

The use of magnesium sulfate in acute asthma: Rapid uptake of evidence in North American emergency departments

Brian H. Rowe, MD, MSc,^a and Carlos A. Camargo, Jr, MD, DrPH,^b for the Multicenter Airway Research Collaboration (MARC) Investigators Edmonton, Alberta, Canada, and Boston, Mass

Background: Systematic reviews of approximately 13 randomized trials support treatment with intravenous magnesium sulfate (MgSO₄) in patients with severe acute asthma; however, little is known about its actual clinical use. **Objective:** We sought to examine the use of intravenous MgSO₄ in the emergency department (ED) and physician attitudes toward its use.

Methods: Data for MgSO₄ use were obtained from observational cohort studies of ED patients with acute asthma. Investigators were asked about MgSO₄ through a brief Internet-based survey. The main outcomes were the percentage of sites reporting MgSO₄ use and patient factors that potentially modified the use of this agent.

Results: Among 9745 ED patients with acute asthma, 240 (2.5%) received MgSO₄. Increasing age, previous intubation, higher initial respiratory rate, lower initial PEF, higher number of β -agonists in the ED, and use of systemic corticosteroids were associated with MgSO₄ use ($P < .01$). Overall, 103 (87%) of 119 potential sites completed the survey. Most (92%) respondents stated their EDs had MgSO₄ available, and 64% had recently used it. More respondents listed severity (96%) and failure to respond to initial β -agonists (87%) as factors prompting their use of MgSO₄. Other factors, such as age, sex, and duration of exacerbation, less commonly influenced MgSO₄ use.

Conclusion: Most ED physicians accept the efficacy of MgSO₄ in acute asthma. Despite this belief and the ready availability of MgSO₄, its ED use remains uncommon (2.5% of cases).

In both practice and theory, emergency physicians appear to appropriately restrict its use to patients with severe acute asthma. (*J Allergy Clin Immunol* 2006;117:53-8.)

Key words: Asthma, treatment, emergency department, magnesium, severe

Asthma is an important health care problem worldwide. More than 27 million persons in the United States have at some time received a diagnosis of asthma, and the attack prevalence (those experiencing an emergency department [ED] visit for an exacerbation in the past year) is approximately 1.8 million.¹ The burden of illness is high in both children and adults, and the costs associated with asthma are staggering. In 1998, the expenditures for asthma exceeded 12 billion dollars in the United States,² and 25% of asthma costs are expended on acute care (ED visits and hospitalizations).³

The treatment of acute asthma in the ED has been the subject of much research, and synthesis of asthma trials into systematic reviews is common.^{4,5} Despite efforts to standardize asthma care, wide gaps still remain between what is known to be effective treatment and what is practiced.⁶ The initial ED treatment management involves inhaled albuterol either through a nebulizer (intermittent or continuous) or metered-dose inhaler and chamber devices.⁷ In addition, multiple doses of inhaled anticholinergics and systemic⁸ and inhaled⁹ corticosteroids have been shown to be effective; however, aminophylline, heliox, and antibiotics have not been shown to improve outcomes.

In severe acute asthma (eg, severe bronchoconstriction with lack of response to β -agonists) recent evidence suggests intravenous magnesium sulfate (MgSO₄) might be helpful. Two systematic reviews both conclude that MgSO₄ is not only safe but also effective in patients with severe exacerbations.^{10,11} Patients with clinically severe asthma, pulmonary flows of less than 30% of predicted value in adults and less than 50% in children, or both who exhibit a poor response to bronchodilator therapy appear to benefit from intravenous MgSO₄. This agent has been shown to be easy to use, extremely safe, and inexpensive. However, given its recent demonstration of efficacy, the use of this agent by front-line emergency physicians is unknown.

From ^athe Department of Emergency Medicine, University of Alberta, and Capital Health, Edmonton, and ^bthe Department of Emergency Medicine, Massachusetts General Hospital, and the Channing Laboratory, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston.

Dr Rowe is supported by the Canadian Institute of Health Research (CIHR) Chairs Program (Ottawa, Canada). Dr Camargo is supported by grant HL-63841 from the National Institutes of Health (Bethesda, Md). MARC is supported by grant HL-63253 from the National Institutes of Health.

Disclosure of potential conflict of interest: B. Rowe has consulted with Boehringer-Ingelheim on a COPD care map and has received grants from AstraZeneca, Trudell-Monaghan, Abbott, GlaxoSmithKline, and Boehringer-Ingelheim. C. Camargo has consultant arrangements with AstraZeneca, GlaxoSmithKline, Aventis, Dey, Discovery, Genentech, Merck, Novartis, Schering, and Sepracor; has received grant money from Abbott, AstraZeneca, Boehringer-Ingelheim, GlaxoSmithKline, Trudell-Monaghan, Aventis, Dey, Fovort, Merck, and Novartis; and is on the speakers' bureau for AstraZeneca, GlaxoSmithKline, and Schering.

Received for publication July 3, 2005; revised August 21, 2005; accepted for publication September 12, 2005.

Available online November 29, 2005.

Reprint requests: Brian Rowe, MD, MSc, Department of Emergency Medicine, University of Alberta, 1G1.43 WMC, 8440-112th St, Edmonton, Alberta, Canada T6G 2B7. E-mail: brian.rowe@ualberta.ca.

0091-6749/\$32.00

© 2005 American Academy of Allergy, Asthma and Immunology

doi:10.1016/j.jaci.2005.09.033

Abbreviations used

ED: Emergency department
 EMNet: Emergency Medicine Network
 ICU: Intensive care unit
 MARC: Multicenter Airway Research Collaboration
 MgSO₄: Magnesium sulfate
 OR: Odds ratio
 PEF: Peak expiratory flow

The 2 objectives of this study were (1) to determine the prevalence of use of MgSO₄ among a group of North American ED providers and (2) to determine whether MgSO₄ use adheres to the current evidence according to asthma severity and response to initial therapy.

METHODS**Setting**

In 2001, we conducted a survey of site investigators participating in the Multicenter Airway Research Collaboration (MARC). MARC is part of the Emergency Medicine Network (EMNet), a research collaboration with 140 participating EDs across North America (<http://www.emnet-usa.org>). The MARC program emphasizes acute airway research and education.

Practice data

Between 1997 and 2001, a total of 10,169 patients were enrolled in observational asthma studies in MARC sites in the United States and Canada. At the time of the study, physicians were unaware of the study and did not use a particular protocol at each site. Chart review was conducted on patients aged 2 to 54 years currently having an asthma exacerbation, including a new diagnosis of asthma made by the emergency physician. Patients were excluded if previously enrolled.

Forms were reviewed by site investigators, submitted to the EMNet Coordinating Center, and further reviewed by trained personnel and underwent double data entry. Patients were managed at the discretion of the treating physician, and cases in which intravenous MgSO₄ was used were identified. Pulmonary functions were recorded as early during the ED visit as possible (usually peak expiratory flows [PEFs]); however, in some cases they were not recorded. Missing pulmonary function values do not necessarily represent a management failure; in some cases they were not obtained because the patient was breathing so poorly that it was not indicated or patients were unable or unwilling to perform this measurement.

The institutional review board at each hospital approved the studies.

Survey methods

A cover letter and a brief survey were distributed by e-mail to each of the 119 MARC site leaders at the time of the survey. They were asked to complete the survey form (see [Appendix](#)) and return it by fax, mail, or e-mail to the EMNet Coordinating Center. Two reminders were sent to sites that had not yet responded.

Survey instrument

The survey instrument consisted of 2 parts: a preliminary survey of the use of intravenous MgSO₄ in the hospital and a second part regarding interest in research in this area. If the site MARC representative did not respond, he or she was asked to participate in a structured telephone interview conducted by a trained research assistant.

TABLE I. Characteristics of patients who received intravenous MgSO₄ as part of their ED treatment for acute asthma

	Overall (n = 9745)	Intravenous MgSO ₄ , % (n = 240)	No MgSO ₄ , % (n = 9505)	P value
Demographic features				
Age (y), mean (SD)	9745	34.9 (11.8)	27.1 (14.9)	<.001
Sex				
Female	5567	68 (162)	58 (5405)	.001
Male	4065	32 (75)	42 (3990)	
Race-ethnicity				
White	2183	22 (50)	24 (2133)	.49
(non-Hispanic)				
Black	4768	50 (113)	51 (4655)	
(non-Hispanic)				
Hispanic	1942	25 (57)	21 (1885)	
Asian	216	1 (3)	2 (213)	
Other	193	2 (4)	2 (189)	
Missing	443	5 (13)	5 (430)	
Insurance status				
Private	2475	32 (60)	31 (2415)	.51
Public	3475	39 (72)	43 (3403)	
None	2124	29 (53)	26 (2071)	
Missing	1671	23 (55)	17 (1616)	
Site location				
US patients	9057	99 (237)	93 (8820)	<.001
Canadian patients	688	1 (3)	7 (685)	
Chronic asthma features				
Ever hospitalized for asthma (%)				
Yes	4878	80 (168)	59 (4710)	<.001
No	3274	20 (42)	41 (3232)	
Missing	1593	3 (30)	16 (1563)	
Ever intubated for asthma (%)				
Yes	1061	34 (75)	12 (986)	<.001
No	7397	66 (148)	88 (7249)	
Missing	1287	7 (17)	13 (1270)	
Acute asthma features				
Duration of asthma attack				
<24 h	4669	57 (127)	51 (4542)	.05
≥24 h	4490	43 (94)	49 (4396)	
Missing	586	8 (19)	6 (567)	

MARC site and patient data

Site characteristics, such as the type of ED (ie, general ED, ED in a pediatric-only hospital, or ED in an adult-only hospital) and number of ED visits over 1 year, were obtained from each site. Published sources provided additional information, such as the presence of an emergency medicine residency program and hospital type (ie, public or private not-for-profit hospital).

Data collection–statistical analysis

All forms were reviewed by trained personnel and then double data entered. All analyses were performed with STATA 7.0 software (StataCorp, College Station, Tex). Data are presented as proportions (with 95% CIs), means (with SDs), or medians (with interquartile ranges). The association between MgSO₄ use and other factors was

TABLE II. Multivariate characteristics of patients who received intravenous MgSO₄ as part of their ED treatment for acute asthma

	Overall (n = 9745)	Intravenous MgSO ₄ , % (n = 240)	No MgSO ₄ , % (n = 9505)	P value
Respiratory rate (beats/min), mean (SD)	9544	28 (8)	25 (8)	<.001
Initial predicted PEFR (%), mean (SD)	2832	40 (27)	51 (22)	.001
Initial predicted PEFR level (%)				
<50%	1529	22 (52)	16 (1477)	<.001
≥50%	1303	6 (16)	14 (1287)	
Missing	6913	72 (172)	71 (6741)	
No. of β-agonist puffs in first hour at ED, mean (SD)	9475	2.5 (1.1)	1.7 (1.1)	<.001
No. of β-agonist puffs over entire ED stay, mean (SD)	9397	5.4 (3.5)	3.1 (2.3)	<.001
Received ipratropium bromide in ED				
Yes	4512	57 (137)	44 (4410)	<.001
No	3639	43 (102)	56 (3502)	
Missing	1594	0.4 (1)	17 (1593)	
Received systemic corticosteroids in ED				
Yes	6810	95 (229)	70 (6581)	<.001
No	2882	5 (11)	30 (2871)	
Missing	53	0 (0)	1 (53)	
Continuous nebulization used during ED stay				
Yes	669	20 (46)	7 (623)	<.001*
No	8757	80 (188)	93 (8569)	
Missing	319	3 (6)	3 (313)	
Final ED predicted PEFR (%), mean ± SD	3085	64 (32)	75 (24)	.002
Final predicted PEFR level (%)				
<50%	495	13 (30)	5 (465)	<.001
≥50%	2590	22 (52)	27 (2538)	
Missing	6660	66 (158)	68 (6502)	
Outcomes				
ED Length of stay (h), mean ± SD	8889	4.7 (3.1)	3.5 (2.6)	<.001
ED disposition				
Admitted	1726	60 (140)	17 (1586)	<.001
Sent home	7612	30 (71)	81 (7541)	
AMA/LWT/other	245	10 (23)	2 (222)	
Missing	162	3 (6)	2 (156)	

PEFR, Peak expiratory flow rate; AMA, against medical advice; LWT, left without treatment.

*P values were calculated after exclusion of missing values (except PEF).

examined by using the χ^2 test, the Student *t* test, and the Wilcoxon rank sum test, as appropriate; a logistic regression analysis was used to determine the factors associated with MgSO₄ use in the patient sample. All *P* values are 2 tailed, with a *P* value of less than .05 considered statistically significant.

RESULTS

Practice data

From 10,169 ED visits, 9745 (96%) charts documented information regarding administration of MgSO₄ while at the ED. Of these, 240 (2.5%; 95% CI, 2.2% to 2.8%) patients received MgSO₄ (Table I). The frequency of MgSO₄ use was 10 times higher among admitted (8%) versus non-admitted (0.9%) patients (Table II). The logistic regression model (Table III) identified several factors as being associated with MgSO₄ use: patient demographics (increasing age, *P* < .001; female sex, *P* = .03), US site (*P* = .03), past history (ever intubated, *P* < .001; duration of symptoms

<24 hours, *P* = .03), asthma severity (higher initial respiratory rate, *P* < .001; initial predicted PEF <50%, *P* = .01; or PEF missing, *P* = .02), and treatment (higher number of β-agonists during ED stay, *P* < .001; corticosteroid use, *P* < .001).

Survey response rate

Of 119 different sites approached, 58 (49%) responded to the first mailing, and 45 (38%) responded to the subsequent mailings and telephone calls, for a total of 103 (87%) site responses. Overall, there were 20 (19%) Canadian sites and 83 (81%) US sites represented. Sites that responded did not differ in terms of ED characteristics from those that did not (data not shown).

Availability and recent use

Overall, 94 (92%; 95% CI, 85% to 97%) survey respondents stated that their EDs had MgSO₄ and used it for acute asthma; 66 (64%; 95% CI, 54% to 73%) had

TABLE III. Multivariate characteristics of patients who received intravenous MgSO₄ as part of their ED treatment for acute asthma

	OR	95% CI	P value
Demographics			
Age (per 5-y increase)	1.2	1.2-1.3	<.001
Female sex	1.5	1.1-2.1	.03
White (vs nonwhite)	1.2	0.8-1.7	.34
US ED	3.7	1.1-12.2	.03
Severity markers			
Ever intubated for asthma	2.5	1.8-3.4	<.001
Duration of symptoms <24 h	1.4	1.03-1.9	.03
Initial respiratory rate (per 5-breath/min increase)	1.2	1.1-1.3	<.001
No. of β -agonist puffs during ED stay (per 1-puff increase)	1.1	1.1-1.2	<.001
Initial predicted peak flow			
$\geq 50\%$	1.0	Reference	
<50%	2.1	1.2-3.9	.01
Missing	1.9	1.1-3.3	.02
Concomitant therapy			
Received systemic corticosteroids in ED	5.4	2.6-11.1	<.001

Of 7445 in the model, 182 received MgSO₄ in the ED. Area under the receiver operating characteristic curve = 0.82. $P = .18$, Hosmer-Lemeshow.

personally prescribed it in the preceding 6 months. Compared with the ED, respondents reported that fewer intensive care units (ICUs; 40 [39%]) used MgSO₄ for acute asthma ($P < .001$). Few EDs (4 [4%]) reported using this agent in a nebulized solution in patients with acute asthma.

Factors influencing MgSO₄ use

More respondents listed severity (96%) and failure to respond to initial β -agonists (87%) as factors that would prompt their use of MgSO₄. Other factors, such as age (10 [11%]), sex (1 [1%]), and duration of exacerbation (18 [21%]) were less commonly cited as factors influencing MgSO₄ use. By using a 1- to 5-point scale (mean $\pm$ SD; 1 = strongly agree and 5 = strongly disagree), respondents disagreed (3.9 ± 0.9) with the use of MgSO₄ in all patients presenting to the ED with asthma. Conversely, 72% of respondents agreed or strongly agreed with the statement that MgSO₄ is beneficial in the treatment of severe acute asthma (2.1 ± 0.8).

Comparisons

Although the use of MgSO₄ was higher in US sites than in Canadian sites (Table II), this factor was only marginally significant in the multivariable model ($P = .03$, Table III). US and Canadian emergency physicians reported no difference in the availability of MgSO₄ (94% vs 85%, $P = .18$) or in recent use (67% vs 50%, $P = .14$). The percentage of physicians who reportedly would use intravenous MgSO₄ was similar ($P > .2$) between the 2 countries for all factors listed earlier (Fig 1). These results suggest that the difference in the use of

MgSO₄ between countries is more likely a result of severity differences at presentation.

DISCUSSION

Acute asthma is a common ED presentation, and standardized treatment guidelines are now available in North America.^{4,5} However, new agents have recently been evaluated in asthma treatment, such as intravenous and inhaled MgSO₄, leukotriene modifiers, and long-acting β -agonists. Consequently, guidelines need to be updated to remain valid, and physicians need to continue to receive education and review updates to remain current.

Relieving the bronchospasm associated with the acute attack is an important component of asthma treatment in the ED, and this research was designed to determine the current patterns of use of intravenous MgSO₄ by emergency physicians. This agent acts as a bronchodilator in acute severe asthma and has been the subject of several clinical trials and systematic reviews.^{10,11} The ED data suggest that emergency physicians rarely use the agent in clinical practice; however, when they do, it appears the use is appropriate. For example, it is being used more frequently in patients with severe airflow limitation, in conjunction with aggressive treatment (eg, systemic corticosteroids, more β -agonists, and ipratropium bromide), and in patients who often required prolonged ED care or hospitalization. Moreover, MgSO₄ effectiveness relies on early recognition and administration during a severe attack; widespread use of other effective asthma therapies (eg, systemic and inhaled corticosteroids, continuous β -agonists, and ipratropium bromide) would therefore not be expected to reduce the need for MgSO₄.

The survey results suggest that the penetration of the findings from recent trials and systematic reviews has been relatively successful for emergency physicians in both the United States and Canada; however, the effectiveness of this agent appears to be less accepted in the ICU settings of these same hospitals. We found that the availability and use of MgSO₄ was high among ED physicians, and the factors influencing their use of this agent match those based on evidence. For example, emergency physicians appropriately use MgSO₄ for patients with severe asthma and those who fail to respond to initial therapy. Conversely, they do not appear to use this agent on the basis of age, sex, or duration of exacerbation.

The systematic review evidence demonstrating a benefit in acute asthma suggests it improves pulmonary functions and reduces admissions in patients who fail to respond and who have severe airflow limitation.^{10,11} Clearly, emergency physicians surveyed do not believe this therapy should be applied to all patients and would reserve this for the most severe cases. The review also found a benefit in children, as well as adults, and those surveyed also did not differentiate between the 2 groups. The data from the practice setting largely confirm these perceptions; however, ED physicians appear to use the agent in older individuals and in women more than expected.

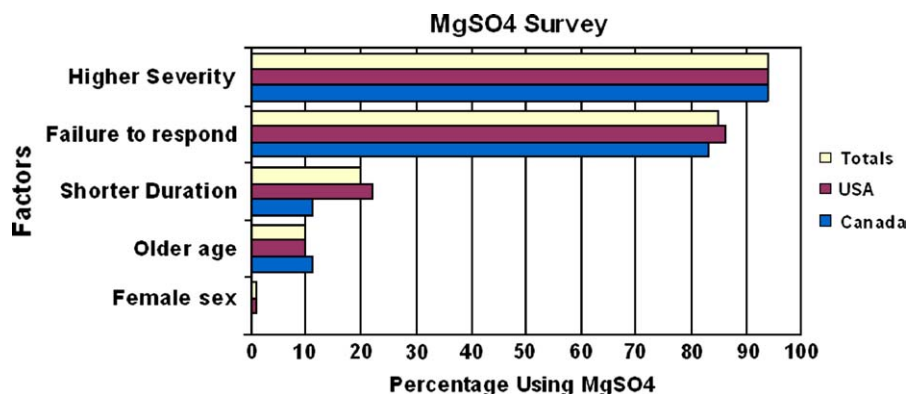


FIG 1. Perceptions of physicians regarding the factors that would stimulate administration of MgSO₄ to patients with acute asthma.

Despite the potential benefit of this agent, it has not received the same approval in the ICU and prehospital settings. For example, less than 50% of investigators reported the use of MgSO₄ by the hospital ICUs; we suspect emergency medical service use of MgSO₄ is even less well accepted. This “dissemination gradient” might be explained by the fact that the reviews were originally published in the Cochrane Library and emergency medicine journals^{10,11} and might not have filtered down to internists-intensivists or emergency medical service providers. It is therefore not surprising that a call for more research has been made by funding agencies dealing with this area (<http://nccam.nih.gov>).

These survey and patient data have several potential limitations. First, we were unable to confirm self-reports of either the availability or use of MgSO₄ in the EDs we surveyed. This shortcoming does not allow us to comment on the effect of this agent on ED patients. To better understand the use of MgSO₄, we compared our survey results with those from the largest collection of ED-based asthma studies conducted to date. In more than 10,000 patients presenting to multiple North American EDs with acute asthma, approximately 2% of patients received MgSO₄. The frequency of MgSO₄ use was 10 times higher among admitted (8%) versus nonadmitted (0.9%) patients, and appropriate demographic, historical, treatment, and severity indications appeared to guide therapy.

Second, these prospective studies were completed before the weight of evidence had been presented, and it would be interesting to see how these results have changed over time. It is likely that the patterns of MgSO₄ use will continue to evolve and might require monitoring to ensure that therapy is being used appropriately.

Third, there were some missing data in the study that might have biased the results, especially involving PEF measures. The multivariate model, however, demonstrates that patients who did not have PEF received MgSO₄ more frequently than the reference group (PEF $\geq 50\%$, Table III). This positive association was similar to that observed for patients who had a PEF of less than 50% (odds ratio, approximately 2.0). These findings suggest that patients who had severe asthma were spared the delays associated

with PEF measures to ensure prompt treatment of their acute bronchospasm.

Finally, the study sample included only physicians practicing in and leading MARC sites, and therefore the results of the survey might not be applicable to all general emergency physicians and their departments. The same could be said for the results of the patient sample. The results might be less impressive for those both outside academic settings and not focused on asthma research. Although possibly nongeneralizable to all physicians, this group of predominantly academic physicians serves low-income and minority patients, a population that has been identified as having severe asthma.¹² It is somewhat reassuring that this evidence has percolated to the place where it is likely to be needed most and most effective.

In summary, in this multicenter clinical and survey evaluation of intravenous MgSO₄ use in patients with acute asthma, we found a high prevalence of emergency physicians having ready access to this treatment and reporting recent and appropriate use. In addition, the clinical practice evaluation demonstrated that MgSO₄ use was rare, albeit appropriate. The use of MgSO₄ by other providers appeared to be less common, however, and suggests that widespread dissemination of the effect of MgSO₄ has yet to reach all who treat severe asthma exacerbations.

We thank the MARC Investigators for their ongoing dedication to emergency asthma research. We would also like to thank the EMNet staff (Jennifer Emond and Dr Sunday Clark) for their assistance with data collection and analyses.

REFERENCES

1. Mannino DM, Homa DM, Akinbami LJ, Moorman JE, Gwynn C, Redd SC. Surveillance for asthma—United States, 1980-1999. CDC Surveillance Summaries, March 29, 2002. MMWR Morb Mortal Wkly Rep 2002;51:1-13.
2. Weiss KB, Sullivan SD. The health economics of asthma and rhinitis. I. As economic impact. J Allergy Clin Immunol 2001;107:3-8.
3. Krahn MD, Berka C, Langlois P, Detsky AS. Direct and indirect costs of asthma in Canada. CMAJ 1996;154:821-31.
4. Boulet L-P, Becker A, Berube D, Beveridge R, Ernst P, on behalf of the Canadian Asthma Consensus Group. Canadian asthma consensus report, 1999. CMAJ 1999;161(suppl):S1-61.

5. National Heart, Lung, and Blood Institute, National Asthma Education and Prevention Program. Expert panel report 2: guidelines for the diagnosis and management of asthma. Bethesda (MD): US Department of Health and Human Services, National Institutes of Health; Publication no. 97-4051, 1997. Available at: <http://www.nhlbi.nih.gov/guidelines/asthma/asthgdln.pdf>.
6. Cabana MD, Rand CS, Powe NR, Wu AW, Wilson MH, Abboud PA, et al. Why don't physicians follow clinical practice guidelines? A framework for improvement. *JAMA* 1999;282:1458-65.
7. Cates CJ, Bara A, Rowe BH. Holding chambers versus nebulisers for beta-agonist treatment of acute asthma (Cochrane Review). In: *The Cochrane Library*, Issue 1. Chichester (United Kingdom): John Wiley & Sons, Ltd; 2005.
8. Rowe BH, Spooner CH, Ducharme FM, Bretzlaff JA, Bota GW. The effectiveness of corticosteroids in the treatment of asthma: a meta-analysis of their effect on preventing admission (Cochrane Review). In: *The Cochrane Library*, Issue 1. Chichester (United Kingdom): John Wiley & Sons, Ltd; 2005.
9. Edmonds ML, Camargo CA Jr, Pollack CV, Rowe BH. Early use of inhaled corticosteroids in the emergency department treatment of acute asthma (Cochrane Review). In: *The Cochrane Library*, Issue 1. Chichester (United Kingdom): John Wiley & Sons, Ltd; 2005.
10. Rowe BH, Bretzlaff JA, Bourdon C, Bota GW, Camargo CA Jr. Intravenous magnesium sulfate treatment for acute asthma in the emergency department: a systematic review of the literature. *Ann Emerg Med* 2000;36:181-90.
11. Alter HJ, Koepsell TD, Hilty WM. Intravenous magnesium as an adjunct in acute bronchospasm: a meta-analysis. *Ann Emerg Med* 2000;36:191-7.
12. Camargo CA Jr, Clark S. Emergency department management of acute asthma between 1996-2001: potential impact of the 1997 NAEPP guidelines [abstract]. *J Allergy Clin Immunol* 2002;109(suppl):S156.

APPENDIX

EMNet Steering Committee: Edwin D. Boudreaux, PhD; Barry E. Brenner, MD, PhD; Carlos A. Camargo, Jr, MD, DrPH (Chair); Rita K. Cydulka, MD, MS; Theodore J. Gaeta, DO, MPH; and Michael S. Radeos, MD, MPH.

EMNet Coordinating Center: Carlos A. Camargo, Jr, MD, DrPH (Chair); Sunday Clark, MPH; Jennifer A. Emond, MS; Jessica L. Hohrmann, MPH; and Sunghye Kim, MD—all at Massachusetts General Hospital, Boston, Mass.