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Subclinical right ventricular dysfunction in asthma: association with disease severity and control assessed by echocardiography

Asma Bouslimi,[1] Sabrine Maddeh,[2] Amira Triki,[3] Rana Dahmani,[1] Abdelmajid Sakhri[2]

[1]Department of Cardiology, Military Hospital of Bizerte, Faculty of Medicine of Tunis, University of Tunis El Manar, Tunis; [2]Department of Pneumology, Military Hospital of Bizerte, Faculty of Medicine of Tunis, University of Tunis El Manar, Tunis; [3]Department of Occupational Medicine, Faculty of Medicine of Tunis, University of Tunis El Manar, Tunis, Tunisia

Correspondence: Amira Triki, Department of Occupational Medicine, Faculty of Medicine of Tunis, University of Tunis El Manar, Tunis, Tunisia. E-mail: amiratk31@gmail.com

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Abstract

Asthma is a chronic inflammatory airway disease that may affect the cardiovascular system, particularly the right ventricle (RV). Early subclinical RV dysfunction in asthma remains insufficiently explored. We conducted a retrospective observational study to identify clinical factors associated with subclinical RV dysfunction assessed by transthoracic echocardiography (TTE) in adult asthmatic patients without clinical signs of right heart failure. All participants underwent TTE with conventional RV parameters and RV free wall longitudinal strain (RVFWLS) assessment; body mass index (BMI) was recorded for all participants. RV dysfunction was defined by abnormal RVFWLS, pulmonary artery systolic pressure, RV hypertrophy, or fractional area change. A total of 80 patients were included (mean age 45±15.9 years; 75% women; mean BMI 27.3±4.8 kg/m^2). RVFWLS was impaired in 40% of patients, whereas conventional RV indices (tricuspid annular plane systolic excursion, S′) remained largely preserved. Pulmonary hypertension was observed in 16.2%. In multivariable analysis, age 45 years [odds ratio (OR) 5.0, 95% confidence interval (CI) 1.4-17.0], uncontrolled asthma (OR 9.7, 95% CI 3.4-27.8), and severe asthma (OR 3.8, 95% CI 1.4-10.0) were independently associated with impaired RVFWLS. Pulmonary hypertension was independently associated with late-onset asthma (OR 11.9, 95% CI 1.1-22.2) and severe asthma (OR 10.1, 95% CI 1.5-64.8). Subclinical RV dysfunction is frequent in adult asthmatics, particularly in those with uncontrolled or severe disease. RVFWLS appears to be a sensitive marker of early cardiac involvement related to asthma severity. Targeted echocardiographic evaluation may help identify high-risk patients and support multidisciplinary management.

Key words: asthma, right ventricle, echocardiography, pulmonary hypertension, strain imaging.

Introduction

Asthma is a common chronic inflammatory disease of the airways affecting nearly 300 million people worldwide [1-4]. Although primarily a respiratory condition, asthma may exert systemic effects on the cardiovascular system through chronic inflammation, intermittent hypoxemia, and increased pulmonary vascular resistance. Epidemiological studies have demonstrated increased risks of coronary artery disease, heart failure, and stroke in asthmatic individuals, even after adjustment for traditional cardiovascular risk factors [5,6], suggesting that asthma may promote early cardiac remodeling.

One of the most severe cardiovascular complications of poorly controlled asthma is chronic cor pulmonale, which reflects advanced RV remodeling secondary to sustained pulmonary hypertension. However, clinical manifestations of RV failure generally occur late, when damage has become irreversible.

Transthoracic echocardiography (TTE) is a non-invasive tool for assessing RV morphology and function. Conventional RV indices such as TAPSE or systolic annular velocity (S') may fail to detect early dysfunction. In contrast, RVFWLS assessed by speckle-tracking echocardiography is a more sensitive marker of subclinical RV impairment.

Data on subclinical RV dysfunction in adult asthmatic populations remain limited, particularly in low- and middle-income settings. The present study aimed to identify clinical factors associated with subclinical RV dysfunction in adult asthmatic patients, with particular focus on disease severity and control.

Materials and Methods

Study design and population

This retrospective study was conducted in the cardiology department of the Military Hospital of Bizerte between July and December 2023, in accordance with the STROBE statement [7]. Adult asthmatic patients (18 years) without history or clinical signs of right heart failure were eligible. Exclusion criteria were: i) established right heart failure or chronic cor pulmonale; ii) other cardiac or pulmonary diseases that could affect RV function; iii) echocardiographic abnormalities unrelated to asthma; and iv) incomplete data.

Data collection

Sociodemographic characteristics, asthma-related data (onset, duration, severity, control), occupational exposures, and treatment adherence were collected from structured interviews and medical records. Weight and height were measured and BMI calculated (kg/m^2); obesity was defined as BMI 30 kg/m^2. Asthma control was assessed using the validated GINA

questionnaire [8]. Severe asthma was defined per GINA step 4-5 criteria [9]. Late-onset asthma was defined as onset after 40 years.

Echocardiographic assessment

All patients underwent TTE using standardized protocols performed by experienced cardiologists. RV assessment included end-diastolic diameter, anterior wall thickness, TAPSE, S′, FAC, PASP, and RVFWLS by two-dimensional speckle-tracking. Strain analysis was performed offline by a single blinded operator. Cut-off values were defined per ASE recommendations [10]. RV dysfunction was defined as at least one abnormal parameter: RVFWLS >−20%, TAPSE <17 mm, S′ <9.5 cm/s, FAC <35%, or PASP 35 mmHg.

Statistical analysis

Data were analyzed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as mean±SD or median (IQR); categorical variables as frequencies and percentages. Variables with $p<0.20$ on univariate analysis or clinical relevance were entered into multivariable logistic regression. Models were restricted to one predictor per 10 events (EPV rule) [11]. Results are expressed as OR with 95% CI; $p<0.05$ was considered significant.

Ethical considerations

The study was approved by the Local Ethics Committee of the Military Hospital of Bizerte (No. CE 03/2023). Written informed consent was obtained from all participants.

Results

Patient characteristics

Eighty asthmatic patients were included (mean age 45±15.9 years; 75% women). The female predominance is consistent with the known epidemiology of adult-onset asthma and the referral pattern of our pneumology consultation. Late-onset asthma was present in 78.8%. Asthma was uncontrolled in 41.3% and severe in 25%. Treatment adherence was reported by 70% and incorrect inhalation technique in 68.8%. Characteristics are summarized in Table 1.

Echocardiographic findings

Conventional RV indices were largely preserved: mean TAPSE 22.8±3.0 mm; S′ impaired in one patient only. RVFWLS was impaired in 40% (mean −20.3%). Pulmonary hypertension (PASP 35 mmHg) was observed in 16.2%. RV hypertrophy in 13.8%, abnormal FAC in 8.8% (Table 2).

Factors associated with right ventricle dysfunction

In multivariable analysis, impaired RVFWLS was independently associated with age 45 years, uncontrolled asthma (Figure 1), and severe asthma. Pulmonary hypertension was independently associated with late-onset asthma and severe asthma. BMI was not independently associated with RVFWLS (OR 1.12, 95% CI 0.87-1.45; p=0.38) or pulmonary hypertension (OR 1.09, 95% CI 0.81-1.47; p=0.56) after adjustment. No independent predictors were retained for FAC or RV hypertrophy (Table 3).

Discussion

This study demonstrates that subclinical RV dysfunction is frequent in adult asthmatic patients even without overt right heart failure. RVFWLS was impaired in 40% despite preserved conventional parameters, confirming the superior sensitivity of strain imaging for early myocardial impairment.

Right ventricle free wall strain

RVFWLS was impaired in 40% of our cohort, consistent with studies showing a strong correlation between RV strain and RV ejection fraction measured by cardiac MRI [12-15]. In asthmatic populations, Tuleta et al. reported reduced longitudinal strain particularly in severe disease [16], while Abbas et al. demonstrated similar findings in pediatric severe asthma [17]. Our results extend these observations to an adult North African population.

Pulmonary hypertension

Pulmonary hypertension was identified in 16.2% and was independently associated with late-onset and severe asthma, consistent with Mincewicz et al. [18]. Chronic inflammation, recurrent hypoxemia, and pulmonary vascular remodeling progressively increase RV afterload, leading to subclinical dysfunction before overt cor pulmonale [18,19].

Sex distribution and right ventricle function

The female predominance (75%) is notable given that females generally show better RV systolic performance and higher strain values than males [20]. The high rate of impaired RVFWLS (40%) despite this protective effect reinforces the clinical significance of our findings. Sex was included as a covariate in multivariable models but was not retained as an independent predictor, suggesting that asthma-specific factors drove the observed RV abnormalities.

Body mass index and right ventricle function

Obesity can impair RV function through increased filling pressures and sleep-disordered breathing [21]. In our cohort (mean BMI 27.3±4.8 kg/m²; 22.5% obese), BMI was not independently associated with RV dysfunction after adjustment for asthma severity and control, suggesting that airway-related mechanisms predominate in this population.

Asthma as a cardiovascular risk factor

Our results are consistent with epidemiological data linking asthma to increased cardiovascular risk [5,6]. Uncontrolled asthma (OR 9.7) and severe asthma (OR 3.8) were the strongest predictors of impaired RVFWLS, underscoring that optimal disease control may be cardioprotective.

Sample size considerations

The sample size of 80 patients is a recognized limitation. However, multivariable models adhered to the EPV rule [11], the effect sizes observed are large and clinically meaningful, and findings are consistent with the literature. Larger multicenter prospective studies are needed to confirm these results.

Conventional right ventricle parameters

FAC showed limited sensitivity, consistent with its known inter- and intra-observer variability [22]. RV hypertrophy was present in a minority, confirming that structural remodeling lags behind functional impairment [23,24].

Strengths and limitations

Strengths include systematic advanced echocardiographic assessment and blinded offline strain analysis. Limitations include the retrospective single-center design, modest sample size, absence of a control group, and lack of cardiac MRI validation.

Conclusions

Subclinical RV dysfunction is common in adult asthmatic patients, particularly in those with uncontrolled or severe disease. RVFWLS is a sensitive marker of early cardiac involvement related to asthma severity. Targeted echocardiographic evaluation may be considered in high-risk asthmatic patients to support early detection and multidisciplinary management.

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Table 1. Baseline characteristics of the study population (n=80).

Variable	Value
Age, years (mean±SD)	45±15.9
Female sex, n (%)	60 (75.0)
BMI, kg/m² (mean±SD) †	27.3±4.8
Obesity (BMI 30 kg/m²), n (%) †	18 (22.5)
Age at asthma onset, years (median, range)	29.5 (1-73)
Late-onset asthma (>40 years), n (%)	63 (78.8)
Asthma duration, years (mean, range)	15.3 (1-60)
Asthma control, n (%)	
Controlled	31 (38.8)
Partially controlled	16 (20.0)
Uncontrolled	33 (41.3)
Severe asthma, n (%)	20 (25.0)
Treatment adherence, n (%)	56 (70.0)
Incorrect inhalation technique, n (%)	55 (68.8)

†New variables added in revised manuscript. BMI, body mass index; SD, standard deviation.

Table 2. Echocardiographic parameters of right ventricular function.

Parameter	Mean±SD	Abnormal n (%)	Cut-off (ASE 2015)
TAPSE (mm)	22.8±3.0	0 (0)	<17
S′ (cm/s)	12.5±2.0	1 (1.3)	<9.5
FAC (%)	39.3±5.0	7 (8.8)	<35
RVFWLS (%)	−20.3±3.0	32 (40.0)	>−20
PASP (mmHg)	37.1±7.0	13 (16.2)	35
RV hypertrophy, n (%)	—	11 (13.8)	Wall thickness >5 mm

TAPSE, tricuspid annular plane systolic excursion; S′, tricuspid annular systolic velocity; FAC, fractional area change; RVFWLS, right ventricular free wall longitudinal strain; PASP, pulmonary artery systolic pressure; ASE, American Society of Echocardiography.

Table 3. Independent predictors of right ventricular dysfunction (multivariable logistic regression).

Variable	OR	95% CI	p-value
a) Impaired RVFWLS			
Age 45 years	5.0	1.4-17.0	0.021
Uncontrolled asthma	9.7	3.4-27.8	0.001
Severe asthma	3.8	1.4-10.0	0.009
BMI (per kg/m²) †	1.12	0.87-1.45	0.38
b) Pulmonary hypertension (PASP 35 mmHg)			
Late-onset asthma	11.9	1.1-22.2	0.010
Severe asthma	10.1	1.5-64.8	0.015
BMI (per kg/m²) †	1.09	0.81-1.47	0.56

†New variable added in revised manuscript. OR, odds ratio; CI, confidence interval; RVFWLS, right ventricular free wall longitudinal strain; PASP, pulmonary artery systolic pressure; BMI, body mass index.

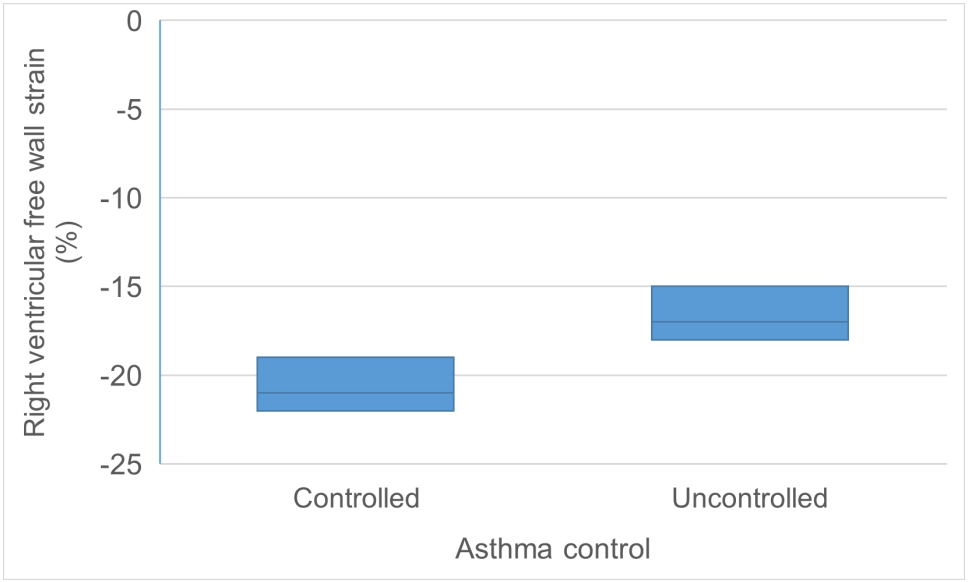

Figure 1. Right ventricular free wall longitudinal strain according to asthma control status. Patients with uncontrolled asthma exhibited significantly more impaired RVFWLS values compared with those with controlled disease.