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CAN PATIENT TRAINING HELP METERED DOSE INHALER TECHNIQUE?

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ABSTRACT

Asthma is a chronic inflammatory disease of the airways that affecting millions of people worldwide. Inhaled administration is the mainstay of asthma management and metered dose inhalers (MDIs) are the most widely prescribed inhalation device. Poor disease control and increased hospitalizations is linked to poor inhaler technique. Previous studies to assess inhaler technique have used subjective measures and there is very limited data about the inhalation characteristics used by patients when they use their inhalers. Thus, the aim of this study was to evaluate the effect of counselling of asthmatic patients who use pMDIs on improving their lung function using an inhalation profile recorder. 60 asthmatic patients who attending the outpatient respiratory clinic of Tripoli medical centre (TMC) were recruited to take apart in the study. Their mean (SD) age was 36.67(±11.04). Patients divided equally to three group; group one: no counselling, group two: standard counselling (reading leaflets by themselves) and group three: verbal counselling (physical training on the proper use of MDI). The inhalation parameters were recorded by inhalation profile recorder for each patient monthly for 6 months and the lung function was measured at each visit. The mean (SD) of PIF (L/min) before counselling in group one, group two and group three, were 183.63(58.78), 181.79(56.07), 113.89(38.33), respectively, and after counselling was 155.06(51.26), 149.53(53.29) and 88.08(25.89) respectively. An analysis of data revealed a significant different between the mean of PIF pre and post counselling (P = 0.001) for the three different groups. The mean (SD) of Vi/FVC for group, one, two and three were 0.702(0.362), 0.66(0.332) and 0.680(0.653), respectively. Post counselling improvement in PEFR was 20% in group one, 30 % and 60 % in group two and three respectively. 53% of the patients were having good coordination, this percentage was increased when the range of TsIn was increased from 0.00 - 0.20 sec to 0.00 -0.25 sec and 0.00 - 0.30 sec, respectively. In conclusion, verbal counselling and training of asthmatic patients promote the correct inhalation technique and improve their lung function.

KEYWORDS: *Inhaled corticosteroids, inhalation flow rate, Inhalation profile recorder, Pressurised Metered Dose Inhalers, Dry Powder Inhalers, Asthma, COPD.*

INTRODUCTION

The pressurized metered dose inhaler (pMDI) is the most widely used delivery system and commonly used in the management of asthma and COPD compared to other devices.[1,2]

The quantities of drug from a pMDI deposited in the lung are small[3,4], in that only about 10-20% of the emitted dose reaches the lungs even when the correct inhalation technique is used.[5] A high proportion of the emitted drug particles are deposited in the mouth and oropharynx. Incorrect use of the pMDI may lead to less than the optimal therapeutic response[6,7], therefore patient's inhalation technique needs to be checked.[8]

It is estimated that about 75% of patients make errors when using their pMDIs[9] as they need to co-ordinate the device actuation with inhalation to receive the intended therapeutic dose.

A very fast inhalation, bad co-ordination between the start of an inhalation and dose actuation are the most common errors that asthmatic patient made during the use of their MDIs.

60-92% of patients inhale too fast and do not use a slow inhalation when they used their pMDI.[10,11] Failure to use a slow inhalation was more common than good co-ordination between dose actuation and co-ordination.[12,13] It is estimated that approximately 50% of patients do not obtain sufficient therapy from their inhalers due to poor inhalation technique.[14]

Only 8% of adult asthmatics used their pMDI with a slow flow and good co-ordination.[15] When MDIs were

used correctly, only about 10%-20% of the nominal dose reaches the targeted airways.[16] However, only a small amount is needed to produce a useful clinical effect and despite the consistent problems with pMDI inhaler technique these products have and continue to provide significant healthcare benefit.

Although the guidelines[17] do recognize this, they do appreciate that disease control could be improved without escalating the dose by better inhalation technique and compliance. It has been shown that good inhaler technique is associated with better asthma control.[11,18] Thus, patients with poor technique get sub-optimal benefit from their inhalers.

Most studies suggested that a large proportion of patients do have problems using their inhalers, but they are subjective assessments.

This study has been designed to provide objective assessments of inhaler technique by measuring inhalation parameters by inhalation profile recorder (figure1) when the patients use their inhalers. It has been designed to measure the peak inhalation flow rate (PIF), the time between the start of an inhalation and the pressing of the canister (TsIn), inhaled volume (Vi) and the duration of the inhalation (Ti) when patients inhale through an empty pMDI. The aim of this work is to determine if new simple MDI training methods can improve and retain the correct MDI inhalation technique, by measuring the inhalation characteristics of asthmatics when they use a metered dose inhaler before training, after training and four weeks later.

Patients and Methods

Hospital research ethics approval from Respiratory department, Tripoli Medical Centre (TMC) was obtained (2015/10). Stable asthmatic patients who were attending an out-patient clinic and were prescribed a pMDI inhaled steroids were invited to take part in the study, with a condition that they did not experience any exacerbation of asthma within the last 12 weeks or required treatment with oral prednisolone or illness during the previous 4 weeks. The study objectives and procedure were described to the patients using relevant patient information sheets, and all gave signed informed consent. Sixty subjects were required for this study, divided equally to 3 different groups. They were using their untrained real-life MDI inhalation technique. Then they randomised in either; group 1; non-counselling (no training) or group 2; standard counselling (with guidance from patient information leaflet)) or group 3; full counselling including demonstration (according to ERS/ISAM consensus statement). All subjects were asked to make two separate inhalations through the empty MDI that was attached to an inhalation profile recorder and inhalation profiles were recorded and lung function test was assessed after each visit.

After training the two separate MDI inhalations were repeated and recorded. All patients were return 4 weeks later and the two separate inhalations was repeated and recoded. The same procedure was repeated for 6 months. Flow and time measurements during an inhalation were downloaded in a Microsoft Excel spreadsheet to compute the inhalation profile. Patient's gender, age, height and weight were obtained together with their current medication. Their spirometry (PEF, FEV_1 and FVC) was measured using a Micro Loop Spirometer (Viasys Healthcare) and their percentage predicted values were calculated. The patients were asked to complete the Asthma Control Questionnaire (ACQ).[19]

A ratio of Vi/FVC was calculated to indicate the depth of inhalation. The inhalation profile with the slowest peak inhalation flow was chosen for the final data analysis. Co-ordination was defined as GOOD if TsIn was between 0-0.2 seconds[19], EARLY if TsIn< 0 seconds where the actuation occurred before the start of an inhalation, and TsIn would be negative. TsIn considered to be LATE if it is >0.2 seconds where the actuation occurs after the start of an inhalation and TsIn would be positive. If actuation occurred at the start of an inhalation, then this would be represented as a TsIn of zero. Inhalation flow was classified as SLOW if < 90 L/min[4,20,21] and FAST if > 90L/min with those > 200 L/min further classified as VERY FAST. Those with good co-ordination and slow flow were defined as using a GOOD technique. A deep inhalation was considered when IV/FVC ratio is> 60% min.[19]

Statistical analysis: The normality of all data collected were assessed using SPSS statistical software and the most appropriate statistical test was applied. Spirometry data were compared before and after training for each patient. The before and after differences for all parameters were then compared between the three experimental groups, to determine if the extent of counselling had any effect on inhalation profile and subjective assessment of asthma control. The statistical parameters used in this study were, Arithmetic mean (X), Standard deviation (SD), One-sample t test, Dependent t test, and the Independent sample t test.

RESULTS

A total of sixty patients (majority were females) completed the study. Their mean (SD) age was 36.67 (±11.04). They were having a stable mild to moderate asthma according to the results of their asthma control questionnaire (ACQ) and they were using inhaled steroids by MDI daily and short acting beta agonist as a required for the management of their asthma. The Mean (SD) of the patients' characteristics and inhalation parameters in each group are shown in tables 1 and 2 respectively. The mean (SD) of PIF and TsIn of all groups pre and post counselling are shown in table 3.

In group 1; the TsIn values were ranged from -1.524 to 1.08 sec. Eleven patients had negative TsIn, two patients

had a positive TsIn and seven patients had a good coordination. Four patients had a good IFR (<90L/min), the others had fast and very fast IFR. The improvement of PEFR in group 1 was 20%; from those 5% had a coordination from (0.0 - 0.2).

While in Group 2; the TsIn values were ranged from -1.88 to 1.184 sec. Six patients in this group had negative TsIn and two patients had a positive TsIn and twelve patients had a good coordination. Despite the standard counselling of this group only two patients managed to create the optimum inhalation flow rate needed for the MDI. Six patients show an improvement in the PEFR after the first visit, where two of them had a negative coordination (TsIn was close to zero). And in group three; the TsIn values were ranged from -0.232 to 1.316 sec. Seven patients had a positive TsIn (>0.2 sec), and thirteen patients had a good coordination. Because of the full counselling of this group, eighteen patients managed to have a good inhalation flow rate through their MDIs. The improvement in the PEFR after the first visit was 60% (twelve patients). Seven patients were having an acceptable range of TsIn (0.00-0.20) and the remaining (five patients) were having a TsIn between 0.00 and 0.30 sec.

The percentage of patients had a good coordination among the three different groups was increased when the range of TsIn was increased from 0.00-0.20 sec to 0.00-0.25 sec and 0.00-0.30 sec. (figure 2). This figure shows that in group three the good coordination was increased from 65% at the range (0.00-0.20) to 90% at the range (0.00-0.30). Patient inhalation flow rate and coordination together were important factors for drug delivery to the lung and accordingly the clinical effect and the improvement in the lung function. The results of this study shows that in group three when we considered that the optimum range of TsIn was between 0.00 and 0.20 sec and the optimum inhalation flow rate is between 40-90 L/min, 35% of the patients had improvement in lung function while when we increased the range to reach 0.25sec and 0.30sec the improvement in lung function was 45% and 50% respectively (figure 3).

Despite the high inhalation flow rate (90-200 L/min) three patient in group one and four patients in group two shows an improvement in their lung function. These patients were having a very good coordination, where their TsIn were close to zero.

Statistical analysis revealed a significant different between the mean of PIF pre and post counselling using paired t test (P = 0.001) for the three different groups. Considering the normal range of the inhalation flow rate through the MDI is between 40 and 90 L/min and using one sample t test, the results showed that there is a statistical significance difference between this normal range and the mean PIF pre and post counselling for group one and group two (P = 0.001) while in group three it shows a significance difference between the normal range and the mean PIF pre counselling (P = 0.012) but no significant difference between the normal range and the mean PIF post counselling (P = 0.744). Comparing the three different groups statistically the results shows that there is no significant difference in the post counselling PIF between group one and two (P = 0.74), but it shows a significant difference between group one and three (P = 0.001) and group two and three (P = 0.001) using independent sample t test.

Table 1: Mean (SD) of patient's characteristics and spirometry measurements for three different groups.

Characteristic	GROUP 1	GROUP 2	GROUP 3
Gender(M/F)	(2/18)	(1/19)	(2/18)
Age/ years	35.75(11.13)	37.75(10.66)	36.5(11.79)
Weight/ kg	76.55(13.9)	77.4(13.81)	70.55(15.92)
height/ cm	162(4.33)	160.85(4.85)	162.05(5.79)
PEFR	224(78.35)	197.09(73.39)	209.09(78.63)
%Predicted	47.20(16.43)	41.10(14.89)	43.49(15.26)
FVC	2.61(0.68)	2.449(0.702)	2.526(0.792)
%Predicted	76.40(23.45)	74.77(25.03)	75.42(24.32)
FEV_1	2.058(0.509)	2.059(0.711)	1.995(0.575)
%Predicted	78.56(14.85)	73.52(27.57)	68.75(15.26)

Table 2: Mean (SD) of inhalation parameters of the patients in the three different groups.

	Group 1	Group 2	Group 3
IFR	152.81(60.75)	148.95(63.89)	87.66(36.160)
Vi	1.715(0.761)	1.506(0.572)	1.434(0.565)
Vi/FVC	0.702(0.362)	0.666(0.332)	0.680(0.653)
Ti	1.065(0.451)	1.028(0.487)	1.50(0.551)

Table 3: Mean (SD) of peak inspiratory flow rate (PIF) and TsIn pre and post counselling for the three different groups.

	GROUP1		GROUP2		GROUP3	
	Pre-Counselling	Post counselling	Pre-counselling	Post counselling	Pre-counselling	Post counselling
PIF L/MIN	183 (58.78)	155 (51.26),	181(56.07)	149 (53.29)	113 (38.33)	88 (25.89)
TsIn sec	0.35 (0.51)	-0.24(0.44)	0.11(0.69)	-0.01 (0.36)	0.23 (0.40)	0.23(0.20)

Figure 2: Inhalation profile recorder.

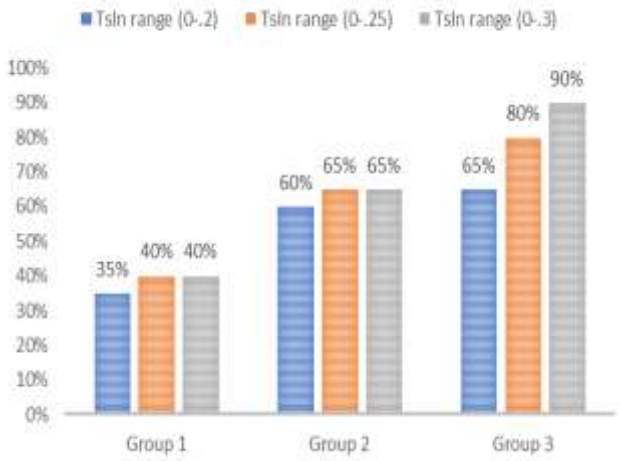

Figure 2: Patients good coordination at different ranges of TsIn in percentage.

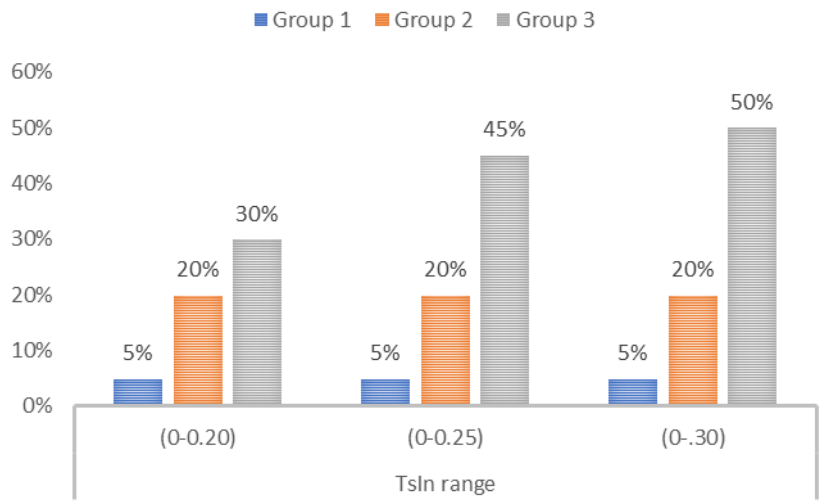

Figure 3: Percentage of patients improved in PEFR according to coordination (TsIn range) In the three different groups.

DISCUSSION

Asthma is a chronic inflammatory disease has a major impact on the lives of people. It affects different age groups and associates with poor quality of life and life expectancy.[22] Several different types of medications are commonly used in management of asthma and inhalation is the preferred route of delivery for drugs intended for asthma. The significant role of an efficient inhaler in treatment process[23] has led to introduction of several inhaler devices to the market with the most commonly used in the treatment of asthma are the pressurized metered dose inhalers (pMDIs) and the dry powder inhalers (DPIs).[24]

The Gaining Optimal Asthma Control (GOAL) study showed that despite that current asthma treatments are effective and can achieve good asthma control in patients, asthma remains insufficiently controlled.[25,26] There are many reasons that might explain why asthma remains poorly controlled. Such reasons include: poor compliance with therapy, wrong inhaler choice by physician and improper inhalation technique.[16,27] There has been much research attempting to understand the reasons for poor technique and the ways in which inhaler technique can be improved and maintained over time. Research shows that some of the potential reasons for poor inhaler technique are linked to the device, the patient and the health care professional.[28]

It has been reported that inadequate inhaler instruction and poor inhaler technique are major causes of poor disease control.[4,29]

The inhalation technique by patients is considering one of the main factors affecting the fraction of the inhaled aerosol depositing in the lung along with its distribution.[30] Inadequate pMDI use adversely affects airways distribution and results in poor drug delivery, decreased disease control and increased inhaler use. Many studies have found that using the correct inhalation technique through pMDIs results in a significant increase in bronchodilator response[15], and misuse of pMDIs is correlated to reduced asthma control[12,18], increased corticosteroid use[31] and hospitalization.[32] Efficient inhalation technique by patients is crucial for the success of therapy. Several factors should be included in the assessment of the inhalation technique; including the IFR, coordination between inhalation and device actuation and inhalation volume.

Measuring the inhalation technique of patients used to be done by using direct observation method, which could have some limitations, therefore throughout this study an inhalation profile recorder system has been used to obtain reliable quantitative inhalation measurements in order to assess technique. The MDI is still the most frequently prescribed inhaler device worldwide despite the fact that most patients cannot use it correctly[33], because it has an advantage of being cost effective[34] and portable. However, MDIs drug delivery is highly dependent on patient technique; misuse can result in a suboptimal (even zero) lung deposition. Most of the dose is deposited in the oropharynx causing high oropharyngeal impaction unless a holding chamber or spacer is used. Studies showed that MDI users had worse techniques than users of other delivery devices.[9,35] Patients creating a high PIF through their MDIs lead to decreases lung deposition, with increased deposition in the mouth and central area of the lungs.[3,36-38] This may affect the amount of the drug that will reach the peripheral regions of the lungs, subsequently affecting the clinical efficacy of the inhaled therapy.[3,39] Using a slow inhalation flow has been shown to improve asthma quality of life.[11] The results of this study show that all patients in the three different groups created a high inhalation flow rate during the first measure (pre-counselling) of their first visit and throughout the period of the study (six visits) for group one and group two.

In this study we aimed to evaluate the effect of counselling of asthmatic patients who use pMDIs on improving their lung function. The results confirmed that counselling of patients by health care professionals play an important role in patient achievement of correct technique use of their inhalers and control of their illness. Considering inhalation flow of < 90 L/min is the optimum flow rate through an MDI, the results shows that there was a significant difference in pre and post counselling of group one, group two while in group three it shows no significant difference in post counselling. These mean that most patients in this group (group three) managed to create the acceptable IFR after counselling. This result confirm that verbal counselling and training is the best method for improving the patient's inhalation technique including reducing the IFR to the acceptable levels (< 90 L/min), and increase in the inhalation time, compared to counselling of patients by reading of leaflet without demonstration or training (theoretical knowledge) as in group two. Farr and his colleagues recommended that coordination between inhalation and device actuation, should be between > 0 and < 0.2 seconds for good inhalation technique. Research show UP to 96%[24,28] of patients do not use their pMDIs correctly where co-ordination of actuation and inhalation is the major error made by patients. They generally prime the device too early or too late which effects drug delivery to the lungs.[40] The results of this study show that 65% of the patients in the first group were unable to have a good co-ordination of actuation and inhalation, most of them were having a negative coordination (actuation before inhalation). Counselling the patients either by reading the leaflet of the MDI in second group or verbal counselling in third group helped the patient to obtain a good co-ordination of actuation and inhalation, the percentage of improvement was 60% and 65% respectively. Coordination alone is not enough to improve the lung deposition and hence the clinical effect. Slow and deep inhalation is required to minimize the oropharyngeal delivery of medication and increase the peripheral deposition.[40] Patients with good coordination

and a slow inhalation flow maintained for as long as possible are particularly important for achieving good asthma control.[41] Lung deposition is reduced when there is poor coordination between the actuation of the dose and the start of inhalation. and when a fast inhalation flow is used.[38,42]

The results of this study show that the improvement in PEFR in group one was 5%, which is due to their poor coordination and fast inhalation. Despite the good coordination of patients in group two the improvement in PEFR was slightly increased when compared to group one to become 20%, since most of patients in this group had a fast inhalation flow rate. Although the patients in this group were having a high flow rate the results shown some improvement in the PEFR, this could be because these patients were having a good coordination between the actuation and the inhalation where their TsIn were near zero which mean that the IFR at actuation was not too fast. In group three when a verbal counselling where been given to the patients the results shows a significant improvement in the lung Function, it shows a 60% improvement in the PEFR and this is due to the fact that these patients were having a slow IFR and good coordination. When the improvement in the PEFR after the first visit was 60% (twelve patients); seven patients of them were having an acceptable range of TsIn (0.00 - 0.20) and the remaining (five patients) were having a TsIn between 0.00 and 0.30 sec. The percentage of patients had a good coordination among the three different groups was increased when the range of TsIn was increased from 0.00-0.20 sec to 0.00-0.25 sec and 0.00-0.30 sec. The results show that in group three the good coordination was increased from 40% at the range (0.00 - 0.20) to 90% at the range (0 - 0.3). Patient inhalation flow rate and coordination together were important factors for drug delivery to the lung and accordingly the clinical effect and the improvement in the lung function. The results of this study shows that in group three when we considered that the optimum range of TsIn was between 0.00 and 0.20 sec and the optimum inhalation flow rate is between 40-90 L/min, 35% of the patients had improvement in lung function while when we increased the range to reach 0.25 second and 0.30 sec the improvement in lung function was 45% and 50% respectively. This indicate that for patients having good inhalation flow rate (40 - 90 L/min) the rang of TsIn can be extended to 0.30 sec.

Although many patients fail to exhale before an inhalation[41] the definition of a complete inhalation with respect to the inhaled volume has yet to be fully defined, although there is a suggestion that an IV/FVC ratio of > 0.6 could indicate this.[41] The results of this study show that there is a direct proportion between the inhalation flow rate and the inhaled volume, and indirect proportion between the inhalation flow rate and the inhalation time, it means that when patients decrease their inhalation flow rate, the inhaled volume decreases and the time of inhalation increases. The results show that in group one when the inhalation flow rate was fast the time of inhalation was short, and the inhalation volume was large. The same finding was seen in group two where when the patients read a leaflet by themselves, they managed to increase their inhalation time and slightly decrease their IFR, but their inhaled volume was decreased. And in group three after training of patients the time of inhalation was significantly increased, but the inhaled volume decreased with the acceptable level of IFR. Most of the patients included in this study managed to have a deep inhalation; Vi/FVC ratio of > 60%. The results of the current study confirm that patients who had deep inhalation alone can't have an improvement in their lung function. Proper inhalation technique including good coordination, slow inhalation flow rate, long inhalation time and deep inhalation are needed for the optimum delivery of the drug to the lung and the improvement of the lung function.

CONCLUSION

First, verbal counselling and training of patient is more effective than theoretical counselling. Second, for achievement of asthma control patients must have good coordination and slow inhalation flow rate. Third, patients can be improved regardless of fast inhalation flow rate when their actuation is near zero. Last, the % of improvement was increased when the range of actuation extended from (0 - 0.2) to (0 - 0.3) for patients have slow inhalation flow rate.

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