

GUIDELINES FOR THE EMERGENCY MANAGEMENT OF ASTHMA IN ADULTS

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Abstract • Résumé

Objective: To develop a set of comprehensive, standardized evidence-based guidelines for the assessment and treatment of acute asthma in adults in the emergency setting.

Options: The use of medications was evaluated by class, dose, route, onset of action and optimal mode of delivery. The use of objective measurements and clinical features to assess response to therapy were evaluated in relation to the decision to admit or discharge the patient or arrange for follow-up care.

Outcomes: Control of symptoms and disease reflected in hospital admission rates, frequency of treatment failures following discharge, resolution of symptoms and improvement of spirometric test results.

Evidence: Previous guidelines, articles retrieved through a search of MEDLINE, emergency medical abstracts and information from members of the expert panel were reviewed by members of the Canadian Association of Emergency Physicians (CAEP) and the Canadian Thoracic Society. Where evidence was not available, consensus was reached by the expert panel. The resulting guidelines were reviewed by members of the parent organizations.

Values: The evidence-based methods and values of the Canadian Task Force on the Periodic Health Examination were used.

Benefits, harms and costs: As many as 80% of the approximate 400 deaths from asthma each year in Canada are felt to be preventable. The use of guidelines, aggressive emergency management and consistent use of available options at discharge are expected to decrease the rates of unnecessary hospital admissions and return visits to emergency departments because of treatment failures. Substantial decreases in costs are expected from the use of less expensive drugs, or drug delivery systems, fewer hospital admissions and earlier return to full activity after discharge.

Recommendations: Beta₂-agonists are the first-line therapy for the management of acute asthma in the emergency department (grade A recommendation). Bronchodilators should be administered by the inhaled route and titrated using objective and clinical measures of airflow limitation (grade A). Metered-dose inhalers are preferred to wet nebulizers, and a chamber (spacer device) is recommended for severe asthma (grade A). Anticholinergic therapy should be added to β_2 -agonist therapy in severe and life-threatening cases and may be considered in cases of mild to moderate asthma (grade A). Aminophylline is not recommended for use in the first 4 hours of therapy (grade A). Ketamine and succinylcholine are recommended for rapid sequence intubation in life-threatening cases (grade B). Adrenaline (administered subcutaneously or intravenously), salbutamol (administered intravenously) and anesthet-

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ics (inhaled) are recommended as alternatives to conventional therapy in unresponsive life-threatening cases (grade B). Severity of airflow limitation should be determined according to the forced expiratory volume at 1 second or the peak expiratory flow rate, or both, before and after treatment and at discharge (grade A). Consideration for discharge should be based on both spirometric test results and assessment of clinical risk factors for relapse (grade A). All patients should be considered candidates for systemic corticosteroid therapy at discharge (grade A). Those requiring corticosteroid therapy should be given 30 to 60 mg of prednisone orally (or equivalent) per day for 7 to 14 days; no tapering is required (grade A). Inhaled corticosteroids are an integral component of therapy and should be prescribed for all patients receiving oral corticosteroid therapy at discharge (grade A). Patients should be given a discharge treatment plan and clear instructions for follow-up care (grade C).

Validation: The guidelines share the same principles of those from the British Thoracic Society and the National Institutes of Health. Two specific validation initiatives have been undertaken: (a) several Canadian centres have been involved in the collection of comprehensive administrative data to assess compliance and outcome measures and (b) a survey of Canadian emergency physicians, conducted to gather baseline information on treatment patterns, was conducted before development of the guidelines and will be repeated to re-evaluate emergency management of asthma.

Sponsors: These guidelines were endorsed by the Canadian Association of Emergency Physicians, the Canadian Thoracic Society and the Association des médecins d'urgence du Québec. Financial sponsors of this project were the Canadian Lung Association, Glaxo Canada Inc., Astra Pharma Inc. and Fisons Pharmaceuticals.

Objectif : Élaborer une série de lignes directrices détaillées, normalisées et fondées sur des données probantes pour l'évaluation et le traitement de l'asthme aigu chez les adultes en contexte de salle d'urgence.

Options : On a évalué l'utilisation de médicaments selon la catégorie, la posologie, la voie d'absorption, le début de l'effet et la méthode optimale d'administration. L'utilisation de mesures objectives et de caractéristiques cliniques pour déterminer la réaction au traitement a été évaluée en fonction de la décision d'admettre ou de libérer le patient ou d'organiser des soins de suivi.

Résultats : Contrôle des symptômes et de la maladie reflété dans les taux d'hospitalisation, la fréquence des échecs du traitement à la suite de la libération, l'élimination des symptômes et l'amélioration des résultats de tests de spirométrie.

Preuves : Des membres de l'Association canadienne des médecins d'urgence (ACMU) et de la Société canadienne de thoracologie ont examiné des lignes directrices antérieures, des articles extraits au moyen d'une recherche dans MEDLINE, des résumés sur la médecine d'urgence et des renseignements provenant des membres du groupe d'experts. En l'absence de données probantes, les membres du groupes d'experts ont dégagé un consensus. Les lignes directrices ainsi établies ont été revues par les membres des organisations mères.

Valeurs : On a utilisé les méthodes et les valeurs fondées sur des données probantes Groupe d'étude canadien sur l'examen médical périodique.

Avantages, préjudices et coûts : On estime qu'il est possible de prévenir jusqu'à 80 % des quelque 400 décès causés par l'asthme chaque année au Canada. L'utilisation de lignes directrices et de traitements d'urgence énergiques, et le recours uniforme aux options disponibles au moment de la libération devraient réduire les taux d'hospitalisations inutiles et les visites répétées aux services d'urgence parce que le traitement a échoué. On prévoit réduire considérablement les coûts en utilisant des médicaments ou des systèmes d'administration de médicaments moins coûteux, en réduisant les hospitalisations et en permettant aux patients de reprendre plus rapidement toutes leurs activités après la libération.

Recommandations : Les β_2 -agonistes représentent le traitement principal contre l'asthme aigu à l'urgence (recommandation de catégorie A). Il faudrait administrer des bronchodilatateurs par inhalation et les titrer au moyen de mesures objectives et cliniques de la limitation du débit aérien (catégorie A). On préfère les inhalateurs doseurs plutôt que les nébuliseurs et l'on recommande une chambre de séparation dans les cas d'asthme grave (catégorie A). Il faudrait ajouter une thérapie aux anticholinergiques à la thérapie aux β_2 -agonistes dans les cas graves et qui peuvent être mortels et on peut l'envisager dans les cas d'asthme bénin à modéré (catégorie A). L'aminophylline n'est pas recommandée au cours des quatre premières heures du traitement (catégorie A). La kétamine et la succinylcholine sont recommandées pour une intubation rapide dans les cas de vie ou de mort (catégorie B). L'adrénaline (administrée par voie sous-cutanée ou intraveineuse), le salbutamol (administré par voie intraveineuse) et les anesthésiques (inhalés) sont recommandés comme solutions de rechange au traitement classique dans les cas graves qui ne réagissent pas (catégorie B). Il faudrait déterminer la gravité de la limitation du débit de l'air en fonction du volume expiratoire maximal par seconde ou du débit maximal expiratoire, ou des deux, avant et après le traitement et au moment de la libération (catégorie A). La possibilité de

libérer le patient devrait être fondée à la fois sur les résultats de tests de spirométrie et sur l'évaluation des facteurs de risque clinique de rechute (catégorie A). Tous les patients devraient être considérés comme candidats à une thérapie aux corticostéroïdes systémiques au moment de la libération (catégorie A). Ceux qui ont besoin de corticostéroïdes devraient recevoir de 30 à 60 mg de prednisone par voie orale (ou l'équivalent) par jour pendant 7 à 14 jours. Il n'est pas nécessaire de diminuer progressivement la dose (catégorie A). Les corticostéroïdes inhalés font partie intégrante de la thérapie et il faudrait les prescrire à tous les patients qui prennent des corticostéroïdes par voie orale au moment de la libération (catégorie A). Il faudrait remettre aux patients un plan de traitement à la libération et des instructions claires sur les soins de suivi (catégorie C).

Validation : Les lignes directrices sont fondées sur les mêmes principes que celles de la British Thoracic Society et des National Institutes of Health. On a entrepris deux initiatives précises en ce qui a trait à la validation : a) plusieurs centres canadiens ont participé à la collecte de données administratives détaillées pour évaluer l'observation et les mesures des résultats et b) un sondage auprès des médecins d'urgence du Canada, qui visait à réunir des données de base sur les tendances du traitement, a été effectué avant l'élaboration des lignes directrices et on le répétera pour réévaluer le traitement de l'asthme en salle d'urgence.

Commanditaires : Ces lignes directrices ont l'appui de l'Association canadienne des médecins d'urgence, de la Société canadienne de thoracologie et de l'Association des médecins d'urgence du Québec. Le projet a reçu l'appui financier de l'Association pulmonaire canadienne, de Glaxo Canada Inc., d'Astra Pharma Inc. et de Fisons Pharmaceuticals.

The true burden of asthma in Canada is hard to quantify because the rates of death (400 to 500 per year) and hospital admissions (78 400 per year) underestimate the disability and lost quality of life experienced by the 5% of Canadians who have this disease.¹ Despite improved understanding of the pathophysiologic features of asthma and more pharmacological options, increased death and hospital admission rates have been reported in many countries, including Canada, over the past 20 years.¹⁻¹² This may reflect numerous possibilities: changes in the incidence, prevalence or severity of the disease, changes in its management or a change to the preferred diagnosis of asthma (diagnostic transfer) from bronchitis, bronchiolitis or other less exact respiratory diagnoses.⁷

Most deaths from asthma are associated with the patient's and physician's failure to recognize the severity of the attack.^{6-8,13} The implication of such observations is that inappropriate or suboptimal therapy results in poor disease control.

Although most deaths from asthma occur outside hospital, appropriate management of acute asthma in the emergency department will have an important impact.^{7,14,15} Two recent Canadian reviews concluded that asthma was often undertreated in the emergency department and that the importance of routine spirometry in patients with acute asthma was generally underappreciated.^{16,17} Optimal management of acute asthma in the emergency department includes aggressive treatment of the particular episode, recognition of the patient as being at high risk for future life-threatening attacks¹⁸ and provision of a clearly written asthma management plan (including instructions for follow-up) to the patient at the time of discharge from the emergency department.⁷ A survey report published in 1992 showed that 32% of patients with asthma presenting to a Canadian emer-

gency department had never discussed a plan of asthma management with their physician and that an additional 37% had no plan at all.¹⁹ Other investigators have found evidence of poor asthma control both before and after visits to the emergency department by patients with acute asthma.^{16,17,20-24}

Although most people with asthma have a primary care physician, they still use the emergency department as an important point of contact with health care providers. Therefore, physicians, nurses and respiratory technologists in the emergency department can have a positive influence on asthma control, beyond the treatment of the acute attack.

There have been several large-scale attempts to develop asthma management guidelines,²⁵⁻³⁰ but their focus has been on maintenance therapy with an emphasis on preventive strategies. Only a few have addressed the emergency management of acute asthma.²⁶⁻²⁸ Also, previous efforts in developing guidelines have demonstrated weaknesses in the methods of evaluating the evidence and a lack of involvement of potential users in the development process.

The guidelines presented in this article were developed by the CAEP/CTS Asthma Advisory Committee, a committee of emergency physicians and respirologists representing the Canadian Association of Emergency Physicians (CAEP) and the Canadian Thoracic Society (CTS), who used the evidence-based approach recommended by the CMA.³¹ The executive of CAEP appointed a chair and cochair to create a plan for assessing the need for guidelines, setting terms of reference and recruiting an advisory committee. A questionnaire evaluating practice norms and compliance with consensus statements available at that time was sent to CAEP members and all directors of emergency departments across

Canada in November 1992. Emergency physicians from tertiary care centres and community hospitals across Canada were invited to participate in the development of the guidelines. The CTS and the College of Family Physicians of Canada were asked to appoint representatives to the advisory committee. Previously published guidelines, articles identified through a search of MEDLINE and Emergency Medical Abstracts, and information from committee members were the sources of evidence used in the development of the guidelines. The levels of evidence established by the Canadian Task Force on the Periodic Health Examination were applied.³² Two consensus meetings were held in 1993 to review the proposed guidelines. A poster summary of the guidelines was reviewed by committees at CAEP and the CTS before final approval was granted by the executive of both organizations.

These guidelines concur with the opinions expressed in a recent review of the assessment and management of status asthmaticus³³ and share the principles of three recently published consensus statements (two national and one international).²⁶⁻²⁸ However, only the evidence supporting the CAEP/CTS guidelines was graded. Differing philosophies of therapy and, to some extent, availability of certain drugs account for some of the variations between countries. (A table summarizing the similarities and differences of the guidelines and consensus statements is available from the corresponding author upon request.)

RECOMMENDATIONS

THERAPY WITH β_2 -AGONISTS

1. Beta₂-agonists should be considered first-line therapy for the management of acute asthma in the emergency department (grade A recommendation; five level I trials,³⁴⁻³⁸ nine level II studies³⁹⁻⁴⁷ and five level III reports^{26,27,29,48,49}).

Inhaled β_2 -agonists produce the quickest relief of acute bronchospasm, with the fewest side effects.^{34,47,49} Prior treatment with inhaled β_2 -agonists (with the use of a metered-dose inhaler or a wet nebulizer) does not preclude successful reversal of airflow limitation in the emergency department.⁴¹

DRUG ADMINISTRATION

- 2a. Bronchodilators should be administered by the inhaled route instead of the parenteral route in most cases (grade A recommendation; seven level I trials,^{34-38,50,51} four level II studies⁵²⁻⁵⁵ and four level III reports^{26,27,29,56}).

The inhaled route is preferred for the administration of bronchodilators in acute episodes of asthma. This has

been confirmed in several small trials,^{34,35,37,52-54} and two multicentre trials have clearly demonstrated that inhaled salbutamol is more effective and safer than intravenously administered salbutamol.^{50,51} In the few studies claiming that the parenteral route was more efficacious,^{57,58} the dose of inhaled bronchodilators was low by current standards.²⁶⁻²⁹ Intravenous use of bronchodilators should be considered only if the response to nebulization is poor or the patient is coughing excessively, is moribund at presentation or becomes so despite inhalation therapy.

- 2b. Bronchodilators should be titrated to effect using objective and clinical measures of airflow to guide the dose and frequency of administration (grade A recommendation; four level I trials^{38,59-61} and two level II studies^{62,63} [see also recommendations 5 and 6]).

The dose of inhaled or intravenously administered β_2 -agonists needed to reverse an asthma attack cannot be standardized. A patient's ability to use the inhaled route, the efficiency of the delivery system, the relative amounts of bronchospasm versus airway narrowing due to inflammatory mucosal edema and secretions, and unpredictable patient factors such as reduced sensitivity or down-regulation of β_2 -agonists in severe asthma all influence drug dosing.

Relief of bronchospasm with inhaled bronchodilators is best achieved if the principle of cumulative dosing is followed: sequential doses build upon the therapeutic effects of previously administered doses.⁶⁴⁻⁶⁶ The frequency of dosing will be determined by the patient's response and by the time required to nebulize the dose completely, so that administering a dose every 15 to 20 minutes with a wet nebulizer, or even continuous administration with a wet nebulizer, may be necessary initially, because of the inherent low efficiency of these devices.^{38,60-62,66,67} The optimal number of puffs from a metered-dose inhaler is not known. The British Thoracic Society states that 20 to 40 puffs may be necessary.²⁸ We recommend 4 to 8 puffs every 15 to 20 minutes in most cases of acute asthma. However, it may be necessary to increase the dosage to 1 puff every 30 to 60 seconds (up to 20 puffs if required). The dosage should be adjusted according to objective measures of airflow limitation and symptoms. Once maximum relief has been achieved, further administration of bronchodilators by any route will provide no further clinical benefit and, in fact, may result in toxic effects.

- 2c. The use of a metered-dose inhaler, with or without a chamber (valved spacer device), is preferred over the use of a wet nebulizer for patients with mild to moderate asthma; a spacer device is recommended whenever the metered-dose inhaler is used for severe asthma (grade A recommendation; three level I trials,^{59,68,69} four level II studies⁷⁰⁻⁷³ and three level III reports⁷⁴⁻⁷⁶).

Aerosol bronchodilator therapy given by wet nebulizer or metered-dose inhaler is at least equally effective for acute asthma.^{59,70-74,77-79} For mild to moderate asthma, the addition of a spacer device to the metered-dose inhaler is not necessary because the inhaler on its own can be effective provided a multiple-puffing regimen is used.^{74,80}

Two studies have claimed that the wet nebulizer was better than the metered-dose inhaler with a spacer device,^{75,76} probably because eight to nine times more medication was administered with the nebulizer. It has been shown that more rapid and more profound bronchodilation is achieved when sufficient doses are given with a metered-dose inhaler plus spacer device than when conventional doses are administered with a wet nebulizer,^{59,68,71} even in patients with the most severe airflow limitation (forced expiratory volume at 1 second [FEV₁ of less than 0.67 L).⁵⁹ In one study⁷¹ patients with severe asthma (those with an FEV₁ of less than 30% of predicted) had significantly faster (30 minutes v. 60 minutes) and greater relief of airflow limitation and used seven times less salbutamol with a metered-dose inhaler plus spacer device than with a wet nebulizer. In another study⁶⁸ 6.5 times more salbutamol on average was required with the use of a wet nebulizer than with a metered-dose inhaler plus spacer device to achieve a maximum response.

All the studies demonstrating the superiority of metered-dose inhalers plus spacer devices showed similar therapeutic response plateaus, with maximum bronchodilation occurring after 800 to 1600 µg (8 to 16 puffs) of salbutamol.^{59,68,71}

Compared with wet nebulizers, metered-dose inhalers plus spacer devices offer the advantages of greater cost savings, faster access to therapy, more efficient use of paramedic staff time and quicker achievement of maximum bronchodilation.⁸¹⁻⁸³ Administration of salbutamol with a metered-dose inhaler plus spacer device takes about 2 to 3 minutes for each treatment, as compared with 10 to 20 minutes for each treatment with a wet nebulizer. Quicker achievement of maximum bronchodilation permits earlier triage and discharge decisions.

ANTICHOLINERGIC THERAPY

3. Anticholinergic therapy should be added to β_2 -agonist therapy in cases of severe asthma and may also be helpful in cases of mild or moderate asthma (grade A recommendation; eight level I trials,⁸⁴⁻⁹¹ one level II study⁹² and one level III report⁹³).

In all 10 controlled, double-blind studies of ipratropium bromide therapy for acute asthma in adults, the combination of ipratropium bromide with a β_2 -agonist

was superior to a β_2 -agonist alone.⁸⁴⁻⁹³ This combination was especially beneficial to patients with the most severe airflow limitation (an FEV₁ of less than 1 L or a peak expiratory flow rate [PEFR] of less than 140 L/min): the mean increase in the FEV₁ was 55.6%, as compared with 38.9% with a β_2 -agonist alone.⁸⁵⁻⁸⁸ In one study the combination of ipratropium bromide plus nebulized salbutamol, in addition to producing greater bronchodilation, was associated with fewer adverse effects (e.g., tachycardia and tremor) than were larger doses of β_2 -agonists alone.⁸⁵

In three trials nebulized ipratropium bromide alone produced initial bronchodilation equivalent to that achieved with an inhaled β_2 -agonist (salbutamol or fenoterol), but because of its slower response time, ipratropium bromide alone is not recommended.^{84,92,93} It may be particularly useful in treating bronchospasm provoked by β -blockers.⁹⁴

The optimal dose of nebulized ipratropium bromide for acute asthma is not clearly known, but it is generally accepted that 500 µg will produce the peak bronchodilator response in acute asthma (level III evidence).⁹⁵

There have been no randomized studies of ipratropium bromide therapy for acute asthma administered with a metered-dose inhaler, with or without a spacer device, but one can reasonably expect that this method would be as effective as a wet nebulizer, provided adequate dosing is achieved (level III evidence; consensus opinion).

AMINOPHYLLINE THERAPY

4. Aminophylline therapy is not usually recommended for use as a bronchodilator in the first 4 hours of asthma management in the emergency department (grade A recommendation; nine level I trials^{34,36-38,44,47,50,96,97} and four level II studies^{42,43,45,46}).

Aminophylline does not usually provide a significant, additive bronchodilator effect compared with adequate doses of inhaled β_2 -agonists in cases of acute asthma^{34,36,47,96,97} and, in fact, appears to be associated with an increased risk of adverse effects.^{36,46,47}

Intravenous aminophylline therapy may have a role, however, in the treatment of patients with severe acute asthma admitted to hospital once the initial crisis in the emergency department has passed.^{98,99}

It has been suggested that aminophylline may improve respiratory muscle function in acute asthma.^{98,100} Indirect evidence that supports this role comes from a placebo-controlled study showing that despite no change in the FEV₁, there was a reduction in the number of hospital admissions from the emergency department among patients given aminophylline.¹⁰¹

The weight of evidence is against the routine use of

aminophylline early in the treatment of acute asthma. This conclusion is supported by a meta-analysis of 13 adequately designed trials involving patients with severe acute asthma.⁹⁶

INTUBATION

5. Ketamine and succinylcholine are recommended agents for rapid sequence intubation (RSI) in cases of life-threatening asthma (grade B recommendation; 11 level II-3 or level III reports¹⁰²⁻¹¹²).

Since the patient's condition can deteriorate rapidly, once the decision has been made intubation should be accomplished as quickly and with as much control as possible using a modified RSI technique. Ketamine is recommended as the agent of choice because it has a rapid response time, provides good levels of anesthesia and is a good bronchodilator (level III evidence).¹⁰²⁻¹⁰⁴ Ketamine has been reported to be useful in the treatment of severe bronchospasm refractory to conventional bronchodilators and may obviate the need for endotracheal intubation in this setting.¹⁰⁵⁻¹¹⁰ Pretreatment with benzodiazepines helps prevent the occasional emergence reactions (hallucinogenic episodes) associated with ketamine.

Immediately after administration of the sedative, paralysis should be induced with succinylcholine because it has the fastest response time and the shortest duration of action of drugs in its class. This is important if the intubation is unsuccessful. Paralysis following intubation should be maintained using vecuronium (0.15 mg/kg intravenously). Bag-and-mask ventilation does not precede intubation in an RSI technique and should be used only in failed attempts. It is difficult or even impossible to use bag-and-mask ventilation in cases of acute asthma because of severe hyperinflation and it may cause harm by provoking gastric distention and an increased risk of aspiration.

MANAGEMENT OF REFRACTORY CASES

6. Adrenaline (administered subcutaneously or intravenously), salbutamol (administered intravenously) and inhaled anesthetics are recommended as alternatives to conventional therapy in unresponsive cases of life-threatening asthma (grade B recommendation; seven level II-3 reports¹¹³⁻¹¹⁹).

Parenteral bronchodilator therapy is indicated when the inhaled route is not practical, for example in patients who are coughing excessively, are too weak to inspire adequately or are moribund (level III evidence; expert panel [see recommendations 2 a and b]).

Patients with bronchospasm receiving ventilation who do not respond to conventional bronchodilator

therapy may benefit from an inhaled anesthetic agent with bronchodilating properties, such as ether,¹¹³ halothane,¹¹⁴⁻¹¹⁷ enflurane¹¹⁷ and isoflurane.^{118,119} Hypotension and cardiac dysrhythmias are associated with the use of these agents and are more likely to occur in hypoxemic patients.

The mode of ventilation for status asthmaticus may be a crucial factor for a successful outcome.^{32,120-122} Because of extreme hyperinflation, it is often difficult or nearly impossible to use ventilation because of the combination of severe restrictive and obstructive defects. Ventilation strategies emphasize caution with attempts to abruptly reduce the partial pressure of carbon dioxide to normal levels.¹²⁰⁻¹²² It is advisable to follow a controlled mechanical hypoventilation approach that accepts moderate to high degrees of hypercarbia until lung function improves, with occasional intravenous administration of bicarbonate in order to keep the pH level above 7.2.¹²⁰⁻¹²² The risk of barotrauma and volutrauma (shock) can be minimized with slow machine rates (6 to 8 breaths/min) allowing a low inspiration/expiratory ratio and with low tidal volumes (6 to 8 mL/kg). With ventilation patients may also require frequent suctioning of mucous secretions often seen in life-threatening attacks.

OBJECTIVE MEASUREMENT OF AIRFLOW

- 7a. The severity of airflow limitation should be determined objectively using the FEV₁ or PEFR, or both (grade A recommendation; one level I study,¹²³ three level II studies¹²⁴⁻¹²⁶ and one level III report¹²⁷).

It has been consistently shown that the severity of airflow limitation in asthma attacks correlates poorly with the traditionally assessed clinical signs (e.g., wheezing). Many patients may have near-normal physical findings yet will have clinically important signs of airflow limitation when spirometric tests are performed. Similarly, changes in clinical signs after treatment do not always reflect changes in spirometric test results. Furthermore, it has been shown that physician estimates of PEFR are frequently inaccurate.¹²³

The standard outcome measures used in the emergency department to assess the severity of airflow limitation are the FEV₁ and the PEFR.¹²⁸ There is a high correlation between these two measurements following bronchodilator therapy.¹²⁹ When possible, the best value of three attempts at each measurement should be recorded. Because optimal results depend on patient effort, specially trained personnel (respiratory therapist, nurse and physician) should be present to monitor the test procedure.¹²⁸ The measurement of FEV₁ and PEFR is not recommended in moribund patients or those who appear confused, cyanotic or exhausted.

7b. The optimal way to record the FEV₁ or PEFR is the percent of predicted or, ideally, the percent of previous best (grade C recommendation; three level III reports²⁶⁻²⁸ and consensus opinion).

Results from two studies suggest that the percent predicted values are not more useful than absolute values in making clinical decisions.^{129,130} However, the subjects were less than 40 years of age and were unlikely to have had any component of fixed airway obstruction (e.g., chronic obstructive pulmonary disease). To be consistent with all patient groups we recommend that the FEV₁ and the PEFR be recorded as the percent of previous best, if known, or the percent of predicted based on simple nomograms. This is consistent with other consensus guidelines.²⁶⁻²⁸

7c. The FEV₁ or the PEFR should be measured before bronchodilator therapy has been started and after it has been completed (grade A recommendation; one level I trial,¹³¹ one level II study¹²⁹ and two level III reports^{127,132}).

Physician estimates of response to therapy are often inaccurate in acute asthma.¹²³ Several studies have shown that failure of initial bronchodilator therapy to improve the FEV₁ or the PEFR substantially is predictive of a more prolonged attack course, or even of the need for hospital admission.^{36,132} Thus, objective measurement after the completion of bronchodilator therapy is the best method of predicting outcome of the asthma attack (see recommendation 8).

7d. All patients should be informed of their post-treatment spirometric test results when they are discharged (grade C recommendation; consensus opinion).

Patients will be able to pass this information along to other clinicians. Knowledge of the spirometric test results may allow both the patient and the clinician to determine the most appropriate approach to the disposition of the patient after treatment of subsequent asthma attacks.

DISCHARGING PATIENTS FROM THE EMERGENCY DEPARTMENT

8. Consideration for discharge should be based on spirometric test results (percent of previous best, percent of predicted or absolute value) and assessment of clinical risk factors for relapse.

- Patients with a pretreatment FEV₁ or a PEFR of less than 25% of previous best or of predicted (an FEV₁ of less than 1.0 L or a PEFR of less than 100 L/min) usually require admission to hospital (grade B recommendation; one level II study¹³²).
- Patients with a post-treatment FEV₁ or a PEFR of less

than 40% of previous best or of predicted (an FEV₁ of less than 1.6 L or a PEFR of less than 200 L/min) usually require admission to hospital (grade A recommendation; one level I study¹³¹).

- Patients with a post-treatment FEV₁ or a PEFR of 40% to 60% of previous best or of predicted (an FEV₁ of 1.6 to 2.1 L or a PEFR of 200 to 300 L/min) are possible candidates for discharge (grade C recommendation; consensus opinion).
- Patients with a post-treatment FEV₁ or a PEFR of more than 60% of previous best or of predicted (an FEV₁ greater than 2.1 L or a PEFR greater than 300 L/min) are likely candidates for discharge (grade A recommendation; one level I trial¹³¹ and two level II studies^{129,133}).

The above recommendations for spirometric test results should be considered as general guidelines to assist in clinical decision making. Individual patient factors must be taken into account. Patients with very severe airflow limitation initially or severe residual airflow limitation after treatment are at high risk (more than 75% probability) for relapse and will usually require admission to hospital. Conversely, patients who exhibit mild residual airflow limitation can be discharged with a high degree of confidence (less than 15% probability of relapse). It is difficult to decide the most appropriate plan for patients who exhibit moderate residual airflow limitation. The risk of relapse in the best designed study was determined to be about 26%.¹³¹ We recommend that an asthma risk profile be considered in these patients: the higher the risk profile, the lower the threshold should be for recommending admission.

Important factors that define a patient at high risk for relapse include the following: (a) hospital admission or visit to the emergency department in the previous 12 months, (b) recent corticosteroid use, (c) use of multiple categories of asthma medication, (d) previous severe or life-threatening asthma attack, (e) presence of psychosocial problems^{7,10,134} and (f) the frequent, regular use of inhaled β_2 -agonists.¹³⁵⁻¹³⁷

CORTICOSTEROID THERAPY

9a. All patients treated in the emergency department for an acute episode of asthma should be considered candidates for systemic corticosteroid therapy (oral or intravenous) (grade A recommendation; three level I trials,¹³⁸⁻¹⁴⁰ conclusions confirmed in meta-analysis¹⁴¹).

Corticosteroid therapy has been shown to be clinically efficacious in the treatment of acute episodes of asthma. In placebo-controlled trials corticosteroids were found to be associated with rapid resolution of airflow limitation in admitted patients¹³⁸ and a decrease in the relapse rate among those discharged from the emergency

department.^{139,140} No subgroup of emergency patients have been prospectively identified who do not benefit from corticosteroid therapy. Post-hoc analysis in a study of the role of corticosteroids in patients discharged from the emergency department¹⁴⁰ suggested that the effect of oral corticosteroids in reducing the relapse rate may be confined to patients with an FEV₁ of less than 60% of predicted on discharge. On the basis of expert consensus opinion (grade C recommendation), systemic corticosteroid therapy may be omitted in occasional cases of very mild asthma (an FEV₁ or a PEF of more than 60% of predicted), in which the patient has no markers of risk for asthma-related death or for readmission.

- 9b. Corticosteroids should be administered as soon as possible after initiation of bronchodilator therapy (grade A recommendation; meta-analysis¹⁴¹ of three level I trials¹⁴²⁻¹⁴⁴).

Despite a conflicting conclusion in one study,¹³⁸ a meta-analysis¹⁴¹ of three relevant studies¹⁴²⁻¹⁴⁴ revealed that the early administration of corticosteroids (within 30 minutes) significantly reduces hospital admission rates.

- 9c. Oral and intravenous routes of corticosteroid administration are equally efficacious (grade A recommendation; four level I trials¹⁴⁵⁻¹⁴⁸).

For admitted patients intravenous corticosteroid therapy has no advantage over oral therapy regarding the rate of resolution of airflow limitation.¹⁴⁸ Since the onset of anti-inflammatory effects of corticosteroids are not seen for several hours, it is sufficient to administer corticosteroids orally to most patients in the emergency department. The parenteral route is preferred if patients are unable to take medication orally (e.g., they are too breathless or are intubated) or if they are unable to readily absorb an oral dose (e.g., because of vomiting). For patients with severe symptoms intravenous corticosteroid therapy may have an early effect (within 1 to 6 hours) by reversing β_2 -receptor down regulation seen in chronic β_2 -agonist use.¹⁴⁹

In studies involving patients admitted to hospital, no clear trends emerged regarding the appropriate intravenous dose of corticosteroids. Studies that failed to delineate a benefit between high-dose and low-dose intravenous corticosteroid therapy were not double-blind (level II studies),¹⁵⁰⁻¹⁵³ had samples that were too small to achieve adequate statistical power (level II study),¹⁵² involved patients with mild disease¹⁵⁴ or had cointervention or variable doses of oral corticosteroid in the low-dose groups.¹⁵⁵ Only one level I trial¹⁵⁶ has shown a positive dose-response relation between high-dose and low-dose regimens. The findings of two reviews indicated that a sufficient intravenous dose is 100 to 200 mg

of methylprednisolone (or equivalent) per day or 500 to 1000 mg of hydrocortisone (or equivalent) per day.^{157,158} Methylprednisolone is the more expensive of the two but has less mineralocorticoid activity. It is likely that any parenterally administered corticosteroid (dexamethasone, methylprednisolone, hydrocortisone) will be equally efficacious if given in equivalent doses. If the oral route is chosen, doses equivalent to 40 mg of prednisone orally are recommended.¹⁴¹

ORAL CORTICOSTEROID THERAPY AFTER DISCHARGE

10. Patients discharged from the emergency department who require corticosteroid therapy should be given 30 to 60 mg of prednisone orally (or equivalent) per day for 7 to 14 days. No tapering is required over this period (grade A recommendation; four level I trials^{139,140,159,160}).

Out-patients with exacerbations of asthma have been found to respond, in a dose-related fashion, to increased doses of prednisone from 0.2 to 0.6 mg/kg per day (14 to 42 mg of prednisone per day for a 70-kg adult).¹⁵⁹ Placebo-controlled trials of oral corticosteroid therapy involving patients discharged from the emergency department have shown a decrease in the relapse rate with the use of a dose equivalent to 40 mg of prednisone per day.^{139,140} No trials have compared oral prednisone regimens starting at doses higher than 40 mg/d. It is not known whether a higher initial dose of prednisone would be efficacious; however, some experts recommend up to 60 mg as the initial dose.¹⁵⁸ The range of 30 to 60 mg/d reflects a dose of 0.6 mg/kg per day for patients 50 to 100 kg. The minimum duration of oral corticosteroid therapy following discharge that has been studied has been 8 days,^{139,140} but up to 14 days of treatment may be needed to achieve a maximum response.¹⁵⁹ No tapering appears to be required to prevent a recurrence of asthma symptoms during this period.¹⁵⁹ Physicians should individualize the drug regimen. Longer than 14 days of treatment may be required for patients with a history of corticosteroid dependence or multiple recent exacerbations. These patients should be referred to an asthma specialist or clinic for close out-patient follow up.

INHALED CORTICOSTEROID THERAPY AFTER DISCHARGE

11. Inhaled corticosteroid therapy is an integral component of asthma therapy and should be prescribed for all patients receiving oral corticosteroid therapy at discharge (grade A recommendation; two level I trials^{160,161}).

In one study, inhaled corticosteroid therapy was compared with a placebo after a 14-day nontapered course

of oral corticosteroid therapy in ambulatory patients with unstable asthma.¹⁶¹ The other study compared tapering and nontapering of corticosteroid therapy in patients with acute episodes of asthma receiving inhaled corticosteroid therapy.¹⁶⁰ The conclusions of the two studies were similar: there was no significant worsening of spirometric test results after termination of the nontapered oral regimen in patients receiving inhaled corticosteroid therapy. The inhaled dose varied from 1500 µg/d¹⁶¹ to a mean of 908 µg/d (range 400 to 2000 µg/d).¹⁶⁰

The recommended dose at discharge of inhaled corticosteroids (beclomethasone or budesonide) is 500 to 1000 µg/d, but this may depend on the dose and duration of oral corticosteroid therapy (grade C recommendation; expert panel opinion). The more markers of risk for asthma-related death or readmission in the patient's history,^{18,134,136} the higher the recommended dose of inhaled corticosteroids.

DISCHARGE TREATMENT PLAN AND FOLLOW-UP CARE

12. A discharge treatment plan and clear instructions for follow-up should be given to patients discharged from the emergency department (grade C recommendation; consensus opinion).

Most experts believe that educating patients about asthma is the key to optimal disease control.^{7,11,26-28,33} Proper drug-delivery technique should be ensured and compliance optimized through improved understanding of the pathophysiologic features of asthma and the pharmacologic characteristics of the drugs. Although there are practical and theoretical deterrents to comprehensive education in the emergency department, the principles used in the development of action plans should be applicable in any situation. Asthma clinics and teaching centres have been successful in reducing absenteeism, the number of hospital admissions and visits to the emergency department, and the use of corticosteroids and β_2 -agonists.¹⁶²⁻¹⁶⁷ Whenever possible, emergency staff should develop brief written treatment plans with clear instructions for follow-up care and review of drug-delivery techniques (grade C recommendation; level III evidence [consensus opinion]).

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