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Review

Adverse Events in Non-invasive Ventilation Approaches: Systematic Review

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Abstract

Non-invasive ventilation (NIV) plays a critical role in the management of acute and chronic respiratory failure, offering benefits over invasive mechanical ventilation. However, its use is associated with various adverse events that may impact clinical outcomes. This systematic review aimed to evaluate the types, frequencies, and clinical consequences of complications related to NIV. A systematic search of PubMed, EMBASE, and Cochrane Library databases was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses 'PRISMA' guidelines, covering studies published between 2000 and February 2023. Eligible studies included randomized controlled trials, observational cohorts, and systematic reviews reporting adverse events in adults receiving NIV for respiratory failure. Thirty-two studies involving approximately 6,000 patients were analyzed. NIV-related complications were frequently reported, including, physiological (e.g., hypercapnia 2-10%, hypoxemia 1-5%), mechanical (e.g., skin breakdown 5-15%, air leaks 5-25%), and patient-related events (e.g., discomfort 10-30%, anxiety 5-15%). Face masks were linked to higher rates of air leaks and intolerance, while helmet interfaces showed fewer complications. Helmet interfaces and newer ventilator technologies showed advantages in minimizing certain adverse events. Although NIV offers substantial benefits compared to invasive ventilation, its effectiveness can be compromised by preventable complications. Structured monitoring, early intervention, and a multidisciplinary care approach are essential for maximizing outcomes. Further research is needed to develop strategies that enhance patient comfort, minimize complications, and optimize NIV application across different clinical settings.

KEYWORDS: Non-invasive ventilation, complications, adverse effects, tolerance

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INTRODUCTION

Non-invasive ventilation (NIV) has gained an important place in the management of acute and chronic respiratory failure in recent years and stands out as a less invasive alternative to mechanical ventilation. NIV is preferred especially in conditions such as acute hypercapnic respiratory failure, cardiogenic pulmonary edema, chronic obstructive pulmonary disease (COPD), and congestive heart failure due to its potential to prevent patient intubation, reduce complications related to invasive procedures, and shorten hospital stay.[1-6] These advantages support the widespread clinical use of NIV, ranging from intensive care units (ICUs) to emergency departments.

However, in addition to the benefits of NIV, adverse events that may occur during the implementation process are important clinical problems that should not be ignored. The frequency and severity of these adverse events may vary depending on patient factors, interface type, ventilation settings, and clinician experience.[7-9] In addition to local complications such as mask-related pressure sores, nasal and oral mucosal dryness, aerophagia, gastric distension, respiratory problems such as synchronization disorders between the ventilator and the patient, and hyperventilation or inadequate ventilation may adversely affect the effectiveness of NIV.[10,11] Since these adverse events may lead to treatment failure, increased need for intubation and increased overall mortality rates, they are considered conditions that require early diagnosis and intervention.

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Despite various studies investigating the incidence, mechanisms, and clinical outcomes of adverse events associated with NIV, comprehensive systematic reviews in this area remain limited. Considering the increasing use of NIV across different clinical settings, a systematic evaluation of related adverse events could be valuable for optimizing patient safety and improving clinical outcomes. Furthermore, supportive studies aimed at helping clinicians anticipate and manage potential complications during NIV application may contribute significantly to enhancing patient safety and treatment efficacy.

This systematic review aims to fill this gap by providing a comprehensive review of adverse events in different NIV approaches, detailing their pathophysiology, clinical implications, and management strategies. By synthesizing existing data and highlighting under-researched mechanisms, this review aims to enhance patient safety, improve clinical outcomes, and contribute to more effective NIV practices in a variety of clinical settings.

MATERIAL AND METHODS

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[12] A detailed search strategy was developed to capture studies reporting adverse events or complications associated with NIV. Multiple databases, including MEDLINE (PubMed), EMBASE, and the Cochrane Library, were searched from the year 2000 through February 2025. The search combined terms related to NIV (e.g., 'non-invasive ventilation', 'NIPPV', 'BiPAP', 'CPAP') with terms related to adverse events or complications (e.g., 'complications', 'adverse effects', 'side effects', 'failure', 'tolerance'). For practical reasons, only studies published in English were included. Additionally, reference lists of relevant review articles and clinical practice guidelines were manually screened to identify further eligible studies.

Main Points

- Non-invasive ventilation (NIV) significantly reduces the need for invasive mechanical ventilation but is associated with specific physiological, mechanical, and patient-related complications.
- Early recognition and management of adverse events such as hypercapnia, hypoxemia, skin breakdown, and patient-ventilator asynchrony are crucial for successful NIV outcomes.
- Appropriate patient selection, optimized ventilator settings, and interface choice (e.g., helmet vs. face mask) can minimize complication rates and improve tolerance.
- Multidisciplinary care teams and structured protocols are key to maximizing the benefits of NIV while reducing treatment failure and mortality rates.
- Future research should focus on improving NIV interface design, patient comfort strategies, and early detection of complications to further enhance clinical outcomes.

Inclusion criteria: We included randomized controlled trials, observational cohort studies, and large case series reporting adverse events, complications, or safety outcomes in adult patients receiving NIV for acute or chronic respiratory failure. Studies directly comparing NIV with invasive mechanical ventilation in terms of complications were also included for comparative analysis. Both acute care settings (e.g., ICU, emergency departments) and non-ICU settings (e.g., step-down units) where NIV was used were considered (Table 1).

Exclusion criteria: We excluded case reports and small case series (<10 patients) due to limited generalizability. Studies focusing solely on pediatric populations (given differences in physiology and interfaces in children) and those evaluating NIV use in non-acute contexts (e.g., sleep apnea or chronic home use) were also excluded. Furthermore, studies that did not specifically report adverse events and that combined NIV and invasive ventilation outcomes without stratifying by modality were omitted (Table 1).

Two independent reviewers screened titles and abstracts for eligibility, and full texts were retrieved for all studies meeting the inclusion criteria. From each study, detailed data were extracted regarding study design, patient population, NIV indication, and reported complications. Additionally, outcome measures such as NIV failure rates (need for intubation), length of stay, and mortality rates (when reported) were recorded, particularly if they were associated with complications. This review adheres to the structured format recommended by JAMA for systematic reviews, incorporating a clearly defined methodology and structured reporting of outcomes.[13]

RESULTS

The search yielded 1,245 records (PubMed: 512, EMBASE: 589, Cochrane: 144). After removing duplicates (n = 312), 933 titles and abstracts were screened. Of 102 full-text articles assessed, 32 studies met inclusion criteria (10 register of controlled trials, 10 observational studies, 8 systematic reviews, 4 meta-analyses), involving approximately 6,000 patients across acute respiratory failure (ARF), COPD, Coronavirus disease-2019 (COVID-19), and mixed conditions. These studies encompassed various clinical contexts, including acute hypercapnic respiratory failure, acute hypoxemic respiratory failure [pneumonia, acute respiratory distress syndrome (ARDS), cardiogenic pulmonary edema], and postoperative or immunocompromised patient populations. The study selection process is summarized in a PRISMA flow diagram (Figure 1).

Adverse events were categorized as physiological, mechanical, and patient-related, with frequencies and associated studies summarized in Tables 2, 3. Studies included ARF (n = 14), COPD (n = 10), COVID-19 (n = 5), and mixed conditions (n = 3). Table 3 lists the studies.

Table 1. Inclusion and exclusion criteria for study selection

Criteria type	Details
Inclusion criteria	- Randomized controlled trials, observational cohort studies, and large case series (≥10 patients) - Adult patients receiving NIV for acute or chronic respiratory failure - Studies reporting adverse events, complications, or safety outcomes - Studies comparing NIV with invasive mechanical ventilation for complications - Settings: ICU, emergency department, step-down or other acute care units - Published in English - Study period: 2000-February 2025
Exclusion criteria	- Case reports or small case series (<10 patients) - Studies limited to pediatric populations - Studies evaluating non-acute or home use of NIV (e.g., sleep apnea) - Studies not reporting adverse events or complications - Studies combining NIV and invasive ventilation outcomes without stratification

NIV: non-invasive ventilation, ICU: intensive care unit

Table 2. Summary of adverse events in NIV studies

Category	Adverse event	Frequency (%)	Notes
Physiological	Hypercapnia and respiratory acidosis	2-10%[2,6,8,27,32]	Common in COPD with suboptimal settings; mitigated by monitoring.[9,25]
	Hypoxemia	1-5%[7,10,28,31]	Seen in ARF with inadequate oxygenation; helmet NIV may improve.[1,5]
	Hemodynamic effects	1-3%[1,7,8,18]	Rare, linked to severe ARF or cardiovascular comorbidities.[27]
Mechanical	Barotrauma	<1%[4,7,14,20]	Rare, associated with high BiPAP pressures.[8]
	Pressure ulcers/skin breakdown	5-15%[1,5,14,21,22,28,33]	Higher in ICU with prolonged use; helmets reduce incidence.[5,23]
	Air leaks	5-25%[1,8,17,22,23,28,29,34]	More frequent with face masks; impacts ventilation efficacy.[6,24]
	Gastric insufflation and aspiration	0.5-10%[2,6,11,27]	Insufflation common with BiPAP; aspiration rare in conscious patients.[7]
Patient-related	Patient-ventilator asynchrony	2-8%[6,17,29]	Affects COPD and ARF; trigger sensitivity adjustments help.[8]
	Discomfort and pain	10-30%[3,7,18,24,30,32,34]	Higher with face masks vs. helmets; education improves tolerance.[5,23]
	Anxiety, claustrophobia and psychological distress	5-15%[4,7,9,10,16,25]	Contributes to intolerance; psychological support beneficial.[7]
	Delirium	1-5%[1,7,22]	Seen in ICU settings; sedation protocols needed.[18]
	Sleep disturbances	5-10%[9,25]	Common in home NIV for COPD; humidification helps.[16]

COPD: chronic obstructive pulmonary disease, ARF: acute respiratory failure, NIV: non-invasive ventilation, ICU: intensive care units

Table 3. Included studies on adverse events in NIV

Author (year)	Study design	Population	NIV type	Key adverse events
Antonelli et al.[1] (2000)	RCT	ARF (post-transplant)	BiPAP	Skin breakdown (10%), air leaks (15%)
Lightowler et al.[2] (2003)	Systematic review	COPD	BiPAP	Hypercapnia (5%), gastric distension (8%)
Keenan et al.[3] (2004)	Systematic review	ARF	CPAP/BiPAP	Mask intolerance (20%), air leaks (20%)
Burns et al.[4] (2013)	Meta-analysis	ARF	CPAP/BiPAP	Claustrophobia (10%), air leaks (20%)
Navalesi et al.[5] (2007)	RCT	COPD	BiPAP	Skin breakdown (5%), air leaks (12%)
Carrillo et al.[6] (2012)	Observational	COPD	BiPAP	Hypercapnia (8%), asynchrony (6%)
Ferreyro et al.[7] (2020)	Meta-analysis	ARF	CPAP/BiPAP	Mask intolerance (15%), skin breakdown (10%)
Girault et al.[8] (2011)	RCT	ARF	BiPAP	Hypercapnia (7%), air leaks (18%)
Pisani et al.[9] (2012)	Observational	COPD	BiPAP	Claustrophobia (12%), sleep disturbances (8%)
Bellani et al.[10] (2017)	Observational	ARDS	CPAP/BiPAP	Nasal dryness (18%), claustrophobia (12%)
Vital et al.[11] (2013)	Systematic review	ARF (post-surgery)	CPAP	Gastric distension (5%), aspiration (1%)
Cabrini et al.[14] (2015)	Meta-analysis	ARF	CPAP/BiPAP	Skin breakdown (6%), air leaks (10%)
Frat et al.[15] (2015)	RCT	ARF	HFNC	Nasal dryness (15%), discomfort (10%)
Rochwerg et al.[16] (2017)	Systematic review	ARF	HFNC	Nasal dryness (20%), discomfort (15%)
Carteaux et al.[17] (2016)	Observational	ARF	BiPAP	Asynchrony (5%), air leaks (20%)
Hess[18] (2013)	Systematic review	ARF	CPAP/BiPAP	Mask intolerance (15%), skin breakdown (10%)
Nava et al.[19] (2011)	RCT	ARF	CPAP	Air leaks (12%), skin breakdown (8%)
Liu et al.[20] (2016)	Meta-analysis	ARF	CPAP/BiPAP	Skin breakdown (5%), mask intolerance (8%)
Franco et al.[21] (2020)	Observational	COVID-19	CPAP	Skin breakdown (6%), air leaks (10%)
Aliberti et al.[22] (2020)	Observational	COVID-19	CPAP	Skin breakdown (8%), air leaks (10%)
Grieco et al.[23] (2021)	RCT	COVID-19	CPAP	Air leaks (12%), skin breakdown (4%)
Perkins et al.[24] (2022)	RCT	COVID-19	CPAP	Mask intolerance (20%), air leaks (15%)
Windisch et al.[25] (2005)	Observational	COPD	BiPAP	Sleep disturbances (10%), mask intolerance (22%)
Rochwerg et al.[26] (2020)	Systematic review	ARF	HFNC	Nasal dryness (18%), discomfort (10%)
Hill et al.[27] (2007)	Systematic review	ARF	CPAP/BiPAP	Hypercapnia (6%), gastric distension (7%)
Esquinas et al.[28] (2014)	Systematic review	ARF	CPAP/BiPAP	Skin breakdown (5%), air leaks (12%)
Carron et al.[29] (2013)	Observational	ARF	BiPAP	Asynchrony (5%), air leaks (20%)
Conti et al.[30] (2002)	RCT	COPD	BiPAP	Mask intolerance (15%), skin breakdown (10%)
Hilbert et al.[31] (2001)	Systematic review	ARF	CPAP/BiPAP	Claustrophobia (10%), nasal dryness (15%)
Tan et al.[32] (2024)	RCT	COPD	HFNC/BiPAP	Hypercapnia (6%), discomfort (15%)
Squadrone et al.[33] (2005)	Observational	ARF	CPAP	Skin breakdown (3%), air leaks (12%)
Nava et al.[34] (2006)	RCT	ARF	BiPAP	Discomfort (10%), air leaks (12%)

RCT: register of controlled trial, HFNC: high-flow nasal cannulas, COPD: chronic obstructive pulmonary disease, ARF: acute respiratory failure, NIV: non-invasive ventilation, CPAP: continuous positive airway pressure, BiPAP: bilevel positive airway pressure

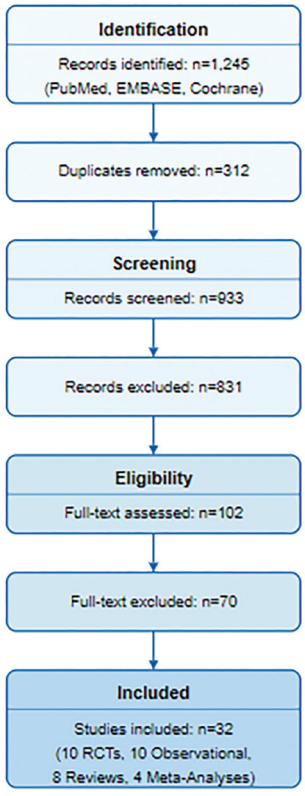

Figure 1. PRISMA flow diagram of study selection

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses, RCTs: register of controlled trials

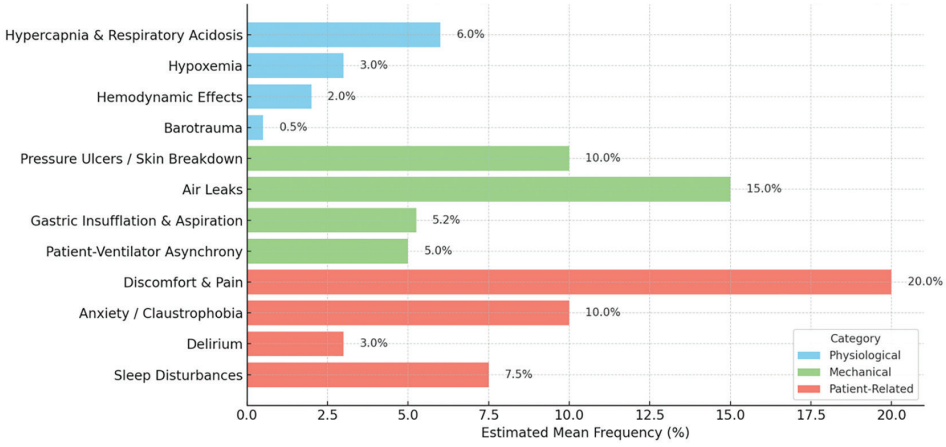

Figure 2. Estimated mean frequency of adverse events in NIV studies (by category)

NIV: non-invasive ventilation

DISCUSSION

This review synthesizes NIV adverse events across 32 studies, categorizing them into physiological, mechanical, and patient-related complications (Figure 2). The findings inform clinical practice and highlight areas for improvement.

Physiological Complications of Non-invasive Ventilation

Hypercapnia and Respiratory Acidosis: While NIV is commonly used to manage hypercapnic respiratory failure, inadequate ventilator settings or worsening of the patient's condition can lead to persistent or worsening CO_2 retention. Insufficient tidal volume or backup rate on a bilevel device may result in elevated $PaCO_2$ levels and respiratory acidosis.[2,6,8,27] This often serves as an early indicator of NIV failure and reflects inadequate ventilatory support. In patients with severe ARDS or pneumonia, NIV may fail to provide sufficient ventilation, with reported intubation rates ranging from 30% to 50% across multiple series.[2,6,8,27] If hypercapnia is unrecognized, it can lead to CO_2 narcosis (altered mental status or coma) and cardiac arrhythmias. Therefore, timely monitoring of arterial blood gases during NIV is essential.[32] Worsening or non-improving hypercapnia and acidemia within the first few hours of NIV use are strong predictors of failure and the need for intubation.

Clinical guidelines recommend severe acidosis (pH < 7.25) or rising CO_2 levels as criteria for early intubation instead of prolonged NIV to avoid adverse outcomes.

Hypoxemia: Similarly, refractory hypoxemia (inability to maintain adequate oxygen saturation or PaO_2), is a critical complication. NIV typically improves oxygenation through positive end-expiratory pressure (PEEP) and pressure support; however, in conditions such as ARDS or severe pneumonia, it may not fully correct gas exchange deficits.[7,10,28,31] Worsening hypoxemia during NIV (e.g., inability to maintain SpO_2 > 88-92% despite high FiO_2) indicates that the patient's respiratory failure may be too severe for non-invasive support. Helmet NIV may improve oxygenation compared to face masks.[5] Life-threatening hypoxemia is generally considered a relative contraindication to NIV. In studies included in this review, development of severe hypoxemia despite NIV frequently prompted intubation, and delayed intubation was often associated with worse outcomes.[7,10,31] Hypoxemic complications of NIV also include cardiac arrhythmias and myocardial ischemia triggered by low oxygen levels. Thus, as with hypercapnia, ongoing or worsening hypoxemia requires urgent reassessment and transition to invasive ventilation. Some evidence suggests that early application of NIV in acute hypoxemic respiratory failure may reduce intubation rates (e.g., one study reported a decrease from approximately 52% to 25%),[7] but this benefit is limited to patients who show an early improvement in oxygenation; patients who do not improve are at risk if NIV is prolonged.

Hemodynamic Effects: Application of positive intrathoracic pressure during NIV can have significant impacts on a patient's hemodynamics. Increased intrathoracic pressure can reduce venous return, leading to decreased cardiac output and hypotension, particularly in patients with hypovolemia or underlying cardiac dysfunction.[1,7,8,18] Most patients tolerate the hemodynamic effects of NIV well if appropriately resuscitated; however, hemodynamic instability (e.g., shock or severe hypotension) is generally considered a contraindication or a criterion for NIV failure. In this review, episodes of hypotension were reported during NIV, especially when higher PEEP levels were applied or when patients had concurrent myocardial infarction or sepsis.[1,7,8,18] Myocardial ischemia may also be triggered by elevated intrathoracic pressures (reducing coronary perfusion) or by hypoxemia and hypercapnia when NIV fails to meet ventilatory demands. Additionally, arrhythmias such as tachycardia or bradycardia can occur in the setting of respiratory acidosis or hypoxemia. Although NIV is not typically a direct cause of arrhythmias, the physiological stress associated with respiratory failure and the application of positive pressure may reveal underlying arrhythmic predispositions.

Barotrauma: Barotrauma is a rare but serious complication associated with NIV, with pneumothorax being the most concerning manifestation. Positive pressure ventilation can cause alveolar rupture, particularly in fragile lungs (e.g., in patients with bullous COPD or ARDS), leading to air leakage into the pleural space. Although the incidence is lower than invasive mechanical ventilation, case series, have reported that pneumothorax complicating NIV.[4,7,14,20] New-onset chest pain, hypotension, or unilateral absence of breath sounds in a patient undergoing NIV should raise suspicion for pneumothorax. Under these circumstances, immediate initiation of invasive management, including chest tube placement, is necessary

Mechanical Complications

Pressure Ulcers and Skin Injury: Prolonged application of a mask, especially when tightly secured, can cause skin injuries and ischemia. The nasal bridge, cheeks, and forehead are particularly vulnerable areas. Patients often develop erythema or skin rashes at mask contact points, which, if left unaddressed, can progress to open pressure ulcers. A systematic review and meta-analysis reported that the incidence of facial pressure injuries in adults receiving NIV is approximately 25%, indicating that about one in four patients may experience some degree of skin breakdown.[1,5,14,21,22,28,33] Reports from ICUs show that the incidence of pressure ulcers among NIV patients varies between 10% and 30%, depending on the preventive measures implemented.[7] These injuries are not only painful but also carry a risk of secondary infection. Risk factors for mask-associated pressure injuries include prolonged use of non-invasive ventilation, use of a non-rotating single mask, excessive mask tightness to prevent air leaks, and patient-related factors such as fragile skin or edema. It should also be noted that newer NIV interfaces, such as helmets or full-face masks, may distribute pressure more evenly and potentially reduce the incidence of facial ulcers.

Air Leaks: A certain amount of air leak is expected during NIV, as most circuits (especially single-limb systems) use an intentional leak port to remove exhaled CO_2. However, excessive or uncontrolled leaks around the mask seal are clinically challenging. Large leaks can impair effective ventilation by reducing tidal volumes and contributing to hypercapnia, and trigger ventilator alarms, disrupting therapy. Air leaks directed toward the eyes can cause dryness, irritation or, in severe cases, corneal ulceration. Other consequences of significant leaks include patient discomfort (sensation of air blowing on the face or eyes), sleep disturbances, and patient-ventilator asynchrony.[1,8,17,22,23,28,29,34] Clinically, persistent large leaks may prevent the ventilator from properly sensing breaths or delivering target pressures, leading to inadequate gas exchange.[14] Although modern NIV devices incorporate leak compensation algorithms, these mechanisms have limitations. Tightening mask straps may reduce leaks but can exacerbate pressure injuries. Therefore, clinicians are advised to aim for minimal, controlled leaks rather than striving for complete leak elimination.

Gastric Insufflation and Aspiration: Another mechanical consequence of positive pressure is gastric insufflation, particularly if elevated mask pressures overcome lower esophageal sphincter tone or if the patient develops aerophagia. This can lead to abdominal distension, discomfort, and nausea. More concerningly, in the event of vomiting, the unprotected airway during NIV increases the risk of aspiration, which can result in chemical pneumonitis or aspiration pneumonia.[2,6,11,27] Although the exact incidence is unclear, aspiration events during NIV have been reported, especially in agitated, sedated, or delirious patients. The literature identifies active vomiting and impaired airway protection as absolute contraindications

to NIV.[7] To mitigate aspiration risk, clinicians often minimize or avoid sedation, elevate the head of the bed, and consider gastric decompression with a nasogastric tube in patients undergoing prolonged NIV-although the tube itself may slightly increase nasal air leaks.

Patient-ventilator Asynchrony: Asynchrony refers to the mismatch between the patient's spontaneous respiratory effort and the ventilator's support in timing or delivery. During NIV, asynchrony can manifest as missed triggers, auto-triggering, double triggering, or early/late cycling. Significant asynchrony (typically defined as an asynchrony index >10%) is associated with reduced comfort, sleep fragmentation, and poor treatment tolerance in NIV patients.[6,17,29] While asynchrony during invasive mechanical ventilation has been associated with adverse outcomes, such as prolonged ventilation and increased mortality, in NIV it is primarily linked to patient discomfort and reduced tolerance. Causes of asynchrony in NIV include excessive air leaks, inappropriate trigger sensitivity settings, and irregular breathing patterns.[8] Asynchrony is particularly problematic during sleep, where it can lead to frequent arousals.

Patient-related (Tolerance and Psychological) Complications

Discomfort and Pain: Patients often report pain at pressure points (such as the nasal bridge and around the ears due to straps) and general discomfort from the sensation of forced airflow. Dryness of the oral and nasal passages, especially if humidification is inadequate, can lead to throat irritation and coughing. Some patients develop sinus or ear pain due to continuous positive pressure. This physical discomfort can make patients reluctant to wear the mask. In our review, many studies noted that a portion of patients (typically 10-15%) refused or removed NIV despite appropriate indications due to intolerable discomfort.[3,7,18,24,30,32,34] Adjustments such as using softer masks, adding humidification, or allowing short mask-off breaks can help, although severe pain may necessitate alternative strategies or analgesics.[8] An advantage of NIV compared to invasive ventilation is that patients can communicate their discomfort, allowing for timely interventions; however, unlike intubated patients, they may actively resist therapy.

Anxiety, Claustrophobia, and Psychological Distress: NIV can be frightening for some patients. The sensation of having a tight mask on their face may trigger claustrophobia or panic. Patients already experiencing respiratory distress are often anxious, and the added challenge of synchronizing with a machine can exacerbate this anxiety.[9,16,25] Anxiety is common during NIV; patients may feel they have lost control of their breathing, which is distressing. Many clinicians have observed that some patients may not tolerate NIV at all due to claustrophobia, necessitating intubation or an alternative approach like high-flow nasal cannula when appropriate.[4,7,9,10] Untreated anxiety can lead to tachypnea, ventilator struggles, worsened synchronization, and compromised efficacy. Therefore, addressing the patient's psychological comfort is a priority. Simple measures, such as explaining the procedure, having a family member or staff member stay with the patient, or choosing interfaces that cover less of the face (e.g., nasal masks instead of full-face masks), can help reduce panic.[20,23]

Delirium and Sleep Disturbances: In a large prospective study of ICU patients on NIV, the incidence of delirium was approximately 18%.[1,7,22] Outcomes were significantly worse in patients who developed delirium: NIV failure (requiring intubation) was much more common among delirious patients (37.8% vs. 21.0% in non-delirious patients), and ICU mortality was higher (33% vs. 14%).[1,7,22]

Delirium may present as agitation (attempting to remove the mask, non-cooperation) or as quiet confusion (more difficult to detect and may rapidly deteriorate). Both hyperactive and hypoactive forms have been observed; some data suggest that patients with mixed or hypoactive delirium may remain on NIV longer, possibly because they tolerate the mask but they require prolonged ICU stays. Patients on NIV should be regularly assessed for delirium. Being on NIV while awake can cause significant difficulties in initiating or maintaining sleep due to noise, mask discomfort, and patient-ventilator asynchrony. When the ventilator fails to synchronize with the patient's effort, the resulting discomfort may wake the patient or prevent deep sleep. Sleep deprivation can worsen delirium, reduce NIV tolerance, and impair immunity over time, indirectly affecting recovery.[9,25] Strategies include minimizing nighttime disturbances, adjusting ventilator settings for comfort (e.g., lower backup rate or modes like AVAPS or NAVA for more natural breathing), and cautious use of sleep aids (since sedatives can cause hypoventilation).[16] In summary, insomnia and poor sleep quality are major patient-related complications of NIV, intricately linked with delirium and anxiety, potentially undermining NIV success.

CONCLUSION

In conclusion, NIV offers invaluable ventilatory support in modern critical care without the risks associated with intubation. This systematic review highlights that while NIV provides significant benefits, it can also lead to a series of adverse events that clinicians must recognize and manage. Complications associated with NIV can generally be categorized as physiological disturbances (including hypercapnia, hypoxemia, and hemodynamic effects), mechanical/interface issues (including pressure ulcers, air leaks, and ventilator asynchrony), and patient-centered problems (including anxiety, delirium, and sleep disturbances). Evidence suggests that although many of these complications are common, they are largely predictable and can often be prevented with proactive measures. Strategies such as careful patient selection, meticulous monitoring, protective interface measures, and selective sedation can significantly mitigate these risks. Patients successfully managed with NIV tend to have shorter ICU stays and, in many cases, better survival rates than those requiring intubation. However, NIV is not suitable for every patient, and its inappropriate use may lead to preventable morbidity. Successful NIV implementation relies on appropriate patient selection, exclusion of high-risk cases, and predefined intubation criteria. When guided by an experienced multidisciplinary team, this structured approach minimizes complications and optimizes clinical outcomes. In recent years, smart ventilator modes that can self-adjust in response to patient effort and artificial intelligence-based algorithms that

provide real-time asynchrony detection have shown promising results in improving patient-ventilator interaction and reducing complications. Such advanced technologies have significant potential, especially for the development of personalized NIV applications. Large randomized trials investigating structured NIV weaning and rest breaks or comparing different interface strategies (nasal, full-face, or helmet) would be valuable in guiding best practices. Moreover, considering current findings related to delirium, research focusing on early mobilization and delirium prevention specifically in NIV patients may improve outcomes.

Ethics

Footnotes

Authorship Contributions

Surgical and Medical Practices: H.A.S., A.M.E., Concept: H.A.S., A.M.E., Design: H.A.S., A.M.E., Data Collection or Processing: H.A.S., A.M.E., Analysis or Interpretation: H.A.S., A.T.F., A.M.E., Literature Search: H.A.S., A.T.F., A.M.E., Writing: H.A.S., A.M.E.

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Clinical Implications of NIV

- Patient selection: Carefully select patients based on established criteria to maximize NIV success and exclude those at high risk of failure.

- Monitoring: Implement meticulous monitoring to detect and manage physiological disturbances (e.g., hypercapnia, hypoxemia) early.

- Interface management: Use protective measures to prevent mechanical issues such as pressure ulcers and air leaks.

- Patient Comfort: Address patient-centered issues like anxiety and delirium through selective sedation and early mobilization strategies.

- Infection control: Leverage NIV's lower risk of severe infections, particularly ventilator-associated pneumonia, compared to invasive ventilation.

- Structured framework: Apply a structured approach with clear intubation endpoints to minimize complications and optimize outcomes.

- Multidisciplinary team: Engage an experienced team of physicians, nurses, and respiratory therapists to ensure successful NIV implementation.

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