Original Article

Use of a standardized asthma severity score to determine emergency department disposition for paediatric asthma: A cohort study

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Abstract

Background: We recently introduced a clinical practice pathway for the management of asthma that uses the Pediatric Respiratory Assessment Measure (PRAM) to guide emergency department (ED) treatment and disposition. The pathway recommends discharge for patients who achieve improvement to PRAM <4 at 1 hour after the last bronchodilator. We evaluated practice variation and patient outcomes associated with PRAM-directed disposition recommendations.

Methods: We conducted a retrospective cohort study of children aged 2 to 17 years treated for moderate asthma (PRAM score 4–7) using our asthma clinical pathway. We measured 1) the proportion of children discharged per pathway criteria who returned to our ED within 24 hours and 2) the proportion of children observed beyond the pathway discharge criteria who deteriorated (PRAM ≥4).

Results: We analyzed 385 patient records from September 2013 to February 2015. Among 145 (37.7%) patients discharged per pathway criteria, 4 (4/145; 2.8%) returned within 24 hours. The remaining 240 (62.2%) were observed beyond the pathway discharge criteria; 76/240 (31.7%) had a subsequent deterioration (PRAM score ≥ 4) and 25/240 (10.4%) were hospitalized. Of those who deteriorated, 46/76 (60.5%) worsened within the first additional hour of observation.

Conclusion: We observed significant deviation from our PRAM-directed pathway discharge criteria and that a significant proportion of observed patients experienced clinical deterioration beyond the first hour of observation. We recommend observing children with moderate asthma for 2 or 3 hours from last bronchodilator therapy if PRAM < 4 is maintained, to capture the majority (97.7% or 99.7%) of patients who require further intervention and hospitalization.

Keywords: *Asthma; Clinical decision tool; Disposition from emergency.*

Asthma exacerbations are a common problem seen in the paediatric emergency department (PED), as well as the leading cause of hospitalization (1). Management of acute asthma exacerbation is associated with significant practice variation with regard to both treatment and disposition decisions (2). Early accurate assessment of severity and institutionally developed clinical management pathways help standardize the management of

acute asthma exacerbations to provide consistent and effective treatment in the PED (3). Several clinical assessment tools are available and have been compared for both initial assessment of an asthma exacerbation and subsequent assessment of response to treatment. The Pediatric Respiratory Assessment Measurement (PRAM) score is reliable to assess the severity of an acute asthma exacerbation and is sensitive to changes in

clinical status (4–7). In 2013, an asthma clinical pathway was introduced to our PED that uses the PRAM score documented by nursing staff for the assessment of disease severity, treatment, as well as for disposition decisions upon reassessment (Supplementary Appendix 1). The pathway was developed using an already established treatment and disposition protocol previously implemented at other children's hospitals in Canada. Pathway implementation utilized a step wise approach, including a divisional meeting soliciting feedback and concluding with group consensus, development of a preprinted order sheet, and posters with the asthma pathway to facilitate use amongst the group.

Our asthma pathway for patients with moderate asthma presentations (PRAM 4–7) suggests that upon completion of three initial treatments with inhaled bronchodilators and a dose of oral corticosteroid, patients receive hourly bronchodilator treatment and assessment until a PRAM score of <4 ('mild' distress) is maintained for one hour after treatment, at which time discharge from the PED is recommended. Hospitalization is recommended for a PRAM score >3, 6 hours after the oral corticosteroid has been given. Our pathway was modelled on a similar pathway used by children's hospitals in Calgary and Edmonton which also use PRAM-directed disposition guides and at the time, 1 hour from last bronchodilator once a PRAM < 4 was achieved was accepted as appropriate timing for disposition. Other children's hospitals in Canada also use PRAM for assessment and treatment but PRAM-based disposition timing varies between 1 and 3 hours after achieving mild disease severity. Currently, there are no empirical data to guide timing of disposition home using a PRAM based clinical pathway.

Following introduction of this care pathway we observed practice variation amongst clinicians with regard to disposition and the timing of discharge. Some clinicians expressed concern for clinical deterioration in the PRAM score beyond the 1-hour discharge criterion and before the usual 4-hourly dosing of bronchodilator typically advised upon discharge from the PED. These clinicians preferred to observe patients for a longer period of time, deviating from the protocol. We used this practice variation as an opportunity to study the outcomes of patients who reached mild disease severity as per the PRAM score, stratified by clinicians' adherence to the clinical pathway recommended disposition in order to evaluate the safety of PRAM-based disposition decisions.

METHODS

Study design, population, and setting

We conducted a retrospective cohort study using chart review at the BC Children's hospital PED, a major paediatric referral centre for BC with approximately 45,000 patient visits per year. In our review, we included children aged 2 to 17 years treated with our clinical pathway for moderate asthma exacerbation as

defined by a PRAM score of 4 to 7. We excluded any child with concurrent pneumonia treated with antibiotics, foreign body aspiration, anaphylaxis, sepsis, and significant comorbidity (e.g., congenital heart or chronic lung disease) that might affect the decision to admit to hospital. We also excluded patients who never reached a mild asthma status defined as a PRAM score of <4 that was maintained for at least 1 hour after the last bronchodilator treatment in the PED, those in whom PRAM scores were not recorded prior to each treatment, and those requiring adjunctive therapies in addition to the moderate asthma clinical pathway (magnesium sulfate, aminophylline, or noninvasive positive pressure ventilation).

Study outcomes

Primary outcomes

The primary outcome of this study was the frequency of clinical deterioration associated with adherence or nonadherence to clinical pathway disposition recommendations. This was defined as the proportion of patients with a return visit to the PED for respiratory distress within 24 hours of discharge among those discharged after maintaining a PRAM <4 for 1 hour after their last bronchodilator treatment (pathway adherent cohort) and the proportion of patients with subsequent PRAM score deterioration (PRAM $\geq$ 4 within the following 3 hours) for those patients who had met eligibility for discharge home as per the clinical pathway (PRAM <4, 1 hour postbronchodilator treatment) but were kept for longer observation at the physician's discretion (pathway deviation cohort). The goal of this study was to define a duration of observation that minimizes potentially adverse clinical outcomes.

Secondary outcomes

Other outcomes included the final PED disposition (home, ward, or ICU) and PED total length of stay (LOS) among patients who were observed beyond the pathway discharge criteria.

Study procedures

Ethics approval was obtained from the local research ethics board. Subjects were identified by review of our electronic administrative database. A patient list was generated using the following terms in the discharge diagnosis: asthma, wheeze, reactive airways disease, cough, respiratory distress, and work of breathing. We reviewed charts of all identified potential subjects and data were extracted for all children meeting inclusion criteria during the study period of September 2013 to February 2015.

The primary investigator trained three research assistants using sample charts. All four reviewers extracted data using a standardized online data collection tool. Any ambiguities encountered throughout the study were reviewed by the primary investigator. About 10% of the charts reviewed by the

research assistants were re-reviewed by the primary investigator for accuracy. All de-identified manually collected data was entered into RedCap, which is a secure password protected, web-based application designed exclusively to support data capture in clinical research studies.

Analyses

We used descriptive analyses to summarise our data. Binary variables were reported using proportions and 95% confidence intervals. Continuous variables are presented with means and 95% confidence intervals or medians with interquartile range (IQR) as appropriate.

When comparing LOS between subjects kept in the PED for prolonged observation versus those who are discharged as per the clinical pathway recommendation, we used the Mann–Whitney test, as LOS is not expected to be normally distributed. For patient emergency department (ED) disposition, we compared proportions using the chi-square test for 2 or more proportions. We used regression modelling in attempt to identify patient characteristics associated with adherence or non-adherence to clinical pathway.

Assuming that 50% (proportion resulting in the largest sample size requirement) of patients will worsen and reach a PRAM score >3 within 4 hours of their last treatment after having reached a PRAM of <4 an hour after their last treatment, aiming for a 90% confidence level with 5% precision, the largest sample size required given these criteria would be 271 subjects with pathway non-adherent management. Anticipating the proportion of subjects with deterioration to be lower than 50%, we estimated the study period to be 18 months, given the prevalence of asthma in our PED. If the proportion of patients who deteriorated within 4 hours is more or less than 50% then the required sample size will be lower than 271.

RESULTS

We reviewed 976 charts with an asthma-related PED visit for eligibility and 385 (39.4%) met inclusion criteria and were analyzed in this study. [Figure 1](#) shows the flow of study cases. Less than 30% (281/976) of screened charts were excluded due to incomplete documentation of clinical pathway adherence and PRAM scores. Baseline clinical characteristics and clinical asthma severity did not differ between patients who were discharged per the asthma pathway 1 hour after achieving and maintaining a PRAM <4 and those who were observed beyond the pathway discharge point ([Table 1](#)). Furthermore, regression analysis did not identify patient age, sex, presenting CTAS, PRAM on arrival, prearrival bronchodilator use, previous asthma-related hospitalizations or ICU stays, and time to PRAM <4 to be associated with adherence to the clinical pathway disposition recommendation.

Outcomes of clinical pathway adherent cohort

We identified 145 patients (37%) who were treated and discharged home within 1 hour of achieving and maintaining PRAM <4 in accordance with the current asthma clinical pathway. Their median total ED LOS was 3.9 hours (IQR 3.1, 4.9). Approximately 3% (4/145) patients in this cohort returned to the emergency department (RTED) within 24 hours for an asthma-related issue. All four RTEDs were subsequently discharged home in accordance with our pathway without prolonged observation at their return visit, and none had any further return visits. [Table 2](#) shows the patient and visit characteristics of the patients discharged home according to the clinical pathway stratified by their return outcome measure.

Figure 1. Overview of patients reviewed for the study. 385/976 patients met the inclusion criteria. The included patients were subsequently separated into the PRAM protocol adherence vs deviation groups. PRAM Paediatric respiratory assessment measure.

Table 1. Patient and visit characteristics stratified by adherence to ED disposition in accordance with the clinical pathway

Characteristics	All subjects 385	Clinical pathway adherent* 145 (37.0%)	Clinical pathway deviation 240 (63.0%)	P value
Mean Age years (SD)	5.1 (3)	5.3 (3)	5.0 (3)	0.34
Triage category				0.63
CTAS 2 (%)	358 (67.3%)	95 (65.5%)	163 (67.9%)	
CTAS 3 (%)	127 (33.3%)	50 (34.5%)	77 (32.1)	
Median PRAM** at arrival (IQR)	6 (5,6)	6 (5,6)	6 (5,6)	0.36
Median time to PRAM<4 in hours (IQR)	3.1 (2.5, 4.3)	3.1 (2.6, 4.1)	3.2 (2.4, 4.3)	0.95
Male (%)	69.4%	69.7%	69.2%	0.92
Disposition –				P<0.001
Home (%)	360 (93.5%)	145 (100%)	215 (89.6%)	
Ward (%)	25 (6.5%)		25 (10.4%)	
ICU (%)	0		0	
Previous hospitalizations				0.20
No (%)	295 (76.6%)	106 (73.1%)	189 (78.8%)	
Yes (%)	90 (23.4%)	39 (26.9%)	51 (21.2%)	
Previous ICU				0.93
No (%)	374 (97.1%)	141 (97.2%)	233 (97.1%)	
Yes (%)	11 (2.9%)	4 (2.8%)	7 (2.9%)	
Bronchodilator used prior to ED arrival (%)	238 (61.8%)	96 (66.2%)	142 (59.2%)	0.20
Median ED LOS in hours (IQR)	5.3 (4, 7)	3.9 (3.1, 4.9)	6.1(5, 8.1))	P<0.001
Return to ED within 24 h of discharge (%)	6 (1.6%)	4 (2.8%)	2 (0.8%)	0.14
PRAM deterioration (%)	76 (19.7%)		76 (31.7%)	P<0.001

ED Emergency department; IQR interquartile range; LOS Length of stay.

*Discharged home in accordance with our asthma clinical pathway.

**PRAM: pediatric respiratory assessment measure.

Table 2. Patient and visit characteristics for patients discharged in accordance with the clinical pathway with and without return to ED within 24 h of discharge

	No return visits to the ED:	Patients with a return visit to the ED within 24 h of discharge:	P value
Number (%)	141 (97.2%)	4 (2.8%)	
Mean Age years (SD)	5.3 (3)	7.0 (7)	0.29
CTAS			0.69
2 (%)	92 (65.2%)	3 (75%)	
3 (%)	49 (34.8%)	1 (25%)	
Median PRAM at arrival index visit (IQR)	6 (5,6)	7 (6,7)	0.47
Male (%)	70.9%	25%	0.16
Previous hospitalizations			0.51
No (%)	102 (72.3%)	4(100%)	
Yes (%)	39 (27.7%)		
Bronchodilator used prior to ED visit N (%)	95 (67.4%)	1 (25%)	0.22
Median ED LOS in hours (IQR)	3.9 (3.1, 4.9)	4 (3, 5.9)	0.59

CTAS Canadian Triage and Acuity Score; ED Emergency department; IQR interquartile range; LOS Length of stay; PRAM Paediatric respiratory assessment measure.

Outcomes of clinical pathway deviation cohort

The remaining 240 patients (63%) were observed in the ED beyond their eligibility for discharge according to the clinical pathway and comprised the pathway deviation cohort. Their median total ED LOS was 6.1 hours (IQR 5, 8.1). Among these, 76 (31.7%) subsequently had clinical deterioration as reflected by PRAM ≥ 4 and received further ED treatment. Table 3 displays the patient characteristics of this cohort stratified by deterioration outcome.

Figure 2 shows the timing of clinical deterioration among the 76 patients in the pathway deviation cohort who had a worsening of their PRAM score during their extended ED observation: 46 (60.5%) worsened in the second hour after last bronchodilator treatment, 25 (32.9%) in the third hour, and 5 (6%) in the fourth hour. After 4 hours patients were considered due for their next scheduled treatment regardless of their PRAM score.

Additionally, 25/240 (10.4%) patients in the pathway deviation cohort were eventually hospitalized. Among those hospitalized, 10/25 (40%) had evidence of clinical deterioration as reflected by a PRAM score ≥ 4 within 2 hours of their last bronchodilator, an additional 8 (32%) within the third hour, and 1 (4%) in the fourth hour. Six (25%) patients were hospitalised for unclear reasons despite a PRAM score < 4 throughout their ED stay; these six patients had a median ED LOS of 8.6 hours (IQR 8, 11.6). Among the 215 patients eventually discharged

home from the ED, 2/215 (0.9% versus 2.8% [4/145] in the pathway adherent cohort, $P=0.14$) returned to the ED within 24 hours with signs and symptoms consistent with an asthma exacerbation and were subsequently discharged home in accordance with our pathway.

DISCUSSION

Our study examined ED provider adherence to a PRAM-based ED asthma treatment protocol and is the first study to examine patient outcomes associated with PRAM-directed disposition decisions. We found wide practice variation despite introduction of a clinical pathway with $< 1/3$ of patients managed per the protocol. While only two patients discharged after maintaining PRAM < 4 1 hour after the last bronchodilator treatment returned to the ED for further asthma treatment in 24 hours and none was subsequently admitted, a significant proportion of those observed beyond the pathway guidelines experienced clinical deterioration prior to the 4-hour scheduled bronchodilator recommended for home use. Individual patient characteristics, clinical disease severity, and ED treatment did not differ between the cohort discharged per pathway and those kept for observation, suggesting that unmeasured factors such as ED utilization and perceived family readiness for discharge may account for the practice variation.

Table 3. Patient and visit characteristics of children kept in the ED for observation beyond clinical pathway recommendations, stratified by deterioration outcome

	No PRAM score deterioration	PRAM score deterioration	P value
Number (%)	164 (68.3%)	76 (31.7%)	
Mean Age years (SD)	5.0 $\pm$ 3	5.1 $\pm$ 3	0.81
CTAS			
2 (%)	109 (66.5%)	54 (71.1%)	0.58
3 (%)	55 (33.5%)	22 (28.9%)	
Male (%)	71.3%	64.5%	0.85
Median PRAM at arrival (IQR)	6 (5,6)	6 (5,7)	0.36
Disposition –			
Home (%)	158 (96.3%)	57 (75%)	< 0.001
Ward (%)	6 (3.7%)	19 (25%)	
ICU (%)	0	0	
Previous hospitalizations			
No (%)	131 (79.9%)	58 (76.3%)	0.65
Yes (%)	33 (20.1%)	18 (23.7%)	
Previous ICU			
No (%)	159 (97%)	74 (97.4%)	0.86
Yes (%)	5 (3%)	2 (2.6%)	
Bronchodilator used prior to ED visit (%)	91 (55.5%)	51 (67.1%)	0.12
Median ED LOS in hours (IQR)	5.5 (4.7, 6.7)	8.1 (6.9, 10.6)	< 0.001
Return to ED within 24 h of discharge (%)	1 (0.6%)	1 (1.3%)	0.58

CTAS Canadian Triage and Acuity Scale; ED Emergency department; IQR interquartile range; LOS Length of stay; PRAM Paediatric respiratory assessment measure.

Figure 2. Detailed overview of patients who were included in this study, comparing patient outcomes with PRAM protocol pathway adherence versus deviance. Outcomes include further PRAM deterioration, RTED and final disposition. *PRAM* Paediatric respiratory assessment measure; *RTED* Return to emergency department.

Our observed deviation from the asthma clinical pathway is consistent with reports from another Canadian study that found only 36% of children with an acute asthma exacerbation were managed according to their institution's care pathway (8). Though commonly used as a method to decrease practice variability, standardize and improve quality of care, clinical practice guidelines have limitations and can foster resistance from clinicians (9–11). Some researchers have utilized clinician practice variability as an opportunity to further study and refine clinical pathways by allowing for practice variability while collecting and reporting data related to this variability in order to improve and standardize care in an iterative way through Standardized Clinical Assessment and Management Plans (SCAMPs) (12–14). Similarly, we analyzed patient outcomes related to adherence to or deviation from our acute asthma clinical pathway in order to validate the safety of the pathway discharge criteria.

Overall, our observed frequency of ED return visits was low, and we found no statistically significant difference between the two study groups (2.8% among pathway adherent versus 0.9% among pathway deviant, $P=0.14$). Previously reported general RTED rates ranges from 3 to 8.7% (15–19) and 4.1% in an asthma specific population (20). The discrepancy between our findings and prior studies may be related to the time frame applied to the returns: most studies report returns within 48 hours to 7 days as opposed to the 24 hours time frame used in our study. We chose a shorter time-frame given the acute nature of asthma in order to capture return visits most likely to reflect premature discharge from the ED. The lower return rate in our study might also reflect the fact that we only examined return visits to our PED and some patients may have returned to

another site. Previous work suggests that up to 13.6% of RTED visits occur to centres other than the one where the initial visit occurred (19).

Despite the low return visit rate among those discharged per pathway, we observed that a significant proportion of the patients kept for observation in deviation from the protocol experienced clinical deterioration (31.7%) and 10.4% were hospitalized. It is possible that patients in the pathway adherent cohort also experienced clinical deterioration prior to the 4-hour scheduled bronchodilator recommendation and that caregivers may have provided extra bronchodilator treatments at home; however, these data were not captured in our health records and did not result in significant RTED or subsequent hospitalization in that cohort.

We examined patient and clinical disease severity variables in an attempt to identify differences between the two cohorts that might explain pathway deviations and the observed deterioration and subsequent hospitalization within the pathway deviant cohort. However, there were no differences between the groups with regard to previous hospitalization or ICU admission for asthma, bronchodilator use prior to ED arrival, presenting triage category, median PRAM at arrival to the ED, or time to reaching PRAM <4. This suggests that unmeasured factors might account for the observed outcome differences. For example, while we analyzed past hospitalization and ICU admission for asthma, we were unable to capture previous ED visits or ED LOS; frequent use of ED services may create an impression of poor asthma control, inadequate outpatient follow-up, or poor understanding of home asthma care by the family that might explain a clinician's preference for further observation or even

admission to hospital. Additional unmeasured potential explanatory variables include other social considerations such as distance from home, time of day, and history of medical comorbidities. Finally, illness-specific factors such as infectious versus allergic asthma triggers and baseline asthma control might be important but were not collected in our study.

Considering data from both cohorts, we found that prolonging the observation period of our pathway to allow discharge after maintaining a PRAM <4 for 2 hours after treatment would miss 8% (30/385) of those who received further bronchodilator treatment in ED and 2.3% (9/385) patients hospitalized. Extending this observation period to 3 hours would miss 1.3% (5/385) of those who received further bronchodilator treatment in ED and 0.3% (1/385) of hospitalizations.

Limitations

The main limitation of this chart review includes incomplete documentation; clinical management decisions may have been made based on clinical acumen and other factors of significance, but not documented. The number of charts reviewed was less than our estimated largest required sample size, however, since the proportion of patients that deteriorated was below 50%, the precision around that outcome was unaffected. Our ability to determine the exact timing of disposition decisions was limited, as most medical records document only the time of final disposition. Finally, this study explores the experience of a single centre with a PRAM score guided asthma management clinical pathway and our findings can only be generalized to similar tertiary care paediatric ED centres.

CONCLUSION

An important proportion of observed patients had a deterioration in PRAM score beyond the first hour of observation after reaching a mild status. Patients with moderate asthma observed for at least 2 hours once a PRAM < 4 is achieved from last bronchodilator therapy captured 97.7% of those who might require further intervention and possible hospitalization. However, expanding the observation to three hours once a PRAM < 4 is achieved would capture 99.7% of patients requiring further intervention or hospitalization. Thus, we recommend observation of 2 to 3 hours depending on local risk tolerance and resource capacity.

SUPPLEMENTARY DATA

Supplementary data are available at *Paediatrics & Child Health* Online.

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