Improved Management of Acute Asthma Among Pregnant Women Presenting to the ED

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BACKGROUND: A multicenter study in the late 1990s demonstrated suboptimal emergency asthma care for pregnant women in US EDs. After a decade, follow-up data are lacking. We aimed to examine changes in emergency asthma care of pregnant women since the 1990s.

METHODS: We combined data from four multicenter observational studies of ED patients with acute asthma performed in 1996 to 2001 (three studies) and 2011 to 2012 (one study). We restricted the data so that comparisons were based on the same 48 EDs in both time periods. We identified all pregnant patients aged 18 to 44 years with acute asthma. Primary outcomes were treatment with systemic corticosteroids in the ED and, among those sent home, at ED discharge.

RESULTS: Of 4,895 ED patients with acute asthma, the analytic cohort comprised 125 pregnant women. Between the two time periods, there were no significant changes in patient demographics, chronic asthma severity, or initial peak expiratory flow. In contrast, ED systemic corticosteroid treatment increased significantly from 51% to 78% across the time periods (OR, 3.11; 95% CI, 1.27-7.60; *P* 5 .01); systemic corticosteroids at discharge increased from 42% to 63% (OR, 2.49; 95% CI, 0.97-6.37; *P* 5 .054). In the adjusted analyses, pregnant women in recent years were more likely to receive systemic corticosteroids, both in the ED (OR, 4.76; 95% CI, 1.63-13.9; *P* 5 .004) and at discharge (OR, 3.18; 95% CI, 1.05-9.61; *P* 5 .04).

CONCLUSIONS: Between the two time periods, emergency asthma care in pregnant women significantly improved. However, with one in three pregnant women being discharged home without systemic corticosteroids, further improvement is warranted. CHEST 2015; 147 (2): 406 – 414

ABBREVIATIONS: MARC 5 Multicenter Airway Research Collaboration

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Asthma is one of the most common serious problems that occur during pregnancy, complicating 4% to 8% of all pregnancies. [1-3] Additionally, 27% of pregnant patients with asthma have at least one ED visit or hospital admission during pregnancy. 4 Th e literature suggests that poor asthma control may negatively impact various aspects of pregnancy. For example, studies have demonstrated associations of poorly controlled asthma (as evidenced by impaired pulmonary function or exacerbations) with increased risk of maternal and fetal complications, such as preeclampsia, spontaneous abortion, intrauterine growth retardation, preterm birth, and low birth weight. [4-11]

To prevent these complications, rapid therapeutic intervention at the time of an exacerbation is imperative. The guidelines for the management of asthma during pregnancy recommend adult pharmacotherapy that does not differ substantially from that in nonpregnant patients (eg, early administration of systemic corticosteroids) because a severe exacerbation presents more risk to the fetus than does use of this asthma medication. [3, 12, 13] However, our multicenter study in the late 1990s demonstrated suboptimal emergency asthma care in pregnant women. 14 For example, only 44% of pregnant women with acute asthma were treated with systemic corticosteroids in the ED, and 38% were prescribed oral corticosteroids at ED discharge. Notwithstanding the clinical importance of this issue, to our knowledge, there have been no efforts since to examine changes in emergency asthma care in pregnant women.

To address this knowledge gap, we analyzed data from several multicenter observational studies of ED patients with acute asthma during two time periods: 1996 to 2001 and 2011 to 2012. We aimed to investigate possible changes in emergency care in pregnant women with acute asthma between the two periods. More specifically, we sought to test whether treatment with systemic corticosteroids had increased over time.

Materials and Methods

Study Design and Setting

The current analysis combined the data from four multicenter observational studies of adult ED patients with acute asthma: 1996 to 2001 (three studies) and 2011 to 2012 (one study). All these studies were performed by the Multicenter Airway Research Collaboration (MARC), a program of the Emergency Medicine Network, an international research collaboration involving > 225 participating EDs.[15]

During 1996 to 2001, the three observational studies (the MARC-1, -2, and -5 studies) consisted of an ED interview to assess patient characteristics and a chart review to assess the ED presentation, asthma management, and disposition. The design, setting, and methods of data collection used in these studies have been reported in the previously published analyses. [16-18] Additionally, our previous multicenter study of pregnant women with acute asthma between 1996 and 1997 14 is nested in these 1996 to 2001 data.

We recently completed the MARC-36 study, a multicenter chart review study that sought to characterize adult ED patients with acute asthma and to determine the quality of their emergency care during 2011 to 2012. To better evaluate temporal changes in emergency asthma care, we recruited EDs by inviting sites that had participated in the earlier MARC studies during 1996 to 2001. A total of 48 US EDs in 23 states completed the MARC-36 study (e-Table 1); the 1996 to 2001 vs 2011 to 2012 comparisons were based on the same 48 EDs during both time periods. In all these studies, patients were managed at the discretion of the treating physician. The institutional review board at each of the 48 participating centers approved the studies (2013P000368).

Study Participants

In the MARC-36 study, using the *International Classification of Diseases, Ninth Revision, Clinical Modification* code 493.xx, 19 each site identified all visits with a primary ED or hospital discharge diagnosis of asthma during a 12-month period between January 1, 2011, and December 31, 2012 (ie, sites had a 24-month window from which to select the 12-month study period). Similar to the 1996 to 2001 studies, the inclusion criteria were ED visits made by adult patients aged 18 to 54 years and a history of physician-diagnosed asthma before the index ED visit. We excluded ED visits made by patients with a history of physician diagnosed COPD, transfer ED visits, repeat ED visits by the same individual, and ED visits not prompted largely by acute asthma. For the purpose of the primary analysis, we then identified all pregnant patients aged 18 to 44 years with acute asthma.

Data Collection

In the MARC-36 study, onsite chart abstractors reviewed 40 ED charts randomly selected by the Emergency Medicine Network Coordinating Center at Massachusetts General Hospital. All abstractors were trained with a 1-h lecture, and then the abstractors completed two practice charts, which were evaluated with a "criterion standard." If a reviewer's accuracy was, 80% per chart, the reviewer was retrained. Data abstraction was performed with a standardized form and included patients' demographics, asthma history, current asthma medications, presentation, peak expiratory flows, asthma management in the ED or at discharge, and ED disposition. In the 1996 to 2001 studies, chart review was also used to measure the ED presentation, acute asthma management, and ED disposition. [16-18] We classified the severity of acute asthma according to the initial peak expiratory flow at ED presentation as follows: mild, _ 300 L/min; moderate, 200 to 299 L/min; severe, 120 to 199 L/min; and very severe, < 120 L/min. [20, 21]

Outcome Measures

The outcomes of interest were treatment with systemic corticosteroids in the ED, and, among those sent home, at ED discharge.

Statistical Analysis

To examine the change in each outcome among pregnant women from the 1996 to 2001 period and the 2011 to 2012 period, we fi t three regression models. First, we developed

unadjusted models that included only the study period as the independent variable. Second, we examined the adjusted changes between the two time periods by fitting multivariable logistic regression models. Because of the relatively small number of pregnancy cases, we used propensity score adjustment. Propensity score adjustment preserved statistical power by reducing covariates to a single variable. [22] The propensity score was created through a binary logistic regression model with study period as the dependent variable, which included the potential confounding factors: age, history of hospitalization for acute asthma, and respiratory rate and peak expiratory flow at ED presentation. To maximize the efficacy of the propensity score adjustment, missing values in the propensity score model were dummy coded using the missing indicator methods. [23] Third, in the sensitivity analysis, we used an inverse-probability-weighting approach that was based on the computed propensity score to adjust for the differences in patient characteristics and acute asthma severity between the two time periods. [24] Additionally, to compare the proportion of patients who received systemic corticosteroid treatment in the ED and at ED discharge by pregnancy status, we repeated the three models in each time period (e-Appendix 1). All tests were two-tailed, and $P < .05$ was regarded as statistically significant. All analyses were performed with SAS 9.3 (SAS Institute).

Results

Characteristics of Pregnant Women With Acute Asthma

Of the 4,895 adult ED patients with acute asthma in the four studies, the analytic cohort comprised 125 pregnant women (89 patients from the 1996 to 2001 period vs 36 patients from the 2011 to 2012 period). All presented with acute asthma to one of the 48 participating EDs; the ED characteristics are presented in e-Appendix 2.

Unadjusted comparisons of patient demographics, chronic asthma factors, and asthma medications between the two time periods are shown in Table 1. There were no significant changes in the patient demographics between the two time periods. In terms of chronic asthma factors, pregnant patients with acute asthma in the more recent time period were less likely to visit an ED for acute asthma in the past year (*P* 5 .006). Otherwise, there were no significant changes in chronic asthma factors, and chronic asthma burden remained high during the two time periods. Indeed, approximately one-fifth of patients had a documented hospitalization for acute asthma in the past year in both time periods. Despite this persistently large chronic asthma burden, long-term control medications remained underused in this population. For example, the proportion of patients with asthma on inhaled corticosteroids was 28% (95% CI, 19%-39%) in the 1996 to 2001 period vs 25% (95% CI, 12%-42%) in the 2011 to 2012 period (*P* 5 .21). The proportion of patients taking long-acting b -agonists increased from 7% (95% CI, 3%-14%) to 22% (95% CI, 10%-39%) between the time periods (*P* 5 .046), although the proportion remained low in the 2011 to 2012 period.

TABLE 1] Characteristics of Pregnant Women With ED Visit for Acute Asthma, by Time Period

Patient Characteristics	1996-2001 (n = 89)	2011-2012 (n = 36)	*P* Value
Demographics			
Age, median (IQR), y	26 (21-29)	26 (22-31)	.50
Race/ethnicity			.96
Non-Hispanic white	15 (17)	6 (17)	
Non-Hispanic black	40 (45)	16 (44)	
Hispanic ethnicity	27 (30)	11 (31)	
Other	7 (8)	3 (8)	
Current smoker	20 (22)	9 (25)	.13
BMI, median (IQR)	28 (24-39)	31 (28-38)	.41
Having primary care physician	45 (51)	27 (75)	.06
Health insurance[a]			.15
Private	21 (24)	11 (31)	
Public	35 (39)	21 (58)	
No insurance	21 (24)	4 (11)	
Chronic asthma factors			
Ever admitted for asthma	41 (46)	9 (25)	.14
Ever intubated for asthma	9 (10)	2 (6)	.85
Ever used systemic corticosteroids	56 (63)	19 (53)	.14
Admitted for asthma in past year	18 (20)	7 (19)	.61
ED visit for asthma in past year	49 (55)	14 (39)	.006
Current asthma medications			
Current use of oral corticosteroids	8 (9)	4 (11)	.86
Current use of inhaled corticosteroids	25 (28)	9 (25)	.21
Current use of long-acting β-agonists	6 (7)	8 (22)	.046
Current use of leukotriene modifiers	0 (0)	1 (3)	.35

Data are presented as No. (%) unless indicated otherwise. IQR = interquartile range.
[a]Percentages do not sum up to 100% because of missing data.

ED Presentation and Course of Pregnant Women With Acute Asthma

Acute asthma presentation, ED management, and disposition according to the time periods are shown in Table 2. In the more recent time period, pregnant patients with acute asthma had a lower respiratory rate ($P < .001$) and nonsignificantly higher oxygen saturation ($P = .06$) at the ED presentation. In contrast, the proportion of patients who received systemic corticosteroids in the ED increased significantly from 51% (95% CI, 40%-61%) in the 1996 to 2001 period to 78% (95% CI, 61%-90%) in the 2011 to 2012 period (OR, 3.11; 95% CI, 1.27-7.60; $P \leq .01$). Likewise, acute asthma treatment with inhaled anticholinergics and IV magnesium sulfate in the ED increased significantly between the two time periods (both $P \leq .01$).

TABLE 2] Acute Presentation and ED Course of Pregnant Women With Acute Asthma, by Time Period

Variables	1996-2001 (n = 89)	2011-2012 (n = 36)	*P* Value
ED presentation			
Duration of symptoms			
≤3 h prior to ED arrival	8 (9)	2 (6)	.72
Vital signs			
Initial respiratory rate, median (IQR), breaths/min	24 (20-28)	20 (18-22)	<.001
Initial oxygen saturation, median (IQR), %	97 (96-99)	99 (97-100)	.06
Initial PEF,[a] median (IQR), L/min	200 (150-250)	250 (180-350)	.11
Severity based on initial PEF[a]			.46
Mild	11 (16)	5 (33)	
Moderate	29 (43)	6 (40)	
Severe	22 (32)	3 (20)	
Very severe	6 (9)	1 (7)	
Comorbidities[b]	5 (6)	3 (8)	.69
ED treatment			
Inhaled β-agonists	89 (100)	36 (100)	...
Systemic corticosteroids	45 (51)	28 (78)	.01
Inhaled anticholinergics	11 (12)	27 (75)	<.001
IV terbutaline	6 (7)	0 (0)	.18
IV magnesium sulfate	1 (1)	5 (14)	.01
IV methylxanthines	1 (1)	0 (0)	1.00
Mechanical ventilation	0 (0)	1 (3)	.30
ED disposition			.48
Sent home	67 (75)	30 (83)	
Admission to observation unit	3 (3)	1 (3)	
Admission to hospital ward	18 (20)	4 (11)	
Admission to ICU	1 (1)	1 (3)	
ED length of stay, median (IQR), min	175 (140-243)	214 (137-359)	.14
Discharge medications[c]			
Prescribed oral corticosteroids	28 (42)	19 (63)	.054

Data are presented as No. (%) unless indicated otherwise. PEF = peak expiratory flow. See Table 1 legend for expansion of other abbreviation.
[a]Analyzed for 83 patients (66%) with initial PEF available.
[b]Including pneumonia, pneumothorax, congestive heart failure, arrhythmia, otitis, sinusitis, and others.
[c]Analyzed for 97 patients (78%) sent home.

Risk of hospitalizations did not significantly differ by time period, nor did ED length of stay (Table 2). Among the 97 pregnant patients with acute asthma who were discharged to home, prescription of oral corticosteroids increased from 42% (95% CI, 30%-54%) to 63% (95% CI, 44%-80%) between the two time periods, although this increase was of borderline statistical significance (OR, 2.49; 95% CI, 0.97-6.37; *P* 5 .054).

Adjusted Analyses of Outcomes in Pregnant Women With Acute Asthma

In multivariable logistic regression analyses using propensity score (Table 3), pregnant women in recent years were more likely to receive systemic corticosteroids, both in the ED (OR, 4.76; 95% CI, 1.63-13.9; *P* 5 .004) and at ED discharge (OR, 3.18; 95% CI, 1.05-9.61; *P* 5 .04). Sensitivity analyses with the use of an inverse-probability-weighting approach yielded similar results (Table 3).

Comparisons Between Pregnant and Nonpregnant Women by Time Period

We also compared the proportion of pregnant (n 5 125) and nonpregnant women (n 5 2,157) who received systemic corticosteroids in the ED in each time period (Table 4). In the 1996 to 2001 period, pregnant women with acute asthma were signifi cantly less likely to receive

systemic corticosteroids in the ED when compared with nonpregnant women (51% vs 64%; adjusted OR, 0.52; 95% CI, 0.33-0.81; *P* 5 .004). However, in the 2011 to 2012 period, no discrepancy between pregnant and nonpregnant women was observed (78% vs 76%; adjusted OR, 1.11; 95% CI, 0.50-2.49; *P* 5 .80).

Similar to the findings of ED treatment with systemic corticosteroids, in the 1996 to 2001 period, pregnant women were significantly less likely to be prescribed systemic corticosteroids at ED discharge (42% vs 59%; adjusted OR, 0.44; 95% CI, 0.26-0.76; *P* 5 .003). In the 2011 to 2012 period, no significant difference between pregnant and nonpregnant women was observed (63% vs 71%; adjusted OR, 0.87; 95% CI, 0.38-1.96; *P* = .73).

Discussion

In this multicenter analysis, based on the data collected in 1996 to 2001 and 2011 to 2012 from 48 EDs in 23 US states, we observed significant improvement in emergency asthma care in pregnant women with acute asthma. More specifically, we found a significant increase in treatment with systemic corticosteroids both in the ED and at ED discharge between the two time periods. However, our data also demonstrated that approximately one-third of pregnant women with acute asthma were discharged to home without systemic corticosteroids in the 2011 to 2012 period.

Our previous multicenter study between 1996 and 1997, which is nested in the 1996 to 2001 data presented here, demonstrated suboptimal asthma care in pregnant women in the ED. 14 Indeed, only 44% of pregnant women with acute asthma were treated with systemic corticosteroids in the ED compared with 66% of nonpregnant women; 38% of pregnant women were prescribed systemic corticosteroids at ED discharge compared with 64% of nonpregnant women. Another single-center, case-control study also showed underuse of systemic corticosteroid treatment in the ED. 25 Despite the documented associations between poorly controlled asthma during pregnancy and increased risks of maternal and fetal complications, the quality of emergency asthma care in this population has been understudied.

TABLE 3] Unadjusted and Adjusted Analyses for Systemic Corticosteroid Treatment During 2011 to 2012 and 1996 to 2001

Outcomes	Unadjusted		Adjusted With Propensity Score[a]		Adjusted With Use of Inverse Probability Weighting[b]	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Systemic corticosteroids in the ED	3.11 (1.27-7.60)	.01	4.76 (1.63-13.9)	.004	6.22 (2.32-16.7)	<.001
Systemic corticosteroids at ED discharge[c]	2.49 (0.97-6.37)	.054	3.18 (1.05-9.61)	.04	3.03 (1.03-8.89)	.04

[a]Propensity score adjustment for the potential confounding factors (age, history of hospitalization for acute asthma, respiratory rate, and peak expiratory flow at ED presentation).
[b]Inverse probability weighting based on the computed propensity score to adjust for the differences in patient characteristics and acute asthma severity between the two study periods.
[c]Analyzed for 97 patients sent home.

TABLE 4] Unadjusted and Adjusted Analyses for Outcomes Comparing Pregnant and Nonpregnant Women in the 1996 to 2001 and 2011 to 2012 Time Periods

Outcomes	Pregnant Women, No. (%)	Nonpregnant Women, No. (%)	Unadjusted		Adjusted With Propensity Score[a]		Adjusted With Use of Inverse Probability Weighting[b]	
			OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
1996-2001 period								
Systemic corticosteroids in the ED	45 (51)	841 (64)	0.50 (0.32-0.79)	.002	0.52 (0.33-0.81)	.004	0.35 (0.18-0.69)	.002
Systemic corticosteroids at ED discharge	28 (42)	592 (59)	0.43 (0.26-0.73)	.002	0.44 (0.26-0.76)	.003	0.30 (0.13-0.68)	.004
2011-2012 period								
Systemic corticosteroids in the ED	28 (78)	633 (76)	1.03 (0.46-2.31)	.94	1.11 (0.50-2.49)	.80	0.98 (0.42-2.26)	.95
Systemic corticosteroids at ED discharge	19 (63)	481 (71)	0.83 (0.37-1.86)	.64	0.87 (0.38-1.96)	.73	0.81 (0.34-1.95)	.64

[a]Propensity score adjustment for the potential confounding factors (age, history of hospitalization for acute asthma, and respiratory rate and peak expiratory flow at ED presentation).
[b]Inverse probability weighting based on the computed propensity score to adjust for the differences in patient characteristics and acute asthma severity between pregnant and nonpregnant women.

To our knowledge, this is the first study to examine the change in the quality of emergency asthma care in pregnant women. We demonstrated a significant improvement in the guideline-recommended care (ie, an increased use of systemic corticosteroids in the ED and at ED discharge) despite the findings that the acute presentations were less severe in the more recent time period. Parallel to this improvement, we also observed an increased use of inhaled anticholinergics and IV magnesium sulfate in the ED; the current national guidelines recommend the former as a supplemental bronchodilator and the latter as an adjunct agent. 26 It is plausible that the difference in patient population and the increased proportion of EDs affliated with an emergency medicine residency program (ie, academic EDs) within the 48 participating sites contributed to the observed improvement. Alternatively, the improvement of asthma care in pregnant women may reflect a successful dissemination and implementation of the guidelines nationally. Indeed, our observations are in agreement with the improvement in asthma care among the general asthma population (ie, not limited to pregnant women) in the ambulatory setting 27 and the pediatric inpatient setting. 28 Taken together, the observed increase in these guideline recommended treatments reflects, at least in part, a true improvement in the quality of emergency asthma care in pregnant women over the 17-year period.

We identified an opportunity to improve the quality of emergency asthma care in this population by addressing the ongoing gap (ie, the underuse of systemic corticosteroids at the ED discharge in the 2011 to 2012 period). Reasons for the observed underuse of this guideline recommended treatment require further elucidation. Although we observed the underuse not only in pregnant women but also in nonpregnant women, physicians' concerns about adverse effects

of the medication on the fetus may have contributed to the underuse in the pregnant population specifically. [14] Th is uncertainty reflects the scarcity of data on the effects of systemic corticosteroids during pregnancy. [29] Indeed, it remains unclear whether systemic corticosteroid treatment directly causes fetal complications (eg, congenital malformation and low birth weight) or whether it serves as a proxy for asthma sufficiently severe or uncontrolled to cause these complications. [30,31] However, compelling evidence exists that well-controlled asthma during pregnancy leads to good perinatal outcomes. 7 Furthermore, the asthma guidelines clearly state that inadequate control of asthma is a greater risk to the fetus than asthma medications are, and that systemic corticosteroids should be used for most ED patients with acute asthma.[3,12,13,26]

Yet the literature also documents that the publication of guidelines does not necessarily lead to improvement in quality of asthma care in the real world setting. [32] Indeed, multiple studies of the ED management of acute asthma have revealed wide variations in care and suboptimal adherence to the published guidelines. [20,21,33] Th ese data collectively underscore the importance of continuous efforts to implement evidence-based guidelines through knowledge translation initiatives and quality improvement programs. Improvement of the quality of emergency asthma care in pregnant women is the responsibility of health-care providers and hospitals. However, it will require collective eff orts with other stakeholders (eg, professional organizations and federal agencies) to overcome the barriers to implementing asthma guidelines.

This study has several potential limitations. First, our observational data relied on medical record review for the measurement of ED asthma treatments, with possible underestimation of the outcomes of interest. However, a previous study demonstrated good agreement between chart review and direct observation of ED treatments for acute asthma, with k coefficients ranging from 0.7 to 0.8. 34 Furthermore, we used an identical data collection method for the outcomes across the two time periods.
Therefore, these errors likely would have little impact on the observed improvement in emergency asthma care over time. Second, as with any observational data, the observed improvement in emergency asthma care may be confounded by residual factors. Despite an adjustment for important confounding factors with a propensity score analysis and an inverse-probability-weighting analysis, there are other variables that may have contributed for which our study was unable to control or that were not collected a priori (eg, comorbidities, response to initial short-acting b -agonist therapy). It is also possible that the increased proportion of academic EDs between the time periods may have upwardly biased our inferences. Lastly, our sample consisted predominantly of academic EDs in urban areas. Therefore, these findings may not be representative of emergency asthma care among pregnant women in nonacademic or rural EDs. However, these types of EDs train most emergency physicians in the United States, and this has disproportionate implications on the quality of current and future emergency asthma care. Therefore, we believe our findings are highly relevant from educational and policy standpoints.

Conclusions

In summary, on the basis of four observational studies of pregnant women with acute asthma in 48 EDs, we found a significant increase in the ED administration of systemic corticosteroids and prescription of systemic corticosteroids at ED discharge over the 17-year period. These observations support prior optimism that the quality of emergency asthma care can be improved. In contrast, we also observed that more than one-third of pregnant women were still discharged

to home without systemic corticosteroids in the 2011 to 2012 period. For researchers, this observation should facilitate further research to identify the barriers to delivery of guideline recommended asthma care in this large but understudied population. Additionally, for physicians and policy makers, our data underscore the importance of ongoing collective efforts aimed at bridging the care gaps, and thereby decreasing preventable maternal and fetal complications.

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Additional information: The e-Table and e-Appendixes can be found in the Supplemental Materials section of the online article.

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