



## REVIEW

# The need to improve inhalation technique in Europe: A report from the Aerosol Drug Management Improvement Team

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**Summary** Although the principles of asthma management are well established in Europe, the available data indicate that asthma in patients is not well controlled. Many patients derive incomplete benefit from their inhaled medication because they do not use inhaler devices correctly and this may compromise asthma control. The Aerosol Drug Management Improvement Team (ADMIT), incorporating clinicians from the UK, Germany, France, Italy, Spain and The Netherlands, reviewed published evidence to examine ways to improve the treatment of reversible airways disease in Europe. Data indicate that there is 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. Devices which provide reassurance to patients and their physicians that inhalation is

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performed correctly should help to improve patient compliance and asthma control. Educational efforts should also focus on primary prescribers of inhaler devices. ADMIT recommends dissemination of information on the correct inhalation technique for each model of device by the use of an accessible dedicated literature base or website which would enable to match the appropriate inhaler to the individual patient. There is also a need for standardisation of prescribing practices throughout Europe. Regular checking of inhalation technique by prescribers is crucial as correct inhalation is one of the keystones of successful asthma management.

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## Introduction

Despite the publication of comprehensive treatment guidelines following the introduction of the bronchodilator containing pressurised metered dose inhaler (pMDI) in the 1950s and inhaled corticosteroid (ICS) therapy some 20 years later many asthma patients in Europe do not obtain full clinical benefit from this treatment, but the reasons for this are far from clear.<sup>1</sup>

The inability of many patients to use their pMDIs correctly is one possible explanation.<sup>2-6</sup> Efficient use of pMDIs requires coordination between simultaneous inhalation and device actuation, a slow and continuous inspiratory flow rate during inhalation followed by a breath hold of at least 10s.<sup>7</sup> Also, patients frequently fail to exhale fully before inhalation of the medication,<sup>8,9</sup> and they actuate the pMDI before or at the end of inhalation, or while breath-holding.<sup>2,9</sup> When used with a spacer device, pMDIs are bulky, which may reduce patient compliance, and without a spacer device a high proportion of the drug is deposited in the mouth and oropharynx.<sup>10</sup> There is no evidence that the introduction of breath-actuated pMDIs and various spacer attachments have made the pMDIs easier to use.<sup>11</sup> Moreover, the available pMDIs provide no inhalation feedback mechanisms or a dose counter and contain environmentally unfriendly propellants.

In the 1980s, dry powder inhalers (DPIs) were introduced with the aim to avoid the need for coordination between inhalation and actuation of

the device. Inhaler ease of use and patient preference can influence compliance with therapy, as indicated by recent studies with DPIs.<sup>12,13</sup> In one study in patients with symptomatic chronic obstructive pulmonary disease (COPD),<sup>12</sup> 58% of the patients reported no problems using the Diskus<sup>®</sup> compared with only 11% using the Handihaler<sup>®</sup>; 72% of the patients also reported that they would not be happy to use the Handihaler<sup>®</sup>. In another study,<sup>13</sup> although compliance with the Easyhaler<sup>®</sup> and Turbuhaler<sup>®</sup> was high (>97%), twice as many patients with asthma favoured the Easyhaler<sup>®</sup> over the Turbuhaler<sup>®</sup> (59% vs. 33%), and scores of device acceptability significantly favoured the Easyhaler<sup>®</sup> ( $P = 0.001$ ).

Many physicians in Europe are fully aware of the difficulties that patients have using the prescribed inhaler devices correctly and the negative impact that this may have on asthma control.<sup>14</sup> The Aerosol Drug Management Improvement Team (ADMIT), incorporating experts from the UK, Germany, France, Italy, Spain and The Netherlands, was formed in November 2004 with the remit of examining ways to improve the treatment of reversible airways disease in Europe. ADMIT reviewed evidence from published studies relating to inhalation technique. Details of these studies are summarised by country in Table 1, and findings are discussed below.

## Methods

We conducted a literature search in PubMed up to and including the year 2005 for articles investigating

patient inhalation technique in several European countries. Search terms used were [inhalation] or [inhalation technique] or [inhaler] or [device] and [country] where country was Spain, Italy, France, Germany, The Netherlands or the UK (including searches for England, Scotland, Wales and Northern Ireland). A separate search using only the search term [inhalation technique] was also conducted. Each abstract was scanned and those articles dealing specifically with inhalation technique of patients or healthcare professionals in any of the selected countries were chosen for review.

## Inhalation technique: review of evidence from Europe

### Spain

The available data indicate that a substantial proportion of patients, as well as medical and nursing personnel in Spain does not know how to use inhalers correctly, despite physicians' awareness of the importance of correct inhalation technique for treatment outcome. In a nationwide sample of patients ( $n = 746$ ) and medical personnel (466 nurses and 428 physicians),<sup>4</sup> substantial deficiencies were observed, with only 9% of the patients, 15% of the nurses and 28% of the physicians being able to perform the inhalation manoeuvre correctly (Table 1). Other studies have produced similar results, with inhalation technique deficiencies particularly apparent with pMDIs (Table 1).<sup>15–17</sup> The most common errors associated with pMDI use were not holding the breath after inhalation, not waiting 30s between inhalation manoeuvres and lack of coordination between actuation and inhalation.<sup>15</sup> In addition, lack of correct inhalation technique was associated with the absence of instruction before use and younger age.<sup>15</sup> Moreover, in a different study<sup>18</sup> assessing the correct use of the Turbuhaler<sup>®</sup> by 118 healthcare professionals, only 32% of the nurses and 56% of the physicians were able to perform the required deep, forcible sudden inhalation essential for the correct use of this device (Table 1). Training in the use of inhaler devices may improve inhalation technique<sup>15,34</sup> and should start with healthcare professionals directly involved in asthma management.

### Italy

There is a scarcity of data relating to inhaler technique in Italy. However, a recently published study in 1404 experienced outpatients showed that 24% of had incorrect inhalation technique with pMDIs, 17% were unable to use correctly the Aerolizer<sup>®</sup>, and 23% and 24% the Diskus<sup>®</sup> and the

Turbuhaler<sup>®</sup>, respectively (Table 1).<sup>19</sup> There are some data available relating to the use of nebulisers, which provides useful insight into inhaled drug delivery in Italy. The GENEBU project<sup>20,21</sup> showed that the vast majority of the patients selected their nebuliser themselves without any medical advice and did not receive information on the interface system or the optimal fill volume of the nebuliser (Table 1). Nebuliser equipment for home use in Italy is heterogeneous and probably not always utilised effectively. It seems likely that the same pattern of insufficient instruction would be the case for other inhaler devices.

Guidelines on the correct use and maintenance of nebulisers have been published recently<sup>35,36</sup> and their implementation should help to improve the prescription of aerosol therapy with nebulisers and teach the patients best practice for home treatment. But, prescription of pMDIs or DPIs should be encouraged where appropriate, as these devices are easier to use correctly.

### France

Physicians in France recognise that poor compliance is a major barrier to the achievement of good asthma control, with incorrect inhalation technique contributing most, particularly in children and elderly patients.<sup>37</sup>

Data from France suggest that there are differences in use of inhaler devices in real life in the primary care setting compared to controlled clinical studies. In one study,<sup>23</sup> which examined the correct use of inhaler devices in 3811 patients treated for at least 1 month with either the Aerolizer<sup>®</sup>, the Autohaler<sup>®</sup>, the Diskus<sup>®</sup>, the Accuhaler<sup>®</sup>, a pMDI or the Turbuhaler<sup>®</sup> devices, more patients made at least one error in inhalation technique with the pMDI than with the breath-actuated devices (76% vs. 49–55%); additionally, more errors in inhalation technique compromising treatment efficacy were made with the pMDI or the Turbuhaler<sup>®</sup> compared to the other devices. Furthermore, general practitioners (GPs) overestimated good inhaler technique more often for the Turbuhaler<sup>®</sup> than for the Autohaler<sup>®</sup> and pMDI devices (24% vs. 6%) (Table 1).

Errors that may detrimentally influence the efficiency of inhalation treatment in infants are also common. Most of these errors could be avoided by spending more time informing and training parents on the correct use of the devices. In one study,<sup>24</sup> only 47% of the parents received training in administration of treatment through the relevant spacer device. However, it is worth noting that healthcare professionals responsible for teaching patients how to use their inhaler(s) frequently have

incorrect inhalation technique themselves (Table 1).<sup>22</sup> Children often experience difficulty using pMDIs without a spacer device. The extent of drug delivery also varies with different spacer devices as well as different interfaces. In one study in young children,<sup>25</sup> successful drug delivery with the pMDI used with the recommended holding chamber (BabyHaler<sup>®</sup> or Nebuchamber<sup>®</sup>) depended not only on patient age and type of holding chamber but also on inhalation interface (i.e. facemask or mouthpiece). Whether such factors have any effect on treatment efficacy or compliance has yet to be determined. It is clear, however, that there is a need for continued education of prescribers and users in the correct use of these devices to improve treatment outcome.

### Germany

A recent study carried out in 125 device-naïve symptomatic patients with COPD showed that 42% of them experienced difficulty using the Diskus<sup>®</sup> correctly compared with 81% who were unable to use the Handihaler<sup>®</sup> correctly<sup>12</sup> (Table 1). The Diskus<sup>®</sup> was rated higher than the Handihaler<sup>®</sup> for the top three features of an ideal inhaler and, overall, more patients preferred the Diskus<sup>®</sup>.<sup>12</sup> Another study used a new system (Inhalation Manager) developed in Germany to assess the inhalation technique of patients using original devices under everyday conditions.<sup>26</sup> Results for patients aged between 18 and 59 years showed that improvement in inhalation technique was required for only 1.5% of the patients using the Autohaler<sup>®</sup> compared with 16.7% and 38.9% using the Diskus<sup>®</sup> and the Turbuhaler<sup>®</sup>, respectively. There was also evidence that inhalation technique was worse in patients of higher age (Table 1).<sup>26</sup> Clearly, there is a need for improvement of inhaler technique, particularly in older patients. Indeed, the Working Group "Patient Training" of the German Society of Pneumology reports that patient training measures (including inhalation technique) have been markedly broadened for patients suffering from obstructive airway disease,<sup>38</sup> but there is still some way to go.

### The Netherlands

Data from The Netherlands indicate that comprehensive inhalation instruction and repeated follow-up are needed to ensure correct inhalation technique.<sup>30,39</sup> In one study in children,<sup>30</sup> inhalation technique was scored using criteria defined by The Netherlands Asthma Foundation and performance was related to the inhalation instructions given by the GP or pharmacist. For each inhaler, a number of steps were considered essential for

successful drug delivery. Newly referred patients were asked to demonstrate their inhalation technique and to complete a questionnaire on the inhalation instruction received prior to referral. Although 91% of the patients had received inhalation instruction prior to referral, only 29% of these patients using a DPI performed all essential steps correctly, compared with 67% using a pMDI/spacer combination ( $P < 0.01$ ). Moreover, children who had received comprehensive inhalation instructions with repeated checks of correct inhalation technique at the pharmacy or in the clinical trial setting were more likely to perform all essential steps correctly than children who had received a single instruction by a GP (Table 1). These results have been confirmed in other studies.<sup>39,40</sup>

Improvement in correct use of DPIs after instruction and training has also been reported. In one study,<sup>29</sup> patients who administered at least one drug using the Diskhaler<sup>®</sup> or the Diskus<sup>®</sup>/Accuhaler<sup>®</sup> were asked to demonstrate their inhalation technique in the outpatient clinic. After instruction, the percentage of patients who performed all essential steps correctly increased and almost all steps were performed correctly at the second visit (Table 1). van der Palen et al.<sup>31</sup> reported that of 166 patients with asthma who used the same inhaler for a year, 72% performed all essential inhalation steps correctly and the number increased to 80% after 1 year. Patients using the Diskhaler<sup>®</sup> made the fewest errors. Interestingly, at follow-up, older patients were less likely to perform all essential steps for inhalation correctly.<sup>31</sup>

Incorrect inhalation technique is common among patients with pulmonary disease in primary care. In one study in patients with COPD,<sup>32</sup> over 33% of the patients had a very poor inhalation technique and only 42% of the patients performed all essential steps for inhalation correctly. More patients performed all essential steps correctly with the Diskhaler<sup>®</sup> compared with those patients using the Rotahaler<sup>®</sup> or the Turbuhaler<sup>®</sup>. Results from another study have shown that out of 131 patients with COPD in The Netherlands 31% experienced problems using the Diskus<sup>®</sup> and 68% experienced problems with the Handihaler<sup>®</sup>.<sup>12</sup>

Investigators have attempted to identify factors associated with correct inhalation technique. Results from one study<sup>27</sup> showed that children attending a hospital-based asthma unit who had received repeated instructions and children who had previously been asked to demonstrate the use of their inhaler during an instruction session were significantly more likely than other children to have a correct inhalation technique ( $P < 0.001$  and

$P = 0.03$ , respectively). The number of newly referred children demonstrating a correct inhalation technique improved from 57.4% to 97.9% after three comprehensive instruction sessions.<sup>27</sup> A study in 558 patients with asthma or COPD<sup>28</sup> showed that the type of inhaler appeared to be the strongest independent determinant of an incorrect inhalation technique. Patients using the Rotahaler<sup>®</sup>/Spinhaler<sup>®</sup>, the Turbuhaler<sup>®</sup>, a pMDI or the Cyclohaler<sup>®</sup>/Inhaler-Ingelheim were at a significantly higher risk of making mistakes using the devices than those using the Diskhaler<sup>®</sup> (odds ratio [OR] 16.08, 13.17, 11.60 and 3.27, respectively). Other significant determinants of an incorrect inhalation technique were low emotional quality of life (OR 1.73) and being treated in a group practice (OR 2.26).<sup>28</sup>

### United Kingdom

Use of pMDIs in the UK has been extensively investigated over the period from 1982 to 2000.<sup>2,3,5,6</sup> In 1982, 59% of outpatients who had not used an inhaler before and who attended hospital during a 3-month period, were unable to use a pMDI correctly after reading the instruction pamphlet or after receiving instruction by demonstration if they did not understand the pamphlet.<sup>2</sup> Problems encountered using the pMDI included difficulty coordinating aerosol actuation with inhalation (54% of the patients), stopping inhalation after actuation of the aerosol (24%) and breathing through the nose whilst actuating the aerosol in the mouth (12%).<sup>2</sup> Subsequent studies<sup>3,5,6</sup> showed that the percentage of patients able to use a pMDI correctly after reading the instruction pamphlet or after receiving instruction continued to fall in time (Table 1).

Surprisingly, previous ability to use a pMDI correctly was not indicative of correct use during subsequent testing.<sup>2,33</sup> In one study,<sup>33</sup> 14% of the patients who had previously been able to use an inhaler correctly subsequently proved to have totally inefficient coordination of inhalation and inhaler actuation. A later study<sup>2</sup> in 1038 patients already treated by inhalation showed that 13% of these patients subsequently had a poor inhalation technique even though they had previously demonstrated correct use of their inhalers.

Taken together, these observations suggest that the majority of patients with asthma in the UK probably derive incomplete benefit from the use of pMDIs. Although training apparently results in a more efficient use of the devices, training sessions must be repeated and the results checked at regular intervals.

## Discussion and conclusions

Review of the available data indicates that up to 50% of patients in Europe are unable to use their inhaler devices correctly, and up to 40% of children make inhalation technique errors even with spacers.<sup>30,41</sup> Poor inhalation technique may have significant implications for treatment compliance and efficacy and, most importantly, will impact on the patient's confidence in her/his asthma management plan. International asthma management guidelines (GINA)<sup>42</sup> provide little information on inhaler choice and correct inhalation technique. Furthermore, there is no objective compilation of the required inhalation technique for each of the inhaler devices currently available.

Asthma continues to be a poorly controlled disease. However, it is not known to what extent incorrect inhalation technique influences asthma control or how it can be objectively measured. Indeed, the question becomes more complicated when one considers that incorrect inhalation technique may have a direct impact on treatment compliance.

In children, poor inhalation technique depends on age. A recent study by Dubus and Anhoj<sup>25</sup> showed that the amount of corticosteroid inhaled through a pMDI and holding chamber increased with age and more drug was delivered through the Nebuchamber<sup>®</sup> than through the BabyHaler<sup>®</sup> even in very young infants (1–2 months). Use of a facemask rather than a mouthpiece interface also increased the dose of corticosteroid delivered.<sup>25</sup> In adults (20–81 years), there does not appear to be an age-dependent effect on inhalation technique through a pMDI; most patients use their pMDI incorrectly, but females of all ages are more likely to have incorrect inhalation technique through a pMDI than males.<sup>43</sup>

Older patients with asthma often have poor inhalation technique,<sup>44,45</sup> cognitive function being an important determinant of correct inhalation technique,<sup>44</sup> the ability to learn correct inhalation technique<sup>46</sup> and the ability to retain it.<sup>47</sup> In addition, some individuals with a normal abbreviated mental test score who are neurologically intact on examination are nevertheless unable to perform an inhalation correctly through a pMDI despite adequate training and reinforcement<sup>48</sup> possibly due to undetected cognitive impairment and subclinical dyspraxia.<sup>49</sup> Indeed, patients with a minimal test score of <23/30 or an ideomotor dyspraxia score <14/20 are unlikely to use a pMDI correctly.<sup>49</sup>

**Table 1** Summary of studies on inhalation technique by country.

Country	Reference	Study population	Summary of results	Key message(s)
Spain	Carrion Valero et al. <sup>15</sup>	554 patients with chronic respiratory diseases	<p>78% had received prior inhalation instruction</p> <p>31.6% had correct technique: of these</p> <ul style="list-style-type: none"> <li>• 25.3% used a pMDI</li> <li>• 32.4% used an inhalation chamber</li> <li>• 41.5% used a Turbuhaler<sup>®</sup></li> </ul>	A high % of patients, particularly those using pMDIs and those who receive no instruction, use inhalers incorrectly
Spain	Cimas et al. <sup>16</sup>	34 patients who used a Turbuhaler <sup>®</sup>	<p>35.2–47% of the patients used the pMDI correctly</p> <p>74.2% of the patients used the Turbuhaler<sup>®</sup> correctly</p>	A high % of patients are unable to use their inhaler correctly
Spain	Plaza and Sanchis <sup>4</sup>	<p>N = 1640</p> <p>Patients = 746</p> <p>Nurses = 466</p> <p>Physicians = 428</p>	<p><i>Correct coordination of pMDI actuation and inhalation:</i></p> <p>57% patients, 57% nurses, 70% physicians</p> <p><i>Inhalation too slow:</i></p> <p>66% patients, 80% nurses, 83% physicians</p> <p><i>Overall inhalation correct:</i></p> <p>9% patients, 15% nurses, 28% physicians</p>	Most patients and medical personnel are unable to use pMDIs correctly
Spain	Campos et al. <sup>17</sup>	N = 150 adults with asthma	<p>% of the patients with 1 error:</p> <p>50% with pMDI</p> <p>44% with pMDI and spacer</p> <p>42% with Turbuhaler<sup>®</sup></p> <p>% of the patients with 3 errors:</p> <p>18% with pMDI</p> <p>20% with pMDI and spacer</p> <p>14% with Turbuhaler<sup>®</sup></p>	The number of inhalation errors amongst adults with asthma is high for the pMDI and the Turbuhaler <sup>®</sup>
Spain	Plaza et al. <sup>18</sup>	<p>N = 118</p> <p>Nurses = 50</p>	<p><i>Answered theoretical questions on the Turbuhaler<sup>®</sup> correctly:</i></p> <p>2% nurses, 3% residents, 6% physicians</p>	Most medical personnel are unable to use the Turbuhaler <sup>®</sup> correctly

Italy	Melani et al. <sup>19</sup>	<p>Medical residents = 34 Physicians = 34</p> <p>N = 1404 experienced out-patients with asthma and COPD</p>	<p><i>Knew when the Turbuhaler<sup>®</sup> was empty:</i> 23% nurses, 50% physicians <i>Inhaled correctly through the Turbuhaler<sup>®</sup>:</i> 6% nurses, 15% residents, 21% physicians</p> <p><i>% of the patients who failed to use the inhaler correctly:</i></p> <ul style="list-style-type: none"> <li>• 24% pMDI</li> <li>• 3% pMDI and spacer</li> <li>• 17% Aerolizer<sup>®</sup></li> <li>• 23% Diskus<sup>®</sup></li> <li>• 24% Turbuhaler<sup>®</sup></li> </ul>	<p>A high % of patients are unable to use their inhaler correctly.</p>
Italy	Melani et al. <sup>20</sup>	GENEBU project N = 1257	<p>80% of the patients selected a nebulizer without medical advice &gt;80% of the patients were given insufficient information on correct use</p>	<p>Nebulizers for home use are chosen and used by the patients without medical advice</p>
Italy	Melani et al. <sup>21</sup>	<p>GENEBU project N = 1257</p>	<p>&gt; 60% of the patients never received information on correct use of nebulizers &gt; 75% of the patients were given no information on nebulizer hygiene and care</p>	<p>Nebulizer equipment for home use is heterogeneous and used inefficiently</p>
France	Casset et al. <sup>22</sup>	N = 120 pharmacists	<p>N = 57 gave inhalation demonstration to the patients but only 16.3% showed all steps for correct pMDI use <i>Mean number of correct steps were:</i> 10.5/12 for pMDIs 10.4/11 for the Turbuhaler<sup>®</sup> 9.3/12 for the Autohaler<sup>®</sup> 8.1/9 for the Volumatic<sup>®</sup> spacer</p>	<p>Many pharmacists have incorrect inhalation technique</p>
France	Molimard et al. <sup>23</sup>	Asthma patients treated $\geq 1$ month with an inhalation device	<p><i>Made at least 1 error:</i></p>	<p>More pMDI users made errors in inhalation technique</p>

Table 1 (continued)

Country	Reference	Study population	Summary of results	Key message(s)
France	Marguet et al. <sup>24</sup>	N = 3811  Wheezy infants and young children (<5 years)	76% pMDI users, 49–55% breath-activated inhaler users  <i>Made errors compromising efficacy:</i> 11–12% Aerolizer <sup>®</sup> , Autohaler <sup>®</sup> , Diskus <sup>®</sup> users 28% pMDI users 32% Turbuhaler <sup>®</sup> users <i>Overestimation by GPs of correct inhalation technique:</i> 24% Turbuhaler <sup>®</sup> 6% Autohaler <sup>®</sup> and pMDI  <i>Parents:</i>	More Turbuhaler <sup>®</sup> users made errors compromising treatment efficacy GPs more often overestimated correct inhalation technique for the Turbuhaler <sup>®</sup>  Parents of wheezy infants and young children are not given adequate information on the correct use of pMDIs and spacers Parents often make mistakes when administering inhaled medication to their children
France	Dubus and Anhoj <sup>25</sup>	Children with asthma (2–15 years) N = 69	12% given no explanation of treatment 47% given no training in the use of spacers 14% did not shake pMDI 12% did not monitor valves 22% allowed too short a time for inhalation 78% found the procedure easy to follow <i>Children:</i> 22% accepted facemask with difficulty  <i>Babyhaler<sup>®</sup> increased drug delivery through a pMDI by:</i> 3% in young children, 40–41% in adolescents <i>Nebuchamber<sup>®</sup> increased drug delivery through a pMDI by:</i> 7% in young children, 40–41% in adolescents	Successful delivery of inhaled steroids depends on patient age, type of holding chamber and the inhalation interface



Germany	Moore and Stone <sup>12</sup>	N = 125 patients with COPD	<p>When using a mouthpiece instead of a face mask, drug delivery decreases from: 35–22% with Babyhaler<sup>®</sup>, 42–25% with Nebuchamber<sup>®</sup></p> <p>58% of the patients used the Diskus<sup>®</sup> correctly 11% of the patients used the Handihaler<sup>®</sup> correctly 72% of the patients would not be happy to use the Handihaler<sup>®</sup></p>	<p>Many patients are unable to use the Diskus<sup>®</sup> or the Handihaler<sup>®</sup> correctly</p>
Germany	Kamin et al. <sup>26</sup>	<p>72 pulmonologist practices Turbuhaler<sup>®</sup> = 628 Autohaler<sup>®</sup> = 794 Diskus<sup>®</sup> = 795</p>	<p>% of patients who needed to improve inhalation technique: 18–59 years: 1.5% Autohaler<sup>®</sup>, 16.7% Diskus<sup>®</sup>, 38.9% Turbuhaler<sup>®</sup> 60–69 years: 1.5% Autohaler<sup>®</sup>, 31.5% Diskus<sup>®</sup>, 66.1% Turbuhaler<sup>®</sup></p>	<p>Many patients cannot use their breath-activated inhaler correctly Patient inhalation technique worsens with age</p>
The Netherlands	Moore and Stone <sup>12</sup>	N = 131 patients with COPD	<p>69% of the patients used the Diskus<sup>®</sup> correctly 32% of the patients used the Handihaler<sup>®</sup> correctly 35% of the patients would not be happy to use the Handihaler<sup>®</sup></p>	<p>Many patients are unable to use the Diskus<sup>®</sup> or the Handihaler<sup>®</sup> correctly</p>
The Netherlands	Kamps et al. <sup>27</sup>	Children with asthma N = 200	<p>Factors associated with correct inhalation technique: Repeated instruction (both pMDIs and DPIs) Patient demonstration (pMDI only)</p>	<p>Repeated instruction and patient demonstration are essential for correct inhalation technique</p>
The Netherlands	Hesselink et al. <sup>28</sup>	Patients with asthma or COPD N = 558	<p>24.2% of the patients made at least 1 essential error Patients most at risk of incorrect inhalation technique: Rotahaler<sup>®</sup>, Turbuhaler<sup>®</sup>, pMDI and Cyclohaler<sup>®</sup> users Other significant determinants of incorrect inhalation technique: Poor quality of life, treated at group practice</p>	<p>Patients make essential errors when using their inhalers Type of inhaler is the strongest determinant of incorrect inhalation technique</p>

Table 1 (continued)

Country	Reference	Study population	Summary of results	Key message(s)
The Netherlands	van't Veer et al. <sup>29</sup>	Diskus <sup>®</sup> /Diskhaler <sup>®</sup> users N = 97	<i>Patients who performed all essential steps correctly:</i> 12% pre-instruction 62% post-instruction	Patient instruction is essential for correct inhalation technique
The Netherlands	Kamps et al. <sup>30</sup>	Children with asthma N = 95	<i>All essential steps performed correctly:</i> 29% DPI users 67% pMDI/spacer users <i>Following instruction and repeated checks:</i> 79% DPI users 93% pMDI users	In children comprehensive instruction and repeated checks are essential to ensure correct inhalation technique
The Netherlands	van der Palen et al. <sup>31</sup>	166 patients with asthma who used the same inhaler for 1 year	At baseline 72% of the patients performed all inhalation steps correctly After instruction and up to 1 year later 80% of the patients performed all inhalation steps correctly Patients made the least number of errors with the Diskhaler <sup>®</sup>	Many patients use their inhalers incorrectly Inhalation instruction should be an essential ingredient of self-management programmes
The Netherlands	van der Palen et al. <sup>32</sup>	Patients with COPD	> 33% of the patients had incorrect inhalation technique <i>42% performed all essential steps correctly:</i> 86% Diskhaler <sup>®</sup> users 35% Rotahaler <sup>®</sup> users 46% Turbuhaler <sup>®</sup> users	Over 1/3 of experienced inhaler users have poor inhalation technique Inhalation technique can be improved with a good instruction protocol
UK	Crompton et al. <sup>3</sup>	Inhaler naïve patients N = 100	<i>Unable to use pMDI correctly:</i> 79% after reading package insert 48% after receiving instruction	pMDIs are difficult to use correctly Even after instruction many patients are unable to use pMDIs correctly
UK	Crompton and Duncan <sup>6</sup>	Inhaler naïve patients N = 70	<i>Unable to use pMDI correctly:</i> 61% after reading package insert 37% after receiving instruction	pMDIs are difficult to use correctly Even after instruction many patients are unable to use pMDIs correctly

UK	Crompton <sup>5</sup>	Inhaler naïve patients	<p>Unable to use pMDI correctly: 53% after reading package insert 38% after receiving instruction</p>	<p>pMDIs are difficult to use correctly Even after instruction many patients are unable to use pMDIs correctly</p>
UK	Crompton <sup>2</sup>	Inhaler naïve patients N = 1173	<p>54% of the patients were able to use pMDI correctly after instruction</p> <p><i>Common problems:</i> Coordination difficulties 54% Premature inhalation cessation 24% Inhaling through the nose 12% 13% of experienced inhaler users had incorrect inhalation technique</p> <p>14% of experienced inhaler users had incorrect inhalation technique</p>	<p>pMDIs are difficult to use correctly</p> <p>Correct inhalation technique can be lost</p>
UK	Patterson and Crompton <sup>33</sup>			<p>pMDIs are difficult to use correctly</p> <p>Correct inhalation technique can be lost</p>

Abbreviations: DPI, dry powder inhaler; pMDI, pressurised metered dose inhaler.

What about a relationship between age and correct DPI use? DeBoeck et al.<sup>50</sup> showed that although the vast majority of children older than 8 years could perform every step of the inhalation manoeuvre through the Turbuhaler<sup>®</sup> correctly after training, only half of the children younger than 8 years were able to do so. Inability to generate a sufficiently high inspiratory flow rate through the device was cited as the reason for failure. Other investigators have shown an age dependency of peak inspiratory flow (PIF) rate generated through the Turbuhaler<sup>®</sup><sup>51</sup> and through the Clickhaler<sup>®</sup>.<sup>52</sup> Children aged 5 years and older, or with a weight over 20 kg or a height over 113 cm were able to generate inspiratory flow rates for effective drug delivery through the Turbuhaler<sup>®</sup>.<sup>53</sup>

The patient's lung function also determines whether she/he derives complete benefit from the inhaler device. Aerosolisation and drug delivery from DPIs depend to a large extent on a sufficiently high PIF rate generated by the patient. The patient's airflow profile is also important in determining the characteristics of the aerosol delivered through a DPI.<sup>54</sup> Failure to inhale deeply and forcibly at the start of the inhalation manoeuvre means that the drug particles generated are too big to enter the lungs and are simply deposited in the mouth and oropharynx where they have no clinical efficacy.<sup>54</sup> Studies with high airflow resistance DPIs such as the Turbuhaler<sup>®</sup> have shown that in patients with severe obstructive lung disease or in children with asthma, optimal inspiratory flow rates are not achieved in all patients.<sup>55</sup> Failure to achieve adequate inspiratory flow rate reduces the fine particle dose of the drug produced and hence affects drug deposition and thus efficacy.<sup>56</sup> Young children (i.e. <7 years) also have a higher degree of variability in PIF rates.<sup>57</sup>

The low-to-medium airflow resistance of the Novolizer<sup>®</sup> means that it is suited for use even in patients with reduced inspiratory flow rates. Clinical studies have shown that children, elderly patients, adults with moderate-to-severe asthma and patients with COPD (stage IIa–III) are all able to generate sufficient inspiratory flow rates to operate the Novolizer<sup>®</sup> effectively.<sup>58,59</sup> Other DPIs with low airflow resistance have produced similar results.<sup>60,61</sup>

A question often posed is whether inhalers should be matched to the patient, thereby implying a need to define in at least some semi-quantitative way the 'value' of particular device characteristics. Issues which might prove useful for inhaler/patient matching include ease of correct use; ease of teaching correct use; accurate and consistent dose

delivery; feedback that the dose has been released and inhaled correctly, factors which may limit successful delivery of the dose; a mechanism which creates awareness of the amount of drug remaining in the inhaler; the amount and reliability of instruction provided with the inhaler; the need for accessory devices such as spacers; the inherent reliability of the device; the ability to deliver a range of drugs through the same device model; the possibility to refill the device; convenience to carry the device and an appealing design. Clearly, healthcare providers should recognise that patients differ and a device should be matched individually that is most appropriate for their needs and circumstances.

The importance of these issues will vary according to the patient's and the doctor's priorities. Accurate and consistent dose delivery and ease and convenience of correct use are most likely to be important to both the patient and the physician. A device that is easy to teach to use correctly might be more appealing to busy GPs with limited time in their daily schedules and might be better suited for children and elderly patients (who may find learning new skills difficult). An intelligent dose counter that counts the inhalations taken and helps the physicians to monitor patient's compliance is important for those patients who might forget whether they have taken their medication or simply to check how much medication is left. A multiple feedback mechanism for correctly performed inhalation would be useful for those patients who like to be assured that they have taken their medication correctly. The ability to deliver a range of drugs is an important issue for those patients who take more than one drug to control their asthma (e.g. a short acting  $\beta_2$ -agonist and an ICS). A refillable device and no propellant gases would be important to the environmentally aware patient. Finally, the possibility to conveniently carry the device and a visually appealing design may be important to younger patients.

However, the concept of matching an inhaler to a patient becomes redundant if inhaler availability is a problem. One question posed by ADMIT is whether the choice of device should be regulated locally at the point of prescription, nationally or internationally. Other factors that influence inhaler choice include the cost of the device, whether pharmacists are free to distribute generically, whether the same type of device can be used to deliver a range of drugs and whether more than one drug could be administered through a single device (i.e. combination products).

Most patients should be taught how to use at least one inhaler correctly. However, it is clear from the available data that patients do forget instructions on correct inhalation technique and skills for correct inhalation technique deteriorate over time and therefore active re-education is critical to maintain correct inhalation technique. Ideally, GPs and nurses should teach patients how to use their inhalers correctly when they are prescribed, referring to their local pulmonologist(s) for inhaler specific details of inhalation technique to ensure appropriate choice and correct use. However, the typical busy GP or nurse in a practice often has insufficient time or inadequate materials to do this. As an alternative, the local pharmacist could play an important role in reinforcing correct inhalation technique, both when the drug is prescribed for the first time and also when the prescription is repeated. Increasing awareness of the importance of correct inhalation technique for effective asthma management is a crucial first step towards improving asthma control.

Effective inhalation therapy using pMDIs and DPIs is the cornerstone of asthma management, but what is the best way of teaching correct inhalation technique? Methods used at present include verbal instruction, provision of written material such as patient information leaflets, face-to-face demonstration; and multi-media methods such as video demonstrations, touch-screen computer or web-based teaching.

Not everyone is able or willing to read written information. Studies show that individual training in inhalation technique results in greater improvement in inhaler knowledge among hospital pharmacists than provision of written materials.<sup>62</sup> However, it is worth noting that the advantage of individual training may be short lived.<sup>62</sup> The use of video instruction has been found to be as effective as personal instruction and significantly superior to the use of patient information leaflets in teaching correct inhalation technique.<sup>63,64</sup>

Multi-media methods are an alternative for teaching and reinforcing correct inhalation technique.<sup>65</sup> A recent study showed that use of a multi-media and touch-screen computer improved the patient's inhalation technique more effectively than provision of a patient information leaflet, particularly concerning coordination of actuation and inhalation through a pMDI.<sup>65</sup> This form of education was acceptable to patients of all age groups and could be more widely used in primary care. Adolescents in particular tend to respond better to multi-media teaching of inhalation technique in the form of interactive video rather

than to education provided via written instructions on the patient information leaflet of the inhaler.<sup>66</sup>

Elderly patients often receive little or no teaching on the correct use of their inhalers. A study that evaluated a patient teaching programme designed specifically for elderly people showed that one-to-one teaching sessions resulted in significant improvement in inhalation technique, but whether this improvement was sustained over time was not determined.<sup>67</sup>

ADMIT recommends that instructions for correct inhalation technique for each inhaler device currently on the market should be compiled by an Official Board with instructions made readily accessible on the web. Local asthma associations and patient groups could also be involved in promoting the importance and teaching and reinforcing of correct inhalation technique. Information could be disseminated by the use of dedicated literature, school visits by healthcare professionals as well as through patient advocacy groups. Other evidence-based recommendations are summarised in [Table 2](#).

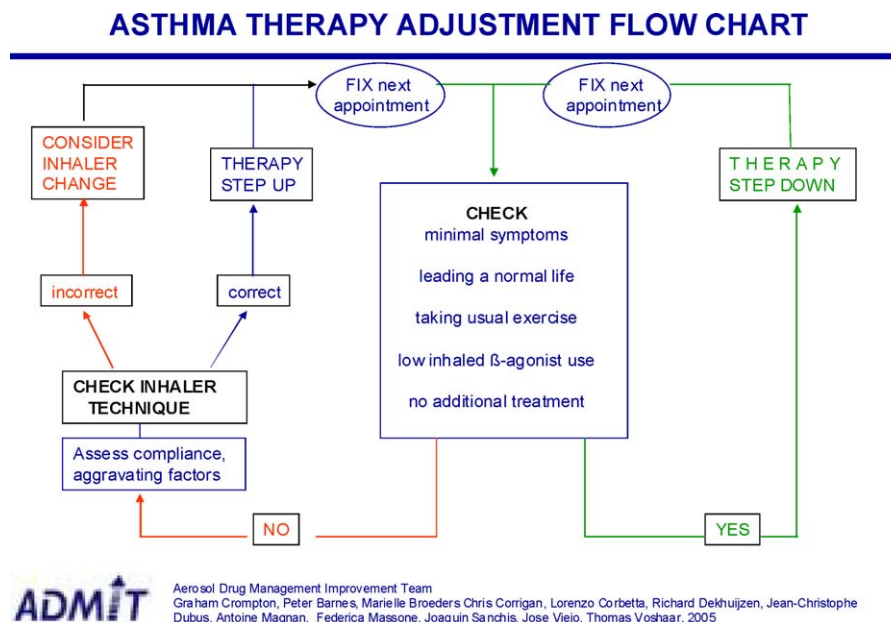
ADMIT provides additional recommendations for asthma therapy adjustment. At each consultation a patient attends the physician should check that the patient has few symptoms, is leading a normal life, performs regularly exercises, is on low-dose relief medication and is not taking any additional medication. If all these conditions are met then therapy should be stepped down according to treatment guidelines and another appointment scheduled for a symptom check. If, however, the patient answers 'no' to any of these checklist questions then compliance and aggravating factors should be assessed. Most importantly, inhalation technique should be assessed. If inhalation technique is incorrect, a change in inhaler device should be considered. If, on the other hand, inhalation technique is correct then asthma therapy should be stepped up according to the treatment guidelines and another appointment scheduled in order to check symptoms ([Fig. 1](#)).

Problems encountered by patients using inhaler devices correctly have led to the concept of one universal 'ideal' inhaler. However, bearing in mind inherent variability among patients, it may be preferable that inhalers should be matched to the patient, specifically with respect to ease of correct use, size, possibility to guide the patient through the inhalation, feedback of the dose delivered and of correctly performed inhalation, availability of an intelligent dose counter with indication of the number of correctly performed inhalations, need for accessory devices, inhaler reliability and cost.

**Table 2** Recommendations of the Aerosol Drug Management Improvement Team (ADMIT).

- Inhalers should be matched to the patient as different inhaler characteristics will be important to different patients.
- In young children, if pMDIs are prescribed, they should be used with a spacer device.
- An alternative to a pMDI should be considered in elderly patients with a minimal test score <23/30 or an ideomotor dyspraxia score <14/20 as they are unlikely to have correct inhalation technique through a pMDI.
- The patient's potential PIF should be estimated before DPI prescription. Those patients with severe airflow obstruction, children and the elderly would benefit from an inhaler device with a low airflow resistance.
- Before prescribing a DPI, check that the patient can inhale deeply and forcibly at the start of the inhalation manoeuvre as airflow profile affects particle size produced and hence drug deposition and efficacy.
- Where possible, one patient should have one inhaler.
- Establish an Official Board to compile instructions for correct inhalation technique for each inhaler device currently on the market.
- Instructions for correct inhaler use should be made readily accessible on a dedicated web site.
- Training in correct inhalation technique is essential for patients and healthcare professionals.
- Inhalation technique should be checked and reinforced at regular intervals (e.g. every time a patient is prescribed a new inhaler).
- Teaching correct inhalation techniques should be tailored to the patient's needs and preferences: written material alone is insufficient to teach correct inhalation technique (one-to-one, group and video tuition are superior tools); group instruction in correct inhalation technique appears to be more effective than personal one-to-one instruction and equally effective like video instruction; younger patients may benefit more from multi-media teaching methods; elderly patients respond well to one-to-one tuition.

DPI, dry powder inhaler; PIF, peak inspiratory flow; pMDI, pressurised metered dose inhaler.

**Figure 1** Asthma therapy adjustment flow chart.

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