Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Awake prone positioning for COVID-19 hypoxemic respiratory failure: A rapid review

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1. Background

Infection with SARS-CoV-2 can result in Coronavirus Disease–19 (COVID-19) [1, 2]. While the majority of patients are asymptomatic or have mild disease [3], approximately 14% develop more severe disease including hypoxemic respiratory failure and/or Acute Respiratory Distress Syndrome (ARDS) [3]. Prone positioning is a life-saving intervention for mechanically ventilated patients with moderate-severe ARDS [4]. Based on this, the World Health Organization (WHO) guidelines recommend these patients be considered for a trial of prone positioning [5].

Recently the use of prone positioning in awake non-intubated COVID-19 patients has been recommended by several notable organizations with the goal of preventing intubation and potentially improving patient-oriented outcomes [6, 7]. In contrast to prone positioning for intubated mechanically ventilated patients with ARDS, there have been no randomized control trials examining the role of awake prone positioning for non-intubated patients with hypoxemic respiratory failure. To further explore this question we used rapid review methodology Tricco et al. [8] to quickly identify and synthesize studies examining the effect of awake prone positioning on patients with hypoxemic respiratory failure (including those with ARDS and/or COVID-19).

2. Methods

We have elected to use "rapid review" methodology rather than "systematic review" methodology primarily due to the speed and efficiency through which we are able to conduct this review, as previously described [8]. In the absence of an EQUATOR guidance document, we used PRISMA guidelines where applicable [9].

Studies were included if they met the following criteria 1) *population* – non-intubated patients with hypoxemic respiratory failure, 2) *intervention* – prone positioning, 3) *comparator* – usual management, 4) *outcomes* – intubation, survival, change in respiratory parameters, adverse events, 5) *setting* – hospitalized patients 6) *study design* – observational or randomized control trial. Studies were not limited to ARDS or COVID-19 patients.

The search strategy was developed by a critical care physician (KP), a critical care epidemiologist (KF) and a medical librarian (NL) (See search details in *Online Supplement*). Briefly, the search strategy involved combinations of keywords and subject headings relating to the concepts of, 1) SARS-Cov-2 or COVID-19 or coronavirus, 2) awake prone positioning, and 3) hypoxemic respiratory failure, including but not limited to ARDS and other potentially relevant conditions. The search was conducted on May 19, 2020 and was updated on August 7, 2020 with no restrictions on publication language or date. Databases and grey literature sources searched included: MEDLINE (Ovid), PubMed, Trip PRO, Cochrane Library, LitCOVID, WHO COVID-19 Research Database, Centre for Evidence-Based Medicine (CEBM), National Institute for Health and Care Excellence (NICE), medRxiv, BMJ Best Practice, Cambridge Coronavirus Free Access Collection, and Google Scholar. Titles and abstracts were reviewed independently and in duplicate (KP and JW) for selection for full text review. Disagreements were resolved through discussion or with a third reviewer (KS). Full text review and data abstraction was conducted independently and in duplicate (KP, KS, JW). Data abstracted included study characteristics, participant demographics, and outcomes.

3. Results

The search yielded 181 unique articles. From this, 162 articles were selected for full text review and 35 articles met inclusion criteria and

Abbreviations: ARDS, acute respiratory distress syndrome;; CPAP, continuous positive airway pressure;; ECMO, extracorporeal membrane oxygenation;; FiO_2, fraction of inhaled oxygen;; HFNC, high-flow nasal cannula;; ICU, intensive care unit;; IQR, interquartile range;; NIV, non-invasive ventilation;; NP, nasal prongs;; PaO_2, partial pressure of arterial oxygen;; PC, prospective cohort;; PP, prone position;; RC, retrospective cohort;; RR, respiratory rate;; SD, standard deviation;; SpO_2, oxygen saturation.

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Table 1
Characteristics of studies examining awake prone positioning in non-intubated patients with hypoxemic respiratory failure due to COVID-19.

Author	Study Type	N	Inclusion Criteria	Exclusion Criteria	Setting	Oxygen Delivery Mode	Prone Positioning Protocol	Study Outcome	Duration of Follow-up	Duration of Prone Positioning	Supine Oxygenation and Resp Rate (if available) mean (SD), median [IQR]	Prone Position Oxygenation and Resp Rate (if available) mean (SD), median [IQR]	Intubation Rate, No. (%)	Adverse Event Reporting
Coppo (2020)	PC	56	Age 18–75, confirmed COVID-19, hypoxemia consent	Pregnant, uncollaborative, altered mental status, NYHA < II, increased BNP, COPD on home NIV or O_2, impending intubation	Non-ICU Medical units, ED, ICU	Helmet CPAP, Reservoir mask, Venturi mask	Assisted proning, encouraged to maintain x 3 h, Repeat up to 8 h/d	PaO_2:FiO_2	Hospital discharge	Median 3 h [3, 4] Up to 7 sessions.	PaO_2:FiO_2 180.5 (76.6) RR 24.5 (5.5)	PaO_2:FiO_2 285.5 (112.9) RR 24.5 (6.9)	18/56 (32)	9% discomfort 4% worsening oxygenation 2% coughing 5 deaths (9%)
Golestani-Eraghi (2020)	PC	10	COVID-19, not mech ventilated, PaO_2: FiO_2 < 150	Not reported	ICU	Helmet NIV	2 h sessions	Not reported	Not reported	Mean 9 h	PaO_2 46.3 (5.2)	PaO_2 62.5 (4.6)	2/10 (20%)	None reported 2 deaths (20%)
Moghadam (2020)	PC	10	COVID-19, not mech ventilated	Not reported	Non-ICU Medical unit	Not reported	Not reported	SpO2, RR, auxiliary muscle use	Hospital discharge	Not reported	SpO_2 86% (0.7)	SpO_2 96% (2.2)	0/10 (0)	Not reported
Elharrar (2020)	PC	24	Hypoxemia, CT chest with COVID-19 and posterior lesions	Requiring intubation, altered consciousness	Non-ICU Medical unit	NP, facemask, HFNC	Single episode, no goal duration	Proportion of patients with PaO_2 increase ≥20%from supine to PP	10 days	17% <1 h 21% 1–3 h 63% >3 h	PaO_2 72.8 (14.2)	PaO_2 91 (27.3) 25% had ≥20% increase PaO2	5/24 (20.8)	42% backpain 17% tolerated <1 h 17% required intubation within 72 h
Ng (2020)	PC	10	Hypoxemia	Drowsy, uncooper-ative, ophthalmic or cervical pathology, pregnancy, hemodyn-amic instability, FiO_2 > 0.5	Non-ICU Medical unit	NP, HFNC, or Venturi mask	1 h sessions, 5 sessions/d spaced 3 h apart. Continued until on RA x 24 h	Not reported	Median 8 days (range 2–19)	Median total duration 21 h (range 2–58)	SpO_2 91.5 (range 88–95)	Not reported	1/10 (10)	Discomfort, nausea, vomiting reported 1 death (10%)
Retucci (2020)	PC	26	COVID-19, spontane-ous breathing, GCS = 15, PaO_2: FiO_2 < 250 after 48 h Helmet CPAP	Requiring intubation, GCS < 15, SBP < 90, SpO_2 < 90% on FiO_2 > 0.8	ICU	Helmet CPAP	Prone/lateral positioning based on CXR or CT scan, 1 h sessions. 39 sessions: 12 prone, 27 lateral	Successful trial, defined as all 4 of: 1. decrease A-aO_2 gradient ≥20%, 2. equal or reduced RR, 3. equal or reduced dyspnea 4. SBP ≥ 90 mmHg	Not reported	1 h	PaO_2:FiO_2 182.9 (43) A-aO_2 207.1 [160.7–251.3] RR 23.7 (4.7)	PaO_2:FiO_2 220 (64.5) A-aO_2 184.3 [141.4–246.8] RR 23.1 (4.5)	7/26 (27)	39% of trials did not meet primary outcome. 25% of prone position trials failed 40% of lateral position trials failed 8% did not tolerate (both in lateral position) 5% discomfort 3% SBP < 90 mmHg 8% increased RR 2 deaths (8%)

Sartini (2020)	PC	15	Hypoxemia (SpO_2 < 94%), FiO2 > 0.6 and CPAP 10 cm H_2O	–	Non-ICU Medical Unit	NIV	Not reported	PaO_2:FiO_2, RR, patient comfort with NIV	14 days	Median 3 h (IQR 1–6)	PaO_2:FiO_2 58–117** Supine RR: 21–31**	PaO_2:FiO_2 114–122** PP: 18–27**	1/15 (6.6)	1 death (7%)
Thompson (2020)	PC	29	Confirmed COVID-19, Severe hypoxemia (RR > 30 and SpO_2 < 93% on 6 L O_2 by NP and 15 L by NRB	Altered mental status, inability to turn without help, immediate intubation needed, mild hypoxemia.	Step-down unit (interme-diate)	NP or NRB	Repeated episodes, up to 24 h per day, use a pillow under hips/pelvis.	Change in SpO_2 at 1 h	Up to 49 days or to hospital discharge	Median 4 h (range 1–24) in not-intubated group, Median 6 h (range 1–24) in intubated group.	SpO_2 65–95% **	SpO_2 90–100%** Median SpO_2 improvement 7% [4.6–9.4]	16/29 (55)	13% refused 3 deaths (10%)
Tu (2020)	PC	9	COVID-19 confirmed, HFNC >2 days, PaO_2: FiO_2 < 150	–	Not reported	HFNC	Repeated episodes, as long as tolerated	SpO_2 PaO_2	Hospital discharge, mean LOS 28 (10) d	Median 2 h [1–4] per session, median 5 [3–8] sessions	SpO_2 90% (2) PaO_2 69 (10)	SpO_2 96% (3) PaO_2 108 (14)	2/9 (22)	None reported 1 intubated patient required ECMO 0 deaths (0%)
Caputo (2020)	PC	50	Hypoxemia (SpO_2 < 90%)	NIV use, DNR order	ED	NP or facemask	Not reported	SpO_2 5 min after PP, intubation rate within 24 h	3 days	Not reported	SpO_2 84% [75–90]	SpO_2 94% [90–95]	13/50 (26.0)	22% required intubation within 60 min
Zhang (2020)	PC	23	COVID-19, Hypoxemia (SpO_2 < 90%), Age 18–80, consent	Need for intubation, inability to self position, basal lung disease, unstable spine, high ICP, severe burns, abdo surgery, abdo HTN, cranial injury, tracheotomy, immuno-suppresion, pregnant, imminent death.	Not reported	NP, HFNC, NIV	Evaluated muscle strength first, self position prone, 1-2 h sessions 3–4 times/day for 5 days. Vitals measured at 10 min and 30 min in PP	SpO2, RR, ROX	90 days	Median 9 h [8–22]	SpO_2 91.1 (1.5), RR 28.2 (3.1) ROX 3.35 (0.46)	SpO_2 95.5 (1.7) RR 24.9 (1.8) ROX 3.96 (0.45)	8/23 (35)	10 deaths (43%)
Bastoni (2020)	RC	10	Receiving helmet NIV, awake & able to prone	Need for rapid intubation & ICU, End-stage comorbid disease	ED	Helmet CPAP 10–20 cmH2O	Nurse assisted, Morphine infusion for sedation.	PaO_2:FiO_2, Lung US signs	Hospital discharge	1 h	PaO_2:FiO_2 68 (5)	PaO_2:FiO_2 97 (8) No change in lung US findings	6/10 (60)	40% did not tolerate or refused. 4 deaths (40%)
Burton-Papp (2020)	RC	20	COVID-19, Hypoxemia, received CPAP or NIV	–	ICU	CPAP or NIV	Not described	ΔP/F	Hospital discharge	Median 3 [2] Median 5 cycles per patient [6.25]	–	$\Delta PaO_2/FiO_2$ + 28.7 [95%CI 18.7–38.6] ΔRR −0.98 [95%CI -2-0.04]	7/20 (35)	None reported 2 intubated patients required ECMO 0 deaths
Cohen (2020)	RC	2	52 Female 40 Male	–	Non-ICU Medical unit	HFNC, NP	Self-prone as long as possible	–	Discharge from unit	2–4 h per day	Patient 1. SpO_2 90% on HFNC FiO2 1.0, RR 45 Patient 2. SpO_2 92% on 4 L	Patient 1. SpO_2 100% on HFNC FiO2 1.0, RR 25 Patinet 2. SpO_2 96% on 2 L	0/2 (0)	None reported
Damarla (2020)	RC	10	Confirmed COVID-19, rapidly increasing O_2 requiring ICU	Requiring intubation	ICU	NP or HFNC	Alternate prone/supine every 2 h, supervised first episode	SpO_2, RR at 1 h	28 d	2 h	SpO_2 94% [91–95] RR 31 [28–39]	SpO_2 98 [97–99] RR 22 [18–25]	2/10 (20)	None 0 deaths

(continued on next page)

Table 1 (*continued*)

Author	Study Type	N	Inclusion Criteria	Exclusion Criteria	Setting	Oxygen Delivery Mode	Prone Positioning Protocol	Study Outcome	Duration of Follow-up	Duration of Prone Positioning	Supine Oxygenation and Resp Rate (if available) mean (SD), median [IQR]	Prone Position Oxygenation and Resp Rate (if available) mean (SD), median [IQR]	Intubation Rate, No. (%)	Adverse Event Reporting
Despres (2020)	RC	6	COVID-19, PaO_2: $FiO_2 \leq 300$	Requiring intubation	ICU	NP, HFNC	As long as tolerated	PaO_2:FiO_2	Not reported	Median 2 h [1–7]	PaO_2:FiO_2 183 [144–212]	PaO_2:FiO_2 168 [156–225]	3/6 (50%)	Not reported
Dong (2020)	RC	25	COVID-19, Severe disease (RR ≥ 30, SpO2 ≤ 93% or PaO_2:FiO_2 ⟨300), or critical disease (Requiring ventilation, shock, organ failure)	Excluded patients who received PP but rapidly improved or who did not tolerate first session.	ICU	NP, Mask, HFNC, NIV	Daily session >4 h, nurse instructions, lateral positioning if PP not tolerated	Survival, intubation, PaO_2:FiO_2	Hospital discharge	Mean 4.9 h (SD 3.1)	PaO_2:FiO_2 194 [164–252] RR 27 [26–30]	PaO_2:FiO_2 348 [288–390] RR 22 [20—22]	0/25	16% Sternal pain 4% Scrotal pain 4% Lumbago 4% Pruritis 0 deaths
Froelich (2020)	RC	3	Confirmed COVID-19	–	Not reported	NP. Face Mask, HFNC	Varied positions, supine, lateral, prone, ergonomic prone.	SpO_2	Not reported	<30 min	Patient 1. SpO_2 94% on 4 L Patient 2. SpO_2 95% on 6 L Patient 3. SpO_2 91% on 15 L	Patient 1. SpO_2 97% on 4 L Patient 2. SpO_2 97% on 6 L Patient 3. SpO_2 95% on 15 L (lateral position only)	0/3 (0)	33% Hip and back pain 33% Inability to maintain prone position due to jaw dislocation
Huang (2020)	RC	3	$SpO_2 < 92\%$ on ≥6 L or PaO_2: $FiO_2 < 200$, bilateral opacities, RR < 30	Accessory muscle use, Contraindic-ations (cervical instability, pregnancy)	Not reported	HFNC, Venturi mask	Four 2 h sessions daily	PaO_2:FiO_2	Up to 6 days	Not reported	Patient 1. PaO_2:FiO_2 84.8 Patient 2. PaO_2:FiO_2 160 Patient 3. PaO_2:FiO_2 60.6	Patient 1. PaO_2:FiO_2 114 Patient 2. PaO_2:FiO_2 169 Patient 3. PaO_2:FiO_2 133	1/3 (33)	Not reported
Paul (2020)	RC	2	42 Male 35 Male	–	ICU	HFNC, NIV	Not reported	–	Hospital discharge	2–3 h sessions, over 3 days	Patient 1. SpO_2 92% on FiO_2 0.7 Patient 2. FiO_2 0.8	Patient 1. SpO_2 98% on FiO_2 0.5 Patient 2. FiO_2 0.4	0/2 (0)	Anxiety and discomfort in both patients
Ripoll-Gallardo (2020)	RC	13	PaO_2: $FiO_2 < 150$	Requiring intubation, hemodyn-amic instability, multiorgan failure	Non-ICU Medical unit	Helmet CPAP	Encouraged as long as possible	PaO_2:FiO_2	Hospital discharge	Mean 2.4 h (SD 0.87)	PaO_2:FiO_2 113 [108–121]	PaO_2:FiO_2 138 [126–178]	9/13 (69)	No complications 7 deaths (54%)
Solverson (2020)	RC	17	Suspected or confirmed COVID-19, ICU consult, Hypoxemia (5 L to maintain SpO2 ≥ 90%), at least 1 prone session	–	ICU, non-ICU medical ward	NP, HFNC	Encouraged as long as possible	SpO_2 Tolerability	Hospital discharge	35% < 1 h Median 75 min (range 30–480), Median 2 sessions (range 1–6) per day	SpO_2 91% (range 84–95) RR 28 (range 18–38) SpO_2:FiO_2 152 (range 97–233)	SpO_2 98% (range 92–100) RR 22 (range 15–33) SpO_2:FiO_2 165 (range 106–248)	7/17 (41)	47% pain/discomfort 6% delirium 2 deaths (12%)

Sztajnbok (2020)	RC	2	43 Male 37 Male	–	ICU	NRB	Encouraged as long as possible	–	ICU discharge	8–10 h, single sessions	Patient 1. SpO_2 100% on 10 L, RR 30 Patient 2. SpO_2 94% on 10 L, RR 28	Patient 1. Decreased to 5 L Patient 2. SpO_2 96% on 3 L, RR 22	0/2 (0)	Not reported
Xu (2020)	RC	10	COVID-19 confirmed,		Not reported		Target 16 h/d, target $SpO_2 > 90\%$	PaO_2:FiO_2	Hospital discharge, mean LOS 17.7 d	4–6 h sessions	PaO_2:FiO_2 89–228	PaO_2:FiO_2 200–325** on day 3 of PP	0/10 (0)	0 deaths
Cascella (2020)	CR	1	54 Male Received tocilizumab	–	Not reported	NIV	3 sessions per day	PaO_2:FiO_2	Hospital discharge	Mean 90 min per session	PaO_2:FiO_2 150	PaO_2:FiO_2 300	0/1 (0)	Not reported
Vibert (2020)	CR	1	23 Female pregnant Hypoxemia	–	ICU	HFNC and NIV	Not reported	–	Hospital discharge	2 h periods	SpO_2 89%, FiO_2 0.6, 60 L/min	SpO_2 96%, FiO_2 0.6, 60 L/min	0/1 (0)	No adverse patient or fetal events
Elkattawy (2020)	CR	1	36 Male Hypoxemia	–	Non-ICU Medical unit	NP	Not reported	–	1 day	>12 h per day	SpO_2 94%, 4 L/min NP	SpO_2 95%, room air	0/1 (0)	Not reported
Slessarev (2020)	CR	1	68 Male Hypoxemia	–	ICU	HFNC	Not reported	–	4 days	16–18 h per day	PaO_2:FiO_2 100**	PaO_2:FiO_2 250**	0/1 (0)	1 Nosebleed
Whittemore (2020)	CR	1	60 Male Hypoxemia	–	ICU	NRB	Not reported	SpO_2	Hospital discharge	>18 h per day	SpO_2 82% on 12 L NRB	SpO_2 94% on 12 L NRB	0/1	Not reported

* High flow nasal cannula success/failure, ** Range, estimated from a figure. Abbreviations: ARDS, acute respiratory distress syndrome; BNP, B-type natriuretic peptide; CPAP, continuous positive airway pressure; CR, case report; CT, computed tomography; DNR, do not resuscitate; ECMO, extracorporeal membrane oxygenation; ED, emergency department; FiO_2, fraction of inhaled oxygen; GCS, Glasgow Coma Scale; HFNC, high-flow nasal cannula; HFPV, high-frequency percussive ventilation; HTN, hypertension; ICP, intracranial pressure; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; NIV, non-invasive ventilation; NP, nasal prongs; NRB, non-rebreather face mask; NYHA, New York Heart Association; PaO_2, partial pressure of arterial oxygen; PC, prospective cohort; PP, prone position; RC, retrospective cohort; RA, room air; ROX, ROX index = SpO2/FiO2 x 1/respiratory rate; RR, respiratory rate; SBP, systolic blood pressure; SD, standard deviation; SpO_2, oxygen saturation; US, ultrasound.

were included in the final rapid review synthesis. A total of 35 studies (including 12 prospective cohorts, 18 retrospective cohorts, and 5 case reports) with 414 patients were synthesized (see Table 1 for COVID-19 studies and Table 2 for non-COVID-19 studies) [10-44]. Twenty-nine of these studies ($n = 364$ patients; 11 prospective cohorts, 13 retrospective cohorts, 5 case reports) report on the use of awake prone positioning in COVID-19 patients [10-17,19-21,24-29,31-33,35-39,41-44]. Only one study included data from a control group [44]. Seventeen studies (128 patients) were conducted exclusively within the ICU [12,16-19,22,23,25,29-31,34,35,37,40-42], two in the emergency department (60 patients) [10,13], eight exclusively on a non-ICU hospital ward (104 patients) [14,20,21,27,28,32,33,38], and two studies included patients in multiple settings (73 patients) [15,36]. The setting was not reported in 6 studies (49 patients) [11,24,26,39,43,44]. The frequency and duration of prone positioning was protocolized in only 15 studies (223 patients) [10,14-16,18,19,25,26,28,30,31,38,39,43,44]. The duration of prone positioning sessions varied from <1 h to >18 h (Tables 1 and 2) and was not reported in three studies [13,26,27]. All studies demonstrated improvements in oxygenation while patients were in the prone position except one [17]. When reported, improvements in oxygenation were generally not sustained after returning to the supine position, [15,20,31,34-36] except in two studies in which patients were receiving NIV [33,40]. One hundred twenty-one patients (29%) of the 414 patients (35 studies) required invasive mechanical ventilation. Adverse events were variably reported and included 42 deaths among the 414 patients (10.1% of all patients), discomfort, nosebleeds, sternal pain, back pain, and intolerance of awake prone positioning. Follow-up duration was variably reported (Tables 1 and 2) and was not reported in eight studies [17,18,22-25,30,31].

4. Discussion

In this rapid review, we present a synthesis of 35 studies (414 patients) that examined the use of awake prone positioning for non-intubated patients with hypoxemic respiratory failure. There has been significant attention on its use as a potential treatment for COVID-19 through news organizations, social media, and institutional guidelines. However, the evidence to support prone positioning in this population is limited to uncontrolled prospective or retrospective cohorts and case reports with small sample sizes and limited follow-up.

The cohorts and case studies in this rapid review describe an improvement in oxygenation while patients were in the prone position. The impact of improved oxygenation on clinical outcomes such as survival remains unclear. In contrast to non-intubated patients, prone positioning invasively ventilated patients with moderate-severe ARDS within an ICU is a proven life-saving intervention and is supported by meta-analyses of randomized control trials [4,45,46]. Although many invasively ventilated patients improve their oxygenation when in the prone position, these changes are not associated with survival [47]. The survival benefit is more likely mediated through a reduction in ventilator induced lung injury and not improved oxygenation [47]. Given that non-intubated patients are not at risk for ventilator induced lung injury, potential clinical benefits may be mediated through improved oxygenation, preventing intubation (which can be influenced by clinician decision making and bias), reduced respiratory work, or a reduction in patient self-inflicted lung injury [48].

In this synthesis, many patients receiving awake prone positioning were treated in monitored settings and not general wards (182 of 414 patients, 44%). Key details to offer this intervention safely such as the frequency, duration and adverse events were often not described or provided in limited detail. In six studies, awake prone positioning was not tolerated by some patients for even short durations [10,18,20,24,34,36]. Invasively ventilated patients with ARDS require greater than 12 h of prone positioning to receive a mortality benefit from prone positioning, which often requires sedation and paralysis to

Table 2
Characteristics of Studies Examining Awake Prone Positioning in Non-intubated Patients with Hypoxemic Respiratory Failure not due to COVID-19.

Author	Study Type	N	Inclusion Criteria	Exclusion Criteria	Setting	Oxygen Delivery Mode	Prone Positioning Protocol	Study Outcome	Duration of Follow-up	Duration of Prone Positioning	Supine Oxygenation and Resp Rate (if available) mean (SD), median [IQR]	Prone Position Oxygenation and Resp Rate (if available) mean (SD), median [IQR]	Intubation Rate, No. (%)	Adverse Event Reporting
Ding (2020)	PC	20	ARDS (Berlin) on NIV with CPAP 5 cm H_2O and PaO_2:FiO_2 < 200	Requiring intubation	ICU	HFNC or NIV	>30 min, 2 times daily for 3 days	Intubation rate, change in PaO_2:FiO_2	Not reported	Mean 2 h	PaO_2:FiO_2 95 (22) / 102 (15) *	PaO_2:FiO_2 130 (35) / 113 (25)*	9/20 (45.0)	2 non-tolerant 1 death (5%)
Perez-Nieto (2020)	RC	6	ARDS (Berlin criteria) non-infections ARDS, and PaO_2:FiO_2 < 100	–	ICU	HFNC or NIV	2–3 h, 2 times daily for 2 days	–	Not reported	2–3 h every 12 h	PaO_2:FiO_2 80 [67–91]	PaO_2:FiO_2 116 [101−131]	2/6 (33.3)	1 death (17%)
Scaravilli (2015)	RC	15	PaO_2:FiO_2 < 300, and undergone one PP without intubation	–	ICU	NP, HFNC or NIV	Not reported	Change in PaO_2:FiO_2	Hospital discharge	Median 3 (IQR 2–4)	PaO_2:FiO_2 127 (49) RR: 26 (10)	PaO_2:FiO_2 186 (72) RR: 25 (11)	2/15 (13.3)	No displaced catheters, pressure sores, neuropathy, vomiting, change in hemodynamics or vasopressors 2 patients non-tolerant, 3 patients died without intubation: 2 patients put on ECMO before intubation, and 1 patient changed goals of care
Feltracco (2012)	RC	3	Post lung transplant, and hypoxemia	–	ICU	HFPV	Not reported	–	Not reported	1–3 h 5–6 times per day, 1 h 3–4 times per Day	–	–	0/1 (0)	Not reported
Feltracco (2009)	RC	2	Post lung transplant, and hypoxemia	–	ICU	NIV	Not reported	–	Not reported	6-8 h per day	FiO_2 0.80	FiO_2 0.60	0/1 (0)	Not reported
Valter (2003)	RC	4	Hypoxemia	–	ICU	NIV	Not reported	–	Hospital discharge	1–5 h	FiO_2 0.70 [0.60–0.70] RR: 31 (26–38)	FiO_2 0.40 [0.30–0.50] RR: 20 (18–21)	0/1 (0)	Not reported

be tolerated [45,46]. Furthermore, patients included in this rapid review were heterogeneous in terms of hypoxemia severity. Prone positioning invasively ventilated patients is only beneficial in moderate-severe ARDS, not all severities of hypoxemia [45].

In summary, although awake prone positioning may be a promising therapy for patients with hypoxemic respiratory failure (including those with COVID-19), the supporting evidence is limited to case reports and cohort studies. These studies, when synthesized, highlight the lack of key details to inform clinicians and trialists. Many questions remain unanswered when considering the use of awake prone positioning. What are the effects on patient outcomes? What is the optimal frequency and duration? What are the criteria for stopping prone positioning? Which patients are most likely to benefit and which ones should be excluded? What are the potential adverse events that could occur? Ongoing randomized controlled trials (NCT04402879, NCT04383613, NCT04383613, NCT04350723, NCT04365959, NCT04347941) will be crucial in answering these questions.

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Declaration of Competing Interest

Authors do not report any conflicts of interest.

Appendix A. Supplementary data

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