

# Pediatric Dyspnea Scale for use in hospitalized patients with asthma

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**Background:** Asthma is a leading cause of pediatric hospitalizations across the country, yet no clinical instrument exists that incorporates the child's perception of dyspnea in determining discharge readiness.

**Objective:** We sought to develop the Pediatric Dyspnea Scale (PDS) to support discharge decision making in hospitalized asthmatic patients and to compare the performance of the PDS with traditional markers of asthma control in predicting outcomes after discharge.

**Methods:** Asthmatic children aged 6 to 18 years hospitalized for an exacerbation were included in the study. The PDS score, demographics, asthma severity, spirometric results, peak expiratory flow rate, and fraction of exhaled nitric oxide were assessed at the time of discharge. A telephone call 14 days after discharge determined relapse, activity limitation, asthma control, and asthma-related quality-of-life outcomes.

**Results:** Eighty-nine patients were enrolled, of whom 70 completed the telephone follow-up. Eight patients had a relapse, and 29 complained of limited activity. A PDS score of greater than 2 on the 7-point scale was a significant predictor of these poor outcomes, with each additional point of the PDS doubling the risk. A higher score on the PDS also correlated with worse asthma control and poor asthma-specific quality of life. The PDS performed better than FEV<sub>1</sub>, peak expiratory flow rate, or fraction of exhaled nitric oxide in predicting the outcomes of interest.

**Conclusion:** The PDS, which is easy to use in children as young as 6 years of age, might be able to predict adverse outcomes after hospitalization for an asthma exacerbation and should be used as a tool to help guide inpatient discharge decisions. (*J Allergy Clin Immunol* ■■■■;■■■;■■■-■■■.)

**Key words:** Asthma, discharge, dyspnea, hospitalized, outcome, pediatric, scale, spirometry, symptoms, exhaled nitric oxide

## Abbreviations used

|           |                                                       |
|-----------|-------------------------------------------------------|
| ACT:      | Asthma Control Test                                   |
| ATS:      | American Thoracic Society                             |
| CHOM:     | Children's Hospital of Michigan                       |
| ED:       | Emergency department                                  |
| FeNO:     | Fraction of exhaled nitric oxide                      |
| ICU:      | Intensive care unit                                   |
| ITG-CASF: | Integrated Therapeutics Group–Child Asthma Short Form |
| NIH:      | National Institutes of Health                         |
| OR:       | Odds ratio                                            |
| PDS:      | Pediatric Dyspnea Scale                               |
| PEFR:     | Peak expiratory flow rate                             |

Asthma is a leading cause of chronic illness among children in the United States. Almost 9% of American children have asthma, nearly two thirds of whom have experienced at least 1 asthma attack in the preceding year.<sup>1,2</sup> Asthma causes an average of 20 days of restricted activity annually per asthmatic child, including 10 days of missed school, a disease-related burden that is almost twice that of children afflicted with other chronic disorders.<sup>3</sup> Three percent of all pediatric hospitalizations nationwide are asthma related.<sup>1</sup> More than 2.5 billion dollars a year are spent on asthma management, with hospitalizations accounting for a significant proportion of that cost.<sup>4</sup>

A well-accepted definition of relapse after discharge from the hospital is the need for unscheduled medical care,<sup>5</sup> such as repeat hospitalization or a return to the emergency department (ED). A lack of relapse has traditionally been looked at as a measure of successful inpatient treatment. Therefore determining the appropriate time for discharge is a cornerstone of inpatient asthma management. This determination has typically relied on physical examination findings,<sup>6,7</sup> subjective symptoms,<sup>8,9</sup> pulse oximetry,<sup>10</sup> peak expiratory flow rate (PEFR),<sup>9,11</sup> and FEV<sub>1</sub>.<sup>12</sup> Even a constellation of these measures, however, cannot consistently predict which patients will experience a relapse after discharge.<sup>13</sup>

The National Institutes of Health (NIH) guidelines recommend using patient symptoms as one of the criteria for discharge decisions.<sup>14</sup> A modified Borg scale has been successfully used to assess dyspnea in adult patients with asthma and chronic obstructive pulmonary disease,<sup>8</sup> but children can have comprehension difficulties with this scale. Pianosi and McGrath have published the Dalhousie Dyspnea Scale to assess dyspnea during bronchoconstriction,<sup>15,16</sup> but this has not been evaluated in an acute clinical setting. To our knowledge, there is no published clinical instrument for the inpatient management of acute pediatric asthma that incorporates a validated dyspnea assessment tool.

The objective of our study was to determine the usefulness of the Pediatric Dyspnea Scale (PDS), reported for the first time

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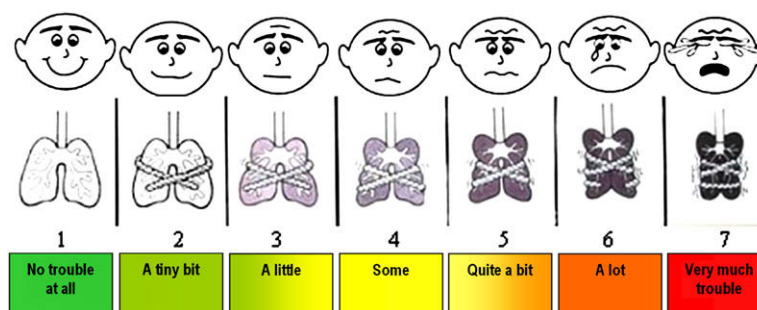


**FIG 1.** PDS. Each patient is asked to answer the question “How much difficulty are you having breathing?” by choosing the column that best corresponds to his or her perceived symptoms.

here, as an instrument for making discharge decisions. A secondary objective was to determine how the PDS compared with other measurements for prediction of poor outcome (relapse, activity limitation, a decrease in asthma control, and poor asthma-related quality of life) at 14 days after discharge.

## METHODS

### Study population

Children aged 6 to 18 years of age with a physician’s diagnosis of asthma admitted to the Children’s Hospital of Michigan (CHOM) in Detroit for an asthma exacerbation were eligible for the study. Patients were enrolled between March 1 and October 15, 2007. Exclusion criteria included patients discharged from the ED after acute management of asthma, pneumonia requiring antibiotics, chronic diseases other than asthma, or developmental delay such that required measurements and questionnaires could not be completed. The study was approved by the institutional review board, and patients were enrolled after written informed consent was obtained.

All patients were managed by the CHOM Asthma Service, which was comprised of an allergist, an allergy fellow-in-training, an asthma nurse educator, and a dedicated social worker. Patients received standardized treatment in accordance with NIH guidelines for care in the hospital, which included systemic corticosteroid administration.<sup>17</sup> All measurements were performed by 2 research assistants not part of the CHOM Asthma Service. The CHOM Asthma Service personnel were not privy to study data.

### Study protocol

Patients were approached and enrolled on the day of discharge. Discharge decisions were made by the CHOM Asthma Service, and members of the research team were not involved in discharge decision making. At discharge, demographic and historical data were collected from the patients, their parents/guardians, or the medical record. Demographics included age, race/ethnicity, and sex. Historical asthma information included number of prior hospitalizations, ED visits, and courses of oral corticosteroids in the preceding year, as well as the need for intensive care unit (ICU) admissions or intubations ever. Asthma severity based on 2002 NIH/National Asthma Education and Prevention Program guidelines was also determined.<sup>17</sup>

At the time of discharge, the parent or guardian was asked to provide a parental assessment of the patients’ asthma symptoms at that moment measured on an ordinal scale from 1 through 4 (very well controlled, somewhat controlled, not very controlled, or not controlled at all). Patients were asked to rate the degree of their breathlessness on the PDS (described below). Airway inflammation was assessed by measuring the fraction of exhaled nitric oxide (FeNO).<sup>18</sup> This was followed by measurement of airflow limitation based on spirometric results and PEFR.

### Development of the PDS

We developed the PDS (Fig 1) to determine a subjective rating of the patient’s symptoms. The PDS asks the patient, “How much trouble breathing

are you having?” The scale incorporates 3 components: (1) a faces scale similar to the Wong-Baker scale<sup>19</sup> to estimate an overall sense of wellness or discomfort, (2) a “chest tightness” graphic adapted with permission from the Dalhousie Dyspnea Scale,<sup>15</sup> and (3) a series of color-coded descriptions of the extent of breathing difficulties. The PDS is scored from 1 through 7, where 1 indicates “no trouble at all” breathing and 7 indicates “very much trouble.” Patients chose one column of responses based on what most closely matched their asthma symptoms, and a score of 1 through 7 was assigned accordingly.

Face validity of the PDS was assessed first by showing the scale to a group of 10 individuals, including physicians, nurses, and parents. This group believed that the PDS was adequately designed to measure an asthmatic child’s perception of respiratory symptoms.

### Measurement of exhaled nitric oxide

Patients performed FeNO measurements using the NIOX MINO Airway Inflammation Monitor (NIOX, MINO; Aerocrine AB, Solna, Sweden) at least 1 hour after albuterol inhalation and before performing spirometry. Multiple attempts were allowed until 3 acceptable readings were detected with the device, a mean of which was used for analysis. The device was set on the 6-second mode, which is recommended by the manufacturer for children less than 130 cm tall or those having difficulties with longer exhalations.<sup>20</sup> The NIOX MINO has previously shown excellent correlation with traditional nitric oxide analyzers<sup>21</sup> and reproducibility in hospitalized children with acute asthma.<sup>22</sup>

### Measurement of FEV<sub>1</sub> and PEFR

Patients were asked to perform FEV<sub>1</sub> measurements with the Puritan Bennett Renaissance II portable spirometer (Puritan-Bennett, Wilmington, Mass) in accordance with American Thoracic Society (ATS) standards.<sup>23,24</sup> Because the patients were experiencing an asthma exacerbation, ATS recommendations of up to 8 spirometric measurements were not followed. Instead, 3 maneuvers were recorded, and the best value was chosen. FEV<sub>1</sub> percent predicted was calculated based on Wang and Dockery standards.<sup>25</sup> Three PEFR readings were obtained by using the Airlife Asthma Check peak flowmeter, and the best value was again chosen for analysis.

### Telephone follow-up 14 days after discharge

Parents of the patients received a telephone call at 14 days after discharge, and the status of 4 identified outcomes was assessed. Relapse was defined as the need for an additional course of oral corticosteroids, a return visit to the ED, repeat hospitalization, or an unscheduled physician visit. Limited activity was defined as answering “yes” to the following question: “Has your child’s asthma limited him/her in any way since discharge from the hospital?” Asthma control and asthma quality of life were measured on 2 standardized questionnaires, the pediatric Asthma Control Test (ACT) and the Integrated Therapeutics Group–Child Asthma Short Form (ITG-CASF). The pediatric ACT is scored on a scale from 0 to 27, with higher numbers indicating greater control.<sup>26</sup> The ITG-CASF is a 10-item, asthma-specific quality-of-life score

(0–100) that assesses daytime and nighttime symptoms, as well as functional limitation.<sup>27</sup> A higher number indicates better asthma quality of life. Parents were asked to respond to the questions unless they believed the child would be able to provide more accurate answers.

### Statistical analysis

The outcome variables of relapse and limited activity were both scored as dichotomous. All demographic, historical, and measured data were used as potential predictors. On univariate analysis, associations between outcomes and continuous or categorical predictors were assessed by using point-biserial or  $\chi^2$  analysis, respectively. Differences between the groups were assessed by using a Mann-Whitney *U* analysis for continuous predictor variables. Next any factor correlated with the outcome at a significance level of less than .20 was entered into a logistic regression model by using backward selection.

The outcome variables of asthma control (measured with the ACT) and asthma quality of life (measured with the ITG-CASF) were both scored as continuous. On univariate analysis, associations between these outcomes and continuous and categorical predictors were assessed by using a Pearson correlation coefficient or ANOVA, respectively. Next any factor related to these outcomes at a significance level of less than .20 was entered into a linear regression model by using backward selection. Given that *a priori* we strongly hypothesized higher scores on the PDS would be associated with worse outcomes, all analyses with the PDS were done by using 1-sided tests of the null hypothesis. All statistics were performed with SPSS Version 15 software (SPSS, Inc, Chicago, Ill).

## RESULTS

One hundred sixty-five pediatric asthmatic patients were screened at the time of discharge. Of these, 60 (36.4%) did not meet eligibility criteria (42 had pneumonia requiring antibiotics, and 18 were discharged after hours), and 16 (9.7%) refused to participate. Demographic information for the 89 patients who were enrolled is presented in Table I

### Measured parameters

Mean values of the measured parameters are listed in Table II. Thirteen patients were unable to perform acceptable FeNO measurements despite allowance of multiple attempts. Therefore the mean FeNO measurement of 28.4 ppb is based on 76 patients. FeNO measurements ranged from 6 to 194 ppb. The mean FEV<sub>1</sub> percent predicted value was 64.4%, which is indicative of moderate airway obstruction. PEFR readings ranged from 70 to 580 L/min, with a mean of 239 L/min. A mean of the parental assessment responses was 1.91, whereas the mean of responses chosen on the PDS was 2.17.

### Telephone follow-up at 14 days

Seventy (78.6%) patients completed the study by participating in the day 14 telephone follow-up call. Baseline and measured characteristics of the 19 patients who were lost to follow-up and the 70 patients who were contacted were compared. Parental assessment of poor asthma control at the time of discharge for those lost to follow-up was slightly higher (2.1 vs 1.9), and this approached significance, with a *P* value of .056. The remaining characteristics showed no difference, including no difference for responses on the PDS.

### Factors associated with relapse

Of the 70 patients who were reached for follow-up, 8 (11.4%) experienced a relapse. On univariate analysis, only the PDS was significantly associated with relapse, although ED visits in the

**TABLE I.** Patient characteristics (n = 89)

|                                              |            |
|----------------------------------------------|------------|
| <b>Demographics</b>                          |            |
| Age (y), mean (SD)                           | 10.9 (3.4) |
| Male sex, n (%)                              | 58 (65.2)  |
| Race, n (%)                                  |            |
| Black                                        | 83 (91.4)  |
| White                                        | 3 (3.4)    |
| Arabic                                       | 2 (2.2)    |
| Other                                        | 1 (1.1)    |
| <b>Asthma characteristics</b>                |            |
| Asthma severity classification, n (%)        |            |
| Mild intermittent                            | 18 (20.2)  |
| Mild persistent                              | 25 (28.1)  |
| Moderate persistent                          | 24 (27.0)  |
| Severe persistent                            | 22 (24.7)  |
| Previous ICU admission, n (%)                | 20 (22.5)  |
| Previous intubation, n (%)                   | 8 (9.0)    |
| ED visits in past 1 y, n (%)                 |            |
| 0                                            | 28 (31.5)  |
| 1-2                                          | 34 (38.2)  |
| 3-7                                          | 24 (26.9)  |
| ≥8                                           | 3 (3.4)    |
| Hospitalizations in past 1 y*, n (%)         |            |
| 0                                            | 56 (62.9)  |
| 1-2                                          | 26 (29.2)  |
| 3-6                                          | 7 (7.9)    |
| Days in hospital before discharge, mean (SD) | 2.2 (0.74) |

\*The "Hospitalizations in past 1 y" category excludes current admission.

**TABLE II.** Measured parameters (n = 89)\*

| Parameter                    | Mean  | SD   |
|------------------------------|-------|------|
| FeNO (ppb)                   | 38.4  | 29.4 |
| FEV <sub>1</sub> (L/min)     | 1.31  | 0.90 |
| FEV <sub>1</sub> % predicted | 55.2  | 23.4 |
| PEFR (L/min)                 | 239.0 | 98.9 |
| Parental assessment          | 1.91  | 0.67 |
| PDS                          | 2.17  | 1.05 |

\*For FeNO, n = 76.

previous year trended toward significance (*P* = .14). The PDS score was 2.6 in children who experienced a relapse compared with 1.9 in those who did not (*P* = .027). After controlling for other factors, the odds of experiencing a relapse approximately doubled for each additional point on the PDS (odds ratio [OR], 2.04; *P* = .033).

### Factors associated with limited activity

Twenty-nine (32.6%) of the 70 children had limited activity caused by persistent asthma symptoms after discharge. On univariate analysis, the PDS was significantly associated with activity limitation. Children who complained of activity limitations after discharge had a higher score on the PDS compared with those who did not (2.3 vs 1.8, *P* = .030). After controlling for other factors, the OR for having limited activity was 1.7 times greater for each additional point on the PDS (OR, 1.66; *P* = .034).

### Factors associated with decreased asthma control after discharge

Asthma control was assessed by using the ACT. The mean ACT score at 14 days was 21.7 (95% CI, 20.7–22.6). On univariate

**TABLE III.** Factors associated with the ACT and ITG-CASF after discharge

| Outcome  | Factor  | Regression coefficient (B) | SE    | P value |
|----------|---------|----------------------------|-------|---------|
| ACT      | PDS     | −0.770                     | 0.449 | .046    |
|          | 1-yr ED | −0.315                     | 0.158 | .050    |
|          | ICU     | −2.711                     | 0.974 | .007    |
| ITG-CASF | PDS     | −4.202                     | 2.163 | .028    |

1-yr ED, Number of ED visits in the last year; ICU, ever required admission to the ICU.

analysis, the PDS, the number of asthma ED visits in the previous year, asthma severity as determined by NIH category, and any previous requirement for asthma-related ICU care were all associated with a lower ACT score. Factors associated with the ACT on univariate analysis were entered into the multivariable regression model. As shown in Table III, factors that remained significantly associated with poor asthma control on the ACT included the PDS, an increased number of ED visits in the previous year, and a history of requiring ICU care for asthma (overall  $R^2 = 0.207$ ,  $P = .002$ ).

### Factors associated with decreased asthma quality of life after discharge

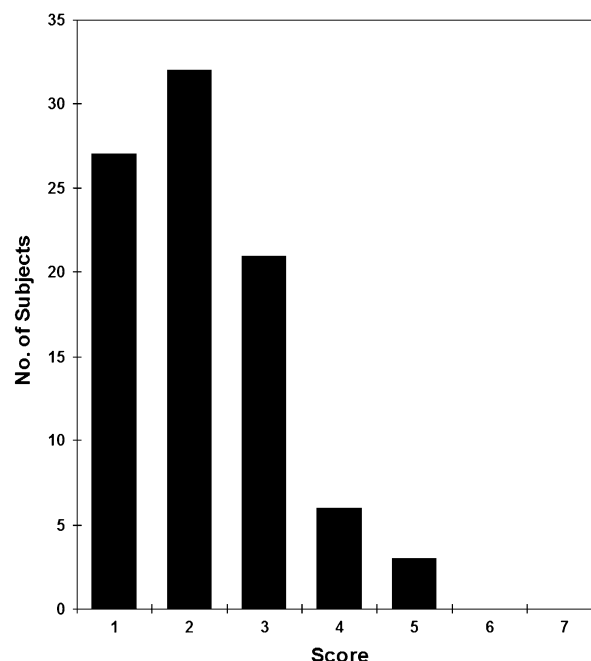
Asthma-related quality of life was measured with the ITG-CASF. The mean ITG-CASF score at 14 days was 86.3 (95% CI, 82.1–90.4). On univariate analysis, the ITG-CASF was positively correlated with female sex and FEV<sub>1</sub> percent predicted and negatively correlated with the PDS. Factors associated with the ITG-CASF on univariate analysis were entered into the multivariable regression model. As shown in Table III, only the PDS remained significantly correlated with the ITG-CASF (overall  $R^2 = 0.051$ ,  $P = .033$ ).

### Validity of the PDS

Fig 2 shows a frequency graph of the patients' responses on the PDS. The most frequently chosen response was 2, which was described as "a tiny bit" of trouble breathing. Predictive validity (the extent to which the PDS predicts multiple outcomes) was assessed. As shown in Table IV, the PDS was significantly associated with all outcomes measured in this study. For the 2 dichotomous outcomes (relapse and limited activity), the ORs indicate the increased odds of the specified outcome for each additional point on the PDS. For the 2 continuous outcomes (ACT and ITG-CASF), the regression coefficients indicate a negative correlation between the PDS and quality of life/asthma control outcomes. Of note, the PDS did not correlate with any of the measured parameters from Table II (data not shown).

### DISCUSSION

NIH criteria recommend including patient symptoms among the criteria for discharge decisions.<sup>14</sup> This approach seems appropriate because continuing or recurrent symptoms are often major factors driving decisions to seek further medical care. Currently, however, no instrument for assessing asthma symptoms in an acute-care setting has been validated for the pediatric population. This lack led us to develop the PDS, the validation of which we report here.

**FIG 2.** Responses on the PDS (n = 89). Bars show the number of patients who chose each column. A value of 1 indicates no trouble at all with breathing, whereas a value of 7 indicates very much trouble.**TABLE IV.** Association of the PDS with outcome measures

| Outcome             | OR   | B      | P value |
|---------------------|------|--------|---------|
| Relapse             | 2.04 |        | .033    |
| Activity limitation | 1.66 |        | .034    |
| ITG-CASF            |      | −4.202 | .028    |
| ACT                 |      | −0.770 | .046    |

The Visual Analog, Likert, and modified Borg scales have been evaluated in adults<sup>28</sup> but were not designed for and have not been successfully studied in children. The Dalhousie scale is validated only for children 8 years of age and older, and its effectiveness in a clinical setting has yet to be determined.<sup>15,16</sup> This scale requires the understanding and ability to decipher 3 physical constructs related to dyspnea: exhaustion, chest tightness, and throat constriction. It also is mounted on a large poster board with 3 sliding cursors and has multiple subscales that must be individually completed, making it potentially burdensome in a hospital setting.

The PDS incorporates 3 components. The first is a series of faces showing affect, a measure of overall wellness or discomfort. The second component is the "chest tightness" graphics that had previously been included in the Dalhousie Dyspnea Scale.<sup>15</sup> The third is an ordinal series of descriptions of the patient's difficulty in breathing, which is also color coded from green to red as a further cue. We hypothesized that a combination of graphics, ordinal scale, words, and color gradation of responses would help young children better quantify their symptoms.

The validity of the PDS was established by looking at its relation with the 4 major outcomes at 14 days after discharge: relapse, limitation of activity, poor asthma control as measured by the ACT, and asthma-related quality of life as measured by the

ITG-CASF. These short-term patient-oriented outcomes after an asthma exacerbation provide an important measure of asthma morbidity.<sup>29</sup> At the time of discharge, a score of greater than 2 on the PDS was found to be the cutoff above which patients were more likely to experience a relapse or activity limitation. Each additional point on the scale almost doubled the odds of having either of these poor outcomes. In addition, worse scores on the ACT or ITG-CASF were also correlated with higher scores on the PDS. In fact, the PDS was the only factor associated with decreased quality of life after discharge.

FEV<sub>1</sub> and PEFR have traditionally been looked at as measures of airflow limitation caused by bronchoconstriction. These measurements have shown reproducibility in adolescents,<sup>12</sup> but cost, time, effort, and difficulty in obtaining these measurements during acute asthma and their questionable utility in guiding management have limited their use.<sup>13,30</sup> FEV<sub>1</sub> and PEFR did not correlate with the PDS in our study, showing that spirometric measurements and perception of dyspnea are at times unrelated, which is consistent with previous findings by other investigators.<sup>31,32</sup> Airway inflammation as measured based on FeNO has shown reproducibility in children as young as 6 years of age but does not correlate with spirometry.<sup>22</sup> Similar to FEV<sub>1</sub>/PEFR measurements, FeNO did not correlate with the PDS in our study. However, the PDS was found to be superior in our study because it predicted the outcomes of interest. Future studies are required to assess whether the combination of the PDS with other objective measures improves the ability to predict adverse outcomes.

There were limitations to our study. We did not test the PDS in a younger age group and therefore cannot assess its usefulness in children under the age of 6 years. Serial measurements on the PDS were not determined, either starting from the ED or from admission until discharge in the inpatient unit. We did not follow patients for months or years to assess long-term asthma morbidity. A number of patients refused to participate or were not able to be contacted at follow-up. Not all spirometric measurements met ATS standards because patients were recovering from acute asthma exacerbation. Finally, this study was conducted at an inner-city hospital, and therefore the results might not be generalizable to all populations.

In conclusion, the PDS is a promising instrument that will assist in clinical decision making for acute pediatric asthmatic patients. The ease of use in children as young as 6 years of age and a cutoff score of 2 in its ability to predict favorable versus poor outcomes after discharge from the hospital make the PDS an appealing option for health care providers. The usefulness of the PDS in other settings, such as the ED and outpatient clinic, remains to be determined.

**Clinical implications: This study validates the PDS, which can assist discharge decisions and minimize adverse short-term outcomes in hospitalized pediatric asthmatic patients.**

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