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ORIGINAL ARTICLE – OPEN ACCESS

Evaluation of Proper Inhaler Use in Children with Acute Asthma Admitted to the Emergency Department: A Single-Center Cross-Sectional Study

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ABSTRACT

Objective: This study aimed to determine the accuracy of the inhaler technique used among asthmatic patients admitted to the emergency department (ED) due to acute asthma attack.

Materials and Methods: A total of 303 patients with childhood asthma were enrolled in this study. A survey consisting of 22 questions was conducted on patients and/or their parents during ED visits. Additionally, multiple logistic regression analysis was performed to determine the independent predictors affect the use of rescue inhaler treatment.

Results: In the study, although 258 patients were prescribed a rescue inhaler asthma treatment, only 212 (85.1%) used this treatment before the ED visits. Only 193 (78.4%) patients properly used an inhaler device. A total of 61 (23.7%) patients knew that they had run out of inhalers according to the number of doses recommended in the prospectus. According to multiple analysis, a close regular follow-up by the primary physician, by either allergist/immunologist or chest disease specialist, and the administration of inhaler by the parents were identified as independent risk factors for the use of rescue inhaler therapy.

Conclusion: Only three-quarters of the patients were found to use rescue inhaler therapy correctly. The improper use of inhaler device was more common in adolescents who administered the drug themselves. Patients who were followed-up by either allergist/immunologist or chest disease specialist had a two times higher chance of using rescue inhaler therapy in this study.

Keywords: Asthma, rescue, inhaler, therapy

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INTRODUCTION

Asthma is a chronic inflammatory bronchial airway disease characterized by bronchial hypersensitivity and reversible airway obstruction (1). The incidence and prevalence of asthma have been increasing over the past 20 years that is estimated to affect more than 300 million people worldwide (2). The primary goals in the treatment of asthma are the following: to control the daily symptoms of patients, prevent acute asthma attacks, maintain an adequate respiratory function, and improve the quality of life of such patients (3). Medical therapy in asthma consisted of rescue and regular inhaler treatment. Inhaled therapy is recommended as the first choice because it is the most effective route of delivery of medication to the lungs and has the least systemic side effects (3). In an inhaled therapy, patients often use a metered-dose inhaler (MDI) or a dry powder inhaler (e.g., Diskus, inhaler capsule, or Turbuhaler) (3).

Proper use of asthma inhalers has been well-known to prevent the development of acute asthma attacks and reduces hospitalization and the incidence of asthma-related mortality (4). In contrast, improper use of asthma inhaler can lead to the development of acute asthma attacks, thereby resulting in more frequent emergency department (ED) visits (5). Several previous studies conducted among adult patients admitted to the ED due to acute asthma attack showed that approximately half of these patients were not using inhaler treatment regimen correctly (6, 7). However, studies that evaluated the proper inhaler device use in childhood patients who were admitted to the ED due to acute asthma attack was limited. This study aimed to determine the accuracy of the inhaler technique used among asthmatic patients admitted to the ED and to evaluate the features of these patients along with factors related to the improper use of inhaler device.

MATERIALS and METHODS

This was a cross-sectional study, which enrolled patients with childhood asthma admitted to the Medeniyet University of Göztepe Training and Research Hospital ED due to acute asthma attack between November 2013 and April 2014. The study design was approved by the Clinical Research Ethics Committee of Göztepe Training and Research Hospital (dated 08.10.2013 and numbered: 0066), and it was conducted according to the "Good Clinical Practice" guidelines of the Declaration of Helsinki. A written and verbal informed consent was obtained from all subjects.

Table 1. Baseline demographic data of all study participants

	n	%	Mean±SD	Min.–Max.
Age, years			8.8±2.8	6–17
Gender				
Boys	156	51.5		
Girls	147	48.5		
The mean age at diagnosis of asthma, years			4.8±2.6	0.75–14
Duration of illness, years*			4.8±2.6	0.75–14
The mean number of emergency department and visits in the last year			2.8±2.2	1–10
The mean number of corticosteroid requirement due to asthma attacks			1±1.4	0–5
The number of hospitalization due to acute asthma attacks in the last year				
0	285	94.1		
1	17	5.6		
2	1	0.3		
Regular clinic follow-up				
Yes	116	38.3		
No	187	61.7		
The physician who followed up				
Allergist/immunologist or chest disease specialist	216	71.3		
Pediatrician or primary physician	87	28.7		
Any formal education about asthma				
Yes	153	50.5		
No	150	49.5		
The person who administered the drug				
Mother	254	83.8		
Father	8	2.7		
Caregiver	3	1		
Itself	38	12.5		
Mother's educational status				
Primary school	178	58.8		
Middle or high school	94	31		
University	3	10.2		
Father's educational status				
Primary school	122	40.2		
Middle or high school	144	47.5		
University	37	12.2		
Family income			1.905.8±1.116.4	0–7.000
The presence of atopy				
Yes	203	67		
No	51	16.8		
Not known	49	16.2		
Exposure to passive smoking				
Yes	223	73.6		
No	80	26.4		

SD: Standard deviation; Min.: Minimum; Max.: Maximum

Study Cohort

In this study, the inclusion criteria included the following: I) being between 6 and 17 years old and II) having a documented diagnosis of asthma as diagnosed by their primary physician. Furthermore, the exclusion criteria included the following: I) having an undocumented diagnosis of asthma, II) diagnosed with chronic disease, and

III) patients who did not want to participate in the study. Finally, the study cohort consisted of 303 patients with childhood asthma.

Data Collection

During ED visits, a survey consisting of 22 questions was conducted on patients and/or their parents who agreed to participate in the study. Information was collected from all patients regarding the demographic data, including age, sex, duration of their illness, and education status, etc. All patients and/or their parents were asked whether they had a previous diagnosis of atopy, were active cigarette smokers, or had passive cigarette smoking exposure. Also, all patients and/or their parents were investigated as regards their primary physician (whether they had been followed up by allergist/immunologist or chest disease specialist or pediatrician or primary care physician). Additionally, the data was collected on whether they received any formal education about asthma as a disease from their primary physician. A trained study coordinator evaluated all of the patients for regular inhaler use. Data about how long they had been using this treatment, how they used their inhaler device, and whether they had any knowledge about how their drug ran out were gathered. Also, all participants were asked whether they had already used any rescue inhaler. In case of using rescue inhaler device, all subjects were evaluated regarding which type of inhaler they used and whether they received their treatment before they were admitted to the ED. The study coordinators also evaluated whether the participants knew how to use inhaler properly following specific steps in the checklist, which were evaluated and confirmed in previous studies (8, 9). The subjects who fulfilled all of the steps required were defined as those who properly use their inhaler device.

Statistical Analysis

Number Cruncher Statistical System (NCSS) 2007 and Power Analysis and Sample Size (PASS) 2008 statistical software (Utah, USA) were used for statistical analysis. Categorical and descriptive variables were presented as mean±standard deviation, median (IQ: 25–75), frequency, ratio, minimum, and maximum values. The Student-t test was used for comparison of two groups with variables showing normal distribution and the Mann–Whitney U test for comparison of two groups with variables showing no normal distribution. The Pearson's Chi-Squared test, Fisher's Exact Test, Fisher–Freeman–Halton Test, and Yates' Continuity Correction test were used to compare qualitative data. Univariate and multiple logistic regression analyses were performed to determine the independent predictors of the use of rescue therapy. Variables with a p value of <0.05 in univariate regression were included into backward stepwise (conditional) logistic regression analysis. The goodness-of-fit test presented adequate calibration for the fitted multiple model (Hosmer–Lemeshow goodness-of-fit=8.226, p=0.292). Significance was assessed at levels $p<0.01$ and $p<0.05$, respectively.

RESULTS

Baseline demographic features of 303 patients included in the study are shown in Table 1. The mean age of the study cohort was 8.8±2.8 (6–17) years. Of the patients, 156 (51.5%) and 147 (48.5%) were boys and girls, respectively. The mean age at the diagnosis of asthma and the mean duration of illness were 4.8±2.6 (0.75–14) years and 4.8±2.6 (0.75–14) years, respectively. In this study, the mean number of ED visits due to acute asthma attack was 2.8±2.2 (1–10), and the mean systemic corticosteroid use requirement was 1.0±1.4 (1–5). A total of 18 (6.2%) patients had one or more ED visits in the last year. A total of 216 (71.3%) patients were followed-up by an allergist/immunologist or chest disease specialist. A total of 150 (49.5%) patients were observed to have formal education regarding the medications or the asthma inhalers given by any healthcare professional. Only 38 (12.5%) patients delivered inhaler treatment by themselves. In most patients (83.3%), inhaler therapy was administered by their mother, in 2.7% by their father, and in 1.0% by their caregiver. Educational status of the patients was as follows: 178 (58.8%), 94 (31.0%), and 31 (10.2%) patients were in elementary school, middle or high school, and college, respectively. While 67.0% of the patients had a known atopy, 16.2% of them were not evaluated on whether they had any atopy until the time of the study.

Table 2. Participants receiving regular asthma treatment

	n	%
Receiving regular treatment		
No	96	31.7
Drug was offered but the patient refused	22	23.2
Drug was offered but the patient later gave up	14	14.7
No drug was offered by the physician	59	62.1
Yes	207	68.3
Metered-dose inhaler with a spacer	155	74.9
Metered-dose inhaler without a spacer	20	9.2
Turbuhaler	16	7.7
Diskus	10	4.8
Inhaler capsule	2	1
Nebulizer	5	2.4
Proper use of inhaler device (n=207)		
No	59	28.5
Yes	148	71.5
Ability to tell if MDI was empty(n=207)		
Yes (according to the prospectus recommendations)	48	23.2
No	159	76.8
Feeling of less drug coming out than before	13	8.2
No drug came out after pressing inhaler	146	91.8
No tasting of drug	0	0
Medical treatment duration, (months), Mean±SD (min.–max.)	32.2±25.6 (3–132)	

MDI: Metered-dose inhaler; SD: Standard deviation; Min.: Minimum; Max.: Maximum

This study has found that 207 (68.3%) patients received a regular asthma treatment (Table 2). Among these patients, only five were treated with nebulizer. Of those who used regular inhaler therapy, 74.9%, 9.2%, 7.7%, 4.8%, and 1.0% were using MDI device with a spacer, MDI device without a spacer, Turbuhaler, Diskus inhaler, and inhaler capsules, respectively. A total of 148

Table 3. Comparison of subjects receiving regular treatment in terms of proper or improper use of inhaler device

	Proper use of inhaler device (n=148)		Improper use of inhaler device (n=95)		p
	n	%	n	%	
Age, years, median (1st–3rd quartiles)	9.0 (7.2–12.0)		8.0 (6.0–10.0)		a**0.015**
Duration of illness, years, (1st–3rd quartiles)	5.0 (3.2–7.0)		4.0 (3.0–6.0)		b**0.042**
The number of emergency department and visits in the last year, (1st–3rd quartiles)	1.0 (1.0–2.0)		1.0 (1.0–4.0)		b**0.023**
The number of patients who received corticosteroid due to asthma attacks	86	58.1	51	53.7	d0.497
The number of hospitalization due to acute asthma attacks in the last year	7	4.7	6	6.3	c0.807
Parents' educational status					
Primary school	56	37.8	33	34.7	
Middle school	68	45.9	49	51.6	d0.678
High school or university	24	16.2	13	13.7	
The presence of atopy					
Yes	100	67.6	71	74.7	
No	23	15.5	16	16.8	d0.170
Not known	25	16.9	8	8.4	
The physician who followed up					
Allergist or chest disease specialist	116	78.4	73	76.8	d0.779
Pediatrician or primary physician	32	21.6	22	23.2	
The presence of formal education	77	52.0	46	48.4	d0.583
The person who administered the drug					
Self	12	8.1	20	21.1	e**0.007***
Others	136	91.9	75	78.9	
Exposure to passive smoking					
No	103	69.6	76	80.0	c0.099
Yes	45	30.4	19	20.0	
Income					
Low	122	84.4	79	83.2	
Middle	16	10.8	13	13.7	d0.406
High	10	6.8	3	3.2	

a: Student-t test; b: Mann–Whitney U test; c: Yates' Continuity Correction test; d: Pearson's Chi-squared test; *: p<0.01

(71.5%) patients were determined to fulfill all of the practical application steps required on the proper use of an inhaler. Of note, only 23.2% of those using regular treatment knew that they had run out of inhalers according to the number of doses recommended in the prospectus.

Patients who received regular treatment were compared in terms of proper or improper use of inhaler device (Table 3). Patients who properly use their inhaler device were younger, had a shorter duration of illness, and had more ED visits compared to those who did not properly use their inhaler device (p=0.015, p=0.042, and p=0.023, respectively). Also, the frequency of improper use of inhaler device was significantly higher in patients who administered these drugs by themselves (p=0.007). No significant differences were found between groups in terms of other variables.

In this study, although 258 patients were prescribed a rescue inhaler asthma treatment, only 212 (85.1%) of them used this treatment before the ED visits (Table 4). Of the 258 patients who had a rescue inhaler asthma treatment, only 193 (78.4%) of them properly used an inhaler device. A total of 61 (23.7%) patients knew that they had run out of inhalers according to the number of doses recommended in the prospectus. In the study, 14.9% of patients (n=45) did not use rescue inhaler treatment during the ED visits. Of these patients, 51.1% had not been prescribed inhaler by their physicians, 40% did not carry the drug with them, and 8.9% of them gave up the use of inhaler device.

Patients who received rescue inhaler therapy were compared in terms of proper or improper use of inhaler device (Table 5). As noted, patients with proper use of inhaler device were followed up by either allergist/immunologist or chest disease specialist,

Table 4. Patients using rescue inhaler treatment

	n	%
Receiving rescue treatment		
No	45	14.9
Drug was not prescribed by the physician	23	51.1
Patient did not carry the drug with him/her	18	40
Patient did not use the drug	4	8.9
Yes	258	85.1
Metered-dose inhaler with a spacer	180	69.8
Metered-dose inhaler without a spacer	30	11.6
Turbuhaler	22	8.5
Diskus	26	10.1
Proper inhaler use (n=258)		
No	65	25.2
Yes	193	74.8
Ability to tell if MDI was empty (n=257)		
Yes (according to the prospectus recommendations)	61	23.7
No	196	76.3
Feeling of less drug coming than before	19	9.7
No drug came after pressing inhaler	176	89.8
No tasting of drug	1	0.5
Receiving rescue inhaler before ED visit		
Yes (3 times with 20 min interval)	212	70
No	91	30
No drug was prescribed	48	53.3
Did not know how to use	9	10
Others	33	36.7

MDI: Metered-dose inhaler

received regular treatment, had a closer follow-up, and had passive smoking exposure compared to those who used their inhaler device improperly (p=0.005, p=0.001, p=0.018, and p=0.037, respectively). Additionally, the frequency of improper use of inhaler device was more common in patients who administered their inhaler by themselves (p=0.002). No significant differences were found between groups in terms of other variables.

Variables, such as the person who admnistered the drug, the specialization of the physician who followed up, parents' educational status (middle or low), exposure to passive cigarette smoking, use of regular treatment, and being followed by a regular physician, were found to have an effect on the use of rescue inhaler treatment according to univariate analysis. These variables were included in the multiple logistic regression analysis using a backward stepwise (conditional) logistic regression analysis. Based on the multiple logistic regression analysis results, a close regular follow-up by the primary physician [odds ratio (OR): 0.354, 95% confidence interval (CI): 0.158–0.791], being followed up by either allergist/immunologist or chest disease specialist [OR: 2.351, 95%CI: 1.069–5.704], and the administration of inhaler by the parents [OR: 4.407, 95%CI: 1.873–10.367] were identified as independent risk factors for the use of rescue inhaler therapy. Table 6 shows the results of multiple logistic regression analysis.

DISCUSSION

The main findings of this study were as follows: I) approximately one out of four patients receiving regular therapy used inhaler treatment properly, II) only three-quarters of the patients used rescue inhaler therapy correctly, III) the patients who were followed up by either an allergist/immunologist or chest disease specialist had a two times higher chance of using rescue inhaler therapy, and IV) the improper use of inhaler device for both regular and rescue treatments was more common in adolescents who administered the drug themselves.

Asthma, which is a chronic inflammatory bronchial airway disease, ranks among the most common causes of ED visits and hospitalization (10). The most important goal in the treatment of asthma is to control the disease by preventing asthma attacks. In particular, regular inhaler treatment should be effectively used to prevent such attacks (3–5). However, this study has noted that approximately one out of four patients receiving regular therapy did not fulfill all of the practical application steps required in using inhaler properly. Furthermore, the ratio of improper use of regular inhaler device was significantly higher in those who administered the drugs by themselves. Additionally, only 23.2% of these patients were aware that they had run out of inhalers according to the number of doses recommended in the prospectus. Besides that, 14 patients gave up regular inhaler therapy despite being offered by the primary physician. Hence, this study's findings provide evidence that more efforts are needed to educate patients and families about not only long-term adherence to inhaler treatment but also for the proper use of inhaler device.

All patients with asthma are at risk of developing an acute asthma attack (11). Experiencing such event is one of the most important factors in the morbidity and mortality of the disease. Choosing the appropriate inhaler and giving a written action plan to all patients with asthma reduce the number of ED visits, systemic corticosteroid requirements, and hospitalizations due to acute asthma attacks (12, 13). Therefore, all patients should have rescue inhaler treatment that can be used during an acute asthma attack. However, this study has observed that 45 (14.9%) patients did not use rescue inhaler treatment during ED visits. Moreover, rescue inhaler treatment was not prescribed by the primary physician or most patients did not carry the drug with them, and 8.9% of them gave up the use of inhaler device later. Besides that, only three-quarters of the patients used rescue inhaler therapy correctly in this study. Therefore, considering the apparent clinical benefits of rescue inhaler use in patients with asthma, every effort should be made to increase the use of such therapy in clinical practice.

A previous study showed that adult patients with asthma followed up by chest disease specialists were more likely to use rescue inhalers properly than those followed by internal medicine specialists (14). This study also found that the frequency of proper use of rescue inhaler was significantly higher in patients followed up by allergist or chest disease specialists. Additionally, patients who were followed-up by either allergist/immunologist or chest disease specialist had a two times higher chance of using rescue inhaler therapy according to our logistic regression analysis.

Table 5. Comparison of patients using rescue inhaler in terms of proper or improper use of inhaler device

	Proper use of inhaler device (n=193)		Improper use of inhaler device (n=65)		p
	n	%	n	%	
Age, years, median (1st–3rd quartiles)	8.0 (6.0-10.0)		9.0 (6.6-10.2)		[a]0.097
Duration of illness, years, (1st–3rd quartiles)	4.0 (3.0-6.0)		5.0 (4.0-6.6)		[b]0.126
The number of emergency department and visits in the last year, (1st–3rd quartiles)	1.0 (1.0–2.0)		1.0 (1.0–3.0)		[b]0.332
The number of patients who received corticosteroid due to asthma attacks	103	53.4	37	56.9	[d]0.619
The number of hospitalization due to acute asthma attacks in the last year	10	5.2	5	7.7	[e]0.540
The presence of atopy					
Yes	122	63.2	52	80.0	
No	37	19.2	9	13.8	[c]0.228
Not known	34	17.6	4	6.2	
The physician who followed up					
Allergist or chest disease specialist	169	87.5	45	69.2	[c]**0.005***
Pediatrician or primary physician	24	12.5	20	30.8	
Receiving regular treatment	154	79.7	39	60.1	[c]**0.018**
Regular clinic follow-up	157	81.3	16	24.6	[c]**0.001***
The presence of formal education	95	49.2	36	55.4	[d]0.390
The person who administered the drug					
Self	15	7.8	15	23.1	[c]**0.002***
Others	178	92.2	50	76.9	
Parents' education status					
Primary school					
Middle school	89	46.1	33	50.8	[d]0.092
High school or university	37	19.2	5	7.7	
Exposure to passive smoking					
No	136	70.5	55	84.6	[c]**0.037**
Yes	57	29.5	10	15.4	
Income					
Low	159	82.4	55	84.6	
Middle	21	10.9	10	15.4	[d]0.073
High	13	6.7	0	0.0	

a: Student-t test; b: Mann-Whitney U test; c: Yates' Continuity Correction test; d: Pearson Chi-square test; *: p<0.01

Table 6. Independent variables that have an effect on the rescue inhaler use according to multiple logistic regression analysis

	p	Odds ratio	%95 Confidence interval	
The physician who followed up (allergist or chest disease specialist)	0.001**	2.351	1.069	5.704
Regular follow-up	0.011*	0.354	0.158	0.791
Administration of the drug by the parents	0.001**	4.407	1.873	10.367

*: p<0.05; **: p<0.01

In this study, improper use of inhaler device for both regular and rescue treatments was significantly more frequent in adolescents who administered the treatment themselves. Also, the administration of inhaler by the parents was identified as an independent risk factor for the use of rescue inhaler therapy. During the adolescent period, most patients often do not want to accept their

illness, have fewer clinical follow-up visits, and feel less need to use rescue treatment (15). They are also often more careless when using medication. A previous study showed that a video-assisted interactive training was more successful in adolescents in terms of properly using MDI (110) (16). Additionally, group therapy and training with peers have increased the likelihood of properly using an inhaler device as shown in previous studies (17, 18). Therefore, when teaching adolescents about inhaler device use, the primary physician should prefer and use the abovementioned methods.

Recent studies showed conflicting data on whether the patients' and their parents' socioeconomic and educational status are related to the proper use of inhaler device. A study conducted by Capanoglu et al. (19) showed that the ratio of the proper use of an inhaler device was significantly higher in adult patients with asthma as the education level increased. However, this study found that it might not have a significant effect on the proper use of inhaler device in such patients (20). In this study, educational status and monthly income level of the parents did not differ between the groups. Since a large proportion of the enrolled subjects had low or middle economic status, study results may not have truly reflected the impact of the economic status on the proper use of inhaler device. Meanwhile, in this study, a few parents had a high level of education, and logistic regression analysis showed that the level of education of the parents had no significant effect on the proper use of inhaler device.

In this study, while most patients demonstrated the proper use of an inhaler device, only one out of four patients could tell if the MDI was empty. Several previous studies showed that most patients could not tell if the MDI was empty based on the number of doses recommended in the prospectus (21, 22). The most important factor was demonstrated to be the lack of a dose counter in the MDI. Recently, a dose counter has been added to MDI devices produced in Western countries. However, the MDIs used in our country do not have a dose counter. This may support why most patients cannot tell if the MDI is empty. Therefore, adding a dose counter to MDIs will increase the knowledge of patients in determining whether the MDI is empty. On the other hand, Turbuhaler form has a dose counter which indicates that the drug is running out. However, studies show that the optimal maximum inspiratory flow rate for the effective use of a Turbuhaler form must be at least 60 ml/second (23). At the same time, patients must breathe in forcefully and deeply through the mouth to use the Turbuhaler form (23). For these reasons, Turbuhaler forms are recommended for use in children over the age of 12. When all patients were asked about the most important features expected to be found in an ideal inhaler device, most of them reported that a dose counter and ease of use were the most important factors during attacks.

Limitations of the Study

This study had several limitations: First, the study was conducted in a single center, which might not represent inhaler practice in other geographical areas. Second, as it was a cross-sectional study, we acknowledged that temporal variations in the use of inhaler devices by the patients might not be established. Finally, multicenter studies with large populations to determine the frequency of proper use of inhaler device in patients with childhood asthma are needed.

CONCLUSION

Therefore, this study found that only three-quarters of the patients used rescue inhaler therapy correctly. The improper use of inhaler device was more common among adolescents who administered the drug themselves. A close regular follow-up by the primary physician, being followed-up by either allergist/immunologist or chest disease specialist, and the administration of inhaler by the parents were identified as independent risk factors for the use of rescue inhaler therapy. Our findings highlight the importance of multidisciplinary approach to patients to define and solve reasons for the improper use of inhaler device.

Ethics Committee Approval: The study design was approved by the Clinical Research Ethics Committee of Göztepe Training and Research Hospital (dated 08.10.2013 and numbered: 0066), and it was conducted according to the "Good Clinical Practice" guidelines of the Declaration of Helsinki.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – AAÇ, MA; Design – AAÇ, MA; Supervision – EB, MÖ, MA; Resource – AAÇ, PA; Materials – AAÇ, PA; Data Collection and/or Processing – AAÇ, PA, EB, MÖ; Analysis and/or Interpretation – MA; Literature Search – AAÇ, PA, EB, MÖ; Writing – AAÇ; Critical Reviews – EB, MÖ, MA.

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