intensive Care Society	ANZICS	No	n/a	anzics@anzics.com.au	COVID-19 guidelines. No guidance regarding prone positioning
British association of critical care nurses	BACCN	Yes	Dec 2017	https://www.baccn.org/static/uploads/resources/NRCP_Prone_Position_ICU_pt.pdf?fbclid=IwAR2_SULd-UZRPse_OpgBLJlWpmxcjNUfrqS1YWQN3HQeJsBs5764KWAQQ3Q	Step-by-step procedure. No specific dressing/device choices.
European Pressure Ulcer Advisory Panel & National Pressure Injury Advisory Panel & Pan Pacific Pressure Injury Alliance	EPUAP/ NPIAP/ PPPIA	Yes	Nov 2019	https://www.epuap.org/pu-guidelines/	The International Clinical Practice Guideline (2019) page 126–139, 3rd edition. Available for purchase.
Faculty of intensive care medicine & Intensive Care Society & Federacion Latinoamericana de Enfermeria en Cuidado Intensivo	FICM & ICS FLECI	Yes Yes	Nov 2019 Jul 2020	https://www.ficm.ac.uk/sites/default/files/prone_positioning_in_adult_critical_care_2019.pdf https://aec-cba.com/wp-content/uploads/2020/07/fleci_protocolo_prono.pdf	“ Guidance for Prone Positioning in Adult Critical Care” “ Protocolo Latinoamericano de Enfermería Crítica: Cuidado al Paciente COVID-19 en Decúbito Prono”
Massachusetts General Hospital	n/a	Yes	Aug 2020	https://www.massgeneral.org/assets/MGH/pdf/news/coronavirus/prone-positioning-protocol.pdf	“ Prone positioning guideline ”. Procedure and product suggestions
National Institute for Health and Care Excellence	NICE	No	n/a	https://www.nice.org.uk/guidance/cg179/resources/pressure-ulcers-prevention-and-management-pdf-35109760631749	Refers to Intensive Care Society & Faculty of Intensive Care Medicine
National Pressure Injury Advisory Panel	NPIAP	Yes	2020	https://cdn.ymaws.com/npiap.com/resource/resmgr/online_store/posters/npiap_pip_tips_-_proning_202.pdf	“ PIP (pressure injury prevention) tips for prone positioning”
Nebraska Medicine	n/a	Yes	n/s	https://www.nebraskamed.com/sites/default/files/documents/covid-19/proning-protocol.pdf	COVID-19 proning protocol – “Pronocol”; not specific devices, mention padding of bony prominences, pillows/blankets.
NHS England and NHS improvement	NHS	Yes	Apr 2020	https://tvs.org.uk/wp-content/uploads/2020/05/Pressure-ulcer-prevention-guidance-when-proning-patients-V5-17th-April-2020-1.pdf	“ Pressure-ulcer-prevention-guidance-when-proning-patients-V5-17th-April-2020-1.pdf ”
Nurses Specialized in Wound, Ostomy and Continence Canada	NSWOCC	Yes	May 2020	www.nswoc.ca	“NSWOCC Best Practice Recommendations for Skin Health Among Critically Ill Patients - With an emphasis on critically ill individuals suffering from COVID-19”
Rush University Medical Center	n/a	Yes	March 2020	https://www.massnurses.org/files/file/Rush%20University%20%20Prone%20Positioning%20Checklists.pdf	Detailed guidance ; specific device choices
Tissue Viability Society	TVS	Yes	2021	https://tvs.org.uk/pressure-ulcer-prevention-and-management/	List of available guidelines from organisations like NPIAP, NHS, NSWOCC with hyperlinks. Some links to industry websites regarding product offering.
Scottish Intercollegiate Guidelines Network	SIGN	No	n/a	https://www.sign.ac.uk/our-guidelines/	n/a
Sociedad de Medicina Intensiva.	SOCHIMI	Yes	2020	https://medicina-intensiva.cl/revista/pdf/71/21.pdf	Ventilation in prone position in patients with acute respiratory distress syndrome (ARSD) COVID-19 severe pneumonia.
Revista Chilena de Medicina Intensiva	WHO	No	n/s	https://www.who.int/	n/a
World Health Organisation	WUWHS	Yes	2016	www.woundsinternational.com	“Consensus document 2016: Role of dressings in pressure ulcer reduction”.
World Union Wound Healing Societies	WHO	No	n/s	https://www.who.int/	n/a
Wound, Ostomy & Continence Nursing	WOCN	No	n/a	https://www.wuwhs.org/wp-content/uploads/2020/07/WUWHS_PUP_consensus_Web.pdf	Mention the prone position.
Wounds UK, TVN TV	WUWHS TVS/TVN	Yes Yes	n/a n/s	https://www.wocn.org/covid-19/ https://tvntv.co.uk/pressure-ulcers/reposition-reposition-and-reposition-covid-19/	Guidance on PU risk reduction under PPEs, not for prone positioning Video – skin care for patients in prone positioning. Device suggestions

Abbreviations: n/s = not stated; n/a = not applicable; PPEs = personal protective equipment.

interface).

Name of database interface: MEDLINE (via the PubMed interface)		
Concept	Search strategy	Results (29/07/21)
#1 Prone Position	“Prone Position” [MeSH Terms] OR “Prone Position” [Title/Abstract] OR “prone ventilation” [Title/Abstract]	7,964
#2 Pressure ulcer/ injury	“pressure ulcer” [MeSH Terms] OR “pressure ulcer*” [Title/Abstract] OR “pressure injur*” [Title/Abstract] OR “pressure sore*” [Title/Abstract] OR “bedsore” [Text Word] OR “decubitus ulcer” [Text Word]	17,318
#3 Skin/tissue damage'skin	“skin damage” [Title/Abstract] OR “skin damage” [Text Word] OR “skin integrity” [Title/Abstract] OR “skin integrity” [Text Word] OR “skin breakdown” [Text Word] OR “skin injur*” [Title/Abstract] OR “skin injur*” [Text Word] OR “tissue viability” [Text Word] OR “skin tear*” [Title/Abstract] OR “skin tear*” [Text Word] OR “tissue damage” [Title/Abstract] OR “tissue damage” [Text Word] OR “moisture associated skin damage” [Text Word] OR “MASD” [Text Word]	46,747
#4 Combine #2 OR #3	“pressure ulcer” [MeSH Terms] OR “pressure ulcer*” [Title/Abstract] OR “pressure injur*” [Title/Abstract] OR “pressure sore*” [Title/Abstract] OR “bedsore” [Text Word] OR “decubitus ulcer” [Text Word] OR “skin damage” [Title/Abstract] OR “skin damage” [Text Word] OR “skin integrity” [Title/Abstract] OR “skin integrity” [Text Word] OR “skin breakdown” [Text Word] OR “skin injur*” [Title/Abstract] OR “skin injur*” [Text Word] OR “tissue viability” [Text Word] OR “skin tear*” [Title/Abstract] OR “skin tear*” [Text Word] OR “tissue damage” [Title/Abstract] OR “tissue damage” [Text Word] OR “moisture associated skin damage” [Text Word] OR “MASD” [Text Word]	63,086
#5 Combination of concepts #1 AND #4	(“pressure ulcer” [MeSH Terms] OR “pressure ulcer*” [Title/Abstract] OR “pressure injur*” [Title/Abstract] OR “pressure sore*” [Title/Abstract] OR “bedsore” [Text Word] OR “decubitus ulcer” [Text Word] OR “skin damage” [Title/Abstract] OR “skin damage” [Text Word] OR “skin integrity” [Title/Abstract] OR “skin integrity” [Text Word] OR “skin breakdown” [Text Word] OR “skin injur*” [Title/Abstract] OR “skin injur*” [Text Word] OR “tissue viability” [Text Word] OR “skin tear*” [Title/Abstract] OR “skin tear*” [Text Word] OR “tissue damage” [Title/Abstract] OR “tissue damage” [Text Word] OR “moisture associated skin damage” [Text Word] OR “MASD” [Text Word])) AND (“Prone Position” [MeSH Terms] OR “Prone Position” [Title/Abstract] OR “prone ventilation” [Title/Abstract])	167

Abbreviation: MeSH: medical subject heading.

* = Truncation symbol, representing any character or no character.

Fig. 1 outlines the screening process. After database searching and locating two additional records from the clinical trials registry, 208 records were included, and 147 records were available for screening after duplicates (n = 61) were removed. After assessing the title and abstracts, 80 records mentioning both “prone position” and “pressure ulcers/injuries” were included. Thirty-eight records were excluded due to mention of generic or product brand names but were used to complete the product inventory. After removing 24 records that did not refer to other guidelines or products, this resulted in seven (n = 7) records that contained guidelines/recommendations.

Critical care and wound care associations, healthcare organisations and guideline development organisations were searched using the Google browser. These included the World Health Organisation (WHO), National Institute for Health and Care Excellence (NICE) and critical care societies but the focus was on wound care associations who are likely to publish guidance on skin/tissue damage prevention e.g., the European Pressure Ulcer Advisory Panel (EPUAP). If guidelines were identified, they were explored in detail, using their reference lists to establish if any protocols were available from other sources like universities or hospitals.

Clinical practice guidelines (CPGs) were appraised by using the valid and reliable Appraisal of Guidelines for Research and Evaluation (AGREEII) instrument[21]. Two appraisers (AF and SS) individually evaluated the CPGs. Guidance documents e.g., recommendations/tips, which could not be assessed with an instrument, were evaluated by the expert panel.

Internet searches were conducted using the Google® browser (July–November 2020) to find equipment/devices and teaching aids that clinicians can use either to assist with the prone manoeuvre, but more importantly aids to minimise skin damage - in preparation for the expert consultation (November 2020). Media searches included YouTube® videos, industry websites and virtual conferences to broaden the search. The equipment was added to the inventory list and categorised according to their function e.g., dressings, prone positioning support, and traditional aids. It was beyond the scope of this article to evaluate the evidence for the effectiveness of products in preventing skin/tissue damage in the prone position. Educational resources were listed by duration of online content, conflict of interest, whether theoretical or a demonstration.

2.3. International expert consultation

Consultations with clinical- and academic experts in the field of critical care, prone positioning, pressure ulcers/injuries, skin integrity and biomechanical research were an integral part of this study. The experts were invited to be part of an 11-member international expert advisory panel. These members are experts in the field of nursing science, bioengineering aspects, critical care, and skin/wound care with the relevant medical/clinical and practical expertise. In addition, a wide geographical spread (eight countries): two experts were from the United States of America, three from Belgium, and one expert each were from Chile, Canada, Finland, Israel, Australia, and South Africa.

The role of the expert panel was to review the search results and together with the research team, identify gaps and clinician needs. Two 2-h recorded online sessions were held (25/26 November 2020) to gain the experts’ feedback/suggestions. A draft of the review, and gap analysis results were sent to the members one week prior to the online

Table 3
Inventory of equipment/devices identified from screening literature, guidance documents, internet or industry websites and online conferences.

Device/Equipment	Company	Website	Description
Mechanical systems assisting prone manoeuvre Rotoprone® (bed)	Arjo, Inc.	https://www.arjo.com/en-us/products/medical-beds/critical-care/rotoprone/	Automated prone positioning and kinetic therapy (lateral side-to-side rotation up to 62°)
Positioning systems – equipment to reposition from supine to prone and/or manage the patient in prone position.			
Triadyne® prone kit	Arjo, Inc.	https://arjo-us.wistia.com/medias/ypyq700mb7 (internal training only)	Inflatable mattress – Manage patient in PP
MaxiMove® and repositioning sleeve	Arjo, Inc.	https://www.arjo.com/en-us/solutions/prone-positioning/the-arjo-prone-positioning-product-portfolio/	Passive lift to move patient into PP
Maxislide® & MaxiTube®	Arjo, Inc.	https://arjo-us.wistia.com/medias/pg2hqmgkgh	Device-assisted manual PP. Move patient to PP
Inflatable Prone Ventilation (IPV) (air)	Ergotrics™	https://ergotrics.com/product/ips/?lang=en	Disposable inflatable cushion that lifts and positions the patient in prone position. The IPV is used for Prone Ventilation in the Intensive Care Unit
Inflatable Board (air)	Ergotrics™	https://ergotrics.com/product/ibo/?lang=en	Inflatable board to tilt patient into PP
Sage Prevalon™ AirTap patient repositioning system (air)	Stryker™	https://www.stryker.com/us/en/sage/products/sage-airtap.html https://sphmjournal.com/product/dec2016v6n4-sph-initiative-in-level-i-trauma-center-results/	Microclimate body pad and glide sheet
HoverMatt™ air transfer system (air)	Hovertech International™	https://hovermatt.com/products/hovermatt-air-transfer-system/	Inflatable air mattress to transfer patient
Tortoise® turning and positioning system with/without fluidized positioning pad.	Mölnlycke™	https://www.youtube.com/watch?v=wxnQ-Cc5lJM	Aid in turning and positioning of patient (transfer pad) with positive air displacement (tucked/untucked) and separate pressure redistribution pad (fluidized positioning pad)
Support Surfaces			
National Pressure Injury Advisory Panel	NPIAP	https://www.npuap.org/resources/educational-andclinical-resources/support-surface-standards-initiative-s3i/	Support Surface Standard Initiative 2019 (S3I)
Repose™ and Repose™ prone kit	Frontier™ Medical group	https://www.reposedirect.com/product/prone-kit/	Comprised of a single air cell. Described as a reactive mattress, which means that small movements result in interface pressure being equalised across the entire surface.
Prone positioning aids/support			
Aderma® Dermal pad	Smith & Nephew™	https://www.smith-nephew.com/uk/products/wound_management/product-search/aderma/	Dermal gel pads.
Aligel™, AliLite™, Freedom™ Comfort mask C-prone®	Alimed™ Hill-rom Allen Medical systems	https://www.alimed.com/prone-position/ https://www.hillrom.com/en/products/spine-disposables Capasso et al. [31]	Gel prone positioning sets (chest rolls etc.) Comfort Prone Face Masks are used with C-Prone® head positioning systems. Normally utilized during surgery. Used for lateral positioning of patient's head in PP, reduce shear and maceration on the face.
Dermisplus® Prevent	Frontier™ Medical group	https://www.reposedirect.com/dermisplus/	Pressure redistribution gel pads - redistributing peak pressures on anatomical sites prone to pressure damage.
GentleTouch® Prone Positioning Pillows	Hill-rom INC	https://www.mizuhosi.com/product/gentletouch/ Ibarra et al. [33]	Disposable prone position pillow to support the patient's head. Made from Contourethane™ to equalize pressure on the face.
GMF Conforming Comfort® Customizable Manual Prone Positioning System	Global Medical Foam, Inc.	https://www.globalmedfoam.com/	Dual density manual customizable prone positioning system. Foam with different densities and a monolithic fabric cover.
Rebacare® Free Ear/Tube/Luna/Comfort XL	Rebacare®	https://www.rebacare.com/products/pillows/free-ear_-9401;-pillow	Patented free ear pillow designed for prone positioning. Other devices/designs available
Z-Flo® fluidized positioner	Mölnlycke™	https://www.molnlycke.ae/products-solutions/x-draft-molnlycke-z-flo-fluidised-positioner/ https://www.youtube.com/watch?v=wxnQ-Cc5lJM	Viscoelastic materials with shape memory for repositioning body parts

(continued on next page)

Table 3 (continued)

Device/Equipment	Company	Website	Description
Prophylactic dressings:			
a. Silicone adhesive multilayer dressings			
Allevyn® Life	Smith & Nephew™	https://www.smith-nephew.com/uk/products/wound_management/product-se-arch/allevyn-life/	Multi-layer foam dressing with a silicone wound contact layer
Aquacel® foam	Convatec™	https://www.convatec.com/advanced-wound-care/aquacel-dressings/aquacel-foam/#	Layered foam dressing with silicone border.
Biatain® Silicone	Coloplast™	https://www.coloplast.us/Biatain-Silicone-New-en-us.aspx	Soft, flexible and absorbent foam dressing with silicone adhesive.
Mepilex® border flex	Mölnlycke™	https://www.molnlycke.us/see-the-proof/clinical-evidence/	Bordered soft foam dressing with a five-layer construction and a Safetac® technology wound contact layer.
b. Hydrocolloids			
Comfeel® Plus	Coloplast™	https://www.coloplast.com/products/wound/comfeel-plus/	Hydrocolloid promoted for protection of skin at risk or injury and in early wound stages.
Duoderm™ Extra Thin	Convatec™	https://www.convatec.com/advanced-wound-care/duoderm-dressings/duoderm-extra-thin-dressing/	Thin dressing, designed to reduce the risk of further skin breakdown due to friction.
Liquid barrier film/non-alcohol barrier wipe			
Cavilon™ no-sting barrier film	3 M™	https://multimedia.3m.com/mws/media/7167780/cavilon-no-sting-barrier-film-clinical-summary.pdf	Acrylate-based polymer solution for skin protection against moisture (saliva, bodily fluids, incontinence), friction and adhesives.
Traditional			
Pillows, towels, blankets	n/a	n/a	For positioning the patient.
Endotracheal tape or ties	n/a	n/a	To secure the endotracheal tube
Absorptive pads	n/a	n/a	For use underneath patient's face for absorption of increased respiratory secretions
Home-made devices			
Head cushion	n/a	Perrillat A, Foletti JM, Lacagne AS, Guyot L & Graillon N. Facial pressure ulcers in COVID-19 patients undergoing prone positioning: How to prevent an underestimated epidemic? <i>J Stomatol Oral Maxillofac Surg</i> 2020; 121: 442–444.	Semi lunar shaped, soft prone-positioning head cushion. Email correspondence to author N.Graillon [01/10/2020]. Confirmed foam plates were designed by nurses and physiotherapists
Nose and face protection	UK	Stubington TJ, Mansuri MS. Novel technique using surgical scrub sponges to protect the nose and face during prone ventilation for coronavirus disease 2019. <i>J Laryngol Otol</i> 2020; 134:735–738. https://doi.org/10.1017/S0022215120001590	Novel pressure-relieving technique using surgical scrub sponges Low cost, easily available materials
Generic product suggestions			
Chest padding, c-letter shaped pad, endotracheal tape or ties, eye protection (silicone pads, fox shields), facial pillows, moisture/skin barrier, silicone foam, silicone gels, soft prone positioning head cushion, specialized mattresses, transparent film, hyper oxygenated fatty acids.			

Abbreviations: PP = prone position; n/a = not applicable.

Table 4
Other media/educational resources related to the patient in prone position (manoeuvre and/or management).

Type of media	Speaker, title, details	Website	Year	Conflict of Interest	Theory	Demonstration/ Hands-on	Duration (minutes)
Online Educational videos	Mobility is Medicine supported by Atlas Lift Tech.	Prone Safely Series: A Three-Part Puzzle. Website: https://mobilityismedicine.org/videos/	Jun–Nov 2020	No	Yes	No	60 and 10-13 sessions
	Joyce Black, Kathleen Vollman & Gail Powell-Cope: The pursuit of HAPI-less. Prone safely - pressure injury prevention.	https://www.youtube.com/watch?v=AXd1q6C9dtko					
	Joyce Black: COVID-19 and tips for safe skin and prone. What should skin care involve for patients in the prone position?	https://woundsinternationaltv.com/editors-chioce/covid-19-and-tips-for-safe-skin-and-prone/?_cldee=Y2Fyb2xpbmEud2VsbGVyQG1vbmFzaC5lZHU%3d&recipientid=contact-02554ddf6fd8e911a812000d3a7ed483-61c7c45c041942b98c48dc9b35475faa&esid=f125779b-b4ac-aa11-a812-000d3a7ed30d	Jun 2020	No	Yes	No	5:24
	Kathleen Vollman: Address positioning to reduce PUs. 8Ps Petal network (prevention, PEEP, pipes and pump, paralysis, positioning, protein and protocol-based care).	https://www.aacn.org/education/ce-activities/nti19347/ards-unlocking-the-eight-key-care-components-for-successful-short-and-long-term-outcomes	2013	Disclosed	Yes	No	90
YouTube videos prone manoeuvre	NEJM video referring to article	https://www.nejm.org/doi/full/10.1056/NEJMoa1214103	Jun 2013	No	Yes	Yes	5:12
	Mention some PU reduction strategies						
	Mount Sinai Health System. Prone Positioning for the COVID-19 Patient.	https://www.youtube.com/watch?v=ECdxhNFLwVo	April 2020	No	Yes	Yes	19:41
	Rush University Medical Center. Four-phase checklist implementation	https://www.youtube.com/watch?v=lcBPaHQUvXY	April 2020	No	Yes	Yes	15:32
YouTube videos prone positioning system	Mölnlycke™: Instructional sales training video – Tortoise turning positioning system. Z-Flo	https://www.youtube.com/watch?v=wxnQ-Cc5lJM	April 2020	Sponsored	Yes	Yes	10:51
	ArjoHuntleigh – Pressure Injury Prevention – Prone positioning and Nimbus Professional Product information	https://www.youtube.com/watch?v=59W_2x_PAGc	April 2020	Sponsored	No	No	1:49
Video recording	A step by step an easy and ergonomic technique to perform pronation maneuvers in patients with severe ARDS. Raffaele Di Faenza, Hedwige Gay, Isabella Fontana, Roberto Fumagalli	https://vimeo.com/436411191	July 2020	No	Yes	Yes	9:06
	Suggest wedges, pads, pillows for pressure relief						
	Tissue Viability Nurse Society What adjustments to skin care need to be made for patients in the prone position? Jacqui Fletcher shares guidance for each part of the body.	https://tvntv.co.uk/skin-integrity/skin-care-for-patients-in-the-prone-position/	May 2020	No	yes	No	10:41
Webinars	Kathleen Vollman and Nancy Morgan	Relias. Prone positioning: an evidence-based practice for ARDS patients. https://www.relias.com/resource/prone-positioning-an-evidence-based-practice-for-ards-patients	25 June 2020	Disclosed	yes	No	60
	Kathleen Vollman: Upside Down You Turn Me: the When, the Why & How of Prone Positioning ARDS Patients. Conference presentation: Australian and New Zealand intensive care society.	https://www.youtube.com/watch?v=Ucqq_UpzKkM	Jan 2018	Disclosed	Yes	No video but practical photos	12:18
	Some pressure ulcer reduction tips. Kathleen Vollman and Sharon Dickinson	Why Prone? Why Now? Improving Outcomes for ARDS Patients https://www.aacn.org/education/ce-activities/wb0042/why-prone-why-now-improving-outcomes-for-ards-patients . Additional resources blueprint and tools and tactics	Aug 2017	No	Yes	No	60
	ArjoHuntleigh - Angela Rouse Product orientated	Nursing considerations for RotoProne™ therapy -	28 Feb 2020	Sponsored	yes	No	40

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Table 4 (continued)

Type of media	Speaker, title, details	Website	Year	Conflict of Interest	Theory	Demonstration/ Hands-on	Duration (minutes)
	ArjoHuntleigh - Allison Whitaker Skin care checklist	Prone positioning	28 Aug 2020	sponsored	yes	No	40
	Mölnlycke™ - M. Barakat-Johnson Clinical evidence and value of prone prevention dressing pack	3-series webinar Pressure injury risk, prevention, and best practices in prone positioned patients & implementation strategies	12 Nov 2020	Sponsored	yes	No	20 min each

ARDS: acute respiratory distress syndrome.

- The expert panel agreed that amongst a crisis like COVID-19, there is no time for the clinicians to search the plethora of resources, evaluate the evidence and then teach and implement it. The resources are varied in duration from less than 2 min up to 1 h, with some showing hands-on prone manoeuvring, or others focusing on theory.

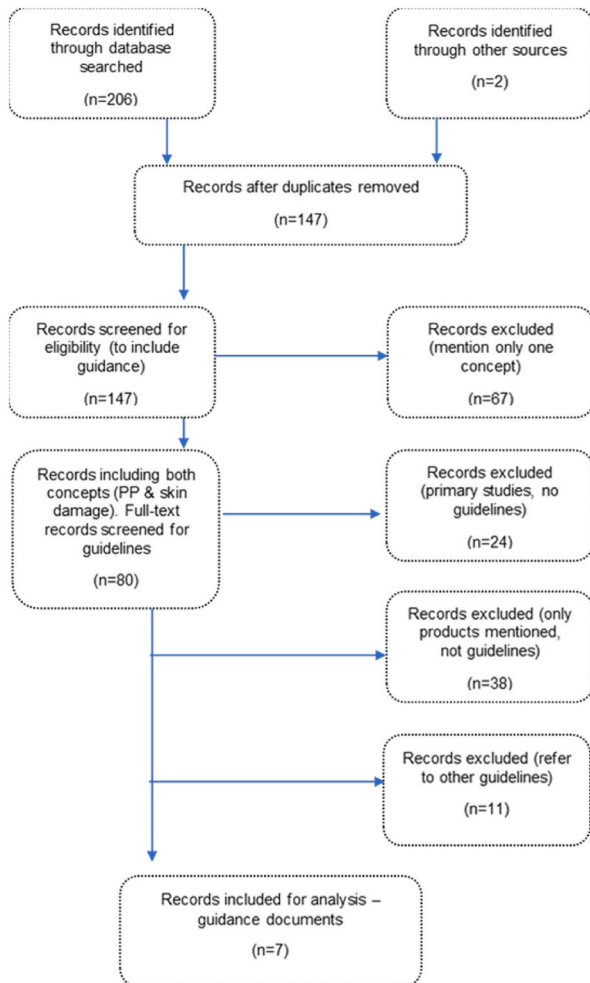


Fig. 1. Flow diagram for study selection of records containing guidance regarding skin damage prevention during prone positioning. Abbreviation: PP = prone position.

meeting. During the meeting, the following questions were asked:

Questions to experts during feedback session 25th/26th November 2020

- 1a) What are the key considerations before clinical guidance related to skin damage for the patients in the prone position are implemented in a clinical setting?
- 1b) What key descriptors should be present in a clinical guidance for prevention of skin damage for the patient in the prone position?
- 1c) What are the barriers to guideline implementation related to the prevention of skin damage in prone positioned patients?
- 1d) What is your perspective on how barriers to guideline implementation related to prevention of skin damage in prone positioned patients can be avoided?
- 2a, b) What comprises the ideal equipment/device to prevent skin damage for the patient in the prone position, and what is missing?
- 3a) What components/content should educational material related to prevention of skin damage for patients in the prone position consist of?
- 3b) How should educational resources related to prevention of skin damage for patients in the prone position be organised for successful conveyance to clinicians in critical care units?
- 4) What future research is needed to assist clinicians to optimally care for the critically ill patient in the prone position to prevent skin damage?

Further consultation via e-mail ensued between the research team and the experts after the meeting to ensure correct interpretation of their feedback, sharing of any extra materials the experts deemed fit – enhancing the comprehensiveness of the study. All the relevant recorded or written comments were collated and incorporated into the final gap analysis and reviewed by the experts.

2.4. Ethical considerations

The Ethics Committee of Ghent University confirmed that no ethical approval was needed for doing this gap analysis since only public available data were collected, without patient involvement.

3. Results

3.1. Guidelines identified

A total of 24 guideline documents were identified: seven from the literature search (Table 1) and 17 from organisations (Table 2). The most recent (through July 2021) literature search identified seven guidelines/recommendations that address prevention of patient skin/tissue damage in the prone position. Authors described either best

practises, implementation strategies, protocols, clinical guidelines, checklists, or educational programmes. Not all resources, such as protocols or videos, were available as a hyperlink, via reference, or in supplemental documentation (Table 1). Eleven (n = 11) articles referenced other organisations such as the Faculty of intensive care medicine & Intensive Care Society (FICM & ICS)[22].

During the internet search, 21 organisations were searched and 17 published guidance documents/materials, were identified. The WHO did not publish guidance, however NICE referred to the FICM & ICS 2019 guideline and the Tissue Viability Society's website provided a reference site to guidelines from other organisations or industry (Table 2).

One CPG was found regarding PU prevention, with a specific chapter on prone positioning – from the European Pressure Ulcer Advisory Panel/National Pressure Injury Advisory Panel and the Pan Pacific Pressure Injury Alliance (EPUAP/NPIAP/PPPIA)[30]. This CPG was of high methodological quality and clinical content according to the AGREEII appraisal instrument. The two appraisers reached a 94% consensus, scoring half of the domains e.g., scope and purpose, clarity of presentation and applicability of the CPG as 'strongly agree' per each item.

Since the guidance documents are not all CPGs and cannot be appraised with a validated tool, the expert panellists' perspectives and opinions regarding the guidance documents' key considerations, key descriptors and barriers to implementation were instrumental in identifying gaps.

- The expert panel mentioned that guidance documents should address the aetiology of tissue damage in the prone position vs. the dorsal position, why certain recommendations for tissue protection is recommended (the rationale) yet keep guidance documents simple and easily accessible. Guidance documents should be based on evidence and speak to the specific audience. Before implementation, all stakeholders should be involved to gain insight from a multidisciplinary team to get commitment for driving the successful implementation. A bundled approach is necessary to address not only PUs but include preventative strategies for MASD, skin tears and incontinence-associated dermatitis.

3.2. Inventory of identified equipment/devices and educational resources

Thirty-eight records (n = 38) emerged from the literature review that did not include guidance documents but did mention devices/devices used in clinical practice to help prevent pressure ulcers or MASD (Table 3). Generic product suggestions were mentioned in 18 records and products with brand names in 20 records. Twenty-five product names were listed. Surgical products were not listed (exclusion criterion) unless a surgical product was used in a critical care setting, as described by Capasso and colleagues[31].

- The experts noted that few of the equipment/devices were designed for use in prone position to specifically avoid skin damage. Dressings for example have been designed for wound healing/treatment and have not been extensively studied for the prevention of skin/tissue damage in prone position. A recent biomechanical study did however indicate a reduction of soft tissue stress exposure on the forehead (52%) and chin (78%) when multilayered foam dressings are applied prophylactically in the prone position[32].

3.3. Other multimedia resources identified

Resources were found in the form of YouTube® video recordings showing the prone positioning manoeuvre, webinar educational sessions, blogs, company product training videos etc. Sixteen digital resources were identified (Table 4) during the search, up until November 2020. Five of the resources (31.3%) showed practical hands-on training of the prone positioning manoeuvre or equipment use, and 31.3% were of duration less than 10 min. Of note is the HAPI-less project/video series (hospital-acquired pressure injuries) which gives theoretical tips on PU reduction strategies (Mobility is Medicine, 2020)[34]. The Rush University Medical Center [35] developed a four-phased checklist and during their recording showed the practical hands-on prone manoeuvre and how to use the checklist from preparing to management of the patient.

4. Discussion

The main aim of this study was to perform a gap analysis of the current state of guideline documents or recommendations and to explore, through expert consultation, what is needed for clinicians to help prevent skin/tissue damage in patients in the prone position.

The guidance documents vary from a high methodological quality CPG [30] for purchase, to recommendations and useful practical tips for patient management strategies (Tables 1 and 2). Institutions/hospitals base their prone positioning protocol on different guidance documents or create their own protocol according to accessible resources, staff competence and availability. The guidance documents of institutions/hospitals are not always publicly available due to internal privacy/-sharing policies. The analysis revealed that there is a lack of an open-access, holistic, yet simple evidence-based guidance document, written after seeking consultation and buy-in from stakeholders in the multidisciplinary team. The stakeholders should include clinical nurses, medical doctors, other health care team members, former patients, and policy makers. Perceived complexity should be avoided by not using foreign abbreviations or referral to unknown device categories which might be unavailable. An explanation of the principles/rationale of a recommended strategy, or what not to do – based on clinical evidence – should rather be employed to decrease barriers to implementation.

Secondarily, the aim was to see what is available (devices and educational resources) and what the experts suggest in relation to the current list (Tables 3 and 4).

Even though some of the products are widely used in clinical practice, there is a lack of non-industry sponsored, high-level evidence specifically for patients in the *prone position*. This provides an opportunity for further research, both for robust clinical trials with a pragmatic design and computer modeling to analyse skin and subdermal tissue loading conditions with and without specific devices. The evidence for the efficacy of prone products has not been evaluated and this may be of interest for a future systematic review.

During a crisis like COVID-19, there is a lack of time and staff resources to refer to long didactic or online educational sessions. There is a need for short 5-min videos to practically show different aspects of patient management e.g., how to secure the endotracheal tubes in the prone position, how to perform pressure relieve/micro-shifts etc. It is imperative to first conduct a skin and wound management competency-based training needs assessment before any educational strategy can be designed/recommended. A training needs assessment can identify competency gaps [36] related to this topic and guide impactful and fit-for-purpose skills development for clinicians.

Limitations to this study are the dynamic nature of an internet search with new information posted per second and therefore the search had to be limited to a specific period. Hospitals predominantly post their protocols/guidelines on their intranet, not available to public searches and therefore a vast number of guidance documents are not available for review/utilization.

The strength of this study was the comprehensive literature search which was recently repeated (July 2021) to include the latest publications. Of note was the increased publications since the previous search ending November 2020 on this topic - which is directly linked to the second surge of the COVID-19 pandemic and the clinical and academic need related to patient management strategies.

A second strength is the congregation of insights from experts across Europe, Americas, Africa, and Australia into the diverse clinical practices from their different countries and current research being conducted related to this topic.

5. Conclusions

This gap analysis, including a comprehensive search and expert consultation, provides the basis for the design of a competency-based education and training intervention for an interdisciplinary team of clinicians caring for the skin of ICU patients in the prone position.

Declaration of competing interest

Authors AF, DB, AG, SS, YW, HHC, FC, KL have no competing interests to declare.

JB declared being a consultant and speaker for Mölnlycke, Sage: A Division of Stryker, and Mobility is Medicine.

KV declared being a consultant and speaker for Sage: A Division of Stryker and Mobility is Medicine.

MA declared being a speaker for Mölnlycke.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jtv.2021.09.005>.

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References

- [1] Mosby's Medical. In: *Nursing & allied health dictionary*. sixth ed. St Lois, Missouri: Mosby Inc; 2002.
- [2] Ranieri VM, Rubenfeld GD, Thompson BT, et al. ARDS definition task force. Acute respiratory distress syndrome: the berlin definition. *J Am Med Assoc* 2012;307:2526–33. <https://doi.org/10.1001/jama.2012.5669>.
- [3] Piehl MA, Brown RS. Use of extreme position changes in acute respiratory failure. *Crit Care Med* 1976;4:13–4.
- [4] Guérin C, Reignier J, Richard JC, et al. PROSEVA Study Group. Prone positioning in severe acute respiratory distress syndrome. *N Engl J Med* 2013;368:2159–68. <https://doi.org/10.1056/NEJMoa1214103>.
- [5] Scholten EL, Beitler JR, Prisk GK, Malhotra A. Treatment of ARDS with prone positioning. *Chest* 2017;151:215–24. <https://doi.org/10.1016/j.chest.2016.06.032>.
- [6] Sud S, Friedrich JO, Adhikari NK, et al. Effect of prone positioning during mechanical ventilation on mortality among patients with acute respiratory distress syndrome: a systematic review and meta-analysis. *CMAJ (Can Med Assoc J)* 2014;186:E381–90. <https://doi.org/10.1503/cmaj.140081>.
- [7] Li Q, Guan X, Wu P, et al. Early transmission dynamics in wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med* 2020;382:1199–207. <https://doi.org/10.1056/NEJMoa2001316>.
- [8] Yang X, Yu Y, Xu J, Shu H, Xia J, Liu H, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med* 2020;8:475–81. [https://doi.org/10.1016/S2213-2600\(20\)30079-5](https://doi.org/10.1016/S2213-2600(20)30079-5).
- [9] Lee JM, Bae W, Lee YJ, Cho YJ. The efficacy and safety of prone positional ventilation in acute respiratory distress syndrome: updated study-level meta-analysis of 11 randomized controlled trials. *Crit Care Med* 2014;42:1252–62. <https://doi.org/10.1097/CCM.0000000000001122>.
- [10] Mora-Arteaga J, Bernal-Ramirez O, Rodriguez S. The effects of prone position ventilation in patients with acute respiratory distress syndrome. A systematic review and metaanalysis. *Med. Intensiva (English Edition)* 2015;39:359–72. <https://doi.org/10.1016/j.medine.2014.11.004>.
- [11] Munshi L, Del Sorbo L, Adhikari NKJ, et al. Prone position for acute respiratory distress syndrome. A systematic review and meta-analysis. *Ann Am Thorac Soc* 2017;14:S280–s288. <https://doi.org/10.1513/AnnalsATS.201704-3430T>.
- [12] Gattinoni L, Tognoni G, Pesenti A, et al. Effect of prone positioning on the survival of patients with acute respiratory failure. *N Engl J Med* 2001;345:568–73. <https://doi.org/10.1056/NEJMoa010043>.
- [13] Chan MC, Hsu JY, Liu HH, et al. Effects of prone position on inflammatory markers in patients with ARDS due to community-acquired pneumonia. *J Formos Med Assoc* 2007;106:708–16. [https://doi.org/10.1016/S0929-6646\(08\)60032-7](https://doi.org/10.1016/S0929-6646(08)60032-7).
- [14] Gefen A, Creehan S, Black J. Critical biomechanical and clinical insights concerning tissue protection when positioning patients in the operating room: a scoping review. *Int Wound J* 2020;17:1405–23. <https://doi.org/10.1111/iwj.13408>.
- [15] Shearer SC, Parsa KM, Newark A, Peesay T, Walsh AR, Fernandez S, et al. Facial pressure injuries from prone positioning in the COVID-19 era. *Laryngoscope* 2021;131(7). E2139–e42.
- [16] Challoner T, Vesel T, Dosanjh A, Kok K. The risk of pressure ulcers in a prone COVID population. *Surgeon* 2021. <https://doi.org/10.1016/j.surge.2021.07.001>. In press.
- [17] Peko L, Barakat-Johnson M, Gefen A. Protecting prone positioned patients from facial pressure ulcers using prophylactic dressings: a timely biomechanical analysis in the context of the COVID-19 pandemic. *Int Wound J* 2020;17:1595–606. <https://doi.org/10.1111/iwj.13435>.
- [18] Clay AS, Chudgar SM, Turner KM, Vaughn J, Knudsen NW, Farnan JM, et al. How prepared are medical and nursing students to identify common hazards in the intensive care unit? *Ann Am Thorac Soc* 2017;14(4):543–9. <https://doi.org/10.1513/AnnalsATS.201610-773OC>.
- [19] Gaspar S, Botelho Guedes F, Vitoriano Budri AM, Ferreira C, Gaspar de Matos M. Hospital-acquired pressure ulcers prevention: what is needed for patient safety? The perceptions of nurse stakeholders. *Scand J Caring Sci* 2021;00:1–10. <https://doi.org/10.1111/scs.12995>.
- [20] Golden SH, Hager D, Gould LJ, Mathioudakis N, Pronovost PJ. A gap analysis needs assessment tool to drive a care delivery and research agenda for integration of care and sharing of best practices across a health system. *Joint Comm J Qual Patient Saf* 2017;43:18–28. <https://doi.org/10.1016/j.jcjq.2016.10.004>.
- [21] Brouwers MC, Kerkvliet K, Spithoff K. The AGREE Reporting Checklist: a tool to improve reporting of clinical practice guidelines. *BMJ* 2016;352:i1152. <https://doi.org/10.1136/bmj.i1152>.
- [22] [Guidance For: prone positioning in adult critical care](https://www.ficm.ac.uk/). Faculty of Intensive Care Medicine and Intensive Care Society; November 2019 [Available from: [prone_position_in_adult_critical_care_2019.pdf](https://www.ficm.ac.uk/)].
- [23] Douglas IS, Rosenthal CA, Swanson DD, Hiller T, Oakes J, Bach J, et al. Safety and outcomes of prolonged usual care prone position mechanical ventilation to treat acute coronavirus disease 2019 hypoxemic respiratory failure*. *Crit Care Med* 2021;49(3):490–502. <https://doi.org/10.1097/CCM.0000000000004818>.
- [24] Klaiman T, Silvestri JS, Srinivasan T, Szymanski S, Tran T, Oredoka F, et al. Improving prone positioning for severe acute respiratory distress syndrome during the COVID-19 pandemic. An implementation-mapping approach. *Ann Am Thorac Soc* 2021;18(2):300–7. <https://doi.org/10.1513/AnnalsATS.202005-571OC>.
- [25] Miguel K, Snyderman C, Capasso V, Walsh MA, Murphy J, Wang XS. Development of a prone team and exploration of staff perceptions during COVID-19. *AACN Adv Crit Care* 2021;32(2):159–68. <https://doi.org/10.4037/aacnac2021848>.
- [26] Mitchell, Seckel. AACN advanced critical care, vol. 29; 2018. p. 415–25. Available at, www.aacnacconline.org. 4.
- [27] Montanaro J. Using in situ simulation to develop a prone positioning protocol for patients with ARDS. *Crit Care Nurse* 2021;41(1):12–24. <https://doi.org/10.4037/ccn2020830>.
- [28] Oliveira VM, Weschenfelder ME, Deponti G, Condessa R, Loss HS, Barrios PM, et al. Good practices for prone positioning at the bedside: construction of a care protocol.

- Rev Assoc Med Bras 2016;62(3):287–93. <https://doi.org/10.1590/1806-9282.62.03.287>.
- [29] Santos VB, Aprile D, Lopes CT, Lopes JL, Gamba MA, Costa K, et al. COVID-19 patients in prone position: validation of instructional materials for pressure injury prevention. *Rev Bras Enferm.* 2021 2021;74(Suppl 1):e20201185. <https://doi.org/10.1590/0034-7167-2020-1185>.
- [30] European pressure ulcer advisory Panel, national pressure injury advisory Panel and Pan pacific pressure injury alliance. In: *Prevention and treatment of pressure ulcers/injuries: clinical practice guideline. The international guideline.* Emily haesler. EPUAP/NPIAP/PPPIA; 2019.
- [31] Capasso V, Snyderman C, Miguel K, Wang X, Crocker M, Chornoby Z, et al. Pressure injury development, mitigation, and outcomes of patients prone for acute respiratory distress syndrome. *Adv Skin Wound Care* 2021. <https://doi.org/10.1097/01.ASW.0000767404.02594.85>. online ahead of print.
- [32] Peko L, Barakat-Johnson M, Gefen A. Protecting prone positioned patients from facial pressure ulcers using prophylactic dressings: a timely biomechanical analysis in the context of the COVID-19 pandemic. *Int Wound J* 2020;17:1595–606. <https://doi.org/10.1111/iwj.13435>.
- [33] Ibarra G, Rivera A, Fernandez-Ibarburu B, Lorca-Garcia C, Garcia-Ruano A. Prone position pressure sores in the COVID-19 pandemic: the Madrid experience (20) 30732-4 *J Plast Reconstr Aesthetic Surg* 2020 Dec 26:S1748–6815. <https://doi.org/10.1016/j.bjps.2020.12.057> [Online ahead of print].
- [34] Mobility is Medicine. Proning safely: pressure injury prevention [Video]. YouTube, <https://www.youtube.com/watch?v=AXd1q6C9dtko>; 2020, May 21.
- [35] Rush University System for Health. Prone positioning for patients with acute respiratory distress syndrome (ARDS) [Video]. YouTube, <https://www.youtube.com/watch?reload=9&v=IcBPaHQUvXY>; 2020, April 2.
- [36] Adewole DA, Salawu MM, Bello S. Training needs assessment and preferred approach to enhancing work performance among clinical nurses in University College Hospital (UCH), Ibadan, Oyo State, South-western Nigeria. *LJNM* 2020;12: 130–8. <https://doi.org/10.5897/LJNM2020.0434>.