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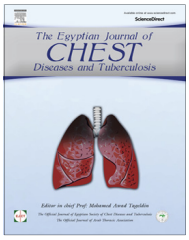

ORIGINAL ARTICLE

# Reliable quantitative score for grading chest X-ray using the dynamic of blood cell count in adult asthma

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Shortness of breath (SOB);
Saturation of arterial blood with oxygen ($SaO_2$);
Shwachmann–Kulczycki (S–K)

**Abstract** The purpose of the present study was to rate the level of spread of asthma-induced bronchial morphological changes on chest X-ray (CXR), using the modified Shwachman–Kulczycki (S–K) rating scale as predicted by the dynamic of blood cell count (CBC). A sample of 40 asthma patients' records was classified into 4 groups based on their clinical presentations and frequency of their visits to the hospital; Group-1 $\leqslant$2 visits per week with reversible symptoms, Group-2 $\geqslant$2 visits per week with irreversible symptoms, Group-3: $\geqslant$3–4 visits per week with irreversible symptoms; Group-4: patients with severe shortness of breath in whom $SaO_2$ was threatening, hence were admitted as inpatients. Patients' CXR were scored based on the modified Shwachman–Kulczycki (S–K) scale rating. Blood analysis showed that RBC and their indices (HCT, HGB, MCH, RDW) were highest in group-2. White blood cells and their derivatives (NEU, EOS and LYM) were highest in group 4. CXR for group-2 showed bilateral increased bronchovascular markings but normal both lung fields and ruled out for costo-phrenic angles type of fever. Chest X-ray for group-3 showed hyperinflation, perihilar marking associated with bronchial thickening and unfolding aorta. In patients in group-4 development of broncho-pneumonic infiltration type of SOB and some evidence of bronchial edema with significant ($p < 0.05$) elevation in WBC were observed. The regression of S–K score on the dynamic of some CBC parameters was significant ($p < 0.05$). The best subsets that describe the model were:

$$\text{S–K} = 14.242 + \beta 1_{\text{NEU}(-1.28)} + \beta 2_{\text{EOS}(-10.929)} + \beta 3_{\text{HCT}(0.577)} + \beta 4_{\text{HGB}(-.898)} + \beta 5_{\text{RDW}(0.546)} + \beta 6_{\text{RBC}(-1.966)} + \varepsilon$$

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Based on the results of the present study it can be concluded that monitoring CBC parameters can be an objective estimate of the S–K score for CXR in order to classify the severity of asthma using an objective numerical value to assess patients' treatment follow up, without the need for X-ray equipment setup.



## Introduction

Asthma is a lung disease that is characterized by inflammation, obstruction, and hyper-responsiveness of the airways. Chronic asthma represents a chronic inflammatory process of the airways followed by healing whose end results involve altered morphology of the airways referred to as remodeling [10] which in turn leads to a widespread narrowing of different degrees in severity.

The majority of guidelines classify asthma's severity into four levels of severities; intermittent, mild persistent, moderate persistent and severe persistent (NAEPP, NAC) based on clinical symptoms and pulmonary function tests [44]. There were no previous studies that had utilized chest radiology report (CXR) to classify asthma severity. CXR has been considered the 'gold standard' with respect to the presence or absence of relevant morphological pathological changes regarding the progression of bronchial thickness inducted by asthma. Specifically, a radiology report considered the 'gold standard' with respect to the presence or absence of relevant pathological changes with regard to asthma-induced bronchial morphological progressions [43]. CXR clarifies the clinical significance of hyperinflation, bronchial wall thickening or small localized areas of atelectasis and those clinical signs are considered powerful morphological indicators to differentiate between mild, moderate and severe asthma that are manifested by the early inflammatory responses [30]. Additionally CXR is necessary when there is no response to initial therapy, with worsening inflammatory responses. Most often primary cares' physicians do not require a chest X-ray (CXR) mainly because of the tremendous cost expenses and lack of X-ray equipment setups as well as lack of specialist staff.

On the other hand the dynamic of blood cell count (CBC) has been used as a reliable clinical predictor for the severity of a variety of inflammatory conditions [35,4], yet its implementations to classify asthma severity have been ignored. Clearly, chronic inflammatory process of the airways must be associated with a significant rise in white cell count (WBC), yet its implementations to classify the severity of asthma had been poorly understood. There is a general agreement that asthma involves progressive bronchial wall thickness mainly due to inflammatory responses that involve proliferation and migrations of white blood cell; eosinophil, neutrophil and lymphocyte [34,40]. Similarly the utilization of the dynamic changes in red blood cells (RBC) counts and their indices had been ignored in asthma classification. It is reasonable to assume that early stages of asthma elicit hypoxic stimulus that inducts the release of RBC whereas late stages of asthma represent sustained hypoxia which leads to tissue damage and ischemia which in turn impact the sources (organs) of RBC productions [28,35,9]. Altogether there is a need to model the relationships of the dynamic changes in blood cell counts and the morphological changes in CXR, as clinical outcome for treatment and follow up of asthma in primary care clinic. The reasons for modeling this relationship are that many general physician offices and primary clinics may have an automated CBC system which is tremendously less expensive, easy to operate and able to generate self-explanatory comprehensive CBC report [21,12,11,29,38,20], from which the morphological changes in CXR can be easily predicted.

Shwachman–Kulczycki (S–K) rating score was first implemented as a quantitative score for the assessments of the morphological changes in CXR of cystic fibrosis [45,5,13]. The present study aimed to implement the use of the modified S–K scoring system in asthma in relation to blood cell count (CBC) dynamic as an objective score to classify asthma severity, hence provides an optimization of the control of asthma episodes and treatment follow up. Furthermore the quantitative rating scale of the radiological appearances on CXR in asthma can provide a numerical value to quantify the impact of underlying chronic inflammations of the bronchial tree, hence provides useful diagnostic profile. Furthermore a numerical prediction of CXR rating score based on CBC dynamic allows for its implementations in primary care clinic and in general physician offices without the need for X-ray equipment setup.

The present study is the first report to implement S–K – CBC-dependent rating score system in asthma. Our goal was to introduce a reliable, simple and objective score to classify the progression of asthma as well as monitor treatment effectiveness. We have derived a simple regression equation from CBC dynamic to provide single numerical score to classify the morphological pathological changes on CXR of asthma.

## Materials and methods

### *Sample selection*

A sample of 40 adult asthmatic patients, ranging in age from 20 to 55 years old was classified into four groups of different severities; mild, moderate, heavy and severe. Asthma patients with additional clinical conditions related to cancer, eczema, and chronic illnesses (diabetes mellitus, chronic kidney disease, etc.), or chronic inflammation (rheumatoid arthritis, cigarette smokers) were excluded from the study.

### *Patients' classification criteria*

The assessments of asthma severity were based on a combination of the clinical presentation of the patients and airflow limitation parameters that included number of patient visits (episodes) per week, respiratory rate (FR), peak expiratory