Collecting Quality Spirometry at Home

Alex Stenzler

There is no doubt that healthcare is moving from the hospital to home. For patients with respiratory diseases, this is driven by both the need to discharge patients from hospitals as quickly as possible, and the recognition that "IF" quality spirometry data can be collected from the home, it might provide early detection of patients failing treatment, as well as provide more frequent monitoring, while lowering the institutional or physician office burden. It also would reduce the burden on patients who have to travel great distances for a test that could easily be done from home. That is a big "IF" that I believe we are on the cusp of being able to deliver on. There are many factors that can affect our ability to get quality spirometry data from the home and those of us managing patients at home might find these important to consider.

Selecting Devices

There are several critical areas that require our attention if we intend to get spirometric measurements at home that meet ATS/ERS criteria and provide data that can be interpreted and used in the treatment decision making process. As reported by McCarthy, it starts with selecting a spirometer that is capable of making measurements at home and if used correctly, will produce accurate data.[1,2]

It seems clear that to avoid the need for daily calibration, spirometers for home use should be limited to either ultrasonic or turbine based devices. These units have been demonstrated to retain their calibration for more than a year or two and still meet ATS/ERS performance criteria.[3,4] In addition, if FVC is an important parameter for identifying subjects who might be failing treatment or for diseases where FVC is an important parameter, only spirometers that meet the ATS/ERS low flow criteria should be selected.[2]

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Two other important characteristics to consider when selecting a spirometer for the home are:

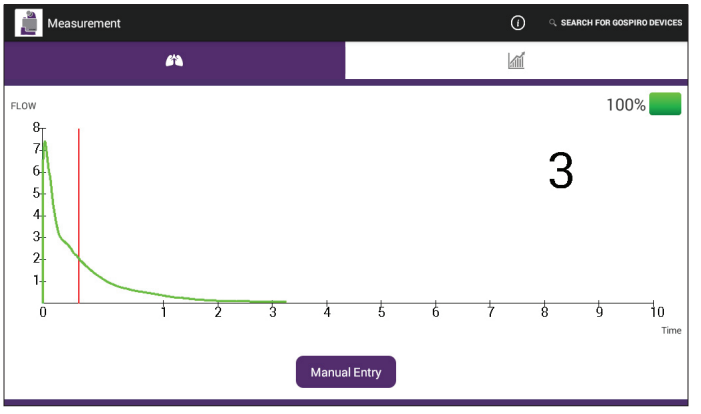
- Its having been tested and cleared specifically for home use; and
- It providing feedback to the patient as to the quality of their performance.

Not every spirometer gives the patient enough information about how they performed to correct bad efforts.[2]

Flow Time Presentation

When thinking about how to get the most reliable spirometric data from patients at home, we should give them the best tools to help them perform a good measurement. Most systems are designed for physicians and healthcare providers to interpret the output from the test, and therefore graphics are always presented as either a volume time curve or a flow volume loop. To the physician or healthcare provider, that is the presentation that they need to interpret the results and those graphs provide the visual information they need to understand the patient's disease. However, for the patient, those displays are nearly meaningless. If they see a flow volume loop, can they determine if they reached peak flow in less than 120 to 160 milliseconds? Can the patient tell if they've exhaled for at least 6 seconds? If they see a volume time curve, can they determine anything about their time to reach peak flow or know their back extrapolated volume? The two factors that a patient needs to focus on to perform a good spirometric measurement are:

Figure 1. Flow-Time trace displaying instantaneous flow versus time with countdown timer. Note the expanded time of the first second to provide the patient with the highest resolution where they need it the most. (Courtesy of Monitored Therapeutics, Inc.)



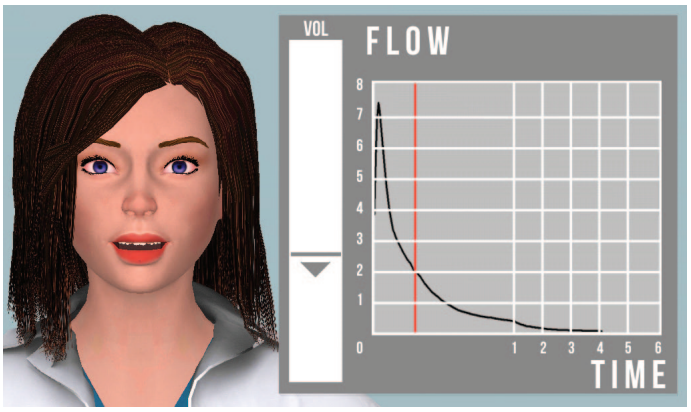
- They need to reach peak flow early; and
- They need to exhale for at least 6 seconds (or longer).

The graphical presentation to provide that information to patients therefore is not a flow volume loop or a volume time curve; it's a flow versus time curve (See Figure 1). Presenting the patient with instantaneous flow versus time, it becomes visually clear to the patient what the target for initial effort has to be to reach peak flow early in the forced exhalation. And with a time graph, it allows the patient to assure that they have exhaled for 6 seconds. In these days of digital data, it should not be necessary for physician and patients to only see the same data presentations. The flexibility of digital data can provide each with what means the most to them; flow volume curves for the physician and flow time curves for the patient.

Avatar Coaching

One recent area of interest is the use of avatars to coach patients through the spirometric maneuver. While gaming programs have been available for decades to get a patient to exhale for at least six seconds and primarily used for children, they don't provide direct, real-time verbal guidance to the patient. What we've now seen is a home spirometry system that uses a human-like avatar that talks the patient through each measurement. The availability of Bluetooth spirometers enables the avatar to watch the patient breathe on the spirometer and know exactly what the patient is doing instantaneously. This enables the avatar to coach the patient with quiet breathing and then have them take a maximum inhalation and then forcefully exhale for at least six seconds, encouraging at every point of their exhalation, just as would be done by a pulmonary technologist in a hospital laboratory (See Figure 2). The avatars know exactly where the patient is in the maneuver. The sophistication of the avatars has broadened to their ability to review how the patient performed the maneuver, telling them if they made a mistake, such as not exhaling forcefully enough or that they held their breath too long and offering feedback to improve their performance.

Figure 2. An avatar developed to coach the patient through the full spirometric maneuver in real time with posttest review and corrective action feedback. (Courtesy of Monitored Therapeutics, Inc.)



Minimizing the burden of testing

Even with measurement technology that is accurate and doesn't require patient calibration, and systems such as the described avatar to get the best efforts from the patients at home, if they don't perform the measurements, then all of these capabilities bring no value to home monitoring. To get test results, the burden to the patient needs to be as low as possible and the positive feedback as high as possible. What we know from the reported experience from several studies is that reminders work.[6,7] This is true for both medications that patients should take, as well as reminders for patients to perform tests. And the burden of the test should be low. When we think spirometry, we think "three reproducible measurements". That's because the ATS/ERS states that criteria for measurements performed in the laboratory. But patients don't go the PFT lab every day or even three times per week; they go once a year or perhaps once every three months. We need to disconnect our thinking of what is necessary for laboratory visits from what is really needed from patients at home. I believe that when you are collecting 2 to 7 measurements a week from a patient at home, as long as each measurement meets ATS/ERS criteria for a good maneuver, that a single measurement per session is sufficient. The variability of multiple measurements will sort themselves out within a few days if the changes are small and any large change can be addressed, particularly if the maneuver is good and the data immediately available for review with alarm triggers. Reducing the requirement from three forced maneuvers to one significantly reduces the time demand, but more importantly reduces the aversion to self-testing generated by the fatigue of the frequent three test requirement.

Experience with home spirometry collection

To evaluate how these technology interventions can impact the quality of home spirometry monitoring, we reviewed 2,100 spirometric measurements that were collected from 25 patients at home in a pilot self-testing program during a one year time frame. These patients averaged 84 measurements during that period. We used a GoSpiro turbine based spirometer with a Flow Time target scale for the patient to follow and an avatar to coach the patients through the maneuver. With only a single training session, we found that 82% of the measurements met ATS/ERS criteria for Forced Expiratory Time and 86% met the back extrapolated criteria for a good test as well. The time to peak flow criteria was met by the patients in 79% of measurements. Considering that previous reports have demonstrated that only 60% of spirometric studies collected in seventeen physician offices met the ATS/ERS criteria for good tests, the results from our evaluation demonstrated that home testing can outperform physician office testing.[5]

Conclusions

With more than 80% of self-administered spirometry tests by patients at home meeting ATS/ERS criteria for a good maneuver, it suggests that with use of the appropriate equipment and digital coaching technology with patient focused visual targets, high quality spirometry can be collected from patients at home that will provide meaningful and interpretable data. I believe that broader use of these technologies and further communication improvements and forecasting algorithms will realize the goal of enabling that transition from hospital to home.

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the study. Jerry Krishnan (JK), Chenghui Li (CL) received fees as consultants to eMAX Health.

Authors' contributions

All authors were involved in conceptualization, development and finalization of study design. JK and JC contributed significantly to core study design. ZD and CL were involved in conducting the analysis and interpreting results.

MS, RK, PB, GG contributed to manuscript text, content, and flow development. All authors were involved in developing the results into manuscript. All authors were involved in reviewing interim drafts to prepare a final version. All authors read and approved the final manuscript.

Competing interests

This study was funded by Teva Pharmaceuticals.

Ethics approval and consent to participate

The authors confirm that according to local legislation, ethics approval is not required for this retrospective study. The data used in this study has been recorded and presented in such a manner that subjects cannot be identified and consent to participate from the subjects is therefore not required.

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