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Original Article

Efficacy of Adjunct Corticosteroid Therapy in the Management of Pediatric Renal Colic: A Quasi-Experimental Study on Pain Reduction and Stone Expulsion

Tariq Ahmad[1], Akbar Azam[2], Sajjad Ali[1], Syed Muhammad[1], Ejaz Ullah[1] Younas Khan[1], Abdul Jabbar[1] & Syed Zia ur Rehman[3]

[1] Khyber Teaching Hospital, Peshawar, Pakistan
[2] Lady Reading Hospital, Peshawar, Pakistan
[3] Naseer Teaching Hospital, Peshawar, Pakistan

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Abstract

Background: Renal colic is a frequent and highly painful urological emergency in children, primarily caused by ureteric obstruction due to urinary calculi. Although non-steroidal anti-inflammatory drugs (NSAIDs) remain the cornerstone of management, their potential adverse effects highlight the need for safer and more effective adjunct therapies. Corticosteroids, due to their anti-inflammatory properties, may offer additional benefits in reducing pain and facilitating stone passage.

Objective: This study aimed to evaluate the efficacy of corticosteroids as adjunct therapy in pediatric renal colic, with a focus on pain reduction, analgesic requirement, and spontaneous stone expulsion rates.

Methodology: A quasi-experimental study was conducted at the Department of Urology, Khyber Teaching Hospital Peshawar over a two-year period. A total of 121 children aged 5–15 years with ureteric stones ≤6 mm were included. Participants were allocated into two groups: one receiving corticosteroids (deflazacort) in combination with standard NSAID therapy, and the other receiving standard therapy alone. Pain intensity was measured using the Visual Analog Scale (VAS) at predefined intervals, and patients were followed for two weeks to assess stone passage.

Results: The mean age of participants was 12.5±2.3 years, with a slight male predominance (53%). The corticosteroid group demonstrated significantly greater pain reduction at all time points ($p<0.01$), reduced analgesic requirements, and a higher spontaneous stone expulsion rate (89% vs. 60%, $p<0.01$). Additionally, the mean time to stone passage was significantly shorter in the intervention group (3.2±1.3 days vs. 5.8±1.5 days, $p<0.01$). Adverse effects were minimal, with transient hyperglycemia observed in a small proportion of patients receiving corticosteroids.

Conclusion: Adjunct corticosteroid therapy significantly improves pain control, reduces analgesic dependency, and enhances spontaneous stone expulsion in children with renal colic. These findings support the potential role of corticosteroids as an effective adjunct in pediatric renal colic management.

Keywords: Corticosteroids, NSAIDs, Pain management, Pediatric urolithiasis, Renal colic, Stone expulsion.

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Corresponding Author:
Dr. Tariq Ahmad
Assistant Professor,
Department of Peads Urology,
Khyber Teaching Hospital, Peshawar, Pakistan
drtaqriqurologistikd@gmail.com

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Introduction

Renal colic is a common and distressing urological emergency characterized by acute, severe pain resulting from urinary tract obstruction, most frequently due to ureteric calculi. It represents a significant global health burden, with an annual incidence of 1–5% in developed countries and a lifetime risk of up to 20% in men and 5–10% in women [1]. Ureteric stones account for approximately 75% of all urinary calculi, and their incidence is increasing due to evolving dietary patterns, sedentary lifestyles, and environmental factors [2]. In high-income European countries, more than 750,000 cases are reported annually, with recurrence rates approaching 25% [3]. The underlying pathophysiology involves increased intrarenal pressure, ureteral smooth muscle spasm, and local inflammatory responses, all contributing to the characteristic severe pain [4].

The primary objectives in the management of renal colic are rapid pain relief and facilitation of spontaneous stone passage. Non-steroidal anti-inflammatory drugs (NSAIDs), including ibuprofen, diclofenac, and ketorolac, are considered first-line agents due to their ability to inhibit prostaglandin synthesis and reduce inflammation-mediated pain [5]. However, NSAIDs are associated with potential adverse effects such as gastrointestinal bleeding, renal dysfunction, and cardiovascular complications, particularly with repeated or high-dose use [6]. Opioids, although effective for severe pain, are limited by side effects including nausea, respiratory depression, and risk of dependency [7]. Additionally, pharmacological agents such as alpha-blockers and calcium channel blockers have been used to facilitate ureteral relaxation and enhance stone expulsion, though their efficacy in pediatric populations remains variable [8,9].

Corticosteroids have emerged as a potential adjunct therapy in renal colic due to their potent anti-inflammatory effects. They reduce ureteral wall edema, decrease intrarenal pressure, and suppress inflammatory mediators such as prostaglandins and leukotrienes [10,11]. These mechanisms may not only alleviate pain but also improve ureteral patency, thereby enhancing spontaneous stone passage [12]. Several studies have suggested that corticosteroids, when combined with NSAIDs or alpha-blockers, may improve clinical outcomes in renal colic; however, the evidence remains inconsistent and largely derived from adult populations [13,14]. Consequently, corticosteroids are not routinely included in standard treatment guidelines due to the lack of robust, large-scale randomized controlled trials [15].

In pediatric populations, where minimizing drug-related adverse effects is particularly important, the potential role of corticosteroids warrants further investigation. This study was therefore designed to evaluate the efficacy of corticosteroids (deflazacort) as adjunct therapy in children with renal colic. Specifically, the study aimed to assess their impact on pain reduction using the Visual Analog Scale (VAS), total analgesic requirement within the initial hours of treatment, and spontaneous stone expulsion rates over a two-week follow-up period.

Methodology

Participants

This quasi-experimental study included pediatric patients aged 5–15 years presenting with acute renal colic secondary to ureteric stones ≤6 mm, confirmed through imaging. Participants were recruited consecutively from the emergency department of a tertiary care hospital after meeting predefined inclusion and exclusion criteria. Children with normal renal function and no prior history of chronic kidney disease were eligible, while those with larger stones, urinary tract infections, anatomical abnormalities, contraindications to corticosteroids, or recent recurrent stone episodes were excluded. Written informed consent was obtained from parents or guardians, and assent was obtained from children when appropriate.

Interventions

Participants were allocated into two treatment groups based on a non-random assignment approach at the time of clinical management. The intervention group received oral deflazacort (0.9 mg/kg/day) for three days in addition to standard therapy, which included weight-based NSAID analgesics and supportive hydration. The control group received standard therapy alone, consisting of NSAIDs and hydration according to institutional protocols. Both groups were managed under similar clinical conditions with identical follow-up schedules to ensure comparability.

Outcomes

The primary outcomes included pain reduction and spontaneous stone expulsion. Pain intensity was assessed using the Visual Analog Scale (VAS) at baseline and at multiple time intervals (30 minutes, 1 hour, 3 hours, and 6 hours post-treatment). Secondary outcomes included total analgesic requirement within the first 6 hours, time to stone expulsion, and incidence of adverse effects. Stone passage was evaluated over a two-week follow-up period using patient-reported outcomes (urine straining) and imaging confirmation where clinically indicated.

Sample Size

A total of 121 participants were included in the study, with 61 patients in the intervention group and 60 in the control group. The sample size was determined based on feasibility and patient availability during the study period, while ensuring sufficient statistical power to detect clinically meaningful differences between groups.

Assignment Method

A non-random, quasi-experimental allocation method was employed, where participants were assigned to treatment groups based on clinical decision-making at presentation. This approach reflects real-world clinical practice but introduces potential selection bias, which was addressed through baseline comparability assessment.

Blinding

Blinding was not implemented in this study due to the nature of the intervention and clinical setting. Both participants and treating physicians were aware of the treatment allocation, which may introduce performance and assessment bias, particularly in subjective outcomes such as pain scoring.

Unit of Analysis

The primary unit of analysis was the individual participant. Repeated measurements of pain scores over time were analyzed within participants to assess longitudinal changes, while between-group comparisons were conducted at the group level.

Statistical Methods

Continuous variables were summarized as mean ± standard deviation or median with interquartile range, depending on data distribution, while categorical variables were expressed as frequencies and percentages. Between-group comparisons were performed using independent t-tests or Mann–Whitney U tests for continuous variables and chi-square or Fisher's exact tests for categorical variables. Repeated measures of pain scores were analyzed using repeated-measures ANOVA or linear mixed-effects models to account for within-subject correlations over time. A p-value of <0.05 was considered statistically significant, and all analyses were conducted using SPSS software.

Results

Participant Flow

A total of 121 eligible pediatric patients diagnosed with renal colic were enrolled in the study over the study period. All participants were allocated into two groups using a non-randomized approach: 61 patients received corticosteroids in addition to standard therapy, while 60 patients received standard therapy alone. There were no reported dropouts during the acute observation period; all participants were included in the primary analysis. Follow-up for stone expulsion was completed for the majority of participants over the two-week period, with consistent monitoring protocols applied across both groups.

Recruitment

Participants were recruited consecutively from the emergency department of the study setting between June 2022 and June 2024. Recruitment followed a standardized screening protocol to ensure eligibility criteria were met, including confirmation of ureteric stones ≤6 mm and clinical presentation consistent with acute renal colic. The recruitment strategy ensured representation across age groups and both genders, enhancing the external validity of the findings.

Baseline Data

The study population had a mean age of 12.5±2.3 years, with 53% males and 47% females. The distribution of stone size, location, and baseline pain scores was comparable across groups. The mean baseline VAS pain score was 8.1±1.3 in the corticosteroid group and 8.0±1.2 in the standard therapy group. Detailed demographic and clinical characteristics are presented in Table 1.

Baseline Equivalence

Statistical analysis confirmed no significant differences between the intervention and control groups at baseline across key variables, including age ($p=0.78$), gender distribution ($p=0.72$), stone size ($p=0.65$), stone location ($p>0.05$), and baseline pain scores ($p=0.53$). This comparability suggests that the groups were well balanced prior to intervention, supporting the validity of subsequent outcome comparisons (Table 1).

Numbers Analyzed

All 121 participants were included in the final analysis, with 61 in the corticosteroid group and 60 in the standard therapy group. Analyses were conducted on a complete-case basis, as no significant missing data were reported for primary outcomes. Subgroup analyses based on stone size were also performed, as reflected in Tables 3 and 4.

Outcomes and Estimation

The addition of corticosteroids resulted in significantly improved clinical outcomes. Pain reduction was more rapid and pronounced in the corticosteroid group at all measured time points (30 minutes to 6 hours), with statistically significant differences ($p<0.01$) compared to the control

group (Table 2, Figure 1). The mean pain score at 6 hours was substantially lower in the intervention group (2.1±0.6) compared to the control group (4.3±0.9).

Spontaneous stone expulsion rates were significantly higher in the corticosteroid group (89%) compared to the standard therapy group (60%) ($p<0.01$), with consistent findings across stone size categories (Table 3). Additionally, the mean time to stone expulsion was significantly shorter in the corticosteroid group (3.2±1.3 days) compared to the control group (5.8±1.5 days) ($p<0.01$) (Table 4).

Furthermore, the total analgesic requirement within the first 6 hours was significantly reduced in the corticosteroid group (1.2±0.5 doses vs. 2.6±0.8 doses, $p<0.01$), and fewer patients required rescue opioid therapy (13% vs. 32%, $p<0.05$) (Table 5). These findings indicate both statistical and clinical significance in favor of corticosteroid use.

Ancillary Analyses

Subgroup analyses based on stone size demonstrated that patients with smaller stones (≤4 mm) had higher expulsion rates and shorter expulsion times compared to those with larger stones (>4 mm to ≤6 mm) in both groups. However, the corticosteroid group consistently showed superior outcomes across all subgroups, reinforcing the robustness of the intervention effect (Tables 3 and 4).

Adverse Events

The incidence of adverse events was low and comparable between groups. Mild gastrointestinal discomfort was the most frequently reported side effect in both groups (18% in the corticosteroid group vs. 15% in controls, $p=0.72$). Transient hyperglycemia was observed only in the corticosteroid group (11%, $p<0.05$), but it was clinically mild and did not require intervention. No serious adverse events were reported during the study period, indicating that the intervention was generally safe and well tolerated (Table 6).

Table 1. Comparison of demographic and clinical characteristics of patients of both treatment groups

Parameter	Steroid + Standard Therapy Group (n=61)	Standard Therapy Group (n=60)	p-value
Mean Age (years ± SD)	12.7 ± 2.5	12.3 ± 2.2	0.78 (NS)
Male, n (%)	33 (54.1)	31 (51.7)	0.72 (NS)
Female, n (%)	28 (45.9)	29 (48.3)	0.72 (NS)
Mean Stone Size (mm ± SD)	4.5 ± 1.1	4.6 ± 1.0	0.65 (NS)
Proximal Ureteral Stones, n (%)	19 (31.1)	21 (35.0)	0.61 (NS)
Middle Ureteral Stones, n (%)	17 (27.9)	15 (25.0)	0.70 (NS)
Distal Ureteral Stones, n (%)	25 (41.0)	24 (40.0)	0.88 (NS)
Baseline Pain Score (VAS ± SD)	8.1 ± 1.3	8.0 ± 1.2	0.53 (NS)

Table 2. Mean pain scores (VAS scale) at different time intervals for patients in both treatment groups

Time Interval	Steroid + Standard Therapy (VAS ± SD)	Standard Therapy (VAS ± SD)	p-value
Baseline	8.1 ± 1.3	8.0 ± 1.2	0.53 (NS)
30 min	6.3 ± 1.1	7.5 ± 1.0	<0.01**
1 hour	4.8 ± 0.9	6.2 ± 1.1	<0.01**
3 hours	3.2 ± 0.8	5.1 ± 1.0	<0.01**
6 hours	2.1 ± 0.6	4.3 ± 0.9	<0.01**

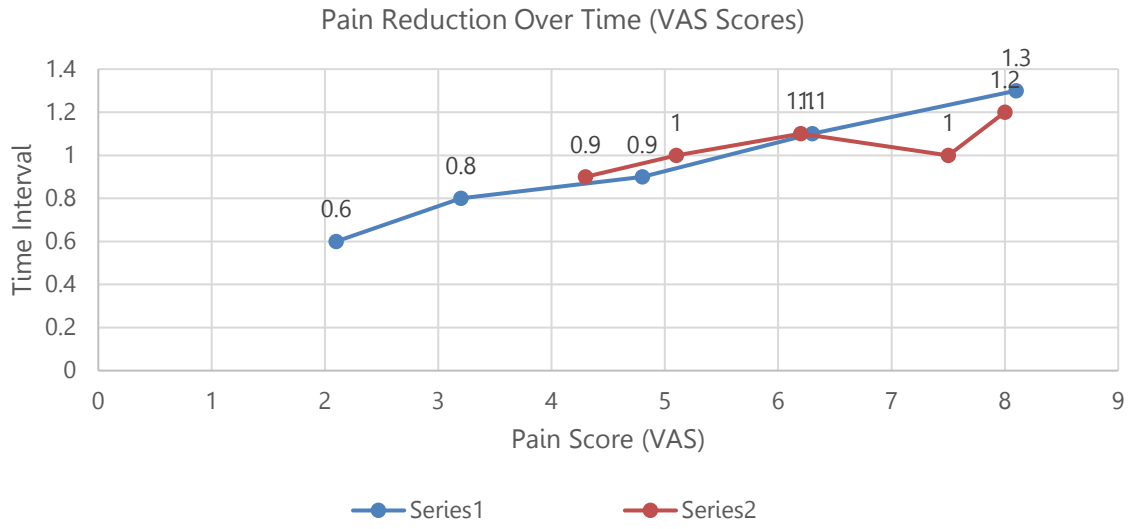


Figure 1. Mean VAS pain scores at baseline, 30 minutes, 1 hour, 3 hours, and 6 hours after treatment initiation in both treatment groups. Error bars represent standard deviation

Table 3. Spontaneous stone passage within two weeks, stratified by stone size

Parameter	Steroid + Standard Therapy (n=61)	Standard Therapy (n=60)	p-value
Overall stone passage	89% (54/61)	60% (36/60)	<0.01
Stones ≤4 mm	98% (40/41)	86% (32/37)	<0.05
Stones >4 mm to ≤6 mm	64% (13/20)	38% (9/23)	<0.05

Table 4. Mean time to stone passage (days) in both treatment groups, stratified by stone size

Parameter	Steroid + Standard Therapy (Mean ± SD, days)	Standard Therapy (Mean ± SD, days)	p-value
Time to Expulsion (All Stones)	3.2 ± 1.3	5.8 ± 1.5	<0.01**
Time to Expulsion (Stones ≤4 mm)	2.5 ± 1.1	4.3 ± 1.4	<0.01**
Time to Expulsion (Stones >4 mm to ≤6 mm)	4.8 ± 1.6	7.2 ± 1.9	<0.05**

Table 5. Comparison of NSAID doses required within 6 hours and the percentage of patients needing opioid rescue therapy in each group

Parameter	Steroid + Standard Therapy	Standard Therapy	p-value
Total NSAID Doses in 6 Hours (Mean ± SD)	1.2 ± 0.5	2.6 ± 0.8	<0.01**
Patients Requiring Rescue Opioids (%)	8 (13)	19 (32)	<0.05**

Table 6. Incidence of gastrointestinal discomfort, transient hyperglycemia, and dizziness/headache in both groups

Adverse Effect	Steroid + Standard Therapy (%)	Standard Therapy (%)	p-value
Mild GI discomfort (nausea, dyspepsia)	11 (18)	9 (15)	0.72 (NS)
Transient Hyperglycemia	7 (11)	0 (0)	<0.05**
Dizziness/Headache	4 (7)	6 (10)	0.68 (NS)

Discussion

This quasi-experimental study evaluated the efficacy of corticosteroids as adjunct therapy in the management of pediatric renal colic and demonstrated that the addition of deflazacort to standard NSAID therapy significantly improved clinical outcomes. Patients receiving corticosteroids experienced more rapid and sustained pain relief, reduced analgesic requirements, and higher spontaneous stone expulsion rates compared to those receiving standard therapy alone. These findings suggest that corticosteroids may play a meaningful role in optimizing the management of renal colic in children.

Pain in renal colic is primarily driven by ureteral obstruction, increased intrarenal pressure, and an associated inflammatory response. NSAIDs remain the first-line treatment due to their inhibition of prostaglandin synthesis, which reduces inflammation and nociceptive signaling [23]. However, the enhanced pain relief observed in the corticosteroid group in this study supports the hypothesis that targeting inflammation through additional mechanisms may provide superior symptom control. Corticosteroids exert potent anti-inflammatory effects by suppressing multiple inflammatory pathways, including prostaglandin and leukotriene synthesis, thereby reducing ureteral edema and local tissue irritation [11]. This dual anti-inflammatory action likely explains the significantly lower pain scores observed at all time points in the intervention group.

The higher rate of spontaneous stone expulsion observed in the corticosteroid group (89% vs. 60%) is clinically noteworthy. While corticosteroids are not traditionally considered first-line agents for facilitating stone passage, their ability to reduce ureteral wall edema may improve luminal patency and decrease resistance to stone movement. Previous studies, particularly in adult populations, have reported mixed results regarding the role of corticosteroids in medical expulsive therapy [16,17]. Current guidelines do not universally recommend corticosteroids due to inconsistent evidence and limited pediatric data [18,9]. However, the findings of this study contribute important evidence suggesting that corticosteroids may enhance stone passage, particularly in smaller stones, consistent with known patterns of spontaneous expulsion [19,10].

The significantly shorter time to stone expulsion in the corticosteroid group further supports their potential role in accelerating recovery. Reduction in peri-stone inflammation may facilitate earlier resolution of obstruction, leading to faster clinical improvement. Similar observations have been reported in studies evaluating anti-inflammatory adjuncts in renal colic, although effect sizes vary depending on study design and patient population [20,21]. Given the quasi-experimental nature of this study, residual confounding cannot be excluded, but the consistency of findings across multiple outcomes strengthens the observed association.

Another important finding was the reduced requirement for additional analgesics and opioid rescue therapy in the corticosteroid group. This has practical implications in pediatric care, where minimizing exposure to repeated analgesic dosing and opioids is particularly desirable. Reduced analgesic burden not only improves patient comfort but may also decrease the risk of drug-related adverse effects. However, corticosteroid use was associated with transient hyperglycemia in a small proportion of patients, consistent with known metabolic effects of systemic glucocorticoids [22]. These effects were mild and did not require intervention, suggesting that short-term use is generally safe when appropriately monitored.

The findings of this study support the biological plausibility that corticosteroids improve outcomes in renal colic primarily through anti-inflammatory mechanisms, rather than direct effects on ureteral smooth muscle. By reducing edema and inflammation around the obstructing stone, corticosteroids may enhance both symptom relief and stone passage, providing a complementary approach to standard NSAID therapy.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the quasi-experimental design with non-randomized allocation introduces the possibility of selection bias and limits the ability to establish causal relationships. Although baseline characteristics were comparable between groups, unmeasured confounding factors may have influenced the outcomes. Second, the absence of blinding may have introduced performance and assessment bias, particularly in subjective outcomes such as pain measurement using the Visual Analog Scale.

Third, the sample size, while adequate for detecting overall differences, may limit the power of subgroup analyses, particularly when stratified by stone size or location. Fourth, follow-up duration was limited to two weeks, restricting the assessment of long-term outcomes such as recurrence rates or delayed adverse effects. Fifth, imaging confirmation of stone passage was not uniformly applied to all

participants, as ultrasound and clinical assessment were used in many cases, which may affect the precision of outcome classification.

Additionally, adherence to medication was not objectively verified, which may influence the observed treatment effects. Finally, the study was conducted at a single center, which may limit the generalizability of the findings to other settings or populations.

Conclusion

In conclusion, the addition of corticosteroids (deflazacort) to standard NSAID therapy was associated with significantly improved clinical outcomes in children with renal colic. Patients receiving adjunct corticosteroid therapy experienced faster and greater pain relief, reduced analgesic requirements, and higher rates of spontaneous stone expulsion within a short follow-up period. These findings suggest that corticosteroids may serve as an effective adjunct in the management of pediatric renal colic, particularly in cases involving small ureteric stones.

Authors' Contributions:

All authors meet the ICMJE criteria for authorship.

Author 1: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 2: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 3: Analysis and interpretation of data, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 4: Analysis and interpretation of data, critical revision, final approval, agreed to be accountable for all the work.
Author 5&6: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 7&8: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.

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