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



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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.

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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 Proning 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 bradyarrythmias, 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 checks 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].

 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, healthcare 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. <u>Best practice of proning (B-POP) multi- stakeholder policy</u> . 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.
			<u>Menu of implementation strategies</u> (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. <u>New curriculum</u> "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_6jT9R7W Js&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 <u>Clinical Practice Guideline</u> . [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.	2021	Brazil (São Paulo, Rio Grande do Sul, state of Rio de Janeiro	COVID-19 patients in prone position: validation of instructional materials for
[29]		and state of Goiás.) Author: Universidade Federal de São	pressure injury prevention.
		Paulo.	Content and face validation of a <u>checklist and banner</u> 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.op engrey.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

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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	https://www.aacn.org/blog/ards-covid-19-and-pronat ion-therapy	Blog, prone procedure training video, recorded sessions, and prone position articles.
			2017	https://www.aacn.org/clinical-resources/covid-19/proc edure-manual-covid-19-resources	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/Man ual-Prone-Positioning-Guide-RN_RT.pdf https://aams.org/wp-content/uploads/2020 /04/UMPC-STAT-MedEvac-Prone-Positioning_Tranpo rt-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 Zeeland 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/N RCP_Prone_Position_ICU_pt.pdf?fbclid=IwAR2_SULd -UZRPse_OpgBLJIwpmxcjNUfrqS1YWQN3HQeJsBs57 64KWAQQ3Q	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 &	FICM & ICS	Yes	Nov 2019	https://www.ficm.ac.uk/sites/default/files/prone_positi on_in_adult_critical_care_2019.pdf	"Guidance for Prone Positioning in Adult Critical Care"
Federacion Latinoamericano de Enfermeria en Cuidado Intensivo	FLECI	Yes	Jul 2020	https://aec-cba.com/wp-content/uploads/2020/07/flec iprotocoloprono.pdf	"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/resource s/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_tipsproning_202.pdf	"PIP (pressure injury prevention) ${\bf tips}$ for prone positioning"
Nebraska Medicine	n/a	Yes	n/s	https://www.nebraskamed.com/sites/default/files/do cuments/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/Pr essure-ulcer-prevention-guidance-when-proning-patient s-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%20Uni versity%202_%20Prone%20Positioning%20Checklists. pdf	Detailed guidance ; specific device choices
Tissue Viability Society	TVS	Yes	2021	https://tvs.org.uk/pressure-ulcer-prevention-and-mana gement/	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 intensive. Revista Chilena 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.
World Health Organisation	WHO	No	n/s	https://www.who.int/	n/a
World Union Wound Healing Societies	WUWHS	Yes	2016	www.woundsinternational.com https://www.wuwhs.org/wp-content/uploads/2020/0 7/WUWHS_PUP_consensus_Web.pdf	"Consensus document 2016: Role of dressings in pressure ulcer reduction". Mention the prone position.
Wound, Ostomy & Continence Nursing	WOCN	No	n/a	https://www.wocn.org/covid-19/	Guidance on PU risk reduction under PPEs, not for prone positioning
Wounds UK, TVN TV	TVS/TVN	Yes	n/s	https://tvntv.co.uk/pressure-ulcers/reposition-repositi	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	17,318
#3	Skin/tissue damage`skin	ulcer" [Text Word] "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 "skin tear*"	46,747
		[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]	
#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 integrity" [Title/ Abstract] OR "skin integrity" [Title/ Abstract] OR "skin integrity" [Text Word] OR "skin injur*" [Title/ Abstract] OR "skin injur*" [Title/ Abstract] OR "skin injur*" [Title/ Abstract] 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"	63,086
#5	Combination of concepts #1 AND #4	("pressure ulcer" [MeSH Terms] OR "pressure ulcer*" [Title/Abstract] OR "pressure sore*" [Title/Abstract] OR "pressure sore*" [Title/Abstract] OR "bedsore" [Text Word] OR "decubitus ulcer" [Text Word] OR "skin damage" [Title/Abstract] OR "skin integrity" [Title/ Abstract] OR "skin integrity" [Title/ Abstract] OR "skin integrity" [Text Word] OR "skin injur*" [Title/ Abstract] OR "skin injur*" [Text Word] OR "tissue viability" [Text Word] OR "skin tear*" [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 You-Tube® 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

Device/Equipment

Mechanical systems Rotoprone® (bed)

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

Website

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 pro	ne and/or manage the patien	t in prone position.		
Triadyne® prone kit MaxiMove® and repositioning sleeve	Arjo, Inc. Arjo, Inc.	https://arjo-us.wistia.com/medias/ypyq700mb7 (internal training only) https://www.arjo.com/en-us/solutions/prone-positioning/the-arjo-prone-position ing.product.portfolio/	Inflatable mattress – Manage patient in PP Passive lift to move patient into PP	
Maxislide® & MaxiTube®	Arjo, Inc.	https://arjo-us.wistia.com/medias/pg2hqmgkhg	Device-assisted manual PP. Move patient to	
Inflatable Prone Ventilation (IPV) (air)	Ergotrics TM	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) Sage Prevalon™ AirTap patient repositioning system (air)	Ergotrics™ Stryker™	https://ergotrics.com/product/ibo/?lang = en https://www.stryker.com/us/en/sage/products/sage-airtap.html https://sphmjournal.com/product/dec2016v6n4-sph-initiative-in-level-i-trauma -center-results/	Inflatable board to tilt patient into PP Microclimate body pad and glide sheet	
HoverMatt™ air transfer system (air) Tortoise® turning and positioning system with/without fluidized positioning pad.	Hovertech International [™] Mölnlycke [™]	https://hovermatt.com/products/hovermatt-air-transfer-system/ https://www.youtube.com/watch?v=wxnQ-Cc5IjM	Inflatable air mattress to transfer patient 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- ndards-initiative-s3i/	sta Support Surface Standard Initiative	
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 TM	https://www.smith-nephew.com/uk/products/wound_management/product-sea rch/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	
Dermisplus® Prevent	Frontier TM Medical group	https://www.reposedirect.com/dermisplus/	shear and maceration on the face. Pressure redistribution gel pads - redistributing peak pressures on anatomical	
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	
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	
Rebacare® Free Ear/Tube/Luna/Comfort XL	Rebacare®	https://www.rebacare.com/products/pillows/free-ear9401;-pillow	Patented free ear pillow designed for prone	
Z-Flo® fluidized positioner	Mölnlycke TM	https://www.molnlycke.ae/products-solutions/x-draft-molnlycke-z-flo-fluidised-posi tioner/ https://www.youtube.com/watch?y=wxpO-Cc5JiM	Viscoelastic materials with shape memory for repositioning body parts	
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Description

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Table 3 (continued)

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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	Multi-layer foam dressing with a silicone	
Aquacel® foam	Convatec TM	https://www.convatec.	Layered foam dressing with silicone border.	
Biatain® Silicone	Coloplast TM	com/advanced-wound-care/aquacel-dressings/aquacel-foam/# 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 TM Extra Thin	Convatec TM	https://www.convatec.com/advanced-wound-care/duoderm-dressings/duoderm-ext ra-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 М ^{тм}	https://multimedia.3m.com/mws/media/7167780/cavilon-no-sting-barrier-film-c linical-summary.pdf	Acrylate-based polymer solution for skin protection against moisture (saliva, bodily fluids, incontinence), friction and adhesives.	
Traditional Pillows, towels, blankets Endotracheal tape or ties Absorptive pads	n/a n/a n/a	n/a n/a n/a	For positioning the patient. To secure the endotracheal tube 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. J Laryngol Otol 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. Joyce Black, Kathleen Vollman & Gail Powell-Cope: The pursuit of HAPI-less. Proning safely - pressure injury prevention	Proning Safely Series: A Three-Part Puzzle. Website: https://mobilityismedicine.or g/videos/ https://www.youtube.com/watch?v=AX d1q6C9dko	Jun–Nov 2020	No	Yes	No	60 and 10-13 sessions
	Joyce Black: COVID-19 and tips for safe skin and proning. What should skin care involve for patients in the prone position?	https://woundsinternationaltv.com/edito rs-chioce/covid-19-and-tips-for-safe-ski n-and-proning/?_cldee=Y2Fyb2xpbm Eud2VsbGVyQG1vbmFzaC5lZHU%3d &recipientid=contact-02554ddf6fd 8e911a812000d3a7ed 483-61c7c45c041942b98c48dc9b35475f aa&esid=f125779b-b4ac-ea11-a812-000d 3a7ed30d	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-act ivities/nti19347/ards-unlocking-the-e ight-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 Mention some PU reduction strategies	https://www.youtube.com/watch?v=E_ 6jT9R7WJs	Jun 2013	No	Yes	Yes	5:12
	Mount Sinai Health System. Prone Positioning for the COVID-19 Patient	https://www.youtube.com/watch?v=EC dxhNFLwVo	April 2020	No	Yes	Yes	19:41
	Rush University Medical Center. Four-phase checklist implementation	https://www.youtube.com/watch?v=lc BPaHQUvXY	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=wx nQ-Cc5IjM	April 2020	Sponsored	Yes	Yes	10:51
	ArjoHuntleigh – Pressure Injury Prevention – Prone positioning and Nimbus Professional Product information	https://www.youtube.com/watch?v=59 W_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 Suggest wedges, pads, pillows for pressure relief	https://vimeo.com/436411191	July 2020	No	Yes	Yes	9:06
	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/s kin-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-pos itioning-an-evidence-based-practice-fo r-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. Some pressure ulcer reduction tips.	https://www.youtube.com/watch?v=Uc qq_UpzKKM	Jan 2018	Disclosed	Yes	No video but practical photos	12:18
	Kathleen Vollman and Sharon Dickinson	Why Prone? Why Now? Improving Outcomes for ARDS Patients https://www.aacn.org/education/ce-acti vities/wb0042/why-prone-why-now-imp roving-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

(continued on next page)

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 <u>key considerations</u> before <u>clinical guidance</u> related to skin damage for the patients in the prone position are implemented in a clinical setting?
- 1b) What <u>key descriptors</u> should be present in a clinical guidance for prevention of skin damage for the patient in the prone position?
- 1c) What are the <u>barriers to guideline implementation</u> related to the prevention of skin damage in prone positioned patients?
- 1d) What is your perspective on how <u>barriers to guideline implementation</u> related to prevention of skin damage in prone positioned patients <u>can be</u> <u>avoided</u>?
- 2a, 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 <u>educational material</u> related to prevention of skin damage for patients in the prone position consist of?
- 3b) How should <u>educational resources</u> related to prevention of skin damage for patients in the prone position be organised for <u>successful conveyance</u> to clinicians in critical care units?
- 4) What future <u>research</u> 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 competencybased 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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