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EXPERT REVIEWS

Inhaler technique and training in people with chronic obstructive pulmonary disease and asthma

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Asthma and chronic obstructive pulmonary disease are both common conditions with an increasing prevalence worldwide. Inhaled therapy for these conditions has a number of advantages over systemic therapy, including reduced side effects and quicker onset of action. The effective use of inhaled therapy is critically dependent upon the nature of the drug-delivery system and the ability of the patient to use the system correctly. There are a wide number of inhaler devices on the market, each with positive and negative aspects. A crucial part of patient care is to ensure that the choice of inhaler device for the individual is an effective therapy. There are a number of interventions that can help with the choice of inhaler device and also improve the ability of the patient to use inhaled therapy. Inhaler technique training needs to be a cornerstone of the care of patients with asthma or chronic obstructive pulmonary disease to ensure optimal therapy.

Keywords: asthma • COPD • dry powder inhaler • inhaler technique • metered-dose inhaler

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Asthma and chronic obstructive pulmonary disease (COPD) are both common respiratory disorders. Worldwide approximately 300 million have asthma and 10% of the adult population over the age of 40 years may have COPD [101,102]. The mainstay of treatment is with inhaled therapy for both conditions.

The NICE [103] and the Global Initiative for Chronic Obstructive Lung Disease [102] both recommend that prior to prescription of a new inhaler for a patient with COPD the patient should receive training and education in the use of the device. Both of these guidelines also advise that inhaler technique should be regularly assessed at each clinic visit. Likewise, the British Thoracic Society [1] and the Global Initiative for Asthma [101] advise that patients with asthma should have similar education prior to prescription of inhaled therapy and regular checks of inhaler technique. A recent systematic review suggested that up to 25% of patients have not received any verbal instruction for the use of their prescribed inhaler [2]. The Aerosol Drug Management Improvement Team report found a clear need for specific training of patients in correct inhalation technique for the various devices currently available, and this should be repeated frequently to maintain correct inhalation technique [3]. This group have also now published guidance on the importance of inhaler choice and technique in the management of patients with COPD [4].

Intentional nonadherence to treatment in asthma is particularly common and has been shown to be closely related to patient's beliefs, particularly owing to doubts about the necessity for medication, concerns about the potential for adverse drug reactions and perceived consequences and perceptions of their illnesss [5–7]. Another important consideration is unintentional nonadherence. This may occur when the patient forgets to take their medication or is unable to use their prescribed inhaler devices [8,9].

The use of inhaled therapy has a number of advantages over systemic (oral or intravenous) administration. It allows a smaller dose to be administered, there is a faster onset of action and fewer systemic side effects [10,11]. The deposition of the inhaled drug in the lung is dependent on particle size, inhalation technique and the type of inhaler device. An integral part of the deposition of the drug within the lung is the inhaler technique of the patient using the device. Correct inhaler technique is essential for the most effective delivery of inhaled drugs; however, a number of studies have identified that errors in inhaler technique are common [2,12–15]. Errors in inhaler technique are associated with suboptimal delivery of the drug into the lungs and may also potentially increase the risk of adverse effects, particularly with inhaled corticosteroids, but despite this, one study demonstrated that approximately a fifth of older patients receiving inhaled therapy could not recall receiving inhaler technique training [16].

Inhaler types

There is a wide variety of different inhalers currently on the market, they can be broadly classified into pressurized metered dose (pMDI), dry powder (DPI), breath-actuated metered-dose (BA-MDI) and soft mist inhalers.

Pressurized metered-dose inhalers

pMDIs are widely prescribed as they are cheap and can deliver a wide variety of asthma or COPD medications [17]. In a UK based study of people over the age of 70 years living at home, 15.8% of subjects were using an inhaler, of whom 42.8% were using a metered-dose inhaler (MDI) [16]. Despite their wide prescription many patients cannot use pMDIs correctly, even with education and training [13,18,19]. Lenney *et al.* demonstrated that only 79% of patients could use a pMDI correctly after expert training [15]. Many of the difficulties with pMDIs are related to the need to coordinate activation of the device while inhaling slowly and deeply. Al-Showair *et al.* demonstrated that approximately 60 and 92% of patients with COPD and asthma, respectively, were inhaling too fast from a pMDI [20,21].

A spacer is a device that can be attached to a pMDI and produces a reservoir into which the drug aerosol can be generated. This allows the patient to actuate the inhaler without having to coordinate inhalation. There is evidence that the addition of a spacer can increase deposition within the lung of the patient [22]. Spacers achieve this by reducing aerosol particle velocity due to the spray encountering air resistance, and a reduction in aerosol particle diameter due to evaporation. The use of a spacer device has long been recognized to improve the inhalation of drugs from pMDIs, particularly for patients with difficulty using a pMDI alone [16,23]. The use of a spacer in combination with a pMDI may reduce the risk of adverse side effects, particularly in relation to the use of high-dose inhaled corticosteroids [24].

New developments in drug formulation have allowed for the development of new pMDIs that produce aerosols containing extra-fine particles. The use of extra-fine particle pMDIs has been

shown to demonstrate equivalent efficacy to other preparations but with a reduced equivalent dose of corticosteroid [25–28]. These newer formulations have been reported to be less dependent upon inhaler technique than other MDIs due to longer duration of aerosol emission [29] and lung deposition being affected less by inspiratory flow [30] and coordination [31].

One concern about pMDIs is the 'cold-Freon' effect that can result from the impact of the aerosol plume on the back of the throat. Some of the newer hydrofluoralkane (HFA)-containing MDIs produced much softer and warmer plumes, when compared with the chlorofluorocarbon (CFC)-containing MDIs, which may improve patient tolerability, and therefore compliance [32].

CFC-containing MDIs have gradually been phased out across Europe in recent years and many are now formulated to contain HFA propellants. This has had a significant effect on the characteristics of the spray from MDIs, in particular producing softer, warmer sprays. In one study, the HFA-beclometasone MDI was found to produce a plume with a spray duration of 510.8 ms from a Beclazone™ (IVAX, UK) 50 CFC-free MDI, 278.5 ms from a Qvar™ (TEVA, UK) 50-µg MDI, compared with 185.2 ms from a Becotide™ (GlaxoSmithKline, UK) 100-µg MDI. This was associated with a reduction in the maximum plume impact force on the throat (45.6, 34.3 and 106.1 mN, respectively. Additionally the minimum plume temperature was higher for the HFA-containing MDIs (-1.9, 3.7 and -32.2°C). The authors' report concludes that MDIs with warm and softer plumes should minimize throat deposition and reduce the likelihood of the cold-Freon effect [32].

Breath-actuated metered-dose inhalers

BA-MDIs are a development from the original pMDIs. They contain a flow trigger that ensures that inhalation and actuation of the inhaler are coordinated appropriately, as the drug is released only when the patient inhales through the inhaler device. BA-MDIs have been demonstrated to improve the deposition of aerosol within the lungs for patients who have difficulty coordinating inhalation and actuation of pMDIs [31,33]. Chapman *et al.* found that for elderly patients, BA-MDIs were preferred when compared with standard MDIs [19]. Lenney *et al.* found that 91% of patients had good inhaler technique with the Easi-Breathe® (IVAX, UK) inhaler device after expert training and was by far the most popular inhaler device of seven devices tested, including the pMDI, pMDI plus Volumatic® spacer (GlaxoSmithKline, UK), Accuhaler® (GlaxoSmithKline, UK) and Turbohaler® (Astrazeneca, Sweden) [15]. In a later study by Ho *et al.* BA-MDIs were only found to be used correctly by 72% of individuals [16]. An important consideration for the use of BA-MDIs is the need for the patient to be able to generate sufficient inspiratory flow to trigger the delivery of the aerosol.

Dry powder inhalers

There are a number of DPIs currently available on the market. Some of these devices are single dose, such as the HandiHaler® (Boehringer Ingelheim, Germany) or Aerolizer® (Novartis, Switzerland), that require loading of a capsule containing the drug in powder form. Others are multiple dose, such as Turbohaler (also known as the Turbuhaler) or Accuhaler (also known as the Diskus® [GlaxoSmithKline, UK]).

The main advantages DPIs have over pMDIs are that the generation of the drug aerosol is driven by the patient's inhalation. As a consequence there is no need for an aerosol propellant or coordination between actuation of the device and inhalation. If the patient cannot generate an appropriate inspiratory flow then the drug may not be delivered optimally. A recent systematic review of studies examining inhaler technique using DPIs found that between 4 and 94% of patients did not use their inhaler correctly. The most frequently reported errors included failure to exhale prior to inhaling through the device, failure to breath-hold after inhalation, incorrect positioning of the device and failure to inhale through the device with a sufficiently high inspiratory flow [2]. However, the studies included in the systematic review are subjective by nature and no consistent pattern is discernible to determine the easiest DPI to use as different studies favored different DPI devices.

Soft mist inhalers

Soft mist inhalers are a recent innovation and the only current device on the European market is the Respimat® (Boehringer Ingelheim, Germany). The Respimat does not require a propellant or the patient's inspiratory flow to generate an aerosol. The aerosol is generated by a spring that forces the liquid drug formulation through an extremely fine nozzle system, resulting in an aerosol containing a high fine particle fraction [34]. The Respimat has a long aerosol generation time and a low aerosol velocity. These features reduce problems with coordination of actuation and inhalation, and result in a higher lung and lower oropharyngeal deposition [34]. However, recent data have implicated tiotropium when delivered via the Respimat device with a nonsignificant increase in cardiovascular mortality compared with placebo [35]. This effect has not been observed when tiotropium is delivered via the HandiHaler DPI device [36]. Although this increase in mortality may just be a chance finding, postulated reasons include the fact that the Respimat device achieves greater systemic absorption of tiotropium compared with the HandiHaler device. As a consequence, the Medicines and Healthcare products Regulatory Agency have advised that Spiriva Respimat should be used with caution in patients with known cardiac rhythm disorders [104].

Aerosol science & inhaled medication

The deposition of the inhaled drug in the lung is dependent on particle size, inhalation technique and the type of inhaler device. There is a complex interaction between these three factors that results in the need for different techniques for different inhalers [37,38]. Patients using a pMDI should use a slower inhalation [37,39], compared with a DPI, which requires a faster inhalation rate [37,40].

Effects of particle size on lung deposition

Depending on their particle size, inhaled drug particles will deposit in different regions of the lung. Particles <1 µm are likely to reach

the peripheral airways and alveoli or be exhaled, particles 1–5 µm will deposit in the large and conducting airways, while particles >5 µm will predominately deposit in the oropharynx [10,11].

Historical data of examining lung deposition of terbutaline demonstrated 10.7% of the metered dose was deposited in the whole lung when administered via pMDI at an inhalation flow of 30 l/min and 31.6% when administered via pMDI plus Nebuhaler at an inhalation flow of 15 l/min [41]. Deposition of inhaled corticosteroids administered via pMDIs with extra-fine particle formulations have demonstrated improved lung deposition compared with conventional pMDIs [42–44]. However, randomized controlled studies have, as yet, failed to demonstrate any significant differences in clinical effects compared with equivalent doses of conventional inhaled corticosteroid pMDIs [25–28].

This knowledge is useful since it is known that β_2 receptors predominate in the small conducting airways and alveoli; however, airway smooth muscle is present in the trachea and small conducting airways [30,38]. Consequently the ideal particle size for inhaled β_2-agonists will be in the top end of the range of 1–5 µm, as this would allow deposition of drug particles in the region of airway where both airway smooth muscle and β_2 receptors exist. Larger particles of β_2-agonists in the range of 3–6µm have been demonstrated to achieve greater lung deposition in the central and intermediate airways than small particles (1.5 µm), and consequently produce greater bronchodilation [30]. By contrast, airway inflammation is present throughout the respiratory tract, although there is a similar, but more severe, inflammatory process in the peripheral airways compared with the central airways [45].Consequently, a particle size distribution from <1 µm up to 5 µm may be desirable for inhaled anti-inflammatory drugs, such as corticosteroids [38,46].

Usmani *et al.* described the lung deposition and clinical effects of three sizes (1.5, 3 and 6 µm) of monodisperse salbutamol in 12 asthmatic patients [30]. Although lung deposition was greatest for the 1.5 µm particles, the 6 µm particles produced the greatest clinical response in terms of lung function. The smaller particles were less likely to be deposited in the oropharynx, which may explain the reduction in local side effects with extra-fine particle inhaled corticosteroids perpetrations [47].

There are three different mechanisms of deposition of aerosols: inertial impaction, sedimentation and diffusion (Figure 1). However, for the particle size used in aerosol therapies of approximately 1–10 µm, only two of these mechanisms predominate – inertial impaction and gravitational sedimentation. The third mechanism, Brownian motion/diffusion, is only relevant in aerosols of less than 1 µm in diameter [10], and therefore is unlikely to be of consequence for inhaled drugs.

Inertial impaction occurs in either the oropharynx or at bifurcations of main branches of the bronchial tree, particularly in the large central airways. It occurs mainly with large particles or high velocity particles (i.e., those with high inertia), where they are unable to follow the airstream when it changes direction, thus impacting on the airway wall [10,48].

Gravitational sedimentation occurs for smaller particles that are able to follow the airstream and penetrate the more peripheral bronchioles and alveoli. Here the airstream flows slower, allowing the particles to settle on to the airway surfaces either during the course of slow steady breathing or during breath-holding [10,48]. Breath-holding is important for smaller particle sizes owing to the increased chance of exhalation of the drug, because they can remain airborne for a considerable time [30]. The mechanism of the deposition of inhaled aerosols and the size of aerosol particles has a number of implications for practice (Box 1).

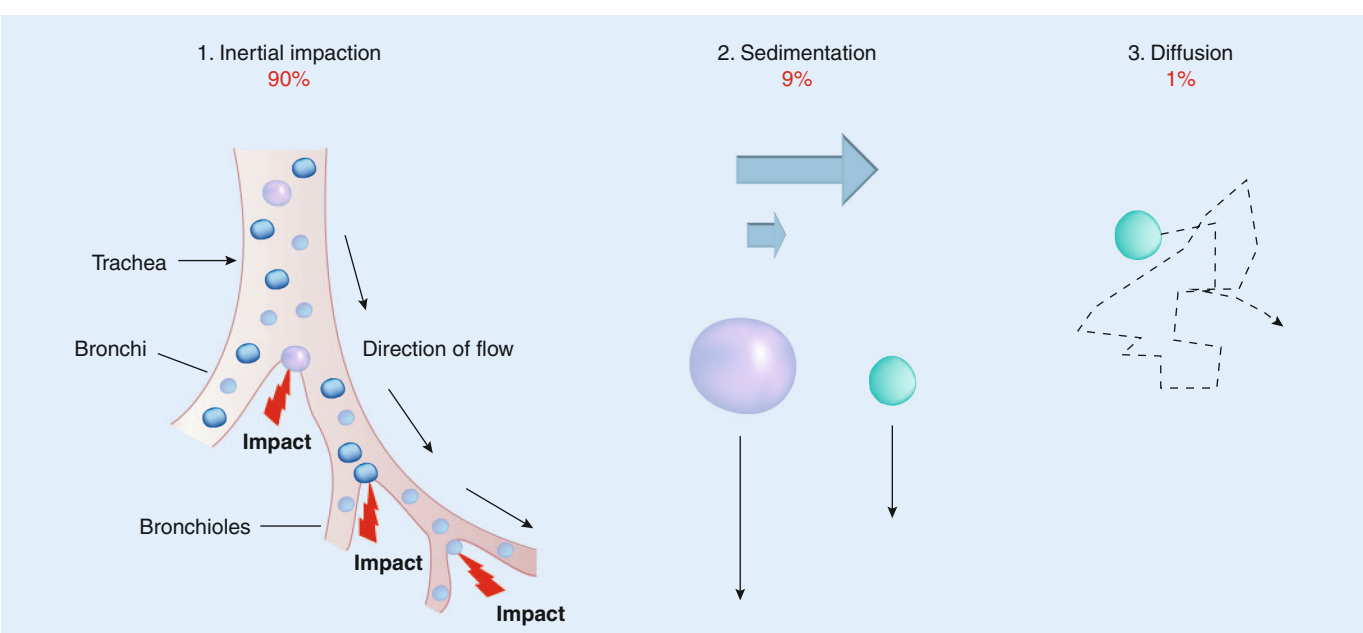

Figure 1. Particle deposition in the respiratory tract.
Adapted with permission from [48].

Box 1. Implications for practice on the mechanism of aerosol deposition and particle size.

- Particle size is important: those that are too small may be exhaled; those that are too large experience inertial impaction in the oropharynx and large conducting airways.
- Increased aerosol particle speed increases the probability of deposition by impaction in the oropharynx and large conducting airways; slow aerosol particle speed allows more particles to penetrate the peripheral bronchial tree.
- Increasing the inhalation volume allows the aerosol to penetrate peripheral bronchioles.
- Breath-holding increases gravitational sedimentation.

Effects of inspiratory flow on lung deposition

The total lung deposition of an inhaled drug is strongly affected by the speed of inhalation. DPIs require a fast and deep inhalation to 'suck up' the drug in the inhaler device. A fast inhalation rate generates a large internal turbulent force in the inhaler device, which is required to break up the formulation of the metered dose to produce particles of a size distribution that will penetrate the peripheral airways [38,48,49]. Failure to achieve this high internal force increases the likelihood of the dose impacting in the mouth and throat. By contrast, aerosol inhalers, such as the MDI, require a slow and deep inhalation, with an inspiratory flow rate of less than 60 l/min. This is owing to the device generating its own aerosol, and so a slower inhalation rate is required to ensure that the drug deposits in the peripheral airways, since a fast inhalation will increase the velocity of the drug particles, thus increasing inertial impaction in the oropharynx as described above [21,38]. Some of the effect of excessive inspiratory flow with a pMDI can be mitigated by the particle size used in the aerosol. Usmani *et al.* demonstrated that increasing the inspiratory flow from 30.8 to 67.1 l/min increased the deposition of 1.5-µm particles, but reduced the deposition of 6-µm particles. However, a greater clinical effect was observed with 6-µm particles of salbutamol administered via a pMDI with good inhaler technique than with 1.5-µm particles administered via a pMDI with either good or bad inhaler technique [30].

Faster inspiratory flow rates increase inertial impaction of aerosols in the oropharynx and at bifurcations in the large central airways, thus reducing lung deposition in the peripheral airways. In one study determining whole lung deposition using the charcoal block method, deposition of radiolabeled terbutaline was reduced by a third by increasing the airflow through the MDI device from 30 to 180 l/min (mean ± standard deviation: 11.2 ± 4.0 vs 7.2 ± 2.2; $p < 0.05$) [50]. A significant proportion of patients with asthma and COPD have been shown to have an inspiratory flow too high for an MDI, which could potentially reduce the clinical effectiveness of inhaled drugs [20,21].

Other studies have demonstrated that lung deposition from dry powder devices increases as inspiratory flow increases. Borgstrom *et al.* demonstrated that the percentage of the metered dose from a budesonide Turbohaler deposited in the lung as measured by gamma scintigraphy increased from a mean ± standard deviation 14.8 ± 3.3% at an inspiratory flow rate of 36 l/min to 27.7 ± 9.5% at 58 l/min [50]. A further study highlighted the variability in dose delivered by the Turbohaler device, by demonstrating that the fine particle fraction was more strongly influenced by inspiratory flow rate through a Turbohaler compared with an Accuhaler (12–24% at 30–60 l/min vs 15–21% at 30–90 l/min, respectively) [51].

As a consequence, when a patient uses an aerosol inhaler, such as the MDI, a slow inspiratory flow rate will produce significantly greater lung deposition than when used at a faster inspiratory flow rate. By contrast, when dry powder inhalers, such as a Turbohaler or Accuhaler are used, a faster inspiratory flow rate will produce significantly greater lung deposition than a slower inspiratory flow rate.

The ability of patients to use specific inhalers can vary with time. During times of increased hyperinflation, such as acute exacerbations of asthma of progression to severe emphysema, patients may not be able to generate sufficient inspiratory flow through high-resistance devices. In this situation, a low-resistance device, such as a pMDI or pMDI plus spacer, may be more appropriate.

Effect of resistance of inhaler device on lung deposition

Another important determinant of the inspiratory flow through an inhaler is the resistance to airflow through the device. The MDI is a low-resistance device and is easy to inhale through since there is little resistance to airflow. This means that the patient needs to apply less effort to inhalation to generate the appropriate inspiratory flow and optimum drug deposition. A low-resistance device, such as an MDI, means that it is relatively easy to generate too great an inspiratory flow, essentially inhaling too fast, which is a common error in the use of MDIs [37,38,52].

DPI devices have a high resistance to airflow, which limits the inhalation flow rate through the device, and consequently patients using a DPI need to apply greater effort to generate the necessary inspiratory flow to allow for optimum drug delivery. The ability to generate appropriate inspiratory flow is particularly important for patients with severe airflow obstruction, young children and the elderly [40]. Peak inspiratory flow through a Accuhaler, Turbohaler and HandiHaler device have been shown to be too slow among 4.9, 14.2 and 57.0% of patients with COPD, respectively [20].

The effect of increased airflow resistance on inhalation flow has been demonstrated [20], and it can be seen that lower inhalation flows can be achieved through the devices with the highest airflow resistance (the Easyhaler® [Orion Pharma, UK]and HandiHaler) than through devices with lower resistance, such as the Accuhaler (Table 1). Consequently, using the same amount of effort of inhalation, patients can achieve faster inspiratory flows through the Accuhaler, than through a Turbohaler, HandiHaler or Easyhaler device.

Choosing the correct inhaler

One of the crucial factors in determining whether the patient has an appropriate inhaler technique is the inspiratory flow through

Table 1. Resistance of dry powder inhaler devices.

Device	Mean (CV) resistance $(cm\ H_2O)^{0.5}$ l/min	Inhalation flow (l/min) for an inspiratory effort corresponding to a pressure drop of 4 kPa across the device	Ref.
Accuhaler®	0.078 (0.32)	82.4	[20]
Easyhaler®	0.155 (0.21)	41.2	[62]
HandiHaler®	0.158 (5.88)	40.4	[20]
Turbohaler®	0.110 (0.50)	58.3	[20]

the particular device and the ability to coordinate actuation and inhalation of the inhaler. Voshaar *et al.* have proposed that the use of inspiratory flow measurements and the ability to coordinate actuation and inhalation of inhalers may provide guidance to the most appropriate inhaler for individual patients (Table 2) [53]. This guide suggests that patients who naturally have a tendency to have a fast inhalation would be better suited to DPIs, whereas those with a slower inhalation speed would be best suited to a pMDI.

Devices such as the In-Check DIAL® inspiratory flow meter (Clement Clarke Ltd, UK) can be used to ensure that patients can inhale through their inhaler device at the clinically effective inspiratory flow rate. The device mimics the internal resistance of a range of inhaler devices (Table 3), allowing the measurement of inspiratory flow rate through different devices [49,54]. The In-Check DIAL inspiratory flow meter can be used as part of the inhaler technique assessment to guide inhaler device selection and conserve placebo inhalers, which should be single-patient use only. If a patient is physically unable to achieve the required optimum inspiratory flow rate, there is no point checking their technique with that device. If their inspiratory flow is too great for the device then they may benefit from training and education or alternatively trying a different device.

It should be noted, however, that the inspiratory flow rates described in Table 3 are the optimum inspiratory flow rates for each device listed. Patients who use any particular inhaler device, but cannot achieve the optimum inspiratory flow rate, will often gain clinical benefit from that device (assuming that their overall technique is satisfactory), but potentially not the maximum benefit. For example, if a patient can only inhale through a Turbohaler device at an inspiratory flow rate of 36 l/min, approximately 15% of the metered dose will reach the lungs, but if the inspiratory flow rate can be increased to 56 l/min then lung deposition will almost double to approximately 28% [50]. It is likely that patients will achieve a clinical benefit at both inspiratory flow rates, but would seem inherently obvious that they could potentially gain greater benefit at the higher flow rate owing to greater lung deposition.

Table 2. Suitability of inhaler devices according to the patient's inspiratory flow and ability to coordinate inhaler actuation and inhalation.

Good actuation–inhalation coordination		Poor actuation–inhalation coordination	
Inspiratory flow		*Inspiratory flow*	
>30 l/min	*<30 l/min*	*>30 l/min*	*< 30 l/min*
pMDI BA-MDI DPI Nebulizer SMI	pMDI Nebulizer	pMDI + spacer BA-MDI DPI Nebulizer SMI	pMDI + spacer Nebulizer SMI

Adapted with permission from [53].

Additionally, for optimal drug delivery it is important that the inspiratory flow at the start of inhalation is fast enough to break up the weak bonds between the drug and carrier particles to ensure that the optimal particle size is achieved to allow deposition of the drug in the appropriate region of the lungs [49]. If the peak inspiratory flow is only achieved gradually (i.e., an inhalation commencing with a slow inspiratory flow, which gradually increases), the initial force required to generate an appropriate drug particle size will not be achieved and the delivered dose will be reduced. A final note of caution with training aids, such as the In-Check DIAL inspiratory flow meter, is that it assesses just one component of inhaler technique and does not teach the patient how to hold, prime and position their inhaler device [38].

Alternative training aids are available to assist inhaler technique training. The Turbohaler Trainer (AstraZeneca, Sweden) produces an audible whistle if the patient inhales at an inspiratory flow rate above 35 l/min. This ensures the patient is inhaling to achieve clinically significant lung deposition rather than achieving the optimal inspiratory flow rate. It is useful for patients who do not like using the Turbohaler device because they cannot taste the drug, like they can with more 'familiar' devices, such as the MDI. Similarly, the Accuhaler training Device (Vitalograph, Ennis, Ireland) can be used to ensure patients can achieve the optimum inspiratory flow rate above 30 l/min. The 2-Tone Trainer® (Canday Medical Ltd, UK) can be used to help patients learn the correct inspiratory flow rate through an MDI device. It mimics the airflow resistance through an MDI, such that if a patient inhales too slowly, no sound is heard, while if they inhale correctly, one tone is heard. If the patient inhales at the correct flow rate then two tones are heard. The 2-Tone Trainer has been demonstrated to maintain the recommended MDI technique post-training with improvements in Asthma Quality of Life Questionnaire score [21].

Training aids, such as the In-Check DIAL inspiratory flow meter, Turbohaler Trainer, Accuhaler Training Device and 2-Tone Trainer, are tools for determining whether a patient has the physical capacity to use a particular inhaler device. These devices are just one aspect of inhaler use, therefore, it is essential that healthcare professionals have access to placebo inhaler devices to assess a patient's overall inhaler technique, since these will allow the patient to be assessed on the priming, positioning and coordination of the device. Most UK hospitals and general practitioners have access to placebo inhalers, but many centers advise that

placebo inhalers should be 'single-patient use' only, since there is a theoretical risk of infection when using placebo inhalers among patients [105]. However, if placebo inhalers are used for more than one patient, the British Thoracic Society advise that they should be decontaminated after each time they are used (Box 2).

Since many UK centers can only obtain a limited supply of placebo inhalers, it is impossible for all patients with asthma or COPD to have their inhaler technique assessed during hospital admission or at clinic reviews. If a patient has their own inhalers, then an extra dose of these could be given if it is thought unlikely to cause undue harm. If a patient is to be newly prescribed an inhaler, a judgement must be made to decide which patients should receive education, training and assessment on correct inhaler technique using placebo inhalers prior to being given a prescription, and which patients can receive training and assessment using their new inhaler devices after receiving their dispensed prescription. In these situations, the use of the In-Check DIAL inspiratory flow meter may aid this decision as patients who inhale fast are more likely to be suitable for a DPI device, and slow inhalers are more likely to be suitable for a pMDI device.

Table 3. Inhaler devices that can be mimicked by the In-Check Device®.

Device	Clinically effective inspiratory flow
Accuhaler®	30–90 l/min†
Autohaler®	30–60 l/min†
Clickhaler®	15–60 l/min†
Easi-Breathe®	20–60 l/min†
HandiHaler® (using adapter)	20–60 l/min‡
pMDI	25–60 l/min†
Turbohaler®	30–90 l/min†

†Data taken from from Clement Clarke Ltd, UK.
‡Data taken from [63].

Choice of inhaler to prescribe

While no guideline gives specific recommendations on which inhaler device should be used, they do advise that patients newly started on an inhaler should receive education and training on that device, but do not go into further details [1,101–103]. The American College of Chest Physicians and American College of Asthma, Allergy and Immunology have provided more useful advice on prescribing inhalers, recommending that a number of factors are considered when prescribing inhaler devices [55]. These factors included drug availability, patient ability to use, cost, convenience of device, device durability and patient or prescriber device preference [55]. While these factors are perfectly reasonable issues to consider when prescribing a new inhaler device, it is strange that patient preference for the inhaler device is the last consideration, as this may affect adherence to the prescribed treatment, therefore we would suggest that a pragmatic approach for inhaler choice could be used (Box 3).

There are a number of studies assessing the preference of different inhaler devices in patients with asthma and COPD, but most are industry-sponsored studies. In fact, one review reported that "of the 29 studies, 23 were sponsored by the pharmaceutical industry, and 83% of the sponsored trials favored the device manufactured by the sponsoring company" [56]. One independent study comparing multiple inhaler devices found that the most popular device was the Easi-Breathe inhaler, followed by the Autohaler® (3M, USA), Clickhaler® (Generics UK Ltd, UK) and Accuhaler. The pMDI and Turbohaler devices were ranked fifth and sixth preferred device, respectively, with pMDI via Volumatic the least preferred device [15]. However, despite the fact that the Easi-Breathe inhaler was the most preferred inhaler in this study, prescribing is restricted by the limited number of drugs available in this device, with only Qvar® (Beclometasone, Teva UK) and Salamol™ (salbutamol, IVAX) being available in the Easi-Breathe in the UK.

Inhaler technique training

Inhaler technique checks need to be an integral part of the routine management of any patient with either asthma or COPD. The Aerosol Drug Management Improvement Team group proposed a practical algorithm in order to improve the instruction of patients regarding correct inhaler use (Figure 2) [3]. This algorithm emphasizes the need for a consistent assessment of asthma control, and to only step treatment up once appropriate assessments of aggravating factors, compliance and inhaler technique are assessed.

This algorithm was specifically designed with asthma in mind; however, it could equally apply to the care of people with COPD. Patient perception of their own inhaler technique correlates poorly with actual use of the inhaler, hence inhaler technique should be observed and checked regularly [16].

Once a person has been identified to have an incorrect inhaler technique it is essential that action is undertaken to remedy the situation. Incorrect inhaler technique could have a direct effect upon the patient in terms of disease control and the consequent potential effects on morbidity, mortality and quality of life. There are also wider socioeconomic impacts in terms of the financial cost of the inhalers and the cost of treating exacerbations of either

Box 2. Guidance for decontamination of placebo inhalers.

Inhaler canisters and other devices that can be washed must be:

- Disassembled where possible
- Washed thoroughly, ideally in an ultrasound bath or according to guidelines
- Soaked for 1 h in a hypochlorite solution
  - 10,000 parts per million if there is potential blood contamination
  - 1000 parts per million if no risk of blood contamination
- Dried thoroughly prior to further use.

Dry powder devices and device parts that cannot be washed:

- Decontaminated by thoroughly wiping with an appropriate alcohol wipe

Data taken from [105].

Box 3. Suggested pragmatic approach towards inhaler choice.

- Confirm the diagnosis: is the diagnosis asthma or chronic obstructive pulmonary disease?
- Determine the severity of respiratory disease: the treatment required for asthma and chronic obstructive pulmonary disease should be sufficient to treat the severity of the condition.
- Objectively assess which device the patient can use: using placebo inhalers and training tools as appropriate.
- Is the patient happy with that device? Once the patient has been taught how to use a particular inhaler device, it is imperative that their views are sought to ensure that they would be happy to use that device.
- Decide on the class of drug required: with few exceptions, the choice of the actual drug to prescribe within a class is unlikely to be as important as the class of drug.
- Select the drug that is available in that device: once the inhaler device and class of drug is known, the drug often picks itself.

airways disease. In one study of 4078 adults with asthma treated with inhaled corticosteroids delivered by pMDI, poor technique was identified in 71% of patients. Asthma stability was found to be worse in patients with poorer inhaler technique (as determined by the number of errors made in their inhaler technique), than patients with good inhaler technique [57].

Inhaler technique training needs to be undertaken by a healthcare professional proficient in providing inhaler technique training. There is evidence that the training is not always delivered by appropriately trained staff [58,59]. The training could be delivered by a wide variety of healthcare professionals, including medical staff, nursing staff and pharmacists, depending upon the individual practices. It should not be simply assumed that all healthcare professionals have perfect inhaler technique. A number of studies have identified that a variety of healthcare professionals often have poor knowledge on the optimal use of different inhaler devices [59,60]. Therefore, the regular ongoing education of healthcare professionals is likely to be of paramount importance to ensure that they are able to adequately teach patients inhaler technique, and thus not unwittingly contribute to patients' poor inhaler technique.

Adequate time and resources need to be set aside for inhaler technique training; however, it does not need to be prolonged. Basheti *et al.* studied the effect of a monthly community pharmacist-delivered inhaler technique session [61]. The training session only lasted a few minutes, but resulted in a clinical and statistically significant improvement in quality of life and asthma control. Another important finding from this study is that once the monthly inhaler training stopped there was a decline in inhaler technique with an associated decline in some asthma outcomes. This would suggest that inhaler technique training may need to be a continuous process rather than a one-off session at the initiation of therapy, and patients on long-term inhaled therapy should not be assumed to be proficient in the use of their inhaler therapies.

The components of inhaler technique training are also important. In a small study, the most effective method of delivering training for the use of a Turbohaler was a combination of verbal counseling and physical demonstration [61].

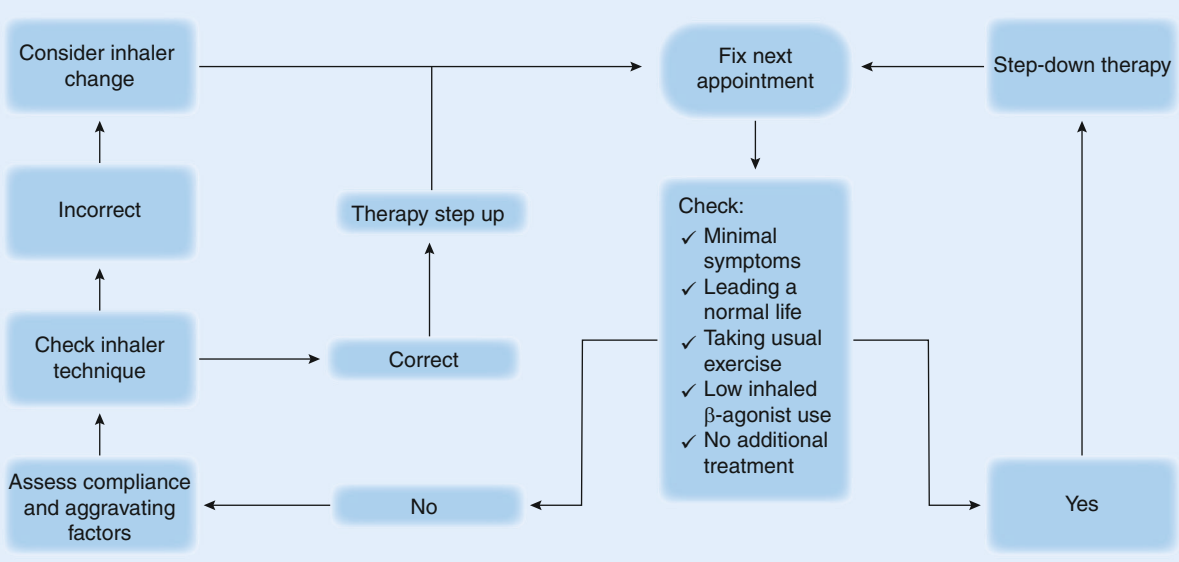

Figure 2. Asthma therapy adjustment flow chart.
Adapted with permission from [3].

Expert commentary

Asthma and COPD are both common conditions worldwide with an increasing prevalence. Both conditions are associated with a significant morbidity and mortality. Effective drug therapies are available in the form of inhaled corticosteroids and bronchodilators. These therapies can be delivered by a variety of different inhalation devices.

Correct use of the inhalation devices will maximize the beneficial effects of therapy, while minimizing potential adverse effects. Inhaler technique assessment and training needs to be delivered at the initiation of therapy with a new inhaler device, but also needs to be repeated throughout the period that the patient received inhaled drug therapy. A detailed assessment of the patient's coordination and inspiratory flow patterns could potentially allow for a recommendation of particular inhalers that are more suitable for individual patients. This would potentially increase the chances of successful inhalation therapy with consequent positive effects on the control of the patient's condition.

Identification of poor inhaler technique is an integral part of the management of patients with asthma or COPD. Identification of poor inhaler technique should lead to either inhaler technique training or instigate a change of device to enable the patient to use their inhaler accurately. Advances also need to be made to address the questions that surround the most efficient method of delivering inhaler technique education. These questions include the frequency of inhaler check and who should deliver the information. This may be most appropriate from healthcare professionals, but the use of expert patients could be an alternative.

Five-year view

Identification of poor inhaler technique and the provision of appropriate training are going to remain essential for the management of patients with asthma and COPD for the foreseeable future. Further research needs to address questions regarding the nature and frequency of inhaler technique training. New ways of delivering inhaler technique training should be developed, such as via video delivered to smartphones or via online asthma action plans with integrated inhaler technique video clips. Inhaler device development should focus on producing devices that are easy to use in an effort to maximize the efficacy of inhaled therapy.

Key issues

- Chronic obstructive pulmonary disease and asthma are both common conditions with an increasing worldwide prevalence.
- Inhaled delivery of drugs is essential for the management of chronic obstructive pulmonary disease and asthma to minimize systemic side effects of the currently available therapies.
- A wide variety of inhalers are available on the market, all of which have relative positive and negative aspects.
- Inhaler technique is repeatedly recognized to be poor in a significant number of patients.
- Inhaler technique training and education has been demonstrated to be successful.
- Advances in inhaler design and improvement in education may result in more efficient delivery of inhaled drugs.

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Inhaler technique and training in people with chronic obstructive pulmonary disease and asthma

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Activity Evaluation
Where 1 is strongly disagree and 5 is strongly agree

	1	2	3	4	5
1. The activity supported the learning objectives.					
2. The material was organized clearly for learning to occur.					
3. The content learned from this activity will impact my practice.					
4. The activity was presented objectively and free of commercial bias.					

1. Your patient is a 22-year-old woman with recently diagnosed asthma. She requires treatment with an inhaled corticosteroid plus short-acting inhaled albuterol for rescue therapy. What should you consider regarding different types of inhaler before writing her a prescription?

- ☐ **A** Spacers are ineffective in improving drug delivery among persons using pMDIs
- ☐ **B** Extra-fine particle pMDIs require a higher dose of corticosteroid
- ☐ **C** BA-MDIs require the patient to generate at least moderate inspiratory flow
- ☐ **D** The Accuhaler has consistently been demonstrated to be the easiest DPI to use

2. What is the best particle size for this patient's inhaled corticosteroid and β_2-agonist to ensure the best treatment efficacy?

- ☐ **A** <1 µm
- ☐ **B** 4 µm
- ☐ **C** 12 µm
- ☐ **D** ≥15 µm

3. What can you tell this patient regarding the use of her inhalers?

- ☐ **A** DPIs require a slow and steady inspiratory effort
- ☐ **B** pMDIs require a fast and deep inhalation
- ☐ **C** Faster inspiratory flow rates reduce the impaction of aerosols in the oropharynx
- ☐ **D** Lung deposition from dry powder devices increases as inspiratory flow increases

4. The patient leaves with her prescription and returns for a follow-up visit 4 weeks later. At this time, she reports that she still has frequent symptoms of shortness of breath and poor exercise tolerance. What is the next best step in her care?

- ☐ **A** Assess compliance and aggravating factors for her asthma
- ☐ **B** Check her inhaler technique
- ☐ **C** Consider changing her inhaler
- ☐ **D** Increase the dose of her inhaled corticosteroid