Factors related to the incorrect use of inhalers by asthma patients*

Fatores relacionados ao uso incorreto dos dispositivos inalatórios em pacientes asmáticos

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Abstract

Objective: To evaluate inhaler technique in outpatients with asthma and to determine associations between the correctness of that technique and the level of asthma control. Methods: This was a cross-sectional study involving patients ≥ 14 years of age with physician-diagnosed asthma. The patients were recruited from the Asthma Outpatient Clinic of the Hospital de Clínicas de Porto Alegre, in the city of Porto Alegre, Brazil. The patients completed two questionnaires (a general questionnaire and an asthma control questionnaire based on the 2011 Global Initiative for Asthma guidelines), demonstrated their inhaler technique, and performed pulmonary function tests. Incorrect inhaler technique was defined as the incorrect execution of at least two of the predefined steps. Results: We included 268 patients. Of those, 81 (30.2%) showed incorrect inhaler technique, which was associated with poor asthma control (p = 0.002). Logistic regression analysis identified the following factors associated with incorrect inhaler technique: being widowed (OR = 5.01; 95% CI, 1.74–14.41; p = 0.003); using metered dose inhalers (OR = 1.58; 95% CI, 1.35–1.85; p < 0.001); having a monthly family income < 3 times the minimum wage (OR = 2.67; 95% CI, 1.35–1.85; p = 0.008), and having ≥ 2 comorbidities (OR = 3.80; 95% CI, 1.03–14.02; p = 0.045). Conclusions: In the sample studied, incorrect inhaler technique was associated with poor asthma control. Widowhood, use of metered dose inhalers, low socioeconomic level, and the presence of ≥ 2 comorbidities were associated with incorrect inhaler technique.

Keywords: Metered dose inhalers; Dry powder inhalers; Asthma/therapy.

Resumo

Objetivo: Avaliar a técnica inalatória em pacientes com asma atendidos ambulatorialmente, estabelecendo associações dessa com o grau de controle da doença. Métodos: Estudo transversal envolvendo pacientes com idade ≥ 14 anos e diagnóstico médico de asma, recrutados no Ambulatório de Asma do Hospital de Clínicas de Porto Alegre (RS). Os pacientes completaram dois questionários (um geral e um questionário de controle da asma baseado nas diretrizes da Global Initiative for Asthma de 2011). Os pacientes demonstraram a técnica inalatória e realizaram testes de função pulmonar. A técnica inalatória incorreta foi definida como a execução incorreta de pelo menos duas etapas da avaliação. Resultados: Foram incluídos 268 pacientes. Desses, 81 (30,2%) apresentaram técnica inalatória incorreta, que foi associada com falta de controle da asma (p = 0,002). A regressão logística identificou os seguintes fatores associados com a técnica inalatória incorreta: ser viúvo (OR = 5,01; IC95%, 1.74–14.41; p = 0.003); utilizar inalador pressurizado (OR = 1,58; IC95%, 1.35–1.85; p < 0.001); ter renda familiar mensal < 3 salários mínimos (OR = 2,67; IC95%, 1.35–1.85; p = 0.008), e ter ≥ 2 comorbidades (OR = 3,80; IC95%, 1.03–14.02; p = 0.045). Conclusões: Na amostra estudada, a técnica inalatória incorreta se associou com a falta de controle da asma. Viuvez, uso de inalador pressurizado, baixo nível socioeconômico e presença de ≥ 2 comorbidades se associaram à técnica inalatória incorreta.

Descritores: Inaladores dosimetrados; Inaladores de pó seco; Asma/terapia.
Introduction

Asthma is one of the most common chronic conditions. Although the results of clinical findings have shown that asthma control can be achieved in most patients, epidemiological evidence suggests that there is a significant gap between treatment goals and the actual level of control achieved with treatment in the general population. Therefore, there remains the challenge of identifying the factors that are related to poor asthma control and of developing strategies to ensure that asthma control is achieved and maintained.

Inhaled drugs are the primary treatment for asthma. Incorrect handling of inhalers and inappropriate inhaler technique result in low bronchial deposition of the drug and can contribute to poor asthma control. Understanding the frequency and type of inhaler technique errors, as well as their associations with the level of asthma control, may allow the development of educational strategies to help reduce the morbidity of the disease.

The objective of the present article was to assess inhaler technique in outpatients with asthma and to determine associations between the correctness of that technique and the level of asthma control.

Methods

This was a cross-sectional study. The study protocol was approved by the Research Ethics Committee of the Hospital de Clínicas de Porto Alegre (HCPA, Porto Alegre Hospital de Clínicas), located in the city of Porto Alegre, Brazil. Written informed consent was obtained from all patients or their legal guardians, in the case of those under 18 years of age. The study population consisted of patients treated at the HCPA outpatient clinics specializing in asthma. Individuals aged 18 years or older who had a previous diagnosis of asthma were sequentially recruited. A physician who was a member of the research team confirmed the diagnosis on the basis of the following criteria: symptoms consistent with asthma, accompanied by reversible airflow obstruction (an increase in FEV₁ ≥ 12% and ≥ 200 mL after administration of an inhaled short-acting β₂ agonist) or by hyperresponsiveness to a bronchial challenge agent. Patients should have made two prior visits to one of the outpatient clinics mentioned above, and the pharmacological treatment regimen should have already been adjusted to the level of asthma severity. Patients should be receiving inhaled corticosteroids alone or in combination with long-acting β₂ agonists.

The exclusion criteria were declining to participate in the study, having another chronic lung disease (emphysema, chronic bronchitis, or bronchiectasis), not using inhaled drugs, and failing to complete all of the evaluations required by the study protocol.

The questionnaire used to interview patients included a checklist for assessing patient handling of the device used to inhale the corticosteroid. Prior to the study outset, the principal investigator trained all members of the research team on the correct use of each device and on how to score each stage of the evaluation process. Patients were asked to demonstrate their inhaler technique, using placebo. For metered dose inhalers, patients were assessed for their performance of the following steps: a) shaking the inhaler before using it; b) exhaling normally before using the inhaler; c) holding the inhaler at an appropriate distance (3–5 cm) from the lips if a spacer is not used or, if a spacer is used, placing the inhaler in the mouth and creating an adequate seal with the lips; d) inhaling slowly and deeply after squeezing the inhaler; and e) performing a breath-hold of at least 10 seconds (after inhalation). For dry powder inhalers, patients were assessed for their performance of the following steps: a) exhaling normally before using the inhaler; b) placing the inhaler in the mouth and creating an adequate seal with the lips; c) inhaling as forcefully and deeply as possible; and d) performing a breath-hold of at least 10 seconds (after inhalation).

Asthma severity was categorized on the basis of the daily medication regimen in use, as proposed in the Global Initiative for Asthma (GINA) guidelines.

The level of asthma control was assessed in accordance with the classification proposed in the 2011 GINA guidelines (Chart 1).

The pulmonary function was assessed with a computerized spirometer (MasterScreen v4.31; Jaeger, Würzburg, Germany). We recorded FVC, FEV₁, and the FEV₁/FVC ratio. All parameters are expressed as a percentage of the predicted value for age, gender, and height.

Measurements of PEF were performed with a portable peak flow monitor (Vitalograph; Boehringer Ingelheim, Ingelheim am Rhein,
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**Results**

A total of 334 eligible patients were examined. Thirty patients declined to participate, 27 patients were excluded because they had another chronic lung disease, 7 patients were excluded because they did not use the prescribed inhaled drug, and 2 patients were excluded because they failed to complete all of the evaluations required by the study protocol. Therefore, 268 individuals completed the study. Of those, 187 patients showed correct inhaler technique and 81 (30.2%) showed incorrect technique.

Table 1 shows the general characteristics of the study patients. One hundred and ninety-nine patients (74.3%) were female, and 223 (83.2%) were White. The mean age was 50.9 ± 16.5 years. Most patients (60.1%) had had 8 years of schooling or less, and 186 (69.4%) had a monthly family income of less than three times the national minimum wage. Asthma severity was classified as mild persistent in 37 (13.8%) of the patients, as moderate persistent in 89 (33.2%), and as severe persistent in 142 (53.0%). Asthma was classified as controlled in 47 (17.5%) of the patients, as partially controlled in 74 (27.6%), and as uncontrolled in 147 (54.9%).

Table 2 shows the comparison between groups formed on the basis of inhaler technique assessment. Statistically significant differences

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**Chart 1 - Criteria for assessing the level of asthma control.**

| Level of asthma control | Controlled (presence of all criteria) | Partially controlled (presence of any criteria in any given week) | Uncontrolled (presence of any criteria) |
|-------------------------|--------------------------------------|------------------------------------------------|--------------------------------------|
| **Level of asthma control** | **Controlled** | **Partially controlled** | **Uncontrolled** |
| | (presence of all criteria) | (presence of any criteria in any given week) | (presence of any criteria) |
| • Daytime symptoms twice a week or less | • Daytime symptoms twice a week or less | • Daytime symptoms twice a week or less | • 3 or more criteria of partially controlled asthma in any given week |
| • No limitation of activities | • Any limitation of activities | • Any limitation of activities | • Exacerbation requiring the use of oral corticosteroids in any given week |
| • No nocturnal symptoms/ awakenings | • Any nocturnal symptom/ awakening | • Any nocturnal symptom/ awakening | • Hospitalization/emergency room admission for asthma in the last 12 months |
| • Rescue medication twice a week or less | • Rescue medication more than twice a week | • Rescue medication more than twice a week | • Rescue medication more than twice a week |
| • Normal pulmonary function | • Pulmonary function < 80% of the predicted value or of the personal best value, if known | • Pulmonary function < 80% of the predicted value or of the personal best value, if known | • Pulmonary function < 80% of the predicted value or of the personal best value, if known |

*a* In accordance with the Global Initiative for Asthma. (4)
of schooling or less being higher among those with incorrect inhaler technique; monthly family income ($p = 0.016$), the proportion of patients with an income of less than three times the national minimum wage being higher among those with incorrect inhaler technique; and level of asthma control ($p = 0.007$), the proportion of patients with uncontrolled asthma being higher among those with incorrect inhaler technique.

Table 3 shows that there was a statistically significant difference in type of inhaler used ($p < 0.001$) between the two groups formed on the basis of inhaler technique assessment, the proportion of patients with correct technique being higher among those using dry powder inhalers than among those using metered dose inhalers. In addition, the proportion of patients with correct inhaler technique differed significantly among each specific type of inhaler used ($p < 0.001$), the proportion of patients with correct inhaler technique being higher among those using Aerolizer® or Turbuhaler®. In contrast, we found a higher proportion of patients with incorrect technique among those using metered dose inhalers without spacers.

Table 4 shows the logistic regression for factors related to incorrect inhaler technique. The following variables were independently associated with incorrect inhaler technique: being widowed ($OR = 5.01; 95\% CI, 1.74-14.41; p = 0.003$); using metered dose inhalers ($OR = 1.58; 95\% CI, 1.35-1.85; p < 0.001$); having a monthly family income of less than three times the national minimum wage ($OR = 2.67; 95\% CI, 1.35-1.85; p = 0.008$); and having two or more comorbidities ($OR = 3.80; 95\% CI, 1.03-14.02; p = 0.045$).

**Discussion**

The present study showed that the number of inhaler technique errors has a significant impact on the level of asthma control. The variables that were associated with incorrect inhaler technique were being widowed, using metered dose inhalers, having a monthly family income of less than three times the national minimum wage, and having two or more comorbidities.

Incorrect inhaler technique in asthma treatment can substantially reduce lung deposition of the drug, undermining the effectiveness of asthma treatment. In the present study, incorrect inhaler technique (i.e., making 2 or more errors) was
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More errors, found no association between the correctness of inhaler technique and the level of asthma control.

Table 2 - Comparison between groups formed on the basis of inhaler technique assessment.

| Variable                          | Correct technique | Incorrect technique | p      |
|----------------------------------|-------------------|---------------------|--------|
| Gender                           |                   |                     |        |
| Female                           | 136 (72.7)        | 63 (77.8)           | 0.474  |
| Male                             | 51 (27.3)         | 18 (22.2)           |        |
| Age, years                       | 50.4 ± 16.5       | 52.7 ± 16.8         | 0.296  |
| Ethnicity                        |                   |                     |        |
| White                            | 155 (82.9)        | 68 (84.0)           | 0.971  |
| Non-White                        | 32 (17.1)         | 13 (16.0)           |        |
| Age at diagnosis of asthma, years | 26.0 (71.0)      | 24.0 (40.0)         | 0.966  |
| Marital status                   |                   |                     |        |
| Married/spouse                   | 106 (56.7)        | 36 (44.4)           | 0.002  |
| Divorced/separated               | 22 (11.8)         | 12 (14.8)           |        |
| Widowed                          | 10 (5.3)          | 16 (19.8)           |        |
| Single                           | 49 (26.2)         | 17 (21.0)           |        |
| Level of education               |                   |                     |        |
| < 9 years of schooling           | 105 (56.1)        | 56 (69.1)           | 0.023  |
| ≥ 9 years of schooling           | 64 (34.2)         | 24 (29.6)           |        |
| College                          | 18 (9.6)          | 1 (1.2)             |        |
| Monthly family income, number of times the national minimum wage | | | 0.016 |
| < 3                              | 120 (64.2)        | 66 (81.5)           |        |
| 3-10                             | 65 (34.8)         | 14 (17.3)           |        |
| > 10                             | 2 (1.1)           | 1 (1.2)             |        |
| Smoking status                   |                   |                     | 0.226  |
| Never smoker                     | 119 (63.6)        | 43 (53.1)           |        |
| Former smoker                    | 63 (33.2)         | 34 (42.0)           |        |
| Smoker                           | 5 (2.7)           | 4 (4.9)             |        |
| Comorbidities                    |                   |                     | 0.055  |
| 0                                | 117 (62.6)        | 43 (53.1)           |        |
| 1                                | 64 (34.2)         | 30 (37.0)           |        |
| ≥ 2                              | 6 (3.2)           | 8 (9.9)             |        |
| Level of asthma severity (GINA)  |                   |                     | 0.094  |
| Mild intermittent or persistent  | 31 (16.6)         | 6 (7.4)             |        |
| Moderate persistent              | 63 (33.7)         | 26 (32.1)           |        |
| Severe persistent                | 93 (49.7)         | 49 (60.5)           |        |
| Level of asthma control (GINA)   |                   |                     | 0.007  |
| Controlled                       | 39 (20.9)         | 8 (9.9)             |        |
| Partially controlled             | 57 (30.5)         | 17 (21.0)           |        |
| Uncontrolled                     | 91 (48.7)         | 56 (69.1)           |        |
| FVC, % of predicted              | 83.5 ± 20.8       | 84.5 ± 22.0         | 0.748  |
| FEV₁, % of predicted             | 68.0 ± 23.7       | 71.2 ± 21.5         | 0.337  |
| FVC/FEV₁, % of predicted         | 65.8 ± 13.2       | 66.8 ± 11.1         | 0.605  |
| PEF, % of predicted              | 64.9 ± 22.9       | 61.3 ± 20.2         | 0.232  |

GINA: Global Initiative for Asthma. *Values expressed as n (%), except where otherwise indicated. †Correct technique was defined as making < 2 inhaler technique errors; incorrect technique was defined as making ≥ 2 inhaler technique errors. ‡Values expressed as mean ± SD. §Value expressed as median (interquartile range). ∥Statistically significant adjusted standardized residuals (< −1.96 or > 1.96). The independent sample t-test was used for variables with normal distribution; the Mann-Whitney U test was used for variables without normal distribution; and the chi-square test was used for categorical variables.

Associated with poor asthma control. It is of note that a previous study, in which incorrect inhaler technique was defined as making one or more errors, found no association between the correctness of inhaler technique and the level of asthma control.
patients using metered dose inhalers without spacers are considered. Metered dose inhalers are more difficult to use, because they require greater motor coordination. The use of a spacer reduces the need for greater motor coordination, but, despite that, metered dose inhalers remain more difficult to use than dry powder inhalers, which leads to a higher proportion of inhaler technique errors. However, one factor to be considered in the present study is that the number of inhaler technique steps assessed was greater for metered dose inhaler use (five steps) than for dry powder inhaler use (four steps). This may indicate a bias in the present study, with the requirement for classifying the technique as correct being more stringent for individuals using metered dose inhalers. However, this is more likely to represent the greater complexity of performing the inhaler technique with metered dose inhalers than with dry powder inhalers.

In the present study, a higher proportion of patients with inappropriate technique were found among those with a monthly family income of less than three times the national minimum wage. Previous studies have shown that errors in using inhalers are common, and that they could undermine the effects of treatment. Studies have suggested that 32% to 96% of asthma patients make errors when using their inhalers, and that, in 28% to 68% of cases, those errors are important to the point of undermining the effects of treatment. In the present study, 30.2% of the patients made two or more inhaler technique errors, and this cut-off point was associated with asthma control. In contrast to these findings, in a study conducted in Brazil, Coelho et al. evaluated handling of inhaler devices by 467 patients with severe asthma who were followed at a center in the state of Bahia and observed that most patients showed appropriate inhaler technique, a finding that was attributed to the intense educational intervention that those patients received at a referral center.

Table 3 - Inhaler technique and type of inhaler used. a

| Variable          | Correct technique | Incorrect technique | p*  |
|-------------------|-------------------|---------------------|-----|
|                   | (n = 187)         | (n = 81)            |     |
| Type of inhaler   |                   |                     |     |
| Metered dose inhaler | 61 (32.6)*        | 59 (72.8)*          | < 0.001 |
| Aerolizer*        | 89 (47.6)*        | 18 (22.2)*          |     |
| Turbuhaler*       | 20 (10.7)*        | 1 (1.2)*            |     |
| Diskus*           | 15 (8.0)          | 3 (3.7)             |     |
| Pulvinal*         | 2 (1.1)           | 0 (0.0)             |     |

aValues expressed as n (%). bCorrect technique was defined as making < 2 inhaler technique errors; incorrect technique was defined as making ≥ 2 inhaler technique errors. cStatistically significant adjusted standardized residuals (< −1.96 or > 1.96). *Chi-square test.

Table 4 - Binary logistic regression for factors related to incorrect inhaler technique.

| Variable                                 | b   | Wald | p    | OR  | 95% CI       |
|------------------------------------------|-----|------|------|-----|--------------|
| Age                                      | 0.003 | 0.09 | 0.770 | 1.00 | 0.98-1.02    |
| Male gender                              | −0.54 | 2.12 | 0.145 | 0.58 | 0.28-1.20    |
| Being widowed                            | −1.61 | 8.93 | 0.003 | 5.01 | 1.74-14.41   |
| Using metered dose inhalers              | 0.45  | 31.75 | < 0.001 | 1.58 | 1.35-1.85    |
| Having had < 9 years of schooling         | 0.41  | 1.55 | 0.213 | 1.51 | 0.79-2.90    |
| Having a monthly family income < 3 times the national minimum wage | 0.98  | 7.03 | 0.008 | 2.67 | 1.35-1.85    |
| Having ≥ 2 comorbidities                 | 1.34  | 4.02 | 0.045 | 3.80 | 1.03-14.02   |
| Constant                                 | −4.14 | 10.33 | 0.001 | 0.016 | -            |
morbidity, it is necessary that socioeconomically disadvantaged patients receive a more intense educational approach.\textsuperscript{[14]}

The level of support provided by family members or caregivers can also contribute to the appropriate performance of the inhaler technique.\textsuperscript{[15]} In our study, we found that inappropriate inhaler technique was more common among widowed patients. Widowhood can contribute to a varying degree of social isolation and loneliness that can negatively impact the treatment of chronic diseases.\textsuperscript{[16]}

The physical or mental impairment induced by the presence of other diseases can negatively impact the use of inhalers. Conditions such as tremors, vision impairment, hearing impairment, arthritis, mood disorders, and cognitive disorders can impair learning of the inhaler technique or its appropriate performance.\textsuperscript{[14]} In the present study, the presence of two or more comorbidities was associated with inappropriate inhaler technique. However, we did not specifically address which diseases were more prevalent in this association.

Since the present study found a large proportion of patients with uncontrolled asthma (69.1%), it is important to highlight the fact that a previous study\textsuperscript{[6]} conducted in Brazil showed that the level of asthma control was associated with asthma severity, access to medication, and appropriate use of inhaled corticosteroids. Therefore, since our study was carried out at a public tertiary care center, it is natural that cases that are more difficult to control will be referred there for treatment and that, in contrast, controlled asthma cases will be sent back for treatment at public primary care clinics.

The present study has some limitations to consider. First, it was a cross-sectional study and, therefore, it does not allow the establishment of a temporal sequence between the quality of the patients’ performance of the inhaler technique and their level of asthma control. Second, the study was carried out at a single center that provides care within the public health system. Consequently, the study population consisted of individuals who had a low monthly family income and a low educational level, and this may limit the generalization of results.

The clinical implications of this study lie primarily in the demonstration of the fact that two or more inhaler technique errors affect the level of asthma control, with 30.2% of the patients studied showing inappropriate inhaler technique on the basis of this definition. In addition, our findings indicate that target group patients such as widowed patients, patients using metered dose inhalers, patients with a monthly family income of less than three times the national minimum wage, and patients with two or more comorbidities require special attention in terms of inhaler technique education. Therefore, it is important that educational strategies for asthma patients be developed to improve their performance of the inhaler technique and increase their level of asthma control.

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