IP International Journal of Medical Paediatrics and Oncology 2024;10(1):3–11

Content available at: https://www.ipinnovative.com/open-access-journals

IP International Journal of Medical Paediatrics and Oncology

Journal homepage: https://www.ijmpo.com/

Review Article

Optimizing ventilatory support in ARDS: A comprehensive guide for ICU nurses on patient care

Sharun NV[1,*]

[1]*College of Nursing, AIIMS, Mangalagiri, Andhra Pradesh, India*

ARTICLE INFO

Article history:
Received 08-03-2024
Accepted 03-04-2024
Available online 11-05-2024

Keywords:
Ventilator
ICU
COVID19
ARDS

ABSTRACT

The emergence of COVID-19 as a global pandemic has placed an unprecedented strain on healthcare systems worldwide, highlighting a critical shortage of trained healthcare professionals equipped to manage such a crisis. This deficit poses a significant challenge to the delivery of healthcare services, particularly in the context of intensive care units (ICUs) where the use of advanced medical technologies, such as ventilators, is paramount. For nurses with limited experience in ICU settings, navigating the complexities of invasive positive pressure ventilation (IPPV), a principal method of mechanical ventilation for critically ill patients can be daunting. This article aims to serve as a comprehensive guide for nurses less familiar with the intricacies of managing patients on IPPV, offering insights and strategies to enhance their competence and confidence in this critical aspect of patient care.

1. Introduction

In late 2019, the emergence of a novel coronavirus marked the onset of a series of pneumonia cases in Wuhan, a city within China's Hubei Province, swiftly escalating into an epidemic across China and subsequently sparking a global surge in cases. By February 2020, the World Health Organization (WHO) had named the disease COVID-19, an acronym for the coronavirus disease that emerged in 2019, with the causative virus being identified as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1]

India reported its first COVID-19 cases on January 30, 2020, in three students returning from Wuhan University, leading to the WHO declaring the outbreak a pandemic on March 11. As of February 2, 2021, India was grappling with 163,353 active cases and had witnessed 154,486 deaths (a mortality rate of 1.43%),[2] a figure that stands in contrast to the global average mortality rate of 2.16%.[3]

A particularly severe complication of COVID-19 is acute respiratory distress syndrome (ARDS), a form of respiratory failure that manifests in a significant number of cases.[4] ARDS can be classified into mild, moderate, and severe categories, based on the extent of hypoxemia.[5] Patients afflicted with moderate to severe ARDS often require the support of invasive positive pressure ventilation (IPPV) and face a grim prognosis.[6,7] The mortality rate for patients developing ARDS due to viral pneumonitis is alarmingly high,[8] placing healthcare providers at considerable risk of infection themselves. The use of protective mechanical ventilation strategies is crucial in ARDS patients to prevent further lung damage and improve outcomes.[9] Lung-protective ventilator settings have been shown to benefit not only ARDS patients but also individuals with uninjured lungs who require ventilation for other reasons.[10]

In the context of COVID-19, which can lead to ARDS, prone positioning has been highlighted as a beneficial strategy in mechanically ventilated ARDS patients. This approach has shown improvements in

* *Corresponding author*.
E-mail address: sharunvijayan@gmail.com (Sharun NV).

https://doi.org/10.18231/j.ijmpo.2024.002

oxygenation and overall outcomes, potentially reducing the need for intubation.[11] Additionally, the use of low tidal volume ventilation and lung-protective strategies has been emphasized in managing acute hypoxemic respiratory failure, including ARDS, to enhance recovery and reduce ventilator-induced lung injury.[12]

Ventilator support plays a critical role in the treatment of ARDS, but it also poses risks such as barotrauma and ventilator-induced lung injury. Therefore, careful management of ventilator settings, including positive end-expiratory pressure (PEEP) levels, is essential to optimize outcomes in ARDS patients.[13] The importance of individualized approaches in mechanical ventilation, considering factors like inspiratory and expiratory muscle activities, has been highlighted to tailor treatment to each patient's specific needs.[14]

In conclusion, ARDS patients require ventilator support to maintain adequate oxygenation and ventilation. Utilizing lung-protective strategies, prone positioning, and personalized ventilator settings are crucial in managing ARDS to improve patient outcomes and minimize complications associated with mechanical ventilation.

2. Nursing Interventions

2.1. Give your patient a "fast hug" (at least once a day[15]

The "FAST HUG" mnemonic prompts healthcare providers to review and manage critical areas including,

1. Feeding (Nutrition): Assessing the patient's nutritional needs to ensure they are met adequately.
2. Analgesia: Managing pain effectively to ensure patient comfort as ordered.
3. Sedation: Evaluating the need for sedation to maintain patient comfort and safety as ordered.
4. Thromboembolic prophylaxis: Implementing measures such as Thrombo Emboli Deterrent Stockings (TEDS) or administering Low Molecular Weight Heparin (LMWH) to prevent blood clots as ordered.
5. Head-of-bed elevation: Adjusting the bed to an appropriate angle to reduce the risk of aspiration and facilitate better breathing.
6. Stress Ulcer prevention: Taking steps to prevent the development of stress ulcers in critically ill patients.
7. Glucose control: Monitoring and managing blood glucose levels to prevent complications.

Vincent and Hatton expanded upon this mnemonic by adding three additional components[16,17] as follows,

1. Bowel movement: Monitoring and managing bowel function to prevent complications.
2. Indwelling catheters: Assessing the necessity of catheters and ensuring their proper management to prevent infections.
3. Drug de-escalation (BID): Regularly reviewing medication regimens to minimize exposure to unnecessary antibiotics and reduce the risk of resistance.

This expanded "FAST HUG BID" approach ensures a holistic and vigilant care regimen, emphasizing the need for a detailed and routine examination of patients' critical care needs, thereby promoting optimal outcomes in the ICU environment.[18]

Nutritional assessment in ARDS patients in the ICU is crucial for optimizing patient outcomes. Enteral nutrition is beneficial in improving oxygenation and extending ventilator-free days in patients with Acute Lung Injury (ALI) and ARDS.[19] Additionally, high caloric intake with a high ratio of enteral nutrition has been associated with lower hospital mortality in ARDS patients undergoing prone positioning therapy.[20] It is recommended that nutritional support, preferably enteral, be initiated within 24-48 hours of ICU admission for ARDS patients.[21]

In ARDS, a high NUTRIC (Nutrition Risk in Critically Ill) score has been associated with higher mortality in patients requiring mechanical ventilation in the ICU.[22] Furthermore, a study on nutrition in COVID-19 patients emphasizes the importance of optimizing nutrition management, especially in those with ARDS, to improve patient outcomes.[23]

It is essential to consider the nutritional status of ARDS patients, particularly those at high nutritional risk. A study found that energy achievement rate is an independent factor associated with ICU mortality in high-nutritional-risk patients with moderate to severe ARDS requiring prolonged prone positioning therapy. Moreover, immune-enhancing enteral nutrition has shown benefits in terms of oxygenation and mortality in adult ICU patients with ALI/ARDS.[24]

2.2. Care of invasive lines

The meticulous management of invasive lines, such as IV cannulas, arterial catheters, and central lines, is paramount in patient care, especially to maintain their patency and ensure sterile conditions.[25–27] Precise documentation of the insertion date and time is crucial for timely replacement based on clinical indications or adherence to hospital protocols, thereby minimizing the risk of infection and other complications.[28,29] Effective care planning and communication in ICUs are essential to prevent overutilization of invasive treatments.[30,31]

Particularly challenging is the management of the endotracheal tube, where inadvertent dislodgement can lead to severe consequences including laryngeal swelling, hypoxemia, bradycardia, hypotension, and potentially fatal outcomes. Proactive measures to prevent premature or accidental removal are essential.[32] Providing adequate sedation and analgesia, coupled with the implementation of standardized protocols, has been shown to reduce the incidence of self-extubation. While the application of soft wrist restraints or mitts may not completely prevent self-extubation, these measures, when used judiciously, can contribute to the overall strategy to mitigate this risk.[33]

Regular monitoring and adjustment of cuff pressure are critical to ensure the integrity and functionality of the endotracheal tube. Utilizing a handheld calibrated aneroid manometer every 8 to 12 hours for this purpose, or employing techniques such as the minimal leak volume or minimal occlusion volume method, helps maintain optimal cuff pressure between 18 and 22 mm Hg.[34,35] This is particularly important during extended periods of intubation, where pressure adjustments may be necessary to secure an adequate seal.

Tracheostomy care warrants diligent attention, with at least tri-daily assessments to prevent infection, a common complication due to the invasive nature of the procedure. The routine replacement of the ventilator circuit and in-line suction tubing, guided by infection control recommendations, further decreases the risk of ventilator-associated infections.[36,37]

Moreover, nasotracheal tubes are associated with a higher risk of sinus infections and ventilator-associated pneumonia (VAP), underscoring the need for careful selection and management of airway devices to mitigate these risks.[38–40]

Such comprehensive care strategies are critical in safeguarding patient health and optimizing outcomes in the critical care setting.

2.3. Monitoring vitals

Monitoring vital signs is a cornerstone of patient care, especially in critical care settings, providing essential insights into the patient's physiological state and guiding therapeutic interventions.[41] Regular and comprehensive monitoring should encompass temperature, pulse, blood pressure (BP), oxygen saturation (SpO2), electrocardiogram (ECG) readings, and pain intensity using a Visual Analogue Scale (VAS). Additionally, assessing skin colour and hemodynamic parameters such as central venous pressure (CVP), arterial blood gas (ABG) values, and random blood sugar levels is crucial for a holistic understanding of the patient's health status.

Auscultation of lung sounds should be performed at least every 2 to 4 hours,[42]

1. To evaluate the adequacy of bilateral air entry, ensuring that ventilation is effectively reaching both lungs.[43,44]
2. To detect the presence or prominence of abnormal breathing sounds, which could indicate complications or changes in the patient's condition.
3. To follow up on the changes in the abnormal breathing sounds noted on the previous day, whether there has been a reduction or aggravation, providing insight into the progression or improvement of pulmonary issues.[45]

Such diligent monitoring is vital for detecting early signs of deterioration or improvement, allowing for timely adjustments in care plans. Healthcare providers need to be adept at interpreting these vital signs and sounds, as they are critical indicators of the patient's overall well-being and the effectiveness of ongoing treatment strategies.

2.4. Management of fluid and electrolyte imbalances

Managing fluid and electrolyte imbalances is crucial for patients on mechanical ventilation, particularly those with Acute Respiratory Distress Syndrome (ARDS).[46,47] Fluid retention is a common complication following 48 to 72 hours of Positive Pressure Ventilation (PPV), especially when Positive End-Expiratory Pressure (PEEP) is utilized. Early recognition of fluid and electrolyte imbalances is key, marked by changes in Central Venous Pressure (CVP), peripheral edema, pulmonary crackles, alterations in blood pressure, irregularities in pulse, and ECG changes. These indicators should prompt immediate communication with the attending intensivist for appropriate management.

In the context of fluid resuscitation, it's imperative to stay informed about current evidence and guidelines, adapting these recommendations to the evolving understanding of disease-specific characteristics, such as the prevalence of heart failure, volume overload, and circulatory failure among ventilated patients. This knowledge aids in tailoring fluid management strategies to optimize patient outcomes.[48,49]

Achieving and maintaining specific perfusion targets is fundamental to the management of fluid and electrolyte imbalances.[50,51] These targets include maintaining a Mean Arterial Pressure (MAP) greater than 65 mmHg, ensuring a urine output of more than 0.5 ml/kg/hr, achieving a capillary refill time of less than 3 seconds, and closely monitoring the level of consciousness. These parameters serve as critical indicators of adequate organ perfusion and fluid balance, guiding the adjustment of fluid therapy and electrolyte supplementation to support physiological stability and recovery in critically ill patients.[52,53]

2.5. Administring medications as ordered

Administering medications accurately and safely is a cornerstone of care for patients undergoing mechanical ventilation, especially those diagnosed with Acute Respiratory Distress Syndrome (ARDS). The need for continuous delivery of medications such as analgesics, sedatives, and drugs for hemodynamic support necessitates the use of infusion devices, like syringe pumps or infusion pumps. For ARDS patients, the central venous line is often the preferred route for administration, as it facilitates the effective delivery of inotropes, Total Parenteral Nutrition (TPN), and other critical medications. Additionally, the central line enables precise monitoring of vital hemodynamic parameters, including Central Venous Pressure (CVP).

It is standard practice to provide prophylactic antibiotics and Proton Pump Inhibitors (PPIs), such as Pantoprazole, to patients on mechanical ventilation to prevent infections and stress ulcers, respectively. This approach underscores the importance of preventing complications that could exacerbate the patient's condition or lengthen the ICU stay.

A critical consideration in the care of ventilated patients is the use of neuromuscular blocking agents (paralytics).[54] These agents should never be administered unless the patient is securely intubated and receiving mechanical ventilation. The rationale behind this guideline is to prevent the administration of paralyzing agents in the absence of adequate ventilation support, which could lead to catastrophic outcomes, including severe hypoxemia and even death. Additionally, when paralytics are used, it is imperative to concurrently administer sedatives. This practice ensures that while the patient is unable to move, they remain unaware and free from the distress of being conscious but immobilized.[55–57]

Rapid-sequence intubation (RSI) embodies the simultaneous administration of a sedative and a paralytic agent to facilitate emergency airway management, aiming to minimize the risk of aspiration and reduce potential injury to the patient.[58] This technique highlights the critical balance between ensuring rapid and secure airway control while minimizing the risk of adverse events, reflecting the complex and nuanced care required for patients in critical conditions.

2.6. *Care bundle for Ventilator-associated pneumonia*

Implementing a care bundle for the prevention of Ventilator-associated pneumonia (VAP), which typically develops more than 48 hours after the initiation of mechanical ventilation, is a proven strategy.[59–61] This bundle includes six critical elements, each to be evaluated daily.[62]

Head-of-Bed Elevation: Elevate the head of the bed to 30–45° to reduce aspiration risk, except when contraindicated.

1. Sedation Assessment: Daily assessment of sedation levels to ensure the patient is comfortable; reducing or pausing sedation as needed, using tools like RASS and CAM-ICU for evaluating agitation and sedation levels.[63–66]
2. Oral Hygiene: Perform oral care using chlorhexidine gluconate (≥ 1–2% gel or liquid) or 1.5% hydrogen peroxide swab every 6 hours. Reposition the endotracheal tube every 24 hours to prevent oral lesions, marking the tube at the lip or teeth level for accurate placement.[67]
3. Subglottic Aspiration: For patients expected to be intubated longer than 72 hours, use a tracheal tube with a subglottic secretion drainage port, aspirating secretions 1- to 2-hourly.
4. Tube Cuff Pressure: Monitor cuff pressure every 4 hours, maintaining it at 20–30 cmH2O or 2 cmH2O above peak inspiratory pressure to prevent air leak and aspiration.
5. Stress Ulcer Prophylaxis: Administer stress ulcer prophylaxis according to standard protocols, focusing on high-risk patients.

Adhering to these guidelines can significantly reduce the incidence of VAP, enhancing patient outcomes during mechanical ventilation.[68,69]

2.7. *Positioning*

While head elevation is generally recommended for patients on mechanical ventilation to reduce the risk of ventilator-associated complications, the prone position has been identified as particularly beneficial for certain COVID-19 patients with moderate to severe Acute Respiratory Distress Syndrome (ARDS), characterized by a P/F ratio of less than 20 kPa.[50,70–72] This positioning technique, which involves turning the patient onto their stomach, enhances oxygenation by promoting greater expansion of the lung's dorsal regions, thereby optimizing alveolar recruitment.

Evidence suggests that prone positioning, especially when integrated with lung-protective ventilation strategies and applied for at least 12 hours, can significantly improve patient outcomes, including reduced mortality rates. However, the success of prone positioning hinges on careful planning and execution. The use of a checklist during the proning process enhances the safety and efficacy of the maneuver, underscoring the importance of a well-informed and trained healthcare team.[70]

Notably, prone positioning is not suitable for all patients, and a thorough risk-benefit assessment is essential before its implementation. Adequate staffing is critical to safely turn the patient and adjust their position, ensuring continuous airway protection and appropriate sedation levels. Special care must be taken to prevent complications such as brachial plexus injury, which can occur if the arms are excessively flexed during the process. Following are the steps involved in the proning,[6]

Explain to the patient, with reassurance, that they will be safe and obtain consent if they can communicate. Close eyes and protect them with gel or pad.

↓

Place the patient's palms against their thighs, thumbs upwards, elbows straight and shoulders neutral.

↓

Slide the patient to the edge using a Sliding sheet.

↓

Roll the patient into the lateral position using the underneath sheet.

↓

Roll the patient into prone, 'Swimmers position' (position elbow, in which the head is semi-rotated should be flexed to no more than 90° to avoid ulnar nerve stretch, and the other arm internally rotated by the side).

↓

Ensure that women's breasts or men's genitals are not compressed. Place two pillows under each shin to prevent peroneal nerve stretch, positioning them to avoid knee and toe pressure from the mattress.

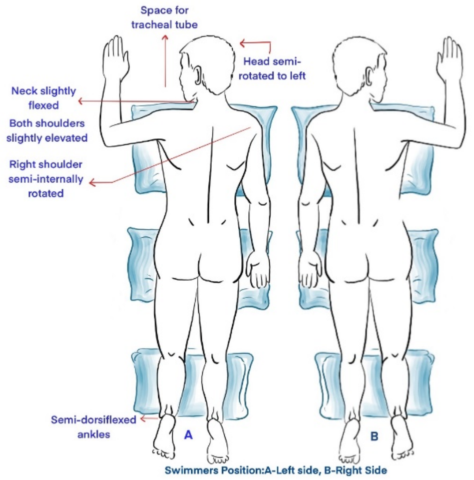

Figure 1: Prone Positioning method.

2.8. Suctioning Patient as indicated

Suctioning in ARDS patients requires a judicious approach, focusing on minimizing potential harm while ensuring patient airways are adequately maintained. Routine, non-indicated suctioning of the airway is discouraged due to the risks of bronchospasm and mechanical trauma to the tracheal mucosa. Instead, the need for suction should be assessed every 2 hours, with the procedure performed only if clinically indicated,[73] utilizing an inline suction catheter to minimize exposure and contamination risks.

The instillation of normal saline into the airway prior to suctioning is not recommended, as it does not enhance secretion removal and may instead contribute to complications.[74] Prior to suctioning, it's critical to pre-oxygenate the patient for at least 3 minutes using the ventilator's built-in hyperoxygenation feature, avoiding bag-mask ventilation to reduce aerosol generation. The suctioning process itself should be brief, not exceeding 10-15 seconds at a time, to mitigate the risks of hypoxemia.[75]

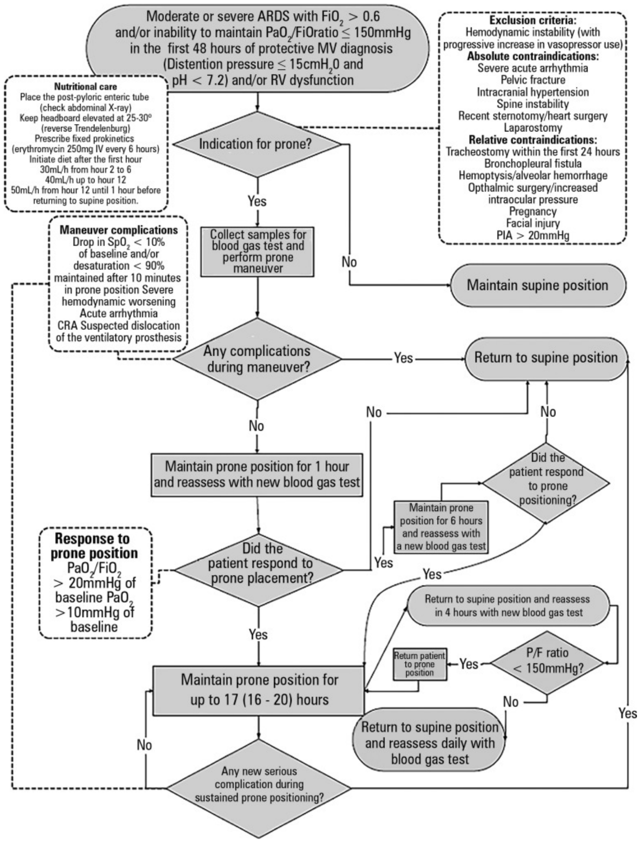

Figure 2: Flow diagram of the prone position care protocol.Adopted from Oliveira VM, Piekala DM, Deponti GN, Batista DC, Minossi SD, Chisté M, Bairros PM, da Silva Naue W, Welter DI, Vieira SR. Safe prone checklist: construction and implementation of a tool for performing the prone maneuver. Revista Brasileira de terapia intensiva. 2017 Apr;29(2):131

Performed correctly and cautiously, suctioning is a lifesaving intervention that can significantly reduce the risks of infection, secretion pooling, and prolonged hypoxia, leading to favourable outcomes for most patients. However, it's essential to avoid overly frequent or aggressive suctioning, as it may precipitate hypoxia and cause iatrogenic injuries to the airway.[76] The suction pressure should ideally be maintained between 100-120 mm Hg, ensuring it does not surpass 120 mm Hg to prevent undue trauma and ensure the procedure's safety and efficacy.

2.9. Monitor for complications

Monitoring for complications is crucial in the management of patients on mechanical ventilation, especially those with ARDS, due to their susceptibility to a wide range of complications.[77,78] These can include, decreased clearance of secretions and ventilator-acquired pneumonia, Central Line Associated Blood Stream Infection (CLABSI), tracheal damage, laryngeal edema, Impaired gas exchange, Ineffective breathing pattern, ET tube kinking, cuff failure, mainstem intubation, Sinusitis, Pulmonary infection, biotrauma, Barotrauma (pneumothorax, tension pneumothorax, subcutaneous emphysema, pneumomediastinum), Decreased cardiac output, Atelectasis, Alteration in GI function (stress ulcers, gastric distention, paralytic ileus), Alteration in renal function, Alteration in cognitive-perceptual status.

2.10. Psychosocial spiritual nursing care

Psychosocial and spiritual care emphasizes continuous communication, addressing pain, agitation, and delirium, providing psychological support, aiding patients with artificial airways in communicating, and ensuring scheduled rest and sleep to support overall well-being.

2.11. Resuscitation in patients with Suspected and confirmed Covid-19 ARDS

For resuscitating patients with suspected or confirmed COVID-19, adhere to the AHA's Interim Guidance for Basic and Advanced Life Support in adults, children, and neonates (April 2020 update), ensuring safety and efficacy.[79]

2.12. Other care

For managing patients, especially with COVID-19 induced ARDS, adopt strategies like swollen lip care with ice for inflammation and preferring Metered Dose Inhalers (MDI) over nebulization to minimize aerosol generation.[80–82] Address stress ulcers and gastrointestinal bleeding by administering H2 receptor blockers or Proton Pump Inhibitors (PPIs) and initiate early enteral nutrition within 24-48 hours of admission. Accommodate for potential anosmia by ensuring nutritional needs, including protein and vitamins, are met. Manage symptoms like nausea and loose stools. Exercise caution with aerosol-generating procedures, including oral care, suctioning, and respiratory interventions like intubation and bronchoscopy. Implement dialysis care for those with acute kidney injury (AKI) according to institutional protocols, highlighting a comprehensive approach to patient care amidst the challenges of COVID-19-induced ARDS.

2.13. Assist with the weaning process

Weaning from mechanical ventilation to spontaneous breathing involves a Spontaneous Breathing Trial (SBT) for patients ready to transition, lasting 30 to 120 minutes.[83–85] Success is indicated by adequate pulmonary function parameters—tidal volume (VT), vital capacity (VC), and negative inspiratory pressure—demonstrating strong respiratory muscle capacity.[86] The process includes gradually reducing the Synchronized Intermittent Mandatory Ventilation (SIMV) rate and pressure support until the patient can breathe independently, followed by transitioning to a T-piece or Continuous Positive Airway Pressure (CPAP) system. During extubation, especially in COVID-19 ARDS patients, avoid suctioning to prevent complications. Post-extubation, monitor for airway obstruction or respiratory insufficiency signs, including tracheal or laryngeal edema, hoarseness, or vocal cord paralysis, providing supplemental oxygen and humidification as needed. Emotional support is crucial as patients may feel anxious about breathing independently, requiring reassurance of their readiness and progress.

3. Note

This article offers a comprehensive guide on managing ARDS patients on Invasive Positive Pressure Ventilation (IPPV). It emphasizes that adjustments to ventilator settings must be executed by an experienced intensivist to ensure patient safety and optimal outcomes. Furthermore, the administration of medications should strictly follow a physician's orders, highlighting the critical role of medical oversight in patient care. Given the heightened risk of COVID-19 transmission within ICU settings, the article strongly advises healthcare workers to utilize sufficient Personal Protective Equipment (PPE) to protect both themselves and their patients from infection. This guidance underscores the importance of adhering to established protocols and safety measures in the critical care of COVID-19-induced ARDS patients.

4. Conclusion

Nursing care is crucial for the recovery of critically ill patients with ARDS on IPPV. Strict infection control measures are essential for all healthcare workers in ICU settings. Nurses in critical care units must possess in-depth knowledge of managing IPPV patients. Successful patient outcomes in the ICU result from effective teamwork, with each member contributing their expertise and supporting less experienced colleagues, particularly in complex care areas. While healthcare professionals each have distinct roles in patient care and treatment, their collective goal is to achieve the best possible patient outcomes. The efficacy of this endeavour hinges on the team's ability to collaborate seamlessly and share knowledge and skills, underscoring the importance of unity and mutual support in the critical care environment.

5. Abbreviations

ARDS - Adult Respiratory Distress Syndrome; CAM-ICU-Continuous Assessment Method for ICU; ET-Endotracheal Tube; FiO2 - Inspired Oxygen Fraction; IPPV-Invasive Positive Pressure Ventilation; IV: Intravenous; MDI-

Metered Dose Inhaler; MV - Mechanical Ventilation; MV-Minute Volume; P/F - The ratio of partial oxygen pressure to inspired oxygen fraction; PaO2 - Partial Oxygen Pressure; PPE-Personal Protective Equipment; PPI-Proton Pump Inhibitors; RASS-Richmond Agitation Sedation Scale; RV - Right Ventricle; SAT-Spontaneous Awakening Trial; SBT-Spontaneous Breathing Trial; SpO2 - oxygen saturation; VAP-Ventilator Associated Pneumonia; VAS-Visual Analogue Scale.

6. Conflict of Interest

None.

7. Source of Funding

None.

References

1. WHO Director-General's remarks at the media briefing on 2019-nCoV on 11 February 2020 ; 2019. [cited 2024 Feb 23]. Available from: https://www.who.int/director-general/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-.
2. MoHFW | Home [Internet]. [cited 2024 Feb 23]. Available from: https://www.mohfw.gov.in/.
3. COVID-19 cases | WHO COVID-19 dashboard [Internet]; 2024. [cited 2024 Feb 23]. Available from: https://data.who.int/dashboards/covid19/cases?n=c.
4. Wu C, Chen X, Cai Y, Xia J, Zhou X, Xu S, et al. Risk Factors Associated With Acute Respiratory Distress Syndrome and Death in Patients With Coronavirus Disease. *JAMA Intern Med*. 2019;180(7):934–43.
5. Ranieri VM, Rubenfeld GD, Thompson BT, Ferguson ND, Caldwell E, Fan E, et al. Acute respiratory distress syndrome: the Berlin Definition. *JAMA*. 2012;307(23):2526–33.
6. Acute Respiratory Distress Syndrome (ARDS) - Physiopedia [Internet]. ARDS; 2024. [cited 2024 Feb 23]. Available from: https://www.physio-pedia.com/Acute_Respiratory_Distress_Syndrome_.
7. Tzotzos S, Fischer B, Fischer H, Zeitlinger M. Incidence of ARDS and outcomes in hospitalized patients with COVID-19: a global literature survey. *Crit Care*. 2020;24(1):516. doi:10.1186/s13054-020-03240-7.
8. Hasan SS, Capstick T, Ahmed R, Kow CS, Mazhar F, Merchant HA, et al. Mortality in COVID-19 patients with acute respiratory distress syndrome and corticosteroids use: a systematic review and meta-analysis. *Expert Rev Respir Med*. 2020;14(11):1149–63.
9. Lemmers DHL, Hilal MA, Bnà C, Prezioso C, Cavallo E, Nencini N, et al. Pneumomediastinum and Subcutaneous Emphysema in COVID-19: Barotrauma or Lung Frailty? *ERJ Open Res*. 2020;6(4):00385–2020. doi:10.1183/23120541.00385-2020..
10. Alencar R, Angelo V, Carmona R, Schultz MJ, Neto AS. Patients With Uninjured Lungs May Also Benefit From Lung-Protective Ventilator Settings. *F1000Res*. 2017;.
11. Gleissman H, Forsgren A, Andersson E, Lindqvist E, Falck AL, Cronhjort M, et al. Prone positioning in mechanically ventilated patients with severe acute respiratory distress syndrome and coronavirus disease 2019. *Acta Anaesthesiol Scand*. 2021;65(3):360–3. doi:10.1186/s43168-024-00261-6.
12. Wilson JG, Matthay MA. Mechanical Ventilation in Acute Hypoxemic Respiratory Failure: A Review of New Strategies for the Practicing Hospitalist. *J Hosp Med*. 2014;9(7):469–75.
13. Guo W, Fang B, Xian YS, Yu Z, Zhou L. Successful treatment of a critically ill patient with acute respiratory distress syndrome from COVID-19 using mechanical ventilation strategy with low levels of positive end-expiratory pressure. *Medicine*. 2020;99(49):e23160. doi:10.1097/MD.0000000000023160.
14. Zhang X, Du J, Wu W, Zhu Y, Jiang Y, Chen R, et al. An experimental study on the impacts of inspiratory and expiratory muscles activities during mechanical ventilation in ARDS animal model. *ARDS Animal Model Sci Rep*. 2017;7:42785. doi:10.1038/srep42785..
15. Vincent JL. Give your patient a fast hug (at least) once a day. *Crit Care Med*. 2005;33(6):1225–9.
16. Vincent WR, Hatton KW. Critically ill patients need "fast hugs bid" (an updated mnemonic). *Crit Care Med*. 2009;37(7):2326–7.
17. Nair A, Naik V, Rayani B. FAST HUGS BID: Modified mnemonic for surgical patient. *Indian J Crit Care Med*. 2017;21(10):713–4.
18. Laurent MR. Give Your Geriatric Patients FAST HUGS BID. *J Am Geriatr Soc*. 2020;68(6):33–5.
19. Li C, Bo L, Liu W, Lü X, Jin F. Enteral Immunomodulatory Diet (Omega-3 Fatty Acid, Γ-Linolenic Acid and Antioxidant Supplementation) for Acute Lung Injury and Acute Respiratory Distress Syndrome: An Updated Systematic Review and Meta-Analysis. *Nutrients*. 2015;7(7):5572–85.
20. Fu PK, Chao WC, Hsu CY, Wang CH, Wang C. Caloric Intake with High Ratio of Enteral Nutrition Associated with Lower Hospital Mortality for Patients with Acute Respiratory Distress Syndrome Using Prone Position Therapy. *Nutrients*. 2021;13(9):3259. doi:10.3390/nu13093259.
21. Seddighi M, Hosseinzadeh S, Allami A. Acute Respiratory Distress Syndrome in a Patient With Suspected Influenza: A Case Report. *J Qazvin Univ Med Sci*. 2019;23(4):364–71.
22. Kumar N, Kumar A, Pattanayak A, Singh K, Singh PK. NUTRIC score as a predictor of outcome in COVID-19 ARDS patients: A retrospective observational study. *Indian J Anaesth*. 2021;65(9):669–75.
23. Thibault R, Séguin P, Tamion F, Pichard C, Singer P. Nutrition of the COVID-19 Patient in the Intensive Care Unit (ICU): A Practical Guidance. *Crit Care*. 2020;24(1):447. doi:10.1186/s13054-020-03159-z.
24. Dee BM, Bruno JJ, Lal LS, Canada TW. Effects of Immune-Enhancing Enteral Nutrition on Mortality and Oxygenation in Acute Lung Injury and Acute Respiratory Distress Syndrome: A Meta-Analysis. *Hosp Pharm*. 2011;46(1):33–40.
25. Ramsamy Y, Hardcastle TC, Muckart D. Surviving Sepsis in the Intensive Care Unit: The Challenge of Antimicrobial Resistance and the Trauma Patient. *World J Surg*. 2016;p. 1165–9. doi:10.1007/s00268-016-3531-0.
26. Daneman N, Scales DC, Lawless B, Muscedere J, Blount V, Fowler R, et al. Infection prevention and control in the intensive care unit: open versus closed models of care. *Infect Control Hosp Epidemiol*. 2013;34(8):867–71.
27. Sharma R, Vishwas A, Jelly P. Impact of COVID-19: nursing perspective and concern. *Int J Community Med Public Heal*. 2020;7(11):4648–52.
28. Brusselaers N, Vogelaers D, Blot S. The rising problem of antimicrobial resistance in the intensive care unit. *Ann Intensive Care*. 2011;1:47. doi:10.1186/2110-5820-1-47.
29. Balachandran R, Nair S, Gopalraj SS, Vaidyanathan B, Kumar RK. Dedicated Pediatric Cardiac Intensive Care Unit in a Developing Country: Does It Improve the Outcome? *Ann Pediatr Cardiol*. 2011;4(2):122–6.
30. Chang D, Parrish J, Kamangar N, Liebler JM, Lee M, Neville T, et al. Time-Limited Trials Among Critically Ill Patients With Advanced Medical Illnesses to Reduce Nonbeneficial Intensive Care Unit Treatments: Protocol for a Multicenter Quality Improvement Study. *JMIR Res Protoc*. 2019;8(11):e16301. doi:10.2196/16301.
31. Chang D, Shapiro MF. Association Between Intensive Care Unit Utilization During Hospitalization and Costs, Use of Invasive Procedures, and Mortality. *JAMA Intern Med*. 2016;176(10):1492–9.
32. Landsperger JS, Byram JM, Lloyd BD, Rice TW, Janz DR. The effect of adhesive tape versus endotracheal tube fastener in critically ill adults: the endotracheal tube securement (ETTS) randomized controlled trial. *Crit Care*. 2019;23(1):161. doi:10.1186/s13054-019-2440-7.

33. Chang LY, Wang KWK, Chao YF. Influence of physical restraint on unplanned extubation of adult intensive care patients: a case-control study. *Am J Crit Care*. 2008;17(5):408–15.
34. Lizy C, Swinnen W, Labeau S, Poelaert J, Vogelaers D, Vandewoude K, et al. Cuff Pressure of Endotracheal Tubes After Changes in Body Position in Critically Ill Patients Treated With Mechanical Ventilation. *Am J Crit Care*. 2014;23(1):1–8.
35. Mpasa F, van Rooyen D, Venter D, Jordan P, Ham-Baloyi WT. Improving nurses' knowledge of managing endotracheal tube cuff pressure in intensive care units: A quasi-experimental study. *Health SA*. 2024;25:1479. doi:10.4102/hsag.v25i0.1479.
36. Jafari Z, Severn M. Timing of Ventilator Circuit Tubing Replacement. Timing of Ventilator Circuit Tubing Replacement: CADTH Health Technology Review [Internet]; 2023. [cited 2024 Feb 27]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK599789/.
37. Alp E, Voss A. Ventilator associated pneumonia and infection control; 2006. [cited 2024 Feb 27]. Available from: http://www.ann-clinmicrob.com/content/5/1/7.
38. Ventilator Associated Pneumonia – an Overview | British Journal of Medical Practitioners [Internet]. [cited 2024 Feb 27]. Available from: https://www.bjmp.org/content/ventilator-associated-pneumonia-overview.
39. Lorente L, Blot S, Rello J. Evidence on measures for the prevention of ventilator-associated pneumonia. *Eur Respir J*. 2007;30(6):1193–207.
40. Pneumatikos IA, Dragoumanis CK, Bouros DE. Ventilator-associated Pneumonia or Endotracheal Tube-associated Pneumonia?An Approach to the Pathogenesis and Preventive Strategies Emphasizing the Importance of Endotracheal Tube. *Anesthesiology*. 2009;110(3):673–80.
41. Pour-Ghaz I, Manolukas T, NForay, Raja J, Rawal A, Ibebuogu UN, et al. Accuracy of Non-Invasive and Minimally Invasive Hemodynamic Monitoring: Where Do We Stand? *Ann Transl Med*. 2019;7(17):421. doi:10.21037/atm.2019.07.06.
42. Raj V, Renjini A, Swapna MS, Sreejyothi S, Sankararaman S. Nonlinear Time Series and Principal Component Analyses: Potential Diagnostic Tools for COVID-19 Auscultation. *Chaos Solitons Fractals*. 2020;doi:10.1016/j.chaos.2020.110246.
43. Hirosawa T, Harada Y, Ikenoya K, Kakimoto S, Aizawa Y, Shimizu T, et al. The Utility of Real-Time Remote Auscultation Using a Bluetooth-Connected Electronic Stethoscope: Open-Label Randomized Controlled Pilot Trial. *JMIR Mhealth Uhealth*. 2021;9(7):e23109. doi:10.2196/23109.
44. Wang B, Liu Y, Wang Y, Yin WH, Liu T, Liu D, et al. Characteristics of Pulmonary Auscultation in Patients with 2019 Novel Coronavirus in China. *Respiration*. 2020;99(9):755–63.
45. Wei TJ, Hsiung PY, Liu JH, Lin TC, Kuo FT, Wu CY, et al. Use of Electronic Auscultation in Full Personal Protective Equipment to Detect Ventilation Status in Selective Lung Ventilation: A Randomized Controlled Trial. *Front Med (Lausanne)*. 2022;9:851395. doi:10.3389/fmed.2022.851395.
46. Alhazzani W, Møller MH, Arabi YM, Loeb M, Gong MN, Fan E, et al. Surviving Sepsis Campaign: guidelines on the management of critically ill adults with Coronavirus Disease 2019 (COVID-19). *Intensive Care Med*. 2020;46(5):854–87.
47. Chiumello D, Brochard L, Marini JJ, Slutsky AS, Mancebo J, Ranieri VM, et al. Respiratory support in patients with acute respiratory distress syndrome: an expert opinion. *Crit Care*. 2017;21(1):240. doi:10.1186/s13054-017-1820-0.
48. Sweeney DA, Malhotra A. Coronavirus Disease 2019 Respiratory Failure: What Is the Best Supportive Care for Patients Who Require ICU Admission? *Curr Opin Crit Care*. 2021;27(5):462–7.
49. Battaglini D, Robba C, Rocco PM, De Abreu M, Pelosi P, Ball L, et al. Perioperative Anaesthetic Management of Patients With or at Risk of Acute Distress Respiratory Syndrome Undergoing Emergency Surgery. *BMC Anesthesiol*. 2019;19:153. doi:10.1186/s12871-019-0804-9.
50. Griffiths MJD, Mcauley DF, Perkins GD, Barrett N, Blackwood B, Boyle A, et al. Guidelines on the management of acute respiratory distress syndrome. *BMJ Open Respir Res*. 2019;6(1):e000420. doi:10.1136/bmjresp-2019-000420.
51. Ahuja S, Grooth H, Paulus F, Ven FL, Neto AS, Schultz M, et al. Association Between Early Cumulative Fluid Balance and Successful Liberation From Invasive Ventilation in COVID-19 ARDS Patients - Insights From the PRoVENT-COVID Study: A National, Multicenter, Observational Cohort Analysis. *Crit Car*. 2022;26(1):157. doi:10.1186/s13054-022-04023-y.
52. Upadhyaya V, Shariff M, Mathew R, Hossain MA, Asif A, Vachharajani TJ, et al. Management of Acute Kidney Injury in the Setting of Acute Respiratory Distress Syndrome: Review Focusing on Ventilation and Fluid Management Strategies. *J Clin Med Res*. 2020;12(1):2020. doi:10.14740/jocmr3938.
53. Wilson JG, Matthay MA. Mechanical Ventilation in Hypoxemic Respiratory Failure. *J Hosp Med*. 2014;37(3):431–44. doi:10.1016/j.emc.2019.04.005.
54. Sessler CN. Comfort and Distress in the Icu: Scope of the Problem. *Semin Respir Crit Care Med*. 2001;22(2):111–4.
55. Nettina SM. Lippincott Manual of Nursing Practice. Lippincott Williams & Wilkins; 2014. p. 251–63.
56. Yousefi H, Toghyani F, Yazdannik A, Fazel K. Effect of using Richmond Agitation Sedation Scale on duration of mechanical ventilation, type and dosage of sedation on hospitalized patients in intensive care units. *Iran J Nurs Midwifery Res*. 2015;20(6):700–6. doi:10.4103/1735-9066.170008.
57. Theerawit P, Soipetkasem P. An Importance of Respiratory Drive and Effort During Mechanical Ventilation. *Clin Crit Care*. 2023;31(1):e0001. doi:10.54205/ccc.v31.259350.
58. P FLR, Bucher L, P FHR, Dirksen S. Medical-Surgical Nursing. Elsevier Health Sciences; 2014. p. 1613–8.
59. Aboul-Fotouh AM, Megahed LAM, Elnakib MM, Madany NMH, El-Kareem HA. Assessment of Nurses' Knowledge and Compliance to Evidence Based Guidelines Regarding Bundle of Ventilator Associated Pneumonia in a Military Hospital. *GSC Biol Pharm Sci*. 2022;21(3):82–98.
60. Amin FM, Samra OA, Lawend J. Effect of Care Bundle Strategies on Nurses' Performance Regarding Prevention of Ventilator Associated Pneumonia at Neonatal Intensive Care Units. *Tanta Scientific Nurs J*. 2021;23(4):96–115.
61. Lee HH, Lin LY, Yang HF, Tang Y, Wang PH. Application of an Automatic Medical Information System to Implement Bundle Care for the Prevention of Ventilator-Associated Pneumonia. *Int J Environ Res Public Health*. 2021;18(21):11128. doi:10.3390/ijerph182111128.
62. Zeb A, Hasnain M, Ahmad I, Khan S, Shah AA. Nurses' Knowledge Regarding Prevention of Ventilator Associated Pneumonia. *LOJ Nur Heal Car*. 2018;2(1):LOJNHC MS ID.129.
63. Cui Q, Ma T, Shen Z, Li S, Zeng M, Liu X, et al. Intraoperative Infusion of Dexmedetomidine for Prevention of Postoperative Delirium in Elderly Patients Undergoing Craniotomy: A Protocol of Randomised Clinical Trial. *BMJ Open*. 2023;13(1):e063976. doi:10.1136/bmjopen-2022-063976.
64. Sessler CN, Gosnell MS, Grap MJ, Brophy GM, Neal PO, Keane KA, et al. The Richmond Agitation-Sedation Scale. *Am J Respir Crit Care Med*. 2002;doi:10.1164/rccm.2107138.
65. Sharma A, Bhatia PK, Harsha MS, Sethi P. Comparison of Quantium Consciousness Index and Richmond Agitation Sedation Scale in Mechanically Ventilated Critically Ill Patients: An Observational Study. *Indian J Crit Care Med*. 2022;26(4):491–5.
66. Yousefi H, Toghyani F, Yazdannik A, Fazel K. Effect of using Richmond Agitation Sedation Scale on duration of mechanical ventilation, type and dosage of sedation on hospitalized patients in intensive care units. *Iran J Nurs Midwifery Res* . 2015;20(6):700–4.
67. Ricard JD, Lisboa T. Caution for Chlorhexidine Gluconate Use for Oral Care: Insufficient Data. *Intensive Care Med*. 2018;44(7):1162–4.
68. Madhuvu A, Endacott R, Plummer V, Morphet J. Ventilation Bundle Compliance in Two Australian Intensive Care Units: An Observational Study. *Aust Crit Care*. 2021;34(4):327–32.
69. Kallet RH. Ventilator Bundles in Transition: From Prevention of Ventilator-Associated Pneumonia to Prevention of Ventilator-Associated Events. *Respir Care*. 2019;64(8):994–1006.

70. Oliveira VM, Piekala DM, Deponti GN, Batista DCR, Minossi SD, Chisté M, et al. Safe prone checklist: construction and implementation of a tool for performing the prone maneuver. *Rev Bras Ter Intensiva*. 2017;29(2):131–41.
71. Gattinoni L, Taccone P, Carlesso E, Marini JJ. Prone position in acute respiratory distress syndrome. Rationale, indications, and limits. *Am J Respir Crit Care Med*. 2013;188(11):1286–93.
72. Lalwani LK, Sharma V, Chaudhry D, Singh PK. Indications for Proning in Acute Respiratory Distress Syndrome: Expanding the Horizon! Indian. *J Crit Care Med*. 2020;24(7):589–91.
73. Xavier GN, Melo-Silva CA, Gaio E, Amado VM. Effects of preoperative physiotherapy on signs and symptoms of pulmonary collapse and infection after major abdominal surgery: secondary analysis of the LIPPSMAck-POP multicentre randomised controlled trial. *J Bras Pneumol*. 2019;45(5):e20180032. doi:10.1590/1806-3713/e20180032.
74. Wang CH, Tsai JC, Chen SF, Su CL, Chen L, Lin CC, et al. Normal saline instillation before suctioning: A meta-analysis of randomized controlled trials. *Aust Crit Care*. 2017;30(5):260–5.
75. Smeltzer SCO, Bare BG, Hinkle JL, Cheever KH. Brunner & Suddarth's Textbook of Medical-surgical Nursing. Lippincott Williams & Wilkins; 2004. p. 129–43.
76. Schults JA, Cooke M, Long DA, Schibler A, Ware RS, Mitchell ML, et al. Normal saline instillation versus no normal saline instillation And lung Recruitment versus no lung recruitment with paediatric Endotracheal Suction: the NARES trial. A study protocol for a pilot, factorial randomised controlled trial. *BMJ Open*. 2018;8(1):e019789. doi:10.1136/bmjopen-2017-019789.
77. Ramlaul A, Chironda G, Brysiewicz P. Alarms in the ICU: A Study Investigating How ICU Nurses Respond to Clinical Alarms for Patient Safety in a Selected Hospital. *South Afr J Crit Care*. 2021;37(2). doi:10.7196/SAJCC.2021.v37i2.469.
78. Udi J, Lang CN, Zotzmann V, Krueger K, Fluegler A, Bamberg F, et al. Incidence of Barotrauma in Patients With COVID-19 Pneumonia During Prolonged Invasive Mechanical Ventilation - A Case-Control Study. *J Intensive Care Med*. 2021;36(4):477–83.
79. Edelson DP, Sasson C, Chan PS, Atkins DL, Aziz K, Becker LB, et al. Interim Guidance for Basic and Advanced Life Support in Adults, Children, and Neonates With Suspected or Confirmed COVID-19. *Circulation*. 2020;141(25):E933–43.
80. Dhand R. Aerosol Delivery During Mechanical Ventilation: From Basic Techniques to New Devices. *J Aerosol Med Pulm Drug Deliv*. 2008;21(1):45–60.
81. Dhand R. Aerosol delivery during mechanical ventilation: from basic techniques to new devices. *J Aerosol Med Pulm Drug Deliv*. 2017;21(1):45–60.
82. Fink JB, Dhand R. Aerosol therapy in mechanically ventilated patients: recent advances and new techniques. *Semin Respir Crit Care Med*. 2000;21(3):183–201.
83. Girard TD, Kress JP, Fuchs BD, Thomason JW, Schweickert WD, Pun BT, et al. Efficacy and safety of a paired sedation and ventilator weaning protocol for mechanically ventilated patients in intensive care (Awakening and Breathing Controlled trial): a randomised controlled trial. *Lancet*. 2008;371(9607):126–34.
84. Thille AW, Gacouin A, Coudroy R, Ehrmann S, Quenot JP, Nay MA. Spontaneous-Breathing Trials with Pressure-Support Ventilation or a T-Piece. *N Engl J Med*. 2022;387(20):1843–54.
85. Akella P, Voigt LP, Chawla S. To Wean or Not to Wean: A Practical Patient Focused Guide to Ventilator Weaning. *J Intensive Care Med*. 2022;37(11):1417–25.
86. Wilson JG, Matthay MA. Mechanical Ventilation in Acute Hypoxemic Respiratory Failure: A Review of New Strategies for the Practicing Hospitalist. *J Hosp Med*. 2014;9(7):469–75.

Author biography

Sharun NV, Associate Professor https://orcid.org/0009-0000-7977-0005

Cite this article: Sharun NV. Optimizing ventilatory support in ARDS: A comprehensive guide for ICU nurses on patient care. *IP Int J Med Paediatr Oncol* 2024;10(1):3-11.