New Developments in the Home Monitoring of Asthma

J Stahlman, L Salmun

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Abstract

INTRODUCTION

There is an increasing demand to improve the outpatient management of asthma. The Center for Disease Control estimates that over 14 million individuals are affected by asthma in the United States ([1]). One study in the United States revealed that over 3 million workdays are lost and approximately 6 billion dollars are spent on this chronic illness each year. The direct cost of hospitalization alone accounted for over 1 billion dollars. Missed school days also accounted for close to a 700 million in indirect costs ([2]). In order to improve continuing care physicians often ask asthma patients to record their symptoms in diaries and lung function with peak expiratory flow rate (PEFR) meters. The purpose of gathering this data is to judge response to therapies, predict exacerbations and treat asthma more efficiently. Physicians also use peak flow meter measurements to assist in classifying the severity of asthma. Despite controversies regarding the usefulness of peak flow meters ([3], [4]), experts continue to recommend home peak flow recordings to objectively assess lung function on a daily basis for patients with moderate to severe asthma ([5]).

The rapid evolution of portable computers and efficient telecommunication is making the details of a patient's disease more accessible to physicians. Advances in home monitoring are being utilized in many areas of medicine. Studies have shown the utility of a computer modem device that can transmit blood glucose levels of diabetics to physicians and nurses ([6],[7], [8]). Modem technology has been implemented to monitor blood pressure in patients with hypertension ([9], [10]) as well as patients who need cardiac rhythm monitoring ([11], [12]). Similar advances are being made to help patients with asthma. The aim of this review is to provide updated information on the development of electronic devices for the monitoring of asthma. Utility of Home Monitoring of Asthma Peak flow monitoring is one of the few objective measures of lung function in asthmatics that can be recorded outside the office or hospital.

Wright introduced the first portable peak flow meter in 1959 ([13]). Over the past 35 years, the use of this device has contributed to defining disease severity as well as monitoring response to medications in both children and adults with asthma. Research on peak flow monitoring has revealed conflicting results. Peak flows have been shown to under and overestimate lung function when compared to a more sensitive marker of airway obstruction such as forced expiratory volume in one second (FEV1) ([14], [15]). The meters themselves have variability depending on the model that may affect accuracy ([16], [17]). Compliance with the use of peak flow meters is also an issue that concerns physicians. Studies have shown that patient reporting is often times inaccurate. False recordings (phantom readings) have been reported to occur over 25 percent of the time ([18], [19]). There have been several randomized controlled studies looking at peak flow monitoring with self management versus conventional symptom diaries and/or physician directed care. Several studies showed benefit for certain groups of patients, particularly those with more severe disease, though other trials showed no difference ([20], [21], [22], [23]).

Over the past several years developments in computer technology have allowed the use of solid state devices to monitor lung function outside the physician's office. Most of these devices are currently used for research purposes. However, two devices are now available for routine patient care. Some of these devices are capable of transmitting data by phone. An advantage of some of the new electronic devices is the ability to measure FEV1 in addition to PEFRs.

The EDC is designed to record symptom scores in response to pre-programmed questions. A computer chip stores times and dates and works with an alarm that reminds patients to make an entry. When used with a turbine flow meter, the EDC measures forced vital capacity (FVC), forced volume in FEV1 and peak expiratory flow rate (19). These readings are displayed digitally and also stored in a memory chip. The EDC downloads data to a personal computer which produces a weekly report. Several studies have utilized the EDC spirometer. One study looked at 33 adult patients from an asthma specialty clinic in London familiar with the use of a peak flow meter (19). They were asked to use the EDC three times daily for one week while recording their lung functions and symptoms in a conventional diary. The patients were not informed that the EDC was keeping a record of their lung function. Problems with the device in this study included data lost due to erasure, battery failure, and an inability to operate the device. These events were rare however, as they occurred in less than 10 percent of patients. On average, patients completed approximately 90 percent of possible entries. Interestingly, there was a significant error rate in entering lung function: overall, 25 percent of the lung functions entered were not verified by the EDC and considered phantom readings. A similar study in New Zealand used the EDC to study 24 adults at an asthma referral center (24). Patients were asked to record symptom scores and peak flow measurements twice daily for one week. Individuals were not aware that the EDC kept track of their data. Again, there were 2 patients that experienced battery failure and another unable to operate the device properly. Compliance was better in this study: greater than 95 percent of entries were complete with only a 5 percent error rate. Recently, the EDC was studied in the home setting (25). First, the device was judged for accuracy against a standard spirometer looking at both FEV1 and PEFR data. The EDC correlated within 5 percent, with a tendency to slightly underestimate lung function. Ten adult patients with obstructive lung disease were asked to use either the EDC or a standard mini-Wright peak flow meter for two weeks while keeping a diary of recordings and symptoms. The EDC and the mini-Wright registered comparable mean diurnal variation in peak flows (8.8% vs 11.3%), and most patients preferred the EDC to a mini-Wright with diary card for recording symptoms and peak flows. The EDC offers advantages such as an alarm and a helpful interface for entering symptom scores and peak flows as well as the ability to monitor FEV1. The disadvantages of the EDC include the need for a personal computer to assemble reports and the short battery life . To our knowledge, this device is only available for research purposes at this time.

The Spirophone AG-SP (Card Guard, Rishon Le Zion, Israel) The Spirophone is a transtelephonic portable personal spirometer that was reviewed recently by Abboud to determine accuracy and reliability (26). The device is essentially a pneumotachograph with transducer, a microprocessor with memory capabilities, and a speaker, which operate on a 9 volt battery. The device is capable of modulating data into tones for transmission by telephone to a receiving center. The center requires a 486 MHz personal computer with 4 Mb of RAM, a receiving demodulator unit and a printer. Patients send data by calling the center and placing the handset next to the Spirophone speaker for transmission.

After showing satisfactory correlation in the clinic with a standard spirometer, Abboud let patients use the Spirophone at home. Five patients were asked to transmit readings once daily for 3 months. It should be noted that the patients had monthly visits to calibrate equipment and review technique. Overall, the transmissions were reliable and no data was lost. There are obvious limitations to the use of the Spirophone for home monitoring of asthma. The device records only one set of data at a time and was not reported to be able to keep track of measurements over extended periods. The Spirophone system is expensive and complicated. Perhaps this system may eventually be useful for monitoring patients needing detailed lung function studies in remote locations.

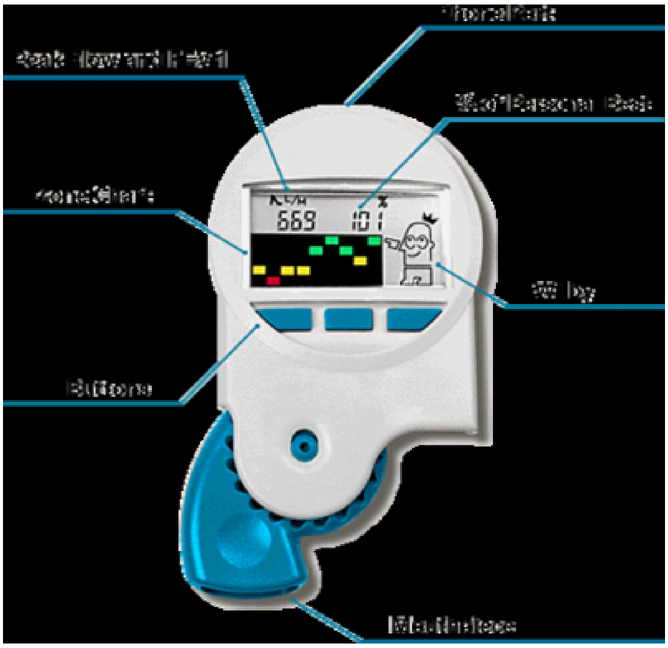
The VMX Wright Mini-Log((Clement Clark, Inc., Columbus, Ohio USA) The VMX Wright Mini-Log((VMX) is a mini-Wright peak flow meter with a computer chip capable of recording up to 400 peak flow values. (Figure 2) Each recording is displayed on a digital screen and the VMX has a port for connecting to a personal computer to download data. This device has been used in two recent clinical research studies looking specifically at peak flow data (27, 28). Both studies found no problems with equipment failures or with understanding the use of the device. Verschelden examined 20 chronic stable asthmatics (patients unaware that the device kept track of recordings with a time and date stamp) for an average of 3 months (28). Of the approximately 1900 peak flow values recorded in the diary, only about 1500 were stored in the computer chip (presumably over 400 inaccurate recordings). Ninety percent of the values that were recorded in the diary were verified by the computer with accuracy usually within 20 liters. The study did not examine the level of compliance of patients utilizing the device without a diary. Based on limited data, the VMX appears to be as reliable as a standard peak flow meter. Conceivably, the VMX could have a role in home monitoring of peak flow secondary to its portability and ease of use. This device may be limited by its ability to measure only peak flows. Of note, Clement Clark is currently marketing a device similar to the VMX capable of measuring more detailed lung functions (29). At the time of this article, there were no published studies using the device.

Figure 1. VMX Wright Mini-Log(Image reproduction with permission of Clement Clark, Inc. AirWatch((ENACT Health Management Systems, Palo Alto, CA, USA) The AirWatch((Figure 3) is a hand-held solid state device capable of measuring both PEFR and FEV1. It has memory capable of storing twice daily peak flows and FEV1 for approximately six months. It has a built in modem which can send data over a standard telephone line to a central computer for processing. Physicians receive data on individual patients in the form of a fax transmission within minutes of a patient sending a report. The PEFR and FEV1 data is in graphical format and compliance with daily monitoring is also reported. The device runs on a small lithium battery which should be changed on a yearly basis.

The AirWatch(has a color LED display which registers the patient's PEFR as both a number and in reference to predetermined zones (green zone: 80-100 percent predicted personal best, yellow zone: 60-80 percent, and red zone: below 60 percent).:

Figure 1

AirWatch (Image reproduction with permission of ENACT Health Management Systems)



A cartoon-like character and warning symbols facilitate the patient's interpreting of the readout (30). The AirWatch(is currently widely available for use in routine patient care in the United States. In addition, the device is being used to help gather data on patients in trials of medication therapy for asthma. Studies of AirWatch(are underway to address questions of reliability, data retrieval, and compliance

DISCUSSION

Three of the reviewed devices are designed for true daily monitoring of lung function in asthmatic patients. The Spirophone seems best suited to periodically obtaining data since it measures a full set of spirometry readings with each use and does not store lung functions for extended intervals. The Spirophone and the AirWatch(have the unique capability of transmitting data by telephone to a physician's office. A potential advantage of the EDC and AirWatch(is their ability to measure detailed lung functions such as FEV1. All these systems seem simple enough that adults and children with some supervision could use them on a regular basis. However, the utility of these devices for routine monitoring of asthmatic patients at home needs to be further investigated. One of the goals of these portable lung function monitors is to facilitate communication between patient and physician.

As mentioned earlier, compliance with peak flow rate monitoring is often questionable and asthmatic patients have been found to falsify their diary entries (31). Diabetes is a disease where compliance with a computer assisted device has already shown benefit. A study of diabetics using a glucometer with a modem found decreased glycosolated hemoglobin levels compared to a control group (6). Long term studies of a portable lung function monitoring device with telecommunication ability would help physicians better understand the utility of monitoring lung function at home. Forced expiratory volume in one second is thought of as a gold standard for assessing airway obstruction (15). It more accurately reflects airway caliber in proximal and peripheral airways while PEFR reflects primarily the large proximal airways (32). FEV1 has not been studied in the home monitoring of asthma on a long term basis. Studies of asthmatic patients monitoring their FEV1 daily at home are needed to ascertain the value of this lung function in both predicting exacerbations and in assisting physicians in making decisions regarding the care of chronic asthma. It is likely that a subset of asthmatics will benefit from FEV1 monitoring: patients with asthma who have poor symptom recognition, or whose lung function deteriorates rapidly, could use FEV1 to monitor their disease regularly. Home

FEV1 monitoring combined with increased compliance and rapid telecommunications will likely improve the care of children and adults with asthma. A new generation of portable lung function devices with solid state technology will aid physicians in deciding which patients with asthma will benefit from technologies such as FEV1 monitoring and modem communication.

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Author Information

Jon E Stahlman, M.D.
Children's Hospital Boston

Luis M Salmun, M.D.
Harvard Medical School