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Clinical Effectiveness of Low-Cost Portable Ventilator Versus Mechanical Invasive Ventilation- A Systematic Review and Meta-Analysis

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A B S T R A C T

The objective of this review is to evaluate the effectiveness of Low-cost portable ventilator (LCPV) versus Mechanical invasive ventilation in reducing the mortality in adults 18 years and over. Introduction: Inclusion criteria: This review includes studies conducted among adults with Chronic obstructive pulmonary disease (COPD), Pneumonia, Severe bronchial asthma, Acute respiratory failure (ARF), neuromuscular diseases, and acute respiratory distress syndrome (ARDS).Methods: Databases to be searched include PubMed, Google scholar and Cochrane the search, titles and abstracts are screened by two independent reviewers for assessment against the inclusion criteria for the review. The full text of selected citations is assessed in detail against the inclusion criteria, and studies selected for retrieval were assessed by two independent reviewers for methodological validity using JBI critical appraisal tools.Results: 14 Studies met the inclusion criteria for review were taken and those studies were statistically pooled studies and outcomes were measured. All the studies demonstrated the effectiveness of LCPV by reducing the mortality. Conclusion: LCPV should be considered as the first-line therapeutic approach for the management of acute respiratory failure, and neuromuscular disorders. Also, LCPV, if readily available in adequate numbers, may reduce the person's length of stay in the ICU, and potentially improve overall outcomes especially in resource constrained settings like in India. Also, LCPV may be lifesaving in COVID 19 and other flu epidemics.

Keywords:LCPV, Pulmonary, Mortality and Ventilation

1. Introduction

A medical ventilator can be a lifesaving and they are used when a person can't breathe properly on all alone. Ventilators can be of two types Noninvasive ventilator (NIV) and mechanical Invasive ventilator (MIV). Mechanical invasive ventilator (MIV) is a device that was placed inside the trachea through the mouth, such as an endotracheal tube or the skin, such as a tracheostomy tube, whereas noninvasive ventilator (NIV) uses the breathing support administered through a face mask or nasal mask, where air was usually added with oxygen, and it was given through the mask under positive pressure. Mechanical ventilation is used to treat 30–40% of patients admitted to critical care [1, 2]. The duration of patient under invasive ventilation is mostly associated with increased mortality rate. Both NIV and MIV are widely used in patients with respiratory disorders (Chronic obstructive pulmonary disease (COPD), neuromuscular diseases, Pneumonia, Severe bronchial asthma, Acute respiratory failure (ARF), and acute respiratory distress syndrome (ARDS). The patients with (Chronic obstructive pulmonary disease (COPD), neuromuscular diseases, Pneumonia, Severe bronchial asthma, Acute respiratory failure (ARF), and acute respiratory distress syndrome (ARDS) are treated with NIV or MIV shows ICU or hospital mortality. Low-cost portable ventilator (LCPV) has become a commonly used alternative to invasive ventilation [2]. LCPV implemented as an alternative to intubation should be provided in an intensive care or high-dependency unit. It can be safely administered in an adequately staffed and monitored ward [3].

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1.1. Review question

What is the effectiveness of LCPV for reducing Mortality, in adults 18 years and over.

1.2. Inclusion criteria: Participants

Articles considered for inclusion criteria was participants (18 years of age or older) with Chronic obstructive pulmonary disease (COPD), Pneumonia, Severe bronchial asthma, Acute respiratory failure (ARF), neuromuscular diseases, and acute respiratory distress syndrome (ARDS) also included.

1.3. Intervention

The intervention of interest was considered as LCPV in adults with pulmonary disease or respiratory failure and neuromuscular diseases.

1.4. Comparator

This review considered studies that compared the intervention of LCPV with MIV.

1.5. Outcomes

This review considered studies that include the following outcomes in adults with mortality.

1.6. Types of studies

Randomized control trail, observational, Retro prospective cohort studies, retrospective studies and prospective studies are included.

1.7. Methods: Search strategy

The systematic review was conducted by primary electronic database search. Searches were conducted in PubMed, Google scholar and Cochrane data bases. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was developed for this review. Studies published in English language are included. All the studies in the database from its inception to the present date are considered.

1.8. Study selection

Following the search, all identified citations were collated and uploaded into EndNote and duplicates were removed. Titles and abstracts were screened by two Assessment of methodological quality independent reviewers for assessment against the inclusion criteria for the review. The full texts of potentially eligible studies were retrieved and assessed in detail against the inclusion criteria by two independent reviewers. Full-text studies that did not meet the inclusion criteria were excluded. Any disagreements that arose between the reviewers were resolved through discussion.

1.9. Data extraction

Data were extracted from studies included in the review by two independent reviewers. The data extracted included specific details about the interventions, populations, study methods and outcomes of significance to the review question. Any disagreements that arose between the two reviewers were resolved through discussion.

1.10. Data synthesis

Quantitative data is pooled in a random-effects meta-analysis model. All Effect sizes are expressed in dichotomous data with risk ratios for categorical data with 95% confidence intervals of the effect sizes are estimated. All studies are pooled to estimate an adjusted relative risk with 95% confidence intervals, irrespective of the study design used and the binary effect measure used. When statistical pooling is not possible, the findings are presented in a narrative form, including tables and figures to aid in data presentation, where appropriate.

1.11. Results: Study inclusion

A total of 5165 articles were identified by the search strategy of different databases like PubMed, Google scholar and Cochrane of which 2038 were removed based on duplicates, 564 articles were removed based the title and abstract. The full texts of 129 articles were screened, of which 16 articles met the inclusion criteria and were included in this review and 14 meta-analyses were included.

1.12. Methodological quality

Studies meeting the inclusion criteria were appraised for methodological quality. Based on the limited number of articles identified that met the inclusion criteria for this review and all studies were included, and any risk of bias was considered during data synthesis.

1.13. Critical Appraisal: Characteristics of included studies

The 14 included studies in the review are appropriate for the study questions and the population being studied are Randomized control trail, observational, Retro prospective cohort studies, retrospective studies and prospective studies, with the outcome of mortality.

1.14. Review Findings: Mortality

Studies that are eligible for inclusion criteria the results of the meta-analysis comparing with LCPV compared with MIV were presented in a forest plot. The forest plot showing with Mortality.Fourteen studies were eligible for inclusion. The results of the meta-analysis comparing with invasive mechanical ventilator with non-invasive portable ventilator were presented in a forest plot. The forest plot showed out of 2329 participants 432 who received LCPV treatment and out of 4078 participants 1111 received MIV treatment (risk ratio 0.60, 95% confidence interval 0.45 to 0.81). It is represented graphically by the diamond; the centre of the diamond equals the total overall estimated risk ratio and the ends of the diamond indicate the limits of the 95% confidence interval [4-17]. The vertical dotted line through the centre of the diamond represents the total overall estimated relative risk. The meta-analysis therefore showed Low-cost portable ventilator (LCPV) was reducing mortality by 40% as compared to mechanical invasive ventilation. The solid vertical line shows no significance and no relative risk. The p value is 0.00001 which is heterogenous and statistically significant.

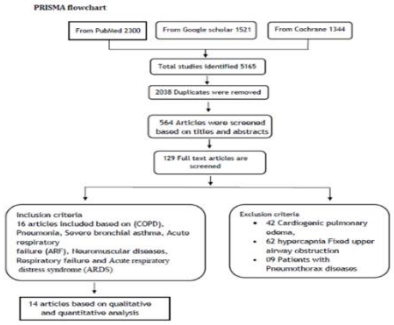
1.15. Discussion

In India, three out of five leading causes of mortalities constitute noncommunicable diseases whereas COPD is the second biggest cause of death. The prevalence of COPD has increased by 29.2% by 2016 which is a serious public health concern. The population-adjusted ARF-hospitalization rates increased in all age groups and patients 85 years and older had the highest age-specific hospitalization rate. While overall rates of mechanical ventilation (NIV or MIV) remained stable over the nine-year period, there was an important shift away from IMV (which decreased from 48% in 2001 to 42% in 2009) towards NIV (which increased from 4% in 2001 to 10% in 2009) [18]. Among patients hospitalized with asthma exacerbation and requiring ventilatory support (NIV or MIV), more than 40% received NIV. Although patients successfully treated with NIV appear to have better outcomes than those treated with MIV [19] ALS patients with mechanical ventilation quality of life QoL, is decreased but NIV improves QoL in terms of cognitive function, encouraging better sleep architecture and brain oxygenation [20]. Patients with ARDS are treated with NIV nearly one-half of them are survived and returned home hence, NIV has a role in treating the patients with ARDS [21] and NIV may be used in the postoperative setting to either prevent or treat ARF whereas NIV was used in 15% of patients with ARDS, irrespective of severity category. Acute respiratory failure, COPD, asthma and neuromuscular disease are frequent and life-threatening complication in chest wall disorders. In all these disorders, invasive mechanical ventilation is the standard treatment when initial management with oxygen supplementation, physiotherapy, cough assistance, or antibacterial drugs are insufficient to stabilize the patient, although this may have potentially life-changing consequences for the patient with neuromuscular disease. Over the last decade, NIV has been increasingly used to manage both acute and chronic respiratory failure in a broad variety of conditions. In patients with amyotrophic lateral sclerosis (ALS), long term NIV may provide survival benefit and may improve patients' well-being and quality of life, [22].

1.16. Conclusion

Conclusion LCPV minimizes mortality in respiratory failure, COPD Neuromuscular diseases and acute respiratory distress syndrome (ARDS). The success of LCPV is dependent on various clinical aspects and the organization of care, but also on a lot of technical issues [23]. LCPV should be considered as the first-line therapeutic approach for the management of acute respiratory failure, and neuromuscular disorders. Also, LCPV, if readily available in adequate numbers, may reduce the person's length of stay in the ICU, mortality and potentially improve overall outcomes especially in resource constrained settings like in India. Also, LCPV may be lifesaving in COVID 19 and other flu epidemics.

Prisma



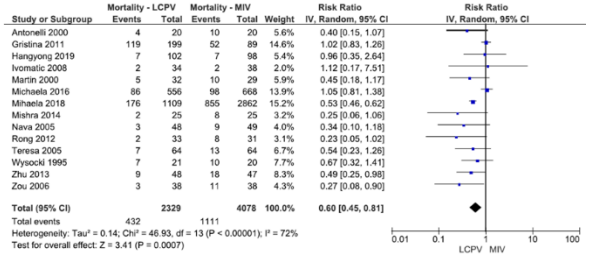


Fig. 1- Forest plot for Mortality

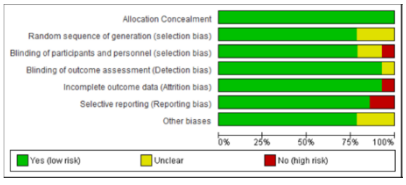


Fig. 2- Risk of bias Graph

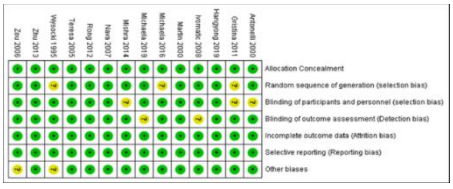


Fig. 3-Risk of bias Summary

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Appendix A. PubMed search strategy

1	((((((((((adult) OR mature) OR patients) OR sick person) OR emergency) OR sufferer) OR ventilation) OR airing) OR respiratory failure) OR respiratory arrest) OR respiratory distress) OR neuromuscular diseases) OR neuromuscular disorder	10606243
2	((((((((((((tidal volume) OR respiratory volume) OR lung volume) OR respiratory rate) OR breathing rate) OR rate of respiration) OR peak pressure) AND heart rate) OR pulse rate) OR heart beat) OR cardiac rate) AND blood pressure) OR stress) AND oxygen saturation) OR oxygenation	118829
3	((((((((((adult) OR mature) OR patients) OR sick person) OR emergency) OR sufferer) OR ventilation) OR airing) OR respiratory failure) OR respiratory arrest) OR respiratory distress) OR neuromuscular diseases) OR neuromuscular disorder)) AND (Portable ventilator) OR respirator) OR breathing device)	32054

4	((((((((((((((adult) OR mature) OR patients) OR sick person) OR emergency) OR sufferer) OR ventilation) OR airing) OR respiratory failure) OR respiratory arrest) OR respiratory distress) OR neuromuscular diseases) OR neuromuscular disorder)) AND (((Portable ventilator) OR respirator) OR breathing device)) AND (((normal ventilator) OR breathing machine) OR oxygen mask)	1604
5	((((adult) OR mature) OR patients) OR sick person) OR emergency) OR sufferer) OR ventilation) OR airing) OR respiratory failure) OR respiratory arrest) OR respiratory distress) OR neuromuscular diseases) OR neuromuscular disorder)) AND (((Portable ventilator) OR respirator) OR breathing device)) AND (((normal ventilator) OR breathing machine) OR oxygen mask)) AND ((((((((((((((tidal volume) OR respiratory volume) OR lung volume) OR respiratory rate) OR breathing rate) OR rate of respiration) OR peak pressure) AND heart rate) OR pulse rate) OR heart beat) OR cardiac rate) AND blood pressure) OR stress) AND oxygen saturation) OR oxygenation)	243

Appendix B. Cochrane search strategy

1	((adult) OR (mature):ti,ab,kw OR (patient with ventilation):ti,ab,kw OR (respiratory disease and neuromuscular disease):ti,ab,kw AND (portable ventilator):ti,ab,kw	654421
2	((((((((((((((tidal volume) ti,ab,kwbreathing rate) ti,ab,kwAND heart rate)ti,ab,kw OR pulse rate) ti,ab,kw AND blood pressure)ti,ab,kw OR stress) ti,ab,kw AND oxygen saturation) OR oxygenation	148025
3	(((portable ventilator) ti,ab,kw AND (((normal ventilator) ti,ab,kw	667
4	((adult) OR (mature):ti,ab,kw OR (patient with ventilation):ti,ab,kw OR (respiratory disease and neuromuscular disease):ti,ab,kw AND (portable ventilator):ti,ab,kw (((normal ventilator) ti,ab,kw AND tidal volume) ti,ab,kwbreathing rate) ti,ab,kwAND heart rate)ti,ab,kw OR pulse rate) ti,ab,kw AND blood pressure)ti,ab,kw OR stress) ti,ab,kw AND oxygen saturation) OR oxygenation	238

Appendix C. Google scholar search strategy: 1521

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