National Asthma Council Australia

AUSTRALIAN ASTHMA HANDBOOK

VERSION 2.0

ACUTE ASTHMA

Clinical management

First aid

This PDF is a print-friendly reproduction of the content included in the *Acute Asthma* section of the *Australian Asthma Handbook* at **asthmahandbook.org.au/acute-asthma**

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ABBREVIATIONS

CFC	chlorofluorocarbon
COPD	chronic obstructive pulmonary disease
COX	cyclo-oxygenase
DXA	dual-energy X-ray absorptiometry
ED	emergency department
EIB	exercise-induced bronchoconstriction
FEV_1	forced expiratory volume over one second
FEV_6	forced expiratory volume over six seconds
FSANZ	Food Standards Australia and New Zealand
FVC	forced vital capacity
GORD	gastro-oesophageal reflux disease
HFA	formulated with hydrofluroalkane propellant
ICS	inhaled corticosteroid
ICU	intensive care unit
IgE	Immunoglobulin E
IL	interleukin
IU	international units
IV	intravenous
LABA	long-acting beta$_2$-adrenergic receptor agonist
LAMA	long-acting muscarinic antagonist
LTRA	leukotriene receptor antagonist
MBS	Medical Benefits Scheme
NHMRC	National Health and Medical Research Council
NIPPV	non-invasive positive pressure ventilation
NSAIDs	nonsteroidal anti-inflammatory drugs
OCS	oral corticosteroids
OSA	obstructive sleep apnoea
PaCO	carbon dioxide partial pressure on blood gas analysis
PaO	oxygen partial pressure on blood gas analysis
PBS	Pharmaceutical Benefits Scheme
PEF	peak expiratory flow
pMDI	pressurised metered-dose inhaler or 'puffer'
PPE	personal protective equipment
SABA	short-acting beta$_2$ -adrenergic receptor agonist
SAMA	short-acting muscarinic antagonist
SaO_2	oxygen saturation
SpO_2	peripheral capillary oxygen saturation measured by pulse oximetry
TGA	Therapeutic Goods Administration

RECOMMENDED CITATION

National Asthma Council Australia. *Australian Asthma Handbook*, Version 2.0. National Asthma Council Australia, Melbourne, 2019.

Available from: http://www.asthmahandbook.org.au

ISSN 2203-4722

SPONSORS

National Asthma Council Australia would like to acknowledge the support of the sponsors of Version 2.0 of the *Australian Asthma Handbook*:

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Managing acute asthma in adults and children

In this section

Clinical management

Managing acute asthma in clinical settings, including emergency departments

http://www.asthmahandbook.org.au/acute-asthma/clinical

First aid

First aid for people to use within the community when someone has asthma symptoms

http://www.asthmahandbook.org.au/acute-asthma/first-aid

Managing acute asthma in clinical settings

Overview

- Wheezing infants younger than 12 months old should not be treated for acute asthma. Acute wheezing in this age group is most commonly due to acute viral bronchiolitis.

▶ Go to: Paediatric Research in Emergency Departments International Collaborative (PREDICT) *Australasian bronchiolitis guidelines*

Advice should be obtained from a paediatric respiratory physician or paediatrician before administering short-acting beta2 agonists, systemic corticosteroids or inhaled corticosteroids to an infant.

Acute asthma management in children, adolescents and adults is based on:

- assessing severity (mild/moderate, severe or life-threatening) while starting bronchodilator treatment immediately
- administering oxygen therapy if peripheral capillary oxygen saturation measured by pulse oximetry (SpO_2) is less than 92% in adults or less than 95% in children
- completing observations and assessments (when appropriate, based on clinical priorities determined by baseline severity)
- administering systemic corticosteroids within the first hour of treatment
- repeatedly reassessing response to treatment and either continuing treatment or adding on treatments, until acute asthma has resolved or patient has been transferred to an intensive care unit or admitted to hospital
- observing the patient for at least 3 hours after respiratory distress or increased work of breathing has resolved
- providing post-acute care and arranging follow-up to reduce the risk of future flare-ups.

Figure. Managing acute asthma in adults

Please view and print this figure separately: http://www.asthmahandbook.org.au/figure/show/65

Figure. Managing acute asthma in children

Please view and print this figure separately: http://www.asthmahandbook.org.au/figure/show/67

Figure. Initial management of life-threatening acute asthma in adults and children

Please view and print this figure separately: http://www.asthmahandbook.org.au/figure/show/94

Notes: The classification of acute asthma severity differs between clinical settings. The definitions of mild/moderate, severe and life-threatening acute asthma used in this handbook may differ from those of some published clinical trials and other guidelines.

The terms 'exacerbation', 'flare-up', 'attack' and 'acute asthma' are used differently by patients and clinicians, and in different contexts.

The classification of flare-ups and the classification of acute asthma overlap (e.g. a flare-up is considered to be at least 'moderate' if it is troublesome enough to cause the patient or carers to visit an emergency department or seek urgent treatment from primary care, yet it might be described as 'mild' acute asthma within acute services).

Table. Severity classification for flare-ups (exacerbations)

Severity	Definition	Example/s
Mild	Worsening of asthma control that is only just outside the normal range of variation for the individual (documented when patient is well)	More symptoms than usual, needing reliever more than usual (e.g. >3 times within a week for a person who normally needs their reliever less often), waking up with asthma, asthma is

Severity	Definition	Example/s
		interfering with usual activities A gradual reduction in PEF† over several days
Moderate	Events that are (all of): • troublesome or distressing to the patient • require a change in treatment • not life-threatening • do not require hospitalisation.	More symptoms than usual, increasing difficulty breathing, waking often at night with asthma symptoms
Severe	Events that require urgent action by the patient (or carers) and health professionals to prevent a serious outcome such as hospitalisation or death from asthma	Needing reliever again within 3 hours, difficulty with normal activity

† Applies to patients who monitor their asthma using a peak expiratory flow meter (single PEF measurements in clinic not recommended for assessing severity of flare-ups).

Note: the ATS/ERS Task Force recommended that severe exacerbations should be defined in clinical trials as the use of oral corticosteroids for 3 or more days. However, this definition is not applicable to clinical practice.

Source: Reddel H, Taylor D, Bateman E *et al.* An official American Thoracic Society/European Respiratory Society statement: asthma control and exacerbations: standardizing endpoints for clinical asthma trials and clinical practice. *Am J Respir Crit Care Med* 2009; 180: 59-99. Available at: http://www.thoracic.org/statements

Asset ID: 35

In this handbook, the categories of 'mild' and 'moderate' acute asthma have been merged to avoid confusion between terminologies traditionally used at different levels of the health system. Mild acute asthma can usually be managed at home by following the person's written asthma action plan.

▶ See: *Preparing written asthma action plans for adults*

▶ See: *Providing asthma management education for parents and children*

In this section

Starting systemic corticosteroid treatment

http://www.asthmahandbook.org.au/acute-asthma/clinical/corticosteroids

Response

Assessing response to treatment

http://www.asthmahandbook.org.au/acute-asthma/clinical/response

Add-on treatment

Continuing treatment and considering additional treatment

http://www.asthmahandbook.org.au/acute-asthma/clinical/add-on-treatment

Post-acute care

Providing post-acute care

http://www.asthmahandbook.org.au/acute-asthma/clinical/post-acute-care

Figure. Initial management of life-threatening acute asthma in adults and children

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SEVERITY ASSESSED AS LIFE-THREATENING ACUTE ASTHMA

Any of these findings:

- drowsy
- collapsed
- exhausted
- cyanotic
- poor respiratory effort
- soft/absent breath sounds
- oxygen saturation <90%

⚠ **Consider anaphylaxis and manage if suspected**

⚠ **Consider adrenaline if the patient is unresponsive, cannot inhale bronchodilators, or is considered to be peri-arrest**

GIVE SALBUTAMOL VIA CONTINUOUS NEBULISATION

CHILDREN 1–5 YEARS

Salbutamol 2 x 2.5 mg nebules at a time
Ipratropium 250 microg added to nebulised solution
Use oxygen to drive nebuliser*
Maintain SaO_2 ≥95%

CHILDREN 6–11 YEARS

Salbutamol 2 x 5 mg nebules at a time
Ipratropium 500 microg added to nebulised solution
Use oxygen to drive nebuliser*
Maintain SaO_2 ≥95%

ADULTS AND ADOLESCENTS

Salbutamol 2 x 5 mg at a time
Ipratropium 500 microg added to nebulised solution
Use oxygen to drive nebuliser*
Titrate oxygen to target SaO_2 93–95% in adults/≥95% in adolescents

*Piped oxygen or oxygen cylinder fitted with a high-flow regulator (6 L/min)
SaO_2: Oxygen saturation

ARRANGE IMMEDIATE TRANSFER TO HIGHER-LEVEL CARE AREA NOTIFY SENIOR STAFF

REASSESS IMMEDIATELY AFTER STARTING SALBUTAMOL

Marked improvement

CONTINUE BRONCHODILATOR AND MONITORING

When breathing improves, consider changing salbutamol route of delivery:

pMDI PLUS SPACER

Adults and children 6 years and over: 12 puffs (100 microg/actuation) every 20 minutes

Children 0-5 years: 6 puffs (100 microg/actuation) every 20 minutes

or

INTERMITTENT NEBULISATION

Adults and children 6 years and over: 5 mg nebule every 20 minutes

Children 0–5 years: 2.5 mg nebule every 20 minutes

REASSESS SEVERITY

Figure. Managing acute asthma in adults
Figure. Managing acute asthma in children

Some improvement

CONTINUE SALBUTAMOL AND MONITORING

Marked improvement

No improvement or worsening

No improvement or worsening

VENTILATE

NPPV OR INTUBATION AS REQUIRED

ADD MAGNESIUM SULFATE IV

Dilute in compatible solution as single IV infusion over 20 minutes

Adults and adolescents: 10 mmol

Children 2–12 years: 0.1–0.2 mmol/kg (max 10 mmol)

CONTINUE SALBUTAMOL AND IPRATROPIUM BY CONTINUOUS NEBULISATION*

CONSIDER THE NEED FOR NPPV OR INTUBATION AND VENTILATION

ARRANGE TRANSFER/RETRIEVAL TO ICU

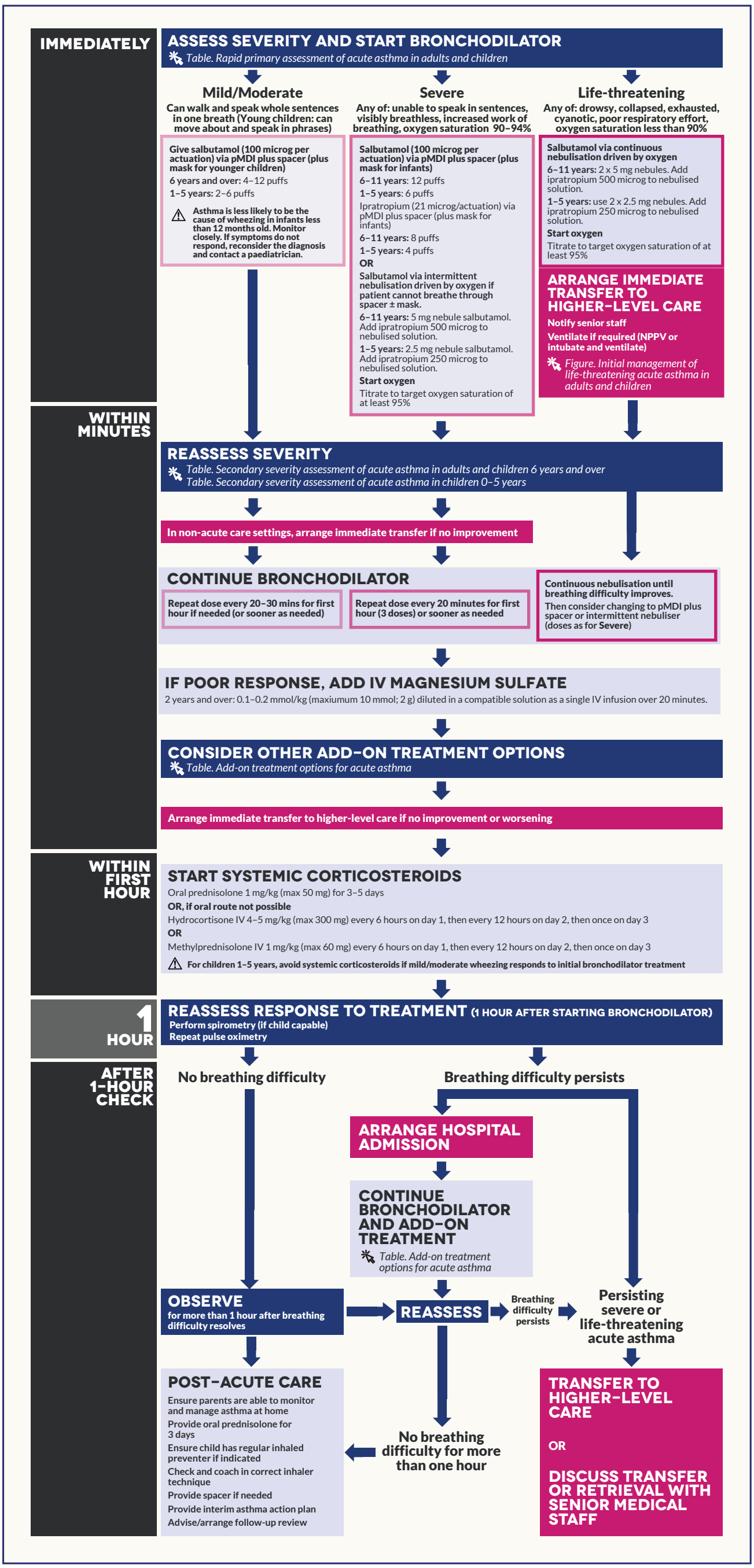
* Salbutamol IV infusion can be considered in critical care units. Follow your hospital/organisation's protocol for dosage and delivery.

⚠ Monitor blood electrolytes, heart rate and acid/base balance (blood lactate)

Salbutamol toxicity can occur with either the inhaled or IV route of administration. Risk may be increased when the inhaled and IV routes are used concomitantly.

Initial management of life-threatening acute asthma. This figure shows in more detail the first stages ('immediate' and 'within minutes') shown in the figures Managing acute asthma in adults and Managing acute asthma in children

Figure. Managing acute asthma in children



For more details on the initial management of life-threatening acute asthma, see *Initial management of life-threatening acute asthma in adults and children*

Figure. Managing acute asthma in adults

AUSTRALIAN ASTHMA HANDBOOK

IMMEDIATELY

ASSESS SEVERITY AND START BRONCHODILATOR

⚠ Consider anaphylaxis and manage if suspected

Table. Rapid primary assessment of acute asthma in adults and children

Mild/Moderate

Can walk and speak whole sentences in one breath

Give 4–12 puffs salbutamol (100 microg per actuation) via pMDI plus spacer

Severe

Any of: unable to speak in sentences, visibly breathless, increased work of breathing, oxygen saturation 90–94%

Salbutamol 12 puffs (100 mcg per actuation) via pMDI plus spacer

Ipratropium 8 puffs (21 microg/ actuation) via pMDI plus spacer

OR

Use intermittent nebulisation if patient cannot breathe through spacer.
Give 5 mg nebule salbutamol. Add 500 microg ipratropium to nebulised solution.

Drive nebuliser with air unless oxygen needed

Start oxygen

Titrate to target oxygen saturation 93–95%

Life-threatening

Any of: drowsy, collapsed, exhausted, cyanotic, poor respiratory effort, oxygen saturation less than 90%

Salbutamol 2 x 5 mg nebules via continuous nebulisation.

Ipratropium 500 microg added to nebulised solution.

Start oxygen

Titrate to target oxygen saturation of 93–95%

ARRANGE IMMEDIATE TRANSFER TO HIGHER-LEVEL CARE

Notify senior staff

Ventilate if required (NPPV or intubate and ventilate

Figure. Initial management of life-threatening acute asthma in adults and children

WITHIN MINUTES

REASSESS SEVERITY

Table. Secondary severity assessment of acute asthma in adults and children aged 6 years and over

In non-acute care settings, arrange immediate transfer if no improvement

CONTINUE BRONCHODILATOR

Repeat dose every 20–30 mins for first hour if needed or sooner as needed

Repeat dose every 20 minutes for first hour (3 doses) or sooner as needed

Continuous nebulisation until dyspnoea improves.

Then consider changing to pMDI plus spacer or intermittent nebuliser (doses as for **Severe**)

IF POOR RESPONSE, ADD IV MAGNESIUM SULFATE

10 mmol diluted (2.5 g) in a compatible solution as a single IV infusion over 20 minutes

CONSIDER OTHER ADD-ON TREATMENT OPTIONS

Table. Add-on treatment options for acute asthma

Arrange immediate transfer to higher-level care if no improvement or worsening

WITHIN FIRST HOUR

START SYSTEMIC CORTICOSTEROIDS

Oral prednisolone 37.5–50 mg then continue 5–10 days

OR, if oral route not possible

Hydrocortisone 100 mg IV every 6 hours

1 HOUR

REASSESS RESPONSE TO TREATMENT (1 HOUR AFTER STARTING BRONCHODILATOR)

Perform spirometry (if patient capable)
Repeat pulse oximetry
Check for dyspnoea while supine

AFTER 1-HOUR CHECK

Dyspnoea resolved

OBSERVE

for more than 1 hour after dyspnoea resolves

POST-ACUTE CARE

Ensure person (or carer) is able to monitor and manage asthma at home

Provide oral prednisolone for 5–10 days

Ensure person has regular inhaled corticosteroid

Check and coach in correct inhaler technique

Provide spacer if needed

Provide interim asthma action plan

Advise/arrange follow-up review

Symptoms and signs unresolved

Any of: any persisting dyspnoea, inability to lie flat without dyspnoea, FEV_1 <60% predicted,

ARRANGE HOSPITAL ADMISSION

CONTINUE BRONCHODILATOR AND ADD-ON TREATMENT

Table. Add-on treatment options for acute asthma

Persisting severe or life-threatening acute asthma

TRANSFER TO HIGHER-LEVEL CARE

OR

DISCUSS TRANSFER OR RETRIEVAL WITH SENIOR MEDICAL STAFF

For more details on the initial management of life-threatening acute asthma, see Initial management of life-threatening acute asthma in adults and children

Completing a rapid primary assessment and starting initial treatment

Recommendations

Assess severity of the acute asthma episode (moderate, severe or life-threatening) and administer a bronchodilator immediately:

- **Make a rapid clinical assessment with the person in a sitting position.**
- **Measure pulse oximetry while the person is breathing air (unless life threatening).**
- **Start bronchodilator according to severity and age.**

Table. Rapid primary assessment of acute asthma in adults and children

Mild/Moderate	Severe	Life-threatening
Can walk, speak whole sentences in one breath (For young children: can move around, speak in phrases) Oxygen saturation >94%	Any of these findings: • Use of accessory muscles of neck or intercostal muscles or 'tracheal tug' during inspiration or subcostal recession ('abdominal breathing') • Unable to complete sentences in one breath due to dyspnoea • Obvious respiratory distress • Oxygen saturation 90–94%	Any of these findings: • Reduced consciousness or collapse • Exhaustion • Cyanosis • Oxygen saturation <90% • Poor respiratory effort, soft/absent breath sounds

Notes

If features of more than one severity category are present, record the higher (worse) category as overall severity level

The severity category may change when more information is available (e.g. pulse oximetry, spirometry) or over time.

The presence of pulsus paradoxus (systolic paradox) is not a reliable indicator of the severity of acute asthma.

Oxygen saturation measured by pulse oximetry. If oxygen therapy has already been started, it is not necessary to cease oxygen to do pulse oximetry.

Oxygen saturation levels are a guide only and are not definitive; clinical judgment should be applied.

Definitions of severity classes for acute asthma used in this handbook may differ from those used in published clinical trials and other guidelines that focus on, are or restricted to, the management of acute asthma within emergency departments or acute care facilities.

Last reviewed version 2.0

Asset ID: 74

Table. Initial bronchodilator treatment in acute asthma (adults and children 6 years and over)

- **Do not use IV short-acting beta$_2$ agonists routinely for initial bronchodilator treatment.**
- **Do not give oral salbutamol.**
- **Monitor for salbutamol toxicity (e.g. tachycardia, tachypnoea, metabolic acidosis, hypokalaemia) – may occur with inhaled or**

IV salbutamol.

Mild/Moderate	Severe	Life-threatening
Give salbutamol† 4-12 puffs (100 microg/actuation) via pMDI and spacer Give one puff at a time followed by 4 breaths Repeat every 20-30 minutes for the first hour if required (sooner, if needed to relieve breathlessness)	Give salbutamol plus ipratropium Salbutamol†: 12 puffs (100 microg/actuation) via pMDI and spacer If patient unable to breathe through a spacer, give 5 mg nebule via nebuliser‡ Ipratropium: 8 puffs (21 microg/actuation) via pressurised metered-dose inhaler and spacer every 20 minutes for first hour. Repeat 4–6 hourly for 24 hours. If salbutamol delivered via nebuliser add 500 micrg ipratropium to nebulised solution every 20 minutes for first hour. Repeat 4–6 hourly. Start oxygen therapy if oxygen saturation <92% in adults or <95% in children and titrate to target: Adults: 93–95% Children: 95% or higher Repeat salbutamol as needed. Give at least every 20 minutes for first hour (3 doses)	Give salbutamol plus ipratropium Salbutamol: 2 x 5 mg nebules via continuous nebulisation driven by oxygen‡ Ipratropium: 500 microg ipratropium added to nebulised solution every 20 minutes for first hour. Repeat 4–6 hourly. Maintain oxygen saturations: Adults: 93–95% Children: 95% or higher Arrange immediate transfer to higher-level care When dyspnoea improves, consider changing to salbutamol via pMDI plus spacer or intermittent nebuliser‡ (doses as for severe acute asthma)

* Give adrenaline if anaphylaxis suspected. Consider adrenaline if the patient is unresponsive, cannot inhale bronchodilators, or is considered to be peri-arrest.

† See *Table. Using pressurised metered-dose inhalers in acute asthma*

‡ See *Table. Using nebulisers in acute asthma*

Note: To deliver nebulised bronchodilators in a patient receiving oxygen therapy, use an air-driven compressor nebuliser and administer oxygen by nasal cannulae.

Last reviewed version 2.0

Asset ID: 80

Table. Initial bronchodilator treatment in acute asthma (children 1–5 years)

- Do not use IV short-acting beta$_2$ agonists routinely for initial bronchodilator treatment.
- Do not give oral salbutamol.
- Monitor for salbutamol toxicity (e.g. tachycardia, tachypnoea, metabolic acidosis, hypokalaemia) – may occur with inhaled or IV salbutamol.
- Closely monitor level of consciousness, fatigue, oxygen saturation, respiratory rate and heart rate. If symptoms do not

respond, contact a paediatrician or senior clinician and reconsider the diagnosis.

- **Wheezing infants younger than 12 months old should not be treated for acute asthma. Acute wheezing in this age group is most commonly due to acute viral bronchiolitis. Advice should be obtained from a paediatric respiratory physician or paediatrician before administering short-acting beta2 agonists, systemic corticosteroids or inhaled corticosteroids to an infant.**

Mild/Moderate	Severe	Life-threatening*
Give salbutamol† 2-6 puffs (100 microg/actuation) via pMDI and spacer plus mask Give one puff at a time followed by 4 breaths Repeat every 20-30 minutes for the first hour if needed (sooner, if needed to relieve breathlessness)	Give salbutamol† plus ipratropium Salbutamol: 6 puffs† (100 microg/actuation) via pMDI and spacer plus mask Give one puff at a time followed by 4 breaths If patient unable to breathe through a spacer, give 2.5 mg nebule via nebuliser‡ Ipratropium: 4 puffs (21 microg/actuation) via pressurised metered-dose inhaler and spacer (+ mask if needed) every 20 minutes for first hour. Repeat 4–6 hourly for 24 hours. If salbutamol delivered via nebuliser, add 250 microg ipratropium to nebulised solution every 20 minutes for first hour. Repeat 4–6 hourly. Start supplementary oxygen if oxygen saturation <95% Titrate to 95% or higher Repeat salbutamol as needed. Give at least every 20 minutes for first hour (3 doses)	Give salbutamol plus ipratropium Salbutamol: 2 x 2.5 mg nebules via continuous nebulisation driven by oxygen‡ Ipratropium: 250 microg ipratropium added to nebulised solution every 20 minutes for first hour. Repeat 4–6 hourly. Maintain oxygen saturation at 95% or higher Arrange immediate transfer to higher-level care When dyspnoea improves, consider changing to salbutamol via pMDI plus spacer or intermittent nebuliser‡ (doses as for severe acute asthma)

***Give adrenaline if anaphylaxis suspected. Consider adrenaline if the patient is unresponsive, cannot inhale bronchodilators, or is considered to be peri-arrest.**

† See *Table. Using pressurised metered-dose inhalers in acute asthma*

‡ See *Table. Using nebulisers in acute asthma*

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Asset ID: 81

Table. Using pressurised metered-dose inhalers in acute asthma

Administration of salbutamol by health professionals for a patient with acute asthma

1. **Use a salbutamol pressurised metered-dose inhaler (100 microg/actuation) with a spacer that has already been prepared (see note).**
2. **Shake inhaler and insert upright into spacer.**
3. **Place mouthpiece between the person's teeth and ask them to seal lips firmly around mouthpiece.**
4. **Fire one puff into the spacer.**
5. **Tell person to take 4 breaths in and out of the spacer.**
6. **Remove the spacer from mouth. Shake the inhaler after each puff before actuating again. (This can be done without detaching the pressurised metered-dose inhaler from the spacer.)**

Notes

The process is repeated until the total dose is given. Different doses are recommended for patients and carers giving asthma first aid in the community.

New plastic spacers should be washed with detergent to remove electrostatic charge (and labelled), so they are ready for use when needed. In an emergency situation, if a pre-treated spacer is not available, prime the spacer before use by firing at least 10 puffs of salbutamol into the spacer. (This is an arbitrary number of actuations in the absence of evidence that would enable a precise guideline.)

Priming or washing spacers to reduce electrostatic charge before using for the first time is only necessary for standard plastic spacers. Treatment to reduce electrostatic charge is not necessary for polyurethane/antistatic polymer spacers (e.g. Able A2A, AeroChamber Plus, La Petite E-Chamber, La Grande E-Chamber) or disposable cardboard spacers (e.g. DispozABLE, LiteAire).

For small children who cannot form a tight seal with their lips around the spacer mouthpiece, attach a well-fitted mask to the spacer.

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Asset ID: 62

Table. Using nebulisers in acute asthma

Driving nebuliser

Nebulisers can be driven by air, piped oxygen, or an oxygen cylinder fitted with a high-flow regulator capable of delivering >6 L/min.

Salbutamol

Intermittent nebulisation with salbutamol

Use one nebule:

Adults: 5 mg nebule

Children 6 years and over: 5 mg nebule

Children aged 1-5 years: 2.5 mg nebule

Continuous nebulisation with salbutamol using nebules

Put two nebules into nebuliser chamber at a time and repeat to refill when used up.

Adults: use two 5 mg nebules (10 mg) at a time

Children 6 years and over: use two 5 mg nebules (10 mg) at a time

Children aged 1-5 years: use two 2.5 mg nebules (5 mg) at a time

Ipratropium

Add one nebule to salbutamol nebuliser solution:

Adults and children 6 years and over: 500 microg nebule
Children aged 1-5 years: 250 microg nebule

- **If using oxygen to drive a nebuliser, do not exceed 8–10 L/minute and avoid over-oxygenation (increases risk of hypercapnoea).**
- **The use of nebulisers increases the risk (to staff and patients) of nosocomial aerosol infection. If using a nebuliser, follow your organisation's infection control protocols to minimise spread of respiratory tract infections.**

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Notes

- **If oxygen therapy has already been started, it is not necessary to stop oxygen to measure pulse oximetry.**
- **Pregnancy is not a contraindication for bronchodilators in acute asthma.**

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

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Start oxygen therapy for adults with SpO_2 <92% or children with SpO_2 <95%

- **In adults, avoid over-oxygenation (SpO_2>95%), because this increases the risk of hypercapnoea.**

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

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For patients with life-threatening asthma, arrange immediate transfer to the resuscitation area (or arrange transfer to acute service).

Figure. Initial management of life-threatening acute asthma in adults and children

Please view and print this figure separately: http://www.asthmahandbook.org.au/figure/show/94

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

If the patient is unresponsive, cannot inhale bronchodilators, or is considered to be peri-arrest, consider adrenaline. Use any of the following according to the clinical situation:

IM via needle and syringe

For adults or children, use (1:1000) and give 0.01 mg per kg up to 0.5 mg per dose (0.5 mL). Repeat every 3–5 minutes if needed.

IM via auto-injector

Adult: 0.3 mg IM

Child >20 kg: 0.3 mg IM

Child 10–20 kg, 0.15 mg IM

Repeat dose after 5 minutes if required.

IV infusion

Adult, child, initially 0.1 microgram/kg/minute IV initially, then titrate according to response.

Slow IV injection

Adult: 50 micrograms (0.5 mL adrenaline 1:10 000) IV. Repeat according to response. Give IV infusion if repeated doses required.

Child: initial dose 1 microgram/kg (0.01 mL/kg adrenaline 1:10 000) IV. Titrate dose according to response.

If cardiac or respiratory arrest has occurred, initiate resuscitation, start mechanical ventilation and support circulation.

- **Do not use adrenaline in place of salbutamol as initial bronchodilator.**
- **IV administration can be considered if response to repeated IM doses and volume expansion is inadequate. IV adrenaline should only be given by health professionals experienced in its use and with continuous monitoring of ECG, pulse oximetry and BP. IV infusion is safer than slow bolus (used for imminent cardiac arrest).**
- **Auto-injector doses are as recommended by the Australasian Society of Clinical Immunology and Allergy for the management of anaphylaxis. For some children they are higher than the doses recommended by the manufacturer.**

Figure. Initial management of life-threatening acute asthma in adults and children

Please view and print this figure separately: http://www.asthmahandbook.org.au/figure/show/94

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available) with particular reference to the following source(s):

- Australian Medicines Handbook[1]
- ASCIA 2017[2]

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Identify anaphylaxis and manage it according to national guidelines or your organisation's protocols.

Anaphylaxis should be suspected in a patient with sudden-onset asthma-like symptoms and either of the following:

- **features of anaphylaxis (e.g. urticaria or angioedema)**
- **a history of allergy to food, insects or medicines.**

If anaphylaxis is suspected or cannot be excluded, give adrenaline.

If adrenaline is indicated, administer before salbutamol.

Note: Anaphylaxis is defined as (either of):

- **Any acute onset illness with typical skin features (urticarial rash or erythema/flushing and/or angioedema) plus involvement of respiratory symptoms and/or cardiovascular symptoms and/or persistent severe gastrointestinal symptoms**
- **Any acute onset of hypotension or bronchospasm or upper airway obstruction where anaphylaxis is considered possible (even if typical skin features not present).**

▶ **Go to:** *ASCIA's guidelines on acute management of anaphylaxis*

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available) with particular reference to the following source(s):

- ASCIA 2017[2]
- ANZCOR[3]

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Ensure that pregnant women who present with acute asthma receive treatment immediately to minimise risk to the foetus and to the woman.

Note: Salbutamol and oral corticosteroids should be administered as indicated, just as for non-pregnant patients.

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available) with particular reference to the following source(s):

- Namazy et al. 2012[4]

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More information

Salbutamol in acute asthma

Route of administration
Inhaler plus spacer, or nebuliser

Among patients with acute asthma who do not require mechanical ventilation, salbutamol delivered via a pressurised metered-dose inhaler with spacer is at least as effective as salbutamol delivered via nebuliser in preschool children (with viral-induced wheezing or acute asthma)[5] and adults,[67] and is equivalent or superior in school-aged children.[8, 9, 10, [REFERENCE991]]

The use of nebulisers increases the risk of transmitting respiratory infections to staff and other patients,[11] and increases the risk of adverse effects.

Intravenous salbutamol

IV salbutamol is generally reserved for use in patients with severe acute asthma that does not respond to inhaled bronchodilators.

Efficacy

Overall, intravenous short-acting beta$_2$ agonists do not appear to be superior to inhaled short-acting beta$_2$ agonist.[12]

Adults

Benefits have not been demonstrated in adults.[12]

Children

Very limited evidence from one study suggested that the addition of IV salbutamol to inhaled salbutamol reduced recovery time in children with severe acute asthma in the emergency department.[12]

However, there is a lack of consensus on the appropriate dose of IV salbutamol for children.[13] Recommendations differ between guidelines in Australia[14] and elsewhere.[13] Doses have not been calculated based on age-specific pharmacokinetic and pharmacodynamic data. The doses recommended in guidelines are generally relatively higher than for adults on a micrograms per kilogram body weight basis.

Adverse effects

Compared with inhaled salbutamol, intravenous salbutamol is associated with increased risk of adverse effects including tremor and hypokalaemia.[12, 13] Concomitant use of the inhalation and IV routes may increase the risk of salbutamol toxicity.[15]

Note: Salbutamol concentrate for infusion is available in 5 mL ampoules containing salbutamol sulfate equivalent to 5 mg (1 mg/mL) salbutamol in a sterile isotonic solution (*Ventolin obstetric injection*). Salbutamol for injection is also available in ampoules of salbutamol sulphate equivalent to 500 microg salbutamol in 1 mL sterile isotonic solution (*Ventolin injection*).

Salbutamol dosing regimens

There is very little evidence from clinical trials to guide dosing intervals for salbutamol treatment in acute asthma.

One placebo-controlled study conducted in the emergency department among adults with acute asthma (FEV_1 <60% predicted or normal) showed that, in those who did not show a clear response to the first salbutamol dose, repeating the dose at intervals of 30 minutes or less was more effective than every 60 minutes.[16] However, for patients who showed clear improvement after the first dose of salbutamol via pressurised metered-dose inhaler and spacer, there was no advantage in repeating the dose more often than every 60

minutes until full recovery (extra doses can be given as needed).[16]

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Ipratropium in acute asthma

Adults

In adults and older adolescents with severe acute asthma treated in the emergency department, the combination of ipratropium and short-acting beta$_2$ agonist reduces hospitalisation rate and improves lung function, compared with short-acting beta$_2$ agonist alone.[17] Hospitalisation rates are not reduced in patients with mild or moderate acute asthma.[17]

In adults, the combination of ipratropium and short-acting beta$_2$ agonist is associated with a higher rate of adverse effects (e.g. tremor, agitation, and palpitations) than short-acting beta$_2$ agonist alone.[17]

Children

Recent systematic reviews have reported that initial treatment with ipratropium in addition to salbutamol markedly reduces hospitalisation rate and improves clinical scores in children with moderate to severe acute asthma.[8, 10, 18]

However, in children hospitalised due to acute asthma, the combination of ipratropium and short-acting beta$_2$ agonist was not more effective than short-acting beta$_2$ agonist alone.[19]

The combination of ipratropium and short-acting beta$_2$ agonist appears to be well tolerated in children.[18]

Ipratropium bromide alone is less effective than salbutamol alone in acute asthma.[20]

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Assessment of oxygen status in acute asthma

Hypoxia is the main cause of deaths due to acute asthma.[21]

Routine objective assessment of oxygen saturation at initial assessment of acute asthma is needed because clinical signs may not correlate with hypoxaemia.

Pulse oximetry is the internationally accepted method for routine assessment of oxygen status in patients with acute asthma. It should be available in all situations in which oxygen is used.[22]

Pulse oximetry does not detect hypercapnoea, so blood gas analysis is necessary if hypercapnoea is suspected in patients with severe or life-threatening acute asthma. Thoracic Society of Australia and New Zealand clinical practice guidelines for acute oxygen use in adults[22] recommend that arterial blood gas analysis should be considered if oxygen saturation falls below 92% and in those at risk of hypercapnoea. Venous blood gas analysis can be used to assess acid–base balance and lactate,[22] but performs poorly in identifying hypercapnoea.[23]

▶ Go to: Thoracic Society of Australia and New Zealand (TSANZ's) *clinical practice guidelines for acute oxygen use in adults*

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Oxygen therapy in acute asthma

Oxygen is a treatment for hypoxaemia, not breathlessness.[22] Oxygen has not been shown to improve the sensation of breathlessness in non-hypoxaemic patients.[22] When oxygen supplementation is used, pulse oximetry is necessary to monitor oxygen status and titrate to target.

The aim of titrated oxygen therapy in acute care is to achieve adequate oxygen saturation without causing hypercapnoea.[22] Adults with acute asthma and those with overlapping asthma and COPD are at greater risk of hypercapnoeic respiratory failure.

Drying of the upper airway is a potential complication of oxygen therapy,[24, 25] and might contribute to bronchoconstriction.[25]

Few studies have investigated optimal oxygen supplementation protocols for patients with asthma.

Adults

In adults with acute asthma, titrated oxygen therapy using pulse oximetry to maintain oxygen saturation at 93–95% while avoiding hyperoxaemia achieves better physiological outcomes than 100% oxygen at high flow rate (8 L/min).[26] High-concentration and high-flow oxygen therapy cause a clinically significant increase in blood CO_2 concentration in adults with acute asthma.[26, 27]

Thoracic Society of Australia and New Zealand (TSANZ) clinical practice guidelines for acute oxygen use in adults[22] recommend that, in patients with COPD, oxygen should be administered if the SpO_2 is less than 88%, and titrated to a target SpO2 range of 88–92%. For other acute medical conditions, the TSANZ guidelines recommend that oxygen should be administered if the SpO_2 is less than 92%, and

titrated to a target SpO_2 range of 92–96%.

Humidification of oxygen via high flow nasal cannulae may improve comfort and tolerance.[22]

▶ Go to: Thoracic Society of Australia and New Zealand (TSANZ's) *clinical practice guidelines for acute oxygen use in adults*

Children

There is very little evidence available to inform recommendations for oxygen saturation targets in children with asthma.[28] Studies in infants with bronchiolitis suggest that targets as low as >90%[29] or >92%[30] may be achieve similar clinical outcomes as higher targets. Recommendations for oxygen saturation targets during supplemental oxygen vary between clinical guidelines and vary between protocols used in Australian hospitals.

Humidified oxygen can be considered if necessary. Humidification is usually not needed for low flow oxygen (<4 L/minute in children or 2 L/minute in infants) for short term. Humidification may be considered if the oxygen is required for longer than 48 hours or if the nasal passages are becoming uncomfortable or dry.[24]

Guidance on oxygen delivery techniques and practical issues is available from Sydney Children's Hospital Network and The Royal Children's Hospital Melbourne.

▶ Go to: Sydney Children's Hospitals Network resource on *oxygen therapy and delivery devices*
Go to: The Royal Children's Hospital Melbourne guideline on *Oxygen delivery*

Humidified oxygen via high-flow nasal cannulae

Humidified high flow nasal oxygen is a system that has the ability to provide a humidified high-flow mix of air and oxygen via a specialised nasal cannula system. It is able to deliver positive end expiratory pressure of approximately 4–8 cm H_20.

Delivery of high-flow oxygen via nasal cannulae is increasingly common practice in Australian emergency rooms. There is very little evidence to support its use in acute asthma treatment,[22] but it does not appear to be associated with significant risks.

It has been reported to be feasible and safe in children with severe acute asthma in ICU,[31] and at least as effective as conventional oxygen therapy in children with acute asthma with inadequate response to initial bronchodilator treatment.[31] No published studies have evaluated its use in adults with acute asthma.

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Anaphylaxis guidelines and resources

▶ Go to: Australasian Society of Clinical Immunology and Allergy (ASCIA)'s *guidelines on acute management of anaphylaxis*
Go to: Australasian Society of Clinical Immunology and Allergy (ASCIA)'s *Anaphylaxis clinical update*
Go to: Australasian Society of Clinical Immunology and Allergy (ASCIA)'s *Anaphylaxis resources for fact sheets and action plan templates*

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Roles of adrenaline in the management of acute asthma

Adrenaline is not used routinely in the management of severe acute asthma.

Its use should be reserved for situations where inhaled salbutamol cannot be given in a patient with respiratory arrest or pre-arrest status, or when anaphylaxis is suspected.

Anaphylaxis

Anaphylaxis is rare among people with acute asthma. An estimated 3.4% of adults admitted to the intensive care unit for acute severe asthma also meet criteria for anaphylaxis, according to one retrospective study[32]

Intramuscular adrenaline (or intravenous adrenaline in clinical settings with appropriately trained staff) is indicated for patients with anaphylaxis and angioedema, and patients with known allergies to food or other relevant allergens (other than aeroallergens) who have sudden-onset breathing problems, even if they have no other signs of anaphylaxis.[2]

Australasian Society of Clinical Immunology and Allergy recommends that adrenaline should be given before bronchodilators for a patient with sudden-onset breathing problems and known allergy to foods, insects or medicines.[2]

▶ Go to: Australasian Society of Clinical Immunology and Allergy (ASCIA)'s *guidelines on acute management of anaphylaxis*

Asthma

Few studies have compared adrenaline in addition to, or in comparison with, currently recommended bronchodilator treatment in patients with acute asthma, either in hospital emergency departments or pre-hospital acute services.

Hospital or emergency department setting

Nebulised adrenaline

Nebulised adrenaline does not have a significant benefit over salbutamol or terbutaline in the management of moderate-to-severe acute asthma in adults and children.[33]

Intramuscular, intravenous or subcutaneous adrenaline

Adrenaline given IV, subcutaneously or intramuscularly has no benefit over inhaled short-acting beta$_2$ agonists in the management of acute asthma.[34, 35, 36, 37]

Three small clinical trials comparing subcutaneous adrenaline with nebulised salbutamol in children with acute asthma reported equivalent respiratory outcomes including peak expiratory flow rate.[34, 35, 36] Adrenaline was associated with higher rates of adverse effects, including a short-term increase in systolic blood pressure and heart rate.[34, 35]

Another trial in children with acute asthma reported that subcutaneous adrenaline was more effective than nebulised terbutaline in increasing oxygen saturation and FEV_1, but was associated with a higher rate of adverse events including pallor, tremor, dizziness, headache, palpitation, soreness of legs, numbness of extremities, cold sweating, general weakness and nausea.[38]

A clinical trial comparing subcutaneous adrenaline with nebulised terbutaline in adults with acute asthma reported equivalent efficacy.[37] The adrenaline group, but not the terbutaline group, showed an increase in pulse rate.[37] A non-comparative retrospective study of 220 adults who had received IV adrenaline for acute asthma reported that adverse events were common but mostly minor and self-limiting.[39] Major adverse events occurred in approximately 4% of patients and included 2 cases of supraventricular tachycardia, 1 case of chest pain with ECG changes, 1 case of incidental elevated troponin, and 4 cases of hypotension requiring intervention.[39]

Prehospital setting

There is limited evidence to guide the use of adrenaline in patients with acute asthma in the prehospital setting. However, it has no benefit over inhaled salbutamol in patients with acute asthma and is associated with a worse adverse effect profile.

Subcutaneous adrenaline was associated with increased heart rate and increased blood pressure, compared with a nebulised bronchodilator (metaproterenol), in a randomised controlled trial in adults presenting to ambulance services with acute asthma.[40]

In some states, ambulance services give adrenaline to patients with severe, life-threatening acute asthma. In this circumstance inhaled/nebulised salbutamol is preferable initially. When there is an inadequate response with acute and rapid deterioration or when the inhaled route is impractical because the person is not breathing, some ambulance protocols recommend administration of either IM Adrenaline (500 mg, 1:1000), if needed at intervals of 5–10 minutes or IV adrenaline 50–100 mg at intervals of 2–5 minutes.[41]

Ventilation must be adequately supported. If cardiac or respiratory arrest occurs, appropriate resuscitation procedures should be followed.[3]

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Technical notes: pressurised metered-dose inhalers with spacers

Manufacturers of most pressurised metered-dose delivery devices recommend shaking the device before actuating. The physical characteristics of each formulation, including the effects of shaking, differ widely,[42] but for simplicity it is best always to recommend shaking of pressurised metered-dose inhalers.

Pressurised metered-dose inhalers (except for those that are breath-actuated) can be used with a spacer. When a spacer is used with a pressurised metered-dose inhaler, delivery of the medicine to the patient's airways is maximised when the patient takes a slow, deep breath from the spacer after each actuation.[43, 27] Multiple actuations of a pressurised metered-dose inhaler into a spacer can reduce the amount of respirable medicine available because aerosol particles can agglomerate into larger particles or become attached to the spacer walls.[43]

Therefore, the ideal way to deliver inhaled medicines via pressurised metered-dose inhaler and spacer is to shake the device, ask the person to breathe out all the way into the spacer, actuate a single puff into the spacer, and have the person immediately take a slow deep breath from the spacer, then hold their breath for 5 seconds. This process should be repeated until the total intended number of actuations is taken. Patients should be trained to follow these instructions when using their inhalers. Inhaling slowly with a single breath maximises delivery of the medicine to the lungs and minimises deposition in the upper airways when using a manually actuated pressurised metered-dose inhaler with or without a spacer, or when using a breath-actuated pressurised metered-dose inhaler.[44] However, slow breathing may not be possible for patients with acute asthma. Tidal breathing through the spacer (e.g. four breaths in and out without removing the spacer) is used in acute asthma and for very young children. First aid instructions should include how to use inhaler and spacer.

In practice, optimal delivery of inhaled medicines involves a balance between maximising the proportion of respirable medicine and maximising efficiency of inhalation by the patient within real-world constraints. The optimal delivery of salbutamol in real-world circumstances is not well defined. For day-to-day use of salbutamol, most adults gain sufficient relief from symptoms when using a pressurised metered-dose inhaler on its own. A spacer may only be needed during a flare-up. By contrast, the use of a spacer is always recommended for inhaled corticosteroids delivered by manually actuated pressurised metered-dose inhalers, to reduce the risk of local adverse effects and increase delivery to the airways.

Many available in vitro studies of aerosol particle deposition in the airways were performed using older CFC-propelled formulations, which are now obsolete. Similar studies have not been performed for current non-CFC pressurised metered-dose inhalers.

▶ Go to: National Asthma Council Australia's *first aid charts*

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Instruments for assessing acute asthma

Validated scoring systems for assessing the severity of acute asthma, response to treatment, and predicting the need for hospital admission are used in research studies and by some clinicians. These include:

- Pediatric Respiratory Assessment Measure (PRAM)[45] for assessing acute asthma severity and response to treatment in children and adolescents, based on oxygen saturation, effort of breathing (suprasternal retraction and scalene muscle contraction), air entry (assessed by auscultation of the chest) and wheezing
- the CHOP classification tree for predicting need for hospitalisation in adults,[46] based on change in peak expiratory flow severity category, history of acute admission for asthma ('ever hospitalisation'), oxygen saturation while breathing room air, and initial peak expiratory flow.

These instruments are not routinely used in Australian emergency departments.

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References

1. Australian Medicines Handbook. Last modified July 2018: *Australian Medicines Handbook Pty Ltd*. 2018
2. Australasian Society of Clinical Immunology and Allergy. Guidelines. *Acute management of anaphylaxis: ASCIA*. 2017. Available from: https://www.allergy.org.au/images/stories/pospapers/ASCIA_Guidelines_Acute_Management_Anaphylaxis_2017_Updated.pdf/.
3. Australian and New Zealand Committee on Resuscitation. *ANZCOR Guideline 9.2.7 – First aid management of anaphylaxis*. Australian Resuscitation Council; 2016 [September 2018]; Available from: https://resus.org.au/guidelines/
4. Namazy, J A, Murphy, V E, Powell, H, *et al*. Effects of asthma severity, exacerbations and oral corticosteroids on perinatal outcomes. *Eur Respir J*. 2012; 41: 1082-1090. Available from: http://erj.ersjournals.com/content/41/5/1082.long
5. Mitselou N, Hedlin G, Hederos CA. Spacers versus nebulizers in treatment of acute asthma - a prospective randomized study in preschool children. *J Asthma*. 2016; 53: 1059-62. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27186989
6. Cates CJ, Crilly JA, Rowe BH. Holding chambers (spacers) versus nebulisers for beta-agonist treatment of acute asthma. *Cochrane Database Syst Rev*. 2006; Issue 2: CD000052. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD000052.pub2/full
7. Dhuper S, Chandra A, Ahmed A, *et al*. Efficacy and cost comparisons of bronchodilatator administration between metered dose inhalers with disposable spacers and nebulizers for acute asthma treatment. *J Emerg Med*. 2011; 40: 247-55. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19081697
8. Castro-Rodriguez, J. A., Rodrigo, G. J., Rodriguez-Martinez, C. E.. Principal findings of systematic reviews for chronic treatment in childhood asthma. *J Asthma*. 2015; 52: 1038-45. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26303207
9. Cates CJ, Welsh EJ, Rowe BH. Holding chambers (spacers) versus nebulisers for beta-agonist treatment of acute asthma. *Cochrane Database Syst Rev*. 2013; 9: Cd000052. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24037768
10. Pollock M, Sinha IP, Hartling L et al. Inhaled short-acting bronchodilators for managing emergency childhood asthma: an overview of reviews. *Allergy*. 2017; 72: 183-200. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27588581
11. Tran K, Cimon K, Severn M et al. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One*. 2012; 7: e35797. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22563403
12. Travers AH, Milan SJ, Jones AP, *et al*. Addition of intravenous beta(2)-agonists to inhaled beta(2)-agonists for acute asthma. *Cochrane Database Syst Rev*. 2012; 12: CD010179. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD010179/full
13. Starkey ES, Mulla H, Sammons HM, Pandya HC. Intravenous salbutamol for childhood asthma: evidence-based medicine?. *Arch Dis Child*. 2014; 99: 873-877. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24938536
14. Babl FE, Sheriff N, Borland M, *et al*. Paediatric acute asthma management in Australia and New Zealand: practice patterns in the context of clinical practice guidelines. *Arch Dis Child*. 2008; 93: 307-312. Available from: http://adc.bmj.com/content/93/4/307.abstract
15. Abramson MJ, Bailey MJ, Couper FJ, *et al*. Are asthma medications and management related to deaths from asthma?. *Am J Respir Crit Care Med*. 2001; 163: 12-18. Available from: http://www.ncbi.nlm.nih.gov/pubmed/11208619
16. Karpel JP, Aldrich TK, Prezant DJ, *et al*. Emergency treatment of acute asthma with albuterol metered-dose inhaler plus holding chamber: how often should treatments be administered?. *Chest*. 1997; 112: 348-356. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9266868
17. Kirkland SW, Vandenberghe C, Voaklander B et al. Combined inhaled beta-agonist and anticholinergic agents for emergency

management in adults with asthma. *Cochrane Database Syst Rev*. 2017; Issue 1: CD001284. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28076656
18. Griffiths B, Ducharme FM. Combined inhaled anticholinergics and short-acting beta2-agonists for initial treatment of acute asthma in children. *Cochrane Database Syst Rev*. 2013: Cd000060. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23966133
19. Vezina K, Chauhan BF, Ducharme FM. Inhaled anticholinergics and short-acting beta(2)-agonists versus short-acting beta2-agonists alone for children with acute asthma in hospital.*Cochrane Database Syst Rev*. 2014; Issue 7: CD010283. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25080126/
20. Teoh L, Cates CJ, Hurwitz M, *et al*. Anticholinergic therapy for acute asthma in children. *Cochrane Database Syst Rev*. 2012; 4: CD003797. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD003797.pub2/full
21. Hodder R, Lougheed MD, Rowe BH, *et al*. Management of acute asthma in adults in the emergency department: nonventilatory management. *CMAJ*. 2010; 182: E55-67. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2817338/
22. Beasley R, Chien J, Douglas J et al. Thoracic Society of Australia and New Zealand oxygen guidelines for acute oxygen use in adults: 'Swimming between the flags". *Respirology*. 2015; 20: 1182–91. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26486092/
23. Byrne AL, Bennett M, Chatterji R et al. Peripheral venous and arterial blood gas analysis in adults: are they comparable? A systematic review and meta-analysis. *Respirology*. 2014; 19: 168-75. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24383789
24. Sydney Children's Hospital. *Oxygen therapy and delivery devices – SCH. Practice guideline. Guideline No: 0/C/13:7019-01:00*. Sydney Children's Hospital Westmead, Sydney, 2013. Available from: http://www.chw.edu.au/about/policies/alphabetical.htm
25. The Royal Children's Hospital of Melbourne, Oxygen Delivery. *Clinical Guidelines (Nursing)*, The Royal Children's Hospital 2013. Available from: http://www.rch.org.au/rchcpg/hospital*clinical*guideline*index/Oxygen*delivery/
26. Perrin K, Wijesinghe M, Healy B, *et al*. Randomised controlled trial of high concentration versus titrated oxygen therapy in severe exacerbations of asthma. *Thorax*. 2011; 66: 937-41. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21597111
27. Rau JL, Restrepo RD, Deshpande V. Inhalation of single vs multiple metered-dose bronchodilator actuations from reservoir devices : An in vitro study. *Chest*. 1996; 109: 969-974. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8635379
28. Tosif S, Duke T. Evidence to support oxygen guidelines for children with emergency signs in developing countries: a systematic review and physiological and mechanistic analysis. *J Trop Pediatr*. 2017; 63: 402-13. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28158795
29. Cunningham S, Rodriguez A, Adams T et al. Oxygen saturation targets in infants with bronchiolitis (BIDS): a double-blind, randomised, equivalence trial. *Lancet*. 2015; 386: 1041-8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26382998
30. Franklin D, Babl FE, Schlapbach LJ et al. A randomized trial of high-flow oxygen therapy in infants with bronchiolitis. *N Engl J Med*. 2018; 378: 1121-31. Available from:https://www.ncbi.nlm.nih.gov/pubmed/29562151/
31. Ballestero Y, De Pedro J, Portillo N et al. Pilot clinical trial of high-flow oxygen therapy in children with asthma in the emergency service. *J Pediatr*. 2018; 194: 204-10.e3. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29331328/
32. Akenroye AT, Ajala A, Azimi-Nekoo E, de Vos GS. Prevalence of anaphylaxis among adults admitted to critical care for severe asthma exacerbation. *Emerg Med J* 2018: Available from: https://www.ncbi.nlm.nih.gov/pubmed/30093380/
33. Rodrigo GJ, Nannini LJ. Comparison between nebulized adrenaline and beta2 agonists for the treatment of acute asthma. A meta-analysis of randomized trials. *Am J Emerg Med* 2006; 24: 217-22. Available from: https://www.ncbi.nlm.nih.gov/pubmed/16490653/
34. Sharma A, Madan A. Subcutaneous epinephrine vs nebulized salbutamol in asthma. *Indian J Pediatr* 2001; 68: 1127-30. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11838566/
35. Becker AB, Nelson NA, Simons FE. Inhaled salbutamol (albuterol) vs injected epinephrine in the treatment of acute asthma in children. *J Pediatr* 1983; 102: 465-9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/6827423/
36. Kornberg AE, Zuckerman S, Welliver JR et al. Effect of injected long-acting epinephrine in addition to aerosolized albuterol in the treatment of acute asthma in children. *Pediatr Emerg Care* 1991; 7: 1-3. Available from: https://www.ncbi.nlm.nih.gov/pubmed/2027802/
37. Baughman RP, Ploysongsang Y, James W. A comparative study of aerosolized terbutaline and subcutaneously administered epinephrine in the treatment of acute bronchial asthma. *Ann Allergy* 1984; 53: 131-4. Available from: https://www.ncbi.nlm.nih.gov/pubmed/6465622/
38. Lin YZ, Hsieh KH, Chang LF, Chu CY. Terbutaline nebulization and epinephrine injection in treating acute asthmatic children. *Pediatr Allergy Immunol* 1996; 7: 95-9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/8902860/
39. Putland M, Kerr D, Kelly A. Adverse events associated with the use of intravenous epinephrine in emergency department patients presenting with severe asthma. *Ann Emerg Med* 2006; 14: 559-63. Available from: https://www.ncbi.nlm.nih.gov/pubmed/16713785/
40. Quadrel M, Lavery RF, Jaker M et al. Prospective, randomized trial of epinephrine, metaproterenol, and both in the prehospital treatment of asthma in the adult patient. *Ann Emerg Med* 1995; 26: 469-73. Available from: https://www.ncbi.nlm.nih.gov/pubmed/7574130/
41. Ambulance Victoria. *Clinical practice guidelines for ambulance and MICA paramedics*. 2018 edition version 1.4. Melbourne: Ambulance Victoria; 2017. Available from: https://www.ambulance.vic.gov.au/paramedics/clinical-practice-guidelines/
42. Cyr TD, Graham SJ, Li KY, Levering EG. Low first-spray drug content in albuterol metered-dose inhalers. *Pharm Res*. 1991; 8: 658-660. Available from: http://link.springer.com/article/10.1023/A:1015825311750
43. Barry PW, O'Callaghan C. Multiple actuations of salbutamol MDI into a spacer device reduce the amount of drug recovered in the respirable range. *Eur Respir J*. 1994; 7: 1707-1709. Available from: http://www.ncbi.nlm.nih.gov/pubmed/7995401
44. Laube BL, Janssens HM, de Jongh FHC, *et al*. What the pulmonary specialist should know about the new inhalation therapies. *Eur Respir J*. 2011; 37: 1308-1417. Available from: http://erj.ersjournals.com/content/37/6/1308.full
45. Szefler, SJ, Phillips, BR, Martinez, FD, *et al*. Characterization of within-subject responses to fluticasone and montelukast in

childhood asthma. *J Allergy Clin Immunol*. 2005; 115: 233-242. Available from: https://www.ncbi.nlm.nih.gov/pubmed/15696076
46. Basheti, IA; Obeidat, NM; Reddel, HK;. Effect of novel inhaler technique reminder labels on the retention of inhaler technique skills in asthma: a single-blind randomized controlled trial.. *NPJ Prim Care Respir Med*. 2017; 27: 9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28184045

Giving bronchodilator treatment according to severity and age

Recommendations

Give initial salbutamol by inhalation, using doses, routes of administration and dosing schedules according to the patient's age and the severity of acute asthma.

For patients with severe or life-threatening acute asthma, add ipratropium bromide.

- **Do not give oral salbultamol**

Table. Rapid primary assessment of acute asthma in adults and children

Mild/Moderate	Severe	Life-threatening
Can walk, speak whole sentences in one breath (For young children: can move around, speak in phrases) Oxygen saturation >94%	Any of these findings: • Use of accessory muscles of neck or intercostal muscles or 'tracheal tug' during inspiration or subcostal recession ('abdominal breathing') • Unable to complete sentences in one breath due to dyspnoea • Obvious respiratory distress • Oxygen saturation 90–94%	Any of these findings: • Reduced consciousness or collapse • Exhaustion • Cyanosis • Oxygen saturation <90% • Poor respiratory effort, soft/absent breath sounds

Notes

If features of more than one severity category are present, record the higher (worse) category as overall severity level

The severity category may change when more information is available (e.g. pulse oximetry, spirometry) or over time.

The presence of pulsus paradoxus (systolic paradox) is not a reliable indicator of the severity of acute asthma.

Oxygen saturation measured by pulse oximetry. If oxygen therapy has already been started, it is not necessary to cease oxygen to do pulse oximetry.

Oxygen saturation levels are a guide only and are not definitive; clinical judgment should be applied.

Definitions of severity classes for acute asthma used in this handbook may differ from those used in published clinical trials and other guidelines that focus on, are or restricted to, the management of acute asthma within emergency departments or acute care facilities.

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Asset ID: 74

Table. Initial bronchodilator treatment in acute asthma (adults and children 6 years and over)

- **Do not use IV short-acting beta$_2$ agonists routinely for initial bronchodilator treatment.**
- **Do not give oral salbutamol.**
- **Monitor for salbutamol toxicity (e.g. tachycardia, tachypnoea, metabolic acidosis, hypokalaemia) – may occur with inhaled or IV**

salbutamol.

Mild/Moderate	Severe	Life-threatening
Give salbutamol† 4-12 puffs (100 microg/actuation) via pMDI and spacer Give one puff at a time followed by 4 breaths Repeat every 20-30 minutes for the first hour if required (sooner, if needed to relieve breathlessness)	Give salbutamol plus ipratropium Salbutamol†: 12 puffs (100 microg/actuation) via pMDI and spacer If patient unable to breathe through a spacer, give 5 mg nebule via nebuliser‡ Ipratropium: 8 puffs (21 microg/actuation) via pressurised metered-dose inhaler and spacer every 20 minutes for first hour. Repeat 4–6 hourly for 24 hours. If salbutamol delivered via nebuliser add 500 micrg ipratropium to nebulised solution every 20 minutes for first hour. Repeat 4–6 hourly. Start oxygen therapy if oxygen saturation <92% in adults or <95% in children and titrate to target: Adults: 93–95% Children: 95% or higher Repeat salbutamol as needed. Give at least every 20 minutes for first hour (3 doses)	Give salbutamol plus ipratropium Salbutamol: 2 x 5 mg nebules via continuous nebulisation driven by oxygen‡ Ipratropium: 500 microg ipratropium added to nebulised solution every 20 minutes for first hour. Repeat 4–6 hourly. Maintain oxygen saturations: Adults: 93–95% Children: 95% or higher Arrange immediate transfer to higher-level care When dyspnoea improves, consider changing to salbutamol via pMDI plus spacer or intermittent nebuliser‡ (doses as for severe acute asthma)

* Give adrenaline if anaphylaxis suspected. Consider adrenaline if the patient is unresponsive, cannot inhale bronchodilators, or is considered to be peri-arrest.

† See *Table. Using pressurised metered-dose inhalers in acute asthma*

‡ See *Table. Using nebulisers in acute asthma*

Note: To deliver nebulised bronchodilators in a patient receiving oxygen therapy, use an air-driven compressor nebuliser and administer oxygen by nasal cannulae.

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Table. Initial bronchodilator treatment in acute asthma (children 1–5 years)

- Do not use IV short-acting beta$_2$ agonists routinely for initial bronchodilator treatment.
- Do not give oral salbutamol.
- Monitor for salbutamol toxicity (e.g. tachycardia, tachypnoea, metabolic acidosis, hypokalaemia) – may occur with inhaled or IV salbutamol.
- Closely monitor level of consciousness, fatigue, oxygen saturation, respiratory rate and heart rate. If symptoms do not respond, contact a paediatrician or senior clinician and reconsider the diagnosis.

- **Wheezing infants younger than 12 months old should not be treated for acute asthma. Acute wheezing in this age group is most commonly due to acute viral bronchiolitis. Advice should be obtained from a paediatric respiratory physician or paediatrician before administering short-acting beta2 agonists, systemic corticosteroids or inhaled corticosteroids to an infant.**

Mild/Moderate	Severe	Life-threatening*
Give salbutamol† 2-6 puffs (100 microg/actuation) via pMDI and spacer plus mask Give one puff at a time followed by 4 breaths Repeat every 20-30 minutes for the first hour if needed (sooner, if needed to relieve breathlessness)	Give salbutamol† plus ipratropium Salbutamol: 6 puffs† (100 microg/actuation) via pMDI and spacer plus mask Give one puff at a time followed by 4 breaths If patient unable to breathe through a spacer, give 2.5 mg nebule via nebuliser‡ Ipratropium: 4 puffs (21 microg/actuation) via pressurised metered-dose inhaler and spacer (+ mask if needed) every 20 minutes for first hour. Repeat 4–6 hourly for 24 hours. If salbutamol delivered via nebuliser, add 250 microg ipratropium to nebulised solution every 20 minutes for first hour. Repeat 4–6 hourly. Start supplementary oxygen if oxygen saturation <95% Titrate to 95% or higher Repeat salbutamol as needed. Give at least every 20 minutes for first hour (3 doses)	Give salbutamol plus ipratropium Salbutamol: 2 x 2.5 mg nebules via continuous nebulisation driven by oxygen‡ Ipratropium: 250 microg ipratropium added to nebulised solution every 20 minutes for first hour. Repeat 4–6 hourly. Maintain oxygen saturation at 95% or higher Arrange immediate transfer to higher-level care When dyspnoea improves, consider changing to salbutamol via pMDI plus spacer or intermittent nebuliser‡ (doses as for severe acute asthma)

***Give adrenaline if anaphylaxis suspected. Consider adrenaline if the patient is unresponsive, cannot inhale bronchodilators, or is considered to be peri-arrest.**

† See *Table. Using pressurised metered-dose inhalers in acute asthma*

‡ See *Table. Using nebulisers in acute asthma*

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Table. Using pressurised metered-dose inhalers in acute asthma

Administration of salbutamol by health professionals for a patient with acute asthma
1. **Use a salbutamol pressurised metered-dose inhaler (100 microg/actuation) with a spacer that has already been prepared (see note).**

2. **Shake inhaler and insert upright into spacer.**
3. **Place mouthpiece between the person's teeth and ask them to seal lips firmly around mouthpiece.**
4. **Fire one puff into the spacer.**
5. **Tell person to take 4 breaths in and out of the spacer.**
6. **Remove the spacer from mouth. Shake the inhaler after each puff before actuating again. (This can be done without detaching the pressurised metered-dose inhaler from the spacer.)**

Notes

The process is repeated until the total dose is given. Different doses are recommended for patients and carers giving asthma first aid in the community.

New plastic spacers should be washed with detergent to remove electrostatic charge (and labelled), so they are ready for use when needed. In an emergency situation, if a pre-treated spacer is not available, prime the spacer before use by firing at least 10 puffs of salbutamol into the spacer. (This is an arbitrary number of actuations in the absence of evidence that would enable a precise guideline.)

Priming or washing spacers to reduce electrostatic charge before using for the first time is only necessary for standard plastic spacers. Treatment to reduce electrostatic charge is not necessary for polyurethane/antistatic polymer spacers (e.g. Able A2A, AeroChamber Plus, La Petite E-Chamber, La Grande E-Chamber) or disposable cardboard spacers (e.g. DispozABLE, LiteAire).

For small children who cannot form a tight seal with their lips around the spacer mouthpiece, attach a well-fitted mask to the spacer.

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Table. Using nebulisers in acute asthma

Driving nebuliser

Nebulisers can be driven by air, piped oxygen, or an oxygen cylinder fitted with a high-flow regulator capable of delivering >6 L/min.

Salbutamol

Intermittent nebulisation with salbutamol

Use one nebule:

Adults: 5 mg nebule

Children 6 years and over: 5 mg nebule

Children aged 1-5 years: 2.5 mg nebule

Continuous nebulisation with salbutamol using nebules

Put two nebules into nebuliser chamber at a time and repeat to refill when used up.

Adults: use two 5 mg nebules (10 mg) at a time

Children 6 years and over: use two 5 mg nebules (10 mg) at a time

Children aged 1-5 years: use two 2.5 mg nebules (5 mg) at a time

Ipratropium

Add one nebule to salbutamol nebuliser solution:

Adults and children 6 years and over: 500 microg nebule
Children aged 1-5 years: 250 microg nebule

- **If using oxygen to drive a nebuliser, do not exceed 8–10 L/minute and avoid over-oxygenation (increases risk of hypercapnoea).**
- **The use of nebulisers increases the risk (to staff and patients) of nosocomial aerosol infection. If using a nebuliser, follow your organisation's infection control protocols to minimise spread of respiratory tract infections.**

Last reviewed version 2.0

Asset ID: 73

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group.

Key evidence considered:

- Pollock et al. 2017[1]
- Cates et al. 2013[2]
- Mitselou et al. 2016[3]
- Castro-Rodriguez et al. 2015[4]
- Kaashmiri et al. 2010[5]
- Chandra et al. 2005[6]
- Camargo et al. 2003[7]
- Rodrigo & Rodrigo. 2002[8]
- Travers et al. 2001[9]
- Emerman et al. 1999[10]
- Shrestha et al. 1996[11]
- Karpel et al. 1997[12]
- Kirkland et al. 2017[13]
- Pollock et al. 2017[1]
- Castro-Rodriguez et al. 2015[4]
- Vézina et al. 2014[15]
- Griffiths et al. 2013[16]

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For patients with severe acute asthma who are unable to breathe through a spacer, salbutamol can be given by intermittent nebulisation.

Table. Using nebulisers in acute asthma

Driving nebuliser
Nebulisers can be driven by air, piped oxygen, or an oxygen cylinder fitted with a high-flow regulator capable of delivering >6 L/min.
<u>Salbutamol</u>
Intermittent nebulisation with salbutamol
Use one nebule:
Adults: 5 mg nebule
Children 6 years and over: 5 mg nebule
Children aged 1-5 years: 2.5 mg nebule
Continuous nebulisation with salbutamol using nebules
Put two nebules into nebuliser chamber at a time and repeat to refill when used up.
Adults: use two 5 mg nebules (10 mg) at a time

Children 6 years and over: use two 5 mg nebules (10 mg) at a time

Children aged 1-5 years: use two 2.5 mg nebules (5 mg) at a time

Ipratropium

Add one nebule to salbutamol nebuliser solution:

Adults and children 6 years and over: 500 microg nebule
Children aged 1-5 years: 250 microg nebule

- **If using oxygen to drive a nebuliser, do not exceed 8–10 L/minute and avoid over-oxygenation (increases risk of hypercapnoea).**
- **The use of nebulisers increases the risk (to staff and patients) of nosocomial aerosol infection. If using a nebuliser, follow your organisation's infection control protocols to minimise spread of respiratory tract infections.**

Last reviewed version 2.0

Asset ID: 73

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion after literature review yielded insufficient evidence for an evidence-based recommendation

Key evidence considered:

- Pollock et al. 2017[1]
- Cates et al. 2013[2]
- Mitselou et al. 2016[3]
- Chandra et al. 2005[6]
- Camargo et al. 2003[17]
- Rodrigo & Rodrigo. 2002[8]

Last reviewed version 2.0

For patients with life-threatening asthma, deliver salbutamol via continuous nebulisation driven by oxygen until breathing improves, then consider changing to a pressurised metered-dose inhaler plus spacer or intermittent nebuliser.

Table. Using nebulisers in acute asthma

Driving nebuliser

Nebulisers can be driven by air, piped oxygen, or an oxygen cylinder fitted with a high-flow regulator capable of delivering >6 L/min.

Salbutamol

Intermittent nebulisation with salbutamol

Use one nebule:

Adults: 5 mg nebule

Children 6 years and over: 5 mg nebule

Children aged 1-5 years: 2.5 mg nebule

Continuous nebulisation with salbutamol using nebules

Put two nebules into nebuliser chamber at a time and repeat to refill when used up.

Adults: use two 5 mg nebules (10 mg) at a time

Children 6 years and over: use two 5 mg nebules (10 mg) at a time

Children aged 1-5 years: use two 2.5 mg nebules (5 mg) at a time

Ipratropium

Add one nebule to salbutamol nebuliser solution:

Adults and children 6 years and over: 500 microg nebule

Children aged 1-5 years: 250 microg nebule

- **If using oxygen to drive a nebuliser, do not exceed 8–10 L/minute and avoid over-oxygenation (increases risk of hypercapnoea).**
- **The use of nebulisers increases the risk (to staff and patients) of nosocomial aerosol infection. If using a nebuliser, follow your organisation's infection control protocols to minimise spread of respiratory tract infections.**

Last reviewed version 2.0

Asset ID: 73

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion after literature review yielded insufficient evidence for an evidence-based recommendation.

Key evidence considered:

- Camargo et al. 2003[17]
- Rodrigo & Rodrigo. 2002[8]
- Shrestha et al. 1996[11]

Last reviewed version 2.0

When using a nebuliser, follow your organisation's infection control protocols to minimise spread of respiratory tract infections.

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

To deliver intermittent nebulised bronchodilators in a patient receiving oxygen therapy, use an air-driven compressor nebuliser and administer oxygen by nasal cannulae.

Titrate oxygen to target SpO2 93–95% in adults or at least 95% in children.

If nebulised salbutamol is needed for a patient receiving supplemental oxygen, the nebuliser can be driven by piped ('wall') oxygen or an oxygen cylinder fitted with a high-flow regulator capable of delivering >6 L/min. The patient should be changed back to their original oxygen mask once nebulisation is complete.

- **In adults, avoid over-oxygenation (SpO2>95%), because this increases the risk of hypercapnoea.**

▶ **Go to:** *The Thoracic Society of Australia and New Zealand's oxygen guidelines for acute oxygen use in adults*

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available), with particular reference to named source(s):

- Beasley et al. 2015[18]

Last reviewed version 2.0

If non-invasive ventilation has been initiated, salbutamol can be delivered using any of the following options:

- **Briefly interrupt ventilation to deliver salbutamol via pressurised metered-dose inhaler and spacer.**
- **Deliver inline via pressurised metered-dose inhaler.**

Attach nebuliser to the ventilator circuit with the expiration port between the facemask and nebuliser.

- **Do not sedate patient**
- **If no improvement, intubate and start mechanical ventilation**

Note: Non-invasive positive pressure ventilation can be considered if patient is starting to tire, or develops type 2 respiratory failure. Mechanical ventilation should be used for patients with respiratory arrest, acute respiratory failure that does not respond to treatment, or failure to respond to noninvasive positive pressure ventilation.

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available), with particular reference to named source(s):

- Calvert et al. 2006[19]

Last reviewed version 2.0

Do not give oral salbutamol.

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available), with particular reference to named source(s):

- Graig et al. 2016[20]
- Herd 2011[21]

Last reviewed version 2.0

Do not routinely use IV short-acting beta$_2$ agonists.

Note: IV salbutamol can be considered in critical care units for patients with life-threatening acute asthma that has not responded to continuous nebulised salbutamol, after considering other add-on treatment options.

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group.

Key evidence considered:

- Travers et al. 2012[22]
- Travers et al. 2012[23]
- Travers et al. 2001[9]
- Bogie et al. 2007[24]

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More information

Salbutamol in acute asthma

Route of administration
Inhaler plus spacer, or nebuliser

Among patients with acute asthma who do not require mechanical ventilation, salbutamol delivered via a pressurised metered-dose inhaler with spacer is at least as effective as salbutamol delivered via nebuliser in preschool children (with viral-induced wheezing or acute asthma)[3] and adults,[2526] and is equivalent or superior in school-aged children.[4, 2, 1, [REFERENCE991]]

The use of nebulisers increases the risk of transmitting respiratory infections to staff and other patients,[27] and increases the risk of adverse effects.

Intravenous salbutamol

IV salbutamol is generally reserved for use in patients with severe acute asthma that does not respond to inhaled bronchodilators.

Efficacy

Overall, intravenous short-acting beta$_2$ agonists do not appear to be superior to inhaled short-acting beta$_2$ agonist.[28]

Adults

Benefits have not been demonstrated in adults.[28]

Children

Very limited evidence from one study suggested that the addition of IV salbutamol to inhaled salbutamol reduced recovery time in children with severe acute asthma in the emergency department.[28]

However, there is a lack of consensus on the appropriate dose of IV salbutamol for children.[29] Recommendations differ between guidelines in Australia[30] and elsewhere.[29] Doses have not been calculated based on age-specific pharmacokinetic and pharmacodynamic data. The doses recommended in guidelines are generally relatively higher than for adults on a micrograms per kilogram body weight basis.

Adverse effects

Compared with inhaled salbutamol, intravenous salbutamol is associated with increased risk of adverse effects including tremor and hypokalaemia.[28, 29] Concomitant use of the inhalation and IV routes may increase the risk of salbutamol toxicity.[31]

Note: Salbutamol concentrate for infusion is available in 5 mL ampoules containing salbutamol sulfate equivalent to 5 mg (1 mg/mL) salbutamol in a sterile isotonic solution (*Ventolin obstetric injection*). Salbutamol for injection is also available in ampoules of salbutamol sulphate equivalent to 500 microg salbutamol in 1 mL sterile isotonic solution (*Ventolin injection*).

Salbutamol dosing regimens

There is very little evidence from clinical trials to guide dosing intervals for salbutamol treatment in acute asthma.

One placebo-controlled study conducted in the emergency department among adults with acute asthma (FEV_1 <60% predicted or normal) showed that, in those who did not show a clear response to the first salbutamol dose, repeating the dose at intervals of 30 minutes or less was more effective than every 60 minutes.[12] However, for patients who showed clear improvement after the first dose of salbutamol via pressurised metered-dose inhaler and spacer, there was no advantage in repeating the dose more often than every 60 minutes until full recovery (extra doses can be given as needed).[12]

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Ipratropium in acute asthma

Adults

In adults and older adolescents with severe acute asthma treated in the emergency department, the combination of ipratropium and short-acting beta$_2$ agonist reduces hospitalisation rate and improves lung function, compared with short-acting beta$_2$ agonist alone.[13] Hospitalisation rates are not reduced in patients with mild or moderate acute asthma.[13]

In adults, the combination of ipratropium and short-acting beta$_2$ agonist is associated with a higher rate of adverse effects (e.g. tremor, agitation, and palpitations) than short-acting beta$_2$ agonist alone.[13]

Children

Recent systematic reviews have reported that initial treatment with ipratropium in addition to salbutamol markedly reduces hospitalisation rate and improves clinical scores in children with moderate to severe acute asthma.[4, 1, 16]

However, in children hospitalised due to acute asthma, the combination of ipratropium and short-acting beta$_2$ agonist was not more effective than short-acting beta$_2$ agonist alone.[15]

The combination of ipratropium and short-acting beta$_2$ agonist appears to be well tolerated in children.[16]

Ipratropium bromide alone is less effective than salbutamol alone in acute asthma.[32]

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Oxygen therapy in acute asthma

Oxygen is a treatment for hypoxaemia, not breathlessness.[18] Oxygen has not been shown to improve the sensation of breathlessness in non-hypoxaemic patients.[18] When oxygen supplementation is used, pulse oximetry is necessary to monitor oxygen status and titrate to target.

The aim of titrated oxygen therapy in acute care is to achieve adequate oxygen saturation without causing hypercapnoea.[18] Adults with acute asthma and those with overlapping asthma and COPD are at greater risk of hypercapnoeic respiratory failure.

Drying of the upper airway is a potential complication of oxygen therapy,[33, 34] and might contribute to bronchoconstriction.[34]

Few studies have investigated optimal oxygen supplementation protocols for patients with asthma.

Adults

In adults with acute asthma, titrated oxygen therapy using pulse oximetry to maintain oxygen saturation at 93–95% while avoiding hyperoxaemia achieves better physiological outcomes than 100% oxygen at high flow rate (8 L/min).[35] High-concentration and high-flow oxygen therapy cause a clinically significant increase in blood CO_2 concentration in adults with acute asthma.[35, 36]

Thoracic Society of Australia and New Zealand (TSANZ) clinical practice guidelines for acute oxygen use in adults[18] recommend that, in patients with COPD, oxygen should be administered if the SpO_2 is less than 88%, and titrated to a target SpO2 range of 88–92%. For other acute medical conditions, the TSANZ guidelines recommend that oxygen should be administered if the SpO_2 is less than 92%, and titrated to a target SpO_2 range of 92–96%.

Humidification of oxygen via high flow nasal cannulae may improve comfort and tolerance.[18]

▶ Go to: Thoracic Society of Australia and New Zealand (TSANZ's) *clinical practice guidelines for acute oxygen use in adults*

Children

There is very little evidence available to inform recommendations for oxygen saturation targets in children with asthma.[37] Studies in infants with bronchiolitis suggest that targets as low as >90%[38] or >92%[39] may be achieve similar clinical outcomes as higher targets. Recommendations for oxygen saturation targets during supplemental oxygen vary between clinical guidelines and vary between protocols used in Australian hospitals.

Humidified oxygen can be considered if necessary. Humidification is usually not needed for low flow oxygen (<4 L/minute in children or 2 L/minute in infants) for short term. Humidification may be considered if the oxygen is required for longer than 48 hours or if the nasal passages are becoming uncomfortable or dry.[33]

Guidance on oxygen delivery techniques and practical issues is available from Sydney Children's Hospital Network and The Royal Children's Hospital Melbourne.

▶ Go to: Sydney Children's Hospitals Network resource on *oxygen therapy and delivery devices*
Go to: The Royal Children's Hospital Melbourne guideline on *Oxygen delivery*

Humidified oxygen via high-flow nasal cannulae

Humidified high flow nasal oxygen is a system that has the ability to provide a humidified high-flow mix of air and oxygen via a specialised nasal cannula system. It is able to deliver positive end expiratory pressure of approximately 4–8 cm H_20.

Delivery of high-flow oxygen via nasal cannulae is increasingly common practice in Australian emergency rooms. There is very little evidence to support its use in acute asthma treatment,[18] but it does not appear to be associated with significant risks.

It has been reported to be feasible and safe in children with severe acute asthma in ICU,[40] and at least as effective as conventional oxygen therapy in children with acute asthma with inadequate response to initial bronchodilator treatment.[40] No published studies have evaluated its use in adults with acute asthma.

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Heliox in acute asthma

The rationale for its use of heliox (mixture of helium and oxygen in various proportions) in patients with asthma is that the low density may improve airflow in the presence of turbulence within the airways.[41] It has negligible adverse effects.[41]

When giving nebulised bronchodilators in acute asthma, the use of heliox to drive the nebuliser may be more effective than oxygen for

improving lung function and reducing hospital admission rates in adults and children.[42, 4] However, overall evidence for benefits in the treatment of children with acute asthma is inconclusive.[41]

Heliox may not have any benefit for patients with severe asthma requiring mechanical ventilation.[43]

Heliox is not commonly used in Australian emergency departments and is not routinely available.

Last reviewed version 2.0

Technical notes: pressurised metered-dose inhalers with spacers

Manufacturers of most pressurised metered-dose delivery devices recommend shaking the device before actuating. The physical characteristics of each formulation, including the effects of shaking, differ widely,[44] but for simplicity it is best always to recommend shaking of pressurised metered-dose inhalers.

Pressurised metered-dose inhalers (except for those that are breath-actuated) can be used with a spacer. When a spacer is used with a pressurised metered-dose inhaler, delivery of the medicine to the patient's airways is maximised when the patient takes a slow, deep breath from the spacer after each actuation.[45, 36] Multiple actuations of a pressurised metered-dose inhaler into a spacer can reduce the amount of respirable medicine available because aerosol particles can agglomerate into larger particles or become attached to the spacer walls.[45]

Therefore, the ideal way to deliver inhaled medicines via pressurised metered-dose inhaler and spacer is to shake the device, ask the person to breathe out all the way into the spacer, actuate a single puff into the spacer, and have the person immediately take a slow deep breath from the spacer, then hold their breath for 5 seconds. This process should be repeated until the total intended number of actuations is taken. Patients should be trained to follow these instructions when using their inhalers. Inhaling slowly with a single breath maximises delivery of the medicine to the lungs and minimises deposition in the upper airways when using a manually actuated pressurised metered-dose inhaler with or without a spacer, or when using a breath-actuated pressurised metered-dose inhaler.[46] However, slow breathing may not be possible for patients with acute asthma. Tidal breathing through the spacer (e.g. four breaths in and out without removing the spacer) is used in acute asthma and for very young children. First aid instructions should include how to use inhaler and spacer.

In practice, optimal delivery of inhaled medicines involves a balance between maximising the proportion of respirable medicine and maximising efficiency of inhalation by the patient within real-world constraints. The optimal delivery of salbutamol in real-world circumstances is not well defined. For day-to-day use of salbutamol, most adults gain sufficient relief from symptoms when using a pressurised metered-dose inhaler on its own. A spacer may only be needed during a flare-up. By contrast, the use of a spacer is always recommended for inhaled corticosteroids delivered by manually actuated pressurised metered-dose inhalers, to reduce the risk of local adverse effects and increase delivery to the airways.

Many available in vitro studies of aerosol particle deposition in the airways were performed using older CFC-propelled formulations, which are now obsolete. Similar studies have not been performed for current non-CFC pressurised metered-dose inhalers.

▶ Go to: National Asthma Council Australia's *first aid charts*

Last reviewed version 2.0

References

1. Pollock M, Sinha IP, Hartling L et al. Inhaled short-acting bronchodilators for managing emergency childhood asthma: an overview of reviews. *Allergy*. 2017; 72: 183-200. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27588581
2. Cates CJ, Welsh EJ, Rowe BH. Holding chambers (spacers) versus nebulisers for beta-agonist treatment of acute asthma. *Cochrane Database Syst Rev*. 2013; 9: Cd000052. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24037768
3. Mitselou N, Hedlin G, Hederos CA. Spacers versus nebulizers in treatment of acute asthma - a prospective randomized study in preschool children. *J Asthma*. 2016; 53: 1059-62. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27186989
4. Castro-Rodriguez, J. A., Rodrigo, G. J., Rodriguez-Martinez, C. E.. Principal findings of systematic reviews for chronic treatment in childhood asthma. *J Asthma*. 2015; 52: 1038-45. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26303207
5. Kaashmiri, M, Shepard, J, Goodman, B, *et al*. Repeat dosing of albuterol via metered-dose inhaler in infants with acute obstructive airway disease: a randomized controlled safety trial. *Pediatr Emerg Care*. 2010; 26: 197-202. Available from: https://www.ncbi.nlm.nih.gov/pubmed/20179658
6. Chandra, A, Shim, C, Cohen, H W, *et al*. Regular vs ad-lib albuterol for patients hospitalized with acute asthma. *Chest*. 2005; 128: 1115-1120. Available from: https://www.ncbi.nlm.nih.gov/pubmed/16162695
7. Camargo CA, Spooner C, Rowe BH. Continuous versus intermittent beta-agonists for acute asthma. *Cochrane Database Syst Rev*. 2003; Issue 4: CD001115. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD001115/full
8. Rodrigo, G J, Rodrigo, C. Continuous vs intermittent beta-agonists in the treatment of acute adult asthma: a systematic review with meta-analysis. *Chest*. 2002; 122: 160-165. Available from: https://www.ncbi.nlm.nih.gov/pubmed/12114352
9. Travers, A A, Jones, A P, Kelly, K D, *et al*. Intravenous beta2-agonists for acute asthma in the emergency department. *Cochrane*

Database Syst Rev. 2001; Issue 1: CD002988. Available from: http://cochranelibrary-wiley.com/doi/10.1002/14651858.CD002988/full
10. Emerman, C L, Cydulka, R K, McFadden, E R. Comparison of 2.5 vs 7.5 mg of inhaled albuterol in the treatment of acute asthma. *Chest*. 1999; 115: 92-96. Available from: https://www.ncbi.nlm.nih.gov/pubmed/9925067
11. Shrestha, M, Bidadi, K, Gourlay, S, Hayes, J. Continuous vs intermittent albuterol, at high and low doses, in the treatment of severe acute asthma in adults. *Chest*. 1996; 110: 42-47. Available from: https://www.ncbi.nlm.nih.gov/pubmed/8681661
12. Karpel JP, Aldrich TK, Prezant DJ, *et al*. Emergency treatment of acute asthma with albuterol metered-dose inhaler plus holding chamber: how often should treatments be administered?. *Chest*. 1997; 112: 348-356. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9266868
13. Kirkland SW, Vandenberghe C, Voaklander B et al. Combined inhaled beta-agonist and anticholinergic agents for emergency management in adults with asthma. *Cochrane Database Syst Rev*. 2017; Issue 1: CD001284. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28076656
14. Capsomidis, A., Tighe, M.. Archimedes. Question 2. Is oral montelukast beneficial in treating acute asthma exacerbations in children?. *Arch Dis Child*. 2010; 95: 948-50. Available from: http://adc.bmj.com/content/95/11/948.long
15. Vezina K, Chauhan BF, Ducharme FM. Inhaled anticholinergics and short-acting beta(2)-agonists versus short-acting beta2-agonists alone for children with acute asthma in hospital.*Cochrane Database Syst Rev*. 2014; Issue 7: CD010283. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25080126/
16. Griffiths B, Ducharme FM. Combined inhaled anticholinergics and short-acting beta2-agonists for initial treatment of acute asthma in children. *Cochrane Database Syst Rev*. 2013: Cd000060. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23966133
17. Camargo, C A, Spooner, Catherine, Rowe, B H. Continuous versus intermittent beta-agonists for acute asthma. *Cochrane Database Syst Rev*. 2003; Issue 4: . Available from: https://www.ncbi.nlm.nih.gov/pubmed/14583926
18. Beasley R, Chien J, Douglas J et al. Thoracic Society of Australia and New Zealand oxygen guidelines for acute oxygen use in adults: 'Swimming between the flags". *Respirology*. 2015; 20: 1182–91. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26486092/
19. Calvert, L D, Jackson, J M, White, J A, *et al*. Enhanced delivery of nebulised salbutamol during non-invasive ventilation. *J Pharm Pharmacol*. 2006; 58: 1553-1557. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17132219
20. Craig, S, Tuszynski, M, Armstrong, D. It is time to stop prescribing oral salbutamol. *Aust Prescr*. 2016; 45: 245-247. Available from: https://www.racgp.org.au/afp/2016/april/it-is-time-to-stop-prescribing-oral-salbutamol/
21. Herd D. Oral versus inhaled salbutamol for acute paediatric asthma. *Best Bets [serial on the Internet]*. 2011: Available from: https://bestbets.org/bets/bet.php?id=2283/
22. Travers, A H, Milan, S J, Jones, A P, *et al*. Addition of intravenous beta. *Cochrane Database Syst Rev*. 2012; Issue 12: CD010179. Available from: http://cochranelibrary-wiley.com/doi/10.1002/14651858.CD010179/full
23. Travers AH, Jones AP, Camargo CA et al. Intravenous beta2-agonists versus intravenous aminophylline for acute asthma. *Cochrane Database Syst Rev* 2012; Issue 12: CD010256. Available from:https://www.ncbi.nlm.nih.gov/pubmed/23235686/
24. Bogie, A L, Towne, D, Luckett, P M, *et al*. Comparison of intravenous terbutaline versus normal saline in pediatric patients on continuous high-dose nebulized albuterol for status asthmaticus. *Pediatr Emerg Care*. 2007; 23: 355-361. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17572517
25. Cates CJ, Crilly JA, Rowe BH. Holding chambers (spacers) versus nebulisers for beta-agonist treatment of acute asthma. *Cochrane Database Syst Rev*. 2006; Issue 2: CD000052. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD000052.pub2/full
26. Dhuper S, Chandra A, Ahmed A, *et al*. Efficacy and cost comparisons of bronchodilatator administration between metered dose inhalers with disposable spacers and nebulizers for acute asthma treatment. *J Emerg Med*. 2011; 40: 247-55. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19081697
27. Tran K, Cimon K, Severn M et al. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One*. 2012; 7: e35797. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22563403
28. Travers AH, Milan SJ, Jones AP, *et al*. Addition of intravenous beta(2)-agonists to inhaled beta(2)-agonists for acute asthma. *Cochrane Database Syst Rev*. 2012; 12: CD010179. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD010179/full
29. Starkey ES, Mulla H, Sammons HM, Pandya HC. Intravenous salbutamol for childhood asthma: evidence-based medicine?. *Arch Dis Child*. 2014; 99: 873-877. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24938536
30. Babl FE, Sheriff N, Borland M, *et al*. Paediatric acute asthma management in Australia and New Zealand: practice patterns in the context of clinical practice guidelines. *Arch Dis Child*. 2008; 93: 307-312. Available from: http://adc.bmj.com/content/93/4/307.abstract
31. Abramson MJ, Bailey MJ, Couper FJ, *et al*. Are asthma medications and management related to deaths from asthma?. *Am J Respir Crit Care Med*. 2001; 163: 12-18. Available from: http://www.ncbi.nlm.nih.gov/pubmed/11208619
32. Teoh L, Cates CJ, Hurwitz M, *et al*. Anticholinergic therapy for acute asthma in children. *Cochrane Database Syst Rev*. 2012; 4: CD003797. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD003797.pub2/full
33. Sydney Children's Hospital. *Oxygen therapy and delivery devices – SCH. Practice guideline. Guideline No: 0/C/13:7019-01:00*. Sydney Children's Hospital Westmead, Sydney, 2013. Available from: http://www.chw.edu.au/about/policies/alphabetical.htm
34. The Royal Children's Hospital of Melbourne, Oxygen Delivery. *Clinical Guidelines (Nursing)*, The Royal Children's Hospital 2013. Available from: http://www.rch.org.au/rchcpg/hospital*clinical*guideline*index/Oxygen*delivery/
35. Perrin K, Wijesinghe M, Healy B, *et al*. Randomised controlled trial of high concentration versus titrated oxygen therapy in severe exacerbations of asthma. *Thorax*. 2011; 66: 937-41. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21597111
36. Rau JL, Restrepo RD, Deshpande V. Inhalation of single vs multiple metered-dose bronchodilator actuations from reservoir devices

: An in vitro study. *Chest*. 1996; 109: 969-974. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8635379
37. Tosif S, Duke T. Evidence to support oxygen guidelines for children with emergency signs in developing countries: a systematic review and physiological and mechanistic analysis. *J Trop Pediatr*. 2017; 63: 402-13. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28158795
38. Cunningham S, Rodriguez A, Adams T et al. Oxygen saturation targets in infants with bronchiolitis (BIDS): a double-blind, randomised, equivalence trial. *Lancet*. 2015; 386: 1041-8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26382998
39. Franklin D, Babl FE, Schlapbach LJ et al. A randomized trial of high-flow oxygen therapy in infants with bronchiolitis. *N Engl J Med*. 2018; 378: 1121-31. Available from:https://www.ncbi.nlm.nih.gov/pubmed/29562151/
40. Ballestero Y, De Pedro J, Portillo N et al. Pilot clinical trial of high-flow oxygen therapy in children with asthma in the emergency service. *J Pediatr*. 2018; 194: 204-10.e3. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29331328/
41. Rehder KJ. Adjunct therapies for refractory status asthmaticus in children. *Respir Care* 2017; 62: 849-65. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28546381/
42. Rodrigo GJ, Castro-Rodriguez JA. Heliox-driven beta2-agonists nebulization for children and adults with acute asthma: a systematic review with meta-analysis. *Ann Allergy Asthma Immunol*. 2014; 112: 29-34. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24331390
43. Leatherman JW, Romero RS, Shapiro RS. Lack of benefit of Heliox during mechanical ventilation of subjects with severe air-flow obstruction. *Respir Care*. 2018; 63: 375-9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29279363
44. Cyr TD, Graham SJ, Li KY, Levering EG. Low first-spray drug content in albuterol metered-dose inhalers. *Pharm Res*. 1991; 8: 658-660. Available from: http://link.springer.com/article/10.1023/A:1015825311750
45. Barry PW, O'Callaghan C. Multiple actuations of salbutamol MDI into a spacer device reduce the amount of drug recovered in the respirable range. *Eur Respir J*. 1994; 7: 1707-1709. Available from: http://www.ncbi.nlm.nih.gov/pubmed/7995401
46. Laube BL, Janssens HM, de Jongh FHC, *et al*. What the pulmonary specialist should know about the new inhalation therapies. *Eur Respir J*. 2011; 37: 1308-1417. Available from: http://erj.ersjournals.com/content/37/6/1308.full

Completing secondary assessments and reassessing severity

Recommendations

When practical after starting treatment, complete clinical assessments and reassess severity.

Table. Secondary severity assessment of acute asthma in adults and children 6 years and over

Please view and print this figure separately: http://www.asthmahandbook.org.au/table/show/63

Table. Secondary severity assessment of acute asthma in children aged 1-5 years

Please view and print this figure separately: http://www.asthmahandbook.org.au/table/show/64

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

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Complete a brief history, including:

- **reliever taken for this episode (dose, number of doses, time of last dose)**
- **current asthma medicines (regular and as-needed, including type of devices used)**
- **assessment of adherence to preventer (if prescribed)**
- **what triggered this episode, if known (e.g. allergies, immediate hypersensitivity, medicines, respiratory infections**
- **coexisting heart or lung disease, including chronic obstructive pulmonary disease**
- **assess smoking status and exposure to second-hand smoke.**

- **acute asthma is rarely triggered by food allergies, but confirmed food allergy is a recognised risk factor for asthma-related death.**

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

In adults, start oxygen therapy if SpO_2 <92%.

Titrate to target SpO_2 93–95%

- **In adults, avoid over-oxygenation (SpO_2 >95%), because this increases the risk of hypercapnoea.**

▶ Go to: The Thoracic Society of Australia and New Zealand *oxygen guidelines for acute oxygen use in adults*

How this recommendation was developed

Adapted from existing guidance

Based on reliable clinical practice guideline(s) or position statement(s):

- Beasley et al. 2015[1]

Last reviewed version 2.0

In children, start oxygen therapy if SpO_2 <95%.

Titrate to target SpO_2 >95%.

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

Arrange chest X-ray if pneumonia, atelectasis, pneumothorax or pneumomediastinum is suspected.

Note: Chest X-ray is not needed in most cases of acute asthma

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

Consider arterial blood gas analysis for adults with SpO_2 <92%.

- **The risk of hypercapnoea is increased in older adults with asthma or asthma–COPD overlap.**

How this recommendation was developed

Adapted from existing guidance

Based on reliable clinical practice guideline(s) or position statement(s)

- Beasley et al. 2015[1]

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More information

Assessment of oxygen status in acute asthma

Hypoxia is the main cause of deaths due to acute asthma.[2]

Routine objective assessment of oxygen saturation at initial assessment of acute asthma is needed because clinical signs may not correlate with hypoxaemia.

Pulse oximetry is the internationally accepted method for routine assessment of oxygen status in patients with acute asthma. It should be available in all situations in which oxygen is used.[1]

Pulse oximetry does not detect hypercapnoea, so blood gas analysis is necessary if hypercapnoea is suspected in patients with severe or life-threatening acute asthma. Thoracic Society of Australia and New Zealand clinical practice guidelines for acute oxygen use in adults[1] recommend that arterial blood gas analysis should be considered if oxygen saturation falls below 92% and in those at risk of hypercapnoea. Venous blood gas analysis can be used to assess acid–base balance and lactate,[1] but performs poorly in identifying hypercapnoea.[3]

▶ Go to: Thoracic Society of Australia and New Zealand (TSANZ's) *clinical practice guidelines for acute oxygen use in adults*

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Oxygen therapy in acute asthma

Oxygen is a treatment for hypoxaemia, not breathlessness.[1] Oxygen has not been shown to improve the sensation of breathlessness in non-hypoxaemic patients.[1] When oxygen supplementation is used, pulse oximetry is necessary to monitor oxygen status and titrate to target.

The aim of titrated oxygen therapy in acute care is to achieve adequate oxygen saturation without causing hypercapnoea.[1] Adults with acute asthma and those with overlapping asthma and COPD are at greater risk of hypercapnoeic respiratory failure.

Drying of the upper airway is a potential complication of oxygen therapy,[4, 5] and might contribute to bronchoconstriction.[5]

Few studies have investigated optimal oxygen supplementation protocols for patients with asthma.

Adults

In adults with acute asthma, titrated oxygen therapy using pulse oximetry to maintain oxygen saturation at 93–95% while avoiding hyperoxaemia achieves better physiological outcomes than 100% oxygen at high flow rate (8 L/min).[6] High-concentration and high-flow oxygen therapy cause a clinically significant increase in blood CO_2 concentration in adults with acute asthma.[6, 7]

Thoracic Society of Australia and New Zealand (TSANZ) clinical practice guidelines for acute oxygen use in adults[1] recommend that, in patients with COPD, oxygen should be administered if the SpO_2 is less than 88%, and titrated to a target SpO2 range of 88–92%. For other acute medical conditions, the TSANZ guidelines recommend that oxygen should be administered if the SpO_2 is less than 92%, and titrated to a target SpO_2 range of 92–96%.

Humidification of oxygen via high flow nasal cannulae may improve comfort and tolerance.[1]

▶ Go to: Thoracic Society of Australia and New Zealand (TSANZ's) *clinical practice guidelines for acute oxygen use in adults*

Children

There is very little evidence available to inform recommendations for oxygen saturation targets in children with asthma.[8] Studies in infants with bronchiolitis suggest that targets as low as >90%[9] or >92%[10] may be achieve similar clinical outcomes as higher targets. Recommendations for oxygen saturation targets during supplemental oxygen vary between clinical guidelines and vary between protocols used in Australian hospitals.

Humidified oxygen can be considered if necessary. Humidification is usually not needed for low flow oxygen (<4 L/minute in children or 2 L/minute in infants) for short term. Humidification may be considered if the oxygen is required for longer than 48 hours or if the nasal passages are becoming uncomfortable or dry.[4]

Guidance on oxygen delivery techniques and practical issues is available from Sydney Children's Hospital Network and The Royal Children's Hospital Melbourne.

▶ Go to: Sydney Children's Hospitals Network resource on *oxygen therapy and delivery devices*
Go to: The Royal Children's Hospital Melbourne guideline on *Oxygen delivery*

Humidified oxygen via high-flow nasal cannulae

Humidified high flow nasal oxygen is a system that has the ability to provide a humidified high-flow mix of air and oxygen via a specialised nasal cannula system. It is able to deliver positive end expiratory pressure of approximately 4–8 cm H_20.

Delivery of high-flow oxygen via nasal cannulae is increasingly common practice in Australian emergency rooms. There is very little evidence to support its use in acute asthma treatment,[1] but it does not appear to be associated with significant risks.

It has been reported to be feasible and safe in children with severe acute asthma in ICU,[11] and at least as effective as conventional oxygen therapy in children with acute asthma with inadequate response to initial bronchodilator treatment.[11] No published studies have evaluated its use in adults with acute asthma.

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Heliox in acute asthma

The rationale for its use of heliox (mixture of helium and oxygen in various proportions) in patients with asthma is that the low density may improve airflow in the presence of turbulence within the airways.[12] It has negligible adverse effects.[12]

When giving nebulised bronchodilators in acute asthma, the use of heliox to drive the nebuliser may be more effective than oxygen for improving lung function and reducing hospital admission rates in adults and children.[13, 14] However, overall evidence for benefits in the

treatment of children with acute asthma is inconclusive.[12]

Heliox may not have any benefit for patients with severe asthma requiring mechanical ventilation.[15]

Heliox is not commonly used in Australian emergency departments and is not routinely available.

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Spirometry in acute asthma

Spirometry is used alongside clinical assessment and oximetry to assess severity of acute asthma and response to treatment. Clinical assessment alone may underestimate the severity of airflow limitation.[16]

However, no recent clinical trials have compared outcomes of spirometry-guided treatment of acute asthma with non-spirometry-guided treatment.

A study in adults with acute asthma found that, on its own, FEV_1 (measured by spirometry) at 1 hour after admission to the emergency department did not closely correlate with clinicians' decision for or against hospital admission, as assessed clinically.[16] However, the combination at 1 hour of FEV_1 and the patient's ability to lie flat was significantly predictive of the decision for hospital admission.[16]

In adults with poor response to initial bronchodilator treatment, dyspnoea scores at 3 hours from presentation may predict relapse or clinicians' assessment of the need for hospitalisation better than FEV_1, but neither is a strong predictor.[17]

In children with acute asthma, clinical severity scores may be more sensitive than spirometry to detect change clinical status beyond the first 2 hours of treatment.[18] The value of performing spirometry in children before hospital discharge is unclear.[19]

Feasibility and technique

Although some clinical guidelines recommend spirometry before treatment to assess baseline lung function, most children with severe acute asthma and many with mild-to-moderate acute asthma cannot perform spirometry at this time.[20] Younger children (most children under 6 years) are unlikely to be able to perform spirometry, even when they do not have a flare-up.

Most adults with acute asthma can perform spirometry within the first hour of admission to the emergency department.[21] (Hospital staff and primary care health professionals may need specific training in spirometry technique to be able to obtain acceptable spirometry in patients with acute asthma.[21])

It may not be feasible to apply standard spirometry technique and manoeuvre acceptability criteria in patients with acute asthma:[20, 21]

- 80% of patients older than 12 years with acute asthma can perform an FEV_1 manoeuvre. A forced exhalation from total lung capacity for 2 seconds is sufficient and provides useful information about the severity of airflow obstruction
- two attempts may suffice if patients are unable to make three attempts
- variability between manoeuvres of < 10% should be considered acceptable
- patients may not be able to tolerate nose clips
- patients are unlikely to be able to exhale for long enough to demonstrate the time-volume plateau. Although patients should aim for forced exhalation of at least 6 seconds, 2 seconds is acceptable for measuring FEV_1 in clinical assessment during acute asthma. A spirometry manoeuvre might be considered acceptable if back-extrapolated volume is either < 5% of FVC or 0.15 L (whichever is greater), or a time to peak flow < 120 ms.

Table. Tips for performing spirometry in patients with acute asthma

- Ask the patient to sit straight upright, either in a chair or on a stretcher with their legs over the side.
- Make sure the person forms a tight seal around the mouthpiece.
- Tell the patient to take as deep a breath as possible, then blast out air as fast and hard as they can, then keep blowing until asked to stop. Aim for exhalation of maximal force for at least 2 seconds (6 seconds if FVC is measured).

You may need to give the patient lots of coaching, repeat instructions, and give immediate feedback on technique.

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Peak expiratory flow measurement in acute asthma

Peak expiratory flow rate obtained using a peak flow meter underestimates the severity of airflow limitation in patients with acute asthma, compared with FEV_1 obtained by spirometry.[22]

Peak expiratory flow is not a sensitive measure of small clinical improvements as perceived by the patient.[23]

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Instruments for assessing acute asthma

Validated scoring systems for assessing the severity of acute asthma, response to treatment, and predicting the need for hospital admission are used in research studies and by some clinicians. These include:

- Pediatric Respiratory Assessment Measure (PRAM)[24] for assessing acute asthma severity and response to treatment in children and adolescents, based on oxygen saturation, effort of breathing (suprasternal retraction and scalene muscle contraction), air entry (assessed by auscultation of the chest) and wheezing
- the CHOP classification tree for predicting need for hospitalisation in adults,[25] based on change in peak expiratory flow severity category, history of acute admission for asthma ('ever hospitalisation'), oxygen saturation while breathing room air, and initial peak expiratory flow.

These instruments are not routinely used in Australian emergency departments.

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References

1. Beasley R, Chien J, Douglas J et al. Thoracic Society of Australia and New Zealand oxygen guidelines for acute oxygen use in adults: 'Swimming between the flags". *Respirology*. 2015; 20: 1182–91. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26486092/
2. Hodder R, Lougheed MD, Rowe BH, *et al*. Management of acute asthma in adults in the emergency department: nonventilatory management. *CMAJ*. 2010; 182: E55-67. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2817338/
3. Byrne AL, Bennett M, Chatterji R et al. Peripheral venous and arterial blood gas analysis in adults: are they comparable? A systematic review and meta-analysis. *Respirology*. 2014; 19: 168-75. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24383789
4. Sydney Children's Hospital. *Oxygen therapy and delivery devices – SCH. Practice guideline. Guideline No: 0/C/13:7019-01:00*. Sydney Children's Hospital Westmead, Sydney, 2013. Available from: http://www.chw.edu.au/about/policies/alphabetical.htm
5. The Royal Children's Hospital of Melbourne, Oxygen Delivery. *Clinical Guidelines (Nursing)*, The Royal Children's Hospital 2013. Available from: http://www.rch.org.au/rchcpg/hospital*clinical*guideline*index/Oxygen*delivery/
6. Perrin K, Wijesinghe M, Healy B, *et al*. Randomised controlled trial of high concentration versus titrated oxygen therapy in severe exacerbations of asthma. *Thorax*. 2011; 66: 937-41. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21597111
7. Rau JL, Restrepo RD, Deshpande V. Inhalation of single vs multiple metered-dose bronchodilator actuations from reservoir devices : An in vitro study. *Chest*. 1996; 109: 969-974. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8635379
8. Tosif S, Duke T. Evidence to support oxygen guidelines for children with emergency signs in developing countries: a systematic review and physiological and mechanistic analysis. *J Trop Pediatr*. 2017; 63: 402-13. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28158795
9. Cunningham S, Rodriguez A, Adams T et al. Oxygen saturation targets in infants with bronchiolitis (BIDS): a double-blind, randomised, equivalence trial. *Lancet*. 2015; 386: 1041-8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26382998
10. Franklin D, Babl FE, Schlapbach LJ et al. A randomized trial of high-flow oxygen therapy in infants with bronchiolitis. *N Engl J Med*. 2018; 378: 1121-31. Available from:https://www.ncbi.nlm.nih.gov/pubmed/29562151/
11. Ballestero Y, De Pedro J, Portillo N et al. Pilot clinical trial of high-flow oxygen therapy in children with asthma in the emergency service. *J Pediatr*. 2018; 194: 204-10.e3. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29331328/
12. Rehder KJ. Adjunct therapies for refractory status asthmaticus in children. *Respir Care* 2017; 62: 849-65. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28546381/
13. Rodrigo GJ, Castro-Rodriguez JA. Heliox-driven beta2-agonists nebulization for children and adults with acute asthma: a systematic review with meta-analysis. *Ann Allergy Asthma Immunol*. 2014; 112: 29-34. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24331390
14. Castro-Rodriguez, J. A., Rodrigo, G. J., Rodriguez-Martinez, C. E.. Principal findings of systematic reviews for chronic treatment in childhood asthma. *J Asthma*. 2015; 52: 1038-45. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26303207
15. Leatherman JW, Romero RS, Shapiro RS. Lack of benefit of Heliox during mechanical ventilation of subjects with severe air-flow obstruction. *Respir Care*. 2018; 63: 375-9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29279363
16. Wilson MM, Irwin RS, Connolly AE, *et al*. A prospective evaluation of the 1-hour decision point for admission versus discharge in acute asthma. *J Intensive Care Med*. 2003; 18: 275-285. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15035763
17. Schneider JE, Lewis LM, Ferguson I et al. Repeated dyspnea score and percent FEV1 are modest predictors of hospitalization/relapse in patients with acute asthma exacerbation. *Respir Med* 2014; 108: 1284-91. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25087835/
18. Arnold DH, Gebretsadik T, Hartert TV. Spirometry and PRAM severity score changes during pediatric acute asthma exacerbation treatment in a pediatric emergency department. *J Asthma* 2013; 50: 204-8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23259729/

19. Tan CC, McDowell KM, Fenchel M et al. Spirometry use in children hospitalized with asthma. *Pediatr Pulmonol* 2014; 49: 451-7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24000189/
20. Arnold DH, Gebretsadik T, Abramo TJ, Hartert TV. Noninvasive testing of lung function and inflammation in pediatric patients with acute asthma exacerbations. *J Asthma*. 2012; 49: 29-35. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22133263
21. Silverman RA, Flaster E, Enright PL, Simonson SG. FEV1 performance among patients with acute asthma: results from a multicenter clinical trial. *Chest*. 2007; 131: 164-171. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17218571
22. Choi IS, Koh YI, Lim H. Peak expiratory flow rate underestimates severity of airflow obstruction in acute asthma. *Korean J Intern Med*. 2002; 17: 174-179. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12298428
23. Karras DJ, Sammon ME, Terregino CA, *et al*. Clinically meaningful changes in quantitative measures of asthma severity. *Acad Emerg Med*. 2000; 7: 327-334. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.1553-2712.2000.tb02231.x/abstract
24. Szefler, SJ, Phillips, BR, Martinez, FD, *et al*. Characterization of within-subject responses to fluticasone and montelukast in childhood asthma. *J Allergy Clin Immunol*. 2005; 115: 233-242. Available from: https://www.ncbi.nlm.nih.gov/pubmed/15696076
25. Basheti, IA; Obeidat, NM; Reddel, HK;. Effect of novel inhaler technique reminder labels on the retention of inhaler technique skills in asthma: a single-blind randomized controlled trial.. *NPJ Prim Care Respir Med*. 2017; 27: 9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28184045

Starting systemic corticosteroid treatment

Recommendations

For adults with acute asthma, start systemic corticosteroids within 1 hour of presentation (unless contraindicated), regardless of severity at initial assessment.

Give starting dose of prednisolone 37.5–50 mg, then repeat each morning on second and subsequent days (total 5–10 days).

It is usually not necessary to taper the dose unless the duration of treatment exceeds 2 weeks.

Note: Pregnancy is not a contraindication for systemic corticosteroids. Acute asthma in pregnancy should be treated immediately on presentation, to minimise risk to the foetus and to the woman.

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group.

Key evidence considered:

- Rowe et al. 2017[1]
- Normansell et al. 2016[2]
- Rowe et al. 2007[3]
- Cunnington et al. 2005[4]
- Rowe et al. 2001[5]
- Manser et al. 2001[6]

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For children aged 6-11 years with acute asthma (and children aged 1–5 if acute wheezing is severe), start systemic corticosteroids within 1 hour of presentation (unless contraindicated).

Give prednisolone 1 mg/kg (maximum 50 mg) orally each morning for 3 days.

It is usually not necessary to taper the dose unless the duration of treatment exceeds 2 weeks.

Note: A longer course (e.g. 5 days) may be needed for severe cases.

- **For children aged 1-5 years, systemic corticosteroids should generally be limited to those with severe acute wheezing to avoid over-use (particularly for those with intermittent viral-induced wheezing).**

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group.

Key evidence considered:

- Foster et al. 2018[7]
- Castro-Rodrioguez et al. 2016[8]
- van Asperen et al 2010[9]
- Panickar et al. 2009[10]
- Chang et al. 2008[11]
- Smith et al. 2003[12]
- Rowe et al. 2001[5]

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Oral dexamethasone (if available) can be used as an alternative to prednisolone.

Children: 0.6 mg/kg as a single dose (can be repeated on the following day if needed)

Adults: 16 mg for 2 days then cease.

- **Do not exceed 2 days of treatment**

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group.

Key evidence considered:

- Rehrer et al 2016[13]
- Walia 2018[14]
- Bravo-Soto et al. 2017[15]
- Meyer et al. 2014[16]
- Keeney et al. 2014[17]
- Paniagua et al. 2017[18]
- Cronin et al. 2016[19, 20]
- Kravitz et al. 2011[21]
- Gordon et al. 2007[22]
- Qureshi et al. 2001[23]

Last reviewed version 2.0

For adults, if corticosteroids cannot be given orally, give IV hydrocortisone 4 mg/kg (maximum 100 mg) every 6 hours for 24 hours then reduce over next 24 hours or switch to oral prednisolone.

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group.

Key evidence considered:

- Cunnington et al. 2005[4]
- Rowe et al. 2001[5]
- Manser et al. 2001[6]

Last reviewed version 2.0

For children, if corticosteroids cannot be given orally, give intravenously.

Give either of the following:

- **hydrocortisone IV 4 mg/kg (maximum 100 mg) every 6 hours on day 1 then reduce (every 12 hours on day 2, once daily on day 3 and, if needed, once daily on days 4–5) or switch to oral prednisolone**
- **methylprednisolone IV 1 mg/kg (maximum 60 mg) every 6 hours on day 1 then reduce (every 12 hours on day 2, once daily on day 3 and, if needed, once daily on days 4–5) or switch to oral prednisolone.**

- **For children aged 1-5 years, systemic corticosteroids should generally be limited to those with severe acute wheezing.**

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group.

Key evidence considered:

- Rowe et al. 2001[5]
- Smith et al. 2003[12]
- Gleeson et al. 1990[24]
- Becker et al. 1999[25]
- Barnett et al. 1997[26]

Last reviewed version 2.0

Do not use inhaled corticosteroids as a substitute for systemic corticosteroids in adults or children.

Note: Patients taking inhaled corticosteroids should continue taking them as usual during oral corticosteroid treatment.

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available), with particular reference to named source(s):

- Edmonds et al. 2012[27]

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More information

Systemic corticosteroids in acute asthma

Systemic corticosteroids in acute asthma

In adults and school-aged children with acute asthma, systemic corticosteroids given within 1 hour of presentation to an emergency department reduce the need for hospital admission.[5] In children admitted to hospital with acute asthma, systemic corticosteroid treatment may achieve earlier discharge and fewer relapses.[12]

In preschool children with acute viral-induced wheezing, there is inconsistent evidence for the benefits of systemic corticosteroids.[7, 10, 28] Oral corticosteroids may be beneficial in children younger than 6 years with frequent acute wheezing or asthma, but current evidence does not strongly support their use in this age group.[8] The Thoracic Society of Australia and New Zealand position statement on the use of corticosteroids in children[9] recommends that the use of systemic corticosteroids in preschool children, particularly those with intermittent viral induced wheezing, should be limited to those with wheeze severe enough to need admission to hospital.

After an acute asthma episode, treatment with systemic corticosteroids (intramuscular corticosteroids, oral prednisone/prednisolone, or oral dexamethasone) at discharge from the emergency department reduces the risk of relapse in adults[1] and children.[29, 30]

Formulation and route of administration

In adults and children with acute asthma, oral prednisone/prednisolone is as effective as intravenous or intramuscular corticosteroids.[5, 2]

Oral dexamethasone is as effective as prednisone/prednisolone in adults and children[13, 14, 15, 16, 17, 19, 20, 3, 21]

Dose

In adults, 40 mg per day prednisolone/prednisone,[31] up to 80 mg/day methylprednisolone, or up to 400 mg/day hydrocortisone[6] are adequate.

In children the majority of studies in children have used 1–2 mg/kg of oral prednisolone (maximum 60 mg) given initially then 1 mg/kg per day. Current evidence does not support the use of higher doses.[2]

Studies evaluating oral dexamethasone in adults have used a single dose of 12 mg[13] or 16 mg on 2 consecutive days.[21] Most studies evaluating oral dexamethasone in children have used 0.6 mg/kg per dose on one or two consecutive days.[16]

Duration

In adults, an oral or intramuscular corticosteroid course of at least 7 days appears more effective than a shorter course in preventing relapse within 10 days of discharge after acute asthma,[1] although one clinical trial evaluating prednisone reported that 5 days was as

effective as 10 days.[32] Courses less than 5 days are not recommended.

In children, a 3-day course of prednisone/prednisolone is generally as effective as a 5-day course,[11] but 5 days may be needed for children with severe or life-threatening acute asthma.[9]

It is not necessary to taper the dose after a short course of oral prednisone/prednisolone.[1, 33, 34]

Dexamethasone has a longer half-life than prednisone/prednisolone. Longer courses may more pronounced mineralocorticoid adverse effects. Oral dexamethasone treatment in adults or children should not exceed 2 days.

Adverse effects

Short-term use of oral corticosteroids to treat acute asthma is often well tolerated in children and adults,[5, 12, 10, 3] but many patients report significant adverse effects, particularly mood changes, gastrointestinal disturbances,[36] nocturia, and difficulty sleeping. While short courses of high-dose systemic treatment cause fewer adverse effects than prolonged courses of lower doses,[37] more recent analyses have shown a significant association between short courses of oral corticosteroids and sepsis, thromboembolism and fracture.[38, 39]

Oral dexamethasone appears to be well tolerated in adults.[13] In children it may be associated with less vomiting than prednisone/prednisolone.[14, 15, 16, 17, 17, 19, 20] The risk of unwanted mineralocorticoid effects are increased if dexamethasone is taken for more than 2 days.

In people with diabetes or impaired glucose tolerance, corticosteroids increase blood glucose levels. Impaired glucose tolerance is common among people aged over 65 years. In patients with diabetes or impaired glucose tolerance, blood glucose monitoring (e.g. morning and evening samples) may be indicated during treatment with oral corticosteroids.

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Inhaled corticosteroids in acute asthma

Inhaled corticosteroid treatment in acute care

Clinical trial evidence does not support the use of inhaled corticosteroids in place of systemic corticosteroid treatment in the treatment of acute asthma.[40]

Some randomised clinical trials suggest that inhaled corticosteroid treatment may reduce hospital admission rates when given in addition to systemic corticosteroids, but the evidence is conflicting.[40] Overall, evidence from randomised clinical trials does not show that inhaled corticosteroid therapy achieves clinically important improvement in lung function or clinical scores when used in acute asthma in addition to systemic corticosteroids.[40]

Inhaled corticosteroid treatment in post-acute care - short term effects

Current standard follow-up treatment after acute asthma includes a course of systemic corticosteroids, and continuation of inhaled corticosteroids for patients already taking this treatment.

Overall, evidence from short term randomised clinical trials suggests that inhaled corticosteroid treatment, given at discharge from the emergency department after acute asthma, does not provide additional short-term benefit in patients who are also receiving oral corticosteroids.[41]

Some randomised clinical trials suggest that high-dose inhaled corticosteroid treatment at discharge from the emergency department may be as effective as oral corticosteroids in patients with mild acute asthma, but overall evidence does not support replacing oral corticosteroids with inhaled corticosteroids.[41]

These clinical trials were designed to assess short term effects of inhaled corticosteroid in managing the current acute asthma episode. This evidence does not suggest that inhaled corticosteroids should be stopped after or during an acute asthma episode.[41] Regular inhaled corticosteroid treatment is highly effective for preventing asthma flare-ups, including in patients with a recent asthma hospitalisation. A large case-control study showed that, after hospitalisation for asthma, regular ICS were associated with a 39% reduction in the risk of re-hospitalisation within the following 12 months.

Rationale for prescribing inhaled corticosteroids at discharge from acute care

Inhaled corticosteroid treatment reduces the frequency and severity of asthma flare-ups, reduces the risk of asthma hospitalisation and rehospitalisation, and reduces the risk of death due to asthma.[42, 43]

Regular inhaled corticosteroid treatment is therefore indicated for all adults and older adolescents who have experienced a flare-up within the last 12 months, as well as for those with asthma that is not well controlled (asthma symptoms twice or more during the past month, or waking due to asthma symptoms once or more during the past month).

At the time of discharge from the emergency department or hospital, there is an opportunity to start inhaled corticosteroid treatment and to ensure that the patient's usual GP will review the treatment regiment at the follow-up visit.

▶ See: *Prescribing inhaled corticosteroid-based preventers for adults*

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References

1. Rowe BH, Kirkland SW, Vandermeer B et al. Prioritizing systemic corticosteroid treatments to mitigate relapse in adults with acute asthma: a systematic review and network meta-analysis. *Acad Emerg Med*. 2017; 24: 371-81. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27664401/
2. Normansell R, Kew KM, Mansour G. Different oral corticosteroid regimens for acute asthma. *Cochrane Database Syst Rev* 2016; Issue 5: CD011801. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27176676/
3. Rowe BH, Spooner C, Ducharme F, *et al*. Corticosteroids for preventing relapse following acute exacerbations of asthma. *Cochrane Database Syst Rev*. 2007; Issue 3: CD000195. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17636617
4. Cunnington, D, Smith, N, Steed, K, *et al*. Oral versus intravenous corticosteroids in adults hospitalised with acute asthma. *Pulm Pharmacol Ther*. 2005; 18: 207-212. Available from: https://www.ncbi.nlm.nih.gov/pubmed/15707855
5. Rowe BH, Spooner C, Ducharme F, *et al*. Early emergency department treatment of acute asthma with systemic corticosteroids. *Cochrane Database Syst Rev*. 2001; Issue 1: CD002178. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11279756
6. Manser R, Reid D, Abramson MJ. Corticosteroids for acute severe asthma in hospitalised patients. *Cochrane Database Syst Rev*. 2001; Issue 1: CD001740. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11279726
7. Foster SJ, Cooper MN, Oosterhof S, Borland ML. Oral prednisolone in preschool children with virus-associated wheeze: a prospective, randomised, double-blind, placebo-controlled trial. *Lancet Respir Med*. 2018; 6: 97-106. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29373235
8. Castro-Rodriguez JA, Beckhaus AA, Forno E. Efficacy of oral corticosteroids in the treatment of acute wheezing episodes in asthmatic preschoolers: Systematic review with meta-analysis. *Pediatric pulmonology* 2016; 51: 868-76. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27074244
9. van Asperen PP, Mellis CM, Sly PD, Robertson C. *The role of corticosteroids in the management of childhood asthma.* The Thoracic Society of Australia and New Zealand, 2010. Available from: https://www.thoracic.org.au/journal-publishing/command/download_file/id/25/filename/The_role_of_corticosteroids_in_the_management_of_childhood_asthma_-_2010.pdf
10. Panickar J, Lakhanpaul M, Lambert PC, *et al*. Oral prednisolone for preschool children with acute virus-induced wheezing. *N Engl J Med*. 2009; 360: 329-328. Available from: https://www.ncbi.nlm.nih.gov/pubmed/19164186
11. Chang, A B, Clark, R, Sloots, T P, *et al*. A 5- versus 3-day course of oral corticosteroids for children with asthma exacerbations who are not hospitalised: a randomised controlled trial. *Med J Aust*. 2008; 189: 306-310.Available from: https://www.ncbi.nlm.nih.gov/pubmed/18803532/
12. Smith M, Iqbal S, Elliot TM et al. Corticosteroids for hospitalised children with acute asthma. *Cochrane Database Syst Rev*. 2003; Issue 2: CD002886. Available from: https://www.ncbi.nlm.nih.gov/pubmed/12804441
13. Rehrer MW, Liu B, Rodriguez M et al. A randomized controlled noninferiority trial of single dose of oral dexamethasone versus 5 Days of oral prednisone in acute adult asthma. *Ann Emerg Med*. 2016; 68: 608-13. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27117874/
14. Walia MK. Oral dexamethasone versus oral prednisolone in acute asthma: a new randomized controlled trial and updated meta-analysis: pediatric pulmonologist's viewpoint. *Indian Pediatr*. 2018; 55: 159. Available from: https://www.indianpediatrics.net/feb2018/159.pdf/
15. Bravo-Soto GA, Harismendy C, Rojas P et al. Is dexamethasone as effective as other corticosteroids for acute asthma exacerbation in children? *Medwave*. 2017; 17: e6931. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28430773/
16. Meyer JS, Riese J, Biondi E. Is dexamethasone an effective alternative to oral prednisone in the treatment of pediatric asthma exacerbations? *Hosp Pediatr*. 2014; 4: 172-80. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24785562/
17. Keeney GE, Gray MP, Morrison AK et al. Dexamethasone for acute asthma exacerbations in children: a meta-analysis. *Pediatrics*. 2014; 133: 493-9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24515516/
18. Paniagua, N., Lopez, R., Munoz, N., *et al*. Randomized trial of dexamethasone versus prednisone for children with acute asthma exacerbations. *J Pediatr*. 2017; 191: 190-196.e1. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29173304
19. Cronin JJ, McCoy S, Kennedy U et al. A randomized trial of single-dose oral dexamethasone versus multidose prednisolone for acute exacerbations of asthma in children who attend the emergency department. *Ann Emerg Med* 2016; 67: 593-601.e3. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26460983/
20. Cronin J, Kennedy U, McCoy S et al. Single dose oral dexamethasone versus multi-dose prednisolone in the treatment of acute exacerbations of asthma in children who attend the emergency department: study protocol for a randomized controlled trial. *Trials* 2012; 13: 141. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22909281/
21. Kravitz J, Dominici P, Ufberg J, *et al*. Two days of dexamethasone versus 5 days of prednisone in the treatment of acute asthma: a randomized controlled trial. *Ann Emerg Med*. 2011; 58: 200-204. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21334098
22. Gordon, S., Tompkins, T., Dayan, P. S.. Randomized trial of single-dose intramuscular dexamethasone compared with prednisolone for children with acute asthma. *Pediatr Emerg Care*. 2007; 23: 521-7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17726409
23. Qureshi, F., Zaritsky, A., Poirier, M. P.. Comparative efficacy of oral dexamethasone versus oral prednisone in acute pediatric asthma. *J Pediatr*. 2001; 139: 20-6. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11445789
24. Gleeson, J. G., Loftus, B. G., Price, J. F.. Placebo controlled trial of systemic corticosteroids in acute childhood asthma. *Acta Paediatr Scand*. 1990; 79: 1052-8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/2267922

25. Becker JM, Arora A, Scarfone RJ et al. Oral versus intravenous corticosteroids in children hospitalized with asthma. *J Allergy Clin Immunol* 1999; 103: 586-90. Available from: https://www.ncbi.nlm.nih.gov/pubmed/10200005/
26. Barnett, P. L., Caputo, G. L., Baskin, M., Kuppermann, N.. Intravenous versus oral corticosteroids in the management of acute asthma in children. *Ann Emerg Med*. 1997; 29: 212-7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/9018184
27. Edmonds, M, Milan, S J, Camargo, C A, *et al*. Early use of inhaled corticosteroids in the emergency department treatment of acute asthma. *Cochrane Database Syst Rev*. 2012; Issue 12: CD002308. Available from: http://cochranelibrary-wiley.com/doi/10.1002/14651858.CD002308.pub2/full
28. Therapeutic guidelines [Electronic book]: Therapeutic Guidelines Limited; 2018 [cited 2018 April].
29. Castro-Rodriguez, J. A., Rodrigo, G. J., Rodriguez-Martinez, C. E.. Principal findings of systematic reviews for chronic treatment in childhood asthma. *J Asthma*. 2015; 52: 1038-45. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26303207
30. Kirkland SW, Vandermeer B, Campbell S et al. Evaluating the effectiveness of systemic corticosteroids to mitigate relapse in children assessed and treated for acute asthma: A network meta-analysis. *J Asthma* 2018: 1-12. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29693459/
31. Rodrigo GJ, Nannini LJ. Comparison between nebulized adrenaline and beta2 agonists for the treatment of acute asthma. A meta-analysis of randomized trials. *Am J Emerg Med* 2006; 24: 217-22. Available from: https://www.ncbi.nlm.nih.gov/pubmed/16490653/
32. Jones AM, Munavvar M, Vail A, *et al*. Prospective, placebo-controlled trial of 5 vs 10 days of oral prednisolone in acute adult asthma. *Respir Med*. 2002; 96: 950-954. Available from: http://www.resmedjournal.com/article/S0954-6111(02)91369-7/abstract
33. Cydulka RK, Emerman CL. A pilot study of steroid therapy after emergency department treatment of acute asthma: is a taper needed?. *J Emerg Med*. 1998; 16: 15-19. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9472754
34. O'Driscoll BR, Kalra S, Wilson M, *et al*. Double-blind trial of steroid tapering in acute asthma. *Lancet*. 1993; 341: 324-327. Available from: http://www.sciencedirect.com/science/article/pii/0140673693901343
35. Grzelewski, T, Stelmach, I. Exercise-induced bronchoconstriction in asthmatic children: a comparative systematic review of the available treatment options. *Drugs*. 2009; 69: 1533-1553. Available from: https://www.ncbi.nlm.nih.gov/pubmed/19678711
36. Berthon BS, Gibson PG, McElduff P et al. Effects of short-term oral corticosteroid intake on dietary intake, body weight and body composition in adults with asthma - a randomized controlled trial. *Clin Exp Allergy* 2015; 45: 908-19. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25640664/
37. Australian Medicines Handbook. Last modified July 2018: *Australian Medicines Handbook Pty Ltd*. 2018
38. Lefebvre P, Duh MS, Lafeuille MH et al. Acute and chronic systemic corticosteroid-related complications in patients with severe asthma. *J Allergy Clin Immunol* 2015; 136: 1488-95. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26414880/
39. Waljee AK, Rogers MA, Lin P et al. Short term use of oral corticosteroids and related harms among adults in the United States: population based cohort study. *BMJ* 2017; 357: j1415. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28404617/
40. Edmonds ML, Milan SJ, Camargo CA, *et al*. Early use of inhaled corticosteroids in the emergency department treatment of acute asthma. *Cochrane Database Syst Rev*. 2012; 12: CD002308. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD002308.pub2/full
41. Edmonds ML, Milan SJ, Brenner BE, *et al*. Inhaled steroids for acute asthma following emergency department discharge. *Cochrane Database Syst Rev*. 2012; 12: CD002316. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD002316.pub2/full
42. Suissa S, Ernst P, Kezouh A. Regular use of inhaled corticosteroids and the long term prevention of hospitalisation for asthma. *Thorax*. 2002; 57: 880-884.
43. Suissa, S, Ernst, P, Benayoun, S, *et al*. Low-dose inhaled corticosteroids and the prevention of death from asthma. *N Engl J Med*. 2000; 343: 332-336.

Assessing response to treatment

Recommendations

Assess clinical response after each dose of bronchodilator:

- **If dyspnoea/increased work of breathing is partially relieved within first 5 minutes, reassess at 15 minutes.**
- **If dyspnoea/increased work of breathing is not relieved, repeat bronchodilator dose and consider add-on options.**
- **If condition deteriorates at any time, consider add-on treatment options.**
- **Reduced wheezing alone is an unreliable indicator of improvement, as it may indicate deterioration**

Table. Add-on treatment options for acute asthma

Please view and print this figure separately: http://www.asthmahandbook.org.au/table/show/61

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

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Review treatment response again 10–20 minutes after third dose (approximately 1 hour after first dose).

If respiratory distress or increased work of breathing persists, continue giving salbutamol every 20 minutes and consider add-on treatment options.

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion after literature review yielded insufficient evidence for an evidence-based recommendation

Key evidence considered:

- Karpel et al (1997)[1]

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Perform blood gas analysis in adults with features of life-threatening acute asthma (any of):

- **unable to speak due to dyspnoea**
- **reduced consciousness or collapse**
- **exhaustion**
- **cyanosis**
- **SpO_2 <92%**
- **poor respiratory effort**
- **cardiac arrhythmia.**

How this recommendation was developed

Adapted from existing guidance

Based on reliable clinical practice guideline(s) or position statement(s):

- Beasley et al. 2015[2]

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Monitor for signs of salbutamol toxicity (e.g. (e.g. worsening tachycardia, metabolic acidosis, hypokalaemia).

If toxicity is detected or suspected, consider alternative bronchodilators and start supportive treatment to reduce reliance on salbutamol and to minimise adverse effects. Correct hypokalaemia as required.

- **Salbutamol may occur with inhaled or IV salbutamol**

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group

Key evidence considered:

- Travers et al. 2001[3]
- Travers et al. 2012[4]
- Travers et al. 2012[5]
- Cates et al. 2013[6]
- Castro-Rodriguez et al. 2015[7]
- Australian Medicines Handbook 2018[8]

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Perform spirometry and record FEV_1 when feasible during the acute episode.

Note: Do not attempt spirometry in young children. Most children aged 6 and over can perform spirometry reliably.

- **Patients with severe acute asthma are unlikely to be able to perform spirometry**
- **Do not continue attempting to obtain a spirometry reading if the patient is distressed**

Table. Tips for performing spirometry in patients with acute asthma

- **Ask the patient to sit straight upright, either in a chair or on a stretcher with their legs over the side.**
- **Make sure the person forms a tight seal around the mouthpiece.**
- **Tell the patient to take as deep a breath as possible, then blast out air as fast and hard as they can, then keep blowing until asked to stop. Aim for exhalation of maximal force for at least 2 seconds (6 seconds if FVC is measured).**

You may need to give the patient lots of coaching, repeat instructions, and give immediate feedback on technique.

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Asset ID: 66

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion after literature review yielded insufficient evidence for an evidence-based recommendation

Key evidence considered:

- Tan et al. 2014[9]
- Schneider et al. 2014[10]
- Wilson et al. 2003[11]
- Arnold et al. 2013[12]
- Arnold et al. 2012[13]

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In adults, consider admitting patient to hospital if (any of):

- **hypoxia at presentation**
- **FEV_1 <60% predicted (or 50% of usual, if known) at 1-hour check**
- **respiratory distress/increased work of breathing unresolved or unable to lie flat without dyspnoea 1–2 hours after presentation**
- **a history of ICU admission for asthma**
- **presentation for acute asthma within the past 4 weeks**
- **frequent presentations for acute asthma (e.g. several over previous year)**
- **high recent use of $beta_2$ agonists**
- **patient cannot be monitored adequately at home or cannot easily return to hospital if needed**
- **other risk factors for adverse outcomes.**

Table. Risk factors for adverse asthma outcomes in adults and adolescents

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How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available), with particular reference to named source(s):

- Wilson et al. 2003[11]
- Aldington & Beasley. 2007[14]

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In children, consider admitting patient to hospital if (any of):

- **hypoxia at presentation**
- **respiratory distress/increased work of breathing unresolved 1–2 hours after presentation**
- **a history of ICU admission for asthma**
- **presentation for acute asthma within the past 4 weeks**
- **frequent presentations for acute asthma (e.g. several over previous year)**
- **high recent use of $beta_2$ agonists**
- **patient cannot be monitored adequately at home or cannot easily return to hospital if needed**
- **confirmed food allergy**
- **other risk factors for adverse outcomes.**

Table. Risk factors for life-threatening asthma flare-ups in children

Asthma-related factors

Poor asthma control

Admission to hospital in preceding 12 months

History of intubation for acute asthma

Over-use of short-acting beta$_2$ agonist reliever

Abnormal spirometry findings

Reversible expiratory airflow limitation on spirometry despite treatment

Poor adherence to preventer

Incorrect inhaler technique for preventer

Poor adherence to asthma action plan

Exposure to clinically relevant allergens

Exposure to tobacco smoke

Other clinical factors

Allergies to foods, insects, medicines

Obesity

Family-related factors

Frequent failure to attend consultations/lack of follow-up after an acute flare-up

Significant parental psychological or socioeconomic problems

Parent/carer unequipped to manage asthma emergency

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Asset ID: 116

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available), with particular reference to named source(s):

- Burks et al. 2012[15]

Last reviewed version 2.0

More information

Assessment of oxygen status in acute asthma

Hypoxia is the main cause of deaths due to acute asthma.[16]

Routine objective assessment of oxygen saturation at initial assessment of acute asthma is needed because clinical signs may not correlate with hypoxaemia.

Pulse oximetry is the internationally accepted method for routine assessment of oxygen status in patients with acute asthma. It should be available in all situations in which oxygen is used.[2]

Pulse oximetry does not detect hypercapnoea, so blood gas analysis is necessary if hypercapnoea is suspected in patients with severe or life-threatening acute asthma. Thoracic Society of Australia and New Zealand clinical practice guidelines for acute oxygen use in adults[2] recommend that arterial blood gas analysis should be considered if oxygen saturation falls below 92% and in those at risk of hypercapnoea. Venous blood gas analysis can be used to assess acid–base balance and lactate,[2] but performs poorly in identifying hypercapnoea.[17]

▶ Go to: Thoracic Society of Australia and New Zealand (TSANZ's) *clinical practice guidelines for acute oxygen use in adults*

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Spirometry in acute asthma

Spirometry is used alongside clinical assessment and oximetry to assess severity of acute asthma and response to treatment. Clinical assessment alone may underestimate the severity of airflow limitation.[11]

However, no recent clinical trials have compared outcomes of spirometry-guided treatment of acute asthma with non-spirometry-guided treatment.

A study in adults with acute asthma found that, on its own, FEV_1 (measured by spirometry) at 1 hour after admission to the emergency department did not closely correlate with clinicians' decision for or against hospital admission, as assessed clinically.[11] However, the combination at 1 hour of FEV_1 and the patient's ability to lie flat was significantly predictive of the decision for hospital admission.[11]

In adults with poor response to initial bronchodilator treatment, dyspnoea scores at 3 hours from presentation may predict relapse or clinicians' assessment of the need for hospitalisation better than FEV_1, but neither is a strong predictor.[10]

In children with acute asthma, clinical severity scores may be more sensitive than spirometry to detect change clinical status beyond the first 2 hours of treatment.[12] The value of performing spirometry in children before hospital discharge is unclear.[9]

Feasibility and technique

Although some clinical guidelines recommend spirometry before treatment to assess baseline lung function, most children with severe acute asthma and many with mild-to-moderate acute asthma cannot perform spirometry at this time.[13] Younger children (most children under 6 years) are unlikely to be able to perform spirometry, even when they do not have a flare-up.

Most adults with acute asthma can perform spirometry within the first hour of admission to the emergency department.[18] (Hospital staff and primary care health professionals may need specific training in spirometry technique to be able to obtain acceptable spirometry in patients with acute asthma.[18])

It may not be feasible to apply standard spirometry technique and manoeuvre acceptability criteria in patients with acute asthma:[13, 18]

- 80% of patients older than 12 years with acute asthma can perform an FEV_1 manoeuvre. A forced exhalation from total lung capacity for 2 seconds is sufficient and provides useful information about the severity of airflow obstruction
- two attempts may suffice if patients are unable to make three attempts
- variability between manoeuvres of < 10% should be considered acceptable
- patients may not be able to tolerate nose clips
- patients are unlikely to be able to exhale for long enough to demonstrate the time-volume plateau. Although patients should aim for forced exhalation of at least 6 seconds, 2 seconds is acceptable for measuring FEV_1 in clinical assessment during acute asthma. A spirometry manoeuvre might be considered acceptable if back-extrapolated volume is either < 5% of FVC or 0.15 L (whichever is greater), or a time to peak flow < 120 ms.

Table. Tips for performing spirometry in patients with acute asthma

- Ask the patient to sit straight upright, either in a chair or on a stretcher with their legs over the side.
- Make sure the person forms a tight seal around the mouthpiece.
- Tell the patient to take as deep a breath as possible, then blast out air as fast and hard as they can, then keep blowing until asked to stop. Aim for exhalation of maximal force for at least 2 seconds (6 seconds if FVC is measured).

You may need to give the patient lots of coaching, repeat instructions, and give immediate feedback on technique.

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Peak expiratory flow measurement in acute asthma

Peak expiratory flow rate obtained using a peak flow meter underestimates the severity of airflow limitation in patients with acute asthma, compared with FEV_1 obtained by spirometry.[19]

Peak expiratory flow is not a sensitive measure of small clinical improvements as perceived by the patient.[20]

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References

1. Karpel JP, Aldrich TK, Prezant DJ, *et al*. Emergency treatment of acute asthma with albuterol metered-dose inhaler plus holding chamber: how often should treatments be administered?. *Chest*. 1997; 112: 348-356. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9266868
2. Beasley R, Chien J, Douglas J et al. Thoracic Society of Australia and New Zealand oxygen guidelines for acute oxygen use in adults:

'Swimming between the flags". *Respirology*. 2015; 20: 1182–91. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26486092/
3. Travers, A A, Jones, A P, Kelly, K D, *et al*. Intravenous beta2-agonists for acute asthma in the emergency department. *Cochrane Database Syst Rev*. 2001; Issue 1: CD002988. Available from: http://cochranelibrary-wiley.com/doi/10.1002/14651858.CD002988/full
4. Travers AH, Jones AP, Camargo CA et al. Intravenous beta2-agonists versus intravenous aminophylline for acute asthma. *Cochrane Database Syst Rev* 2012; Issue 12: CD010256. Available from:https://www.ncbi.nlm.nih.gov/pubmed/23235686/
5. Travers, A H, Milan, S J, Jones, A P, *et al*. Addition of intravenous beta. *Cochrane Database Syst Rev*. 2012; Issue 12: CD010179. Available from: http://cochranelibrary-wiley.com/doi/10.1002/14651858.CD010179/full
6. Cates CJ, Welsh EJ, Rowe BH. Holding chambers (spacers) versus nebulisers for beta-agonist treatment of acute asthma. *Cochrane Database Syst Rev*. 2013; 9: Cd000052. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24037768
7. Castro-Rodriguez, J. A., Rodrigo, G. J., Rodriguez-Martinez, C. E.. Principal findings of systematic reviews for chronic treatment in childhood asthma. *J Asthma*. 2015; 52: 1038-45. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26303207
8. Australian Medicines Handbook. Last modified July 2018: *Australian Medicines Handbook Pty Ltd*. 2018
9. Tan CC, McDowell KM, Fenchel M et al. Spirometry use in children hospitalized with asthma. *Pediatr Pulmonol* 2014; 49: 451-7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24000189/
10. Schneider JE, Lewis LM, Ferguson I et al. Repeated dyspnea score and percent FEV1 are modest predictors of hospitalization/relapse in patients with acute asthma exacerbation. *Respir Med* 2014; 108: 1284-91. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25087835/
11. Wilson MM, Irwin RS, Connolly AE, *et al*. A prospective evaluation of the 1-hour decision point for admission versus discharge in acute asthma. *J Intensive Care Med*. 2003; 18: 275-285. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15035763
12. Arnold DH, Gebretsadik T, Hartert TV. Spirometry and PRAM severity score changes during pediatric acute asthma exacerbation treatment in a pediatric emergency department. *J Asthma* 2013; 50: 204-8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23259729/
13. Arnold DH, Gebretsadik T, Abramo TJ, Hartert TV. Noninvasive testing of lung function and inflammation in pediatric patients with acute asthma exacerbations. *J Asthma*. 2012; 49: 29-35. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22133263
14. Aldington S, Beasley R. Asthma exacerbations. 5: assessment and management of severe asthma in adults in hospital. *Thorax* 2007; 62: 447-58. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2117186/
15. Burks AW, Tang M, Sicherer S et al. ICON: food allergy. *J Allergy Clin Immunol* 2012; 129: 906-20. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22365653/
16. Hodder R, Lougheed MD, Rowe BH, *et al*. Management of acute asthma in adults in the emergency department: nonventilatory management. *CMAJ*. 2010; 182: E55-67. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2817338/
17. Byrne AL, Bennett M, Chatterji R et al. Peripheral venous and arterial blood gas analysis in adults: are they comparable? A systematic review and meta-analysis. *Respirology*. 2014; 19: 168-75. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24383789
18. Silverman RA, Flaster E, Enright PL, Simonson SG. FEV1 performance among patients with acute asthma: results from a multicenter clinical trial. *Chest*. 2007; 131: 164-171. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17218571
19. Choi IS, Koh YI, Lim H. Peak expiratory flow rate underestimates severity of airflow obstruction in acute asthma. *Korean J Intern Med*. 2002; 17: 174-179. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12298428
20. Karras DJ, Sammon ME, Terregino CA, *et al*. Clinically meaningful changes in quantitative measures of asthma severity. *Acad Emerg Med*. 2000; 7: 327-334. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.1553-2712.2000.tb02231.x/abstract

Table. Add-on treatment options for acute asthma

Agent	Recommended use in acute asthma	Administration and dosage		Notes
Inhaled ipratropium bromide	*Second-line bronchodilator if inadequate response to salbutamol*	Via pMDI 21 microg/actuation every 20 minutes for first hour Repeat every 4–6 hours for 24 hours	**Adults and children 6 years and over:** 8 puffs **Children aged 1-5 years:** 4 puffs	Use spacer (plus mask, if patient cannot use mouthpiece) If a mask is used, ensure a good seal, to avoid contamination of eyes
		Via nebuliser every 20 minutes for first hour Repeat every 4–6 hours	**Adults and children 6 years and over:** 500 microg nebule **Children aged 1-5 years:** 250 microg nebule	If salbutamol is delivered by nebuliser, add to nebuliser solution If a mask is used, ensure a good seal, to avoid contamination of eyes
IV magnesium sulfate	*Second-line bronchodilator in severe or life-threatening acute asthma, or when poor response to repeated maximal doses of other bronchodilators*	IV infusion over 20 minutes	**Adults:** 10 mmol **Children 2 years and over:** 0.1–0.2 mmol/kg (maximum 10 mmol)	Avoid magnesium sulfate in children younger than 2 years Dilute in compatible solution
IV salbutamol *(only in ICU)*	*Third-line bronchodilator in life-threatening acute asthma that has not responded to continuous nebulised salbutamol after considering other add-on treatment options*	Follow hospital/organisation's protocol. If no local protocol is available, use the following as a guide: 1 mg/mL (1000 microg/mL) salbutamol	**Adults and children 12 years and over:** As infusion: Loading dose 200 microg over 1 minute then 5 microg/minute (can increase to 10 microg/minute, then up to 20 microg	Use only in critical care units (e.g. emergency department, intensive care unit/high-dependency unit) Monitor blood electrolytes, heart

Agent	Recommended use in acute asthma	Administration and dosage		Notes
		concentrate for infusion diluted to 5 mg in 50 mL with normal saline	/minute every 15–30 minutes according to response) As bolus: 250 microg over 5 minutes. **Children 2–12 years:** Loading dose of 5 microg/kg/minute (maximum 200 microg/minute) for 1 hour then 1–2 microg/kg/minute (maximum 80 microg/minute).	rate and acid/base balance (blood lactate) Reduce initial dose for older adults. Consider dose reduction for those with impaired renal function. Impaired liver function may result in accumulation of unmetabolised salbutamol
Aminophylline	*Third-line bronchodilator in life-threatening acute asthma that has not responded to continuous nebulised salbutamol after considering other add-on treatment options*	500 mg in 500 mL normal saline (1 mg/mL)	Adult not previously treated with theophylline: Loading: 5 mg/kg IV given at a rate <25 mg/minute. Maintenance: 0.5 mg/kg/hour IV For obese patients, base dose on ideal weight calculated as follows: Females: 45.5 kg + 0.9 kg/cm for each cm height >152 cm Males: 50 kg + 0.9 kg/cm for each cm height >152 cm Therapeutic range: plasma theophylline concentrations 10–20 mg/L (55–110 micromol/L).	Use only in critical care units (e.g. emergency department, intensive care unit/high-dependency unit) Not routinely recommended for treatment of asthma or COPD (superseded by $beta_2$ agonists) Monitor serum theophylline concentration and titrate to maintain within therapeutic range to avoid toxicity (refer local protocols). [!] theophyllines have a narrow

Agent	Recommended use in acute asthma	Administration and dosage	Notes
			therapeutic range; adjust dosage individually according to clinical response and plasma concentrations
Adrenaline	*Limit to patients unresponsive with poor respiratory effort where inhaled bronchodilators cannot be given, or where respiratory arrest imminent*	**IM via needle and syringe** Adults or children, use (1:1000) and give 0.01 mg per kg up to 0.5 mg per dose (0.5 mL). Repeat every 3–5 minutes if needed. **IM via auto-injector** Adult: 0.3 mg IM Child >20 kg: 0.3 mg IM Child 10–20 kg, 0.15 mg IM Repeat dose after 5 minutes if required. **IV infusion** Adult, child, initially 0.1 microgram/kg/minute IV initially, then titrate according to response. **Slow IV injection** Adult: 50 micrograms (0.5 mL adrenaline 1:10 000) IV. Repeat according to response. Give IV infusion if repeated doses required. Child: initial dose 1 microgram/kg (0.01 mL/kg adrenaline 1:10 000) IV. Titrate dose according to response.	Do not use in place of salbutamol for initial bronchodilation
Non-invasive positive pressure ventilation	*Consider if starting to tire or signs of respiratory failure*		Do not sedate patient If no improvement, intubate and start mechanical ventilation

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Continuing treatment and considering additional treatment

Recommendations

If response to initial inhaled salbutamol is incomplete or poor, consider adding ipratropium bromide (if not used initially) or other add-on treatments. Continuing salbutamol as needed.

Note: Ipratropium bromide is recommended in combination with salbutamol in the initial treatment of patients with severe or life-threatening acute asthma.

Table. Add-on treatment options for acute asthma

Please view and print this figure separately: http://www.asthmahandbook.org.au/table/show/61

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available), with particular reference to named source(s):

- Kirkland et al. 2017[1]
- Pollock et al. 2017[2]
- Castro-Rodriguez et al. 2015[3]
- Vézina et al. 2014[4]
- Griffiths et al. 2013[5]

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For adults with severe or life-threatening acute asthma, or with poor response to repeated maximal doses of other bronchodilators, consider adding intravenous magnesium sulfate.

Give magnesium sulfate 10 mmol (2.5 g) diluted in a compatible solution as a single infusion over 20 minutes.

- **Intravenous magnesium sulfate may be associated with hypotension.**

Table. How to administer intravenous magnesium sulfate

Please view and print this figure separately: http://www.asthmahandbook.org.au/table/show/95

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group

Key evidence considered:

- Green 2016[6]
- Kew et al. 2014[7]

Last reviewed version 2.0

For children with severe or life-threatening acute asthma, or with poor response to repeated maximal doses of other bronchodilators, consider adding intravenous magnesium sulfate.

Give magnesium sulfate 0.1–0.2 mmol/kg (maximum 10 mmol) (25–50 mg/kg to maximum of 2 g) diluted in a compatible solution as a single infusion over 20 minutes.

Do not use intravenous magnesium sulfate in children younger than 2 years.

- **Intravenous magnesium sulfate may be associated with hypotension**

Table. How to administer intravenous magnesium sulfate

Please view and print this figure separately: http://www.asthmahandbook.org.au/table/show/95

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group.

Key evidence considered:

- Griffiths et al. 2016[8]
- Irazuzta & Chiriboga 2017[9]

Last reviewed version 2.0

In emergency department or critical care units (e.g. intensive care unit, high-dependency unit), IV salbutamol can be considered for patients with life-threatening acute asthma that has not responded to continuous nebulised salbutamol, after considering other add-on treatment options.

Monitor blood electrolytes, heart rate and acid/base balance (blood lactate).

Note: Follow your hospital/organisation's protocols for dosage and delivery or use doses in the table.

- **Salbutamol toxicity (e.g. tachycardia, tachypnoea, metabolic acidosis, hypokalaemia) may occur with either the inhaled or IV route of administration. Risk may be increased when the inhaled and IV routes are used concomitantly.**
- **The initial dose of salbutamol should be reduced for older adults. Dose reduction may be needed for people with impaired renal function. Impaired liver function may result in accumulation of unmetabolised salbutamol. Refer to TGA-approved product information.**

Table. Add-on treatment options for acute asthma Please view and print this figure separately: http://www.asthmahandbook.org.au/table/show/61

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Table. Add-on treatment options for acute asthma

Add-on treatment options for acute asthma

Agent	Recommended use in acute asthma	Administration and dosage		Notes
Inhaled ipratropium bromide	*Second-line bronchodilator if inadequate response to salbutamol*	**Via pMDI** **21 microg/actuation every 20 minutes for first hour** **Repeat every 4–6 hours for 24 hours**	**Adults and children 6 years and over: 8 puffs** **Children aged 1-5 years: 4 puffs**	**Use spacer (plus mask, if patient cannot use mouthpiece)** **If a mask is used, ensure a good seal, to avoid contamination of eyes**
		Via nebuliser every 20 minutes for first	**Adults and children 6 years and over:**	**If salbutamol is delivered by**

Agent	Recommended use in acute asthma	Administration and dosage		Notes
		hour **Repeat every 4–6 hours**	**500 microg nebule** **Children aged 1-5 years: 250 microg nebule**	**nebuliser, add to nebuliser solution** **If a mask is used, ensure a good seal, to avoid contamination of eyes**
IV magnesium sulfate	*Second-line bronchodilator in severe or life-threatening acute asthma, or when poor response to repeated maximal doses of other bronchodilators*	**IV infusion over 20 minutes**	**Adults: 10 mmol** **Children 2 years and over: 0.1–0.2 mmol/kg (maximum 10 mmol)**	**Avoid magnesium sulfate in children younger than 2 years** **Dilute in compatible solution**
IV salbutamol *(only in ICU)*	*Third-line bronchodilator in life-threatening acute asthma that has not responded to continuous nebulised salbutamol after considering other add-on treatment options*	**Follow hospital/organisation's protocol. If no local protocol is available, use the following as a guide:** **1 mg/mL (1000 microg/mL) salbutamol concentrate for infusion diluted to 5 mg in 50 mL with normal saline**	**Adults and children 12 years and over:** **As infusion: Loading dose 200 microg over 1 minute then 5 microg/minute (can increase to 10 microg/minute, then up to 20 microg /minute every 15–30 minutes according to response)** **As bolus: 250 microg over 5 minutes.** **Children 2–12 years:** **Loading dose of 5 microg/kg/minute (maximum 200 microg/minute) for 1 hour then 1–2 microg/kg/minute (maximum 80 microg/minute).**	**Use only in critical care units (e.g. emergency department, intensive care unit/high-dependency unit)** **Monitor blood electrolytes, heart rate and acid/base balance (blood lactate)** **Reduce initial dose for older adults. Consider dose reduction for those with impaired renal function. Impaired liver function may result in accumulation of unmetabolised salbutamol**

Agent	Recommended use in acute asthma	Administration and dosage		Notes
Aminophylline	*Third-line bronchodilator in life-threatening acute asthma that has not responded to continuous nebulised salbutamol after considering other add-on treatment options*	**500 mg in 500 mL normal saline (1 mg/mL)**	**Adult not previously treated with theophylline:** **Loading: 5 mg/kg IV given at a rate <25 mg/minute.** **Maintenance: 0.5 mg/kg/hour IV** **For obese patients, base dose on ideal weight calculated as follows:** **Females: 45.5 kg + 0.9 kg/cm for each cm height >152 cm** **Males: 50 kg + 0.9 kg/cm for each cm height >152 cm** **Therapeutic range: plasma theophylline concentrations 10–20 mg/L (55–110 micromol/L).**	**Use only in critical care units (e.g. emergency department, intensive care unit/high-dependency unit)** **Not routinely recommended for treatment of asthma or COPD (superseded by beta$_2$ agonists)** **Monitor serum theophylline concentration and titrate to maintain within therapeutic range to avoid toxicity (refer local protocols).** **[!] theophyllines have a narrow therapeutic range; adjust dosage individually according to clinical response and plasma concentrations**
Adrenaline	*Limit to patients unresponsive with poor respiratory effort where inhaled bronchodilators cannot be given, or where respiratory arrest imminent*	**IM via needle and syringe** **Adults or children, use (1:1000) and give 0.01 mg per kg up to 0.5 mg per dose (0.5 mL). Repeat every 3–5 minutes if needed.** **IM via auto-injector** **Adult: 0.3 mg IM**		**Do not use in place of salbutamol for initial bronchodilation**

Agent	Recommended use in acute asthma	Administration and dosage	Notes
		Child >20 kg: 0.3 mg IM **Child 10–20 kg, 0.15 mg IM** **Repeat dose after 5 minutes if required.** **IV infusion** **Adult, child, initially 0.1 microgram/kg/minute IV initially, then titrate according to response.** **Slow IV injection** **Adult: 50 micrograms (0.5 mL adrenaline 1:10 000) IV. Repeat according to response. Give IV infusion if repeated doses required.** **Child: initial dose 1 microgram/kg (0.01 mL/kg adrenaline 1:10 000) IV. Titrate dose according to response.**	
Non-invasive positive pressure ventilation	*Consider if starting to tire or signs of respiratory failure*		**Do not sedate patient** **If no improvement, intubate and start mechanical ventilation**

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How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group

Key evidence considered:

- Starkey et al. 2014[10]
- Travers et al. 2012[11]

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In critical care units (e.g. emergency department, intensive care unit, high-dependency unit), IV aminophylline or can be considered for patients with life-threatening acute asthma that has not responded to continuous nebulised salbutamol, after considering other add-on treatment options.

Monitor blood electrolytes, heart rate and acid/base balance (blood lactate).

Monitor serum theophylline concentration and titrate to maintain within therapeutic range to avoid toxicity (refer local protocols).

Note: Follow your hospital/organisation's protocols for dosage and delivery or use doses in the table. Target blood levels differ between laboratories.

- **IV aminophylline is associated with nausea and vomiting.**

Table. Add-on treatment options for acute asthma

Please view and print this figure separately: http://www.asthmahandbook.org.au/table/show/61

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group.

Key evidence considered:

- Cooney et al. 2016[12]
- Singhi et al. 2014[13]
- Travers et al. 2012[14]
- Nair et al. 2012[15]
- Yung & South. 1998[16]

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Adrenaline can be used for a patient with life-threatening acute asthma if there is no response to other bronchodilators and condition is rapidly deteriorating.

IM via needle and syringe

For adults or children, use (1:1000) and give 0.01 mg per kg up to 0.5 mg per dose (0.5 mL). Repeat every 3–5 minutes if needed.

IM via auto-injector

Adult: 0.3 mg IM

Child >20 kg: 0.3 mg IM

Child 10–20 kg, 0.15 mg IM

Repeat dose after 5 minutes if required.

IV infusion

Adult, child, initially 0.1 microgram/kg/minute IV initially, then titrate according to response.

Slow IV injection

Adult: 50 micrograms (0.5 mL adrenaline 1:10 000) IV. Repeat according to response. Give IV infusion if repeated doses required.

Child: initial dose 1 microgram/kg (0.01 mL/kg adrenaline 1:10 000) IV. Titrate dose according to response.

- **Do not use adrenaline in place of salbutamol as initial bronchodilator.**
- **IV administration can be considered if response to repeated IM doses and volume expansion is inadequate. IV adrenaline should only be given by health professionals experienced in its use and with continuous monitoring of ECG, pulse oximetry and BP. IV infusion is safer than slow bolus (used for imminent cardiac arrest).**
- **Auto-injector doses are as recommended by the Australasian Society of Clinical Immunology and Allergy for the management of anaphylaxis. For some children they are higher than the doses recommended by the manufacturer.**

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

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Montelukast is not recommended for the management of acute asthma in adults or children in acute care settings.

How this recommendation was developed

Evidence-based recommendation

Based on literature search and formulated by multidisciplinary working group

Key evidence considered:

- Wang et al. 2018[17]
- Zubairi et al 2013[18]
- Ramsay et al. 2011[19]
- Todi et al. 2010[20]
- Harmanci et al. 2006[21]

Last reviewed version 2.0

In adults and adolescents, non-invasive positive pressure ventilation can be considered if the patient is starting to tire or shows signs of respiratory failure.

- **Do not sedate patient**
- **If no improvement, intubate and start mechanical ventilation**

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available), with particular reference to named source(s):

- Gupta et al. 2010[22]
- Soma et al. 2008[23]
- Brandão et al. 2009[24]

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Intubate and start mechanical ventilation for patients with:

- **respiratory arrest**
- **acute respiratory failure that has not responded to treatment**
- **severe exhaustion suggesting impending respiratory arrest**
- **inadequate response to non-invasive positive pressure ventilation.**

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

If respiratory distress or increased work of breathing does not respond to treatment, consider transfer to an intensive care unit.

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

In adults, admit patient to hospital if (any of):

- **hypoxia at presentation**
- **FEV_1 <60% predicted (or 50% of usual, if known) at 1-hour check**
- **respiratory distress/increased work of breathing unresolved or unable to lie flat without dyspnoea 1–2 hours after presentation**
- **a history of ICU admission for asthma**
- **presentation for acute asthma within the past 4 weeks**
- **frequent presentations for acute asthma (e.g. several over previous year)**
- **high recent use of $beta_2$ agonists**
- **patient cannot be monitored adequately at home or cannot easily return to hospital if needed**

- **other risk factors for adverse outcomes.**

Table. Risk factors for adverse asthma outcomes in adults and adolescents

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How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available), with particular reference to named source(s):

- Wilson et al. 2003[25]
- Aldington & Beasley. 2007[26]

Last reviewed version 2.0

In children, admit patient to hospital if (any of):

- **hypoxia at presentation**
- **respiratory distress/increased work of breathing unresolved 1–2 hours after presentation**
- **a history of ICU admission for asthma**
- **presentation for acute asthma within the past 4 weeks**
- **frequent presentations for acute asthma (e.g. several over previous year)**
- **high recent use of beta$_2$ agonists**
- **patient cannot be monitored adequately at home or cannot easily return to hospital if needed**
- **food allergy**
- **other risk factors for adverse outcomes.**

Table. Risk factors for life-threatening asthma flare-ups in children

Asthma-related factors

Poor asthma control

Admission to hospital in preceding 12 months

History of intubation for acute asthma

Over-use of short-acting beta$_2$ agonist reliever

Abnormal spirometry findings

Reversible expiratory airflow limitation on spirometry despite treatment

Poor adherence to preventer

Incorrect inhaler technique for preventer

Poor adherence to asthma action plan

Exposure to clinically relevant allergens

Exposure to tobacco smoke

Other clinical factors

Allergies to foods, insects, medicines

Obesity

Family-related factors

Frequent failure to attend consultations/lack of follow-up after an acute flare-up

Significant parental psychological or socioeconomic problems

Parent/carer unequipped to manage asthma emergency

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Asset ID: 116

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available)

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More information

Theophyllines in acute asthma

Few studies have compared IV aminophylline with IV short-acting beta$_2$ agonist in the management of acute asthma in adults and children.

Compared with salbutamol IV aminophylline is associated with a higher rate of adverse effects including giddiness, nausea and vomiting.[14]

It is used mainly as an add-on therapy when there is inadequate response to initial bronchodilator.

Aminophylline plus salbutamol in adults

Overall, evidence from randomised clinical trials in adults with acute asthma treated in emergency departments suggests that intravenous aminophylline given in addition to inhaled beta$_2$ agonists does not achieve greater bronchodilation or reduce hospital admissions, compared with inhaled beta$_2$ agonists alone.[15] No sub-groups that benefit from intravenous aminophylline have been clearly identified.[15]

Aminophylline is associated with vomiting and cardiac arrhythmias.[15]

Theophylline is metabolised mainly by the liver and commonly interacts with other medicines. Its concentration in plasma should be monitored closely in older people or those with comorbid conditions.[27]

Aminophylline plus salbutamol in children

In children with acute asthma requiring hospital admission, the addition of intravenous aminophylline to beta$_2$-agonists and corticosteroids (with or without ipratropium) may improve lung function within 6 hours of treatment, but does not appear to improve symptoms or shorten hospital stay.[28]

The optimal aminophylline dose in children has not been clearly identified. Evidence from clinical trials does not show a clear association between dose and clinical outcomes.[12]

Aminophylline is associated with a significant increased risk of vomiting in children.[28] The rate of adverse effects appears to be higher among children receiving higher loading doses of IV aminophylline (7–10 mg/kg), compared with 5–6 mg/kg.[12]

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Oral montelukast in acute asthma

Evidence from randomised controlled clinical trials does not support routine use of oral leukotriene receptor agonists in acute asthma in adults or children.[29]

In children with acute asthma, the addition of oral montelukast to usual care does not reduce hospital admission rates, based on the findings of a systematic review and meta-analysis.[29]

One small study in adults with acute asthma reported that the addition of oral montelukast to usual care resulted in a slight reduction beta$_2$ agonist requirement,[29] but this difference was clinically nonsignificant.

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Role of ketamine in acute asthma

Ketamine has been proposed by some researchers as a suitable option for pre-intubation sedation in patients with respiratory failure caused by acute asthma (where not contraindicated) because it stimulates the release of catecholamines and may contribute to bronchodilation through direct relaxation effect on bronchial smooth muscle.[30]

Evidence does not strongly support the use of ketamine in non-intubated children with acute asthma.[31] The results of small studies suggest that ketamine at a dose of approximately 1 mg/kg may have some benefit in bronchodilation and clinical symptoms in children.[32] However, benefits compared with other add-on treatments for acute asthma and long-term effects have not been

established.[32] In children with acute asthma who have an inadequate response to initial bronchodilator therapy, the effect of IV ketamine on respiratory status may be equivalent to that to that of IV aminophylline.[33]

Adverse effects associated with ketamine include hypersecretion, hypotension and hypertension, arrhythmias, and hallucinations.[30]

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Antibiotics in acute asthma

Antibiotics are not used routinely in the management of acute asthma but should be used if they would otherwise be indicated.

The role of atypical bacterial infections (e.g. *Chlamydophyla pneumonia*, *Mycoplasma pneumonae*) in asthma is under investigation. Atypical bacterial infections may make acute asthma more severe, especially in patients with poorly controlled asthma. Macrolide antibiotics are active against atypical bacteria and have anti-inflammatory activity. However, their potential anti-inflammatory effects in the treatment of acute asthma have not been well studied.

A systematic review[34] of antibiotic treatment in asthma flare-ups found that the few available randomised controlled trials were heterogeneous and that their findings were inconsistent. It concluded that there was limited evidence that antibiotics given at the time of an asthma flare-up may improve symptoms and lung function at follow-up, compared with standard care or placebo.[34]

The systematic review identified four studies that assessed the use of macrolide antibiotics in the management of asthma flare-ups. Combined results for two of these (416 participants) showed that macrolide treatment was associated with improvement in symptoms.[34] One included study reported an increase in symptoms-free days at 10 days in adults treated with a macrolide, compared with placebo, which was independent of serological evidence for infection with chlamydia pneumonia or mycoplasma pneumoniae. However, the study drug (telithromycin) is no longer in use due to its association with severe liver toxicity.

In a study of adults attending emergency care for acute asthma, treatment with azithromycin 500 mg per day for 3 days was not associated with an improvement in symptoms or lung function, compared with placebo.[35] However, 1 in 10 participants assessed for this trial were excluded as they had already commenced an antibiotic at the time of screening.

In a study of children aged 1–5 years presenting to the emergency department with acute wheezing illness,[36] children were randomised to either azithromycin for 5 days or placebo. Azithromycin treatment did not reduce the duration of respiratory symptoms or the time to a respiratory flare-up in the following 6 months after treatment.[36]

A small (n=40) study assessing clarithromycin treatment in children aged 1–3 years with acute wheezing illness reported an increase in symptoms-free days at 3, 6 and 12 weeks, compared with usual care.[37]

The systematic review of antibiotic treatment in asthma flare-ups[34] included two studies investigating penicillin treatment in patients admitted to hospital with asthma. Neither observed a significant difference in duration of admission, and one reported no difference in asthma symptoms at discharge.[34]

Last reviewed version 2.0

Spirometry in acute asthma

Spirometry is used alongside clinical assessment and oximetry to assess severity of acute asthma and response to treatment. Clinical assessment alone may underestimate the severity of airflow limitation.[25]

However, no recent clinical trials have compared outcomes of spirometry-guided treatment of acute asthma with non-spirometry-guided treatment.

A study in adults with acute asthma found that, on its own, FEV_1 (measured by spirometry) at 1 hour after admission to the emergency department did not closely correlate with clinicians' decision for or against hospital admission, as assessed clinically.[25] However, the combination at 1 hour of FEV_1 and the patient's ability to lie flat was significantly predictive of the decision for hospital admission.[25]

In adults with poor response to initial bronchodilator treatment, dyspnoea scores at 3 hours from presentation may predict relapse or clinicians' assessment of the need for hospitalisation better than FEV_1, but neither is a strong predictor.[38]

In children with acute asthma, clinical severity scores may be more sensitive than spirometry to detect change clinical status beyond the first 2 hours of treatment.[39] The value of performing spirometry in children before hospital discharge is unclear.[40]

Feasibility and technique

Although some clinical guidelines recommend spirometry before treatment to assess baseline lung function, most children with severe acute asthma and many with mild-to-moderate acute asthma cannot perform spirometry at this time.[41] Younger children (most children under 6 years) are unlikely to be able to perform spirometry, even when they do not have a flare-up.

Most adults with acute asthma can perform spirometry within the first hour of admission to the emergency department.[42] (Hospital staff and primary care health professionals may need specific training in spirometry technique to be able to obtain acceptable spirometry in patients with acute asthma.[42])

It may not be feasible to apply standard spirometry technique and manoeuvre acceptability criteria in patients with acute asthma:[41, 42]

- 80% of patients older than 12 years with acute asthma can perform an FEV_1 manoeuvre. A forced exhalation from total lung capacity for 2 seconds is sufficient and provides useful information about the severity of airflow obstruction
- two attempts may suffice if patients are unable to make three attempts
- variability between manoeuvres of < 10% should be considered acceptable
- patients may not be able to tolerate nose clips
- patients are unlikely to be able to exhale for long enough to demonstrate the time-volume plateau. Although patients should aim for forced exhalation of at least 6 seconds, 2 seconds is acceptable for measuring FEV_1 in clinical assessment during acute asthma. A spirometry manoeuvre might be considered acceptable if back-extrapolated volume is either < 5% of FVC or 0.15 L (whichever is greater), or a time to peak flow < 120 ms.

Table. Tips for performing spirometry in patients with acute asthma

- Ask the patient to sit straight upright, either in a chair or on a stretcher with their legs over the side.
- Make sure the person forms a tight seal around the mouthpiece.
- Tell the patient to take as deep a breath as possible, then blast out air as fast and hard as they can, then keep blowing until asked to stop. Aim for exhalation of maximal force for at least 2 seconds (6 seconds if FVC is measured).

You may need to give the patient lots of coaching, repeat instructions, and give immediate feedback on technique.

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Peak expiratory flow measurement in acute asthma

Peak expiratory flow rate obtained using a peak flow meter underestimates the severity of airflow limitation in patients with acute asthma, compared with FEV_1 obtained by spirometry.[43]

Peak expiratory flow is not a sensitive measure of small clinical improvements as perceived by the patient.[44]

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Non-invasive positive pressure ventilation in acute asthma

Few large studies have evaluated non-invasive positive pressure ventilation in patients with acute asthma.

Adults

Few randomised clinical trials have evaluated non-invasive positive pressure ventilation (biphasic positive airway pressure or continuous positive airway pressure) for adults with severe acute asthma.[45]

This technique has not been shown to reduce risk of death or the need for intubation, but may reduce hospital admissions, length of hospital stay and length of ICU stay.[45] It may also improve lung function, but evidence is inconsistent.[45]

Children

A Cochrane systematic review of non-invasive positive pressure ventilation in hospitalised children with acute asthma[46] found insufficient evidence to ascertain whether or not it is beneficial.

A recent randomised clinical trial reported that non-invasive positive pressure ventilation had no advantage over standard care in children aged 2–18 years with acute asthma treated in a paediatric emergency department, with no significant difference between groups in lung function, need for additional treatment, length of stay in the emergency department.[47]

Delivering bronchodilators in patients undergoing noninvasive positive-pressure ventilation

When delivering nebulised salbutamol while using noninvasive positive-pressure ventilation set at pressures commonly used in clinical practice, the amount of salbutamol inhaled is likely to be significantly higher than with a nebuliser alone (based on a bench model of a spontaneously breathing adult). This increase may be because the ventilator tubing acts as a spacer.[48]

The position of the nebuliser in the ventilator circuit significantly affects the total dose of salbutamol inhaled. Salbutamol is delivered most effectively when the nebuliser is positioned immediately after the expiration port (i.e. starting from the facemask, the expiration port is positioned before the nebuliser).[48]

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Salbutamol in acute asthma

Route of administration
Inhaler plus spacer, or nebuliser

Among patients with acute asthma who do not require mechanical ventilation, salbutamol delivered via a pressurised metered-dose inhaler with spacer is at least as effective as salbutamol delivered via nebuliser in preschool children (with viral-induced wheezing or acute asthma)[49] and adults,[5051] and is equivalent or superior in school-aged children.[3, 52, 2, [REFERENCE991]]

The use of nebulisers increases the risk of transmitting respiratory infections to staff and other patients,[53] and increases the risk of adverse effects.

Intravenous salbutamol

IV salbutamol is generally reserved for use in patients with severe acute asthma that does not respond to inhaled bronchodilators.

Efficacy

Overall, intravenous short-acting beta$_2$ agonists do not appear to be superior to inhaled short-acting beta$_2$ agonist.[54]

Adults

Benefits have not been demonstrated in adults.[54]

Children

Very limited evidence from one study suggested that the addition of IV salbutamol to inhaled salbutamol reduced recovery time in children with severe acute asthma in the emergency department.[54]

However, there is a lack of consensus on the appropriate dose of IV salbutamol for children.[10] Recommendations differ between guidelines in Australia[55] and elsewhere.[10] Doses have not been calculated based on age-specific pharmacokinetic and pharmacodynamic data. The doses recommended in guidelines are generally relatively higher than for adults on a micrograms per kilogram body weight basis.

Adverse effects

Compared with inhaled salbutamol, intravenous salbutamol is associated with increased risk of adverse effects including tremor and hypokalaemia.[54, 10] Concomitant use of the inhalation and IV routes may increase the risk of salbutamol toxicity.[56]

Note: Salbutamol concentrate for infusion is available in 5 mL ampoules containing salbutamol sulfate equivalent to 5 mg (1 mg/mL) salbutamol in a sterile isotonic solution (*Ventolin obstetric injection*). Salbutamol for injection is also available in ampoules of salbutamol sulphate equivalent to 500

microg salbutamol in 1 mL sterile isotonic solution (*Ventolin injection*).

Salbutamol dosing regimens

There is very little evidence from clinical trials to guide dosing intervals for salbutamol treatment in acute asthma.

One placebo-controlled study conducted in the emergency department among adults with acute asthma (FEV_1 <60% predicted or normal) showed that, in those who did not show a clear response to the first salbutamol dose, repeating the dose at intervals of 30 minutes or less was more effective than every 60 minutes.[57] However, for patients who showed clear improvement after the first dose of salbutamol via pressurised metered-dose inhaler and spacer, there was no advantage in repeating the dose more often than every 60 minutes until full recovery (extra doses can be given as needed).[57]

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Ipratropium in acute asthma

Adults

In adults and older adolescents with severe acute asthma treated in the emergency department, the combination of ipratropium and short-acting $beta_2$ agonist reduces hospitalisation rate and improves lung function, compared with short-acting $beta_2$ agonist alone.[1] Hospitalisation rates are not reduced in patients with mild or moderate acute asthma.[1]

In adults, the combination of ipratropium and short-acting $beta_2$ agonist is associated with a higher rate of adverse effects (e.g. tremor, agitation, and palpitations) than short-acting $beta_2$ agonist alone.[1]

Children

Recent systematic reviews have reported that initial treatment with ipratropium in addition to salbutamol markedly reduces hospitalisation rate and improves clinical scores in children with moderate to severe acute asthma.[3, 2, 5]

However, in children hospitalised due to acute asthma, the combination of ipratropium and short-acting $beta_2$ agonist was not more effective than short-acting $beta_2$ agonist alone.[4]

The combination of ipratropium and short-acting $beta_2$ agonist appears to be well tolerated in children.[5]

Ipratropium bromide alone is less effective than salbutamol alone in acute asthma.[58]

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Magnesium sulfate in acute asthma

Magnesium sulfate in acute asthma

Clinical trial evidence does not support the use of magnesium sulfate as a substitute for inhaled $beta_2$ agonists.[59]

Its main use is in addition to salbutamol, either in combination with initial bronchodilator treatment, or as an add-on treatment in patients with inadequate response to initial bronchodilator treatment.

Intravenous magnesium sulfate

Adults

IV magnesium sulfate may have a small effect in reducing hospital admissions and may improve lung function in adults with acute asthma who have failed to respond to standard treatment.[6, 7]

In a large, well-conducted randomised controlled trial in adults with moderate-to-severe acute asthma treated in an emergency department (excluding those with life-threatening asthma), IV magnesium sulfate improved dyspnoea scores but did not reduce hospital admission rates.[60]

Current evidence does not indicated whether or not IV magnesium sulfate is more effective for patients with a more severe acute asthma.[6]

The optimal dose and infusion regimen has not been identified.[6]

IV magnesium sulfate IV appears to be well tolerated in adults.[6] Minor flushing is the most common adverse event.[6] Other adverse effects reported in clinical trials include fatigue, nausea, headache and hypotension.[7]

Children

IV magnesium sulfate may reduce hospitalisation rates and improve lung function among children with acute asthma in presenting to the emergency department,[61, 8] but there is limited evidence.[8]

A small randomised controlled trial reported that IV magnesium sulfate was ineffective in reducing respiratory distress in very young children (6 months to 4 years) with acute virus-induced wheezing.[62]

IV magnesium sulfate is generally well tolerated.[8, 9]

Nebulised magnesium sulfate

Nebulised magnesium sulfate may achieve small additional improvement in lung function and reduction in hospital admission rates when added to salbutamol and ipratropium in adults and children with acute asthma, but these benefits have not been clearly demonstrated on current evidence.[59]

Randomised controlled trials have reported conflicting findings. The larger and more recent studies typically show a smaller effect than some of the older, smaller studies.[59] Large, well-designed trials in adults[60, 63] and children[64, 65, 66] have generally not demonstrated clinically important benefits.[59] A systematic review of randomised controlled trials found no overall improvement in lung function when magnesium sulfate was added to salbutamol and ipratropium.[59]

Nebulised magnesium sulfate is well tolerated and does not appear to be associated with an increase in serious adverse events.[59]

Adults

It is uncertain whether nebulised magnesium sulfate improves lung function or symptoms, or reduces hospital admissions, when added to standard treatment in adults.[6]

Some studies suggest that patients presenting with severe acute asthma may benefit, but the data are not conclusive.[6]

A large, well-designed RCT showed no reduction in hospitalisation or dyspnoea rates in adults with acute asthma given add-on nebulised magnesium, compared with standard therapy alone,[60, 63] but this study excluded patients with life-threatening acute asthma.

Children

A recent systematic review found that nebulised magnesium sulfate had no effect on hospitalisation rates or lung function in children with acute asthma.[61]

However, one large, well-designed randomised controlled trial in children reported that nebulised magnesium sulfate was associated with a small improvement in asthma symptom scores at 60 minutes. The effect was greatest in the subgroups of children with more severe acute asthma (SaO_2<92%), and those with more sudden onset (symptoms less than 6 hours before acute attack).[64, 65]

Nebulised magnesium sulfate is well tolerated in children.[64, 65]

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The 1-hour assessment

Very little evidence is available to determine when it is safe to discharge a patient with severe acute asthma from the emergency department. Few studies have correlated features of clinical history, examination, response to medications or objective measures of airflow obstruction with outcomes after discharge including relapse.

Timing of decision to admit or discharge

An Australian 'real world' prospective observational study,[67] which included children and adults aged 1–55 years with acute asthma presenting to emergency departments, correlated severity class assessed at initial presentation and at the 1-hour assessment with clinicians' assessment of need for hospital admission or intensive care unit admission. Compared with assessed severity class at initial presentation, severity class assessed at 1 hour better predicted:[67]

- the decision for hospital admission among patients initially assessed as having 'moderate' acute asthma (e.g. able to speak in phrases, oxygen saturation 92–95%, FEV_1 50–75% predicted, pulse rate 100–120/min)
- the decision to admit to the intensive care unit among patients initially assessed as having 'severe' acute asthma (e.g. physical exhaustion, unable to speak more than a word at time, oxygen saturation < 92%, FEV_1 < 50% or <1 L, pulse rate >120/min).

The 'lie flat' test (adults)

In adults, at 1 hour after initial treatment, the ability to lie flat without dyspnoea may be a useful indicator of adequate recovery without the need for hospital admission, particularly when combined with adequate improvement in FEV_1 measured by spirometry.[25]

Spirometry

A study in adults with acute asthma found that, on its own, FEV_1 (measured by spirometry) at 1 hour after admission to the emergency department did not closely correlate with clinicians' decision for or against hospital admission, as assessed clinically.[25] However, the combination at 1 hour of FEV_1 and the 'lie flat' test was significantly predictive of the decision for hospital admission.[25]

Most adults with acute asthma can perform spirometry within the first hour of admission to the emergency department.[42]

Table. Tips for performing spirometry in patients with acute asthma

- Ask the patient to sit straight upright, either in a chair or on a stretcher with their legs over the side.

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References

1. Kirkland SW, Vandenberghe C, Voaklander B et al. Combined inhaled beta-agonist and anticholinergic agents for emergency management in adults with asthma. *Cochrane Database Syst Rev*. 2017; Issue 1: CD001284. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28076656
2. Pollock M, Sinha IP, Hartling L et al. Inhaled short-acting bronchodilators for managing emergency childhood asthma: an overview of reviews. *Allergy*. 2017; 72: 183-200. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27588581
3. Castro-Rodriguez, J. A., Rodrigo, G. J., Rodriguez-Martinez, C. E.. Principal findings of systematic reviews for chronic treatment in childhood asthma. *J Asthma*. 2015; 52: 1038-45. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26303207
4. Vezina K, Chauhan BF, Ducharme FM. Inhaled anticholinergics and short-acting beta(2)-agonists versus short-acting beta2-agonists alone for children with acute asthma in hospital.*Cochrane Database Syst Rev*. 2014; Issue 7: CD010283. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25080126/
5. Griffiths B, Ducharme FM. Combined inhaled anticholinergics and short-acting beta2-agonists for initial treatment of acute asthma in children. *Cochrane Database Syst Rev*. 2013: Cd000060. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23966133
6. Green RH. Asthma in adults (acute): magnesium sulfate treatment. BMJ Clin Evid 2016; 2016: Available from:https://www.ncbi.nlm.nih.gov/pubmed/26761432/
7. Kew KM, Kirtchuk L, Michell CI. Intravenous magnesium sulfate for treating adults with acute asthma in the emergency department. *Cochrane Database Syst Rev* 2014: Cd010909. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24865567/
8. Griffiths B, Kew KM. Intravenous magnesium sulfate for treating children with acute asthma in the emergency department. *Cochrane Database Syst Rev* 2016; 4: Cd011050. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27126744/
9. Irazuzta JE, Chiriboga N. Magnesium sulfate infusion for acute asthma in the emergency department. J Pediatr (Rio J) 2017; 93 Suppl 1: 19-25. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28754601/
10. Starkey ES, Mulla H, Sammons HM, Pandya HC. Intravenous salbutamol for childhood asthma: evidence-based medicine?. *Arch Dis Child*. 2014; 99: 873-877. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24938536
11. Travers, A H, Milan, S J, Jones, A P, *et al*. Addition of intravenous beta. *Cochrane Database Syst Rev*. 2012; Issue 12: CD010179. Available from: http://cochranelibrary-wiley.com/doi/10.1002/14651858.CD010179/full
12. Cooney L, Sinha I, Hawcutt D. Aminophylline dosage in asthma exacerbations in children: a systematic review. *PLoS One* 2016; 11: e0159965. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27483163/
13. Singhi S, Grover S, Bansal A, Chopra K. Randomised comparison of intravenous magnesium sulphate, terbutaline and aminophylline for children with acute severe asthma. *Acta Paediatr* 2014; 103: 1301-6. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25164315/
14. Travers AH, Jones AP, Camargo CA et al. Intravenous beta2-agonists versus intravenous aminophylline for acute asthma. *Cochrane Database Syst Rev* 2012; Issue 12: CD010256. Available from:https://www.ncbi.nlm.nih.gov/pubmed/23235686/
15. Nair P, Milan SJ, Rowe BH. Addition of intravenous aminophylline to inhaled beta2-agonists in adults with acute asthma. Cochrane Database Syst Rev 2012; Issue 12: CD002742. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23235591/
16. Yung, M., South, M.. Randomised controlled trial of aminophylline for severe acute asthma. *Arch Dis Child*. 1998; 79: 405-10. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1717748/
17. Wang, X., Zhou, J., Zhao, X., Yi, X.. Montelukast treatment of acute asthma exacerbations in children aged 2 to 5 years: a randomized, double-blind, placebo-controlled trial. *Pediatr Emerg Care*. 2018; 34: 160-164. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28590992
18. Zubairi, A. B., Salahuddin, N., Khawaja, A., *et al*. A randomized, double-blind, placebo-controlled trial of oral montelukast in acute asthma exacerbation. *BMC Pulm Med*. 2013; 13: 20. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3616955/
19. Ramsay, C F, Pearson, D, Mildenhall, S, Wilson, A M. Oral montelukast in acute asthma exacerbations: a randomised, double-blind, placebo-controlled trial. *Thorax*. 2011; 66: 7-11. Available from: https://www.ncbi.nlm.nih.gov/pubmed/20956393
20. Todi, V K, Lodha, R, Kabra, SK. Effect of addition of single dose of oral montelukast to standard treatment in acute moderate to severe asthma in children between 5 and 15 years of age: a randomised, double-blind, placebo controlled trial. *Arch Dis Child*. 2010; 95: 540-543. Available from: https://www.ncbi.nlm.nih.gov/pubmed/20522464
21. Harmanci, K, Bakirtas, A, Turktas, I, Degim, T. Oral montelukast treatment of preschool-aged children with acute asthma. *Ann*

Allergy Asthma Immunol. 2006; 96: 731-735. Available from: https://www.ncbi.nlm.nih.gov/pubmed/16729788
22. Gupta, D, Nath, A, Agarwal, R, Behera, D. A prospective randomized controlled trial on the efficacy of noninvasive ventilation in severe acute asthma. *Respir Care*. 2010; 55: 536-543. Available from: http://rc.rcjournal.com/content/55/5/536.short
23. Soma T, Hino M, Kida K, Kudoh S. A prospective and randomized study for improvement of acute asthma by non-invasive positive pressure ventilation (NPPV). *Intern Med* 2008; 47: 493-501. Available from: http://www.jstage.jst.go.jp/article/internalmedicine/47/6/47_493/_article/
24. Brandão DC, Lima VM, Filho VG et al. Reversal of bronchial obstruction with bi-level positive airway pressure and nebulization in patients with acute asthma. *J Asthma* 2009; 46: 356-61. Available from: https://www.ncbi.nlm.nih.gov/pubmed/19484669/
25. Wilson MM, Irwin RS, Connolly AE, *et al*. A prospective evaluation of the 1-hour decision point for admission versus discharge in acute asthma. *J Intensive Care Med*. 2003; 18: 275-285. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15035763
26. Aldington S, Beasley R. Asthma exacerbations. 5: assessment and management of severe asthma in adults in hospital. *Thorax* 2007; 62: 447-58. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2117186/
27. Gupta P, O'Mahony MS. Potential adverse effects of bronchodilators in the treatment of airways obstruction in older people: recommendations for prescribing. *Drugs Aging*. 2008; 25: 415-43.
28. Mitra AA, Bassler D, Watts K, *et al*. Intravenous aminophylline for acute severe asthma in children over two years receiving inhaled bronchodilators. *Cochrane Database Syst Rev*. 2005; Issue 2: CD001276. Available from: https://www.ncbi.nlm.nih.gov/pubmed/15846615
29. Watts, K, Chavasse, R J P G. Leukotriene receptor antagonists in addition to usual care for acute asthma in adults and children. *Cochrane Database Syst Rev*. 2012; Issue 5: . Available from: http://cochranelibrary-wiley.com/doi/10.1002/14651858.CD006100.pub2/full
30. Brenner B, Corbridge T, Kazzi A. Intubation and mechanical ventilation of the asthmatic patient in respiratory failure. *Proc Am Thorac Soc*. 2009; 6: 371-379. Available from: http://www.atsjournals.org/doi/full/10.1513/pats.P09ST4
31. Jat KR, Chawla D. Ketamine for management of acute exacerbations of asthma in children. *Cochrane Database Syst Rev*. 2012; 11: CD009293. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD009293.pub2/full
32. Rehder KJ. Adjunct therapies for refractory status asthmaticus in children. *Respir Care* 2017; 62: 849-65. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28546381/
33. Tiwari A, Guglani V, Jat KR. Ketamine versus aminophylline for acute asthma in children: A randomized, controlled trial. *Annals of thoracic medicine* 2016; 11: 283-8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27803755/
34. Normansell R, Sayer B, Waterson S et al. Antibiotics for exacerbations of asthma. *Cochrane Database Syst Rev* 2018; 6: CD002741. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29938789/
35. Johnston SL, Szigeti M, Cross M et al. Azithromycin for acute exacerbations of asthma : the AZALEA randomized clinical trial. *JAMA Intern Med* 2016; 176: 1630-7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27653939/.
36. Mandhane PJ, Paredes Zambrano de Silbernagel P, Aung YN et al. Treatment of preschool children presenting to the emergency department with wheeze with azithromycin: A placebo-controlled randomized trial. *PloS One* 2017; 12: e0182411. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28771627/
37. Koutsoubari I, Papaevangelou V, Konstantinou GN, *et al*. Effect of clarithromycin on acute asthma exacerbations in children: an open randomized study. *Pediatr Allergy Immunol*. 2012; 23: 385-90. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.1399-3038.2012.01280.x/full
38. Schneider JE, Lewis LM, Ferguson I et al. Repeated dyspnea score and percent FEV1 are modest predictors of hospitalization/relapse in patients with acute asthma exacerbation. *Respir Med* 2014; 108: 1284-91. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25087835/
39. Arnold DH, Gebretsadik T, Hartert TV. Spirometry and PRAM severity score changes during pediatric acute asthma exacerbation treatment in a pediatric emergency department. *J Asthma* 2013; 50: 204-8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23259729/
40. Tan CC, McDowell KM, Fenchel M et al. Spirometry use in children hospitalized with asthma. *Pediatr Pulmonol* 2014; 49: 451-7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24000189/
41. Arnold DH, Gebretsadik T, Abramo TJ, Hartert TV. Noninvasive testing of lung function and inflammation in pediatric patients with acute asthma exacerbations. *J Asthma*. 2012; 49: 29-35. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22133263
42. Silverman RA, Flaster E, Enright PL, Simonson SG. FEV1 performance among patients with acute asthma: results from a multicenter clinical trial. *Chest*. 2007; 131: 164-171. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17218571
43. Choi IS, Koh YI, Lim H. Peak expiratory flow rate underestimates severity of airflow obstruction in acute asthma. *Korean J Intern Med*. 2002; 17: 174-179. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12298428
44. Karras DJ, Sammon ME, Terregino CA, *et al*. Clinically meaningful changes in quantitative measures of asthma severity. *Acad Emerg Med*. 2000; 7: 327-334. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.1553-2712.2000.tb02231.x/abstract
45. Lim WJ, Mohammed Akram R, Carson KV, *et al*. Non-invasive positive pressure ventilation for treatment of respiratory failure due to severe acute exacerbations of asthma. *Cochrane Database Syst Rev*. 2012; 12: CD004360. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD004360.pub4/full
46. Korang SK, Feinberg J, Wetterslev J, Jakobsen JC. Non-invasive positive pressure ventilation for acute asthma in children. *Cochrane Database Syst Rev* 2016; Issue 9: CD012067. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27687114/
47. Navanandan N, Federico M, Mistry RD. Positive expiratory pressure for the treatment of acute asthma exacerbations: a randomized controlled trial. *J Pediatr* 2017; 185: 149-54.e2. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28284473/
48. Calvert, L D, Jackson, J M, White, J A, *et al*. Enhanced delivery of nebulised salbutamol during non-invasive ventilation. *J Pharm Pharmacol*. 2006; 58: 1553-1557. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17132219
49. Mitselou N, Hedlin G, Hederos CA. Spacers versus nebulizers in treatment of acute asthma - a prospective randomized study in

preschool children. *J Asthma*. 2016; 53: 1059-62. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27186989
50. Cates CJ, Crilly JA, Rowe BH. Holding chambers (spacers) versus nebulisers for beta-agonist treatment of acute asthma. *Cochrane Database Syst Rev*. 2006; Issue 2: CD000052. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD000052.pub2/full
51. Dhuper S, Chandra A, Ahmed A, *et al*. Efficacy and cost comparisons of bronchodilatator administration between metered dose inhalers with disposable spacers and nebulizers for acute asthma treatment. *J Emerg Med*. 2011; 40: 247-55. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19081697
52. Cates CJ, Welsh EJ, Rowe BH. Holding chambers (spacers) versus nebulisers for beta-agonist treatment of acute asthma. *Cochrane Database Syst Rev*. 2013; 9: Cd000052. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24037768
53. Tran K, Cimon K, Severn M et al. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One*. 2012; 7: e35797. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22563403
54. Travers AH, Milan SJ, Jones AP, *et al*. Addition of intravenous beta(2)-agonists to inhaled beta(2)-agonists for acute asthma. *Cochrane Database Syst Rev*. 2012; 12: CD010179. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD010179/full
55. Babl FE, Sheriff N, Borland M, *et al*. Paediatric acute asthma management in Australia and New Zealand: practice patterns in the context of clinical practice guidelines. *Arch Dis Child*. 2008; 93: 307-312. Available from: http://adc.bmj.com/content/93/4/307.abstract
56. Abramson MJ, Bailey MJ, Couper FJ, *et al*. Are asthma medications and management related to deaths from asthma?. *Am J Respir Crit Care Med*. 2001; 163: 12-18. Available from: http://www.ncbi.nlm.nih.gov/pubmed/11208619
57. Karpel JP, Aldrich TK, Prezant DJ, *et al*. Emergency treatment of acute asthma with albuterol metered-dose inhaler plus holding chamber: how often should treatments be administered?. *Chest*. 1997; 112: 348-356. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9266868
58. Teoh L, Cates CJ, Hurwitz M, *et al*. Anticholinergic therapy for acute asthma in children. *Cochrane Database Syst Rev*. 2012; 4: CD003797. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD003797.pub2/full
59. Knightly R, Milan SJ, Hughes R et al. Inhaled magnesium sulfate in the treatment of acute asthma. *Cochrane Database Syst Rev* 2017; 11: Cd003898. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29182799/
60. Goodacre S, Cohen J, Bradburn M et al. The 3Mg trial: a randomised controlled trial of intravenous or nebulised magnesium sulphate versus placebo in adults with acute severe asthma. *Health Technol Assess* 2014; 18: 1-168. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24731521/
61. Su Z, Li R, Gai Z. Intravenous and nebulized magnesium sulfate for treating acute asthma in children: a systematic review and meta-analysis. *Pediatr Emerg Care* 2018; 34: 390-5. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29851914/
62. Pruikkonen H, Tapiainen T, Kallio M et al. Intravenous magnesium sulfate for acute wheezing in young children: a randomised double-blind trial. *Eur Respir J* 2018; 51: Available from: https://www.ncbi.nlm.nih.gov/pubmed/29437941/
63. Goodacre S, Cohen J, Bradburn M et al. Intravenous or nebulised magnesium sulphate versus standard therapy for severe acute asthma (3Mg trial): a double-blind, randomised controlled trial. *Lancet Respir Med* 2013; 1: 293-300. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24429154/
64. Powell C, Kolamunnage-Dona R, Lowe J, *et al*. MAGNEsium Trial In Children (MAGNETIC): a randomised, placebo-controlled trial and economic evaluation of nebulised magnesium sulphate in acute severe asthma in children. *Health Technol Assess*. 2013; 17: 1-216. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24144222
65. Powell C, Kolamunnage-Dona R, Lowe J et al. Magnesium sulphate in acute severe asthma in children (MAGNETIC): a randomised, placebo-controlled trial. *Lancet Respir Med* 2013; 1: 301-8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24429155/
66. Alansari K, Ahmed W, Davidson BL et al. Nebulized magnesium for moderate and severe pediatric asthma: A randomized trial. *Pediatr Pulmonol* 2015; 50: 1191-9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25652104/
67. Kelly, A. M., Kerr, D., Powell, C.. Is severity assessment after one hour of treatment better for predicting the need for admission in acute asthma?. *Respir Med*. 2004; 98: 777-81. Available from: https://www.resmedjournal.com/article/S0954-6111(04)00042-3/fulltext

Providing post-acute care

Recommendations

After respiratory distress or increased work of breathing has resolved and symptoms have stabilised, observe the patient for at least 4 hours.

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

For adults, adolescents and children old enough to perform spirometry, record spirometry again before discharge.

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

At discharge, check if the patient has a preventer that contains an inhaled corticosteroid:

- **If the person is already using (or has been prescribed) inhaled corticosteroids, check adherence and inhaler technique, and instruct the patient or parent/carer to continue their inhaled corticosteroid.**
- **For adults and older adolescents with asthma who have not been prescribed inhaled corticosteroids, prescribe an inhaled corticosteroid at a low dose, demonstrate correct inhaler technique, and arrange review of treatment at comprehensive follow-up.**
- **For children younger than 12 years with asthma who are not currently taking a preventer, consider whether preventer treatment is indicated and arrange review of treatment at comprehensive follow-up.**

Note: Regular low-dose inhaled corticosteroid treatment is indicated for all adults and adolescents over 12 years who have had an asthma flare-up in the previous 12 months.

- **For all inhalers: Train the patient or parent/carer how to use their inhaler correctly. A physical demonstration is essential.**

▶ **Go to:** *Prescribing inhaled corticosteroid-based preventers for adults*

▶ **Go to:** *Considering if regular preventer treatment is indicated in children aged 1–5 years*

▶ **Go to:** *Considering if regular preventer treatment is indicated in children 6–11 years*

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

Routine treatment with antibiotics is not recommended after acute asthma.

How this recommendation was developed

Consensus following inconclusive literature search

Based on clinical experience and expert opinion after literature review yielded insufficient evidence for an evidence-based recommendation.

Key evidence considered:

- Normansell et al. 2018[1]
- Johnston et al. 2016[2]
- Stokholm et al. 2016[3]

Last reviewed version 2.0

For patients treated in acute care services, complete all of the following before discharge:

- **Ensure that the patient (or parent/carer) is able to monitor and manage asthma at home.**
- **Check the patient (or parent/carer) has a reliever medicine and assess their inhaler technique.**
- **Provide a spacer, if needed. Make sure the patient (or parent/carer) knows how to use it.**
- **Check that the person has a course of oral prednisolone and understands when and how long to take it (if indicated).**
- **Check the patient (or parent/carer) has a preventer medicine (if indicated) and assess their inhaler technique.**
- **Check that parent/carer knows how to recognise asthma symptoms.**
- **Check the patient (or parent/carer) knows what to do if asthma symptoms worsen or do not improve.**
- **Advise patient (or parent/carer) to make an appointment with their usual GP in 3 days and a second appointment within 2–4 weeks.**
- **For patients of all ages with severe acute asthma or a previous presentation, consider arranging referral to a consultant/respiratory physician.**
- **Provide an asthma discharge plan (interim written asthma action plan), that includes instructions on when and how to use reliever, when and how to use preventer (if indicated), when and how to use systemic corticosteroids, what to do if their asthma deteriorates, and when to call 000 for emergency care.**
- **Explain that the patient needs their own written asthma action plan prepared by their usual doctor (e.g. GP or respiratory physician).**
- **Provide a copy of the discharge summary to the patient's usual GP.**

- **Clearly explain that reliever should only be used as needed for symptoms (or before exercise, if indicated), not regularly. Include this in written information.**

▶ **See:** *Asthma discharge plan for adults*
See: *Asthma discharge plan for children*

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

Arrange follow-up, including:

- **recheck within 3 days by usual GP**
- **comprehensive assessment in 2–4 weeks to review the treatment regimen (e.g. refer to person's GP or arrange specialist assessment).**

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

At the follow-up review, the patient's usual doctor (e.g. GP) should:

- **try to identify trigger factors associated with the acute asthma episode**
- **review the person's written asthma action plan**

- **review the person's reliever use and give instructions to use reliever only as needed**
- **review the treatment regimen and prescribe or adjust inhaled corticosteroid-containing preventer, if indicated**
- **check inhaler technique and correct it, if necessary**
- **assess whether the person has other risk factors for asthma flare-ups**
- **offer specialist review if the person has had more than one emergency visit to health services for acute asthma within the previous 12 months or repeated corticosteroid treatments.**

Note: Regular inhaled corticosteroid treatment is indicated for all adults and adolescents over 12 years who have had an asthma flare-up in the previous 12 months.

- **For all inhalers: Train the patient or parent/carer how to use their inhaler correctly. A physical demonstration is essential.**
- **Clearly explain that when asthma is back under control the reliever should only be used as needed for symptoms (or before exercise, if indicated), not regularly. Include this in written information.**

▶ **Go to:** *Prescribing inhaled corticosteroid-based preventers for adults*

▶ **Go to:** *Considering if regular preventer treatment is indicated in children aged 1-5 years*

▶ **Go to:** *Considering if regular preventer treatment is indicated in children 6 years and over*

How this recommendation was developed

Consensus

Based on clinical experience and expert opinion (informed by evidence, where available).

Last reviewed version 2.0

More information

The 1-hour assessment

Very little evidence is available to determine when it is safe to discharge a patient with severe acute asthma from the emergency department. Few studies have correlated features of clinical history, examination, response to medications or objective measures of airflow obstruction with outcomes after discharge including relapse.

Timing of decision to admit or discharge

An Australian 'real world' prospective observational study,[4] which included children and adults aged 1–55 years with acute asthma presenting to emergency departments, correlated severity class assessed at initial presentation and at the 1-hour assessment with clinicians' assessment of need for hospital admission or intensive care unit admission. Compared with assessed severity class at initial presentation, severity class assessed at 1 hour better predicted:[4]

- the decision for hospital admission among patients initially assessed as having 'moderate' acute asthma (e.g. able to speak in phrases, oxygen saturation 92–95%, FEV_1 50–75% predicted, pulse rate 100–120/min)
- the decision to admit to the intensive care unit among patients initially assessed as having 'severe' acute asthma (e.g. physical exhaustion, unable to speak more than a word at time, oxygen saturation < 92%, FEV_1 < 50% or <1 L, pulse rate >120/min).

The 'lie flat' test (adults)

In adults, at 1 hour after initial treatment, the ability to lie flat without dyspnoea may be a useful indicator of adequate recovery without the need for hospital admission, particularly when combined with adequate improvement in FEV_1 measured by spirometry.[5]

Spirometry

A study in adults with acute asthma found that, on its own, FEV_1 (measured by spirometry) at 1 hour after admission to the emergency department did not closely correlate with clinicians' decision for or against hospital admission, as assessed clinically.[5] However, the combination at 1 hour of FEV_1 and the 'lie flat' test was significantly predictive of the decision for hospital admission.[5]

Most adults with acute asthma can perform spirometry within the first hour of admission to the emergency department.[6]

Table. Tips for performing spirometry in patients with acute asthma

- Ask the patient to sit straight upright, either in a chair or on a stretcher with their legs over the side.

- Make sure the person forms a tight seal around the mouthpiece.
- Tell the patient to take as deep a breath as possible, then blast out air as fast and hard as they can, then keep blowing until asked to stop. Aim for exhalation of maximal force for at least 2 seconds (6 seconds if FVC is measured).

You may need to give the patient lots of coaching, repeat instructions, and give immediate feedback on technique.

Last reviewed version 2.0

Asset ID: 66

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Asthma discharge plans (interim asthma action plans)

An asthma discharge plan is an interim action plan provided after treatment for acute asthma at discharge from an emergency department or hospital admission. Its purpose is to provide written instructions until the person returns to their usual doctor or nurse practitioner for review of their written asthma action plan.

It should include (all of):

- the patient's name
- instructions for oral corticosteroid course (dose, duration, when to take)
- instructions for reliever dose in immediate post-acute period (dose, how to take including use of spacer, duration of this dose)
- instructions for going back to usual as-needed reliever regimen (clearly state the number of actuations to be taken as needed)
- instructions for preventer
- what to do if symptoms getting worse or recur within hours of taking reliever
- instruction to make appointment with usual doctor e.g. GP.

▶ See: *Asthma discharge plan for adults*
See: *Asthma discharge plan for children*

Last reviewed version 2.0

Systemic corticosteroids in acute asthma

Systemic corticosteroids in acute asthma

In adults and school-aged children with acute asthma, systemic corticosteroids given within 1 hour of presentation to an emergency department reduce the need for hospital admission.[7] In children admitted to hospital with acute asthma, systemic corticosteroid treatment may achieve earlier discharge and fewer relapses.[8]

In preschool children with acute viral-induced wheezing, there is inconsistent evidence for the benefits of systemic corticosteroids.[9, 10, 11] Oral corticosteroids may be beneficial in children younger than 6 years with frequent acute wheezing or asthma, but current evidence does not strongly support their use in this age group.[12] The Thoracic Society of Australia and New Zealand position statement on the use of corticosteroids in children[13] recommends that the use of systemic corticosteroids in preschool children, particularly those with intermittent viral induced wheezing, should be limited to those with wheeze severe enough to need admission to hospital.

After an acute asthma episode, treatment with systemic corticosteroids (intramuscular corticosteroids, oral prednisone/prednisolone, or oral dexamethasone) at discharge from the emergency department reduces the risk of relapse in adults[14] and children.[15, 16]

Formulation and route of administration

In adults and children with acute asthma, oral prednisone/prednisolone is as effective as intravenous or intramuscular corticosteroids.[7, 17]

Oral dexamethasone is as effective as prednisone/prednisolone in adults and children[18, 19, 20, 21, 22, 23, 24, 25, 26]

Dose

In adults, 40 mg per day prednisolone/prednisone,[27] up to 80 mg/day methylprednisolone, or up to 400 mg/day hydrocortisone[28] are adequate.

In children the majority of studies in children have used 1–2 mg/kg of oral prednisolone (maximum 60 mg) given initially then 1 mg/kg per day. Current evidence does not support the use of higher doses.[17]

Studies evaluating oral dexamethasone in adults have used a single dose of 12 mg[18] or 16 mg on 2 consecutive days.[26] Most studies evaluating oral dexamethasone in children have used 0.6 mg/kg per dose on one or two consecutive days.[21]

Duration

In adults, an oral or intramuscular corticosteroid course of at least 7 days appears more effective than a shorter course in preventing relapse within 10 days of discharge after acute asthma,[14] although one clinical trial evaluating prednisone reported that 5 days was as effective as 10 days.[29] Courses less than 5 days are not recommended.

In children, a 3-day course of prednisone/prednisolone is generally as effective as a 5-day course,[30] but 5 days may be needed for children with severe or life-threatening acute asthma.[13]

It is not necessary to taper the dose after a short course of oral prednisone/prednisolone.[14, 31, 32]

Dexamethasone has a longer half-life than prednisone/prednisolone. Longer courses may more pronounced mineralocorticoid adverse effects. Oral dexamethasone treatment in adults or children should not exceed 2 days.

Adverse effects

Short-term use of oral corticosteroids to treat acute asthma is often well tolerated in children and adults,[7, 8, 10, 25] but many patients report significant adverse effects, particularly mood changes, gastrointestinal disturbances,[34] nocturia, and difficulty sleeping. While short courses of high-dose systemic treatment cause fewer adverse effects than prolonged courses of lower doses,[35] more recent analyses have shown a significant association between short courses of oral corticosteroids and sepsis, thromboembolism and fracture.[36, 37]

Oral dexamethasone appears to be well tolerated in adults.[18] In children it may be associated with less vomiting than prednisone/prednisolone.[19, 20, 21, 22, 22, 23, 24] The risk of unwanted mineralocorticoid effects are increased if dexamethasone is taken for more than 2 days.

In people with diabetes or impaired glucose tolerance, corticosteroids increase blood glucose levels. Impaired glucose tolerance is common among people aged over 65 years. In patients with diabetes or impaired glucose tolerance, blood glucose monitoring (e.g. morning and evening samples) may be indicated during treatment with oral corticosteroids.

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Inhaled corticosteroids in acute asthma

Inhaled corticosteroid treatment in acute care

Clinical trial evidence does not support the use of inhaled corticosteroids in place of systemic corticosteroid treatment in the treatment of acute asthma.[38]

Some randomised clinical trials suggest that inhaled corticosteroid treatment may reduce hospital admission rates when given in addition to systemic corticosteroids, but the evidence is conflicting.[38] Overall, evidence from randomised clinical trials does not show that inhaled corticosteroid therapy achieves clinically important improvement in lung function or clinical scores when used in acute asthma in addition to systemic corticosteroids.[38]

Inhaled corticosteroid treatment in post-acute care - short term effects

Current standard follow-up treatment after acute asthma includes a course of systemic corticosteroids, and continuation of inhaled corticosteroids for patients already taking this treatment.

Overall, evidence from short term randomised clinical trials suggests that inhaled corticosteroid treatment, given at discharge from the emergency department after acute asthma, does not provide additional short-term benefit in patients who are also receiving oral corticosteroids.[39]

Some randomised clinical trials suggest that high-dose inhaled corticosteroid treatment at discharge from the emergency department may be as effective as oral corticosteroids in patients with mild acute asthma, but overall evidence does not support replacing oral corticosteroids with inhaled corticosteroids.[39]

These clinical trials were designed to assess short term effects of inhaled corticosteroid in managing the current acute asthma episode. This evidence does not suggest that inhaled corticosteroids should be stopped after or during an acute asthma episode.[39] Regular inhaled corticosteroid treatment is highly effective for preventing asthma flare-ups, including in patients with a recent asthma hospitalisation. A large case-control study showed that, after hospitalisation for asthma, regular ICS were associated with a 39% reduction in the risk of re-hospitalisation within the following 12 months.

Rationale for prescribing inhaled corticosteroids at discharge from acute care

Inhaled corticosteroid treatment reduces the frequency and severity of asthma flare-ups, reduces the risk of asthma hospitalisation and rehospitalisation, and reduces the risk of death due to asthma.[40, 41]

Regular inhaled corticosteroid treatment is therefore indicated for all adults and older adolescents who have experienced a flare-up within the last 12 months, as well as for those with asthma that is not well controlled (asthma symptoms twice or more during the past month, or waking due to asthma symptoms once or more during the past month).

At the time of discharge from the emergency department or hospital, there is an opportunity to start inhaled corticosteroid treatment and to ensure that the patient's usual GP will review the treatment regiment at the follow-up visit.

▶ See: *Prescribing inhaled corticosteroid-based preventers for adults*

Last reviewed version 2.0

References

1. Normansell R, Sayer B, Waterson S et al. Antibiotics for exacerbations of asthma. *Cochrane Database Syst Rev* 2018; 6: CD002741. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29938789/
2. Johnston SL, Szigeti M, Cross M et al. Azithromycin for acute exacerbations of asthma : the AZALEA randomized clinical trial. *JAMA Intern Med* 2016; 176: 1630-7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27653939/.
3. Stokholm J, Chawes BL, Vissing NH et al. Azithromycin for episodes with asthma-like symptoms in young children aged 1-3 years: a randomised, double-blind, placebo-controlled trial. *Lancet Respir Med* 2016; 4: 19-26. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26704020/.
4. Kelly, A. M., Kerr, D., Powell, C.. Is severity assessment after one hour of treatment better for predicting the need for admission in acute asthma?. *Respir Med*. 2004; 98: 777-81. Available from: https://www.resmedjournal.com/article/S0954-6111(04)00042-3/fulltext
5. Wilson MM, Irwin RS, Connolly AE, *et al*. A prospective evaluation of the 1-hour decision point for admission versus discharge in acute asthma. *J Intensive Care Med*. 2003; 18: 275-285. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15035763
6. Silverman RA, Flaster E, Enright PL, Simonson SG. FEV1 performance among patients with acute asthma: results from a multicenter clinical trial. *Chest*. 2007; 131: 164-171. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17218571
7. Rowe BH, Spooner C, Ducharme F, *et al*. Early emergency department treatment of acute asthma with systemic corticosteroids. *Cochrane Database Syst Rev*. 2001; Issue 1: CD002178. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11279756
8. Smith M, Iqbal S, Elliot TM et al. Corticosteroids for hospitalised children with acute asthma. *Cochrane Database Syst Rev*. 2003; Issue 2: CD002886. Available from: https://www.ncbi.nlm.nih.gov/pubmed/12804441
9. Foster SJ, Cooper MN, Oosterhof S, Borland ML. Oral prednisolone in preschool children with virus-associated wheeze: a prospective, randomised, double-blind, placebo-controlled trial. *Lancet Respir Med*. 2018; 6: 97-106. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29373235
10. Panickar J, Lakhanpaul M, Lambert PC, *et al*. Oral prednisolone for preschool children with acute virus-induced wheezing. *N Engl J Med*. 2009; 360: 329-328. Available from: https://www.ncbi.nlm.nih.gov/pubmed/19164186
11. Therapeutic guidelines [Electronic book]: Therapeutic Guidelines Limited; 2018 [cited 2018 April].
12. Castro-Rodriguez JA, Beckhaus AA, Forno E. Efficacy of oral corticosteroids in the treatment of acute wheezing episodes in asthmatic preschoolers: Systematic review with meta-analysis. *Pediatric pulmonology* 2016; 51: 868-76. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27074244
13. van Asperen PP, Mellis CM, Sly PD, Robertson C. *The role of corticosteroids in the management of childhood asthma*. The Thoracic Society of Australia and New Zealand, 2010. Available from: https://www.thoracic.org.au/journal-publishing/command/download_file/id/25/filename/The_role_of_corticosteroids_in_the_management_of_childhood_asthma_-_2010.pdf
14. Rowe BH, Kirkland SW, Vandermeer B et al. Prioritizing systemic corticosteroid treatments to mitigate relapse in adults with acute asthma: a systematic review and network meta-analysis. *Acad Emerg Med*. 2017; 24: 371-81. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27664401/
15. Castro-Rodriguez, J. A., Rodrigo, G. J., Rodriguez-Martinez, C. E.. Principal findings of systematic reviews for chronic treatment in childhood asthma. *J Asthma*. 2015; 52: 1038-45. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26303207
16. Kirkland SW, Vandermeer B, Campbell S et al. Evaluating the effectiveness of systemic corticosteroids to mitigate relapse in children assessed and treated for acute asthma: A network meta-analysis. *J Asthma* 2018: 1-12. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29693459/
17. Normansell R, Kew KM, Mansour G. Different oral corticosteroid regimens for acute asthma. *Cochrane Database Syst Rev* 2016; Issue 5: CD011801. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27176676/
18. Rehrer MW, Liu B, Rodriguez M et al. A randomized controlled noninferiority trial of single dose of oral dexamethasone versus 5 Days of oral prednisone in acute adult asthma. *Ann Emerg Med*. 2016; 68: 608-13. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27117874/
19. Walia MK. Oral dexamethasone versus oral prednisolone in acute asthma: a new randomized controlled trial and updated meta-analysis: pediatric pulmonologist's viewpoint. *Indian Pediatr*. 2018; 55: 159. Available from: https://www.indianpediatrics.net/feb2018/159.pdf/
20. Bravo-Soto GA, Harismendy C, Rojas P et al. Is dexamethasone as effective as other corticosteroids for acute asthma exacerbation in children? *Medwave*. 2017; 17: e6931. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28430773/
21. Meyer JS, Riese J, Biondi E. Is dexamethasone an effective alternative to oral prednisone in the treatment of pediatric asthma exacerbations? *Hosp Pediatr*. 2014; 4: 172-80. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24785562/
22. Keeney GE, Gray MP, Morrison AK et al. Dexamethasone for acute asthma exacerbations in children: a meta-analysis. *Pediatrics*. 2014; 133: 493-9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24515516/
23. Cronin JJ, McCoy S, Kennedy U et al. A randomized trial of single-dose oral dexamethasone versus multidose prednisolone for

acute exacerbations of asthma in children who attend the emergency department. *Ann Emerg Med* 2016; 67: 593-601.e3. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26460983/
24. Cronin J, Kennedy U, McCoy S et al. Single dose oral dexamethasone versus multi-dose prednisolone in the treatment of acute exacerbations of asthma in children who attend the emergency department: study protocol for a randomized controlled trial. *Trials* 2012; 13: 141. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22909281/
25. Rowe BH, Spooner C, Ducharme F, *et al*. Corticosteroids for preventing relapse following acute exacerbations of asthma. *Cochrane Database Syst Rev*. 2007; Issue 3: CD000195. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17636617
26. Kravitz J, Dominici P, Ufberg J, *et al*. Two days of dexamethasone versus 5 days of prednisone in the treatment of acute asthma: a randomized controlled trial. *Ann Emerg Med*. 2011; 58: 200-204. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21334098
27. Rodrigo GJ, Nannini LJ. Comparison between nebulized adrenaline and beta2 agonists for the treatment of acute asthma. A meta-analysis of randomized trials. *Am J Emerg Med* 2006; 24: 217-22. Available from: https://www.ncbi.nlm.nih.gov/pubmed/16490653/
28. Manser R, Reid D, Abramson MJ. Corticosteroids for acute severe asthma in hospitalised patients. *Cochrane Database Syst Rev*. 2001; Issue 1: CD001740. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11279726
29. Jones AM, Munavvar M, Vail A, *et al*. Prospective, placebo-controlled trial of 5 vs 10 days of oral prednisolone in acute adult asthma. *Respir Med*. 2002; 96: 950-954. Available from: http://www.resmedjournal.com/article/S0954-6111(02)91369-7/abstract
30. Chang, A B, Clark, R, Sloots, T P, *et al*. A 5- versus 3-day course of oral corticosteroids for children with asthma exacerbations who are not hospitalised: a randomised controlled trial. *Med J Aust*. 2008; 189: 306-310.Available from: https://www.ncbi.nlm.nih.gov/pubmed/18803532/
31. Cydulka RK, Emerman CL. A pilot study of steroid therapy after emergency department treatment of acute asthma: is a taper needed?. *J Emerg Med*. 1998; 16: 15-19. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9472754
32. O'Driscoll BR, Kalra S, Wilson M, *et al*. Double-blind trial of steroid tapering in acute asthma. *Lancet*. 1993; 341: 324-327. Available from: http://www.sciencedirect.com/science/article/pii/0140673693901343
33. Grzelewski, T, Stelmach, I. Exercise-induced bronchoconstriction in asthmatic children: a comparative systematic review of the available treatment options. *Drugs*. 2009; 69: 1533-1553. Available from: https://www.ncbi.nlm.nih.gov/pubmed/19678711
34. Berthon BS, Gibson PG, McElduff P et al. Effects of short-term oral corticosteroid intake on dietary intake, body weight and body composition in adults with asthma - a randomized controlled trial. *Clin Exp Allergy* 2015; 45: 908-19. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25640664/
35. Australian Medicines Handbook. Last modified July 2018: *Australian Medicines Handbook Pty Ltd*. 2018
36. Lefebvre P, Duh MS, Lafeuille MH et al. Acute and chronic systemic corticosteroid-related complications in patients with severe asthma. *J Allergy Clin Immunol* 2015; 136: 1488-95. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26414880/
37. Waljee AK, Rogers MA, Lin P et al. Short term use of oral corticosteroids and related harms among adults in the United States: population based cohort study. *BMJ* 2017; 357: j1415. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28404617/
38. Edmonds ML, Milan SJ, Camargo CA, *et al*. Early use of inhaled corticosteroids in the emergency department treatment of acute asthma. *Cochrane Database Syst Rev*. 2012; 12: CD002308. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD002308.pub2/full
39. Edmonds ML, Milan SJ, Brenner BE, *et al*. Inhaled steroids for acute asthma following emergency department discharge. *Cochrane Database Syst Rev*. 2012; 12: CD002316. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD002316.pub2/full
40. Suissa S, Ernst P, Kezouh A. Regular use of inhaled corticosteroids and the long term prevention of hospitalisation for asthma. *Thorax*. 2002; 57: 880-884.
41. Suissa, S, Ernst, P, Benayoun, S, *et al*. Low-dose inhaled corticosteroids and the prevention of death from asthma. *N Engl J Med*. 2000; 343: 332-336.

Community first aid

For first aid instructions for patients, parents and community members:

▶ See: *First aid instructions for patients, parents and community members*

For information on preparing a written asthma action plan to guide self-management:

▶ See: *Preparing written asthma action plans for adults*
See: *Providing asthma management education for parents and children*