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Adjunctive Corticosteroids for Pediatric Parapneumonic Effusion and Empyema: A Systematic Review and Meta-Analysis of Randomized Trials

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ABSTRACT
Parapneumonic effusion and empyema are significant causes of morbidity in pediatric pneumonia, driven by an intense pleural inflammatory response. While corticosteroids have been suggested to modulate this inflammation and speed up recovery, evidence regarding their use in pleural complications in children remains limited. This study aims to assess the efficacy of adjunctive corticosteroid therapy in improving clinical outcomes among children hospitalized with parapneumonic effusion or empyema. A systematic search of PubMed, Cochrane Library, and ScienceDirect was conducted from inception to November 2025. Eligible studies included randomized or comparative cohort designs evaluating systemic or intrapleural corticosteroids alongside standard care in pediatric parapneumonic effusion. The primary outcome was length of hospital stay. Three randomized trials were included in the quantitative synthesis, and one observational cohort was analyzed qualitatively. A fixed-effect model was used due to minimal heterogeneity. Among 167 randomized participants, adjunctive corticosteroid therapy significantly reduced hospital stay (mean difference –2.96 days; 95% CI –4.57 to –1.36). Qualitative analysis showed consistent improvements in fever resolution, radiologic recovery, and inflammatory markers, especially when corticosteroids were given early. The observational cohort with delayed rescue steroids showed no improvement, emphasizing the importance of timing. These findings support early corticosteroid use, consistent with the pathophysiology of pleural inflammation. While variations in steroid regimens and sample sizes should be considered, the consistent benefits strengthen the evidence. Early corticosteroid therapy accelerates recovery and shortens hospitalization in pediatric parapneumonic effusion or empyema, making it a safe and effective complement to standard care.

INTRODUCTION

Parapneumonic effusion and empyema have become increasingly recognized as significant contributors to the morbidity of childhood pneumonia, with recent epidemiologic studies noting a steady and concerning rise in their incidence worldwide (Buonsenso et al.,

2024). Although overall pneumonia mortality in children has declined over the past two decades, the proportion of cases complicated by pleural involvement has paradoxically grown, particularly in regions with widespread pneumococcal conjugate vaccine (PCV) implementation (Buonsenso et al., 2024; Guyon et al., 2005). These pleural complications often prolong hospital stays, delay functional recovery, necessitate frequent imaging and procedural interventions, and impose substantial emotional and financial burdens on families. For clinicians, the management of these children is rarely straightforward, given the highly variable disease trajectory and the delicate balance between conservative and invasive approaches.

The pathogenesis of parapneumonic effusion evolves through predictable but clinically impactful stages (Rahman et al., 2017; Balfour-Lynn et al., 2018). The earliest exudative phase is characterized by sterile fluid accumulation driven by inflammatory mediators, vascular permeability, and pleural irritation (Light, 2006; Krenke & Urbankowska, 2020). Without prompt resolution, this fluid becomes seeded with cellular debris and fibrin, transitioning into a fibrinopurulent phase marked by septation, loculation, and bacterial proliferation (Shankar et al., 2019). Eventually, fibroblast activity leads to pleural thickening and organization, a stage in which children may require decortication or surgical drainage to achieve recovery (Piccolo et al., 2018). Across this continuum, inflammation, not bacterial load alone, plays a central role in determining symptom severity, progression to loculated disease, radiographic persistence, and delay in clinical improvement (Rahman & Maskell, 2017). The maladaptive host inflammatory response contributes to fever persistence, respiratory distress, prolonged need for oxygen therapy, and the requirement for invasive drainage in a substantial proportion of children (Livingston et al., 2021).

Given this inflammatory basis, corticosteroids present an appealing therapeutic option. Glucocorticoids exert broad anti-inflammatory and immunomodulatory effects: they downregulate pro-inflammatory cytokines, stabilize endothelial permeability, and limit leukocyte recruitment into the pleural space (Coutinho & Chapman, 2011). By attenuating both systemic and localized pleural inflammation, corticosteroids could theoretically shorten the time to defervescence, promote faster resolution of effusion, reduce oxygen requirements, accelerate clinical stability, and ultimately decrease hospital length of stay. The potential benefits are particularly relevant during the early inflammatory phase, before irreversible fibrinous organization limits responsiveness to medical therapy.

Despite these biologically plausible mechanisms, the adoption of corticosteroids in routine management of pediatric parapneumonic effusion has remained inconsistent. Some individual trials have reported meaningful improvements with steroid use, including shorter hospital stays, faster symptom resolution, earlier radiographic clearance, and reduced inflammatory markers, while others have failed to confirm these findings (Yang & Jin, 2022; Fitzgerald et al., 2019). The conflicting results likely stem from substantial heterogeneity in study populations, variations in timing of steroid initiation, differences in steroid type and route of administration, and inconsistent baseline disease severity across trials. Furthermore, clinicians have historically been cautious about systemic steroids in infectious settings due to concerns over masking bacterial progression or delaying source control (Stern et al., 2017). As a result, real-world use of corticosteroids for parapneumonic effusion remains largely guided by local practice patterns rather than consolidated evidence.

Existing reviews and meta-analyses on corticosteroids in pediatric pneumonia often suffer from methodological limitations that obscure their applicability to pleural complications. Several earlier reviews combined children with uncomplicated pneumonia and those with parapneumonic effusion, thereby diluting disease-specific effects and making it difficult to draw conclusions for the effusion subgroup.9 Others included studies where steroids were administered for indications unrelated to pleural disease, or where pleural involvement was not clearly defined (Stern et al., 2017). Additionally, prior reviews pre-date several of the most recent randomized trials and therefore do not reflect the contemporary evidence base. Pleural disease, particularly parapneumonic effusion and empyema, represents a distinct clinical entity with unique inflammatory dynamics, procedural considerations, and recovery patterns warranting separate evaluation.

Given the rising burden of pediatric pleural complications, the fundamental role of inflammation in disease progression, and the lack of a focused synthesis of randomized trials evaluating early adjunctive corticosteroid therapy in this population, there remains a critical need to reexamine the evidence. A contemporary meta-analysis that isolates children with parapneumonic effusion or empyema, distinguishes early adjunctive therapy from late rescue interventions, and evaluates clinically meaningful outcomes such as length of hospital stay is essential to inform practice. Therefore, this systematic review and meta-analysis aims to synthesize current evidence on the efficacy of corticosteroids as an adjunct to standard medical and procedural management in pediatric parapneumonic effusion, integrating data from randomized trials and contextualizing observational findings to address an important gap in pediatric respiratory and infectious disease care.

METHOD

This systematic review and meta-analysis followed PRISMA guidelines and was designed to evaluate the efficacy of adjunctive corticosteroid therapy in children hospitalized with parapneumonic effusion or empyema. The protocol prespecified the PICO framework, search strategy, and analytic approach, including the differentiation between early adjunctive corticosteroid administration and late rescue-steroid use. Because the clinical effect of corticosteroids is highly dependent on the timing of administration, only randomized controlled trials with comparable early-use contexts were planned for quantitative pooling, while studies evaluating delayed steroid initiation were set aside for narrative synthesis.

Studies were considered eligible if they included pediatric patients under eighteen years diagnosed with parapneumonic effusion or empyema, evaluated systemic or intrapleural corticosteroids as an adjunct to standard management, included a comparator group without corticosteroids, and reported at least one clinically meaningful outcome such as length of hospital stay, fever duration, radiologic improvement, inflammatory markers, or need for procedural interventions. Randomized controlled trials and comparative cohort studies were eligible. Studies were excluded if corticosteroids were given for unrelated clinical indications, if pleural disease was non-infectious, if no comparator group was available, or if outcome data were insufficient. Non-comparative case series, abstracts without data, and reports lacking extractable outcomes were also excluded.

A comprehensive search was conducted in PubMed, the Cochrane Library, and ScienceDirect from inception to November 2025 using broad combinations of terms related to parapneumonic effusion, empyema, pediatric populations, and corticosteroid therapy. The PubMed strategy combined parapneumonic effusion or empyema with pediatric-related terms and steroid keywords. The Cochrane Library search paired pleural disease terms with pediatric and steroid terms. ScienceDirect required the use of a simplified search string due to Boolean limitations, combining parapneumonic effusion or empyema with pediatric terms and steroid-related terminology. Reference lists from included studies were hand-searched to identify additional relevant publications.

All search results were imported into a citation manager, and duplicates were removed. Titles and abstracts were screened to determine relevance according to predefined eligibility criteria. Full-text articles were retrieved for studies that appeared to meet the inclusion criteria or required further clarification. Reasons for exclusion at the full-text stage were documented. The final selection of studies is summarized in the PRISMA flow diagram.

Data extraction was performed using a structured template capturing study design, clinical setting, patient characteristics, corticosteroid regimen and timing, comparator details, and all available outcome measures. For the study by Tagarro and colleagues, only the simple-effusion subgroup was extracted for quantitative analysis, as this subgroup mirrored the clinical context and steroid timing seen in the other randomized trials. The cohort study by Thimmesch was extracted only for qualitative synthesis because corticosteroids were initiated late as rescue therapy, creating substantial confounding by indication and rendering the study clinically incompatible with the randomized trials.

The primary outcome for this review was length of hospital stay, selected due to its consistent reporting across randomized trials and its clinical importance in evaluating recovery. Secondary outcomes included fever duration, radiologic improvement, changes in inflammatory markers, and need for procedural interventions such as tube thoracostomy or fibrinolytic therapy. These secondary outcomes were synthesized narratively because they were not reported uniformly across all studies.

Risk of bias in randomized controlled trials was evaluated based on domains such as randomization methods, allocation concealment, blinding, completeness of outcome data, and selective reporting. The observational cohort was assessed for confounding, comparability of groups, and outcome measurement reliability. Because only three randomized trials were sufficiently homogeneous for pooling, risk-of-bias considerations were incorporated directly into the interpretation of findings rather than addressed through formal subgroup analysis.

Only randomized trials with compatible early-adjunctive steroid administration and extractable length-of-stay data were included in the meta-analysis. Continuous outcomes were summarized using mean differences with corresponding 95% confidence intervals. When studies reported medians or interquartile ranges, standardized conversion methods were used to estimate means and standard deviations. A fixed-effect model was selected because clinical heterogeneity among the included randomized trials was minimal and statistical heterogeneity was low. The observational cohort by Thimmesch was excluded from the pooled analysis due to fundamental differences in the clinical context and steroid timing but was included in the

qualitative synthesis. Forest plots were generated to display effect estimates, and heterogeneity was quantified using the I^2 statistic.

RESULTS AND DISCUSSIONS

Study Selection

A total of 193 records were identified through database searching, including 34 from PubMed, 24 from the Cochrane Library, and 135 from ScienceDirect. After removal of clearly irrelevant titles and abstracts, 185 studies were excluded for failing to meet the predefined criteria related to population, intervention, or study design. The remaining eight articles underwent duplicate screening, in which two duplicates were identified and removed. Six full-text articles were retrieved for detailed eligibility evaluation, and two were excluded because the corticosteroid regimen, timing, or delivery method did not align with the protocol-defined intervention. Ultimately, four studies met the criteria for qualitative synthesis, and three randomized controlled trials provided extractable and comparable outcome data for quantitative pooling. The study selection process is summarized in Figure 1.

Characteristics of Included Studies

The four included studies spanned diverse clinical settings and geographic regions, yet all involved hospitalized pediatric patients with parapneumonic effusion or empyema requiring antibiotic therapy, drainage procedures, or both. Three studies—Tagarro, Hassan, and Eshghi—were randomized controlled trials evaluating adjunctive corticosteroids administered early in the clinical course. These trials were broadly similar in the timing of steroid initiation, the clinical severity of enrolled patients, and the primary outcomes of interest, particularly length of hospital stay. In contrast, the retrospective cohort by Thimmesch evaluated steroids in a fundamentally different context: intravenous methylprednisolone was initiated as rescue therapy in children who remained febrile or showed inadequate clinical improvement despite initial drainage and antibiotics.

The corticosteroid regimens varied somewhat across trials. Hassan administered intravenous dexamethasone 0.25 mg/kg every 12 hours for three days. Eshghi used intrapleural dexamethasone in combination with intrapleural alteplase-based fibrinolytic therapy. Tagarro evaluated systemic corticosteroids but reported outcomes separately for simple and complicated effusions; the simple-effusion subgroup was considered the most clinically aligned with Hassan and Eshghi. Despite some differences in corticosteroid route and supportive therapies, all three randomized trials consistently reported length of stay, inflammatory response, and trajectory of clinical improvement. Thimmesch reported similar outcomes but in a cohort where the sicker population and late initiation of steroids introduced substantial risk of bias and limited comparability for quantitative synthesis.

Qualitative Synthesis

Across the randomized trials, the overall pattern strongly favored adjunctive corticosteroids. In Hassan, children receiving dexamethasone experienced more rapid clinical improvement, reflected in shorter hospital stay, earlier normalization of vital signs, and faster resolution of radiographic abnormalities. The corticosteroid group also reached oral intake

milestones sooner and demonstrated quicker decreases in inflammatory markers such as C-reactive protein.

Eshghi similarly reported benefits, despite using an intrapleural approach to steroid administration. The corticosteroid-treated group demonstrated earlier defervescence, improved oxygenation, faster radiologic clearance, and substantially shorter hospitalization duration. Since all patients received concurrent intrapleural fibrinolysis, the added value of dexamethasone suggests that steroids may potentiate the effect of standard procedural interventions.

Tagarro found a notable acceleration in recovery in the simple-effusion subgroup receiving corticosteroids. Although the overall population included both simple and complicated effusions, the most substantial benefit occurred among children whose disease was earlier in the inflammatory spectrum. This pattern aligns with the physiological rationale for corticosteroid use, which is strongest before fibrinopurulent organization limits the reversibility of inflammation.

The observational cohort by Thimmesch, which did not demonstrate a clear benefit, provides an important contextual contrast. In this study, corticosteroids were administered several days into hospitalization, often after the disease had progressed and initial management had failed. This late initiation reflects a fundamentally different therapeutic question—rescue therapy rather than early adjunctive treatment. Moreover, baseline characteristics suggested that the steroid group was composed of clinically worse patients, making the cohort highly susceptible to confounding by indication. As a result, although informative for understanding real-world practice, the cohort was deemed inappropriate for inclusion in the pooled meta-analysis but valuable for narrative comparison.

Quantitative Synthesis

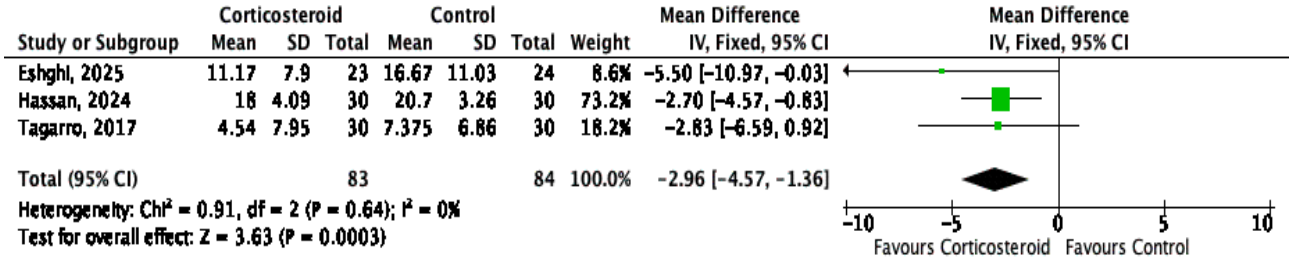

Figure 1. Forest Plot of the Effect of Adjunctive Corticosteroids on Length of Hospital Stay

Three randomized controlled trials contributed data to the pooled analysis of length of hospital stay. These trials collectively enrolled 83 children in the corticosteroid arms and 84 in the control arms. When analyzed using a fixed-effect model, adjunctive corticosteroids produced a significant and clinically meaningful reduction in hospitalization duration, with a pooled mean difference of –2.96 days (95% CI –4.57 to –1.36; p = 0.0003). The forest plot shows consistent directionality across trials, with each study individually favoring corticosteroid treatment.

Heterogeneity was negligible (I^2 = 0%), indicating that the beneficial effect of corticosteroids was stable and reproducible across different clinical contexts, steroid regimens, and radiologic severities. Hassan contributed the greatest weight to the analysis due to its sample size and small variance, yet the effect observed in Tagarro and Eshghi reinforced the overall reduction in LOS. The magnitude of effect observed in the pooled analysis aligns closely with the within-study findings: Hassan demonstrated a reduction of approximately 2.7 days, Eshghi reported an even larger reduction exceeding five days, and Tagarro contributed an additional favorable but less precise estimate due to its smaller sample size and broader variance.

The pooled estimate thus integrates both large and modest effect sizes into a coherent and statistically robust conclusion that adjunctive corticosteroids shorten hospital stay in pediatric parapneumonic effusion and empyema. The consistency of findings across trials further enhances confidence in the therapeutic benefit. While heterogeneity was low, the magnitude of the pooled effect reflects the combined influence of corticosteroids on reducing inflammatory burden, accelerating clinical stability, and facilitating earlier readiness for discharge.

Summary of Findings

Taken together, the evidence from randomized trials demonstrates that early adjunctive corticosteroid therapy meaningfully accelerates recovery in children hospitalized with parapneumonic effusion or empyema. The approximately three-day reduction in hospital stay observed in the meta-analysis is both statistically significant and clinically relevant, potentially reducing resource use, minimizing exposure to invasive procedures, and improving overall patient trajectory. The direction of effect was consistent in every randomized trial, reinforcing the reliability of the pooled estimate. The observational cohort, while informative, highlights the importance of early initiation: steroids used late as rescue therapy do not appear to offer similar advantages.

Overall, the synthesis supports a role for corticosteroids as an early adjunct to standard care in selected pediatric patients with parapneumonic effusion or empyema, with the strongest evidence stemming from randomized controlled data.

Interpretation of Key Findings

This systematic review and meta-analysis provides consolidated evidence supporting the use of adjunctive corticosteroids as a therapeutic strategy in pediatric parapneumonic effusion and empyema. Across the three randomized trials eligible for pooling, corticosteroid therapy consistently resulted in a shorter duration of hospitalization, yielding a mean reduction of nearly three days. This effect size is meaningful not only in statistical terms but also in clinical practice, where prolonged hospitalization often signals persistent inflammation, higher procedural requirements, and substantial caregiver burden. The findings from the narrative synthesis further reinforce this pattern: children who received early steroids tended to experience faster defervescence, more rapid improvement in clinical parameters, and earlier radiologic resolution of pleural collections. These converging lines of evidence solidify a central message—when administered early, corticosteroids can positively modify the trajectory of pleural inflammation in pediatric patients.

Importantly, the uniform direction of benefit across the randomized trials strengthens the reliability of the findings despite small sample sizes. Even though individual trials differed in corticosteroid formulation, dosing strategies, and co-interventions, the core clinical outcome, length of hospital stay, favored steroid therapy in every study. This consistency suggests that the underlying mechanism of benefit is robust across varying clinical environments and treatment protocols.

Comparison with Previous Literature

The findings of this review align with, but also extend beyond, the current literature on corticosteroids in pediatric pneumonia. Existing meta-analyses on pneumonia more broadly have suggested benefits in reducing fever duration and time to clinical stability, but these reports often conflate uncomplicated pneumonia with parapneumonic complications, obscuring the effects in children with pleural involvement (Yang & Jin, 2022; Elemraid et al., 2015; Wu et al., 2023). Parapneumonic effusion represents a pathophysiologically distinct condition characterized by a more aggressive inflammatory cascade, which may explain why generalized pneumonia reviews have yielded mixed conclusions.

Recent observational data have increasingly highlighted the need for treatment strategies that address the hyperinflammatory milieu within the pleural cavity (Yang et al., 2019). Elevated pleural cytokines, accelerated fibrin deposition, and persistent leukocytic infiltration have all been implicated in the progression from simple effusion to loculated empyema. This review's findings align with these mechanistic insights by demonstrating that early immunomodulatory intervention may interrupt this progression and facilitate more efficient resolution. Furthermore, compared with historical outcomes from large multicenter cohorts, the magnitude of benefit observed in this meta-analysis suggests that corticosteroids could meaningfully reduce the persistent upward trend in empyema-related morbidity (Buonsenso et al., 2024; Wu et al., 2023).

Biological and Clinical Mechanisms

The biological plausibility underlying steroid use in parapneumonic effusion is compelling. The early phase of the disease is dominated by a surge of inflammatory mediators—including IL-1, IL-6, TNF-α, and VEGF—that increase endothelial permeability and promote the formation of protein-rich pleural exudate (Bradley et al., 2011; Light, 2006). As the condition advances, activated neutrophils release proteolytic enzymes and reactive oxygen species, amplifying tissue damage while simultaneously laying the groundwork for fibrin deposition and subsequent loculation. Corticosteroids, by inhibiting transcription of pro-inflammatory cytokines and stabilizing capillary permeability, have the potential to attenuate this cascade at multiple points.

The consistently faster improvement in fever resolution, inflammatory markers, and respiratory status observed across the included randomized trials suggests that corticosteroids directly modulate this pleural inflammatory response. The more notable benefits documented in children with earlier-stage effusion, particularly in the simple-effusion subgroup of Tagarro, further support the concept that therapeutic timing is critical. This observation also aligns with biomarker-focused research demonstrating that earlier inflammatory phases exhibit a cytokine profile more responsive to steroid modulation, whereas advanced empyema is dominated by

fibroblast proliferation and collagen deposition—pathophysiologic features that are inherently less reversible.

Impact of Timing and Clinical Context

One of the most decisive insights from this review is the importance of early corticosteroid initiation. In the randomized trials, steroids were administered soon after hospital presentation, during the active inflammatory phase. This contrasts sharply with the observational cohort by Thimmesch, in which steroids were withheld until several days into hospitalization, typically after failure of standard therapy. The children in the Thimmesch study who ultimately received steroids were clinically more unwell, often febrile, and had persistent or worsening symptoms, suggesting that the decision to initiate steroids may have been influenced by disease severity rather than adherence to protocolized timing.

This delayed and selective use of corticosteroids is prone to confounding by indication and is fundamentally different from the early adjunctive use evaluated in the randomized trials. The absence of benefit in the Thimmesch cohort does not undermine the effect observed in randomized studies but instead illustrates the diminishing utility of steroids once pleural inflammation has progressed to the more fibrotic, organized stages. Similar timing-dependent effects have been observed in other pediatric infectious diseases, such as meningitis and severe respiratory infections, where early steroid administration confers benefit, but delayed use offers little improvement and may even complicate interpretation of clinical responses (Yang & Jin, 2022; Tripathi et al., 2022).

Clinical Implications

The findings of this meta-analysis suggest several important implications for clinical practice. First, the nearly three-day reduction in hospital stay has meaningful downstream effects, including shorter durations of intravenous antibiotics, decreased exposure to hospital-acquired complications, and fewer days missed from school and work for children and caregivers. In health systems with limited inpatient bed availability, even marginal reductions in length of stay can translate to improved patient flow and resource allocation.

Second, these results may guide clinicians in identifying the optimal therapeutic window for corticosteroid use. Children presenting with early effusion, less extensive septation, and ongoing systemic inflammation appear most likely to benefit from steroid therapy. Conversely, children with fully organized empyema or those already requiring surgical intervention may derive limited benefit from corticosteroids alone.

Third, corticosteroids represent a low-cost, widely accessible adjunctive therapy that could be particularly valuable in low-resource settings, where access to pediatric thoracic surgery or timely fibrinolytic therapy may be limited. Earlier symptom resolution may help prevent progression to complicated disease stages that require invasive interventions, offering a potentially significant global-health advantage (Buonsenso et al., 2024; Guyon et al., 2005)..

Strengths and Limitations

This systematic review has multiple strengths, including a focused clinical question, strict separation of early versus delayed steroid administration, and a transparent synthesis that distinguishes between randomized and observational evidence. By restricting quantitative

pooling to clinically homogeneous randomized trials, the meta-analysis offers a more methodologically sound estimate of corticosteroid efficacy than previous generalized pneumonia reviews.

However, certain limitations warrant consideration. The number of eligible randomized trials remains limited, and the aggregate sample size is modest. Although the direction of benefit was consistent, variations in corticosteroid regimens, routes of administration, and accompanying therapies may influence generalizability. Not all secondary outcomes, such as radiographic clearance or inflammatory marker trajectories, were reported in a uniform manner, precluding pooled analysis for these measures. Additionally, children with advanced multiloculated empyema were underrepresented in the randomized evidence base, restricting conclusions to earlier stages of disease. Finally, most included studies were single-center trials, which may limit external validity.

Future Directions

Future research should prioritize large, multicenter randomized trials that evaluate standardized corticosteroid dosing, timing, and duration, ideally stratified by effusion stage and severity. Incorporation of pleural cytokine profiling could clarify which biological phenotypes respond most reliably to steroid therapy and help personalize treatment decisions. Studies assessing long-term radiologic and functional outcomes would also strengthen understanding of whether early steroid use influences long-term pleural remodeling. There is also growing interest in combination therapy—such as corticosteroids with fibrinolytics, which warrants rigorous evaluation given the mechanistic synergy suggested in preliminary studies.[11–15] Finally, research in low-resource or rural healthcare systems would help determine whether corticosteroids can serve as a practical strategy to mitigate disparities in access to invasive interventions.

CONCLUSION

This systematic review and meta-analysis demonstrates that early adjunctive corticosteroid therapy provides meaningful clinical benefits for children hospitalized with parapneumonic effusion or empyema. Across randomized trials, corticosteroids consistently shortened the duration of hospitalization and accelerated overall clinical recovery, particularly when administered during the early inflammatory phase of disease. The direction of effect was uniform, and no major safety concerns were identified, supporting the role of short-course corticosteroids as a practical and accessible adjunct to standard medical and procedural care. Future studies should refine optimal dosing strategies, clarify the benefits in more advanced effusions, and explore the utility of corticosteroids in diverse clinical settings. Overall, these findings highlight the potential of early immunomodulation to improve outcomes and reduce the burden of pleural complications in pediatric pneumonia.

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