

CORTICOSTEROID THERAPY FOR ACUTE ASTHMA : A SYSTEMATIC REVIEW

Aulidaweli*

**Faculty of Medicine, University of Malahayati*

***Corresponding Author:**

aulidaweli@gmail.com

Abstract

Background: Asthma is a chronic inflammatory disorder of the airways which affects 300 million people worldwide. Asthma places a huge burden in multiple nations. The main care components for asthma include assessment and monitoring, patient education, addressing environmental controls and comorbid conditions, and pharmaceutical therapy. Corticosteroids therapy is used for maintenance of asthma. While Systemic corticosteroids are often regarded as the first-line treatment for acute asthma since they are unmistakably linked to a quicker recovery to baseline function.

The aim: This study aims to show effectiveness of corticosteroid therapy for acute asthma.

Methods: By comparing itself to the standards set by the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, this study was able to show that it met all of the requirements. So, the experts were able to make sure that the study was as up-to-date as it was possible to be. For this search approach, publications that came out between 2013 and 2023 were taken into account. Several different online reference sources, like Pubmed and ScienceDirect, were used to do this. It was decided not to take into account review pieces, works that had already been published, or works that were only half done.

Results: In the PubMed database, the results of our search brought up 60 articles, whereas the results of our search on ScienceDirect brought up 117 articles. The results of the search conducted by title screening yielded a total 15 articles for PubMed and 7 articles for ScienceDirect. We compiled a total of 9 papers, 6 of which came from PubMed and 3 of which came from ScienceDirect. We excluded 1 duplicate article and 1 review article. In the end, we included seven research (RCT) that met the criteria.

Conclusion: Corticosteroids therapy, whether oral, intravenous and inhaled, is effective to increase lung function (PEF), improve symptoms, and has fewer side effects. Corticosteroids therapy is also effective to reduce admission or hospitalization rate in severe acute asthma.

INTRODUCTION

The National Asthma and Education and Prevention Program Expert Panel Report 3 (NAEPPR3) defines asthma as a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role which causes recurrent episodes of coughing, wheezing, breathlessness, and chest tightness that is often reversible either spontaneously or with treatment.¹ Globally, asthma is ranked 16th among the leading causes of years lived with disability and 28th among the leading causes of burden of disease. Around 300 million people have asthma worldwide.² Prior studies have shown that the prevalence of asthma ranges from 15% to 20% in many countries, especially in the developed nations.³ There is a clear sex disparity in asthma, the prevalence rates in children are higher in boys (65%), while in adults, rates are higher in women (65%) compared with men.⁴ Risk factors for asthma included vitamin D deficiency, tobacco smoke exposure, air pollution, genetic, and stress. Allergen exposure is a significant trigger for asthma symptoms and can lead to increased morbidity.⁵

The diagnosis of asthma is clinical, based on the history and physical examination, yet judicious use of diagnostic testing (lung function testing) can assist in the diagnosis.^{6,7} Mortality from asthma is low compared to other chronic diseases and accounts for less than 1% of deaths globally.³ Though the mortality is low, asthma still leads to frequent acute healthcare resource utilization.^{3,8} Asthma is the 28th cause of loss of years in full health. In the US alone, asthma exacerbations account for approximately two million emergency room visits each year. Asthma places a huge burden at the societal, financial and health-care levels of multiple nations.³

The main care components for asthma include assessment and monitoring, patient education, addressing environmental controls and comorbid conditions, and pharmaceutical therapy.⁶ Systemic glucocorticoids and repeated or continuous administration of short-acting bronchodilators (by nebulizer or metered-dose inhaler with a spacer) are important pharmacologic components of treatment. Systemic corticosteroids are often regarded as the first-line treatment for acute asthma since they are unmistakably linked to a quicker recovery to baseline function. More importantly, early steroid therapy is critical to lessen hospitalisation requirements and improve asthmatic symptoms. In patients without asthma that poses a life-threatening threat, oral steroids have been found to be an acceptable alternative to intravenous medications in the treatment of acute asthma. Although results indicate that adding inhaled budesonide to systemic corticosteroids after an ER visit improves symptoms and lowers the likelihood of relapse, ICSs are normally not administered urgently.⁷ In addition, the additive benefit of inhaled corticosteroid when used with systemic corticosteroid in acute asthma is still unclear. The purpose of this study is to determine the effectiveness of corticosteroid therapy for acute asthma.

METHODS

Protocol

By following the rules provided by Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, the author of this study made certain that it was up to par with the requirements. This is done to ensure that the conclusions drawn from the inquiry are accurate.

Criteria for Eligibility

For the purpose of this literature review, we compare and contrast therapeutic use of corticosteroid for acute asthma. It is possible to accomplish this by researching or investigating the effectiveness of corticosteroid therapy to improve lung function, reduce length of stay in emergency department or hospitalization rate, relieve symptoms in acute asthma, and side effects. As the primary purpose of this piece of writing, demonstrating the relevance of the difficulties that have been identified will take place throughout its entirety.

In order for researchers to take part in the study, it was necessary for them to fulfil the following requirements: 1) The paper needs to be written in English, and it needs to determine effectiveness of corticosteroid for acute asthma. In order for the manuscript to be considered for publication, it needs to meet both of these requirements. 2) The studied papers include several that were published after 2013, but before the time period that this systematic review deems to be relevant. Examples of studies that are not permitted include editorials, submissions that do not have a DOI, review articles that have already been published, and entries that are essentially identical to journal papers that have already been published.

Search Strategy

We used "corticosteroids therapy"; "acute"; and "asthma" as keywords. The search for studies to be included in the systematic review was carried out from September, 21st 2023 using the PubMed and ScienceDirect databases by inputting the words: *("systemic"[All Fields] OR "intravenous"[All Fields] OR "oral" [All Fields] OR "inhalation"[All Fields] "corticosteroids"[MeSH Terms] OR "adrenal cortex hormones"[MeSH Terms] AND "therapy"[MeSH Subheading] OR "drug therapy"[MeSH Subheading] OR "therapeutic use"[MeSH Subheading]) AND ("acuteC[All Fields] OR "acuteb"[All Fields] OR "acutes"[All Fields]) AND "asthma"[MeSH Major Topic] AND ((y_10[Filter]) AND (clinicaltrial[Filter]))* used in searching the literature.

Data retrieval

After reading the abstract and the title of each study, the writers performed an examination to determine whether or not the study satisfied the inclusion criteria. The writers then decided which previous research they wanted to utilise as sources for their article and selected those studies. After looking at a number of different research, which all seemed to point to

the same trend, this conclusion was drawn. All submissions need to be written in English and can't have been seen anywhere else.

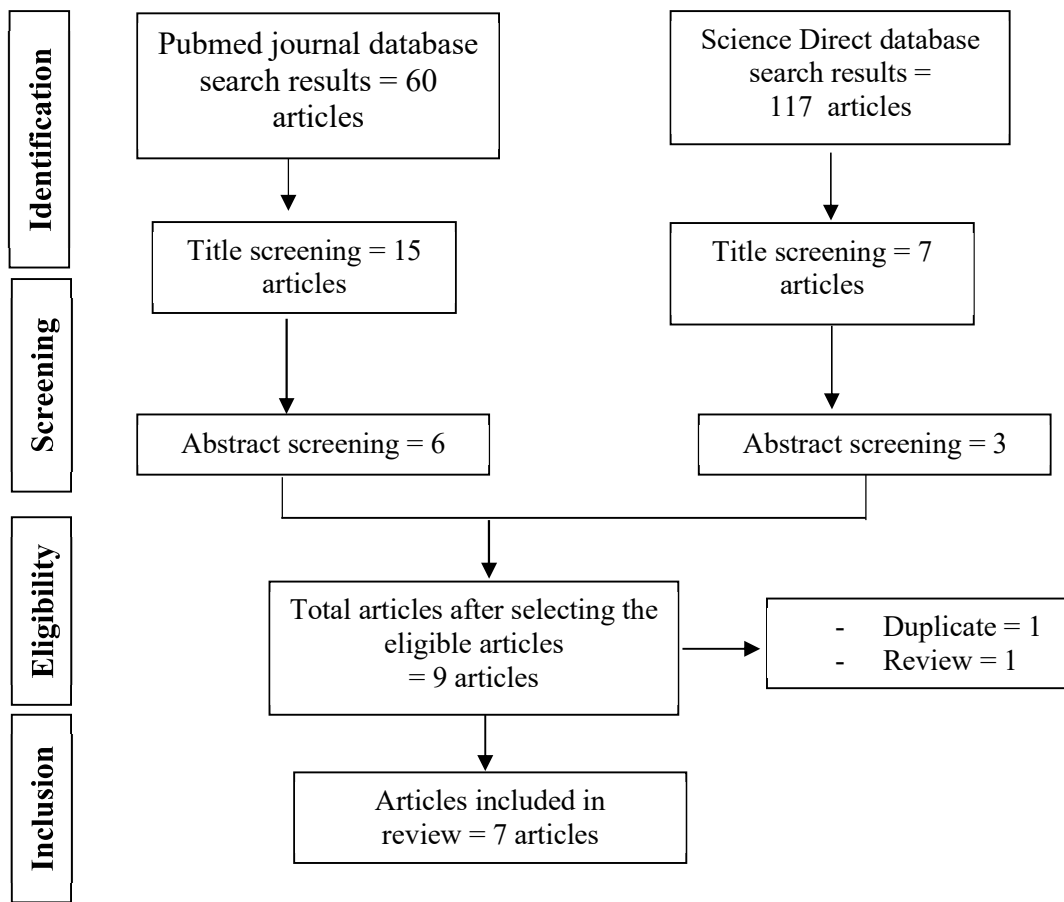


Figure 1. Article search flowchart

Only those papers that were able to satisfy all of the inclusion criteria were taken into consideration for the systematic review. This reduces the number of results to only those that are pertinent to the search. We do not take into consideration the conclusions of any study that does not satisfy our requirements. After this, the findings of the research will be analysed in great detail. The following pieces of information were uncovered as a result of the inquiry that was carried out for the purpose of this study: names, authors, publication dates, location, study activities, and parameters.

Quality Assessment and Data Synthesis

Each author did their own study on the research that was included in the publication's title and abstract before making a decision about which publications to explore further. The next step will be to evaluate all of the articles that are suitable for inclusion in the review because they match the criteria set forth for that purpose in the review. After that, we'll determine which articles to include in the review depending on the findings that we've uncovered. This criteria is utilised in the process of selecting papers for further assessment. In order to simplify the process as much as feasible when selecting papers to evaluate. Which earlier investigations were carried out, and what elements of those studies made it appropriate to include them in the review, are being discussed here.

RESULT

In the PubMed database, the results of our search brought up 60 articles, whereas the results of our search on ScienceDirect brought up 117 articles. The results of the search conducted by title screening yielded a total 15 articles for PubMed and 7 articles for ScienceDirect. We compiled a total of 9 papers, 6 of which came from PubMed and 3 of which came from ScienceDirect. We excluded 1 duplicate article and 1 review article. In the end, we included seven research (RCT) that met the criteria.

Table 1. The literature include in this study

Author	Origin	Method	Sample Size	Result
Alangari, 2014 ⁹	Saudi Arabia	RCT	906 (2 to 12 years)	This finding suggested that addition of budesonide nebulization did not decrease the admission rate of children with acute asthma overall. Nevertheless it may decrease the admission rate of children with severe acute asthma (ASA).
Cronin, 2016 ¹⁰	Ireland	RCT	250 (2 to 16 years)	This findings suggested that dexamethasone has emerged as a potential alternative to prednisolone in the treatment of acute asthma in children.
Demirca, 2015 ¹¹	Turkey	RCT	81 (1 to 16 years)	The results confirm an equal clinical efficacy of high dose nebulized fluticasone propionate to oral steroids in acute moderate asthma in children. From a clinical point of view, fewer side effects, rapid onset of action along with an equal clinical efficacy makes nebulized CS preferable alternative to systemic use in acute moderate asthma.
Gummalla, 2020 ¹²	New York	RCT	80 (18 months to 18 years)	Based on the results, there is no any benefit to providing critically ill children with acute severe asthma (ASA) inhaled budesonide with IV methylprednisolone, when compared to IV methylprednisolone therapy alone. In critically ill children with ASA, intravenous methylprednisolone combined with inhaled budesonide did not shorten the duration of continuous albuterol inhalation treatment, the PICU and hospital LOS, and the need for respiratory support.
Marghli, 2022 ¹³	Tunisia	RCT	50 (18 to 50 years)	The results of the trial did not find a statistically significant difference between budesonide group and control group in decreased of dyspnea, the rate of hospitalization, the discharge criteria before the end of the protocol, the improvement of PEF, and the rates of side effects.
Martins, 2022 ¹⁴	Brazil	RCT	58 (>13 years)	The results of the trial did not find a statistically significant difference between the two groups in decreased of dyspnea, the rate of hospitalization, the discharge criteria before the end of the protocol, the improvement of PEF, and the rates of side effects.
Rehrer, 2016 ¹⁵	California	RCT	376 (18 to 55 years)	This trial did not demonstrate noninferiority of a single dose of dexamethasone to 5 days of prednisone for adult patients with mild to moderate acute asthma. However, enhanced compliance and convenience may support the use of a single oral dose of dexamethasone regardless.

Lung function improvement : peak expiratory flow (PEF)

Three studies used PEF to assess lung function and suggested that corticosteroid therapy can improve lung function in acute asthma. Demirca, *et al.* (2015)¹¹ showed PEF improved significantly in both groups. By day 7, values in patients nebulized CS (83.4 ± 20.3%) were equivalent to systemic CS group (85.8 ± 15.9%). Marghli, *et al.* (2022)¹³ also showed that PEF improved significantly at the different evaluation times compared to the previous evaluation times until 150 min for the budesonide, whereas this statistical significance continues until 180 min in the control group. The average PEF at 180 min was 308 ± 107 l/min and 321 ± 99 l/min respectively in the budesonide (n = 22) and control (n = 27) groups. The increase in PEF at 180 min was 139 and 121% respectively for the budesonide group and control with a difference of 18% (95% CI [-62 to 98%]). Martins, *et al.* (2022)¹⁴ showed PEF increased significantly from 30 minutes (baseline) to hour 4 (P < 0.001) in group inhaled CS (ciclesonide) and group intravenous CS (hydrocortisone), and both treatments were equally effective at hour 4 (C 276.89 ± 100.46 vs. H 293.0 ± 92.24).

Symptoms improvement

Symptoms improvement was measured by different parameter in each articles, included asthma score, Pediatric Respiratory Assessment Measure (PRAM) scores, scorings of total symptom and medication, dyspnea scale, or respiratory effort, accessory muscle use, wheezing and Borg dyspnea scale scores. Overall, using corticosteroid can improve symptom of acute asthma, both systemic and inhalation were similar. Alangari *et. al.*, (2014)⁹ showed that the overall difference in the drop of asthma score between the budesonide and placebo groups at 2, 3, or 4 h was not significant. However, in patients with severe asthma, a steadily increasing difference in the drop of asthma score between the two study groups was noted starting from the second hour until the fourth hour, when it reached 20.87 in favor of the budesonide group (95% CI, 21.69 to 20.06; P 5.04). Cronin *et. al.*, (2016)¹⁰ showed there was no significant difference in PRAM scores at discharge from the ED between the 2 groups of corticosteroids (DEXA 1.01 [SD 1.58] versus PRED 0.99 [SD 1.69]; mean difference 0.02; 95% CI -0.39 to 0.43). Demirca *et. al.*, (2015)¹¹ showed scorings of total symptom and medication were significantly reduced during the treatment period (p = 0.001) in the nebulized and systemic CS groups and no statistical differences between the group comparisons. Marghli *et. al.*, (2022)¹³ showed the decrease in dyspnea scale was no longer

significant in budesonide and control groups. There was no statistically significant difference in the dyspnea scale between the two groups. Martins *et. al.*, (2022)¹⁴ showed there was also no difference between the effects of ciclesonide group and hydrocortisone group at hour 4, i.e. both treatments were equally effective in improving respiratory effort, accessory muscle use, wheezing and Borg dyspnea scale scores. Rehrer *et. al.*, (2016)¹⁵ showed similar symptoms improvement in two group. Shortness of breath, prednisone 32.5%, dexamethasone 29.5%, diff -3.0%, 95% CI -6.3% to 12.4%.

Admission or hospitalization rate

In general population, corticosteroid did not show the decrease in the admission rate for acute asthma but some studies showed reduction in admission rate of children with severe acute asthma. Alangari *et. al.*, (2014)⁹ showed 75 of 458 patients (16.4%) who received budesonide were admitted vs 82 of 448 patients (18.3%) who received placebo (OR, 0.84; 95% CI, 0.58-1.23; P 5 .38). Among the severe group, 27 of 76 patients (35.5%) who received budesonide were admitted vs 39 of 73 patients (53.4%) who received placebo (OR, 0.42; 95% CI, 0.19-0.94; P 5 .03). This implied a 58% reduction in the risk of admission in the budesonide group vs placebo group. Cronin *et. al.*, (2016)¹⁰ showed there were 3 patients (2.5%) in the DEX group and 1 patient (0.8%) in the PRED group who were discharged on day 1 from the ED and required hospital admission at a later stage within 2 weeks of trial enrollment (absolute difference 1.6%; 95% CI -1.6% to 4.9%). Marghli *et. al.*, (2022)¹³ showed the hospitalization rate was 35% and 33% in the budesonide and control groups, respectively, without significant difference (8(35%) - 9(33%); ARR (95% CI) -2(-28 to 24)). Hospitalization rate was 67% and 33% in the budesonide group and control group respectively, without reaching a statistically significant difference. Rehrer *et. al.*, (2016)¹⁵ showed similar rates of hospitalization in the event of a relapse in the 2 PRED and DEX groups (2.9% VS 3.4 %; 95%ci -4.1 to 3.1).

Side effects

Overall, there is no serious side effects after using corticosteroid (systemic or inhalation) for acute asthma. Alangari *et. al.* (2014)⁹ showed the most frequently reported adverse effects, included fine tremors (17 cases) and palpitations (11 cases). None was significantly different between budesonide group and control group. Cronin *et. al.* (2016)¹⁰ showed seven patients in the prednisolone group (5.7%) vomited within 30 minutes of the dose of steroid on day 1 in the ED compared with none in the dexamethasone group (absolute difference -5.7%; 95% CI -9.9% to -1.54%). Seven patients vomited after the prednisolone dose on day 2, and 6 vomited after the dose on day 3. A total of 14 patients vomited after at least 1 dose of prednisolone. Marghli, *et. al.* (2022)¹³ showed the incidence of such as palpitation, tremor, headache, dry mouth were comparable between budesonide and control groups (8(35%) - 9(33%); ARR (95% CI) -2(-28 to 24)). There was no statistically significant difference between the two groups in incidence of side effects. Martins, *et. al.* (2022)¹⁴ showed more patients in the hydrocortisone group complained of dry mouth (Ciclesonide 6.5% vs. Hydrocortisone 25.9%), but there was no statistically significant difference in the frequency of any adverse effect (dry mouth, palpitations, tremors, headache, anxiety) between the groups. Rehrer *et. al.* (2016)¹⁵ showed adverse effect (sleep disturbance, abdominal pain, vomiting, mood disturbance, other) rates did not appear to differ substantially between the 2 groups, except for abdominal pain, which predominated in the prednisone group 4.9%, dexamethasone 1.1%, 95% CI 0.4% to 7.1%.

DISCUSSION

Asthma is a prevalent presentation in pediatric and adult emergency departments, accounting for 10 to 15 of every 1000 visits.¹⁶ The treatment of acute asthma is based on the cornerstones of chronic asthma therapy. However, it is also essential to increase the level of patient monitoring and the aggressiveness of asthma care.⁷ This systematic review identified evidence from randomized controlled trials (RCT) regarding the use of oral/intravenous/inhalation corticosteroids therapy for acute asthma in adults and pediatrics. Identified studies reported that corticosteroid therapy shows some benefits for acute asthma, including PEF improvement, symptoms improvement, a decrease in admission or hospitalization rate, and fewer side effects.

Systemic corticosteroids became available in 1956, and their introduction provided effective treatment for the control of asthma symptoms and exacerbations. However, their widespread use quickly led to the recognition that long-term systemic corticosteroids use is associated with significant adverse events. Inhaled corticosteroids, which have a reduced risk of adverse events but are as effective as systemic corticosteroids for most patients, were introduced in 1972 as a maintenance treatment for patients with asthma.¹⁷ Today, inhaled corticosteroids is the primary therapeutic intervention for persistent asthma along with other controller therapies, including predominantly long-acting β_2 -agonists (LABAs) and leukotriene receptor antagonists, as additional treatments to reduce ICS dosages, control asthma symptoms, and decrease exacerbation risk for patients with asthma.¹⁸

In a meta-analysis, Rodrigo reviewed the rapid clinical effects of ICSs in acute asthma.¹⁹ The Cochrane Collaboration maintains numerous ongoing systematic reviews of randomized controlled trials of systemic steroids versus placebo in acute asthma in children and adults. Short courses of steroids (lasting 3 to 10 days) were found to be effective in reducing the need for additional care within 7 to 10 days (relative risk 0.38, 95% confidence interval [CI] 0.20 to 0.74), fewer hospitalizations (relative risk 0.35, 95% CI 0.13 to 0.95), and less need for β -agonist use (-3.3 activations per day of inhaler; 95% CI -5.6 to -1.0) in patients who were treated in one Cochrane Review. Moreover, steroid therapy improved patient symptom scores, although comparisons between studies were unable to be standardized, resulting in no significant differences. Reports of side effects, such as vomiting and headache, were rare overall, and no significant differences were identified between the groups, although the limited information provided in these studies could have contributed to this

outcome. Different routes of administration did not show significant differences. The review concludes that moderate to severe asthma exacerbations benefit from a short course of systemic steroids. Mild exacerbations can be treated with β -agonist therapy and inhaled corticosteroids, with the addition of systemic steroids if a patient's symptoms do not improve.¹⁶

As we know, increased resistance to airflow is the physiological hallmark of asthma. It is because of airway obstruction that results from smooth muscle constriction, thickening of the airway epithelium, and free secretions within the airway lumen. Obstruction to airflow is manifested by increased airway resistance and decreased flow rates throughout the vital capacity. At the onset of an exacerbation of asthma, obstruction occurs at all airway levels; as the exacerbation resolves, these changes are reversed—first in the large airways (i.e., mainstem, lobar, segmental, and subsegmental bronchi) and then in the more peripheral airways. This anatomic sequence of onset and reversal is reflected in the physiological changes observed during the resolution of an asthmatic episode. Specifically, as an exacerbation of asthma resolves, flow rates first normalize at volumes high in the vital capacity and only later at volumes low in the vital capacity. Because asthma is largely an airway disease rather than an air space disease, no primary changes occur in the static pressure-volume curve of the lungs. However, during severe acute asthma, airway narrowing may cause individual lung units to close at or near their maximum volume, resulting in a change in the pressure-volume curve. This closure can decrease elastic recoil and further depress expiratory flow rates for a given contained gas volume within the thorax.²⁰

Corticosteroids associated with repeated nebulization of mimetic β -2, anticholinergics, and adequate oxygenation are the basis of the treatment for severe acute asthma in the ED. In addition to the delayed anti-inflammatory effect of corticosteroids which happens within a few hours or days, the acute therapeutic response of ICS indicates a different mechanism of action of topical character (nongenomic action). Evidence suggests that ICS decreases airway blood flow by modulating sympathetic nervous system control through potentiating vasoconstriction by increased noradrenergic neurotransmission in the airway vessels.¹³ Glucocorticosteroids inhibit the disposal of organic cations by blocking organic cation transporters expressed by nonneuronal cells through a pharmacologic nongenomic action, thereby interfering with the inactivation of the organic cations by intracellular enzymes. In human airway vascular smooth muscle cells, the glucocorticosteroid action on organic cation uptake occurs within minutes, does not involve gene transcription or protein synthesis, is not mediated through classic steroid receptors, and is cell membrane linked. This steroid effect is likely to acutely increase the concentration of organic cations including α - and β -adrenergic agonists at adrenergic receptor sites on smooth muscle.¹⁹

REFERENCES

- [1]. National Asthma Education. Expert Panel Report 3 (EPR-3): Guidelines for the Diagnosis and Management of Asthma-Summary Report 2007. *J Allergy Clin Immunol.* 2007 Nov;120(5 Suppl).
- [2]. Dharmage SC, Perret JL, Custovic A. Epidemiology of asthma in children and adults. Vol. 7, *Frontiers in Pediatrics.* Frontiers Media S.A.; 2019.
- [3]. Enilari O, Sinha S. The global impact of asthma in adult populations. Vol. 85, *Annals of Global Health.* Ubiquity Press; 2019. p. 1–7.
- [4]. Chowdhury NU, Guntur VP, Newcomb DC, Wechsler ME. Sex and gender in asthma. Vol. 30, *European Respiratory Review.* European Respiratory Society; 2021.
- [5]. Stern J, Pier J, Litonjua AA. Asthma epidemiology and risk factors. Vol. 42, *Seminars in Immunopathology.* Springer; 2020. p. 5–15.
- [6]. Nanda A, Wasan AN. Asthma in Adults. Vol. 104, *Medical Clinics of North America.* W.B. Saunders; 2020. p. 95–108.
- [7]. Lugogo N, Que LG, Carr TF, Kraft M. Asthma: Diagnosis and Management. In: Murray & Nadel's *Textbook of Respiratory Medicine.* 2023. p. 831–49.
- [8]. Trivedi M, Denton E. Asthma in children and adults—what are the differences and what can they tell us about asthma? Vol. 7, *Frontiers in Pediatrics.* Frontiers Media S.A.; 2019.
- [9]. Alangari AA, Malhis N, Mubasher M, Al-Ghamedi N, Al-Tannir M, Riaz M, et al. Budesonide nebulization added to systemic prednisolone in the treatment of acute asthma in children: A double-blind, randomized, controlled trial. *Chest.* 2014;145(4):772–8.
- [10]. Cronin JJ, McCoy S, Kennedy U, An Fhailí SN, Wakai A, Hayden J, et al. A Randomized Trial of Single-Dose Oral Dexamethasone Versus Multidose Prednisolone for Acute Exacerbations of Asthma in Children Who Attend the Emergency Department. *Ann Emerg Med.* 2016 May 1;67(5):593-601.e3.
- [11]. Demirca BP, Cagan H, Kiykim A, Arig U, Arpa M, Tulunay A, et al. Nebulized fluticasone propionate, a viable alternative to systemic route in the management of childhood moderate asthma attack: A double-blind, double-dummy study. *Respir Med.* 2015 Sep 1;109(9):1120–5.
- [12]. Gummalla P, Weaver D, Ahmed Y, Shah V, Keenaghan M, Doymaz S. Intravenous methylprednisolone versus intravenous methylprednisolone combined with inhaled budesonide in acute severe pediatric asthma. *Journal of Asthma.* 2021;58(11):1512–7.
- [13]. Marghli S, Bouhamed C, Sghaier A, Chebbi N, Dlala I, Bettout S, et al. Nebulized budesonide combined with systemic corticosteroid vs systemic corticosteroid alone in acute severe asthma managed in the emergency department: a randomized controlled trial. *BMC Emerg Med.* 2022 Dec 1;22(1).

- [14]. Martins DT, Carlos K, Carvalho LB, Prado LB, Fransolin C, Atallah AN, et al. A randomized clinical trial on inhaled ciclesonide for managing acute asthma in the emergency room. *Sao Paulo Medical Journal*. 2022;140(3):430–8.
- [15]. Rehner MW, Liu B, Rodriguez M, Lam J, Alter HJ. A Randomized Controlled Noninferiority Trial of Single Dose of Oral Dexamethasone Versus 5 Days of Oral Prednisone in Acute Adult Asthma. *Ann Emerg Med*. 2016 Nov 1;68(5):608–13.
- [16]. Shefrin AE, Goldman RD. Use of dexamethasone and prednisone in acute asthma exacerbations in pediatric patients [Internet]. Vol. 55, *Canadian Family Physician • Le Médecin de famille canadien*. 2009. Available from: www.nhlbi.nih.gov/guidelines/asthma/
- [17]. Bleecker ER, Menzies-Gow AN, Price DB, Bourdin A, Sweet S, Martin AL, et al. Systematic literature review of systemic corticosteroid use for asthma management. Vol. 201, *American Journal of Respiratory and Critical Care Medicine*. American Thoracic Society; 2020. p. 276–93.
- [18]. Global Initiative For Asthma (GINA). *Pocket Guide For Asthma Management And Prevention*. 2023;
- [19]. Mendes ES, Cadet L, Arana J, Wanner A. Acute effect of an inhaled glucocorticosteroid on albuterol-induced bronchodilation in patients with moderately severe asthma. *Chest*. 2015 Apr 1;147(4):1037–42.
- [20]. Dzaren JM, Bel EH. Asthma. In: *Goldman-Cecil Medicine*. 27th ed. Elsevier; 2023. p. 537–47