A Patient's Guide to
Aerosol Medication Delivery

3rd Edition

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With a Foreword by
Thomas Kallstrom, MBA, RRT, FAARC
Executive Director/Chief Executive Officer
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Produced by the
American Association
for Respiratory Care

Foreward

Gaining as much information as possible about your aerosol delivery devices is essential. You have taken a positive first step by obtaining this third edition of "A Patient's Guide to Aerosol Medication Delivery." The American Association for Respiratory Care (AARC) asked respiratory therapists who were noted aerosol delivery experts to write this guide. This guide was written with you in mind. As you know, the number of medications and the devices that deliver them changes often. That is why it is important for you to understand the critical differences between these devices and, more importantly, how to use your device(s) correctly so that you can maximize the intended result that the medication delivers. We encourage you to become proficient in the use of your aerosol delivery devices and never hesitate to ask questions of your physician or respiratory therapist.

This Patient Guide will provide you with step-by-step education on all available devices on the U.S. market today. Currently there are four basic types of delivery systems which include nebulizers, metered-dose inhalers, soft-mist inhalers, and dry-powder inhalers. All four have their own specific characteristics and delivery capabilities that required your physician to determine which was the most appropriate for you.

We hope that you find this Patient Guide useful. The American Association for Respiratory Care invites you to learn more about better self-management of lung disease through other online resources that, again, have been created to help you and to allow you to practice a higher level of self-management. Simply go to www.aarc.org or www.yourlunghealth.org. There you will find "Allergy and Asthma Health," (an online magazine), smoking-cessation information, and so much more. We encourage you to learn the most you can about your lung health.

Thomas Kallstrom, MBA, RRT, FAARC
Executive Director/Chief Executive Officer
American Association for Respiratory Care

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Quotes

"I like 'A Patient's Guide to Aerosol Medication Delivery' and think that it is going to be very helpful not only to patients but to medical professionals as well. Very good job."

Vlady Rozenbaum, PhD
Founder-Administrator
COPD-ALERT

"My first reaction was 'Who is going to read 50-plus pages?' After reading it my reaction is 'Where was this when I was first given an inhaler with no instructions.'"

Kenneth Benson
Patient

Introduction

Perhaps the shortness of breath, coughing, excessive phlegm, chest tightness and/or difficulty in catching your breath that you have been experiencing has recently been diagnosed as a lung disease. The good news is that your physician, respiratory therapist, or nurse professional provided you with a brief description of your condition — explained what it is, the causes, and the treatment options. He/she also probably recommended that you start taking medication in the form of a breathing treatment.

You may have already received a few treatments and find that they make your breathing easier. You may also have learned by now that taking control of your obstructive airways disease is the only way to improve your health to the point where you can do all the things you need and want to do. You may also know that controlling your condition will involve understanding as much as possible about these breathing treatments.

But you no doubt still have a lot of unanswered questions: What is an aerosol? What are these breathing devices? What is in them? How do they work? And, why do I have to use them? These are just a few of the questions that this Patient Guide has been developed to help answer. It is written in language that is easy to understand and in a conversational style format that is easy to follow.

This Patient Guide was prepared for you by the American Association for Respiratory Care (AARC), a professional organization of over 47,000 respiratory therapists who are competent, caring, and compassionate individuals dedicated to the detection, management, and treatment of lung diseases.

Respiratory therapists (RTs) are the frontline caregivers for patients with asthma, pulmonary fibrosis, cystic fibrosis, chronic bronchitis, emphysema, chronic obstructive pulmonary disease (COPD), and many other respiratory diseases. They are committed to helping you control and manage your condition. We hope you will find our Patient Guide a valuable resource. It will help you understand how medications enter your lungs and decrease your symptoms.

It is important to note that this Patient Guide is not a substitute for medical information or treatment options provided by your physician. The Guide is primarily intended to describe the devices used to deliver breathing treatments — explaining what they are, how they work, and how to use them correctly.

1 Aerosol Medication Delivery: The Basics

What is an aerosol?

Remove the top from a perfume bottle, hairspray, room deodorizer, or household air freshener and press the button. What you see is an aerosol — a small cloud of tiny particles floating in the air. Did you know that aerosols exist everywhere there is air to breathe? Aerosols occur in the air we breathe such as pollen, fog, and steam. Other types of man-made aerosols are harmful, such as cigarette smoke, automobile emissions, and pollution from factories and coal mines.

Some aerosols seem beneficial. They make us smell fresh, eliminate odors, clean, and disinfect. However, all inhaled aerosols have the potential to cause our lung disease to flare-up. The aerosols we will address in this Guide are medical aerosols that are designed to help you breathe better.

Medical aerosols

A *medical aerosol* is a mixture of medication particles and gas. When you take your breathing treatment, which we will call an *aerosol treatment*, you are breathing in an aerosol that will help you breathe easier. Aerosol treatments can be delivered through:

1. Pressurized metered-dose inhaler (MDI), dry-powder inhaler (DPI), and soft-mist inhaler (SMI) — these are portable, hand-held devices that you can carry in your purse or pocket.

2. Small-volume nebulizer (SVN) — a portable device that has a small plastic tube and cup (nebulizer) that connects to a small machine that pumps air (air compressor). Liquid medication is put into the cup and the machine makes the liquid into an aerosol.

We will discuss all of these devices in more detail throughout this Guide. But first, let us explain some of the terms you need to know about aerosol medication delivery. The most important terms for you to know are listed on page 7.

Common terms

Aerosol: A mix of liquids and solids produced by an aerosol machine such as the small-volume nebulizer (SVN), or a pressurized metered-dose inhaler (MDI), a dry-powder inhaler (DPI), or a soft-mist inhaler (SMI).

Aerosol Deposition: It is what happens when the medication lands on the inside of your air passages. This is how the medication is absorbed into the body after breathing it in through the device.

Aerosol Generator: A device used for producing the aerosol.

Aerosol Output: All the particles that make up the cloud or mist that you see coming from your aerosol device. It is a collection of tiny little droplets of liquid or particles of medication.

Aerosol Therapy: Delivery of solid or liquid aerosol to your lungs for the purpose of treating your breathing problem.

Dry-Powder Inhaler (DPI): A device that delivers the medication in a fine, powdered form. With DPIs the medication is pulled into your lungs as you take in a fast breath. This means you need to breathe in fast and deep to get the medication from the device deep into your lungs.

Flare-up: A sudden appearance or worsening of the symptoms of a disease or condition.

Hydrofluoroalkane (HFA): A liquefied gas that pushes the medication out of the MDI.

Inhaler: A term for any type of self-contained medication-delivery device (e.g., dry-powder inhaler or metered-dose inhaler). Either type of inhaler delivers a single dose of medication for inhalation.

You are possibly carrying one type of inhaler in your purse or pocket right now. With an inhaler, you can take a dose of inhaled medication anytime.

Medication Formulation: The ingredients in the medication "recipe."

Pressurized Metered-Dose Inhaler (MDI): A medication delivery device that contains multiple doses of your medication and dispenses a single dose. The outlet of the device is put into your mouth and when you spray it, a dose of medication is delivered. But remember, you still need to breathe in at the same time with a slow, deep breath.

Respiratory Therapist: A health care professional educated in respiratory medicine who works directly with people who have lung disease.

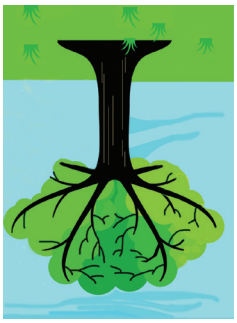
Side Effect: An undesirable effect of a medication or treatment.

Small-Volume Nebulizer (SVN): A device that converts a liquid medication into an aerosol. An SVN includes (1) an air compressor (either electrically or battery powered) and (2) a small plastic nebulizer cup that connects to the compressor with a plastic tube. When the liquid medication is placed into the nebulizer cup and the compressor is turned on, an aerosol is created.

Soft-Mist Inhaler: Respimat® is an inhaler that produces a mist with a slower speed than a MDI, so there may be less aerosol remaining in your mouth when you breathe in.

Spacer: A plastic tube that is placed between the MDI and your mouth. The spacer helps coordination and timing so that more of the aerosol gets into your air passages.

How does the aerosol get into my air passages?



If you imagine the structure of the lung as an upside-down tree, you can begin to picture the size and design of the lung and its air passages (breathing tubes). The base of the tree (the trunk) represents the trachea or windpipe, which is about an inch in diameter in adults, but smaller in kids. Just as the tree continues to branch out into smaller limbs, so do the breathing tubes (air passages). The major tubes are called bronchi and the smaller tubes are called bronchioles. This branching will eventually end with tiny air sacs. The inhaled medication needs to reach *all* of these air passages.

Air passages

Asthma and COPD are lung diseases that cause the air passages to get smaller from the size of a dime to that of a pencil, or even smaller in severe cases.

Airway obstruction, which occurs when your asthma or COPD flares up, will most likely happen at about the fourth or fifth airway branching level. This is important because we want most of the aerosol medication to reach further out in the lungs, so the size and speed of the particles become important.

Breathing pattern

The way we take a breath is important to get medicines deep into the air passages. You must breathe in slowly, hold your breath for about 10 seconds, after breathing the medicine into your lungs and then blow out. This helps the medication get farther into the air passages, which is where the medicine works the best. Once the medication reaches the desired location, it lands on the inside surface of the air passages.

Medication particle deposition

It is a rather complex process since so many things have to work right to have a successful deposit of the medication. Aside from not having the right size of aerosol particles, there is also the common problem of blocked air passages. For example, this might happen with a sudden asthma attack where there is a lot of wheezing or an increased amount of mucus which causes the air passages to become narrow or blocked. If this happens, the medication may not get to where it needs to be. Correct breathing is the other important factor in getting the medication into your air passages. You can begin to see what we mean about this being a complicated process.

What are the different types of aerosol devices?

There are 4 different types of devices used for breathing treatments.

- Pressurized metered-dose inhaler (MDI)
- Dry-powder inhaler (DPI)
- Soft-mist inhaler (SMI)
- Small-volume nebulizer (SVN)

A description of each device can be found in the Common Terms list on page 7. Note that MDIs, DPIs, and SMIs are called *inhalers*, whereas the SVN is called a *nebulizer*.

When used correctly, all 4 types of aerosol devices can provide good breathing treatments. However, there are differences in how each device makes the aerosol. What follows is a brief description of how the devices differ from each other. A more detailed explanation of how each type of device works appears later in this Guide.

Pressurized metered-dose inhaler (MDI)

A MDI is a small, aluminum canister that contains a mixture of both medication and pressurized propellant. The pressure from the growing propellant forces the medication from inside the canister through the device each time the canister is pushed down into the plastic container or boot/actuator (see Figure 1).

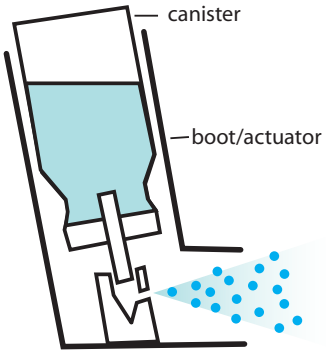


Figure 1. Parts of a MDI

Dry-powder inhaler (DPI)

A DPI is a different type of inhaler that delivers medication as a fine, dry powder. Instead of a forced propellant, you provide the energy needed by taking a deep and fast breath through the DPI mouthpiece. This deep breath also helps to carry the powdered medication farther into the lungs. There are many different types of DPIs available today (see Figure 2 for examples).

Figure 2. Various aerosol devices

Soft-mist inhaler (SMI)

A SMI or Respimat® inhaler is an inhaler that produces a mist with a slower speed than a MDI, so there may be less aerosol remaining in your mouth when you breathe in (see Figure 3).

Figure 3. Soft-mist inhaler

Small-volume nebulizer (SVN)

While there are many different types of SVNs, they all do the same thing. A dose of liquid medication is changed into an aerosol. SVNs do this in 1 of 2 ways — by using gas (the traditional way), or by using a power source (the newest way).

The traditional SVN is actually 2 separate parts — a tabletop electric air compressor and a small plastic medication cup (see Figure 4). The 2 parts are connected together with a piece of tubing. The compressor provides the pressurized gas that the nebulizer needs to turn the liquid into an aerosol mist.

The newer electronic SVNs use sound waves or vibrations to turn the liquid medication into an aerosol mist. This type of nebulizer is called a *vibrating mesh nebulizer*. However, electronic SVNs cost 2 to 3 times more than traditional SVNs.

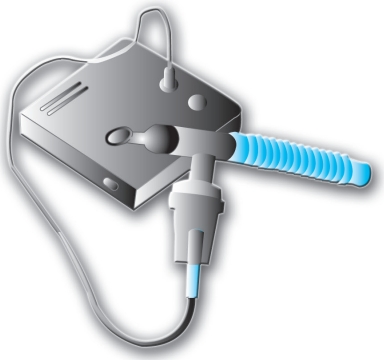


Figure 4. Small-volume nebulizer

What are the advantages and disadvantages of inhaled aerosol medications?

There are a number of advantages and disadvantages that go with aerosol medications used to treat your lung disease compared to oral medications or needle injections. The most important advantages are:

- ✔ Smaller doses (you do not need as much)
- ✔ Quicker action (they work faster)
- ✔ Direct delivery to the lung (it is going directly to the problem area)
- ✔ Fewer unwanted side effects (because you use smaller doses)
- ✔ Medication does not travel to other places where it can cause trouble
- ✔ No pain (no needles).

Just like anything else in life, there are some disadvantages as well. Some of the disadvantages are:

- ✔ The lung does not absorb a medication well— only about 10–15% of what is delivered is absorbed by the lung! That is why correct inhaler use and technique are so important.
- ✔ Your breathing style could create a problem (recall that with certain inhalers you may have to breathe in slowly and deeply, something you are not likely able to do when you are having a flare-up).
- ✔ Some people have trouble pressing the device and breathing at the same time.
- ✔ Some people cannot use them correctly.
- ✔ With so many different types of devices, people can get confused with how each one works.
- ✔ There is a lack of standard technical information (drug companies each use their own confusing language to explain them).

In order to get the best effect from aerosol medications, it is important to listen and follow the instruction and guidance from your health care provider.

2 Aerosol Medications: The Major Categories

What are the currently available aerosol medications?

Your breathing medications come in different forms. Some are liquids that you place into your small-volume nebulizer (SVN) cup. Some come in a metered-dose inhaler (MDI) or soft mist inhaler (SMI). You just spray the medicine into your mouth and breathe in slowly and deeply. Some come in a dry-powder inhaler (DPI). You breathe in a powder, quickly and deeply.

We will talk later about how to use these devices. Table 1 shows currently available aerosol medications — their generic names, brand names, delivery devices, strengths, doses, and cost. Cost varies with insurance, or the lack of it. You may also want to look back at the list of Common Terms on page 7 for a definition of each device.

Table 1. Currently available aerosol medications, brand names, and corresponding inhaler devices for use in the United States

Short-Acting Bronchodilator

Drug	Brand	Device	Strength	Doses	Cost	Cost/Dose
Albuterol Sulfate	AccuNeb®	SVN	0.63 1.25	25 25	$50.20 $50.20	$2.01 $2.01
	Albuterol Sulfate	SVN	2.5	25	$15.30	$0.61
	ProAir® HFA ProAir RespiClick® Proventil® HFA	MDI DPI MDI		200 200 200	$58.99 $55.73 $73.74	$0.30 $0.28 $0.37
	Ventolin® HFA	MDI		200	$56.42	$0.28
Levalbuterol	Xopenex® Inhalation Solution	SVN	0.31/3ml 0.63/3ml 1.25/3ml 1.25/0.5ml	24 24 24 24	$39.16 $39.16 $39.16 $23.08	$1.63 $1.63 $1.63 $0.96
	Xopenex HFA™	MDI		200	$61.61	$0.31
Ipratropium Bromide	Ipratropium Bromide	SVN	vial	25	$4.57	$0.18
	Atrovent HFA®	MDI		200	$331.32	$1.66
Ipratropium Bromide and Albuterol Sulfate	Ipratropium Bromide and Albuterol Sulfate	SVN		120	$59.57	$0.25
	DuoNeb®	SVN		120	$284.54	$2.37
	Combivent® Respimat®	MDI		120	$336.97	$2.81

Long-Acting Bronchodilator

Drug	Brand	Device	Strength	Doses	Cost	Cost/Dose
Aclidinium Bromide	Tudorza Pressair®	DPI	400 mcg	60	$318.10	$5.30
Arformoterol	Brovana®	SVN	15 mcg/2ml	30 60	$457.06 $907.12	$15.24 $15.12
Formoterol	Perforomist®	SVN	20 mcg/2ml	60	$873.92	$9.57
Indacaterol	Arcapta®	DPI	75 mcg	30	$227.70	$7.59
Salmeterol	Serevent®	DPI	50 mcg	60	$340.31	$5.67
Tiotropium	Spiriva® Spiriva Respimat® Spiriva Respimat®	DPI MDI MDI	18 mcg 1.5 mcg 2.5 mcg	30 30 30	$359.25 $359.25 $359.25	$11.98 $11.98 $11.98
Olodaterol	Stiverdi Respimat®	MDI	2.5 mcg	60	$180.74	$3.01
Umeclidinium	Incruse® Ellipta®	DPI	62.5 mcg	30	$314.17	$10.47
Glycopyrrolate	Seebri Neohaler	DPI	15.6 mcg	60	$313.67	$5.23

Combination Drugs

Drug	Brand	Device	Strength	Doses	Cost	Cost/Dose
Fluticasone and Salmeterol	Advair HFA®	MDI	45/21 mcg 115/21 mcg 230/21 mcg	120 120 120	$285.26 $352.74 $461.72	$2.38 $2.94 $3.85
	Advair Diskus®	DPI	100/50 mcg 250/50 mcg 500/50 mcg	60 60 60	$285.26 $352.74 $461.72	$4.75 $5.88 $7.70
	AirDuo RespiClick®	DPI	55/14 mcg 113/14 mcg 232/14 mcg	60 60 60	Newly approved No pricing available	
Budesonide and Formoterol	Symbicort®	MDI	80/4.5 mcg 160/4.5 mcg	120 120	$270.22 $307.87	$2.25 $2.57
Mometasone/ Formoterol	Dulera®	MDI	100/4 mcg 200	120 120	$290.54 $290.54	$2.42 $2.42
Fluticasone furate/ Vilanterol	Breo® Ellipta®	DPI	100/25 mcg 200/25 mcg	60 60	$314.80 $314.80	$5.25 $5.25
Tiotropium/ Olodaterol	Stiolto® Respimat®	MDI	2.5/2.5 mcg	60	$333.16	$5.55
Umeclidinium/ Vilanterol	Anoro® Ellipta®	DPI	62.5/25 mcg	60	$333.16	$5.55
Indacaterol/ Glycopyrrolate	Utibron Neohaler®	DPI	27.5/15.6 mcg	60	$313.67	$5.23
Formoterol/ Gylcopyrrolate	Bevespi Aerosphere®	MDI	9/4.8 mcg	120	$333.16	$2.78

Corticosteroids

Drug	Brand	Device	Strength	Doses	Cost	Cost/Dose
Beclomethasone	QVAR™ 40	MDI	40 mcg	120	$162.14	$1.35
	QVAR™ 80	MDI	80 mcg	120	$211.57	$1.76
Budesonide	Pulmicort Respules	SVN	0.25 mg	30	$277.14	$9.24
			0.5 mg	30	$324.93	$10.83
			1.0 mg	30	$642.92	$21.43
	Generic	SVN	0.25 mg	30	$63.48	$2.12
			0.5 mg	30	$73.47	$2.45
			1.0 mg	30	$145.49	$4.85
	Pulmicort® Flexhaler®	DPI	90 mcg	120	$164.14	$1.37
			180 mcg	120	$214.12	$1.79
Ciclesonide	Alvesco®	MDI	80 mcg	60	$243.51	$4.06
			160 mcg	60	$243.51	$4.06
Flunisolide	Aerospan®	MDI	80 mcg	120	$214.56	$1.79
Fluticasone propionate	Flovent Diskus®	DPI	50 mcg	60	$165.03	$2.75
			100 mcg	60	$173.96	$2.90
			250 mcg	60	$226.57	$3.78
	Flovent HFA®	MDI	44 mcg	120	$173.96	$1.45
			110 mcg	120	$226.57	$1.89
			220 mcg	120	$348.05	$2.90
	ArmonAir® RespiClick®	DPI	55 mcg	60	Newly approved	
			113 mcg	60	No pricing available	
			232 mcg	60		
Fluticasone furoate	Arnuity® Ellipta®	DPI	100 mcg	30	$164.41	$4.48
			200 mcg	30	$214.43	$7.15
Mometasone furoate	Asmanex® HFA	MDI	100 mcg	120	$191.68	$1.60
			200 mcg	120	$224.06	$1.87
	Asmanex®	DPI	110 mcg	30	$190.00	$6.33
			220 mcg	30	$205.00	$6.83

Mucoactive Drugs

Drug	Brand	Device	Strength	Doses	Cost	Cost/Dose
Dornase Alpha	Pulmozyme®	SVN	2.5mg/2.5ml	30	$3173.13	$105.77
N-Acetylcysteine		SVN	4ml/10%	1	$2.46	$2.46
			10ml/10%	1	$4.16	$1.64
			30ml/10%	1	$9.81	$1.31
			4ml/20%	1	$3.21	$3.21
			10ml/20%	1	$6.02	$2.41
			30ml/20%	1	$12.00	$1.60
Hyperosmolar Saline	HyperSal®	SVN	3.5%	60	$52.99	$0.88
			7%	60	$91.94	$1.03
	PulmoSal™ (ph 7.4)	SVN	7%	60	$51.94	$0.87

Other Drugs

Drug	Brand	Device	Strength	Doses	Cost	Cost/Dose
Zanamivir	Relenza®	DPI	5 mg	20	$65.49	$3.28
Tobramycin generic Bethkis Tobi Podhaler	TOBI®	SVN SVN DPI	300mg/5ml 300mg/5ml 300mg/4ml 28 mg	56 56 56 224	$7,578.95 $1590.21 $5862.93 $9152.54	$135.33 $28.40 $209.40 $40.85
Aztreonam	Cayston®	SVN	75 mg	84	$8254.28	$98.27
Cromolyn Sodium		SVN	20mg/2ml	60	$211.63	$3.53
Ribavirin	Virazole®	SPAG	6g	1	$25766.30	$25766.30
Mannitol	Aridol®	DP	Bronchial Challenge Test Kit, No pricing available			

HFA = hydrofluoroalkane; MDI = pressurized metered-dose inhaler; SVN = small-volume nebulizer; DPI = dry-powder inhaler
Cost information from www.goodrx.com. Prices used were from WalMart in 2017.

NOTE:
Medication companies continue to develop new aerosol medications and medication delivery devices for the control of symptoms of lung diseases. This section describes the medications available at the time of this writing. Newer medications may not be included.

How do aerosol medications work?

Table 1 (page 12) lists most of the aerosolized medications in use (at the time of publication) for the treatment of respiratory illness due to air passage narrowing, inflammation, and infection. However, it is common practice to group all of these medications into the following 5 major groups:

- ✔ Short-acting bronchodilators/ rescue/quick-relievers
- ✔ Long-acting bronchodilators/ controllers
- ✔ Inhaled corticosteroids/ anti-inflammatory/controllers
- ✔ Combination medications/controllers
- ✔ Others

We will use this list as a guide to explain how each medication works to treat your lung disease.

The main goal of all the medications used for your lung disease is to open your air passages. If you recall the example, we mentioned a dime and a pencil. These medications help open the air passages to go from the size of a pencil to that of a dime. These medications make the inside of the air passages wider so that it is easier for you to breathe.

The problem with having a lung disease that blocks or shrinks your air passages is that you can have up to 3 bad effects (Figure 5) happening at the same time. First, the inside of the air passages could be irritated and swollen, similar to what happens when you accidentally burn your skin (like a sunburn) or get dust or smoke in your eyes. This is called *inflammation*, which is the primary problem with asthma. Second, the muscles surrounding the outside of the air passage get smaller. This is called *bronchoconstriction*. The third bad effect is when the inside of the air passages fills with mucus. This is called *mucus obstruction*. Mucus obstruction may result in a rattling sound when breathing.

Having a basic idea of these 3 bad effects (or *symptoms*) will better prepare you to understand the 5 medication types we are about to discuss. Figure 5 shows these bad effects.

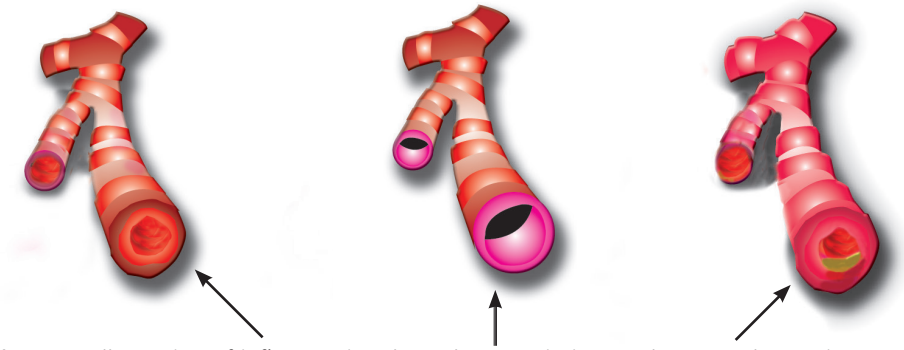


Figure 5. Illustration of inflammation, bronchoconstriction, and mucus obstruction

Medication Types:

Quick-reliever medications

- **Also known as short-acting beta agonists (SABA)**
- Quickly relax tight muscles around the outside of your air passages. This helps make the air passages bigger. Picture in your mind what happens when a snake wraps its long body around another animal. As the snake squeezes around the body of the animal, the animal's ability to breathe is cut-off. A quick-reliever loosens the squeeze of the muscle surrounding the air passages.
- **Quick-relievers** are considered the main medications for sudden symptoms. This means that they are quick-acting. The action starts within a few minutes and lasts 2 to 4 hours.
- You should use a quick-reliever when you have increased symptoms, such as shortness of breath, wheezing, coughing, or chest tightness and need fast relief.

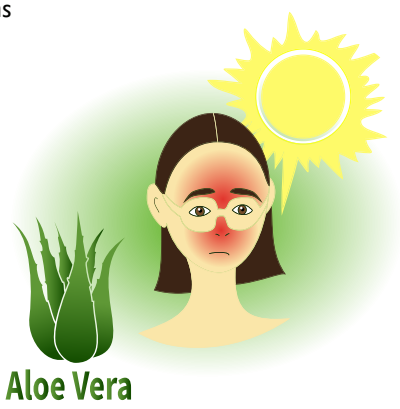
- **For those with Asthma:**
  - You should **not** be using quick-relievers every day.
  - **A quick-reliever should be needed no more than**
    - twice a week during the daytime
    - twice a month during the nighttime.
  - **If you need a quick-reliever more often, talk to** your doctor about using a controller medication, such as an inhaled corticosteroid.
- **For those with COPD,** ask your doctor about using a long-acting bronchodilator if you use a quick-reliever often.

Controller medications

- **LABA, ICS, Mast Cell Stabilizers and Combination Medications are ALL Controllers**
- **Also known as long-acting beta agonists (LABA) and long-acting muscurinic agents (LAMA)**
- Relax the muscles around the air passages (much like the snake example). The air passages get bigger and breathing is easier.
- The effect lasts 12-24 hours depending on the medication used.
- They are taken either once or twice a day to *keep* an open airway, depending on the medication used.
- They are to be used on a daily basis for long-term control.
- It takes time for them to start to work (sometimes 1-2 weeks).
- They are **not** to be used when quick-relief is needed.
- They are **not** be used when you are having an active asthma attack or increase in your asthma symptoms.
- If you have asthma, the long-acting bronchodilator should *always* be prescribed with an inhaled corticosteroid.

Inhaled corticosteroids (ICS)

- Reduce the swelling (inflammation) inside of the air passages.
- Help reduce the swelling in the lining of the air passages.
- Are taken daily to work. It may take a few weeks before they start to work.
- Are **not** good for sudden changes in symptoms or increases in symptoms. They do not work fast.
- Are not the same medications as the steroids taken by athletes, weight lifters, or bodybuilders who are trying to add muscle to their bodies.
- Side effects are minimal when taken properly; always rinse your mouth after taking an inhaled corticosteroid.
- Not taking inhaled corticosteroids harms children with persistent asthma. Long-term swelling harms the air passages.



Mast cell stabilizer

- Prevents asthma symptoms.
- Blocks the release of chemicals in the body that cause swelling.
- Does not work quickly.
- Must be taken many times a day over a period of time.
- Not as good as inhaled corticosteroids.

Combination medications

- Consist of 2 medications combined into one inhaler or solution.
- An advantage of this form of therapy is that it is much easier to take when your doctor has prescribed both medications.

3 Aerosol Medication Delivery Devices: Small-Volume Nebulizers

What are small-volume nebulizers?

A small-volume nebulizer (SVN) is a device that turns a liquid medication into a mist that can be breathed in. SVNs are often used by respiratory therapists in the hospital to deliver breathing treatments to patients. Home-use SVNs can also be used outside the hospital.

What are the different types of SVNs?

There are basically 2 different types of small-volume nebulizers: jet nebulizers and electronic or vibrating mesh nebulizers.

Jet nebulizers

Although there are many different types or models of small-volume medication nebulizers on the market. The jet nebulizer is the most common (see Figure 6). Jet nebulizers are designed for only one patient to use. Do not share your jet nebulizer with another person. Jet nebulizers are also disposable devices. You simply throw them away when you are advised by your respiratory therapist to replace it with a new one.

Figure 6.
A jet nebulizer

Electronic nebulizers

Besides the standard jet nebulizer, there are several other types of hand-held, portable SVNs called *electronic nebulizers.*

The main difference is that these other types of electronic nebulizers do not use a compressor. Instead, they use electrical energy to turn the liquid medication into a mist. Electronic nebulizers are small, quiet, and are powered by batteries.

What are the advantages and disadvantages of SVNs?

Small-volume nebulizers are the oldest devices still used to deliver breathing treatments in the hospital. When patients arrive in the emergency department short of breath and struggling to breathe, respiratory therapists will sometimes use an SVN to quickly deliver medication to the air passages.

Table 2 below shows the advantages and disadvantages of small-volume nebulizers and will be helpful in determining whether they are the best choice for you.

SVNs are helpful for people who are unable to operate or correctly use a metered-dose or dry-powder inhaler, because minimal cooperation or coordination is needed from the patient.

There are also a few disadvantages to the small-volume nebulizer. These devices can be noisy, and take time to use. They also require an electrical outlet to run the compressor. This makes it more difficult to use when traveling. Some of the new portable SVNs have a rechargeable battery. Unfortunately, this type of SVN is sometimes not covered by insurance.

Table 2. Advantages and disadvantages of SVNs

ADVANTAGES	DISADVANTAGES
✔ Work with many medications.	✔ Treatment times last from 15–25 minutes.
✔ Allow more than one medication to be used at the same time.	✔ Device required may be large and bulky.
✔ **Minimal patient cooperation or coordination is needed.**	✔ Power source needed.
✔ Useful when patients cannot use MDI or DPI.	✔ Medication may get into the eyes if a face mask is used.
✔ Medication concentrations and dose can be modified.	✔ **Assembly and cleaning are required.** Germs can collect in the medication cup, if not cleaned well.
✔ Normal breathing pattern can be used, and a breath-hold is not required.	

How do I use these SVNs?

Adults and adolescents

Your breathing pattern has a big influence on the amount of medication that reaches your air passages.

For best results, sit up straight. Breathe normally during your treatment. Every once in a while, take a slow, deep breath and hold the breath for 5–10 seconds before you breathe out. This helps deliver more medication into your lungs.

You can take your breathing treatment using either a mouthpiece or a face mask. The mouthpiece is considered the best connection and is more comfortable. With a face mask, medication can stick to the skin on your face. Sometimes it gets into your eyes. A tight fitting mask reduces the risk of medication getting into your eyes.

Infants and small children

A mouthpiece cannot be used with infants or small children. Instead, use an infant or pediatric face mask attached to the SVN. Giving breathing treatments to infants and smaller children can sometimes be difficult, especially if the child is uncooperative or is crying. Crying greatly reduces the amount of medication that gets into the lungs. Forcing a face mask on an uncooperative, crying child does not work.

Some people use a *blow-by* method of delivering an aerosol to infants. This involves holding the aerosol device close to the face of the squirming/crying infant or child. Blow-by *does not work* and its practice is *strongly* discouraged.

Instead, turn the breathing treatment session into a game. Spend extra time with the infant or small child, letting them play with the nebulizer parts. Let them see an older sibling or parent or favorite stuffed animal "use" the SVN. Also, several manufacturers now have SVNs and face masks especially designed and decorated for pediatric patients. Chapter 7 of this Guide, called Special Applications, provides additional suggestions for giving a breathing treatment to small children and infants.

Technique Box 1 (page 22) lists the steps for correct use of jet and electronic nebulizers. Helpful hints for using all types of SVNs are shown in the sidebar at right.

When using any SVN, the following tips will help you get the best medication delivery possible during a breathing treatment.

You should:

1. Read and follow all written instructions and handouts.
2. Pay attention and ask questions during all training sessions. Ask for additional training if necessary.
3. Make sure that the medication cup is cleaned, dried, and put away between uses.
4. Make sure that the medication cup parts are put together correctly.
5. Make sure that the medication cup is in the upright position during use.

Technique Box 1

Steps for Correct Use of Small-Volume Nebulizers

Technique for jet nebulizers

When a jet nebulizer is used, you should:

1. Wash and dry your hands
2. Gather the compressor (with tubing), jet nebulizer, and mouthpiece (or face mask).
3. Open the medication cup.
4. Twist the top off the medication container and empty **all** the contents into the medication cup.
5. Close the medication cup.
6. Connect one end of the plastic tubing to the medication cup and the other end to the compressor.
7. Plug the compressor's power cord into an electrical outlet.
8. Turn on the compressor's power button. Mist should appear.
9. Sit in an upright position and put the mouthpiece into your mouth and breathe normally. Remember to also keep the medication cup in the upright position during use.
10. Occasionally take a deep breath and hold it for 5–10 seconds.
11. If the treatment must be interrupted, turn off the compressor to avoid medication waste.
12. Continue these steps until the jet nebulizer starts to sputter or rattle.
13. Turn off the nebulizer compressor and store properly.
14. Take the jet nebulizer apart and rinse under warm running water; allow the parts to air dry. When dry, store in a clean place until the next treatment.
15. At least once a week (or more frequently), wash and disinfect your nebulizer parts.
    - Wash all nebulizer parts (except the clear tubing that connects to the compressor) in mild dish soap. Use a small bottle brush to clean the nebulizer parts.
    - After soaking, rinse well in warm water.
16. Replace jet nebulizer every 6 months.

Technique for electronic nebulizers

When an ultrasonic or vibrating mesh nebulizer is used, you should:

1. Wash and dry your hands.
2. Correctly assemble the electronic nebulizer.
3. Follow manufacturer's instructions to properly test the new nebulizer prior to its first use.
4. Twist the top off the unit dose medication container and empty the contents into the medication cup. Do not exceed the volume recommended by the manufacturer.
5. Turn on the electronic nebulizer. You should see the mist coming out of the mouthpiece, You will **not** hear any noise.
6. Sitting in a relaxed, upright position, put the mouthpiece into your mouth and breathe normally.
7. Hold the electronic nebulizer in the position recommended by the manufacturer.
8. Refer to your device's instructions for specific breathing times.
9. If the treatment must be interrupted, turn off the unit to avoid medication waste.
10. Continue these steps until you no longer see any mist. Electronic nebulizers do **not** make a sputtering sound.
11. At the completion of the treatment, disassemble and clean as recommended by the manufacturer. NOTE: Electronic nebulizers are more delicate than jet nebulizers. Use caution when handling and cleaning.
12. When cleaning a vibrating mesh nebulizer, do not touch the vibrating mesh as this will damage the unit. Replacement parts are very expensive.
13. Several times a week, disinfect the nebulizer parts by following the manufacturer's instructions.

What are common problems and solutions to the use of small-volume nebulizers?

There are some problems you might face when using a small- volume nebulizer. The most common problem is absence of any aerosol, or the unit simply does not operate. Below is a basic troubleshooting guide that lists some causes and solutions to common problems. Be sure to use the manufacturer's instructions as well as seek help from your respiratory therapist, home care equipment provider, or health care provider. You should always keep a spare jet nebulizer cup and tubing on hand in case the troubleshooting does not correct the problem.

Troubleshooting

Problems with Jet Nebulizers: Absent or Low Aerosol Output

Causes	Solutions
Loose connection or disconnection	Check the connections and make sure that they are firmly attached.
Obstruction in the opening of the jet nebulizer	Check the opening of the jet nebulizer and clear obstructions when needed.
The compressor does not operate.	The compressor needs to be plugged in to a working electrical outlet. If it is plugged in and the outlet has power but you still have this problem, you may need a new compressor.
The output of the compressor is low.	Clean or replace the inlet filter pad. (Consult the manual.)
The nebulizer does not create mist.	Clean the nebulizer jet or obtain another nebulizer.

Troubleshooting (continued)

Problems with Vibrating Mesh and Ultrasonic Nebulizers: The Unit Does Not Operate

Problems	Solutions
Incorrect battery installation (seen in both vibrating mesh and ultrasonic nebulizers)	Check the battery installation and reinstall if needed.
External power source connection (seen in both vibrating mesh and ultrasonic nebulizers)	Check the connections with the AC adapter and the electrical outlet.
Overheated unit (seen in ultrasonic nebulizers)	Turn off the unit, wait until it cools down, and restart the unit.
Incorrect connection of the control module cable (seen in vibrating mesh nebulizers)	Check the connections with the control module cable and reattach them properly, if needed. Consult the owner's manual.
Malfunctioning electronics (seen in both vibrating mesh nebulizers and ultrasonic nebulizers)	Replace the unit.
Mesh holes blocked with medication due to poor cleaning	Clean according to the manufacturer's instructions.

When is my treatment over?

When using a jet nebulizer, you will know that the treatment is coming to an end when you hear a sputtering or rattling sound. Sputtering happens when there is only a tiny bit of medication left in the medication cup. There may still be a small amount of liquid left in the cup.

There is no sputtering with electronic nebulizers. Instead, the absence of any mist and an empty medication cup will be your signal that the breathing treatment is finished. With some electronic devices, a buzzer sounds to signal the end of treatment.

4 Aerosol Medication Delivery Devices: Pressurized Metered-Dose Inhalers

What are inhalers?

The term “inhaler” describes devices used to give a dose of inhaled medication. There are 3 types of inhalers —

- pressurized metered-dose inhalers (MDIs)
- dry-powder inhalers (DPIs)
- soft-mist inhalers (SMIs)

All inhalers may be carried around in your purse or pocket and used anywhere. There are different inhaler designs. Several inhalers may be prescribed for you, with each having different a different way to use them. Incorrect use can reduce the amount of medication you receive. Your health care provider should show you how to use each of them. You may also follow the medication company’s instructions.

What common inhalers are available in the United States?

Common inhalers are shown in Figure 7 (page 26). You should always use your device and medication as prescribed by your provider. Remember that each medication has a different action. Tell your doctor or health care provider about any uncomfortable effects.

Figure 7. Common Inhalers Available in the United States

Anticholinergics/β_2-Agonist Combination

Combivent® Respimat® (ipratropium bromide and albuterol sulfate) Inhalation Spray
Boehringer Ingelheim Pharmaceuticals, Inc.

Stiolto® Respimat® (tiotropium bromide and olodaterol) Inhalation Spray
Boehringer Ingelheim Pharmaceuticals, Inc.

Utibron™ Neohaler® (indacaterol and glycopyrrolate) Inhalation Powder
Sunovion Pharmaceuticals Inc.

Anoro® Ellipta® (umeclidinium and vilanterol) Inhalation Powder
GlaxoSmithKline

Bevespi Aerosphere™ (glycopyrrolate and formoterol fumarate) Inhalation Aerosol
AstraZeneca Pharmaceuticals

Anticholinergics

Spiriva® Handihaler® (tiotropium bromide) Inhalation Powder
Boehringer Ingelheim Pharmaceuticals, Inc.

Atrovent® HFA (ipratropium bromide HFA) Inhalation Aerosol
Boehringer Ingelheim Pharmaceuticals, Inc.

Tudorza™ Pressair™ (aclidinium bromide) Inhalation Powder
Forest Pharmaceuticals, Inc.

Incruse® Ellipta® (umeclidinium) Inhalation Powder
GlaxoSmithKline

Seebri™ Neohaler® (glycopyrrolate) Inhalation Powder
Sunovion Pharmaceuticals Inc.

β_2-Agonists

ProAir® HFA (albuterol sulfate) Inhalation Aerosol
Teva Specialty Pharmaceuticals

ProAir® RespiClick® (albuterol sulfate) Inhalation Powder
Teva Specialty Pharmaceuticals

Proventil® HFA (albuterol sulfate) Inhalation Aerosol
3M Pharmaceuticals Inc.

Arcapta™ Neohaler™ (indacaterol) Inhalation Powder
Novartis Pharmaceuticals

Striverdi® Respimat® (olodaterol) Inhalation Spray
Boehringer Ingelheim Pharmaceuticals, Inc.

Xopenex® HFA (levalbuterol tartare) Inhalation Aerosol
Sunovion Pharmaceuticals Inc.

Ventolin® HFA (albuterol sulfate HFA) Inhalation Aerosol
GlaxoSmithKline

Serevent® Diskus® (salmeterol xinafoate) Inhalation Powder
GlaxoSmithKline

Serevent® HFA (salmeterol xinafoate) Inhalation Aerosol
GlaxoSmithKline

Corticosteroids

Alvesco® (ciclesonide) Inhalation Aerosol
Nycomed

Asmanex Twisthaler® (mometasone) Inhalation Powder
Schering Corporation

Flovent® Diskus® (fluticasone propionate) Inhalation Powder
GlaxoSmithKline

ArmonAir™ RespiClick® (fluticasone propionate) Inhalation Powder
Teva Specialty Pharmaceuticals

Arnuity® Ellipta® (fluticasone furoate) Inhalation Powder
GlaxoSmithKline

Flovent® HFA (fluticasone propionate) Inhalation Aerosol
GlaxoSmithKline

Pulmicort® Flexhaler® (budesonide) Inhalation Powder
AstraZeneca LP

QVAR® (beclomethasone dipropionate) Inhalation Aerosol
Teva Specialty Pharmaceuticals

Aerospan® (flunisolide) Inhalation Aerosol
Mylan Pharmaceuticals

β_2-Agonist/Corticosteroid Combination

Advair® Diskus® (fluticasone propionate and salmeterol) Inhalation Powder
GlaxoSmithKline

Advair® HFA (fluticasone propionate and salmeterol xinafoate) Inhalation Aerosol
GlaxoSmithKline

Breo® Ellipta® (fluticasone furoate and vilanterol) Inhalation Powder
GlaxoSmithKline

Dulera® (mometasone furoate/ formoterol fumarate dihydrate) Inhalation Aerosol
Merck

Symbicort® (budesonide and formoterol fumarate dihydrate) Inhalation Aerosol
AstraZeneca

AirDuo RespiClick® (fluticasone propionate and salmeterol) Inhalation Powder
Teva Specialty Pharmaceuticals

Other

Relenza® (zanamivir) Inhalation Powder
GlaxoSmithKline

TOBI® Podhaler® (tobramycin) Inhalation Powder
Novartis Pharmaceuticals

What are MDIs?

The first metered-dose inhaler (MDI) was invented in 1955 by Dr. George Maison. He came up with the idea for the device because his teenage asthmatic daughter wanted a better way to take her breathing treatment. A MDI is designed to deliver an exact (metered) amount (dose) of medication in a fine mist that can be breathed directly into the air passages.

How do MDIs work?

The MDI is the most popular way to deliver inhaled medication. The parts of the MDI include the canister, medication/propellant, metering valve, actuator (or boot), and usually a dose counter. Figure 8 is a picture of a MDI with each part labeled and the medication spraying from the boot. Table 3 tells about each part of a MDI.

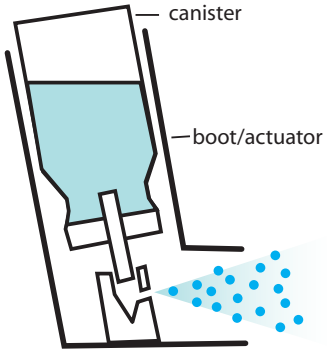


Figure 8. Parts of MDI

Table 3. MDI parts

PART	EXPLANATION
Canister	A metal can that holds the medication and propellant.
Propellant	Pushes the medication into the lungs.
Medication	The active ingredient that has the desired effect on the lungs.
Metering Valve	Measures the dose of medication.
Actuator	Frequently referred to as the "boot," delivers the medication. Each boot is unique to a specific MDI/medication.

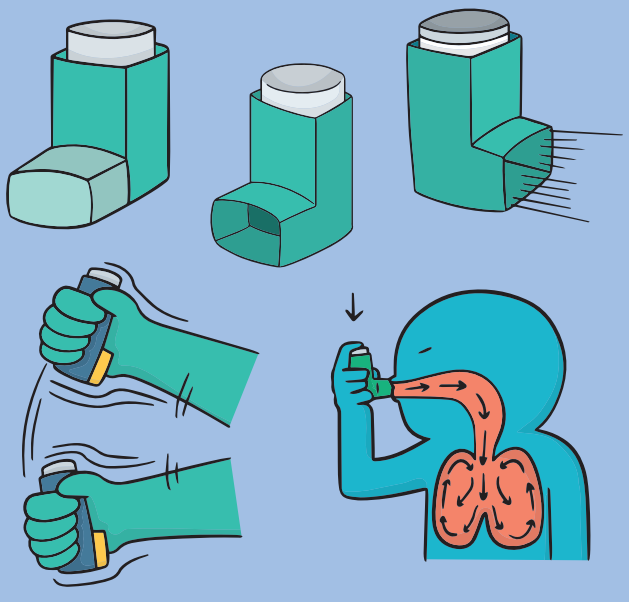
The medication is released from the MDI by pressing the canister into the boot. Note in Figure 8 that the canister is in the boot so that the valve sits inside the nozzle. When the canister valve is pressed into the nozzle, the propellant pushes a dose of the medication through the nozzle. The medication dose becomes a mist, which you breathe into your air passages. The same amount of medication is released with each press of the canister.

How do I use my MDIs?

Technique Box 2

Instructions for Correct Use of Metered-Dose Inhalers

1. If the canister is cold, warm it in your hand.
2. Take the mouthpiece cover off and make sure there are not any loose parts inside the mouthpiece.
3. Shake the MDI for 5 seconds.
4. Prime the MDI into the air according to the MDI instructions, if necessary.
5. Sit up straight or stand up.
6. Breathe all the way out and hold the MDI so the mouthpiece is at the bottom and the canister is sticking out of the top of the MDI.
7. Put the MDI mouthpiece between your lips. Make sure that your tongue is flat under the mouthpiece and does not block the outlet of the MDI.
8. Seal your lips around the mouthpiece.
9. Press down on the canister as you begin to slowly take in a breath.
10. Breathe all the way in, slow and deep.
11. Hold your breath for 10 seconds. If you cannot hold your breath for 10 seconds, then for as long as you can.
12. Wait 30–60 seconds if another puff of medicine is needed.
13. Repeat steps 2–11 until you have breathed-in all the puffs you are supposed to.
14. If taking an inhaled corticosteroid, rinse your mouth after the last puff of medicine and spit the water out — do not swallow.
15. Put the mouthpiece cover back on.



What are the advantages and disadvantages of MDIs?

Table 4. Advantages and disadvantages of the MDI

ADVANTAGES	DISADVANTAGES
✔ Portable, light, and compact	✔ Hand-breath coordination is required.
✔ Easy to use	✔ It has to be pushed by the patient. Proper breathing pattern and breath-hold are required.
✔ Short treatment time	✔ Unwanted stuff in the mouthpiece may be breathed-in.
✔ Same dose every time	✔ Medicine may hit inside the mouth and back of throat instead of the lungs.
✔ Nothing to mix	
✔ Difficult to get it dirty	

What factors affect MDI performance and medication delivery?

For best results from your inhaler:

- Store the canister at or near room temperature. If a MDI is left in a cold car overnight, it might not work until it returns to room temperature.
- **Shake the Canister:** If your MDI is left sitting for an extended period of time between uses, the medication and the propellant separate. You will need to shake the canister before you use the MDI. Keep the nozzle clean. Follow your provider's instructions for periodic nozzle cleaning. Do not use the boot of one medication for another medication.
- Prime the MDI if necessary. MDIs that are brand new or have not been used for an extended period of time should be primed. Shake the MDI and spray the correct number of doses into the air (see Table 5). Refer to the manufacturer's recommendations if you have questions.
- Allow for a pause between each puff from the inhaler. You should wait about 30-60 seconds between each puff for best results.

Table 5. Priming MDIs

GENERIC NAME	BRAND NAME	TIME TO PRIME	# PUFFS
Short-Acting Bronchodilators			
Albuterol Sulfate HFA	ProAir HFA	New & when not used for 2 weeks	3
	Proventil HFA	New & when not used for 2 weeks	4
	Ventolin HFA	New & when not used for 14 days	4
Levalbuterol HCl	Xopenex HFA	New & when not used for 3 days	4
Ipratropium Bromide HFA	Atrovent HFA	New & when not used for 3 days	2
Ipratropium Bromide/ Albuterol Sulfate Combination	Combivent HFA	New & when not used for 24 hours	3
Inhaled Corticosteroids			
Beclomethasone Propionate HFA	QVAR	New & when not used for 10 days	2
Ciclesonide	Alvesco	New & when not used for 10 days	3
Flunisolide Hemihydrate	Aerospan™ HFA	New & when not used for 2 weeks	2
Fluticasone Propionate	Flovent HFA	New	4
		Not used more than 7 days or if dropped	1
Mometasone furoate	Asmanex HFA	New & when not used 5 days	4

Table 5. (continued)

GENERIC NAME	BRAND NAME	TIME TO PRIME	# PUFFS
Combination Medications			
Budesonide in combination with Formoterol	Symbicort HFA	New & not used more than 7 days or if dropped	2
Fluticasone in combination with Salmeterol	Advair HFA	New	4
		Not used more than 4 weeks or if dropped	2
Mometasone & Formoterol	Dulera	New & not used more than 5 days	4

What are common problems and solutions to the use of my metered-dose inhaler?

Sometimes you may have a problem when using your MDI. The most common problem is low mist output or no mist after you press the MDI. Below is a chart that will help you identify the cause as well as the solution for several problems. You should also follow the instructions provided in the manufacturer's instructions as well as ask your respiratory therapist or health care provider.

Table 6. Problem with the MDI: Absent or Low Mist Output

CAUSES	SOLUTIONS
MDI put together wrong	Look to see that the canister/cartridge is correctly seated in the boot.
MDI & spacer attached wrong	Look to see that the MDI mouthpiece is pushed into the spacer inlet.
MDI is empty	Check the dose counter or daily log sheet to make sure there is enough medicine in the canister. If not, get a new MDI.

How do I know If my MDI is empty?

When MDIs first came out, you couldn't tell how many puffs of medication were left in the canister. People thought that as long as they heard or felt something inside the canister when it was shaken, then there was medication left. However, there is more propellant than medication. So even if you still feel/hear something inside the canister when shaken, it may only be propellant.

With a Dose Counter:

Most MDIs have a dose counter. The dose counter tells you how many puffs are left in the MDI (see Figure 9).

1. Check the product label or literature and determine the number of puffs that the MDI has when it is full.
2. Learn to read the counter display. Each dose counter has a specific way of displaying the number of puffs that remain in the canister. For example, some devices will turn red as an indication that the number of puffs is less than 20 puffs and it is nearing time to get a new MDI. Again, be certain to read the instructions to interpret the counter display.
3. Recognize that when the last puff is given (dose counter reads 0), the MDI should be thrown away.

The U.S. Food and Drug Administration (FDA) requires all new MDIs to have a dose counter. The dose counter is set to the total number of puffs. With each puff, the number is decreased until no more puffs are left. Figure 9 shows what these MDI boots look like.

Figure 9. Examples of built-in dose counters

Without a Dose Counter:

If there is no dose counter, manually count and record on a paper every individual puff given, including both priming and therapy doses. This number is then subtracted from the total number of puffs listed on the product label until all have been used.

1. Check the product label or literature and determine the number of puffs that the MDI has when it is full.
2. When using medications on a daily basis, calculate how long the MDI will last by dividing the total number of puffs in the MDI (often 120) by the total puffs used per day. For example, if used twice a day with 2 puffs per treatment, this would calculate to a total of 4 puffs per day. If you divide this by the number of puffs available (120 divided by 4), the canister will last 30 days. Also, you must remember that the medication will run out sooner if the MDI is used more often than planned.
3. Identify the date that the medication will run out and mark it on the canister or on the calendar.
4. Keep track of how many puffs of medicine are administered on a daily log sheet and subtract them to determine the amount of medication left in the MDI.
5. Keep the daily log sheet in a convenient place.
6. Replace the MDI when all of the puffs have been administered.

For example, if a new MDI has 200 puffs when full, you will need a new one when the total number of puffs used (including priming) reaches 200. At that time the old MDI should be thrown away. The manual counting of doses may not be practical and/or dependable, especially if you are using your medication as a quick reliever and are always on the go.

The FDA says that all MDIs not having a dose counter must be used with an external dose-counting device. There are 2 types of external dose counters. In one type, the canister of the MDI is inserted into a new boot that has the dose counter built-in. The other type fits over the end of the canister. Both types record each puff. Figure 10 shows an example of each type of external dose counter.

Your provider can check to make sure your external dose counter works with your MDI. Improper attachment or a poor fit with the canister can result in improper dosing. This could lead to little or no medication being released, as well as an incorrect count of remaining doses. Obtaining an external dose counter will be an added expense. You buy it only once and it keeps track of your puffs. With any external dose counter, you must follow the guidelines and instructions provided in the manufacturer's literature.

Figure 10. Examples of external dose counters for a MDI

What are spacers?

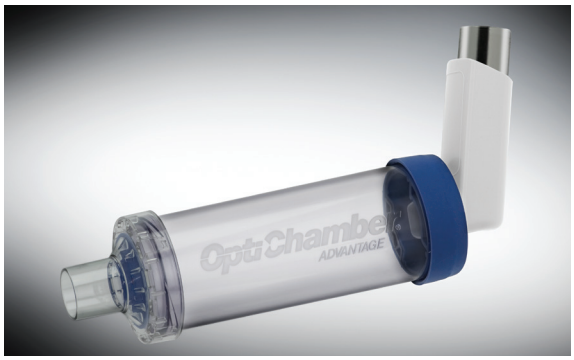


Figure 11. Example of a MDI attached to a spacer

A spacer is a plastic or metal tube that adds space (and volume) between the MDI and your mouth. The MDI aerosol is sprayed directly into the spacer where the mist is temporarily held.

A spacer:

- gives the speed of the mist time to slow down before it is breathed in
- increases the amount of medication delivered to the lungs
- helps people who have difficulty timing the pressing of the inhaler with their breathing-in (Table 7).

Once you press the MDI, you need to breathe in without delay. Waiting longer than 2–3 seconds can decrease the amount of medication. Some spacers make a noise when you inhale too fast. If you hear the noise, breathe in more slowly next time. Remember, MDIs work best when you take a **slow, deep** breath.

Children may need to take about 6 breaths from the spacer to inhale all the medication from a single puff. This is most often delivered with a mask on the spacer. **Do not** remove the mask from the child's face until after 5-6 breaths.

Spacers can be purchased from a pharmacy or from your home care company. Figure 11 shows one example of a spacer.

Table 7. Advantages and disadvantages of using spacers with MDIs

ADVANTAGES	DISADVANTAGES
✔ Less medication remains in the mouth and more medication goes to the air passages.	✔ Large, compared to the MDI alone.
✔ Increases inhaled medication by 2–4 times than the MDI alone.	✔ More expensive than a MDI alone.
✔ Allows use of MDI when the patient is short of breath.	✔ You may need to put it together.
✔ Makes timing of MDI press and inhalation easy.	✔ Patient makes the mistake of putting multiple puffs into chamber prior to inhaling or waiting too long between pressing and breathing in.
	✔ Must be cleaned every week.

How do I use a spacer?

A problem with the use of a spacer is using it wrong. That can decrease medication delivery or, in some cases, cause the dose to be lost.

There are problems when giving an inhaled medication treatment to kids with a MDI. These include: bad mask fit, the spacer volume is too big, and crying. The proper way of giving the treatment must be followed, and Technique Box 3 shows that when using a spacer with a mouthpiece or mask.

Technique Box 3

How to give a treatment using a MDI with spacer

When using a spacer, you should:

1. Wash and dry your hands thoroughly.
2. If the canister is cold, warm the MDI canister in your hand.
3. Remove the MDI mouthpiece cover and make sure there are not any loose parts inside the mouthpiece.
4. Shake the MDI several times.
5. Prime the MDI into the air if it is new or has not been used for several days.
6. Attach the MDI to the spacer.
7. Keep the canister in an upright position.
8. Sit up straight or stand up.
9. Breathe out fully.
10. Follow the instructions below based on if a mouthpiece or mask is being used:

With the mouthpiece:

- Put the spacer mouthpiece between your lips. Keep your tongue flat under the mouthpiece so it does not block the opening, Seal your lips around the mouthpiece.
- Press the MDI and begin to breathe in slowly. If the device produces a noise, you are breathing in too fast. Breathe in more slowly if you hear the noise.
- Move the mouthpiece away from your mouth and hold your breath for 10 seconds or for as long as you can.

With the mask:
(Used primarily for kids or if the patient cannot use the mouthpiece)

- Place the mask completely over the nose and mouth and make sure it fits firmly against the face.
- Hold the mask in place and press the MDI as the person begins to breathe in. If the device produces a noise, be aware that the person is breathing in too rapidly.
- Hold the mask in place while the person takes 6 normal breaths (including breathing in and out) and remove the mask from the child's face.

11. Wait 30–60 seconds if another puff of medication is needed.
12. Repeat the steps above until the prescribed number of puffs is reached.
13. If taking a corticosteroid, you should rinse your mouth after the last puff of medicine and spit the water out. Do not swallow it.
14. Put the mouthpiece cover back on the MDI after each use.

General instruction to receive the full dose from MDIs with a spacer

When using MDIs with a spacer, the following steps should be taken to receive the full dose of medication from the MDI when using the spacer. You should:

1. Assure that the MDI fits properly into the spacer.
2. Remove the cap from the MDI boot.
3. After use, clean and reassemble the MDI spacer according to the manufacturer's instructions.

5 Aerosol Medication Delivery Devices: Soft-Mist Inhalers

What are soft-mist inhalers?

A soft-mist inhaler (SMI) or Respimat® inhaler (Figure 12) is an inhaler that produces a mist with a slower speed than a pressurized metered-dose inhaler, so there may be less aerosol remaining in your mouth when you breathe in. The mist that comes out of the SMI is referred to as a "soft mist." Several medications are made to be taken from the Respimat®. As seen in the picture below, the Respimat® comes in two pieces: a medication cartridge and the inhaler. Instructions for loading the cartridge into the inhaler and taking a dose of medication from the SMI are below. The SMI is not used with a spacer.

Figure 12. The Respimat® soft-mist inhaler

How do soft-mist inhalers work?

The medication in the SMI is stored inside the cartridge. When the clear base is turned, a spring inside the SMI is pressed. When the dose release button is pressed, the energy from the spring presses the medication through the nozzle, releasing the fine mist you breathe-in. There are no parts to fix, so once the cartridge is properly inserted, individual medication doses will be given each time the base is rotated half a full turn and the dose-release button pressed. When the last dose is given, the base can no longer be rotated (it is time to get a new Respimat®).

What are the advantages of the SMI?

The mist comes out of the Respimat® much slower than the mist from a MDI. This allows for more medication to reach the air passages and less medication to be left in the mouth. If the Respimat® dose release button is pressed outside the mouth, there is less chance of spray in the eyes or face.

What factors affect SMI performance and medication delivery?

- Keep the Respimat® at room temperature: 68°F to 77°F (20°C to 25°C).
- Do not freeze your Respimat® cartridge and inhaler.
- If the Respimat® has not been used for more than 3 days, release 1 puff towards the ground (prime it, see Table 8 below).
- If the Respimat® has not been used for more than 21 days, prime the inhaler according to the medication company's instructions until a mist is visible.
- Clean the mouthpiece, including the metal part inside the mouthpiece, with a damp cloth or tissue only, at least once a week. Any minor discoloration in the mouthpiece does not affect your Respimat® inhaler.

Table 8. Priming the Respimat® SMI

- ✔ Rotate the base of the inhaler half a full turn. Open the cap. Point the inhaler toward the ground.
- ✔ Press the dose-release button.
- ✔ Close the cap.
- ✔ If you do not see a mist, repeat the first three steps until a mist is seen.
- ✔ After a mist is seen, rotate the base and press the dose release button three more times.
- ✔ You will prime the inhaler a total of four times, seeing a mist each time.
- ✔ After complete preparation of your inhaler, it will be ready to deliver the number of puffs on the label.

How do I use my Respimat® SMI?

Technique Box 4

Instruction for Correct Use of Respimat® Soft-Mist Inhalers

When preparing the Respimat® for first use (to load the cartridge), you should:

1. With the cap closed, press the safety catch while pulling off the base. (Be careful not to touch the piercing element located at the bottom of the clear base.)
2. Write the "discard by" date on the label of the inhaler. (The discard by date is 3 months from the date the cartridge is inserted.)
3. Take the cartridge out of the box. Push the narrow end of the cartridge into the inhaler. The base of the cartridge will not sit flush with the inhaler. About 1/8 of an inch will remain visible when the cartridge is correctly inserted.
4. Put the clear base back into place.
5. Hold the inhaler upright with the cap closed to avoid accidental release of dose.
6. Turn the clear base in the direction of the white arrows on the label until it clicks (half a turn).
7. Flip the cap until it snaps fully open.
8. Prime the SMI by pointing the inhaler toward the ground. Press the release button. Close the cap. Repeat the process until a spray is visible (see Table 8, page 35).

To take a dose from the Respimat®, you should:

1. Sit up straight or stand up.
2. Turn the clear base in the direction of the white arrows on the label until it clicks (half a turn).
3. Breathe out fully and hold the SMI so the mouthpiece is horizontal to the ground.
4. Place the SMI between your lips and point your inhaler to the back of your throat.
5. Make sure that your tongue is flat under the mouthpiece and does not block the mouthpiece.
6. Seal your lips.
7. While taking in a slow breath through your mouth, depress the dose-release button and continue to breathe in slowly as long as you can.
8. Hold your breath for 10 seconds or for as long as you can.
9. Wait 30–60 seconds if another dose of medicine is needed, then repeat steps 1-8.
10. Replace the mouthpiece cover on the SMI after each use.

What are common problems and solutions with the use of my Respimat® SMI?

It is difficult to insert the cartridge deep enough:
Did you accidentally turn the clear base before inserting the cartridge? Open the cap, press the dose-release button, then insert the cartridge.

Did you insert the cartridge with the wide end first? Insert the cartridge with the narrow end first.

I cannot press the dose-release button:
Did you turn the clear base? If not, turn the clear base in a continuous movement until it clicks (half a turn).

Is the dose indicator on the Respimat® pointing to zero? The Respimat® inhaler is locked after 120 puffs (120 doses). If you have a sample, the Respimat® inhaler is locked after 60 puffs (60 doses). Prepare and use your new Respimat® inhaler.

I cannot turn the clear base:
Did you turn the clear base already? If the clear base has already been turned, follow instruction "Open" and "Press" under "Daily use" to get your medicine.

The dose indicator on the Respimat® reaches zero too soon:
Did you use Respimat® as indicated (1 puff four times daily)? Respimat® will deliver 120 puffs and last 30 days if used at 1 puff four times daily. If you have a sample, Respimat® will deliver 60 puffs and last 15 days if used at 1 puff four times daily.

Did you turn the clear base before you inserted the cartridge? The dose indicator counts each turn of the clear base regardless whether a cartridge has been inserted or not.

Did you spray in the air often to check whether the Respimat® is working? Once you have prepared Respimat®, no test-spraying is required if used daily.

Did you insert the cartridge into a used Respimat®? Always insert a new cartridge into a NEW Respimat®.

My Respimat® sprays automatically:
Was the cap open when you turned the clear base? Close the cap, then turn the clear base.

Did you press the dose-release button when turning the clear base? Close the cap, so the dose-release button is covered, then turn the clear base.

Did you stop when turning the clear base before it clicked? Turn the clear base in a continuous movement until it clicks (half a turn).

My Respimat® does not spray:
Did you insert a cartridge? If not, insert a cartridge.

Did you repeat Turn, Open, Press (TOP) less than three times after inserting the cartridge? Repeat Turn, Open, Press (TOP) three times after inserting the cartridge.

Is the dose indicator on the Respimat® pointing to 0? You have used up all your medicine and the inhaler is locked.

How do I know my Respimat® is Empty? The dose counter is at zero (0) and you are no longer able to rotate the clear base.

6 Aerosol Medication Delivery Devices: Dry-Powder Inhalers

What are DPIs?

A dry-powder inhaler (DPI) is another portable device used to deliver aerosol medications to the air passages. The medication inside of a DPI is a very small powder. When you take a fast, deep breath through the DPI, you pull the medication out of the device and into your air passages.

How do DPIs work?

All DPIs have three parts:

1. An air inlet
2. A chamber for the medication to rest before it is breathed-in
3. A mouthpiece.

The DPI has a chamber for the powdered medication. Some medication chambers are inside of the DPI where you cannot see them. Others have the medication stored in a small capsule that is placed into the chamber. When a capsule is used, the capsule must be punctured (or poked) by the device before breathing in.

It is important to take a fast, deep breath through the mouthpiece to breathe in the medication. The fast breath pulls the medication powder into your air passages. A slow or shallow breath prevents you from receiving the full amount of medication. Make sure that you do not block the air vents on your DPI while breathing in.

What are the advantages and disadvantages of DPIs?

Table 9 below lists the advantages and disadvantages of DPIs. You should discuss these with your respiratory therapist or health care provider at the time the DPI is prescribed. Do not hesitate to ask additional questions at future clinic appointments.

Table 9. Advantages and disadvantages of DPIs

ADVANTAGES	DISADVANTAGES
Small and portable	Full dose of medication is not delivered if you breathe in slowly.
Built-in dose counter	Cannot feel medication entering the air passages.
Breathing in does not need to be coordinated at the same time as another step	Room humidity or breathing out into the mouthpiece may make it difficult to separate medication in future doses.
Quick breathing treatment	Not available for all medications.
	Different styles of DPIs for different medications is confusing.

How do I use my DPI?

The steps for using DPIs vary for each device. Carefully review the steps for your own DPI. Following each step will help you get the most medication into your airways. You can also speak with a respiratory therapist prior to using your dry-powder inhaler. Do not hesitate to ask additional questions at future clinic appointments. Technique Box 5 (page 40) contains the steps for correctly using the most popular DPIs.

Technique Box 5

Steps for Use of Common Dry-Powder Inhalers

Spiriva® HandiHaler®

1. Wash and dry your hands thoroughly.
2. Peel back the aluminum foil and remove one capsule.
3. Open the dust cap by pulling it upward to expose the mouthpiece.
4. Open the mouthpiece.
5. Place the capsule into the center chamber. It does not matter which end is placed into the chamber.
6. Close the mouthpiece firmly until you hear a click (leave the dust cap open).
7. Hold the HandiHaler® with the mouthpiece facing up.
8. Press the piercing button once and release. This makes holes in the capsule and allows the medication to be released when you breathe in.
9. Sit up or stand. Keep your head facing forward.
10. Breathe out fully away from the HandiHaler®.
11. Place the mouthpiece between your lips and close tightly around the mouthpiece.
12. Breathe in fast until your lungs are full. You should hear the capsule vibrating in the chamber.
13. Remove the mouthpiece from your mouth and hold breath for 10 seconds or as long as comfortable.
14. Breathe out slowly away from the HandiHaler®.
15. Open the mouthpiece and remove the used capsule without touching it with your hands. Do not store capsules in the HandiHaler®.
16. Close the mouthpiece and dust cap for storage of the HandiHaler®.
17. Store the HandiHaler® in a cool, dry place.

Technique for using the Advair®, Serevent®, or Flovent® Diskus®

1. Wash and dry your hands thoroughly.
2. Open the device by placing your thumb or finger in the notch and rotating the cover.
3. Hold the device horizontal (like a hamburger) with the dose counter facing upward.
4. Slide the lever from left to right until you hear a click.
5. Breathe out fully away from the Diskus®.
6. Place the mouthpiece into your mouth and close your lips tightly around the mouthpiece.
7. Breathe in quickly and deeply.
8. Remove the mouthpiece from your mouth and hold your breath for 10 seconds or as long as comfortable.
9. Breathe out slowly away from the Diskus®.
10. Store the Diskus® in a cool dry place.
11. Observe the counter for the number of doses remaining and replace the device when appropriate.
12. After each dose of Flovent® or Advair®, rinse your mouth with water to reduce the risk of developing a fungal infection. Do not swallow the rinsing water.

Technique Box 5 (continued)

Technique for using Asmanex® Twisthaler®

1. Wash and dry your hands thoroughly.
2. Hold the inhaler straight up with the pink portion (the base) on the bottom.
3. Hold the pink base and twist the cap in a counter-clockwise direction to remove it.
4. As the cap is lifted off, the dose counter on the base will count down by 1. This action also loads the dose.
5. Make sure the indented arrow located on the white portion (directly above the pink base) is pointing to the dose counter.
6. Breath out away from the Twisthaler®.
7. Place the mouthpiece into your mouth with the mouthpiece facing toward you, and close your lips tightly around it.
8. Breathe in fast and deep while holding the Twisthaler® horizontal.
9. Remove the mouthpiece from your mouth and hold your breath for 5–10 seconds or as long as comfortable.
10. Breath out slowly away from the Twisthaler®.
11. Immediately replace the cap, turn in a clockwise direction, and gently press down until you hear a click.
12. Firmly close the Twisthaler® to assure that the next dose is properly loaded.
13. Be sure that the arrow is in line with the dose-counter window.
14. Store the Twisthaler® in a cool dry place.
15. After each dose, rinse your mouth with water to reduce the risk of developing a fungal infection. Do not swallow the rinsing water.

Technique for using Pulmicort® Flexhaler®:

1. Wash and dry your hands thoroughly.
2. Hold the Flexhaler® in the upright position (mouthpiece up) to load a dose.
3. Twist the cover and lift it off the Flexhaler®.
4. Twist the brown grip fully in one direction as far as it goes. (It does not matter which way you turn it first.)
5. Twist it back in the other direction as far as it will go and you will hear a click.
6. Breathe out away from the Flexhaler®.
7. Place the mouthpiece in your mouth, seal the mouthpiece with your lips, and breathe in deeply and forcefully through the Flexhaler®.
8. Remove the mouthpiece from your mouth and hold your breath for 5–10 seconds or as long as comfortable.
9. Breathe out slowly away from the Flexhaler®.
10. If more than 1 dose is required, repeat Steps 2–9 above.
11. Put the cover back on the Flexhaler® and twist it shut.
12. Store the Flexhaler® in a cool dry place.
13. After each dose, rinse your mouth with water to reduce the risk of developing a fungal infection. Do not swallow the rinsing water.

Technique Box 5 (continued)

Technique for using the Tudorza™ Pressair®:

1. Wash and dry your hands thoroughly.
2. Remove the protective cap by gently squeezing the marked arrows on each side of the cap and pulling outward.
3. Hold the inhaler with the mouthpiece facing toward you and the green button on top. DO NOT place in your mouth yet.
4. Press the green button all the way down and release it. DO NOT hold the button down.
5. Check the control window on the device (above the mouthpiece) to ensure the color has changed from red to green, indicating the dose and device are ready for use.
6. Breathe out away from the device before placing the mouthpiece into your mouth.
7. Place the mouthpiece into your mouth and breathe in quickly and deeply.
8. You will hear a CLICK when the dose is delivered, but continue with your deep breath until your lungs are filled.
9. Remove the device from your mouth and breathe out.
10. Check the control window on the device (above the mouthpiece) to ensure the color has changed from green to red. IF NOT, repeat Step 7.
11. Replace the protective cap on the mouthpiece.

Technique for using the Ellipta®:

1. Wash and dry your hands thoroughly.
2. Open the cover by sliding it downward until you hear a “click”.
3. Hold the device without blocking the air vents with your fingers.
4. Breathe out fully away from the device before placing the mouthpiece into your mouth.
5. Place the mouthpiece into your mouth and breathe in quickly and deeply.
6. Hold your breath for at least 10 seconds.
7. Remove the device from your mouth and breathe out away from the device.
8. Close the Ellipta® by sliding the cover over the top of the mouthpiece.
9. If you are taking Arnuity® or Breo®, rinse your mouth with water to reduce the risk of developing a fungal infection after completing your dose. Do not swallow the rinsing water.

General Steps to Improve the Amount of Medication Received from DPIs

When using DPIs, the following steps should be taken to improve the amount of medication you receive during your breathing treatment. You should:

1. Read and follow the instructions for proper assembly.
2. Keep the DPI clean and dry.
3. Hold the DPI in the proper position while preparing the dose and while breathing in.
4. Puncture the capsule (if using a HandiHaler®).
5. Never breathe out into a DPI.
6. Make sure to breathe in fast and deep to get the medicine into your air passages.
7. Track the doses remaining in the DPI.
8. Do not swallow the capsule (HandiHaler®); it is not a pill.

What are common problems and solutions to the use of my dry-powder inhaler?

Three problems occur with using DPIs:

1. The person cannot breathe in quickly enough to pull the medication out of the device. Ask your therapist about training to breathe-in better.
2. Moisture gets into the DPI and causes the medication to "clump" together. This reduces the medication that can be breathed in.
3. Equipment malfunction.

A respiratory therapist can easily determine if you can breathe in fast enough to use your DPI. Avoid problems with humidity and moisture by taking the following steps:

1. Do not store your DPI in bathrooms, shower areas, and areas with little or no air conditioning.
2. Never breathe out into any DPI. Breathe out *away* from the DPI prior to breathing in from the DPI. After you breathe in, remove the DPI from your mouth and slowly breathe out away from the DPI.

If your equipment malfunctions, speak with your respiratory therapist or health care provider for help.

How do I know my dry-powder inhaler is empty?

It is very important to know the number of doses remaining in your DPI. Some DPIs have dose counters. The table below lists information about dose counters when the device is near empty.

Table 10. Dose counter information for selected DPI devices

	Flexhaler®	Twisthaler®	Diskus®
Number of Medication Doses	60 or 120	30	60
Type of Dose Indicator	"0"	"01"	Red numbers
Meaning of Dose Indicator	Although the indicator counts down each time a dose is loaded, it is not likely that you will see the dose indicator move with every dose. You can usually see the indicator move each time you use about 5 doses. The indicator is marked in intervals of 10 doses alternating numbers and dashes. When it is down to "0", it must be thrown away.	The dose display showing "01" indicates the last dose of medicine is in the Twisthaler® and the medicine must be refilled.	The numbers turning red in the dose display indicates that there are 5 doses left. When the dose window shows "0", there is no medicine left and the Diskus® should be disposed.

7 Aerosol Medication Delivery Devices: Special Applications

How do I help infants and young children take inhaled medications?

Infants and young children need others to help them take their inhaled medications. Two things affect how you proceed. The child's:

- Physical ability
- Thinking ability.

Let's talk about these two issues.

Physical Ability

Most children under the age of 3 years will not hold a mouthpiece in their mouths. Therefore, they need to use a face mask. Make the following adjustments:

- Small-volume nebulizer: place the mask with the round outlet on top of the medication cup.
- Metered-dose inhaler (MDI): use a spacer with a mask.
- Dry-powder inhaler (DPI): not appropriate for children less than age 4 years.

A mask needs to be the correct size for the child's face. The top of the mask should not touch the child's eyes. The bottom of the mask should not be below the bottom of the chin.

Thinking Ability

Most children younger than 5 years of age do not have hand/breath coordination. They cannot breathe in at the same time that they press their MDI. Therefore, they need to use a spacer with their MDI. Thinking skills also affect how much responsibility a child should have. An adult should make sure that children under age 15 years[1] take their medication at the correct time. Adults also need to watch how young children breathe in their medication. Medication will not enter the air passages if children breathe in wrong.

Table 11 (page 45) lists the age to begin using different types of aerosol devices. Notice that the small-volume nebulizer and MDI with spacer are recommended for children up to 5 years of age. Remember to ask your respiratory therapist or other health care professional for additional help.

Reference

Orrell-Valente JK, Jarlsberg LG, Hill LG, Cabana MD. At what age do children start taking daily asthma medicines on their own? Pediatrics 2008; 122(6):e1186-e1192.

Aerosol medication delivery in distressed or crying infants

Children need to be calm when taking inhaled medications. A crying child spends more time breathing out. The child needs to be calm to breathe in the medication. Ways to keep the child calm are:

- Comforting babies by rocking or wrapping snuggly in a blanket.
- Playing games with the child.
- Distracting the child with toys or music.

It is fine to give a sleeping baby inhaled medication. Be careful not to wake-up the baby.

Table 11. Recommended age guidelines for aerosol medication devices

AEROSOL GENERATOR	AGE
Small-volume nebulizer with mask	less than 3 years
Small-volume nebulizer with mouthpiece	4 years or older
MDI with spacer and mask	less than 4 years
MDI with spacer	4 years or older
Dry-powder inhaler (DPI)	4 years or older
Metered-dose inhaler (MDI)	5 years or older
RespiClick®	5 years or older
Breath-actuated nebulizers	5 years or older

Young children less than 4 years	Children greater than 4 years	Children greater than 5 years
Small-volume nebulizer with mask	Small-volume nebulizer with mouthpiece	
MDI + spacer with mask	MDI + spacer	
	Dry-powder inhaler	
		Breath-actuated nebulizers

Selecting the best aerosol device for your child

Babies and young children have opinions. The best device is one that works for both the caregiver and child. The following qualities may affect your decision:

- Easy to use
- Easy to clean
- Less time to take treatment
- Portable
- Cost.

It takes time for children to adjust to new things. It may take a week for a child to learn a new routine.

Mouthpiece or face mask? A frequently asked question is whether to use a mouthpiece or face mask. A mouthpiece is commonly used for children ages 2-3 years and older. Children breathe in more medication with a mouthpiece. Therefore, a mouthpiece is preferred. As always, if a child will not use a mouthpiece, using a mask is better than not breathing in any medication.

Importance of a proper size face mask: It is important to have the correct size mask for your child. Small leaks around the face mask decrease the amount of medication breathed in. Half of the medication could be missed if the mask size is wrong.

Many children do not want to wear a face mask. This happens more when they feel sick. Be persistent and offer encouragement. Use games, play activities, or have your child hold the mask. Give your child lots of positive words for each success. Consider trying a mask that looks like a fish or other animal to make wearing the mask "fun."

Face mask or blow-by? *Blow-by* describes the practice where the medication mist that is coming out of the nebulizer is directed toward the child's face. In the past, blow-by was used for crying babies or unhappy children. Blow-by should not be used. Most of the medication does not enter the air passages if you use blow-by. Use a face mask instead.

Caregiver and patient education

Children may need to change their aerosol device when they grow. Both the caregivers and the children will need to learn about their new devices. This instruction should include how to use the device and how to clean it. Do not hesitate to ask questions about your new devices. Your respiratory therapist or other health professionals will be happy to assist.

8 Aerosol Medication Delivery: Maintenance and Problem Solving

How do I clean my aerosol medication device?

Aerosol medication delivery devices can become contaminated with dirt, debris, and bacteria which can cause serious infections if you do not clean the SVN properly. It is extremely important to follow a strict cleaning and infection control plan to reduce and eliminate the possibility of any problems.

Infection control plan in aerosol medication delivery

Research has shown that medication-delivery devices used at home are frequently contaminated with bacteria. Therefore, ask your respiratory therapist or health care provider how to clean and maintain your inhaled medication device. Request written instructions and review them frequently.

In the hospital, medication delivery devices are cleaned for you. However, at home the cleaning is your responsibility.

Cleaning and maintenance of medication delivery devices

You can prevent aerosol medication delivery devices from becoming infected or malfunctioning at home by following the cleaning instructions for the different types of aerosol medication delivery devices given below:

Pressurized metered-dose inhalers (MDIs): The plastic container (holder or boot) of the MDI should be cleaned at least once a week as described in the directions in Table 12.

Table 12. Cleaning instructions for the MDI

Cleaning the MDI
Frequency of cleaning: Once a week and as needed.
Look at the hole where the medication sprays out from the inhaler.
Clean the inhaler if you see powder in or around the hole.
Remove the MDI canister from the plastic container so it does not get wet.
Rinse the plastic container with warm water and shake out to remove excess water.
Place it on a clean paper towel and dry it overnight.
Replace the canister back inside the MDI and recap the mouthpiece.

When a spacer is used with a MDI, it should be cleaned before first use and then periodically cleaned based on the manufacturer's suggestions. Table 13 provides the steps for cleaning spacers and holding chambers.

Table 13. Cleaning instructions for the MDI spacer and holding chamber

Cleaning the Chamber Device
Frequency of cleaning per manufacturer's recommendation and as needed.
Take apart the device for cleaning.
Soak the spacer parts in warm water with liquid dish soap and gently shake both pieces back and forth.
Rinse with warm water.
Shake to remove excess water.
Air dry the spacer parts in an upright position overnight.
Do not towel dry the spacer.
Reassemble the spacer when it is completely dry.

Dry-powder inhaler (DPI): Your DPI should NOT be submerged in water. It must be kept dry because moisture will decrease the medication delivery. You should wipe the mouthpiece of the DPI with a clean dry cloth. And also follow the recommendations of the manufacturer for periodic cleaning.

Jet nebulizers: Your nebulizer should be cleaned after every treatment. The longer a dirty nebulizer sits and is allowed to dry, the harder it is to thoroughly clean it. Rinsing and washing the nebulizer immediately after each treatment helps reduce infection risk.

Parts of the jet nebulizer should be rinsed with hot water after each treatment. Take extra care not to damage any parts of the aerosol generator (compressor unit). Table 14 provides the daily and weekly cleaning instructions for the jet nebulizer. Electronic nebulizers should be cleaned and disinfected based on the manufacturer's recommendations.

Table 14. Cleaning instructions for the jet nebulizer

CLEANING AFTER EACH USE	CLEANING ONCE OR TWICE A WEEK
Wash your hands before handling equipment.	Wash your hands before handling equipment.
Take apart after every treatment.	Remove the tubing from the compressor and set it aside. The tubing should not be washed or rinsed.
Remove the tubing from the compressor and or rinsed.	Wash nebulizer parts in warm water with liquid dish soap.
Rinse the nebulizer cup and mouthpiece with warm running water.	Disinfect the nebulizer based on the manufacturer's recommendations. The nebulizer parts may be soaked in one of the following solutions:
Shake off excess water.	• 1-part distilled white vinegar in 3-parts water for 60 minutes (not recommended for cystic fibrosis patients), or • A commercial quaternary ammonium compound for 10 minutes.
Air dry.	After soaking, rinse all parts with warm running water.
Wrap the dry nebulizer in a clean paper towel.	Shake off excess water and allow to air dry
	Put together the nebulizer and wrap in a clean, dry paper towel.

Disinfection: You should periodically disinfect and replace your jet nebulizer in order to minimize the risk of infection. Each manufacturer suggests a different method of disinfection for its product, and those steps should be followed. It is also important to note that all solutions should be discarded after disinfection. The varied methods for disinfection include:

- Soaking nebulizer parts in a solution of 1-part distilled white vinegar and 3-parts water for at least 60 minutes.

Final rinse: Be sure to use water for the final rinse.

Drying and maintenance: Because bacteria grow in wet, moist places, nebulizers should be thoroughly dried and stored in a clean, dry place between treatments. Allowing gas flow from the compressor to the nebulizer for a short time after it is rinsed can reduce drying time. It has been reported that nebulizer performance may change over time due to incorrect cleaning, maintenance, or disinfection procedures. Nebulizers can be kept from becoming contaminated by following the manufacturer's instructions for care and cleaning. This is necessary for all aerosol devices used for inhaled medication.

Reference

Gardenhire DS, Hess DR, Myers TR, Rau JL. A guide to aerosol delivery devices for respiratory therapists, 3rd edition. Dallas TX: American Association for Respiratory Care; 2013.

Notes

My Prescriptions

Contacts

For more information, contact the American Association for Respiratory Care (AARC)

www.aarc.org

yourlunghealth.org

972-243-2272

Important Phone Numbers

Doctors, Drug Store, etc.