RESEARCH ARTICLE

Hospital Course of Croup After Emergency Department Management

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ABSTRACT

OBJECTIVES: To describe inpatient management of patients with croup admitted from the emergency department (ED).

METHODS: In a multicentered, cross-sectional observational study based on retrospective chart review, we identified children 6 months to 5 years of age with a discharge diagnosis of croup. All patients were evaluated in the ED and treated with at least 1 dose of racemic epinephrine (RE) before admission. Children with hypoxia or directly admitted to the PICU were excluded.

RESULTS: We identified 628 admissions for croup. Significant interventions, defined as additional RE, helium-oxygen use, or PICU transfer, occurred in 142 patients (22.6%). A total of 137 children received additional RE on the inpatient ward, and 5 received RE and were transferred to the PICU. No patient was treated with helium-oxygen. A total 486 (77.4%) of patients did not receive significant interventions postadmission. Length of stay for children not requiring significant intervention was, on average, <24 hours (18.8 hours [SD 9.3]; range 1.2–111 hours). Children with tachypnea (odds ratio = 2.5; $P = .002$) on arrival to ED and patients who had ED radiographs (odds ratio = 1.7; $P = .018$) had increased odds of receiving a significant intervention after admission.

CONCLUSIONS: Less than one-quarter of children admitted to the general wards for croup received significant interventions after admission. Tachypnea in the ED and use of radiograph were associated with an increased use of significant interventions.

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Croup, or acute laryngotracheitis, is a common pediatric illness that can range in severity from rhinorrhea and a barky cough to stridor, respiratory distress, and, in extreme cases, airway obstruction. Hospital admission rates have varied widely, from 1% to 31% in older studies.[1,2] Authors of a recent study including data from 26 pediatric hospitals across the United States found a median admission rate of 9.1% and significant variations in management between hospitals in inpatient care of croup.[3]

Outpatient management of croup in the clinic, urgent care, or emergency department (ED) is well described and includes corticosteroids for croup of all severities and nebulized inhaled epinephrine for patients presenting with audible stridor. Racemic epinephrine (RE) has been shown to significantly improve croup scores 30 minutes after administration compared with a placebo but with no measurable difference 2 hours posttreatment, suggesting that the effect is transient.[2] RE however effectively bridges the time to the observed effect of concurrently administered glucocorticoid steroids. Discharge after 1 dose of RE and ∼3 hours of observation has been shown to be safe and associated with few revisits.[4–7]

However, there is a paucity of data or clinical practice guidelines used to describe inpatient management of croup. Many physicians choose to admit children requiring >1 RE nebulization.

The primary objective of this study was to evaluate the inpatient course and management of patients admitted with croup, focusing specifically on the subset of patients who were not critically ill. We aimed to study the inpatient course and evaluate what proportion of admitted patients received significant interventions specified as RE, helium-oxygen (heliox), or transfer to an ICU from the inpatient ward. We also aimed to evaluate any association between ED presentation and course and subsequent inpatient course. We hypothesized that most children would not require any significant interventions after admission. Second, we sought to determine if ED presentation and course could predict the presence of more interventions after admission.

METHODS

We conducted a multicentered, cross-sectional observational study based on retrospective chart review involving 3 pediatric tertiary care children's hospitals in Minnesota with a combined annual ED census of ∼115 000. The study period was March 1, 2011 to September 30, 2015. Identification of subjects was based on primary discharge diagnosis of croup (*International Classification of Diseases, Ninth Revision* code of 464.4) and if subjects met the following inclusion criteria: (1) evaluated by the participating ED; (2) treated with at least 1 RE dose in the ED; (3) age 6 months to 5 years of age; and (4) admitted to the hospital. Children were excluded if they had a history of congenital anomalies of the airway, previous tracheal surgery, required supplemental oxygen in the ED (saturation <90%), or were directly admitted to the PICU. At 2 children's hospitals, a data specialist programmed the electronic health record to obtain the clinical data set. From this data set, charts were individually reviewed wherever there were missing data or uncertainty about management. The third hospital's data were hand abstracted from *International Classification of Diseases, Ninth Revision* codes.

Significant interventions were defined as any number of inpatient RE, heliox treatment, or transfer to the PICU. Tachycardia and tachypnea were defined per age (Supplemental Table 5) and correspond largely with the 90th percentile for children presenting to the ED, fever was defined as a temperature ≥38°C, and an abnormal pulse oximetry was defined as <95% on room air.[8,9]

If a patient had multiple hospitalizations (5.4% of analysis sample), 1 admission was randomly selected by using a random number generator (https://www.random.org). This procedure allowed data interpretation as patients rather than admissions. The study was approved by institutional review boards at each site.

Descriptive statistics include mean, SD, median, and minimum and maximum for continuous variables, and the sample size and percentage for categorical variables. χ^2 tests and 2-sample t tests were used to evaluate unadjusted associations between the need for significant intervention after hospitalization for categorical and continuous variables, respectively. The nonparametric Wilcoxon rank-sum test was used to evaluate the associations between the need for significant intervention and hospital length of stay (LOS) and number of RE doses in the ED, which had skewed distributions. The nonparametric Kruskal-Wallis test was used to compare hospital LOS distribution between 3 groups: no additional RE needed, 1 additional dose of RE, 2 or more additional doses of RE after hospital admission. Post hoc Wilcoxon rank-sum tests with Bonferroni adjustment for multiple comparisons were used for pairwise comparisons of hospital LOS distribution. A multiple logistic regression model was used to estimate odds ratios (ORs) (95% confidence intervals) for significant hospital intervention adjusted for patient demographic characteristics, ED vitals, and ED treatments. Patients with missing data were not included in the logistic regression analysis. A significance level of $\alpha = .05$ was used to determine statistical significance for all tests and model estimates. SAS version 9.4 (SAS Institute, Inc, Cary, NC) was used for all analyses.

RESULTS

ED Presentation and Course

We identified 702 patient visits between March 1, 2011, and September 30, 2015, who met inclusion criteria. Twenty patients were admitted directly to the PICU, and 12 had oxygen saturation <90% on room air and were not included in the analysis. Forty patients had multiple visits during the study period, and after randomly selecting 1 admission, the final cohort was 628 patients. A total of 403 (64.2%) patients were boys (Table 1). The overall mean age in months was 17.9 (SD 7.2). The number of nebulized RE given in the ED ranged between 1 and 3 (mean 1.77; SD 0.61). Thirty-three percent of patients required 1 RE in the ED, 58% required 2, and 9% required 3.

Most children (81.5%) received dexamethasone in the ED, with 18.5% who received it before presentation from a clinic

TABLE 1 Descriptive Statistics of Patients With Croup ($N = 628$)

Demographic Characteristics	All Patients
Sex, *n* (%)	
Girls	225 (35.8)
Boys	403 (64.2)
Age, mo	
Mean (SD)	17.9 (7.2)
Median (range)	16.9 (6.0–45.7)
Age group,[a] *n* (%), mo	
6–<12	150 (23.9)
12–<18	193 (30.7)
18–<24	160 (25.5)
24–<30	84 (13.4)
30–<36	37 (5.9)
36–46	4 (0.6)
ED vitals,[b] treatment, imaging	
Heart rate ($n = 602$), beats per minute	
Mean (SD)	152.9 (21.9)
Median (range)	152 (36–212)
Age-defined tachycardia,[c] *n* (%)	287 (47.7)
Respiratory rate ($n = 595$)	
Mean (SD)	38.3 (8.9)
Median (range)	38.0 (20–68)
Age-defined tachypnea,[d] *n* (%)	430 (72.3)
Temperature ($n = 553$)	
Mean (SD)	37.6 (1.0)
Median (range)	37.4 (35.7–41.1)
Temperature ≥38°C, *n* (%)	169 (30.6)
O_2 saturation ($n = 572$)	
Mean (SD)	97.9 (1.7)
Median (range)	98 (91–100)
O_2 saturation 91%–94%, *n* (%)	21 (3.7)
No. RE doses in ED[e]	
Mean (SD)	1.77 (0.61)
Median (range)	2 (1–3)
1 RE dose in ED, *n* (%)	206 (32.8)
2 RE doses in ED, *n* (%)	362 (57.6)
3 RE doses in ED, *n* (%)	60 (9.6)
Other treatments in ED, *n* (%)	
Steroids	512 (81.5)
Antibiotics	11 (1.8)
Bronchodilators	40 (6.4)
Any of steroids, antibiotics, and/or bronchodilators	517 (82.3)
Imaging, *n* (%)	
Radiograph neck only	151 (24.0)
Radiograph chest only	29 (4.6)
Radiograph neck and chest	72 (11.5)
Any radiograph	252 (40.1)

or urgent care. A total of 252 (40.1%) patients had imaging performed in the ED, most commonly radiographs of the neck ($n = 223$; 35.5%) (Table 1). A total of 101 children had chest radiographs performed. Twelve percent of patients were missing 1 or more elements of triage vital signs (Table 1).

Inpatient Course

Patient disposition from ED and those who had significant interventions can be seen in Fig 1. From the cohort, 486 children (77.4%) did not receive any significant interventions after admission. Significant interventions occurred in 142 patients (22.6%). All of these patients received additional RE, and 5 were also transferred to the PICU. No one received heliox. The majority of patients who received an inpatient intervention received a single dose of RE (89 patients; 62.7%). The median number of RE after admission among those with a significant intervention was 1 (mean = 1.8; range 1–17) (Table 2). All children were discharged with a primary diagnosis of croup, but many had additional diagnoses. The most common additional diagnoses were acute upper respiratory infection or viral infection not otherwise specified, which was diagnosed in 220 children (35%). One child was diagnosed with pneumonia in addition to croup. No one had an additional diagnosis of epiglottitis, bacterial tracheitis, or other cause of stridor. We also discovered that 20 children (3.2%) had a history of asthma, 51 (8.1%) had a history of perinatal problems (2 also had asthma), 7 (1.1%) had laryngotracheal anomalies that were not excluded (1 also had asthma), and 14 (2.2%) had developmental delays categorized as not otherwise specified ($n = 6$; 1 also had asthma), other congenital anomaly ($n = 1$), or Down syndrome ($n = 7$; 1 also had asthma).

Hospital LOS

The overall mean hospital LOS, as seen in Table 1, was 22.8 hours (SD 17.8; range 1.2–285.8 hours; median 18.7 hours). The mean LOS was almost twice as long at 36.5 hours (SD 29.6; range 6.7–285.8 hours; median 27.7 hours) for patients with significant interventions as compared with 18.8 hours (SD 9.3; range 1.2–111.4 hours; median 17 hours) for patients who did not receive significant interventions ($P <$

TABLE 1 Continued

Demographic Characteristics	All Patients
Hospital LOS and interventions, h	
Mean (SD)	22.8 (17.8)
Median (range)	18.7 (1.2–285.8)
Heliox[f] after admission, *n* (%)	0 (0.0)
Transfer to PICU from floor, *n* (%)	5 (0.8)
Significant intervention after admission	
Any of RE, heliox,[f] or transfer to PICU, *n* (%)	142 (22.6)
Other interventions after admission, *n* (%)	
Steroids	273 (43.5)
Antibiotics	53 (8.4)
Bronchodilators	27 (4.3)
Any of steroids, antibiotics, and/or bronchodilators	309 (49.2)

[a] 99.4% of patients were <3 y.
[b] The number for initial vitals is <628 because of missing data for some patients.
[c] Age-defined tachycardia is 2 or more SEs above the mean heart rate for age.
[d] Age-defined tachypnea is 2 or more SEs above the mean respiratory rate for age.
[e] All patients had at least 1 RE treatment in ED; the maximum number of RE doses in ED was 3.
[f] No patients were treated with heliox after admission.

.0001 for Wilcoxon rank-sum test, Table 3). Median hospital LOS increased monotonically with an increasing number of RE doses after admission: 17.0 hours for those with no additional RE, 23.5 hours for those with 1 additional RE dose, and 42.7 hours for those with 2 or more doses of RE postadmission. The Kruskal-Wallis test of hospital LOS distribution differences was significant ($P < .0001$); post hoc Wilcoxon rank-sum tests with Bonferroni adjustment for multiple comparisons were used to identify significant differences in hospital LOS distribution between all 3 RE groups.

Univariate Analysis and Logistic Regression

Comparisons of patient characteristics for children who did not require significant interventions versus those who received significant interventions are provided in Table 3. Patients were more likely to receive significant interventions if they had tachycardia, tachypnea on arrival to ED, and if they had any ED radiographs of the neck or chest. A logistic regression model was used to estimate ORs of significant intervention after admission adjusted for patient characteristics and ED interventions.

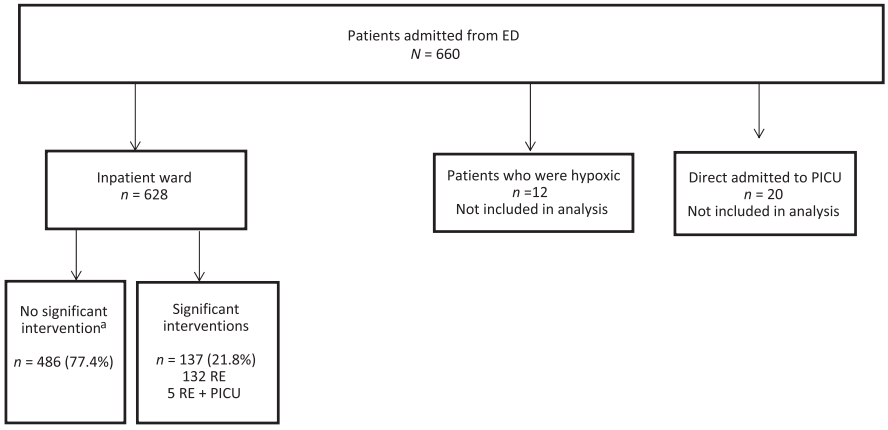

FIGURE 1 Patient flow after ED management. [a] Did not require RE after admission or transfer to PICU. [b] Met criteria for significant intervention ($n = 142$; 22.6%).

Adjusted for other factors in the model, tachypnea ($P = .002$) and use of imaging in the ED ($P = .018$) were significantly associated with significant inpatient interventions (Table 4). The number of RE administered in the ED was not significantly associated with odds of significant inpatient interventions.

DISCUSSION

In our cohort of 628 children admitted to the regular inpatient floor with croup, >3 quarters (77.4%) did not receive any significant interventions after admission from the ED. Of the children receiving interventions after admission, the majority (62.7%) received a single dose of RE, but a minority (20.4%) were treated with a considerable number of RE doses or were transferred to the PICU. Our proportion of children receiving no further RE nebulization is higher than in previous studies of inpatient management of croup by Narayanan and Funkhouser[10] and Rudinsky et al[11] who reported rates of 51% and 34%, respectively. Our cohort before excluding patients who were hypoxic or directly admitted to the PICU consisted of 660 patients, 25(3.8%) of whom were admitted to the PICU at some point during their stay. This is lower than the average of 9% that Tyler et al[3] reported. Whether this implies a more stringent use of resources after admission or a lower threshold to admit is hard to speculate because neither we nor Narayanan and Funkhouser[10] or Rudinsky et al[11] reported the proportion of patients presenting to the ED with croup being admitted, but it is noteworthy that almost one-third of our patients were admitted after only 1 RE nebulization in the ED. Tyler et al[3] reported a significant variation in the management of croup between hospitals, and our results may also reflect the lack of published data to guide physicians caring for children with croup.

In our study, hospital LOS was significantly shorter for children not treated with RE after admission. We found that each additional administration of RE was associated with increased time spent as an inpatient, with median LOS being 6 hours longer for patients receiving 1 dose of RE compared with none and 25 hours longer

TABLE 2 Additional RE Doses After Admission

	All Patients	Patients with Significant Interventions
No. patients	628	142
Mean (SD)	0.41 (1.16)	1.83 (1.82)
Median (range)	0 (0–17)	1 (1–17)
1 RE dose, *n* (%)	89 (14.2)	89 (62.7)
2 or more RE doses, *n* (%)	53 (8.4)	53 (37.3)
3 or more RE doses, *n* (%)	29 (4.6)	29 (20.4)
Any RE, *n* (%)	142 (22.6)	142 (100)

for patients receiving 2 or more doses of RE after admission. Several factors may be responsible for this increase, which is longer than the typically recommended observation time after RE treatment. Time of admission and workflow on the wards likely play a role because rounds and, subsequently, discharges are often performed in the mornings; thus, a child who receives another RE dose midday may not be discharged until the next morning.

Our secondary outcome was determining if ED management or presenting vitals could predict children requiring significant intervention posthospital admission. We found that children presenting with tachypnea and those with radiographs performed in ED had increased odds of a significant intervention posthospital admission. Although tachypnea is an unspecific finding associated with respiratory distress of many kinds, it is possible or even likely that children with an

TABLE 3 Patient Characteristics, ED Treatment, and Hospital LOS by Significant Intervention After Hospital Admission

	No Significant Interventions	Significant Intervention[a]	*P*[b]
No. patients	486	142	
Girls, *n* (%)	165 (34.0)	60 (42.3)	.070
Age, mo			.624
Mean (SD)	17.9 (7.3)	17.6 (6.8)	
Median (range)	17.1 (6.0–45.7)	16.5 (7.1–5.9)	
Age-defined tachycardia ($n = 602$[c]), *n* (%)	211 (45.5)	76 (55.1)	.048
Age-defined tachypnea ($n = 595$[c]), *n* (%)	316 (68.9)	114 (83.8)	<.001
ED triage temperature ≥38°C ($n = 553$[c]), *n* (%)	132 (30.8)	37 (29.8)	.843
ED triage O_2 saturation ($n = 572$[c])			.728
Mean (SD)	97.9 (1.7)	97.9 (1.7)	
Median (range)	98.0 (91–100)	98.0 (92–100)	
No. RE in ED			.143
Mean (SD)	1.7 (0.6)	1.8 (0.6)	
Median (range)	2.0 (1–3)	2.0 (1–3)	
RE in ED group, *n* (%)			.182
1 RE	164 (33.7)	42 (29.6)	
2 RE	281 (57.8)	81 (57.0)	
3 RE	41 (8.4)	19 (13.4)	
Imaging, *n* (%)			.006
Radiograph of neck or chest	181 (37.2)	71 (50.0)	
No radiograph	305 (62.8)	71 (50.0)	
Steroids in ED, *n* (%)			.241
No steroid treatment	85 (17.5)	31 (21.8)	
Any steroids in ED	401 (82.5)	111 (78.2)	
Hospital LOS			<.0001
Mean (SD)	18.8 (9.3)	36.5 (29.6)	
Median (range)	17.0 (1.2–111.4)	27.7 (6.7–285.8[d])	

[a] Significant intervention includes additional RE, transfer to PICU, or heliox (5 patients had additional RE and were transferred to the PICU, 137 patients had additional RE only, no patients were treated with heliox).

[b] *P* values are from χ^2 tests for categorical variables, 2-sample *t* tests of mean for patient age and O_2 saturation, and Wilcoxon rank-sum test for RE in ED and hospital LOS.

[c] The number for initial vitals is <628 because of missing data for some patients.

[d] Without the outlier value of 285.8 for hospital LOS, mean (SD) and median (range) for those with significant interventions were 34.8 (20.8) and 27.4 (6.7, 119.8), respectively. The Wilcoxon rank-sum test for hospital LOS was still significant when the outlier value was excluded ($P < .0001$).

TABLE 4 Logistic Regression Model for Significant Intervention (Any Versus None) After Admission Adjusted for Factors in the Model

Effect	Adjusted OR Estimate	95% Wald Confidence Limits		*P*
Age, each additional mo	1.001	0.972	1.030	.955
Sex, girls versus boys	1.187	0.772	1.826	.434
Age-defined tachycardia, yes versus no	1.212	0.777	1.892	.397
Age-defined tachypnea, yes versus no	2.496	1.406	4.430	.002
Temperature, ≥38°C vs <38°C	0.815	0.500	1.328	.411
O_2 saturation, 91%–94% vs ≥95%	1.227	0.418	3.598	.709
RE in ED, 3 RE vs 1–2 RE doses	1.812	0.943	3.482	.074
Steroids in ED, any steroid versus none	0.743	0.438	1.260	.270
Imaging, radiograph of neck, chest, or both versus no radiograph	1.680	1.094	2.580	.018

elevated respiratory rate had a more severe presentation of croup, which may be more likely to require further treatment.

Neck and chest radiographs can be an adjunct in the evaluation of croup if the diagnosis is unclear[12] but are not routinely indicated. In our study, 40.1% of children had some imaging performed, whereas only 1 child had an additional diagnosis of pneumonia. Causes of stridor other than croup include epiglottitis, bacterial tracheitis, or foreign body to name a few. By virtue of this study's inclusion criteria, children with a primary diagnosis other than croup would not have been included in the cohort, and it is beyond the scope of this study to determine the rate of children with crouplike symptoms eventually being diagnosed with a different etiology. In our study, however, we did find that children diagnosed with croup who had imaging performed in the ED were more likely to receive significant interventions after admission. We speculate that this subset of children may have presented with more severe symptoms, prompting the provider to evaluate for differential etiologies. It may also again point to the variation in care provided to children with croup.

This study has several limitations. Because of its retrospective nature, data were limited to administrative data completed with chart reviews. Missed cases from misidentification errors could have occurred. Children were included from 3 different hospitals without use of croup scores, uniform admission, inpatient, or discharge guidelines or protocols. This study was not powered enough to control potentially important factors such as individual clinician practice, time of the year, ED, or hospital census at the time of admission, to name a few. In addition, the administration of intravenous fluids was not included in the analysis, and although not typically indicated for croup, it is possible that some children's LOS was increased because of the need for intravenous hydration, which could have altered the results. As Tyler et al[3] pointed out, there is significant variation in croup treatment between hospitals, and this may also be true between different providers in the same hospital. A lack of standardization between or within hospitals may increase or decrease admission rates and LOS and even lead to the overtreatment of children with RE and could make the results less generalizable.

CONCLUSIONS

More than three-fourths of children admitted with croup after evaluation and treatment from 3 pediatric EDs received no significant interventions after admission. Predictors for significant interventions were tachypnea on initial vital signs and imaging performed in ED. Our results reveal the largest proportion of children admitted with croup receiving no further RE or other significant interventions after admission in studies to date. In our results, a need for the standardization of admission criteria and hospital-based interventions for croup is also suggested.

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