International Journal of Medicine

https://www.theinternationalmedicine.com

Original Research

RELATIONSHIP BETWEEN SERUM MAGNESIUM AND PULMONARY FUNCTION TESTS IN PATIENTS WITH BRONCHIAL ASTHMA

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Received: 12 Nov 2025 / Accepted: 09 Dec 2025

Abstract

Background: Bronchial asthma is a chronic inflammatory airway disorder affecting a significant proportion of the global population. Magnesium plays an important role in airway smooth muscle relaxation, bronchial reactivity, and inflammatory modulation. Limited data are available from the Indian population regarding the correlation between serum magnesium levels and spirometric parameters in asthma patients. Considering the unique dietary patterns in India compared to Western populations, this study was undertaken to evaluate the relevance of serum magnesium levels in bronchial asthma patients. ***Objectives:*** 1.To determine the prevalence of serum magnesium levels in patients with bronchial asthma. 2. To correlate serum magnesium levels with severity of bronchial asthma based on spirometric values. ***Methods***: A hospital-based case-control study was conducted among 46 bronchial asthma patients and 46 age- and sex-matched controls attending Department of Respiratory Medicine and General Medicine, Sapthagiri Institute of Medical Sciences and Research Centre Bengaluru Karnataka , from April 2025 to September 2025. Asthmatic patients underwent spirometry and were classified as well-controlled, partially controlled, or uncontrolled according to Global Initiative for Asthma (GINA) guidelines. Serum magnesium levels were measured in both cases and controls. Statistical analysis was performed using the Chi-square test for association and Pearson's correlation coefficient for determining correlation.
Results: The age and sex distribution were comparable between cases and controls. The most common symptoms among cases were breathlessness (97.8%) and wheeze (76.1%). Among asthmatics, 65.2% were partially controlled, 23.9% were uncontrolled, and 10.9% were well controlled. Both groups met the recommended daily dietary allowance for magnesium intake. A statistically significant difference in serum magnesium levels was observed between cases and controls ($p = 0.005$). A significant correlation was found between serum magnesium levels and asthma symptom control ($p = 0.029$). However, 87% of patients had normal serum magnesium levels, while only 13% had low magnesium levels, which was statistically non-significant. ***Conclusion***: Low serum magnesium levels may be present in a subset of bronchial asthma patients. Monitoring and maintaining normal serum magnesium levels could potentially contribute to improved asthma symptom control. Further large-scale studies are recommended to validate these findings.

Keywords: *Bronchial asthma; Serum magnesium; Spirometry; Asthma severity; GINA guidelines; Hypomagnesemia*

Introduction

Bronchial asthma is a diverse condition, typically marked by chronic inflammation of the airways. It is characterized by a history of respiratory symptoms like wheezing, shortness of breath, chest tightness, and coughing, which fluctuate in both occurrence and severity, along with variable limitations in expiratory airflow.1 The global occurrence of bronchial asthma stands at around 4.5%.2,3 There are roughly 334 million individuals with asthma across all age demographics worldwide. The frequency of asthma has gradually risen over time, and it is anticipated that an additional 100 million people globally will develop the condition by the end of 2025.4

In a research project focused on the epidemiology of bronchial asthma, respiratory symptoms, and chronic bronchitis among adults (INSEARCH), a survey conducted at 16 locations throughout India found that the prevalence of bronchial asthma in adults stands at 2.05 percent (equating to 17.23 million individuals).5 A recent evaluation using three distinct estimation models (INSEARCH, GINA, and a WHO survey) indicates that the prevalence of bronchial asthma within the Indian population ranges from 2.05 to 3.5% (approximately 17 to 30 million people).6 The estimated cost for treating bronchial asthma per year in 2015 was about `139.45 billion.7

Electrolyte imbalances in patients with asthma have primarily centered around serum potassium, particularly in connection with beta2-agonist therapy (8). Hypokalemia was among the earliest reported electrolyte disturbances observed in asthma patients and was largely associated with the use of beta2-agonists and aminophylline treatment (9).

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DOI: 10.61336/im/25-12-60

A contributing factor to electrolyte imbalances in individuals with asthma is either inadequate intake of electrolytes or the effects of asthma medications (10). Recently, cases of hypomagnesemia, hypophosphatemia, and hypocalcemia have been documented following the administration of beta2-agonists in both healthy subjects and asthmatic individuals (11).

Magnesium (Mg^{2+}) is a key cation found both inside and outside of cells, significant for various intracellular enzymatic processes.12 It is essential for maintaining cellular homeostasis, functioning as an enzymatic cofactor, as well as for the synthesis of acetylcholine and histamine in cholinergic nerve endings and mast cells, respectively. Additionally, magnesium is believed to influence the deactivation of calcium ion influx into respiratory smooth muscles.13 Furthermore, magnesium serves as an anti-inflammatory agent in individuals with bronchial asthma.12

Hypomagnesemia is marked by increased airway responsiveness, wheezing, and changes in lung function. Various studies indicate that magnesium may be crucial in preventing and treating bronchial asthma by facilitating the relaxation of smooth muscles in the bronchi.14 Additionally, other research has demonstrated that administering magnesium via intravenous or inhaled methods can aid in managing acute asthma exacerbations, although findings regarding the impact of oral supplements remain unclear.15 There is a lack of data concerning the relationship between magnesium levels and bronchial asthma patients in the Indian population. Given that Indians have a distinct dietary pattern compared to Western populations, it is important to determine the significance of serum magnesium levels in this specific group of bronchial asthma patients.

OBJECTIVES:
- To determine prevalence of serum magnesium level in bronchial asthma patients.
- To correlate serum magnesium level with severity of bronchial asthma based on spirometric values.

Materials and Methods

Study Design: This is a cross-sectional comparative study.

Study area: The study was conducted in the Department of Respiratory Medicine and General Medicine, Sapthagiri Institute of Medical Sciences and Research Centre Bengaluru. Karnataka.

Study Period: April 2025 to September 2025.

Study population: All patients diagnosed with bronchial asthma as per GINA guidelines and satisfying the study criteria were recruited.

Sample size: The study consisted of 92 subjects. (46 cases and 46 controls)

Sampling method: Simple random Sampling Technique.

Inclusion criteria:
- Age group: above 18 years.
- Patients diagnosed with bronchial asthma as per GINA guidelines.
- Age and sex matched individual controls
- Patients with informed written consent.

Exclusion criteria: Adults with
- Acute exacerbation of asthma
- Active respiratory infections including pneumonia and tuberculosis
- Chronic kidney disease
- Chronic liver disease
- Pregnancy
- Acute gastroenteritis.
- Diabetes mellitus
- Alcoholism
- Medications which affects absorption or excretion of serum magnesium.
- Patients with known contraindications for PFT.
- Patients not willing to give consent.

Ethical consideration: Institutional Ethical committee permission was taken prior to the commencement of the study.
Study tools and Data collection procedure:

Materials:
1. Blood tests-
   - Complete Blood Count
   - Venous blood sample of the patient approximately 2ml to check serum magnesium levels
2. Spirometry, machine name: Smartpft- MEE
3. Chest X- ray

Method:
1. All patients diagnosed with bronchial asthma as per GINA guidelines and satisfying the study criteria were recruited after taking informed consent and their basic demographic, anthropometric and relevant clinic-radiological data were recorded in a proforma.
2. Chest imaging was done with baseline chest X ray. Patients with Chest X ray findings of consolidation were excluded from the study.
3. The patients were then subjected to spirometry according to American Thoracic Society guidelines at PFT lab.
4. Subsequently venous blood sample was collected and sent to biochemistry lab to assess CBC and serum magnesium levels.
5. Age and sex matched control group were selected and their serum magnesium levels were also obtained.
6. Data was collated, entered in MS excel and statistically analysed.

Parameters recorded
- Spirometry values for severity of obstruction
- Severity of bronchial asthma based on consensus-based GINA symptom control tool.
- Consumption of food which are rich sources of magnesium of both cases and controls.

Statistical analysis:
Data was entered into Microsoft Excel (Windows 7; Version 2007), and analyses were conducted using the Statistical Package for Social

Sciences (SPSS) for Windows software (version 22.0; SPSS Inc, Chicago). Descriptive statistics, including mean and standard deviation (SD) for continuous variables, as well as frequencies and percentages for categorical variables, were computed. The data was examined for normality using the Shapiro-Wilk Test. The relationships between variables were evaluated using the Chi-Square test for categorical variables. The unpaired t-test was applied to compare the means of quantitative variables across groups. Pearson's Correlation Coefficient was utilized to assess the correlation between two quantitative variables. Bar charts and pie charts were employed to visually represent the analyzed data. The significance level was set at 0.05.

Results

Table 1: Comparison of Age between Cases and Controls (N=92)

Age Group (Years)	Cases (n=46) n (%)	Controls (n=46) n (%)	Total (n=92) n (%)
18-25	4 (8.7%)	6 (13.0%)	10 (10.9%)
26-35	13 (28.3%)	13 (28.3%)	26 (28.3%)
36-45	7 (15.2%)	7 (15.2%)	14 (15.2%)
46-55	6 (13.0%)	7 (15.2%)	13 (14.1%)
56-65	6 (13.0%)	3 (6.5%)	9 (9.8%)
66-75	6 (13.0%)*	6 (13.0%)	12 (13.0%)
76-85	4 (8.7%)	4 (8.7%)	8 (8.7%)
Total	**46 (100%)**	**46 (100%)**	**92 (100%)**

Statistical Inference: Chi-Square = 1.48, p = 0.961 (Not Significant)
The age distribution of the study participants was well-balanced between the two groups. Out of the 92 total participants, the most common age group for both cases and controls were 26-35 years, representing 28.3% (n=13) of each group. Overall, the ages ranged from 18 to 85 years, with a steady distribution across the middle and older age brackets. Statistical analysis using the Chi-Square test resulted in a p-value of 0.961, which is not significant ($p > 0.05$). This indicates that there is no statistically significant difference in age between the cases and controls.

Table 2: Comparison of Gender between Cases and Controls (N=92)

Gender	Cases (n=46)		Controls (n=46)	
	n (%)		n (%)	
Male	25 (54.3)		24 (52.2)	
Female	21 (45.7)		22 (47.8)	

Chi-Square Test, P Value = 0.834, Not Significant.

Among cases, 25 (54.3%) were male and 21 (45.7%) were female. Among controls, 24 (52.2%) were male and 22 (47.8%) were female.

Among the enrolled subjects, breathlessness was the predominant symptom, seen in 97.8% of cases (45/46), followed by wheeze in 76.1% (35/46). Allergic rhinitis was observed in 45.7% (8/59).

While the majority of patients had normal BMI (69.6%), 19.5% were overweight, and 10.9% belonged to class 1 obesity.

After initial evaluation and examination, CBC and CXR were performed to rule out infection and consolidation. Spirometry was conducted using SmartPFT-MEE equipment, and the severity of obstruction was noted.

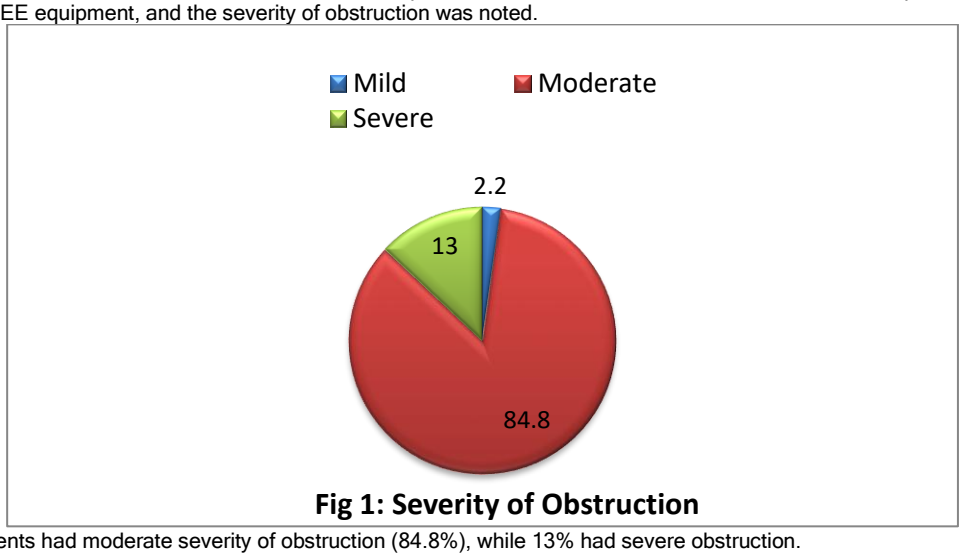

Fig 1: Severity of Obstruction

Majority of the patients had moderate severity of obstruction (84.8%), while 13% had severe obstruction.

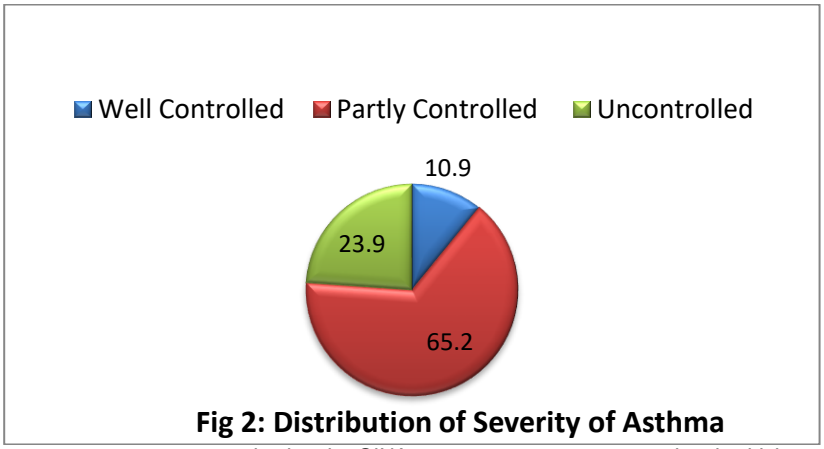

Fig 2: Distribution of Severity of Asthma

Asthma symptom control among cases was assessed using the GINA consensus symptom control tool, which evaluates daytime symptoms, nighttime awakenings due to asthma, reliever use (short-acting β2-agonists) more than twice weekly, and activity limitations. Patients were categorized as well controlled, partly controlled, or uncontrolled asthma.

In this study, 65.2% (30/46) of cases had partly controlled asthma, 23.9% (11/46) had uncontrolled asthma, and 10.9% (5/46) had well controlled asthma.

Comparison of Magnesium-Rich Foods between Cases and Controls

The intake of magnesium-rich foods (average magnesium content in mg per serving) was evaluated for both cases and controls, and both groups met the recommended dietary allowance of magnesium, which is 370 mg.

Table 3: Comparison of Magnesium-Rich Foods between Cases and Controls (N=92)

Food Item	Key Higher Frequency in Controls	Key Higher Frequency in Cases	(P value)	Significance
White Rice	Daily: 100% (46)	Daily: 100% (46)	NA	Not Applicable
Pulses	Daily: 95.7%	Weekly: 41.3%; Monthly: 10.9%	<0.001	Significant
Green Leafy Vegetables	Daily: 82.6%	Weekly: 47.8%	0.002	Significant
Roots & Tubers	Daily: 58.7%	Monthly: 15.2%	0.088	Not Significant
Sugar & Jaggery	Daily: 87.0%	Daily: 89.1%	0.494	Not Significant
Deep Fried Foods	Monthly: 32.6%	Weekly: 26.1%	0.146	Not Significant
Fruits	Daily/Weekly higher	Monthly: 41.3%	0.135	Not Significant
Chocolates/Ice creams/Cool drinks	Weekly/Monthly higher	Occasionally: 69.6%	0.019	Significant
Non-Veg Items	Weekly similar; Never: 26.1%	Occasionally: 30.4%	0.010	Significant
Egg	Daily higher (8.7%)	Weekly: 56.5%; Occasionally: 21.7%	0.020	Significant
Nuts	Monthly: 50.0%	Weekly: 52.2%	0.194	Not Significant

The consolidated analysis indicates statistically significant differences between cases and controls in the consumption of pulses, green leafy vegetables, chocolates/ice creams/cool drinks, non-vegetarian items, and eggs ($p < 0.05$). Controls demonstrated significantly higher daily intake of magnesium-rich foods such as pulses and green leafy vegetables compared to cases, suggesting better dietary magnesium availability among controls. Conversely, cases showed comparatively lower frequency of daily consumption of these protective foods.

Additionally, significant variation was observed in the intake pattern of non-vegetarian foods and eggs, with cases showing more occasional consumption and controls showing a higher proportion of regular or weekly intake. Consumption patterns of chocolates, ice creams, and cool drinks also differed significantly between groups.

No statistically significant association was observed for white rice, roots and tubers, sugar and jaggery, deep fried foods, fruits, and nuts.

Overall, the findings suggest that lower regular intake of magnesium-rich foods such as pulses and green leafy vegetables may be associated with the case group, indicating a possible dietary influence in the studied condition.

Table 4: Comparison of Serum Magnesium Levels between Cases and Controls (N = 92)

Serum Magnesium (mg/dL)	Cases (n = 46) n (%)	Controls (n = 46) n (%)
< 1.7	6 (13.0%)	5 (10.9%)
1.7 - 2.4	40 (87.0%)	37 (80.4%)
> 2.4	0 (0.0%)	4 (8.7%)
Mean ± SD	**1.95 ± 0.19**	**2.07 ± 0.23**

Statistical Test: Unpaired t-test
P Value: 0.005

Inference: Statistically Significant
The mean serum magnesium level was significantly lower among cases (1.95 ± 0.19 mg/dL) compared to controls (2.07 ± 0.23 mg/dL). Although the majority of participants in both groups had magnesium levels within the normal range (1.7-2.4 mg/dL), a higher proportion of controls had levels >2.4 mg/dL. The difference in mean magnesium levels between the two groups was statistically significant (p = 0.005), indicating a significant association between lower serum magnesium levels and the case group.

Table 5: association Mg levels with severity of obstruction

Magnesium	Severity of Obstruction		
	Mild	Moderate	Severe
<1.7		3 (50.0)	3 (50.0)
1.7-2.4	1 (2.5)	36 (90.0)	3 (7.5)
>2.4	-	-	-
Mean (SD)	2.00	1.93 (0.20)	2.05 (0.12)
Chi-Square Test, P Value = 0.015, Significant			

Among the cases with normal serum magnesium levels (40/46), the majority (90%, 36/40) had moderate obstruction, while 7.5% (3/40) had severe obstruction. In contrast, among cases with hypomagnesemia (6/46), half of the patients (50%) had moderate obstruction and the remaining 50% had severe obstruction, indicating a higher proportion of severe obstruction in those with low magnesium levels.

Table 6: Association of Mg levels with severity of asthma

Magnesium	Severity of Asthma		
	Well Controlled	Partially Controlled	Uncontrolled
<1.7		2 (33.3)	4 (66.7)
1.7-2.4	5 (12.5)	28 (70.0)	7 (17.5)
>2.4			
Mean (SD)			
Chi-Square Test, P Value = 0.029, Significant			

Among cases with normal serum magnesium levels (40 patients), 70% (28/40) had partially controlled asthma, 17.5% (7/40) had uncontrolled asthma, and 12.5% (5/40) had well-controlled asthma. In contrast, among cases with low magnesium levels (6 patients), 33.3% (2/6) had partially controlled bronchial asthma, while a higher proportion, 66.7% (4/6), had uncontrolled bronchial asthma, suggesting poorer asthma control in patients with hypomagnesemia.

Discussion

Many electrolytes play an important role in the pathogenesis of bronchial asthma, and serum magnesium is one among them. The therapeutic role of magnesium in the management of severe asthma is well established. Hypomagnesemia is considered one of the most common yet underdiagnosed electrolyte imbalances encountered in clinical practice. Previous studies have demonstrated a correlation between hypomagnesemia and poor symptom control as well as impaired lung function in bronchial asthma. Therefore, serum magnesium is regarded as a potential biomarker for assessing asthma control.

The present study aimed to evaluate the correlation between serum magnesium levels and bronchial asthma. The variables assessed included severity of airway obstruction measured by spirometry (FEV1%) and severity of asthma assessed using the consensus-based GINA symptom control tool. Dietary magnesium intake among cases was evaluated, and serum magnesium levels were measured and compared with age- and sex-matched control subjects.

To minimize confounding factors affecting serum magnesium levels, individuals with comorbidities such as diabetes mellitus, cardiac diseases, chronic renal or liver disease, pregnancy, alcoholic liver disease, patients on diuretic therapy, and those with gastroenteritis were excluded. This approach was adopted to establish an accurate association between serum magnesium levels and asthma control.

The age and sex distribution between cases and controls did not differ significantly (p = 0.961). Most participants (69.6%) had a normal BMI (18.5-24.99 kg/m²), and no significant association was found between BMI and severity of bronchial asthma (p = 0.560). Clinically, the most common symptoms observed were breathlessness (97.8%), wheeze (76.1%), and allergic rhinitis (45.7%), which are consistent with the diagnostic criteria outlined in the International Primary Care Respiratory Group (IPCRG) Guidelines (16).

Based on spirometric FEV1% values, patients were categorized into mild, moderate, and severe obstruction groups. A statistically significant association was observed between serum magnesium levels and severity of airway obstruction (p = 0.015). Patients with hypomagnesemia exhibited significantly greater severity of obstruction compared to those with normal magnesium levels. Similar findings were reported in a study conducted by Hatice Kilic et al. (17).

According to GINA guidelines, asthma control was classified as well controlled, partially controlled, and uncontrolled. A significant correlation was found between serum magnesium levels and asthma control status (p = 0.029). All patients with hypomagnesemia fell into either the partially controlled or uncontrolled asthma categories. Comparable results were reported by Hatice Kilic et al. (17). Furthermore, the proportion of uncontrolled asthma patients was significantly higher among those with low magnesium levels compared to those with normal levels. Similar observations were reported by Daliparty et al. in a study of 160 bronchial asthma patients (18), and O.S.B. Alamoudi also concluded that severe asthma is more frequently associated with hypomagnesemia than moderate or mild asthma (19).

The prevalence of hypomagnesemia in the present study was relatively low (13%), with a mean serum magnesium level of 1.92 mg/dL (SD 0.19) among asthmatics. In contrast, O.S.B. Alamoudi reported a higher prevalence (27%) among chronic stable asthmatics (19). Although significant inter-group differences were observed between cases and controls, intra-group variation among asthma patients was not statistically significant.

Earlier studies attributed hypomagnesemia in bronchial asthma to the use of oral or intravenous beta$_2$-agonists (20). However, in the present study, none of the patients received oral or intravenous beta$_2$-agonists. Moreover, recent studies do not support a significant association between beta$_2$-agonist use and serum magnesium levels in chronic bronchial asthma (20).

With respect to dietary intake of magnesium-rich foods, statistically significant differences were observed between cases and controls in the consumption of pulses ($p < 0.001$), green leafy vegetables ($p = 0.002$), chocolates/cool drinks/ice creams ($p = 0.019$), non-vegetarian foods ($p = 0.010$), and eggs ($p = 0.020$). However, both groups generally consumed a balanced diet meeting the recommended dietary allowance. Britton et al. concluded that variations in dietary magnesium intake may influence lung function, airway reactivity, and respiratory symptoms (21).

Overall, a statistically significant inter-group difference in mean serum magnesium levels was observed between cases (1.95 mg/dL) and controls (2.07 mg/dL) ($p = 0.005$). However, no significant intra-group variation in serum magnesium levels was noted among bronchial asthma patients. These findings suggest that while serum magnesium levels are significantly lower in asthmatics compared to controls and are associated with disease severity and control status, further large-scale studies are required to establish magnesium as a definitive biomarker in bronchial asthma.

Conclusion

This study evaluated the correlation between serum magnesium levels and bronchial asthma. Although a statistically significant association was observed between serum magnesium levels and the severity of asthma symptoms, the overall serum magnesium levels among bronchial asthma patients remained within the normal range and did not show marked statistical deviation. The findings suggest that maintaining normal magnesium levels may contribute to better symptom control and potentially reduce disease severity in bronchial asthma. However, considering the observed intra-group variations in serum magnesium levels among both cases and controls, larger prospective studies are warranted to further validate these findings and to establish the clinical significance of serum magnesium as a reliable biomarker in asthma management.

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