

The efficacy of nebulized magnesium sulfate alone and in combination with salbutamol in acute asthma

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Objective: Evaluation of the efficacy of nebulized magnesium sulfate (MgSO₄) alone and in combination with salbutamol in acute asthma.

Methods: A double-blind randomized controlled study was conducted in Chest and Emergency Departments. Thirty patients of acute attack of bronchial asthma were randomized into three groups: MgSO₄ nebulization (group A), salbutamol nebulization (group B), and their combination (group C). All patients were monitored before and after nebulization (each 20 minutes) for peak expiratory flow rate (PEFR), respiratory rate (RR), heart rate (HR), blood pressure, pulsus paradoxus, oxygen saturation, clinical examination, and Fischl index.

Results: A highly significant improvement in PEFR, PEFR percentage, and Fischl index and significant decrease in RR and HR was observed in all groups. A similar improvement in PEFR was observed in group A and group B ($P=0.389$). The difference in peak expiratory flow (PEF) improvement was insignificant between group B and group C ($P=0.101$), while there was a significant difference between group A and group C ($P=0.014$) in favor of group C.

Conclusion: Nebulized MgSO₄ alone or combined with salbutamol has a clinically significant bronchodilator effect in acute asthma and leads to clinical improvement, increase in PEFR, reduction in HR, and reduction in RR. The response to nebulized MgSO₄ alone (PEFR improvement 54 ± 35.6 L/min, $P=0.001$) is comparable ($P=0.389$) to that of nebulized salbutamol (PEFR improvement 67.0 ± 41.9 L/min, $P=0.001$) and is significantly less than ($P=0.014$) that of nebulized combination (PEFR improvement 92.0 ± 26.9 L/min, $P=0.000$).

Keywords: nebulized magnesium sulfate, salbutamol, acute asthma, peak expiratory flow rate, Fischl index

Introduction

Asthma is a heterogeneous disease, usually characterized by chronic airway inflammation. It is defined by the history of respiratory symptoms such as wheeze, shortness of breath, chest tightness, and cough that vary over time and in intensity, together with variable expiratory airflow limitation.¹ It is the most common chronic lung disease in both the developed and developing countries.^{2,3} Multicenter studies conducted in large general populations indicate that asthma is a disease extremely prevalent with up to one out of ten adults and one out of three children worldwide.^{4,5} Asthma is responsible for a significant personal and social burden, due to staggering costs to the patient and the health care system, and the potential for adverse outcomes.⁶

Asthma exacerbations are acute or subacute episodes of breathlessness, cough, wheezing, and chest tightness, or any combination of these symptoms. Exacerbations are associated with airway obstruction that should be documented and quantified

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by peak expiratory flow (PEF) or forced expiratory volume in 1 second (FEV₁) measurement.^{7,8} Standard treatments for asthma crisis include short-acting bronchodilator, β_2 -agonists, inhaled anticholinergic agents, and corticosteroids, in addition to general management.^{5,9} Use of oxygen in a patient with acute severe asthma is justified only if the partial pressure of oxygen in arterial blood is <60 mmHg. In fact, there is some suggestion that excess oxygen may be harmful for some patients with acute severe asthma.^{10,11} Intravenous methyl xanthine agents, such as theophylline, are less effective,^{6,12} have a low therapeutic index, and exhibit frequent side effects, making them increasingly unpopular.^{13,14} Antibiotics have not been shown to improve outcomes.¹⁵

Some studies suggest MgSO₄ as an additional bronchodilator treatment option in patients resistant to standard therapy. MgSO₄ has been assessed in intravenous and nebulized forms. The nebulized route offers the potential advantage of a quick onset of action and reduced incidence of side effects. Its disadvantages include a reduced dose of drug delivered compared with the intravenous form, and increased respiratory effort of the patient to enhance the drug's effectiveness. The intravenous route provides direct access to the venous system, allowing the delivery of high drug concentrations. Disadvantages include the need for intravenous access and drug administration by infusion lasting ~20 minutes.¹⁶ Several studies^{17–22} had confirmed the bronchodilating effects of intravenous magnesium, but its effects through inhalation are controversial.^{23–28} However, the Global Initiative in National Asthma recommendations approve the use of inhaled MgSO₄ during a crisis.¹

Magnesium, the second most abundant intracellular cation, has a wide range of biological actions that are of potential relevance to the airways.^{23,29} Magnesium is involved with cellular homeostasis through its role as an enzymatic cofactor, as well as being involved in acetylcholine and histamine release, from cholinergic nerve terminals and mast cells, respectively. Investigators have proposed that the effect of MgSO₄ is related to its ability to block the calcium ion influx to the smooth muscles of the respiratory system. Magnesium may increase the bronchodilator response to salbutamol in acute asthma by increasing the affinity of β -receptors to salbutamol or by upregulating β -receptors.^{6,8} This agent has been shown to be easy to use, extremely safe, and inexpensive. However, given its recent demonstration of efficacy, the use of this agent by frontline emergency physicians is unknown.¹⁵

The aim of this study was to make a comparison between the efficacy of nebulized dosage forms of MgSO₄, salbutamol, and a combination of them as bronchodilators in the treatment of acute asthma.

Methods

Materials/instruments

1. Salbutamol respirator solution containing 5 mg of salbutamol per mL (Ventolin respirator solution, Glaxo-SmithKline plc, London, UK)
2. Magnesium sulfate heptahydrate MgSO₄·7H₂O (Sigma-Aldrich, St Louis, MO, USA)
3. Normal saline, 0.9% w/v of NaCl, sterile, pyrogen-free isotonic solution, blood pressure (BP) 2004 (Al Mottahedoon Pharma, El Sharkeya, Egypt)
4. Sterile water for injection, pyrogen-free isotonic solution, BP 2004 (Al Mottahedoon Pharma, Egypt)
5. 0.22 μ m hydrophilic filter (Corning Incorporated, Corning, NY, USA)
6. Ultrasonic nebulizer (Fazzini, Italy)
7. Lungenfunktionsgerät Roland Pulmo Test peak flow meter.

Preparation of isotonic, sterile, aqueous solution of MgSO₄ for inhalation

1. 3 mL dose (3.3% solution, 100 mg)

Four grams of MgSO₄·7H₂O (molecular weight = 246.48 g/mol) were dissolved in 100 mL sterile water for injection using ultrasonic stirrer. After MgSO₄ was completely dissolved, 132 mg of sodium chloride was added to adjust isotonicity of the solution. The pH of the solution was adjusted to 3.4, and the volume was adjusted to 120 mL with sterile water for injection and mixed again. Finally, the solution was sterilized by passing through 0.22 μ m filter unit and aliquoted into individual 3 mL volumes in sterile 10 mL falcon tubes.

2. 2.5 mL dose (4% solution, 100 mg)

Four grams of MgSO₄·7H₂O (molecular weight = 246.48 g/mol) were weighed and then dissolved in 80 mL sterile water for injection using ultrasonic stirrer. The pH of the solution was adjusted to 3.4, and the volume was adjusted to 100 mL with sterile water for injection and mixed again. Finally, the solution was sterilized by passing through 0.22 μ m filter unit and aliquoted into individual 2.5 mL volumes in sterile 10 mL falcon tubes.

All the processes were done aseptically in a laminar airflow hood in our research lab.

Patients

A double-blind, randomized controlled study was conducted in Minia University Hospital Chest and Emergency Departments, Minia, Egypt, between October 2013 and March 2015. The study was approved by the Minia University Research

| | |
|---------------------|-----------|
| MgSO ₄ = | 120.36 |
| H ₂ O = | 18.01 |
| 18.01 x 7 = | 126.07 |
| 120.36/246.4 | 8 = 48.9% |

Table 1 Three groups of asthmatic patients

| Characteristics of group | Group A | Group B | Group C |
|--------------------------|---|---|--|
| Number of patients | 10 | 10 | 10 |
| Nebulized bronchodilator | MgSO ₄ | Salbutamol + isotonic saline | Salbutamol + MgSO ₄ |
| Dosing frequency | 4 | 4 | 4 |
| Dosing interval (min) | 20 | 20 | 20 |
| Dose | 3 mL MgSO ₄ (3.3% solution, 100 mg) | 0.5 mL salbutamol (0.5% solution, 2.5 mg) diluted in 2.5 mL isotonic saline | 0.5 mL salbutamol (0.5% solution, 2.5 mg) Diluted in 2.5 mL MgSO ₄ (4% solution, 100 mg) |

Abbreviations: MgSO₄, magnesium sulfate; min, minutes.

Committee and the Minia University Hospital Ethical Committee. Written informed consent was obtained from all patients.

Patients included were newly diagnosed or known cases of bronchial asthma. Thirty subjects aged between 11 years and 70 years were selected according to the criteria for diagnosis of bronchial asthma, which are

1. Medical history and physical examination
2. Spirometry.

Spirometry was performed in all selected patients to confirm the diagnosis of bronchial asthma. The parameters measured in spirometry were FEV₁, forced vital capacity (FVC), and PEF. Patients with PEF <300 L/min were included; the best of three attempts was considered.

Patients were excluded if any of the following conditions were present: fever, lower respiratory tract infection, cardiac, renal, or hepatic dysfunction, required ventilator care or endotracheal intubation, near-fatal asthma, pregnant or breastfeeding mothers, failed to use PEF meter, or had received oral, inhaled, or parenteral bronchodilators in the past 6 hours, or steroids in the past 12 hours.

Study design

Asthmatic patients were divided into three groups as shown in Table 1. A Fazzini ultrasonic nebulizer was used for the administration of the drugs. All patients were monitored before nebulization, and every 20 minutes up to 1 hour after completion of nebulization. Monitored parameters were PEF, with a handheld Lungenfunktionsgerät Roland Pulmo Test peak flow meter, respiratory rate (RR), heart rate (HR), BP, pulsus paradoxus (PP), oxygen saturation (SO₂), clinical examination, and Fischl index³⁰ (at 0 minute and 120 minutes only). The Fischl index takes into account dyspnea, accessory muscle use, wheeze, HR ≥120 beats/min, RR ≥30 breaths/min, PP ≥18 mmHg, and a PEF ≤120 L/min. The presence of each finding scores 1 point and a total score of 4 points or more implies severe asthma. Patients in group A and group C were also monitored for side effects of MgSO₄ such as hypotension,

arrhythmias, loss of deep tendon reflexes, and respiratory depression before and after each nebulization dose.

After the completion of the four nebulization doses, patients with unsustainable bronchodilatation effect were given supplemental treatment in the emergency department in the form of oxygen, salbutamol nebulization, hydrocortisone injection, and aminophylline infusion.

Results

Out of 45 patients screened over the study period, only 30 patients were included. Only single visits were taken into consideration in our study to avoid patient bias.

Our study showed that the MgSO₄ nebulization, alone or combined with a bronchodilator, resulted in clinical improvement, increase in PEF, reduction in HR, and reduction in RR. However, comparing MgSO₄ with salbutamol, we found that salbutamol (PEFR improvement 67.0±41.9 L/min, PEFR percentage improvement 13.2±7.7, and Fischl index improvement 3.3±1.0) was slightly better ($P=0.389$, $P=0.573$, and $P=0.594$, respectively) than MgSO₄ (PEFR improvement 54±35.6 L/min, PEFR percentage improvement 11.5±7.7, and Fischl index improvement 3.0±1.2) in the management of acute exacerbations of asthma, and a combination of them was the best (PEFR improvement 92.0±26.9 L/min, PEFR percentage improvement 17.1±5.4, and Fischl index improvement 3.4±1.5). **Nebulized MgSO₄ showed early but unsustainable relief, so it may be better used as an adjunct for standard treatment in acute attacks of asthma.**

Baseline patient features are shown in Table 2. There was a significant difference between three groups in age, height, and weight. Regarding other baseline data, differences between the groups were not statistically significant. All patients were presented by dyspnea and wheeze. Tables 3 and 4 show that no statistically significant difference between groups in any parameter was observed after treatment.

There was a highly significant improvement in PEFR, PEFR percentage, and Fischl index in all groups (Tables 5–7).

Table 2 Baseline characteristics of patients

| Parameters | MgSO ₄ | Saline-salbutamol | MgSO ₄ -salbutamol | P-value |
|---------------------------------|-------------------|-------------------|-------------------------------|---------|
| Age (years) | 33.5±17.8 | 48.6±9.9 | 51.3±15.8 | 0.027 |
| Sex (n/%) | | | | 0.272 |
| Male | 4 (40) | 3 (30) | 7 (70) | |
| Female | 6 (60) | 7 (70) | 3 (30) | |
| Height (cm) | 158.7±6.2 | 165.2±9.3 | 172.4±8.0 | 0.003 |
| Weight (kg) | 78.2±14.7 | 89±16.5 | 101.8±13.7 | 0.006 |
| Duration of asthma (years) | 22.2±16.6 | 33.1±11.7 | 35.9±15.5 | 0.110 |
| Accessory muscle use (n/%) | 3 (30) | 7 (70) | 4 (40) | 0.272 |
| PEFR (L/min) | 159±42.0 | 182±63.0 | 184±52.5 | 0.514 |
| PEFR (% pred) | 33.9±9.8 | 36.4±10.5 | 34.1±9.4 | 0.827 |
| SO ₂ (%) | 95.3±3.0 | 96.2±2.2 | 95.9±2.6 | 0.745 |
| RR (breaths/min) | 22.6±3.8 | 23.6±6.2 | 27.0±7.6 | 0.260 |
| HR (beats/min) | 95.1±12.3 | 85.4±14.0 | 95.9±11.8 | 0.144 |
| Systolic blood pressure (mmHg) | 114±12.6 | 116±15.7 | 120±13.3 | 0.626 |
| Diastolic blood pressure (mmHg) | 79.0±8.7 | 78.5±9.4 | 81.0±7.3 | 0.790 |
| PP (mmHg) | 14.6±4.4 | 16.1±3.3 | 13.9±3.8 | 0.441 |
| Fischl index | 3.1±1.1 | 3.6±1.1 | 3.4±1.5 | 0.691 |

Notes: Data are presented as mean ± standard deviation or number and percentage of cases (n%). $P < 0.05$ is statistically significant.

Abbreviations: HR, heart rate; MgSO₄, magnesium sulfate; min, minutes; % pred, percentage predicted; PEFR, peak expiratory flow rate; RR, respiratory rate; PP, pulsus paradoxus; SO₂, oxygen saturation.

A similar improvement in PEFR was observed in MgSO₄ and salbutamol groups ($P=0.389$). The difference in PEF improvement was nonsignificant between salbutamol and combination groups ($P=0.101$); however, there was a significant difference between MgSO₄ and combination groups ($P=0.014$) in favor of the combination group. There was no significant difference between any pair of groups in either PEFR percentage improvement (groups A and B [$P=0.598$], groups B and C [$P=0.231$], groups A and C [$P=0.090$]) or Fischl index improvement (groups A and B [$P=0.613$], groups B and C [$P=0.866$], groups A and C [$P=0.501$]).

The mean basal, as well as final, respiratory (basal: groups A and B [$P=0.718$], groups B and C [$P=0.225$], groups A and C [$P=0.120$]; final: groups A and B [$P=0.378$], groups B and C [$P=0.312$], groups A and C [$P=0.065$]) and heart (basal: groups A and B [$P=0.102$], groups B and C [$P=0.078$], groups A and C [$P=0.890$]; final: groups A and B [$P=0.030$], groups B and C [$P=0.021$], groups A and C

[$P=0.881$]) rates were not significantly different between any pair of groups. According to Tables 5–7, a highly significant decrease in RR and HR was observed in each group.

The difference in both mean basal and final SO₂ between any pair of three groups was nonsignificant (basal: groups A and B [$P=0.455$], groups B and C [$P=0.803$], groups A and C [$P=0.618$]; final: groups A and B [$P=0.528$], groups B and C [$P=0.857$], groups A and C [$P=0.652$]). In Tables 5–7, no significant increase in SO₂ in any of three groups was noted.

The most common adverse reactions associated with MgSO₄ were dry and bitter mouth and dizziness. One patient developed mild transient hypotension. None of the patients in the MgSO₄ group showed any sign of toxicity such as depressed deep tendon reflexes. In the salbutamol group, two patients experienced fine tremors. No clinically significant adverse events were reported in the combination group. None of the adverse effects shown in the three groups was severe enough to necessitate withdrawal from the study.

Table 3 Different parameters after treatment

| Parameters | MgSO ₄ | Saline-salbutamol | MgSO ₄ -salbutamol | P-value |
|---------------------------------|-------------------|-------------------|-------------------------------|---------|
| SO ₂ (%) | 95.5±2.6 | 96.2±2.2 | 96.0±2.4 | 0.807 |
| RR (breaths/min) | 17.5±3.1 | 19.5±4.6 | 21.8±6.5 | 0.175 |
| HR (beats/min) | 90.8±11.3 | 69.6±32.0 | 92.2±11.1 | 0.121 |
| Systolic blood pressure (mmHg) | 109.0±12.2 | 111.0±13.2 | 114.5±12.5 | 0.624 |
| Diastolic blood pressure (mmHg) | 78.5±8.1 | 77.0±8.2 | 79.0±7.7 | 0.847 |
| PP (mmHg) | 8.1±2.3 | 8.5±1.9 | 8.2±1.8 | 0.902 |

Notes: Data are presented as mean ± standard deviation. $P < 0.05$ is statistically significant.

Abbreviations: HR, heart rate; MgSO₄, magnesium sulfate; min, minutes; RR, respiratory rate; PP, pulsus paradoxus; SO₂, oxygen saturation.

Table 4 Response in peak expiratory flow and Fischl index after treatment

| Parameters | MgSO ₄ | Saline-salbutamol | MgSO ₄ -salbutamol | P-value |
|-----------------------------|-------------------|-------------------|-------------------------------|---------|
| PEFR (L/min) | 213.0±45.7 | 249.0±75.0 | 276.0±50.8 | 0.072 |
| PEFR (% pred) | 45.4±11.0 | 49.6±10.3 | 51.2±9.8 | 0.451 |
| Fischl index | 0.10±0.31 | 0.30±0.48 | 0.00±0.00 | 0.142 |
| PEFR improvement (L/min) | 54.0±35.6 | 67.0±41.9 | 92.0±26.9 | 0.068 |
| PEFR percentage improvement | 11.5±7.7 | 13.2±7.7 | 17.1±5.4 | 0.215 |
| Fischl index improvement | 3.0±1.2 | 3.3±1.0 | 3.4±1.5 | 0.779 |

Notes: Data are presented as mean ± standard deviation. $P < 0.05$ is statistically significant.

Abbreviations: MgSO₄, magnesium sulfate; min, minutes; % pred, percentage predicted; PEFR, peak expiratory flow rate.

Discussion

The results of our study revealed that nebulized MgSO₄, either alone or combined with salbutamol, has a significant bronchodilator effect in acute bronchial asthma. **Bronchodilator effect of nebulized MgSO₄ alone is similar to that of nebulized salbutamol and is significantly less than that of nebulized combination.**

The common adverse effects associated with MgSO₄ administration are nausea, vomiting, flushing, thirst, hypotension, drowsiness, confusion, loss of deep tendon reflexes, muscle weakness, respiratory depression, and cardiac arrhythmias.³¹

A systematic review done by Blitz et al⁶ demonstrated that nebulization of MgSO₄ as an adjunct for β₂-agonists improved pulmonary function in patients experiencing asthma exacerbations. They found **no treatment benefit of either MgSO₄ or β₂-agonist alone.** Subsequently, it was recommended to administer nebulized MgSO₄ as an addition to inhaled β₂-agonists in acute asthma attacks.

Abdelnabi et al⁸ concluded that nebulized MgSO₄ improved the clinical condition, increased both PEFR and SO₂, and decreased both HR and RR in case of acute bronchial asthma. They reported a significant bronchodilatation

that was significantly less than that of salbutamol when either was used alone.

Talukdar et al¹⁴ demonstrated a clinically significant bronchodilatory effect of nebulized MgSO₄ in severe bronchial asthma, which was significantly less than that of salbutamol.

Nannini et al²³ showed that in acutely ill asthmatic patients, the peak flow response to isotonic MgSO₄ as an adjunct to nebulized salbutamol was higher than salbutamol with normal saline. Single dose of 0.5 mL salbutamol (2.5 mg) diluted in either 3 mL normal saline or in 3 mL isotonic MgSO₄ (225 mg) was administered to each patient.

In a study conducted by Bessmertny et al,²⁴ nebulized MgSO₄ combined with albuterol failed to show any benefit in addition to that provided by albuterol plus isotonic saline, in adults with mild-to-moderate asthma attacks. Patients received three doses of nebulized albuterol at 20-minute intervals. Either nebulized MgSO₄ (384 mg) or isotonic saline solution was administered to patients immediately after each albuterol dose with a total of three doses.

In a randomized placebo-controlled trial, Hughes et al²⁵ observed an enhanced bronchodilator response after nebulization of three doses of 2.5 mg salbutamol mixed with

Table 5 Changes in various parameters in MgSO₄ group

| Parameters | Basal | Final | P-value |
|---------------------------------|-----------|------------|---------|
| SO ₂ (%) | 95.3±3.0 | 95.5±2.6 | 0.168 |
| RR (breaths/min) | 22.6±3.8 | 17.5±3.0 | 0.000 |
| HR (beats/min) | 95.1±12.3 | 90.8±11.3 | 0.000 |
| Systolic blood pressure (mmHg) | 114±12.6 | 109.0±12.2 | 0.008 |
| Diastolic blood pressure (mmHg) | 79.0±8.7 | 78.5±8.1 | 0.343 |
| PP (mmHg) | 14.6±4.4 | 8.1±2.3 | 0.000 |
| PEFR (L/min) | 159±42.0 | 213.0±45.7 | 0.001 |
| PEFR (% pred) | 33.9±9.8 | 45.4±11.0 | 0.001 |
| Fischl index | 3.1±1.1 | 0.10±0.31 | 0.000 |

Notes: Data are presented as mean ± standard deviation. $P < 0.05$ is statistically significant.

Abbreviations: HR, heart rate; MgSO₄, magnesium sulfate; min, minutes; % pred, percentage predicted; PEFR, peak expiratory flow rate; RR, respiratory rate; PP, pulsus paradoxus; SO₂, oxygen saturation.

Table 6 Changes in various parameters in salbutamol group

| Parameters | Basal | Final | P-value |
|---------------------------------|-----------|------------|---------|
| SO ₂ (%) | 96.2±2.2 | 96.2±2.2 | 1 |
| RR (breaths/min) | 23.6±6.2 | 19.5±4.6 | 0.000 |
| HR (beats/min) | 85.4±14.0 | 69.6±32.0 | 0.000 |
| Systolic blood pressure (mmHg) | 116±15.7 | 111.0±13.2 | 0.004 |
| Diastolic blood pressure (mmHg) | 78.5±9.4 | 77.0±8.2 | 0.081 |
| PP (mmHg) | 16.1±3.3 | 8.5±1.9 | 0.000 |
| PEFR (L/min) | 182±63.0 | 249.0±75.0 | 0.001 |
| PEFR (% pred) | 36.4±10.5 | 49.6±10.3 | 0.000 |
| Fischl index | 3.6±1.1 | 0.30±0.48 | 0.000 |

Notes: Data are presented as mean ± standard deviation. $P < 0.05$ is statistically significant.

Abbreviations: HR, heart rate; min, minutes; % pred, percentage predicted; PEFR, peak expiratory flow rate; RR, respiratory rate; PP, pulsus paradoxus; SO₂, oxygen saturation.

Table 7 Changes in various parameters in MgSO₄-salbutamol group

| Parameters | Basal | Final | P-value |
|---------------------------------|-----------|------------|---------|
| SO ₂ (%) | 95.9±2.6 | 96.0±2.4 | 0.343 |
| RR (breaths/min) | 27.0±7.6 | 21.8±6.5 | 0.000 |
| HR (beats/min) | 95.9±11.8 | 92.2±11.1 | 0.000 |
| Systolic blood pressure (mmHg) | 120±13.3 | 114.5±12.5 | 0.007 |
| Diastolic blood pressure (mmHg) | 81.0±7.3 | 79.0±7.7 | 0.104 |
| PP (mmHg) | 13.9±3.8 | 8.2±1.8 | 0.000 |
| PEFR (L/min) | 184±52.5 | 276.0±50.8 | 0.000 |
| PEFR (% pred) | 34.1±9.4 | 51.2±9.8 | 0.000 |
| Fischl index | 3.4±1.5 | 0.00±0.00 | 0.000 |

Notes: Data are presented as mean ± standard deviation. $P < 0.05$ is statistically significant.

Abbreviations: HR, heart rate; MgSO₄, magnesium sulfate; min, minutes; % pred, percentage predicted; PEFR, peak expiratory flow rate; RR, respiratory rate; PP, pulsus paradoxus; SO₂, oxygen saturation.

2.5 mL isotonic MgSO₄ at 30 minutes intervals, when compared with nebulization of salbutamol mixed with isotonic saline, in patients with severe asthma. FEV₁ at 90 minutes was the primary outcome measure. They found that the improvement was greater in patients with a baseline FEV₁ of <30% of the predicted value.

The results of our study are consistent with a randomized, double-blind, controlled study conducted by Mangat et al,³¹ in which the bronchodilator effectiveness of nebulized MgSO₄ in acute asthma was assessed and compared with nebulized salbutamol. Patients received either four doses of nebulized 3 mL salbutamol (2.5 mg) or four doses of nebulized 3 mL MgSO₄ (3.2% solution, 95 mg). They reported significant improvement in PEFR, PEFR percentage, and Fischl index, as well as significant decrease in RR, in both groups. However, the difference between the two groups was not significant. There was a significant decrease in HR and mean arterial pressure in MgSO₄ group and salbutamol group, respectively. It was concluded that the bronchodilatory effect of nebulized MgSO₄ was significant and similar to that of nebulized salbutamol.

Our results disagreed with a study³² of the efficacy of nebulized MgSO₄ in acute severe asthma. Patients were divided into three groups (salbutamol, salbutamol with MgSO₄, and MgSO₄). There was no significant increase in any of measured parameters (PEFR, FEV₁, FVC, and FEV₁/FVC) in all three groups; however, the percentage increase was quite significant in the two groups where MgSO₄ was used. Also the changes in vital parameters were not significant. It was noted that the response to MgSO₄ was greater in patients with baseline PEFR <50%, thus MgSO₄ may be a good choice in the management of acute severe

asthma. Our study agreed with them in that the bronchodilator response to MgSO₄ was early but unfortunately unsustainable, so a combination of MgSO₄ with standard treatment may be better in treating acute severe asthma.

Conclusion

Nebulized MgSO₄, either alone or combined with salbutamol, has a clinically significant bronchodilator effect in acute asthma. The response to nebulized MgSO₄ alone is comparable to that of nebulized salbutamol and is significantly less than that of nebulized combination. The response to nebulized MgSO₄ alone (PEFR improvement 54±35.6 L/min, $P=0.001$) is comparable ($P=0.389$) to that of nebulized salbutamol (PEFR improvement 67.0±41.9 L/min, $P=0.001$) and is significantly less than ($P=0.014$) that of nebulized combination (PEFR improvement 92.0±26.9 L/min, $P=0.000$).

This suggests that a combination of MgSO₄ and salbutamol may be the best choice for the management of acute exacerbations of asthma.

Nebulized MgSO₄ is a well-tolerated bronchodilator for acutely ill asthmatic patients, and can be administered safely. Being cheap and readily available, it can be commonly used.

Disclosure

The authors report no conflicts of interest in this work.

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