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Peak Expiratory Flow Rate as Predictors of Emergency Department Triage Level in Acute Exacerbation of Chronic Obstructive Pulmonary Disease: An observational Cohort Study

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Peak Expiratory Flow Rate as Predictors of Emergency Department Triage Level in Acute Exacerbation of Chronic Obstructive Pulmonary Disease: An observational Cohort Study

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ABSTRACT

Background: Rapid, bedside identification of patients at highest acuity among those presenting with acute exacerbation of chronic obstructive pulmonary disease (AECOPD) remains a core emergency department (ED) challenge.

Objective: To examine the association between peak expiratory flow measurements obtained at ED presentation and nurse-assigned Emergency Severity Index (ESI) acuity among adults presenting with AECOPD.

Methods: In this single-center observational cohort, 112 adults presenting with acute dyspnea attributed to AECOPD were classified by the treating triage nurse as ESI level 1 (n=64) or level 2 (n=48). Demographic characteristics, vital signs, venous blood gas measurements, and peak expiratory flow rate (PEFR) were recorded at presentation. PEFR was measured in triplicate and the highest reading was retained. Logistic regression was used to examine associations with nurse-assigned triage category. Discrimination was summarized with the receiver operator characteristic (ROC) area under the curve (AUC).

Results: Patients assigned to ESI level 1 had higher respiratory rates, lower oxygen saturation, lower measured PEFR and percent-predicted PEF ratio, and more frequent red-zone readings than patients assigned to level 2. They also had higher rates of bilevel noninvasive ventilation and intensive care unit admission and a longer length of stay. On multivariate analysis, respiratory rate (adjusted odds ratio [OR] 0.79 per breath/min, 95% CI 0.68–0.91), measured PEFR (adjusted OR 1.01 per percentage point, 95% CI 1.00–1.02), and PEF ratio percent-predicted (adjusted OR 1.07 per percentage point, 95% CI 1.03–1.12) independently predicted triage level. Models combining respiratory rate with measured PEFR or percent-predicted PEF ratio had reported AUCs of 0.85 and 0.86, respectively.

Conclusion: A simple bedside combination of respiratory rate and measured PEFR or PEF ratio percent-predicted discriminated ED triage level with good accuracy in patients with AECOPD. Incorporating peak flow meter readings into initial triage assessment may help standardize acuity stratification for this population.

Keywords: Chronic obstructive pulmonary disease; Emergency department; Peak expiratory flow rate; Respiratory rate; Triage.

INTRODUCTION

Background

Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is among the most common reasons for emergency department (ED) presentation among adults with chronic respiratory disease. It accounts for a large share of unscheduled hospital admissions and short-term mortality [1].

ED triage is a front-door prioritization process intended to identify patients who may require immediate assessment, intensive monitoring, or urgent intervention. The issue of waiting for triage in overburdened ED has emerged as a salient problem, jeopardizing the well-being of patients. The implementation of a streamlined triage protocol is imperative to expedite the identification of low-acuity patients, thereby ensuring the allocation of care and resources to cases of greater urgency [2]. The Emergency Severity Index (ESI) triage system demonstrated moderate, context-dependent accuracy for selected surrogate outcomes. However, clinically important under-triage remains a possibility, and pooled estimates are influenced by reference-standard choice, case-mix, resource availability, and implementation quality [3,4]. ESI triage demonstrates high sensitivity but low specificity. Consequently, it would be preferable to modify it in accordance with the varying circumstances. Each ED could more accurately select the triage system that fits their local particularities [5].

Peak expiratory flow rate (PEFR), as measured using a low-cost, portable peak flow meter, has been identified as a simple, reproducible, point-of-care index of large-airway obstruction. This index has been firmly established in asthma action plans; however, its use in the context of COPD exacerbation triage remains far less consistent [6]. However, the PEFR can provide a reliable estimate of the respiratory state of these patients, and the use of PEFR along with the ESI scale may provide a more accurate method for COPD patients in triage since it helps clinicians to correctly identify high-risk patients with COPD [7,8].

Given the importance of early and accurate stratification of acuity in the context of ED crowding and limited capacity for monitored beds, the development of any inexpensive, rapid, and reproducible bedside measure that enhances triage discrimination for exacerbations of COPD holds direct operational and clinical value. The potential value of PEFR in triage depends on whether it provides information beyond routine clinical assessment. PEFR measurement may be infeasible or unreliable in patients who are exhausted, confused, or too unstable to perform a forced expiratory maneuver. It should therefore be considered only as a possible adjunct, never as a reason to delay urgent treatment [9].

The objective of this study was to ascertain the association between PEFR measurements at ED presentation and nurse-assigned ESI level among adults with AECOPD. This investigation sought to determine whether these parameters can independently predict triage level and other clinical outcomes in patients presenting with AECOPD.

METHODS

Study Design and Setting

This was an observational cohort, single-center study conducted in the emergency department of Afzalipour Hospital, Kerman University of Medical Sciences, Kerman, Iran. The data were collected through a meticulous checklist, meticulously administered over the span of one year, from October 2025 to October 2026. The study was conducted with the understanding that all participants had the capacity to provide informed consent. This was confirmed prior to their enrollment in the study.

Selection of Participants

A consecutive convenience sample of adults aged ≥18 years presenting to the ED with acute dyspnea attributed to an exacerbation of previously diagnosed COPD or diagnosed according to Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria during hospitalization was enrolled. Patients with an alternative primary cardiopulmonary diagnosis, inability to perform a peak flow maneuver, and refusal to participate in the study were excluded from the study (see Figure 1). Of the 112 patients who met the eligibility criteria and were included in the final analysis, 64 (57.1%) were assigned to triage level 1 and 48 (42.9%) to triage level 2) by the treating triage nurse using Emergency Severity Index (ESI) protocol, applied without knowledge of the study-specific peak flow meter.

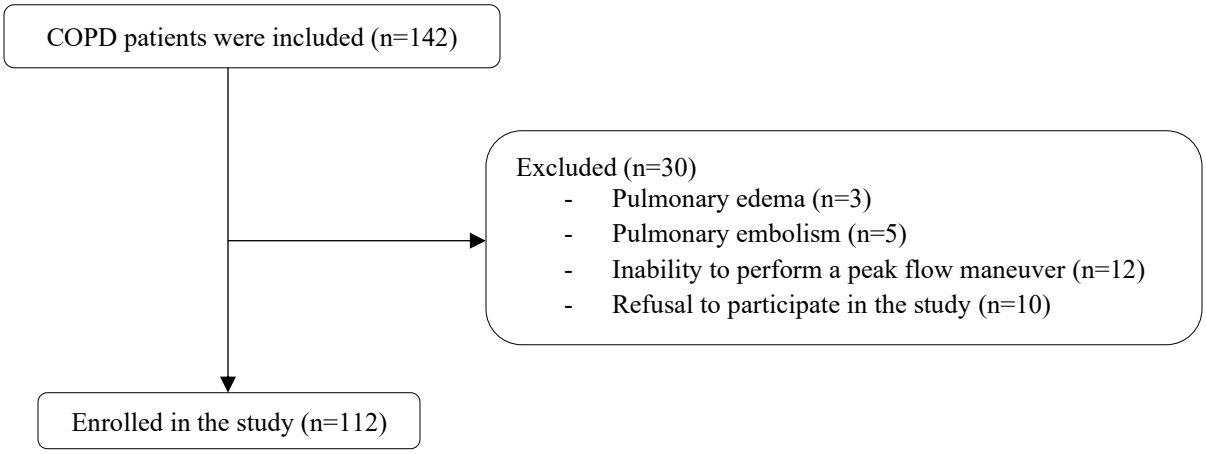


Figure 1. Flow chart showing enrollment of patients

Sample size

To date, no study has directly examined the relationship between ESI triage levels and the PEFR. However, a study by Roudi et al. observed a significant difference in the distribution of triage levels when comparing assessments based on the ESI alone versus those combining ESI with PEFR [6]. The sample size was determined using G*Power 3.1 software, which calculated a total of 100 participants, based on the frequency percentages reported in that study. This calculation was performed under the assumption of a 95% confidence level and 80% statistical power.

Measurements

During the initial evaluation, trained research personnel meticulously documented the participants' demographic information, including their age, sex, height, and weight. Additionally, they recorded the participants' smoking history, defined as the number of pack-years smoked, the duration of their COPD diagnosis, and the number of exacerbations experienced in the previous year. Standard vital signs (systolic and diastolic blood pressure, heart rate, respiratory rate, and pulse oximetry) were measured with calibrated monitors [Pooyandegan Rah SAADAT Co., ALBORZ A9 Device]. A VBG (Venous Blood Gas) sample was obtained from a peripheral vein and subjected to immediate analysis for pH, partial pressure of carbon dioxide (Pco2), bicarbonate (Hco3−), and base excess.

PEFR was measured in triplicate with a standard handheld peak flow meter (Mini-Wright Standard Peak Flow Meter) with the patient in a seated or semi-recumbent position[9]. The highest of three attempts was recorded in L/min (measured PEFR). Estimated PEFR was calculated using the patient's height, age, race, and sex (https://mobile.fpnotebook.com/lung/lab/PkExprtryFlwRt.htm). The peak expiratory flow (PEF) ratio is defined as the relationship between the measured and estimated PEFR. Each reading was classified into a color zone (red, <50% predicted; yellow, 50%–79% predicted; green, ≥80% predicted) consistent with standard self-management action-plan thresholds. No patient in this cohort fell into the green zone. All calculations were performed using the following website: https://www.omnicalculator.com/health/peak-flow.

Outcome

The primary outcome was to ascertain the relationship between triage level, as determined by the nurse-assigned ESI triage category, and peak flow meter readings in patients with AECOPD presenting to the ED. Secondary outcomes encompassed clinical outcomes, including the necessity for invasive mechanical ventilation; the necessity for noninvasive ventilation (bilevel positive airway pressure [BiPAP]) ventilation; the necessity for admission to the intensive care unit (ICU); the length of hospital stay (LOS); in-hospital mortality; and procedure-related complications.

Data Analysis

Continuous variables are reported as mean (standard deviation; SD) and were compared between triage levels with the Mann-Whitney U test because several parameters were non-normally distributed as indicated by the Shapiro-Wilk and skewness-kurtosis assessments. Categorical variables are reported as No. (%) and were compared with the Pearson $\chi 2$ test or, when any expected cell count was <5, the Fisher exact test. Variables associated with triage level at P<.20 on univariate binary logistic regression, in conjunction with variables deemed to be of clinical significance a priori, were entered into a multivariate binary logistic regression model with backward stepwise elimination. The incorporation of mechanical ventilation into the regression model was precluded due to its complete separation from other variables. Notably, all patients receiving mechanical ventilation were classified as triage level 1. The discriminatory capability of the model was evaluated by calculating the receiver operator characteristic (ROC) area under the curve (AUC), derived from the multivariate model's predicted probabilities. Statistical significance was determined by a two-sided P-value less than 0.05. The analyses were executed with the utilization of SPSS software version 21 (Stata Corp., College Station, TX, USA).

Ethical Considerations

The study protocol was reviewed and endorsed by the Kerman University of Medical Sciences Ethics Committee, in accordance with the established ethical code (IR.KMU.AH.REC.1403.228).

All procedures were conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants.

RESULTS

Baseline Characteristics of Study Subjects

The analysis included 112 patients, with a mean age of 66.6 years (SD 10.3) in triage level 1 and 65.7 years (SD 13.8) in triage level 2 (P = .53). The distribution of sex was comparable between the two groups (see Table 1 for details). An analysis of the data revealed that there were no statistically significant differences between triage levels in terms of smoking history, pack-year category, and duration of COPD. Patients assigned to triage level 1 had experienced more frequent exacerbations in the preceding year than those assigned to level 2 (P<.0001).

Main Results

Patients classified as triage level 1 exhibited significantly elevated respiratory rates, diminished oxygen saturation levels, augmented Pco2 concentrations, heightened Hco3− levels, and augmented base excess values when compared with patients classified as triage level 2 (all P≤.01). These findings are indicative of more pronounced hypercapnic respiratory compromise. Subsequent analysis revealed no statistically significant differences between groups in systolic and diastolic blood pressure, heart rate, and pH. The PEF ratio was significantly lower in triage level 1 than in level 2 (23.0% vs. 40.6% predicted, P<.0001). Furthermore, a red-zone peak flow reading was more prevalent in triage level 1 (96.9% vs. 75.0%, P<.001). The estimated PEF, unlike the measured PEFR (P<.0001) in L/min, did not differ (P=.84). The clinical outcomes were found to be associated with the patients' initial triage assignments. Patients classified as triage level 1 exhibited a higher frequency of necessitating BiPAP (28.1% vs. 6.3%, P=.003) and ICU admission (20.3% vs. 2.1%, P=.003). Additionally, these patients demonstrated a significantly prolonged LOS (8.1 vs. 5.4 days, P<.0001). The occurrence of a single fatality within the cohort (triage level 1) precludes the possibility of meaningful comparison of mortality rates. The only complication observed following peak flowmetry was cough, which did not demonstrate a statistically significant difference between triage levels 1 and 2 (P = .72) (see Table 1).

Regression and discrimination

On univariate logistic regression, number of exacerbations in the past year, respiratory rate, oxygen saturation, Pco2, Hco3−, base excess, red-zone color classification, measured PEFR, PEF ratio, need for BiPAP, need for ICU admission and LOS, were each significantly associated with triage level. Age, sex, duration of the illness, smoker, blood pressure, heart rate, pH and complication status were not. After backward stepwise multivariate logistic regression, respiratory rate (adjusted OR 0.79 per breath/min, 95% CI 0.68–0.91, P=.002), measured PEFR (adjusted OR 1.01 per breath/min, 95% CI 1.00–1.02, P=.02) and PEF ratio (adjusted OR 1.07 per percentage point, 95% CI 1.03–1.12, P=.001) remained independent predictors of triage level (see Table 2). The combined multivariate model (respiratory rate plus measured PEFR or respiratory rate plus PEF ratio) discriminated triage level with good accuracy, with an area under the receiver operating characteristic curve of 0.85 or 0.86, respectively (see Figure 2, 3).

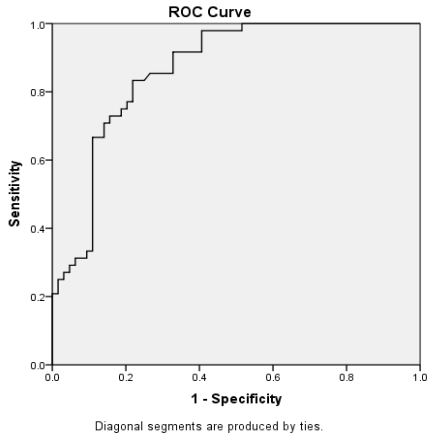


Figure 2. Receiver operating characteristic curve for the multivariate logistic regression model (PEF ratio and respiratory rate) predicting emergency department triage level (Area under the curve=0.86).

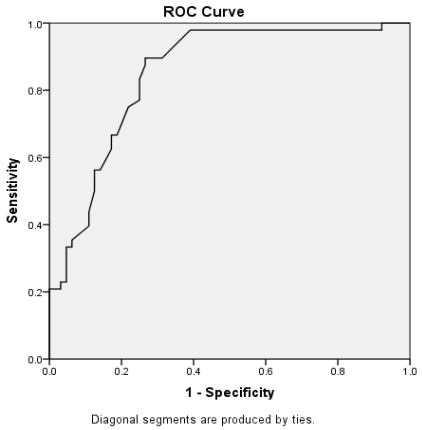


Figure 3. Receiver operating characteristic curve for the multivariate logistic regression model (measured PEFR and respiratory rate) predicting emergency department triage level (Area under the curve=0.85).

DISCUSSION

In this study, the patients presenting to the ED with AECOPD, a simple combination of respiratory rate and peak expiratory flow (especially PEF ratio and measured PEFR), both obtainable within minutes of arrival, independently predicted the nurse-assigned ESI acuity, exhibiting adequate discrimination. The robust correlation that was identified between the triage level and objective markers of severity—including the necessity for BiPAP, ICU admission, and prolonged LOS—reinforces the construct validity of the triage assignments utilized as the reference standard. It is noteworthy that mechanical ventilation was observed exclusively among triage level 1 patients, with complete separation that precluded its inclusion in the regression model. While this pattern limits the statistical modeling of that specific outcome, it provides reassuring evidence that the triage system appropriately identified the most critically ill patients.

The ESI is a widely implemented five-level ED triage algorithm that prioritizes patients according to clinical acuity and anticipated resource requirements. The structured ED triage systems demonstrated moderate, context-dependent accuracy for selected surrogate outcomes. However,

clinically significant under-triage remains a possibility, and pooled estimates are influenced by reference-standard choice, case-mix, resource availability, and implementation quality. Nevertheless, evidence indicates that its diagnostic performance varies across patient populations and clinical outcomes, with both under-triage and over-triage remaining important concerns in routine emergency care [3]. The aforementioned limitations provide a foundation for the investigation of targeted, complaint-specific assessment parameters. These parameters have the potential to complement conventional triage algorithms and enhance the identification of patients requiring urgent intervention [10]. Suamchaiyaphum et al. demonstrated the triage accuracy to be 67% in their observational study. The under- and over-triage rates were 25% and 8%, respectively. The findings indicated a moderate interrater reliability between the triage nurses and the ESI handbook. The accuracy of triage varied across ED locations and patient characteristics, including sex, type of complaint, shift, and mode of arrival. Therefore, the inaccuracy of the triage may be attributed to a combination of factors specific to the nursing personnel and the patient [11].

In patients presenting with dyspnea, incorporating an objective measure of respiratory function may provide additional information beyond routine clinical assessment and vital signs. The peak expiratory flow rate, measured using a portable peak flow meter, is a rapid, noninvasive, and relatively inexpensive method for assessing expiratory airflow limitation. Current asthma management guidelines acknowledge the significance of PEF, or forced expiratory volume in one second (FEV1), in conjunction with clinical observations and oxygen saturation levels, as crucial components of the assessment of acute exacerbation severity [12,13]. In addition, it has been identified as a promising indicator for predicting the severity of pulmonary diseases [14]. The prognostic role of the peak flow meter has been the subject of study in a variety of contexts. In elderly individuals, this tool can serve as an indicator of frailty and the probability of developing pneumonia [15, 16]. Furthermore, a decline in PEFR has been associated with an elevated risk of cardiovascular complications [17]. A randomized clinical trial involving patients with COPD and dyspnea reported differences in triage classification and lower observed rates of both under-triage and over-triage when PEFR measurement was added to the ESI [6]. However, the study's relatively modest sample size limits the generalizability of these findings. Consequently, the incorporation of PEFR measurement into the preliminary evaluation of selected patients with respiratory complaints could serve as a viable strategy to enhance the accuracy of triage decisions. However, it is imperative to acknowledge that PEFR should be regarded as an adjunct to, rather than a replacement for, conventional clinical assessments, including oxygen saturation, respiratory rate, work of breathing, and mental status, in addition to other pertinent indicators of physiological instability. The utility of this test may be constrained in patients who are unable to perform a reliable forced expiratory maneuver or whose respiratory distress necessitates immediate intervention. The present study evaluates the potential utility of incorporating PEFR into respiratory triage, particularly its ability to discriminate between patients assigned to ESI levels 1 and 2 and those assigned to lower-acuity categories. If these findings are confirmed by subsequent observations, they may indicate that PEFR provides supplementary information that could enhance the accuracy of triage classification for patients exhibiting respiratory symptoms. It is imperative that further prospective, adequately powered, and preferably multicenter studies be conducted to validate its incremental diagnostic performance and ascertain whether its implementation improves patient-centered outcomes and resource allocation.

Beyond its potential contribution to triage classification, PEFR may also provide prognostic information regarding subsequent clinical prognosis [18]. In the context of COPD, lung function measurements, including PEFR, are employed in conjunction with clinical response and other

physiological indicators to inform decisions regarding the prediction of the necessity for BiPAP, ICU admission, or LOS. Noninvasive ventilation (NIV) has been demonstrated to be efficacious in the majority of patients with AECOPD complicated by respiratory failure. The NIV has the potential to be lifesaving; however, it can also result in a delay in the initiation of mechanical ventilation. BiPAP represents the primary ventilatory support for acute hypercapnic respiratory failure resulting from a COPD exacerbation. This approach has been demonstrated to reduce the work of breathing, enhance gas exchange, minimize the necessity for intubation, and decrease mortality. The necessity of NIV arises in the context of patients diagnosed with AECOPD exhibiting acute or acute-on-chronic respiratory acidosis, despite the implementation of optimal medical therapy. The criteria for this diagnosis include a pH of ≤ 7.35 and a $PaCO_2$ level of > 45 mmHg. Additionally, the respiratory rate of the patient typically exceeds 20–25 breaths per minute, accompanied by manifestations of augmented respiratory effort [19-21] The present study posits that the use of PEFR as an indicator of respiratory failure, in conjunction with tachypnea, may serve as a valuable prognostic tool for predicting the necessity of BiPAP treatment in patients suffering from AECOPD.

The indication for ICU admission is when a patient with AECOPD exhibits life-threatening features or is at high risk of rapid deterioration, necessitating continuous monitoring and advanced support. The presence of severe dyspnea that does not adequately respond to initial emergency therapy, alterations in mental status, persistent or exacerbating hypoxemia or respiratory acidosis, the necessity for invasive mechanical ventilation, hemodynamic instability, and other high-risk characteristics such as persistent tachypnea is indicative of a condition that necessitates urgent medical attention [22,23]. The present study underscores the significance of PEFR as a promising predictor of the necessity for ICU admission.

The prolonged LOS in patients admitted for AECOPD is predominantly influenced by the severity of the underlying disease, the necessity for advanced respiratory support, the presence of comorbidities, and the complications that arise during the patient's hospital stay. Patients requiring NIV or intubation, exhibiting more severe gas-exchange abnormalities, or having multiple comorbidities generally experience prolonged hospitalization due to the prolonged recovery period and the increased resource demands [24, 25]. The findings of the study indicated a negative correlation between a decrease in PEFR and an increase in LOS. This finding indicated that the PEFR on arrival may serve as a predictor of LOS in hospital for AECOPD patients.

The present study is not without its limitations. First, the study was conducted at a single center with a relatively modest sample size, which limits the study's external generalizability. Therefore, multicenter validation is necessary before these findings can inform practice elsewhere. Second, excluding patients unable to perform PEFR may have introduced selection bias and reduced applicability to the most unstable patients. Third, nurse-assigned ESI category is a pragmatic but imperfect reference outcome and does not independently establish triage correctness. Fourth, smoking history was self-reported and may be subject to recall bias. Finally, only one death occurred, so mortality could not be evaluated. External validation and a prospective impact study are required.

Conclusion

In patients with AECOPD, respiratory rate and peak expiratory flow, both of which can be obtained at the bedside within minutes and without specialized equipment beyond a standard peak flow meter, independently predicted triage acuity level with good discrimination. The incorporation of

peak expiratory flow into COPD exacerbation triage protocols necessitates further multicenter studies with larger sample sizes to validate these findings and determine their clinical applicability in triage.

Abbreviations

AUC: Area Under Curve
AECOPD: Acute Exacerbation of Chronic Obstructive Pulmonary Disease
BiPAP: Bilevel Positive Airway Pressure
ED: Emergency Department
ESI: Emergency Severity Index
FEV1: Forced Expiratory Volume in one second
GOLD: Global Initiative for Chronic Obstructive Lung Disease
ICU: Intensive Care Unit
LOS: Length of Stay
NIV: Noninvasive Ventilation
PEFR: Peak Expiratory Flow Rate
PEF Ratio: Peak Expiratory Flow Ratio
ROC: Receiver Operating Characteristic
SD: Standard Deviation
VBG: Venous Blood Gas

DECLARATIONS

Authors' contributions : Study concept, design, and supervision: M.T, R.P, N.NB, M.Ch, M.M. Acquisition of data: R.P. N.NB, M.Ch, Analysis and interpretation of data: M.M, M.T. Drafting of the manuscript, technical and material support: M.T, R.P, N.NB, M.Ch. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Conflict of Interest : The authors declare no conflict of interest.

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Clinical trial number: Not applicable

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