International Journal of Applied Science-Research and Review
ISSN: 2394-9988

Open Access Research Article

The Effectiveness of Helmet Continuous Positive Airway Pressure in Treating Adult Patients with COVID-19: A Meta-Analysis

Shammah Ahmed Ali*

Department of Clinical Technology, Umm Al-Qura University, Makkah, Saudi Arabia

ABSTRACT

Background: COVID-19 patients frequently develop severe Acute Hypoxemic Respiratory Failure (AHRF) and many patients have received a Helmet CPAP (H-CPAP) to enhance oxygenation and avoid intubation. The current meta-analysis aimed to assess the efficacy of helmet CPAP in treating adult patients with COVID-19.

Methods: The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reporting guideline was followed. Comprehensive databases including PubMed, Web of Science as well as a web search engine (Google Scholar). In addition, we scanned through the reference lists of all primary research and review articles for further studies that might be relevant.

Result: A total of 10 studies were included in the analysis. The observed log odds ratios ranged from -4.7653 to 2.7726. According to the Q-test (*chi-square*), the true outcomes appear to be high heterogeneous (Q (9)=117.7975, p<0.0001, tau^2=4.2264, I^2=96.5472%). 3.7453 to 4.7374 give a 95% prediction interval for the true outcomes. Hence, there is a significant effect after the use of CPAP to treat COVID-19 or suppress its effects.

Conclusion: There is a significant effectiveness of helmets CPAP in treating COVID-19 patients where most studies indicated the benefit of using the helmets. Nine studies showed significant decrease in death number (less than 20%) with 95% CI (0.147-0.418), p-value<0.001 and only one study showed the opposite.

Keywords: Helmet continuous positive airway pressure; COVID-19; Acute respiratory failure; Respiratory support; Non-invasive ventilation

INTRODUCTION

In 2019, China reported a cluster of novel acute atypical respiratory illness. The outbreak was caused by a novel coronavirus, which was named Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) due to its high homology with SARS-CoV-2, which caused severe pulmonary involvement with high mortality in 2002-2003. The new disease was named coronavirus disease 19 (COVID-19) and in

Received:	22-August-2023	**Manuscript No:**	IPIAS-23-17473
Editor assigned:	25-August-2023	**PreQC No:**	IPIAS-23-17473 (PQ)
Reviewed:	08-September-2023	**QC No:**	IPIAS-23-17473
Revised:	01-July-2024	**Manuscript No:**	IPIAS-23-17473 (R)
Published:	29-July 2024	**DOI:**	10.36648/2394-9988-11.21

Corresponding author: Shammah Ahmed Ali, Department of Clinical Technology, Umm Al-Qura University, Makkah, Saudi Arabia, E-mail: ahghamdi2@gmail.com

Citation: Ali SA (2024) The Effectiveness of Helmet Continuous Positive Airway Pressure in Treating Adult Patients with COVID-19: A Meta- Analysis. Int J Appl Sci Res Rev. 11:21.

2020 the World Health Organization (WHO) declared a pandemic affecting nearly the entire world [1].

The respiratory system is the primary target of this virus. Thus COVID-19 patients frequently suffer from severe Acute Hypoxemic Respiratory Failure (AHRF), requiring the use of Continuous Positive Airway Pressure (CPAP). CPAP administered through non-invasive respiratory support, including a Helmet Continuous Positive Airway Pressure (H-CPAP) to enhance oxygenation and avoid intubation.

H-CPAP is an effective noninvasive interface for delivering CPAP through a hood that wraps around the patient's head and secured with a soft, airtight collar that wraps around the neck. H-CPAP provides a more effective administration of positive end-expiratory pressure than the conventional face masks as it has a better seal. Additional advantages: It offers greater comfort to the patient and require less effort to breathe. A small pre-COVID-19 randomized clinical trial compared two Non-Invasive Ventilation (NIV) interfaces in 83 patients with AHRF and found that helmet NIV patients required intubation less often (18% for helmet NIV *vs.* 62% for face masks) and had lower 90-day mortality (34% *vs.* 56%) [2].

H-CPAP has recently been advocated as a treatment option for COVID-19 patients with acute hypoxemic respiratory failure. However, it's use is limited due to the lack of evidence. Therefore, we aimed to conduct a meta-analysis of the application of H-CPAP in treating adult patients with COVID-19, to evaluate the efficacy and safety of H-CPAP.

MATERIALS AND METHODS

Search Strategy

To find relevant original articles, comprehensive databases including PubMed, Web of Science as well as a web search engine (Google Scholar) were searched from January 30, 2022 to February 30, 2022. We searched for ("H-CPAP" or "helmet continuous positive airway pressure" or "helmet-NIV" or "helmet noninvasive ventilation") and ("COVID-19" or "coronavirus disease 2019"). In addition, we scanned through the reference lists of all primary research and review articles for further studies that might be relevant [3].

Registration and Protocol

To comprehensively calculate the use of helmet CPAP in COVID-19 worldwide, a systematic review was conducted following the guideline of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The protocol of this systematic review has been registered at PROSPERO (CRD42021234050).

Study Selection and Data Extraction

Our inclusion criteria were as follows: 1) adults of all ages who were diagnosed with COVID-19 among all healthcare settings worldwide, 2) H-CPAP used to relieve hypoxemia prior to invasive mechanical ventilation and 3) there is at least one of the following outcomes: Success or failure rate, death rate and intubation rate.

There were no restrictions on the study type, country, race, occupation, economic status, religion or underlying disease [4]. H-CPAP success was defined as weaning from H-CPAP successfully without the need to switch to another oxygen-assisted modality. H-CPAP failure was defined as the need for invasive mechanical ventilation and/or death while on H-CPAP support. Exclusion criteria were as follows: 1) studies in a language other than English, 2) full text not available, 3) the studies that focus on pediatric patients and 4) several publications from the same study. The following data were extracted from the studies: 1) first author and publication year, 2) region, 3) study design, 4) sample size, 5) H-CPAP initial sitting, 6) sample characteristics (age, sex), 7) success rate, 8) failure rate, 9) mortality rate and 10) intubation rate.

Data Synthesis

The number of COVID-19 success and failure cases was divided by the total number of COVID-19 cases to calculate the cumulative effectiveness of H-CPAP in COVID-19 patients. Pooled Odds Ratios (OR) and 95% CI were calculated to evaluate the association of H-CPAP in decreasing the number of deaths among positive cases. The pooled OR and 95% CI were presented in a funnel plot and forest plot [5].

Statistical Analysis

Meta-analysis was conducted through the Jamovi 2.3.2 software. To determine heterogeneity, the I2 index was utilized. I2 values of less than 25%, 25%-50%, 50%-75% and 75%-100% were homogenous, indicating low, medium and high heterogeneity levels, respectively. If the I2 value is greater than 50%, the Random Effect Model (REM) was used. The sensitivity analysis was performed to assess the influence of each study in the analysis by omitting different individual studies each time (**Figure 1**).

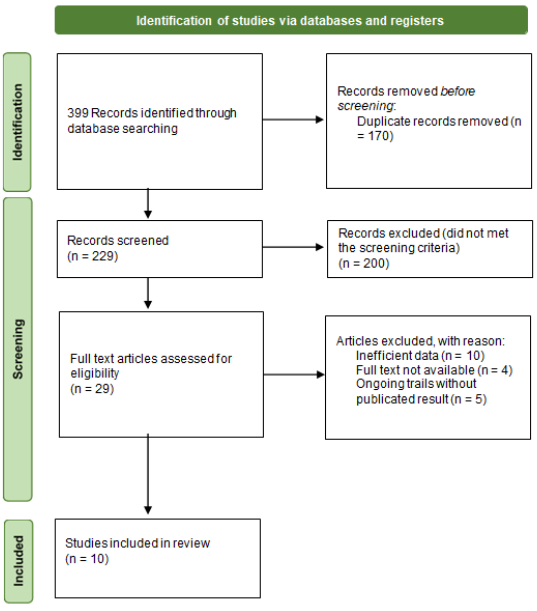

Figure 1: Selection of studies for the meta-analysis (PRISMA).

RESULTS

Description of Study

Figure 1 shows that 399 studies were found from all database searches. Following the removal of 170 duplicates, we eliminated another 200 articles based on their title and abstract. In the remaining 29 studies, we removed 4 articles because the full text was not available and excluded 15 articles by reading their full texts. As a result, in our meta-analysis, we found 10 articles: 7 articles came from Italy, one each from Brazil, India and Saudi Arabia [6].

A total of 809 patients were identified from 10 articles. There were some patients in three articles use High Flow Nasal Canula (HFNC) or invasive ventilation instead of helmet continuous positive airway pressure (61 patient), the remaining 747 patients included in our meta-analysis received helmet CPAP. The results showed that most of the studies used helmet CPAP started with PEEP above of 5 cm H_2O. According to all studies, the patients were all over 18 years of age. It was found that the success rate was more than 50% (390 patients), while 357 patients failed.

The number of intubated patients after helmet CPAP reached 162, a total of 221 patients died either from the helmet CPAP or from failure of intubation after helmet CPAP.

Statistical Analysis

Analyzing the outcomes was conducted using log odds ratios. The random effects model has been fitted to the data, we also report the Q-test for heterogeneity and the I2 statistic in addition to the tau^2 estimate.

Whenever there is evidence of heterogeneity (*i.e.,* $tau^2>0$, regardless of the Q-test result), a prediction interval is included as well. By using studentized residuals and cook's distances, we examine whether studies are outliers and/or influential in the context of the model [7].

Those studies whose Cook's distance is greater than the median plus six times the range of the interquartile range are considered influential. Rank correlation and regression tests, which use the standard error of the observed results as predictors, are used to check the asymmetry of the funnel plot (**Table 1**).

Table 1: Rank correlation and regression tests.

Random-effects model (k=10)							
Intercept	**Estimate**	**se**	**Z**	**p**	**CI lower bound**	**CI upper bound**	
	0.496	0.676	0.734	0.463	-0.828	1.82	
Heterogeneity statistics							
Tau	**Tau^2**	**I^2**	**H^2**	**R^2**	**df**	**Q**	**p**
2.056	4.2264 (SE=2.1628)	96.55%	28.962		9	117.797	<0.001

Note: Tau^2 estimator: Hedges

A total of k=10 studies were included within the analysis. The observed log odds ratios ranged from -4.7653 to 2.7726, with the majority of estimates being positive (80%). The evaluated normal log chances proportion based on the random-effects demonstrate was=0.4961 (95% CI: -0.8282 to 1.8204). Therefore, the mean score was not significantly different from zero (z=0.7342, p=0.4628).

According to Q test, the actual results appear to be heterogeneous (Q(9)=117.7975, p<0.0001, tau^2=4.2264, I^2=96.5472%). The 95% prediction interval for the true result is given by 3.7453 to 4.7374. Therefore, the average result is estimated to be positive, but in some studies the actual result may be negative.

A study of studentized residuals found that the value of one study was above ± 2.8070, which could be a potential outlier in the context of this model. Following Cook's distance, one study may be considered overly influential [8].

Effectiveness of CPAP

Overall, studies showed great significance of CPAP use against COVID-19 by 0.5-folded log odds ratio and confirmed with a heterogeneity of 96.55%.

Publication Bias Assessment

Neither rank correlation nor regression testing showed funnel plot asymmetry (p=0.7275 and p=0.6378, respectively) (**Figures 2 and 3**).

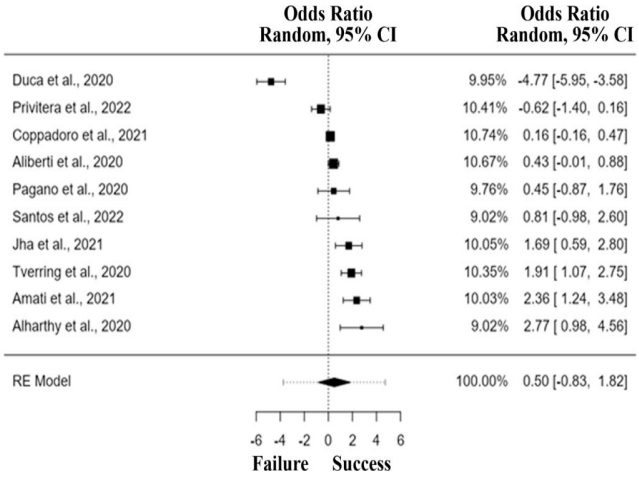

Figure 2: Forest plot.

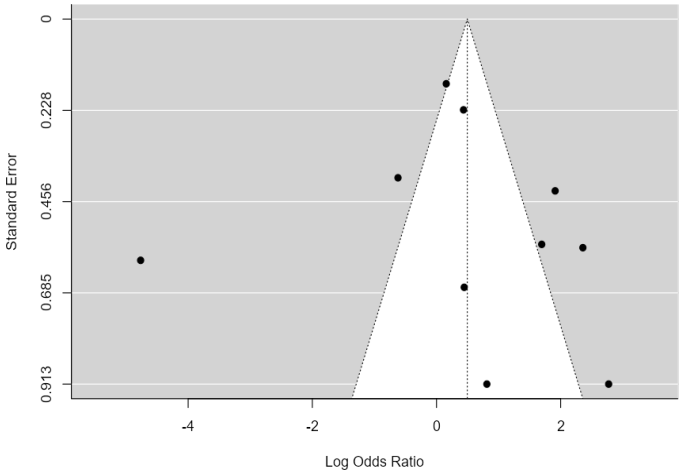

Figure 3: Funnel plot.

DISCUSSION

Using a helmet device for Continuous Airway Pressure (CPAP) and Pressure Support Ventilation (PSV) is beneficial to prevent viral dissemination into the environment. During the COVID-19 outbreak, the number of available ICU beds is less than the entire number of COVID-19 patients requiring NIV or CPAP. The usage of helmets in normal wards could be used to prevent ICU admission [9].

We confirmed the results of our meta-analysis that the H-CPAP is helpful in reducing the number of deaths and successful trials.

The "helmet CPAP bundle" (noise reduction, counterweights mounting mechanism and heated wire tube with active humidification) was recommended for patients who require non-invasive CPAP.

Identification of a positive physiological response to the use of PEEP during H-CPAP treatment, as well as optimal PEEP levels, is critical in patients with AHRF caused by pneumonia in general and COVID-19 in particular.

The respiratory drive increases as the level of dead space ventilation increases, resulting in increased minute ventilation and WOB. Other types of AHRF can result from this increase in air pressure. In these situations, viral aerosolization is likely to play a larger role.

Large diaphragmatic swings and greater WOB in patients undergoing noninvasive mechanical ventilation are thought to enhance the risk of self-inflicted lung injury in these patients. By extending H-CPAP, this circumstance worsens their clinical condition and finally leads to adverse outcomes.

H-CPAP may have physiological and biological advantages over alternative techniques, in addition to its relative ease of use. When used to treat patients with AHRF from COVID-19, H-CPAP reduces air losses compared to face mask interfaces, potentially limiting viral transmission.

H-CPAP may improve the recruitment of non-aerated alveoli in dependent pulmonary areas in various forms of acute hypoxia respiratory failure, hence boosting lung functional residual capacity and lowering shunt. Despite the lack of ventilatory assistance, H-CPAP shifts the tidal volume to a more compliant region of the pressure-volume curve, lowering the patient's effort and Work of Breathing (WOB) and oxygen consumption [10].

During the COVID-19 pandemic, helmet non-invasive ventilation was presented as a way to offer patients with respiratory assistance while also avoiding the requirement for invasive mechanical ventilation. Other potential benefits of the helmet interface include improved patient tolerance and less aerosolization danger.

Helmet interface in patients with severe COVID-19 pneumonia and acute respiratory failure may be a safe and effective treatment option. Only 21 patients (70 percent) out of 30 who were fitted with an NIV helmet had NIV success.

Our study has some limitations. The distribution of resources and recommended criteria vary between countries leading to the absence of a defined strategy for starting H-CPAP. As a result, treatment outcomes were dependent on individual physician judgment, which could have influenced our findings. Incomplete data regarding the characteristics of each patient in the success and failure groups, making the risk factors of H-CPAP failure unclear [11].

CONCLUSION

In our meta-analysis, considerable effectiveness of H-CPAP in treating COVID-19 patients was found, with the majority of studies (more than 50%) indicating that wearing the helmets was beneficial. The detection of a good physiological response to the use of PEEP during helmet CPAP treatment is critical in patients with AHRF caused by pneumonia in general and COVID-19 in particular.

RECOMMENDATIONS

The findings of this meta-analysis supported the conclusion that H-CPAP is considered as an effective and favorable option of treatment due to its characteristics regarding noise reduction and humidification that contribute to the patient's comfort. However, further studies focusing intensively on each patient's health status before receiving H-CPAP may be needed to understand the potential reasons and risk factors leading to failure much better.

FUNDING

This research did not receive any external specific grant from funding agencies in the public, commercial or not-for-profit sectors.

CONFLICTS OF INTEREST

There are no conflicts of interest declared by the authors.

ACKNOWLEDGEMENT

I am very thankfully appreciating the contribution and the effort of all the people who helped us in this research. Also the author would like to thank the deanship of scientific research at Umm Al-Qura university for supporting this work by grant code: (23UQU4210127DSR02)

We would like to acknowledge the effort of any individual for his/her support and guidance throughout this journey especially: Respiratory care program, department of clinical technology, faculty of applied medical science, Umm Al-Qura university, KSA.

REFERENCES

1. Parasher A (2021) COVID-19: Current understanding of its pathophysiology, clinical presentation and treatment. Postgrad Med J. 97(1147):312-320.
2. Amirfarzan H, Cereda M, Gaulton TG, Leissner KB, Cortegiani A, et al. (2021) Use of helmet CPAP in COVID-19-A practical review. Pulmonology. 27(5): 413-422.
3. Munshi L, Hall JB (2021) Respiratory support during the COVID-19 pandemic: Is it time to consider using a helmet?. JAMA. 325(17):1723-1725.
4. Moher D, Liberati A, Tetzlaff J, Altman DG (2010) Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Int J Surg. 8(5): 336-341.
5. Lucchini A, Giani M, Isgro S, Rona R, Foti G (2020) The "helmet bundle" in COVID-19 patients undergoing non-invasive ventilation. Intensive Crit Care Nurs. 58:102859.
6. Jha OK, Kumar S, Mehra S, Sircar M, Gupta R (2021) Helmet NIV in acute hypoxemic respiratory failure due to COVID-19: Change in PaO_2/FiO_2ratio a predictor of success. Indian J Crit Care Med. 25(10):1137-1146.
7. Amati F, Aliberti S, Misuraca S, Simonetta E, Bindo F, et al. (2021) Lung recruitability of COVID-19 pneumonia in patients undergoing helmet CPAP. Arch Bronconeumol. 57:92-94.
8. Tomaz BS, Gomes GC, Lino JA, de Menezes DG, Soares JB, et al. (2022) ELMO, a new helmet interface for CPAP to treat COVID-19-related acute hypoxemic respiratory failure outside the ICU: A feasibility study. J Bras Pneumol. 48(1):e20210349.
9. Privitera D, Capsoni N, Mazzone A, Airoldi C, Angaroni L, et al. (2022) Nursing evaluation during treatment with helmet continuous positive airway pressure in patients with respiratory failure due to COVID-19 pneumonia: A case series. Aust Crit Care. 35(1):46-51.
10. Aliberti S, Radovanovic D, Billi F, Sotgiu G, Costanzo M, et al. (2020) Helmet CPAP treatment in patients with COVID-19 pneumonia: A multicentre cohort study. Eur Respir J. 56(4):2001935.
11. Alharthy A, Faqihi F, Noor A, Soliman I, Brindley PG, et al. (2020) Helmet continuous positive airway pressure in the treatment of COVID-19 patients with acute respiratory failure could be an effective strategy: A feasibility study. J Epidemiol Glob Health. 10(3):201-203.