Evaluating the use of prone positioning for young children with acute respiratory distress syndrome.

Joy Browne MSc
The National Health service (NHS)

Abstract

Acute respiratory distress syndrome (ARDS) refers to a severe condition in which the lungs fail to provide enough oxygen to vital organs of the body (NHS, 2020), and it is usually linked with multiple organ failure (Matthay, Ware, & Zimmerman, 2012). Aim: To evaluate the use of prone positioning for young children with acute respiratory distress syndrome. This review follows the Cochrane Collaboration protocol framework and uses a comprehensive search strategy across databases, including CINAHL Plus, Medline via PubMed, and Cochrane Library. Despite conflicting evidence, most studies indicate that prone positioning enhances oxygen levels and reduces mortality in severe ARDS cases.

Keywords: Prone positioning | kinetic positioning therapy | acute respiratory distress syndrome.

Introduction

Acute respiratory distress syndrome (ARDS) refers to a severe condition in which the lungs fail to provide enough oxygen to vital organs of the body (NHS, 2020), and it is usually linked with multiple organ failure (Matthay, Ware, & Zimmerman, 2012). Although there is no consensus of a specific cause, however, ARDS has been shown to be precipitated by some underlying clinical disorders such as sepsis, acute pancreatitis, pneumonia, inhaling of gastric contents, severe chest trauma (Matthay, Ware, & Zimmerman, 2012; NHS, 2020). Studies have shown that there is an increase of ARDS; it was reported in a research study that up to 19% of intensive care unit cases involved ARDS (Summers et al., 2016). While in the United States, over 190,000 cases of ARDS are recorded yearly with over 74,000 mortalities as a result (Intensive Care Society, 2018; Siegel, 2016). This is consistent with an international observational study conducted by Khemani and colleagues in 2019 which investigated ARDS incidence and epidemiology, which found that cases of ARDS were linked with a mortality as high as 35% (Khemani et al., 2019).

Pathophysiology

The pathophysiology of ARDS is due to severe inflammation because of lung injury which affects the ability of the lungs in regulating fluid exchange and dry alveolar capillary, consequently resulting to fluid in the alveoli and the interstitium (Fujishima, 2014; Intensive Care Society, 2018; Siegel, 2016). Thus, this weakens gas exchange while increasing pulmonary arterial pressure, triggering reduced oxygen and increased carbon dioxide in the blood, consequently resulting to hypoxemia, pulmonary hypertension, and reduced pulmonary compliance (Gibbons, 2015; Intensive Care Society, 2018; Siegel, 2016).

Treatment and management

ARDS has the potential of causing harm and utilising vast healthcare resources because of its complexity, and it remains one of the most challenging conditions for paediatric nurses to manage notwithstanding several clinical advances (Monteverde-Fernández, Cristiani, McArthur, & González-Dambrauskas, 2019; Hon, Leung, Oberender, & Leung, 2021). Nursing management of patients with ARDS involves maintaining the airway, providing adequate oxygenation, and supporting hemodynamic function (Essouri et al., 2015; Orloff, Turner, & Rehder, 2019). Positioning is one of the supportive therapies that nurses offer for patients with ARDS which helps to maintain the airways, improve oxygen levels, and prevent complications (Ng, Miccile, …, Yuse, & Tolland, 2020). Positioning plays a role to augment perfusion in the pulmonary capillary system through the increment of oxygen inflow between the alveoli and pulmonary capillaries (Fan, Brodie, & Slutsky, 2018; Sud, Friedrich, Polli., ... & Guérin, 2014).

The goal of ARDS patients care is to increase perfusion (Grap & Munro, 2004), however, there can be complications such as ventilation/perfusion mismatch, alveolar collapse during positive end-expiratory pressure (PEEP), and immobility (Fan et al., 2018; Sud et al., 2014). There are a variety of positioning interventions that are used to reduce such complication; they are kinetic therapy, continuous lateral rotational therapy, supine, and prone positioning. Although, positioning therapies have been shown to enhance oxygenation by improving atelectasis, V./Q. ratio, reducing the build-up of interstitial fluid, and activating secretions, however, there are conflicting views regarding its role in improving patients' outcome (Sud et al., 2014; Tamburro & Kneyber, 2015; Guérin, Reignier, Richard, Boulain, ... & Ayzac, 2013; Sebat, Henry, Musthafa, & Johnson, 2004). For example, while exploring the effect of prone positioning during mechanical ventilation on mortality among patients with ARDS, Sud and colleagues extracted randomised controlled trials (RCT) studies using electronic databases and conference proceedings. Results indicated that although, prone positioning contributed to 50% reduction of mortality in severe ARDS, and support safety in paediatric, however, there was no difference in outcomes (Sud et al., 2014). Sud et al. (2014) further recommended that while prone positioning may be used in severe PARDS, however, its utility is not recommended as a routine therapy. Similarly, Tamburro and Kneyber (2015) synthesis of 55 research papers regarding ancillary treatment for PARDS highlighted that the routine use of prone positioning is not recommended, however, it may be used in severe cases of

PARDS. On the contrary, in a study of positioning in severe ARDS, Guérin et al. (2013) assessed how early application of prone positioning effects patients' outcomes. Their sample of 466 severe ARDS patients were assigned 16 hours of prone positioning intervention or placed in supine position. They found that the prone positioning group had significantly lowered mortality. Thus, they concluded that early application and the routine use of the prone therapy is recommended (Guérin et al., 2013). Similarly, Sebat et al. (2004) recommended the routine use of prone positioning and specified that it can be accomplished by one nurse. Such conflicting evidence are the basis for the need for further study.

On the other hand, several studies have provided evidence for the effectiveness of the kinetic positioning therapy compared to the prone positioning (Cater, Ealy, Kramer, Abu-Sultaneh, & Rowan, 2020) even during mixed perspectives. For example, Cater et al. (2020) highlighted that the use of kinetic therapy for paediatric patient with ARDS is a safer alternative in the case where there are difficulties implementing prone positioning. Rance (2005) investigation of kinetic therapy established that it improves oxygenation and gaseous exchange, however, Rance (2005) expressed concern about conflicting findings in literature and concluded that it is not effective in severe cases of ARDS (Rance, 2005). These conflicting evidence regarding positioning form the basis for further study. Thus, the aim of this systematic review of literature was to evaluate the use of positioning for young children with acute respiratory distress syndrome and to examine the current state of knowledge.

Research questions

The aim of this research was to evaluate the use of prone positioning for young children with acute respiratory distress syndrome. The questions were asked: (1) Does positioning improve oxygen level in young children? (2) Does positioning prevent complications in young children?

Method and strategy

This systematic review of literature is guided by the protocol framework developed by the Cochrane Collaboration and published in the Cochrane Handbook for Systematic Reviews of Interventions (Cochrane Collaboration, 2008). The Cochrane framework would reduce researchers' biases and improve transparency (Smith, Devane, Begley, & Clarke, 2011) while evaluating the use of positioning for young children with acute respiratory distress syndrome.

Search strategy and criteria for inclusion

Search terms were used to obtain literature regarding acute respiratory distress syndrome from different databases such as CINAHL Plus, Medline via PubMed, Cochrane Library, and Google Scholar. From the onset of the search, research publication date was screened to avoid dated papers, save time, and facilitate the management process. Search terms were carefully selected to extract research that investigated nursing interventions related to prone positioning and kinetic therapy for acute respiratory distress syndrome. Search terms utilised include "acute respiratory distress syndrome", "acute respiratory distress", "prone positioning", "kinetic therapy", and "positioning". Doing so would help in understanding the current state of prone and kinetic positioning as intervention for ARDS. Details of the search items, limiters/expanders, databases, and search results are shown in table 1.

Types of study

(a) Qualitative and quantitative studies, including randomised controlled trials, pre or post intervention research, and quasi-experimental designs, (b) research that used two or more groups, (c) research published in peer-reviewed journals, and (c) research that explored nursing interventions such as positioning in terms of acute respiratory distress syndrome. Excluded research were (a) those that were not written in the English language, (b) research papers that were published prior to 2011, (c) papers that are review of the literature such as scoping reviews, systematic reviews, meta-analysis, and literature reviews. Research studies that explored other types of positioning nursing intervention such as supine or dorsal

recumbent position, Fowler's position, orthopneic positioning, or lateral position were not included in this systematic review.

Types of participants.

Articles included in this review used paediatric patients who have been hospitalised. Although paediatric age ranges from birth to age 16 (NHS, 2021), however, some research papers have explored it up to age 18. Such paper will not be eliminated because there are few original research literatures since 2011 that have investigated prone positioning as a nursing intervention for ARDS in paediatrics.

Types of interventions

Types of study included in this systematic review were those that had used the following nursing interventions; (a) positioning in general, (b) prone positioning, and/or (c) kinetic therapy, and are aimed to improve oxygen levels and prevent complications.

Types of outcome measures

Studies were included if the outcome measure (dependent variable) explored the improvement of oxygen levels and the prevention of complications in children with acute respiratory distress syndrome via means of prone positioning or kinetic therapy.

Selection of studies

Abstracts and titles of research papers extracted and those manually retrieved were reviewed for eligibility in view of the criteria for inclusion/exclusion. *See PRISMA flow chart for search results.*

Evidence summary and Analysis

Critically appraising a research study involves the practice of thorough and systematic assessment to decide whether a research article is reliable or significant in a specific context (Giacomini, Cook, & De Jean, 2009; Booth & Brice, 2004). The Critical Appraisal Skills Programme (CASP) analysis tool was used to appraise included studies (CASP, 2020) and to evaluate their validity and usefulness (Long, French, & Brooks, 2020). See sample of completed CASP in appendices.

All papers included in the study for review have addressed their aim and rationale for the study, however, a common trend is the absence of research questions, but the aims or rationale for individual study were well documented (refer to: Kredel, 2014; Cater, 2020; Girard, 2014; Azam & Senthil Kumar, 2019; Zhou & Siao, 2021; Girard et al., 2014; Apte, 2021; Ng et al., 2020; Beitler et al., 2015; Jozwiak, 2013). *See table 2 for evidence of summary.*

In a randomised controlled trial (RCT), the sample being given the intervention is randomly selected from a population that meet the selection criteria, as well as a control group selected from that eligible population (Hariton & Locascio, 2018; Levin, 2007). In this review, half of the studies utilised randomised controlled trials (refer to: Beitler et al., 2015; Girard et al., 2014; Jozwiak et al., 2013; Kredel et al., 2014; Ng et al., 2020). Most papers provided their process of randomisation while utilising appropriate methods in their investigations. For example, in a randomised controlled trial study that investigated the impact of patient positioning on pressure ulcers in patients with severe ARDS, Girard (2014) showed the process of randomisation which took place in day 1 of the study. In addition, collaborating with nurses and research assistant in ensuring the process was efficient can be highlighted as a means that would ensure the elimination of systematic biases. This has been shown in studies to increase validity (Viera & Bangdiwala, 2007) and improve the effectiveness of research (Hariton & Locascio, 2018). However, studies like Jozwiak et al. (2013) did not focus on the process of randomisation, rather, they focused on their rationale of the effects of prone positioning during ARDS, the justification for their objectives, and the method process in a detailed fashion. Even though Jozwiak et al. (2013) had provided robust rationale for their chosen aim and method, the lack of adequate process of randomisation may impact on the validity of the study.

Consistent with all papers included in this review was that all the participants involved in individual study were accounted for in the conclusion. That is, there was evidence of follow up after the process of randomisation or selection (refer to: Kredel, 2014; Cater, et al., 2020; Girard et al., 2014; Azam & Senthil

Kumar, 2019; Zhou & Siao, 2021; Gaudry et al., 2017; Apte, 2021; Ng et al., 2020; Beitler et al., 2015; Jozwiak, 2013). For example, Kredel et al. (2014) detailed the selection of patients and allocation to 12 bed intensive care unit (ICU) through April 24, 2010, to June 22, 2011, and how one patient was included in later date who also received the same intervention and was accounted for in the result and discussion. Similarly, in another study of prone positioning in ARDS, Gaudry et al. (2017) study was longitudinal in nature and data collection from three ICUs in a hospital in Paris lasted from 2009 to March 2014 and all the participants were accounted for all through the analysis. This has been shown in studies to increase validity and research effectiveness (Viera & Bangdiwala, 2007; Hariton & Locascio, 2018).

The effects of intervention were comprehensively reported across all studies included for review. This may have been the most detailed aspects of the individual studies. The outcomes were measured and clearly specified while detailing their results in clear and comprehensive ways. In addition, the results were reported for each outcome in each study group, and where statistical representation or analysis were made, significant levels were clearly communicated. For example, in a study that investigated the impact of patient positioning on pressure ulcers in patients with severe ARDS, Girard et al. (2021) presented robust details of their outcome using a variety of statistical analysis such as Pearson's correlation analysis, linear multiple logistics regression analysis, and comparing means. These were conducted to test different types of positioning and for each group while comparing scores and detailing a variety of significant levels where $p < .05$ in most times significant levels were measured. In a similar study, Cater et al. (2020) presented a detailed outcome while testing the use of a kinetic therapy in paediatric ARDS using well organised statistical analysis that showed not only patient demographics for each participant included in the case series, but also detailed the relationship between the application of kinetic positioning and oxygenation indices improvement relative to time. That is, a detailed representation of hourly outcome for all participants in the study (Cater et al., 2020).

The protection of human subjects during research studies is an ethical matter which involves the evaluation of risk, the protection of the subjects from the risks identified, and avoiding causing harm to participants and others (Hatcher & Schoenberg, 2007; Oquendo, Stanley, Ellis, & Mann, 2004). All studies included in this systematic review had observed ethical procedures in their individual studies. Care seemed to have been taken to ensure that no harm is caused to participants due to the research. For example, Kredel et al. (2014) obtained ethical approval from the Ethics Committee of the Medical Faculty at their University, and measures were taken to ensure the safety of the positioning intervention and oxygenation. Similarly, Cater et al. (2020) study followed the principles and regulations of the Declaration of Helsinki and the Indiana University Institutional Review Board research approval. Cater and colleagues detailed processes that showed the protection of human subjects while detailing the benefits of their studies which showed that the use of kinetic therapy can be safely used in paediatric patients, and that prone positioning would be more beneficial for larger paediatric patients (Cater et al., 2020). On the other hand, Girard et al. (2014) showed detailed processes involved in their study, as well as elaborated outcome of interventions, however, they did not present ethical procedure that guided the processes of their study. Nevertheless, it seemed that ethical procedures have been adhered to since all the processes involved in the study were well documented and seemed to follow a variety of protocols, even though they did not specifically mention ethical process. Better still, it has been argued that presenting ethical process that guided a study would increase the reliability of the study (Ogunrin, Ogundiran, & Adebamowo, 2013).

Ioannidis (2007) argued that limitations are not properly acknowledged in the scientific literature. Limitations provide a means for comprehending the context of research studies, clarifying the validity of research, and assessing the level of credibility (Ross & Zaidi, 2019). In this review, Cater et al. (2020), Girard et al (2014), Apte et al. (2021), Ng et al. (2020), Beitler et al. (2015), Jozwiak et al. (2013), Kredel et al. (2014) and Gaudry et al. (2017) presented adequate limitations for their individual studies while providing

recommendations for future studies. This is a contributory factor that enhances the validity and credibility of these studies (Ioannidis, 2007; Ross & Zaidi, 2019). On the other hand, although, Zhou and Siao (2021) and Azam (2019) did not present limitations of their respective studies, however, all through their work, they have shown adequately, the processes that have guided their studies, and have conducted their reporting in a compelling manner.

Key Findings

See table 3 for extracted themes.

Theme 1: Prone positioning safety

Results from analysis of several papers published since 2013 showed that prone positioning can be safe to administer to paediatric patients with acute respiratory distress syndrome. For example, Apte et al. (2021), Beitler et al. (2015), Cater et al. (2020), and Azam & Senthil Kumar, (2019) demonstrated that prone positioning can be safe to administer without causing complications for patients with ARDS. In addition, in Gaudry et al. (2017) study, they intended to investigate prone positioning in acute respiratory distress syndrome after abdominal surgery with a sample size of 98 clinical participants, and they found that prone positioning significantly increased PaO2/FiO2 ratio which is the ratio of arterial oxygen partial pressure compared to fractional inspired oxygen while it reduced complications. Consequently, Gaudry et al. (2017) concluded that nurses and intensivist should not refrain from using prone positioning for ARDS patients. This is relatable because nursing management of patients with ARDS involves maintaining the airway, providing adequate oxygenation, and supporting hemodynamic function (Essouri et al., 2015; Orloff, Turner, & Rehder, 2019), thus, this result shows that prone positioning would aid nurses in supporting patients with ARDS which helps to maintain the airways, improve oxygen levels, and prevent complications (Ng et al., 2020). Similarly, this result is consistent with other findings that have demonstrated the safe use of prone positioning and its potentials of reducing complications (Fan, Brodie, & Slutsky, 2018; Sud et al., 2014). Similarly, Azam & Senthil Kumar, (2019) study of early veno-venous extra corporeal membrane oxygenation with prone positioning in the treatment of severe ARDS showed that the intervention is safe for use on VV ECMO for ARDS.

In contrary, Girard et al. (2014) argued that although prone positioning may be useful in improving oxygen level, however, it has been linked to pressure ulcer. This is a study of its kind as currently, there are no other study since 2011 that has confirmed this to the best of the author's knowledge, thus, further research may be required to shed more light on this. Girard et al. (2014) was not alone with regards to their views of adverse effects of prone positioning, Kredel et al. (2014) also had concerns about the safety of prone positioning. In their study, Kredel et al. (2014) concluded that prone positioning was related to facial oedema, however, can be performed safely with experienced nurses/team. This may be why Sud et al. (2014) previously argued that prone positioning utility should not be recommended as a routine therapy. This conflicting evidence are the basis for the need for further study.

Theme 2: Prone positioning effectiveness

90% of papers included in this review have shown some effectiveness of administering prone positioning intervention (Apte et al., 2021; Beitler et al., 2015; Cater et al., 2020; Gaudry et al., 2017; Girard et al., 2014; Jozwiak et al., 2013; Kredel et al., 2014; Zhou & Siao, 2021; Azam & Senthil Kumar, 2019). For example, in Apte et al. (2021) study, they used a plan-do-study to examine prone positioning in patients with ARDS, and the found that it improves the level of oxygen and reduces incidences of complications. Thus, the concluded that prone positioning is effective for moderate to severe ARDS cases (Apte et al., 2021). Similarly, Beitler et al. (2015) and Girard et al. (2014) highlighted respectively in their studies that the use of prone positioning is linked to higher chances of improved outcomes and survival and concluded that it improves survival in moderate to severe cases of ARDS. These results are consistent with other research findings; for instance, in Sud et al. (2014) study, they extracted RCT studies using multiple sourced data, they indicated that although, prone positioning contributed to 50% reduction of mortality in severe ARDS. Similarly,

Tamburro and Kneyber (2015) also recommended the use of prone positioning in severe cases of PARDS. Despite these encouraging findings from this systematic review, there are conflicting views regarding the role of prone positioning in improving patients' outcome (Sud et al., 2014; Tamburro & Kneyber, 2015; Guérin et al., 2013; Sebat et al., 2004). For example, Zhou & Siao (2021) expressed concern over the use of prone positioning in their study which investigated the lateral femoral cutaneous neuropathy caused by prone positioning. They concluded that prone positioning was linked to severe lateral femoral cutaneous neuropathy.

Theme 3: Kinetic therapy versus prone positioning

Only one study compared the effectiveness of prone positioning to kinetic therapy (Cater et al., 2020). In Cater and colleague study, they explored the use of a kinetic therapy in paediatric acute respiratory distress syndrome using a case series. This was a longitudinal study that lasted over 3 years. They found that both prone positioning and kinetic therapy were linked to improve oxygen level as well as the reduction of complications. However, they argued that there are cases where it becomes difficult to carry out prone positioning especially manually; this is in situations that involve larger children. In such situations, kinetic therapy can be used to improve outcome. They concluded that kinetic therapy is effective for larger children with ARDS, where manual prone positioning becomes difficult (Cater, 2020). This finding is contrary to Rance (2005) finding. Rance (2005) investigation of kinetic therapy established that although it improves oxygenation and gaseous exchange, however, Rance (2005) expressed concern about conflicting findings in literature and concluded that it is not effective in severe cases of ARDS (Rance, 2005). These conflicting evidence regarding positioning form the basis for further study.

Conclusion

The aim of this systematic review was to evaluate the use of prone positioning for young children with acute respiratory distress syndrome. To do this, the questions were asked: (1) Does positioning improve oxygen level in young children? (2) Does positioning prevent complications in young children? To answer these questions, themes were extracted from the 10 research papers included in the review for analysis. The results showed that 90% of the papers included in the review demonstrated support for the use of prone positioning in improving oxygen level in young children (refer to: Apte et al., 2021; Beitler et al., 2015; Cater et al., 2020; Gaudry et al., 2017; Girard et al., 2014; Jozwiak et al., 2013; Kredel et al., 2014; Zhou & Siao, 2021; Azam & Senthil Kumar, 2019). However, one study has disagreed with that notion and has presented evidence to support their claims that prone positioning is not safe to be administered as it is linked with severe lateral femoral cutaneous neuropathy (Zhou & Siao, 2021). Nevertheless, far many more studies have shown support for the use of prone positioning in improving outcome and oxygen level in young children (Sud et al., 2014; Tamburro & Kneyber, 2015; Guérin et al., 2013; Sebat et al., 2004). In addition, prone positioning was found to be linked to some complications in three studies. Girard et al. (2014) presented that prone positioning was linked to pressure ulcer, Kredel et al. (2014) study showed that prone positioning may be related to facial oedema, however, can be performed safely with experienced nurses/team, while Zhou & Siao (2021) study concluded that prone positioning was reported to be linked to severe lateral femoral cutaneous neuropathy.

Evaluation of findings

The findings in this review have been shown to be consistent with previous studies, but the results have shown some differences. These differences may have been due to confounding variables unknown to the researchers. All through the papers, there was no specific focus on the effect of confounders which may have impacted on respective findings of individual study.

Importance of finding

The findings of the current review are important to research and nursing practice as they have demonstrated the role of prone positioning in improving oxygen level and reducing complications. Although there were a few conflicting findings which would require future study, however, more studies have

recommended the use of prone positioning based on its effectiveness and safety. Nursing management of patients with ARDS involves maintaining the airway, providing adequate oxygenation, and supporting hemodynamic function (Essouri et al., 2015; Orloff, Turner, & Rehder, 2019). So, the results from this review have provided more insight that would facilitate the support nurses provide to their patients with ARDS. Despite few studies linking the prone positioning to some complications, the benefits of the intervention seem to outweigh the potential risks it poses. Notwithstanding, further research is needed to clarify the risks posed by administering prone positioning in patients with ARDS. Finally, as recommended by Gaudry et al. (2017), nurses and intensivist should not refrain from using prone positioning for patients with ARDS.

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Appendices

Table 1: Table of results

	Search terms	Limiters/Expanders	Last Run Via	Results
S1	(Acute respiratory distress syndrome * Acute respiratory distress) AND (Kinetic therapy)	Limiter – published date: Published between January 2011 and August 2021. Paper type: Literature reviews and editorials.	Interface: Cochrane Library Research Databases: PubMed – 3 Embase – 1 ICTRP - 1	4
S2	(Acute respiratory distress syndrome * Acute respiratory distress) AND (Prone positioning)	Limiter – published date: Published between January 2011 and August 2021. Paper type: Literature reviews and editorials.	Interface: Cochrane Library Research Databases: PubMed – 30 Embase – 54 ICTRP – 5 CT.gov - 29	97
S3	[(Acute respiratory distress) AND (Prone positioning)] OR [(acute respiratory distress syndrome) AND (Kinetic therapy)]	Limiter – published date: Published between 2011 and 2021. Paper type: Literature reviews and editorials.	Interface: PubMed via MEDLINE Research Databases: PubMed NLM – 26	26

PRISMA flow chart showing searches and results

Adapted from Moher et al. (2009).

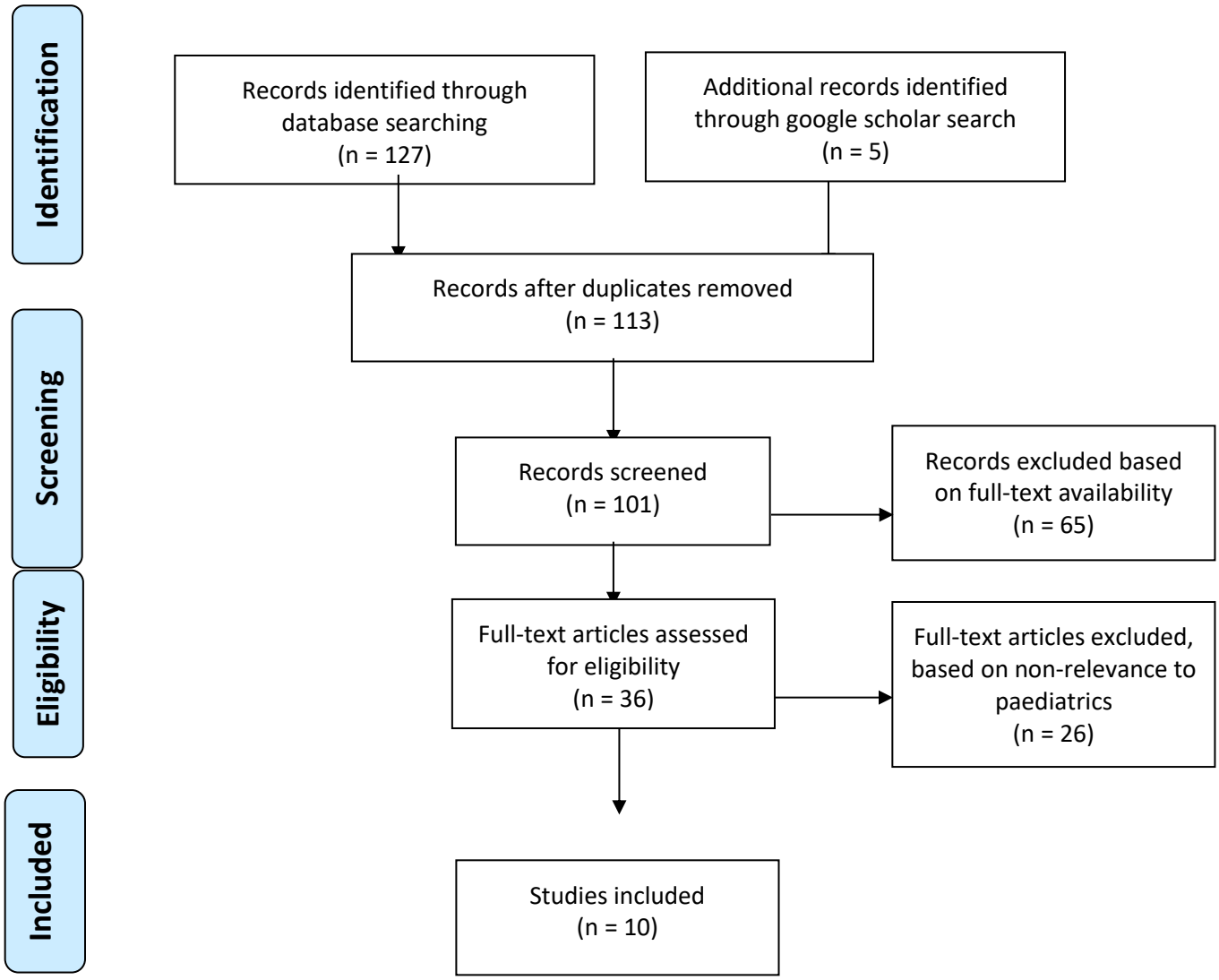


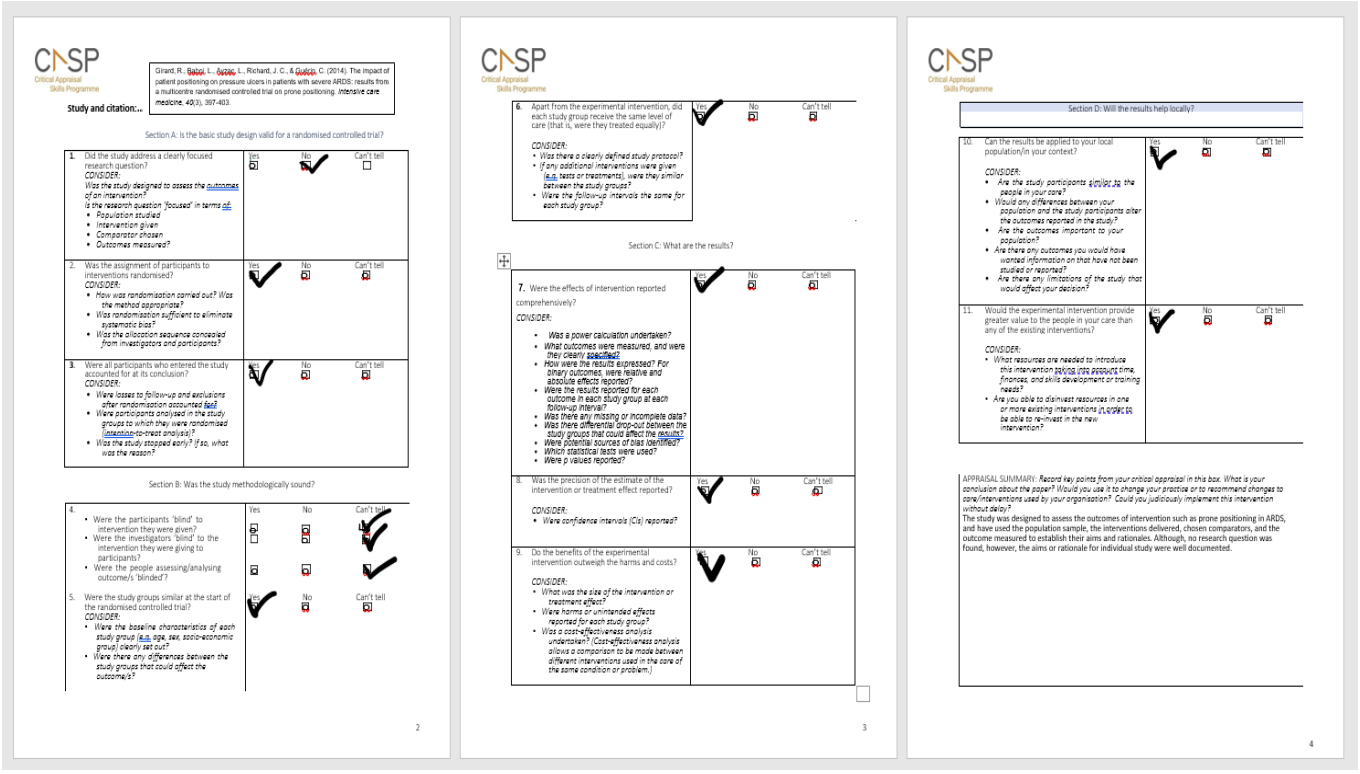
Table 2. Summary of evidence table

Author, Year and Location	Aim of study	Methodology	Key Findings (strengths and weaknesses)
Apte, Jacobs, Shewdin, Murray, Tung, Ramanan, & Massey, (2021), Australia.	To develop, implement, and evaluate a prone positioning program in two intensive care units in Southeast Queensland.	Plan Do Check Act (PDCA) quality improvement model.	Prone positioning, a non-ventilatory intervention improved outcome and reduced complications in ARDS patients.
Beitler, Guérin, Ayzac, L., Mancebo, Bates, Malhotra, & Talmor (2015), California, USA.	To evaluate positive end-expiratory pressure titration during prone positioning for acute respiratory distress syndrome.	Multicentre randomised trials.	The use of prone positioning likely improves survival in moderate-severe ARDS.
Cater, Ealy, Kramer, Abu-Sultaneh, & Rowan (2020), Indianapolis, USA.	To evaluate the use of a Kinetic Therapy Rotational Bed in Paediatric ARDS	Retrospective case series.	Kinetic therapy shown to be useful where manually prone positioning becomes burdensome in larger children.
Gaudry, Tuffet, Lukaszewicz, Laplace, Zucman, Pocard, ... & Ricard (2017), France.	To examine the prevalence of complications in patients with and without prone position in ARDS.	A multicentre retrospective cohort of patients with ARDS.	There was no association between the use of prone positioning and the development of complications in ARDS.
Girard, Baboi, Ayzac, Richard, & Guérin (2014), France.	To investigate the effectiveness of prone positioning over supine.	Prospective multicentre randomised controlled trial.	Prone positioning improved outcome for severe ARDS, however, associated with pressure ulcers.
Jozwiak, Teboul, Anguel, Persichini, Silva, Chemla, ... & Monnet (2013), France.	To investigate the effects of prone positioning during ARDS on all the components of cardiac function.	Randomised clinical trial.	Prone positioning improved oxygen levels and prevent complications, improved arterial oxygen and cardiac index.
Kredel, M., Bischof, L., Wurmb, T. E., Roewer, N., & Muellenbach, R. M. (2014), Germany.	To test the combination of positioning therapy and venovenous extracorporeal membrane oxygenation in ARDS patients	Randomised clinical trial and case series.	Positioning related to facial oedema, however, can be performed safely with experienced nurses/team.
Ng, Miccile, Iracheta, Berndt, Detwiller, Yuse, & Tolland (2020), USA + England.	To investigate prone positioning in ARDS Related to COVID-19.	Randomised clinical trial.	Positive outcome achieved by prone positing team in ARDS related to COVID-19.

Author, Year and Location	**Aim of study**	**Methodology**	**Key Findings (strengths and weaknesses)**
Zhou & Siao, (2021), Massachusetts, USA.	To investigate lateral femoral cutaneous neuropathy caused by prone positioning to treat COVID-19 associated ARDS.	Case studies.	Prone positioning was reported to be linked to severe lateral femoral cutaneous neuropathy.
Azam & Senthil Kumar, (2019), Columbia.	To examine the effectiveness and outcome of prone positioning with Extra Corporeal Membrane Oxygenation (ECMO) therapy in paediatric cases of severe acute respiratory distress syndrome.	Clinical case study.	Prone positioning is a safe and effective therapy for severe cases.

A completed critical analysis using CASP.

A completed copy of the CASP critical analysis tool showing one of the studies included in this review



Study and citation:..

Girard, R., Baboi, L., Ayoub, J., Richard, J. C., & Guérin, C. (2014). The impact of patient positioning on pressure ulcers in patients with severe ARDS: results from a multicentre randomised controlled trial on prone positioning. *Intensive care medicine*, *40*(3), 397-403.

Section A: Is the basic study design valid for a randomised controlled trial?

	Yes	No	Can't tell
1. Did the study address a clearly focused research question? CONSIDER: Was the study designed to assess the outcomes of an intervention? Is the research question 'focused' in terms of: • Population studied • Intervention given • Comparator chosen • Outcomes measured?	☐	☑	☐
2. Was the assignment of participants to interventions randomised? CONSIDER: • How was randomisation carried out? Was the method appropriate? • Was randomisation sufficient to eliminate systematic bias? • Was the allocation sequence concealed from investigators and participants?	☑	☐	☐
3. Were all participants who entered the study accounted for at its conclusion? CONSIDER: • Were losses to follow-up and exclusions after randomisation accounted for? • Were participants analysed in the study groups to which they were randomised (intention-to-treat analysis)? • Was the study stopped early? If so, what was the reason?	☑	☐	☐

Section B: Was the study methodologically sound?

	Yes	No	Can't tell
4. • Were the participants 'blind' to intervention they were given?	☐	☐	☑
• Were the investigators 'blind' to the intervention they were giving to participants?	☐	☐	☑
• Were the people assessing/analysing outcome/s 'blinded'?	☐	☐	☑
5. Were the study groups similar at the start of the randomised controlled trial? CONSIDER: • Were the baseline characteristics of each study group (e.g. age, sex, socio-economic group) clearly set out? • Were there any differences between the study groups that could affect the outcome/s?	☑	☐	☐

2

	Yes	No	Can't tell
6. Apart from the experimental intervention, did each study group receive the same level of care (that is, were they treated equally)? CONSIDER: • Was there a clearly defined study protocol? • If any additional interventions were given (e.g. tests or treatments), were they similar between the study groups? • Were the follow-up intervals the same for each study group?	☑	☐	☐

Section C: What are the results?

	Yes	No	Can't tell
7. Were the effects of intervention reported comprehensively? CONSIDER: • Was a power calculation undertaken? • What outcomes were measured, and were they clearly specified? • How were the results expressed? For binary outcomes, were relative and absolute effects reported? • Were the results reported for each outcome in each study group at each follow-up interval? • Was there any missing or incomplete data? • Was there differential drop-out between the study groups that could affect the results? • Were potential sources of bias identified? • Which statistical tests were used? • Were p values reported?	☑	☐	☐
8. Was the precision of the estimate of the intervention or treatment effect reported? CONSIDER: • Were confidence intervals (CIs) reported?	☑	☐	☐
9. Do the benefits of the experimental intervention outweigh the harms and costs? CONSIDER: • What was the size of the intervention or treatment effect? • Were harms or unintended effects reported for each study group? • Was a cost-effectiveness analysis undertaken? (Cost-effectiveness analysis allows a comparison to be made between different interventions used in the care of the same condition or problem.)	☑	☐	☐

3

Section D: Will the results help locally?

	Yes	No	Can't tell
10. Can the results be applied to your local population/in your context? CONSIDER: • Are the study participants similar to the people in your care? • Would any differences between your population and the study participants alter the outcomes reported in the study? • Are the outcomes important to your population? • Are there any outcomes you would have wanted information on that have not been studied or reported? • Are there any limitations of the study that would affect your decision?	☑	☐	☐
11. Would the experimental intervention provide greater value to the people in your care than any of the existing interventions? CONSIDER: • What resources are needed to introduce this intervention (taking into account time, finances, and skills development or training needs? • Are you able to disinvest resources in one or more existing interventions in order to be able to re-invest in the new intervention?	☑	☐	☐

APPRAISAL SUMMARY: *Record key points from your critical appraisal in this box. What is your conclusion about the paper? Would you use it to change your practice or to recommend changes to care/interventions used by your organisation? Could you judiciously implement this intervention without delay?*

The study was designed to assess the outcomes of intervention such as prone positioning in ARDS, and have used the population sample, the interventions delivered, chosen comparators, and the outcome measured to establish their aims and rationales. Although, no research question was found, however, the aims or rationale for individual study were well documented.

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Table 3: Table of Themes.

	Theme 1 – Prone positioning safety	Theme 2 – Prone positioning effectiveness	Theme 3 – Kinetic therapy versus prone positioning.
Paper 1 Apte et al. (2021)	Prone positioning is safe for patients with moderate to severe ARDS.	Prone positioning is effective for moderate to severe ARDS cases.	
Paper 2 Beitler et al. (2015)	Prone positioning is safe for use.	Prone positioning improves survival in moderate to severe cases of ARDS.	
Paper 3 Cater et al. (2020)	Prone positioning is safe for use.	Prone positioning improves oxygenation.	Kinetic therapy is effective for larger children with ARDS, where manual prone positioning becomes difficult. Kinetic therapy improves oxygenation.
Paper 4 Gaudry et al. (2017)	Nurses and intensivist should not refrain from using prone positioning for ARDS patients.	Prone positioning is beneficial to oxygenation. It also reduces complications.	
Paper 5 Girard et al. (2014)	Prone positioning was linked to pressure ulcer.	Prone positioning improves survival in ARDS patients.	
Paper 6 Jozwiak et al. (2013)		Prone positioning improves cardiac index in ARDS patients.	
Paper 7 Kredel et al. (2014)	Positioning related to facial oedema, however, can be performed safely with experienced nurses/team.	Prone positioning can improve oxygenation.	
Paper 8 Ng et al. (2020)		Positive outcome achieved by prone positing team in ARDS related to COVID.	

Paper 9 Zhou & Siao, (2021)	Prone positioning was reported to be linked to severe lateral femoral cutaneous neuropathy.		
Paper 10 Azam & Senthil Kumar, (2019)	Prone positioning is safe on VV ECMO for ARDS.	Prone positioning can be used for severe ARDS cases.	