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A Delphi consensus on nebulized budesonide for adults with asthma and COPD

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Abstract

Background: Inhaled corticosteroids (ICS) represent an alternative treatment option to systemic corticosteroids (SCS) in the treatment of asthma and chronic obstructive pulmonary disease (COPD); however, detailed clinical guidance on the use of nebulized ICS, such as budesonide, in the management of asthma and COPD remains scarce.

Objective: To review the literature and develop Delphi consensus statements on the use of nebulized ICS for the management of asthma and COPD in adults.

Methods: An expert panel of 13 respiratory physicians, comprising pulmonologists (n = 9), allergists (n = 1), and emergency department consultants (n = 3) from tertiary medical centers in Thailand, undertook a Delphi procedure with the aim of developing evidence-based consensus statements on the use of nebulized ICS in patients with asthma and COPD. Panelists used a 5-point Likert scale to score their agreement with each statement.

Results: A total of 12 Delphi consensus statements pertaining to the use of nebulized ICS in the management of asthma and COPD in both acute and maintenance care were developed. The overall consensus of the panel across the 12 statements was very high (mean agreement score, 4.2–4.9/5). The panelists expressed strongest consensus agreement (84.6% strong agreement) with the following two statements: 1) inhalation devices are the cornerstone of drug delivery in patients with asthma and COPD, and 2) for adult asthma and COPD patients with severe exacerbations, nebulization is more suitable for drug delivery than a pMDI plus spacer.

Conclusion: Nebulized budesonide is an effective and well tolerated treatment option for the management of asthma and COPD.

Key words: Delphi technique, consensus, budesonide, asthma, chronic obstructive pulmonary disease

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Introduction

Asthma is a heterogeneous clinical syndrome characterized by wheezing, chest tightness, shortness of breath, and airway hyperresponsiveness.[1] Airway inflammation is central to both the pathophysiology of asthma and onset of exacerbations.[2] These are defined as acute episodes characterized by a progressive worsening in shortness of breath, cough, wheezing, and chest tightness.[3] Exacerbations are associated with a progressive loss of lung function[4] and are an important predictor of future exacerbations.[5-7] These acute episodes are of varying severity, ranging from mildly increased symptoms to severe, life-threatening attacks resulting in respiratory failure and death.[2,8] Exacerbations can be caused by poor adherence to therapy or triggered by exposure to aeroallergens (e.g. house dust mites, animal fur, or pollen), tobacco smoke, air pollution or viruses, such as rhinovirus or influenza.[9]

Corticosteroids are the most effective therapy for asthma management, in accordance with their ability to suppress airway inflammation.[10,11] Asthma guidelines recommend a stepwise approach to achieving disease control, comprising the commencement of an inhaled corticosteroid (ICS) such as budesonide and increasing ICS dose when asthma is not well controlled, often in combination with a long acting $ß_2$-agonist (LABA) as both maintenance and reliever therapy.[3] For the treatment of acute exacerbations, guidelines recommend the initiation of systemic corticosteroid (SCS) therapy concurrently with intermittent short acting bronchodilators (short-acting $ß_2$ agonists [SABA]).[3] However, a limitation of SCS is that it requires several hours to produce clinically measurable improvements in pulmonary function.[12,13] Therefore, alternative treatment options for acute asthma in adults, particularly ICS, have attracted much interest.[11-15] A Cochrane systematic review and meta-analysis of the effectiveness of ICS in treating acute asthma in the emergency department (ED), which included pediatric and adult studies, concluded that ICS therapy reduces hospital admissions in patients with acute asthma who are not treated with SCS.[16] However, there was insufficient evidence to show that adding ICS therapy to SCS results in clinically important changes in pulmonary function or clinical scores in the treatment of acute asthma.[16] A more recent systemic review and meta-analysis, which also included pediatric and adult patients with moderate-to-severe asthma exacerbations, concluded that there was no difference between the hospital admission rates of ICS and SCS; however, the combination of ICS plus SCS resulted in fewer hospital admissions than SCS alone.[17]

Chronic obstructive pulmonary disease (COPD) is most commonly associated with a history of exposure to tobacco smoke and is characterized by persistent respiratory symptoms, including breathlessness, cough and sputum production, due to airway and/or alveolar dysfunction.[18] A substantial number of patients with COPD suffer from acute exacerbations (AECOPD), defined as acute worsening of respiratory symptoms, resulting in the need for additional therapy.[18] Most AECOPDs are associated with airway infections, involving respiratory virus (most commonly rhinovirus) infection and 'dysbiosis' of the airway microbiome.[19]

The pharmacological approach to managing AECOPD risk involves combination bronchodilator therapy, comprising LABA plus long-acting muscarinic antagonists. Guidelines indicate that mild AECOPD episodes can be managed with repeated dosing of SABA; however, for AECOPD that fails to respond to SABA treatment, short-course SCS should be introduced.[18-20] Long-term SCS use does not provide additional benefit in terms of improved lung function[19] but increases the risk of adverse effects, including osteoporosis, hyperglycemia, steroid myopathy[21] and an increased risk of pneumonia.[19]

There is an urgent unmet need for improved asthma and COPD care in developing countries,[22,23] where a lack of emphasis on the prevention of future exacerbations remains common.[24] For instance, surveys from Thailand reported that 36% of patients had experienced an exacerbation in the previous year,[25] while 28.7% had at least one severe exacerbation within the past year.[26] Notably, nebulizers offers several advantages over other inhalation devices for patients with asthma and COPD, including a lack of requirement for rapid or forceful inspiration, manual dexterity or coordination between device actuation and inspiration.[27] However, practical guidance on the use of nebulized ICS for the management of asthma and COPD in clinical practice remains scarce. Therefore, an expert panel was convened to review the literature and develop evidence-based recommendations on the use of nebulized ICS for the management of asthma and COPD in adults. Guidance on the utilization of nebulized budesonide for managing asthma and COPD in both stable and exacerbation stages in Thailand has been published separately.[28] In this article, we describe the development of Delphi consensus statements on the use of nebulized budesonide for adults with asthma and COPD.

Methods

Expert panel

The expert panel consisted of 13 respiratory physicians, including nine pulmonologists, one allergist, and three ED consultants, who were treating patients with asthma and COPD in tertiary medical centers in Thailand. Panel members were jointly selected by AstraZeneca and a group of respiratory advisers who had worked collaboratively in the Medical Association in Thailand as guideline committee members. Selection was based on a relevant publication history and clinical expertise in asthma and COPD.

Narrative review: literature search strategy and inclusion criteria[28]

The PubMed database (https://pubmed.ncbi.nlm.nih.gov/) was used to identify published studies that evaluated nebulized budesonide in adults with asthma or COPD. Searches included the keywords 'asthma', 'COPD', 'budesonide', 'nebulized', 'adult', 'exacerbation' and 'maintenance' and were carried out without any time filters. Included studies were restricted to clinical studies, including randomized controlled trials, observational studies, and real-world studies that were published in English and assessed the efficacy or effectiveness of nebulized budesonide either as maintenance therapy or in the management of acute exacerbations in adults with asthma or COPD. Case studies and review articles were excluded from the study. A flow diagram of the literature search process has been previously published.[28]

Development of Delphi consensus recommendations

The Delphi procedure is a facilitated group technique that uses structured questionnaires to reach a consensus on the specific topic under study among a panel of selected experts.[29] The results of the literature searches were independently reviewed by each member of the expert panel in order to inform the development of consensus statements (described herein) and separately, consensus recommendations on the utilization of nebulized budesonide for managing asthma and COPD in both stable and exacerbation stages in Thailand.[28]

Subsequently, a panel meeting was held in Thailand on 15 December 2021 to discuss the published evidence and develop Delphi consensus statements on the use of nebulized budesonide in adults with asthma and COPD. Consensus statements were compiled into a questionnaire that was circulated to all panel members. Respondents were asked to use a 5-point Likert scale to score their agreement with each statement, comprising 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree). Completed questionnaires were collated, and individual scores were analyzed to derive a total agreement score for each statement. The predefined threshold of consensus agreement for a Delphi statement was that 10 of 13 (76.9%) panel members recorded a score of ≥ 4 (agree), in line with the widely accepted threshold of 75%.[30] The second and final panel meeting was held on 27 April 2022 to review panel responses and finalize Delphi consensus recommendations (**Figure 1**).

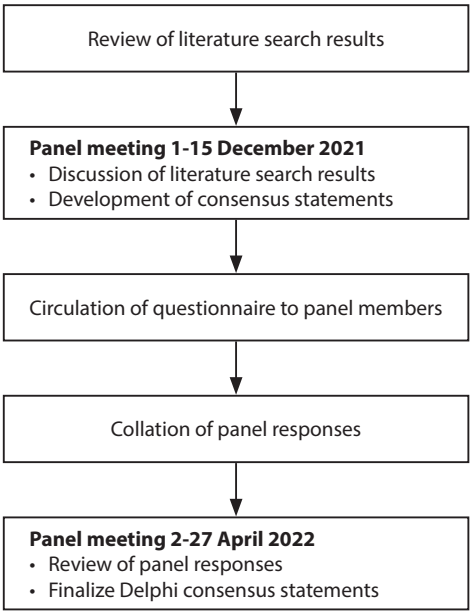

Figure 1. The Delphi procedure.

Results

Overview of results from the literature search on the use of nebulized budesonide for the management of asthma and AECOPD in adults

A brief review of included studies is presented here, with additional details published separately.[28] A total of 10 asthma studies met the inclusion criteria. Otulana et al.[31] conducted a small open-label trial (n = 18) that demonstrated the efficacy of 4–8 mg/day nebulized budesonide in patients with steroid-dependent asthma. However, another small study (n = 13) in outpatient asthma, did not demonstrate any effect of nebulized budesonide on mucociliary clearance or forced expiratory volume in 1 s (FEV_1).[32] Murphy et al.[33] conducted a dose ranging study in which all evaluated nebulized budesonide dosages (0.5–4 mg/day) had similar efficacy in patients with steroid-dependent persistent asthma. Additionally, all nebulized budesonide doses were comparable to budesonide administered via DPI based on asthma control outcomes. Sheikh Motahar-Vahedi et al.[34] demonstrated the efficacy of nebulized budesonide 1.5 mg/day vs placebo in patients with moderate-to-severe exacerbations, while Nematollahi et al.[35] reported that the efficacy of nebulized budesonide plus SABA was significantly greater than that of SABA alone in patients with post-rain asthma with dyspnea. Vogelmeier et al.[36] reported that the efficacy of 1–2 mg/day nebulized budesonide as add-on to standard of care was significantly greater than that of standard of care alone in patients with severe SCS-dependent asthma. Chian et al.[37] reported that the efficacy of nebulized budesonide 2 mg twice daily was similar to that of SCS (15 mg prednisolone twice daily) in patients with severe exacerbations. Marghli et al.[38] showed that the efficacy of nebulized budesonide 2 mg/day plus SCS was not significantly different from that of SCS alone in patients with acute exacerbations. Conversely, Ediger et al.[39] found that the efficacy of nebulized budesonide 4 mg/day plus SCS 1 mg/kg/day was significantly greater than that of SCS alone in patients with acute exacerbations. Finally, Ito et al.[40] reported that the efficacy of nebulized budesonide 1 mg/day plus SCS plus LABA was significantly greater than that of SCS plus LABA in patients with severe exacerbations.

For COPD, a total of 15 studies met the inclusion criteria. In total, 10 studies compared the efficacy and/or safety of nebulized budesonide vs SCS in AECOPD, of which nine reported that the efficacy of nebulized budesonide was similar to that of SCS.[41-49] One of these 10 studies reported that the upward trend of peak expiratory flow rate (PEFR) improvement in the nebulised budesonide group was significantly better than that in the SCS group

during the first 24 h of treatment.[50] Regarding safety data, five of these 10 studies reported that SCS was associated with a higher level of systemic toxicities (osteoporosis, hyperglycemia) than nebulized budesonide.[41,43,44,46,47] In addition to these 10 studies, two studies showed that the efficacy of nebulized budesonide was significantly greater than that of placebo in patients at GOLD stage 4 COPD receiving invasive

mechanical ventilation[51] and in patients with AECOPD receiving non-invasive mechanical ventilation.[52] Zhang et al.[53] demonstrated that high-dose budesonide (8 mg/day) improved pulmonary function and symptoms more effectively than budesonide 4 mg/day in the early treatment of AECOPD. Finally, Chen et al.[54] and Nguyen et al.[55] reported that the efficacy of nebulized budesonide plus SCS was similar to that of SCS alone in patients with AECOPD.

Delphi consensus statements

A total of 12 Delphi consensus statements pertaining to the management of asthma and COPD in both acute and maintenance care were developed (**Table 1**). The overall consensus agreement across the 12 statements was very high (mean agreement score, 4.2–4.9/5; **Figure 2**).

Table 1. Delphi consensus statements.

No.	Statement
1	Inhalation devices, including pMDIs, DPIs, and nebulizers are the cornerstone of drug delivery for patients with asthma and COPD.
2	The advantages of nebulization are minimally required coordination and effort independence compared with pMDIs and DPIs. Therefore, nebulization should be considered as an effective alternative drug delivery in patients with asthma and COPD.
3	A substantial number of asthma and COPD patients are unable to actuate pMDIs regardless of the spacer used. These include, but are not limited to, patients with movement disorders, manual dexterity problems, and impaired cognitive function. Thus, nebulization provides an alternative drug delivery method.
4	A significant number of patients, especially elderly patients, may generate insufficient PIFR for dispersion of DPIs, leading to suboptimal drug delivery and poor outcomes. Thus, for these patients, nebulization provides an alternative drug delivery method.
5	Comorbidities such as bronchiectasis, pneumonia, osteoporosis, diabetes, and cardiovascular diseases are prevalent in asthma and COPD patients and affect treatment outcomes.
6	Frequent systemic corticosteroids bursts for treating asthma and COPD exacerbation are associated with subsequent increased risks of pneumonia, sepsis, venous thromboembolism, and bone fracture.
7	Although the use of pMDIs with a spacer may be as effective as nebulization, for asthma and COPD patients with severe exacerbations, nebulization is more suitable for drug delivery.
8	Among hospitalized patients with asthma and COPD exacerbations, the addition of high-dose nebulized budesonide to systemic corticosteroids can improve clinical outcomes.
9	The adverse effects of systemic corticosteroids, such as pneumonia, sepsis, and hyperglycemia are not uncommon. Hence, high-dose nebulized budesonide should be used as an alternative treatment in selected patients with a high benefit:cost ratio.
10	In severe and refractory asthma exacerbation, adjunctive treatment with high-dose nebulized budesonide to standard adjunctive to therapy is recommended.
11	In the COVID-19 pandemic, effective drug delivery is mandatory for treating the imminent respiratory failure and severe cardiopulmonary compromise. Nebulization can be used under standard infectious control measures.
12	In the home setting, self-administration of nebulized corticosteroids added to regular standard treatment is a treatment. This strategy may prevent the early treatment of asthma and COPD exacerbations with systemic corticosteroids, leading to a lower incidence of systemic toxicities.

COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; DPI, dry powder inhaler; PIFR, peak inspiratory flow rate; pMDI, pressurized metered-dose inhaler.

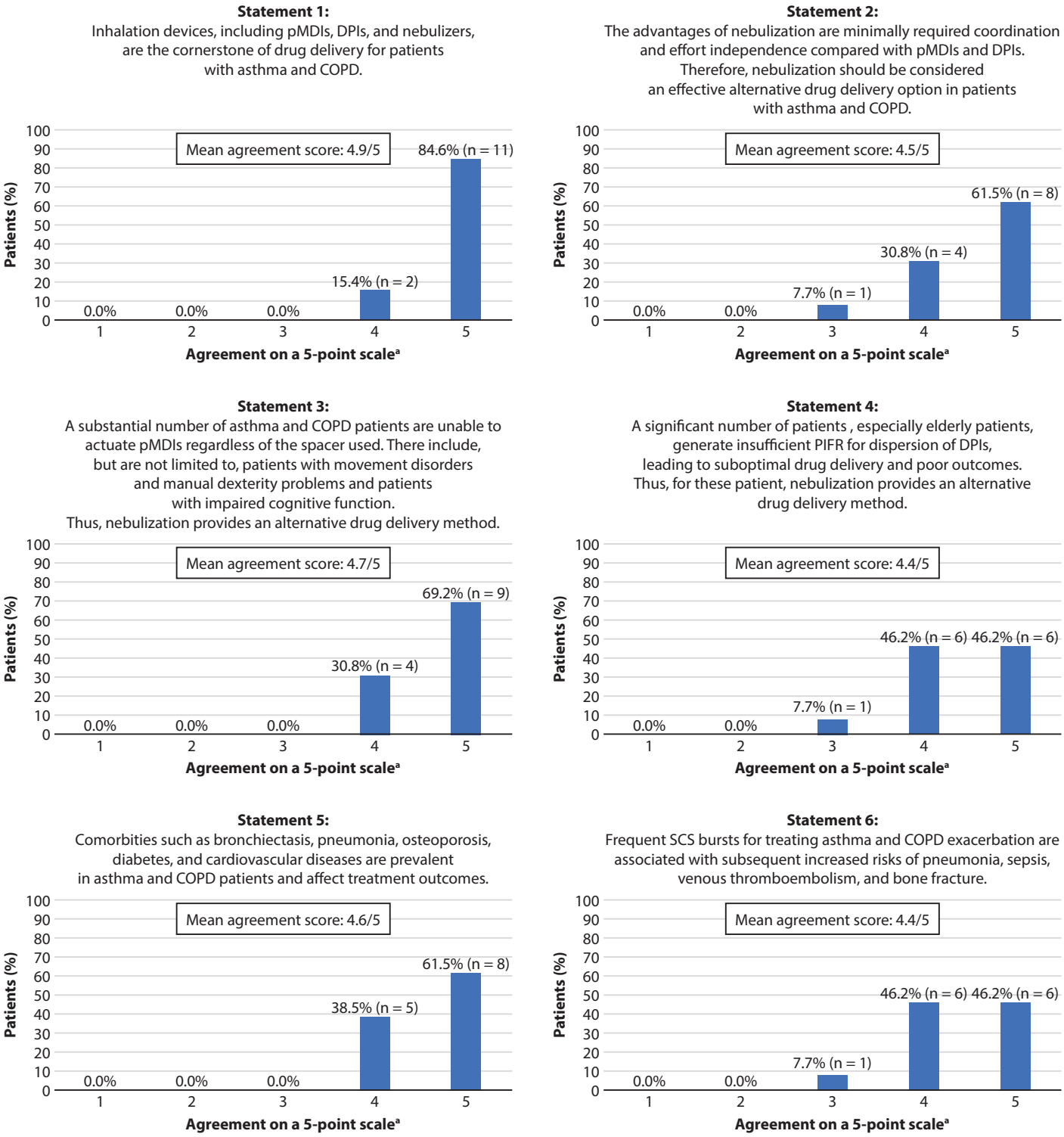

Figure 2. Strength of expert panel agreement across the 12 Delphi consensus statements.

COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; DPI, dry powder inhaler; PIFR, peak inspiratory flow rate; pMDI, pressurized metered-dose inhaler; SCS, systemic corticosteroids; VTE, venous thromboembolism.

[a]The 13 panel members scored their agreement with each statement using a 5-point Likert scale: 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly agree).

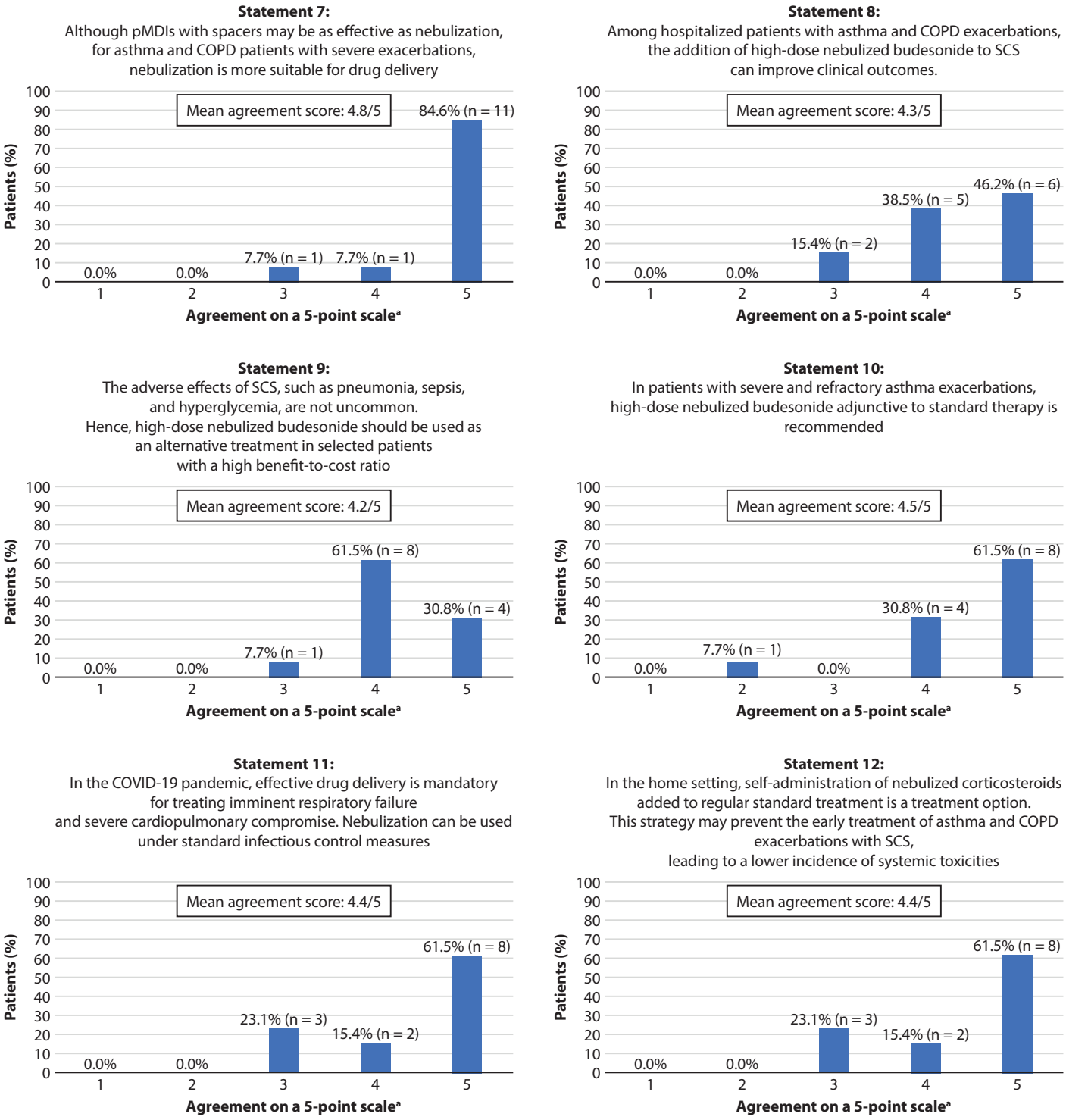

Figure 2. (Continued)

Discussion

The Delphi method is a broadly accepted strategy for developing consensus recommendations based on objective expert opinion and is designed to provide guidance in areas of interest where limited evidence-based literature is available.[56] The aim of this Delphi study was to develop consensus-based statements on the use of nebulized budesonide for adults with asthma and COPD.

Strong consensus agreement was reached that inhalation devices are the cornerstone of drug delivery in patients with asthma and COPD (**Statement 1**). This is perhaps not surprising as the delivery of inhaled therapy has long been the principal strategy in the treatment and management of both chronic respiratory diseases.[57] The choice of inhaler (pMDI, DPI or nebulizer) depends on a combination of factors, including patient inspiratory flow,[58] inhaler handling characteristics,[59-61] required inhaler technique[62-65] and patient preference.[66,67] As each inhaler type offers different advantages and limitations, a personalized approach to the selection of the most appropriate device for the patient is highly recommended to increase the likelihood of device adherence and of achieving improved disease outcomes.[68,69] In addition, effective patient education is crucial, not only to help patients develop good inhaler technique but also to highlight the link between therapy adherence and optimal disease control.[69,70]

Another statement for which strong consensus was reached was that for adult asthma and COPD patients with severe exacerbations, nebulization is more suitable for drug delivery than a pMDI plus spacer (**Statement 7**). This is consistent with the findings of a systematic review comparing the effects of nebulizers vs pMDIs plus spacer for the treatment of COPD, reporting no difference between nebulizers vs pMDI plus spacer for the primary outcome of FEV_1 at 1 h. However, for the secondary outcome of change in FEV_1 closest to 1 h after dosing during AECOPD, the authors found a greater improvement in FEV1 in patients treated with a nebulizer than in those treated with pMDI plus spacer.[71] Patients with asthma or COPD have reported benefits in symptom relief, ease of use and improved quality of life when using nebulizers.[72,73] The Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines recommend evaluating the benefits of nebulizer treatment symptomatically and, if beneficial, adopting nebulizer treatment as long as similar benefits are not achievable by simpler, cheaper or more portable alternatives.[18] In adult asthma, numerous studies have demonstrated the clinical equivalence of nebulizers and other inhaler devices based on improvement in FEV_1 and PEFR.[74] Notably, practical guidance pertaining to the use of nebulized budesonide for the management of asthma exacerbations and AECOPD in adults has been published separately.[28]

There was strong agreement that a substantial number of patients with asthma and COPD, including those with movement disorders, manual dexterity problems, impaired cognitive function and elderly patients, are unable to properly actuate pMDIs or DPIs; therefore, for these patients, nebulization provides an alternative delivery method to pMDIs and DPIs (**Statement 3**). Physical conditions that affect inhaler handling are well documented. Children, the elderly, and patients with conditions that impact manual dexterity require special consideration to ensure the selection of the most appropriate inhaler.[59-61,69,70] In elderly patients, common conditions that cause difficulties in manipulating inhalers include osteoarthritis, joint pain, stroke, muscle weakness, cognitive impairment and dementia.[75-78] In accordance with **Statement 2** ('The advantages of nebulization are minimally required coordination and effort independence compared with pMDIs and DPIs') and **Statement 4** ('A significant number of patients, especially elderly patients, may generate insufficient peak inspiratory flow rate [PIFR] for dispersion of DPIs, leading to suboptimal drug delivery and poor outcomes'), the available evidence supports the argument that the principal advantage of nebulizers as an alternative delivery method is that they remove the need for patient coordination between inhalation and actuation. This makes nebulizers particularly useful for patients with cognitive, neuromuscular or inspiration flow impairments.[76,77,79] Overall, nebulized inhalation therapy provides patients with asthma and COPD an alternative administration route that offers ease of use without requirements for forceful inspiration, manual dexterity or complex hand–breath coordination. With the recent advent of more sophisticated nebulizer devices, treatment via nebulization is a valuable alternative to handheld inhalation devices.[27]

There was consensus agreement with the statement that comorbidities are prevalent in patients with asthma and COPD and have a negative impact on treatment outcomes (**Statement 5**). Systemic chronic inflammation associated with asthma appears to be an important factor in the development of comorbidities; thus, asthma is associated with an increased risk of cardiovascular disease, which has been attributed to systemic inflammation.[80,81] Moreover, the use of SCS, reduced activity/exercise and poor sleep due to breathing difficulties can promote comorbidities such as obesity, diabetes, depression, osteoporosis and pneumonia.[82] In a post hoc analysis of the Asthma Reality (ARL), cross sectional, non-interventional real-life study, Tomisa et al.[83] showed that concomitant COPD, ischemic heart disease and cerebrovascular disease were the common comorbidities with the strongest negative effects on asthma control. Comorbidities commonly associated with COPD include bronchiectasis, cardiovascular disease, osteoporosis, lung cancer, diabetes, metabolic syndrome, depression and anxiety.[18] A large number of studies have shown that the presence of comorbidities negatively influence patient outcomes and is associated with increased hospitalization and mortality rates.[84-89]

The panelists agreed that frequent SCS bursts for treating asthma and COPD exacerbations are associated with increased risks of adverse events, such as pneumonia, sepsis, venous thromboembolism and bone fractures (**Statement 6**). It has been recognized for many years that the long-term use of SCS in the control of asthma symptoms and exacerbations is associated with serious adverse events.[90,91] However, there is growing evidence that even brief dosing periods (3–7 days) of SCS are enough to cause significantly negative outcomes for patients, including increased risks of type 2 diabetes, loss of bone density, hypertension and gastrointestinal ulcers/bleeds.[92,93] Bleecker et al.[94] conducted a systematic literature review to investigate the real-world extent and burden of SCS use in children, adolescents and adults with asthma. The authors showed that patients receiving repeated short-term, high SCS dosages may incur a greater risk of adverse events than those receiving long term, low SCS dosages, as the risk of AEs increases with the cumulative SCS dosage. In a UK cohort study, Heatley et al.[95] showed that frequent (< 90 day gap), intermittent SCS prescriptions were associated with a higher risk of SCS related adverse outcomes than less frequent (≥ 90 day gap) intermittent SCS prescriptions. In adult AECOPD, Walters et al.[96] conducted a systematic review and meta-analysis of the efficacy of short-term (3–7 day) vs long term (10–15 days) SCS treatment. Short-term SCS treatment did not increase the risk of treatment failure or re-exacerbation vs long-term treatment but also did not reduce the risk of an adverse event vs long-term treatment. Current guidelines recommend that patients with AECOPD should be treated with SCS for only 7–14 days in response to data that SCS use is cumulatively associated with adverse effects such as osteoporosis, hyperglycemia and muscle weakness.[18]

There was consensus agreement with the statement that high-dose nebulized budesonide should be used as an alternative to SCS in selected patients with AECOPD with a high benefit:risk ratio (**Statement 9**). As reported here, there is strong supporting evidence that the efficacy of nebulized budesonide in AECOPD is similar to that of SCS; therefore, nebulized budesonide is a valid alternative to SCS. The expert panel recommended that high-dose nebulized budesonide (4–8 mg/day) should be used, in line with the studies discussed in the literature search above.[41,44,45,47,48,53] With regard to the selection of patients with AECOPD most likely to benefit from ICS therapy, the GOLD guidelines recommend the addition of ICS to regular bronchodilator therapy (LABA) for the management of COPD patients with moderate-to-very-severe airflow limitation and frequent exacerbations not adequately controlled by LABA.[18] The potential risks to be considered are that ICS is associated with an increased incidence of pneumonia, tuberculosis and mycobacterial disease.[19,97] Since most patients with AECOPD are older and have one or more comorbidities, confirmation of a positive benefit:risk balance prior to the administration of high-dose ICS is recommended.[97,98]

There was strong consensus that adjunctive treatment with high-dose nebulized budesonide is recommended for hospitalized patients with asthma exacerbations (including severe, refractory exacerbations) or AECOPD (**Statements 8 and 10**). Three articles reviewed in this study evaluated the efficacy of high-dose nebulized budesonide (1–4 mg/day) plus SCS vs SCS in asthma patients with exacerbations.[38-40] In addition, there is an abundance of supporting evidence presented above that high-dose nebulized budesonide (4–8 mg/day) is as effective as SCS in the treatment of patients with AECOPD.[41,43-45,47,48]

Overall, there was good agreement with the statement that nebulization can be used to treat patients with asthma or COPD infected with COVID-19 as long as standard infectious control measures are in force (**Statement 11**). In light of the ongoing coronavirus disease (COVID-19) pandemic, there is an urgent need to understand the risk of viral aerosol transmission during nebulizer treatment of asthma/COPD patients infected with respiratory viruses. Goldstein et al.[99] performed a systematic literature search with the aim of assessing the risk of transmitting coronaviruses by administration of drugs via a nebulizer. Overall, no evidence was identified that nebuliser treatment increases the risk of transmission of coronaviruses similar to COVID-19.

The panelists agreed that in the home setting, self-administration of nebulised corticosteroids adjunctive to standard treatment is a valid treatment option for early treatment of asthma and COPD exacerbation. This strategy may reduce exposure to SCS and its associated adverse effects (**Statement 12**). Given that most patients with asthma and COPD are already self-managing their disease (albeit sometimes sub-optimally from a clinician's perspective), healthcare professionals have a responsibility to ensure that all their patients with asthma or COPD receive personalized advice to enable them to optimise self-management,[100,101] including how best to self-administer nebulized corticosteroids.

Conclusion

The participants in this Delphi study expressed strong consensus agreement with the statement that inhalation devices are the cornerstone of drug delivery in patients with asthma and COPD. Another statement for which strong consensus was reached was that for adult asthma and COPD patients with severe exacerbations, nebulization is more suitable for drug delivery than a pMDI plus spacer. There was also strong agreement that a substantial number of asthma and COPD patients, including those with movement disorders, manual dexterity problems, impaired cognitive function, and elderly patients, are unable to properly actuate pMDIs or DPIs; therefore, for these patients, nebulization provides an alternative delivery method to pMDIs and DPIs. In addition, there was strong agreement that comorbidities are prevalent in asthma and COPD patients and have a negative impact on treatment outcomes.

Nebulized inhalation therapy provides patients with asthma and COPD an alternative administration route that offers ease of use with no requirements for forceful inspiration, manual dexterity, or hand–breath coordination. Specifically, nebulized budesonide is an effective and well-tolerated treatment option for the management of asthma and COPD.

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Competing interests

The authors report no competing interests related to this manuscript.

Data availability

Data underlying the findings described in this manuscript may be obtained in accordance with AstraZeneca's data sharing policy described at https://astrazenecagrouptrials.pharmacm.com/ST/Submission/Disclosure. Data for studies directly listed on Vivli can be requested through Vivli at www.vivli.org. Data for studies not listed on Vivli could be requested through Vivli at https://vivli.org/members/enquiries-about-studies-not-listed-on-the-vivli-platform/. AstraZeneca Vivli member page is also available, outlining further details: https://vivli.org/ourmember/astrazeneca/. The datasets supporting the conclusions of this article are available from the corresponding author on a reasonable request.

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