Developing a spirometry protocol for children and young people

Janice Mighten and Debra Forster explain why technically acceptable results in younger patients depend on a procedural structure specific to these age groups

Abstract

The practicalities of obtaining technically acceptable spirometry results with children and young people demand a protocol that follows national guidance and is adjusted to local conditions. Although there is guidance for adults, to date there has been no equivalent for children and young people. The procedural structure should be developed to include consistent standards and values, acknowledgement of contraindications, competence of the testing procedure among clinicians, and constant recalibration and cleaning of equipment. Only if these requirements are met can the results be valid.

Keywords
Lung function tests, protocol design, respiratory conditions, spirometry in children

PROVIDING HIGH standards of practice based on the best available evidence with robust procedures and protocols is of paramount importance for the safety of patients and staff. The development of a specific paediatric procedure for spirometry ensures a consistent approach that is vital for the correct interpretation of tests and subsequent clinical decisions.

This article aims to highlight and discuss the need for a locally appropriate evidence-based procedure for performing spirometry with children and young people. This will be achieved by reviewing the components of a locally adapted spirometry protocol, developed as part of a university-accredited spirometry module endorsed by the Association for Respiratory Technology and Physiology (ARTP 2003).

Spirometry

Spirometry and measurements of lung function are used to identify the severity of lung disease, to note any changes following response to treatment – such as the use of a bronchodilator – and to monitor constantly for disease progression or regression (Vyas and Youle 2013). This has been common practice in adult medicine for many years, using National Institute for Health and Care Excellence (NICE) (2010) criteria for assessing severity in chronic obstructive pulmonary disease (COPD).

To date, there are no such specific criteria for children and young people, so the development of any assessment protocol for children has been, and continues to be, local but based on current NICE guidance for adults.

There are many conditions where spirometry is considered the best diagnostic tool for assessing lung function (Box 1), and its use is common in paediatric medicine. However, many healthcare professionals have used spirometers with little or no structured method. This does not support best practice in a modern health service. Those procedures or protocols that are in place in some areas are adult based. However, most of the information available is applicable to children and young people. A good example of this is guidance used in Gloucestershire; it outlines a comprehensive, evidence-based protocol that can provide a good template for any spirometry procedure.

The objective of spirometry is to outline the disease process clearly and to guide practice, with a safe, standardised approach.

Protocol development

When devising a spirometry procedure, it is necessary to acknowledge varying local policies. However, certain components are necessary in children’s and adult-focused environments, which include:

- Standards.
- Contraindications.
- Calibration.
- Procedure for lung function testing.
- Competence.
- Environment and equipment.
- Care and cleaning of the spirometer.
- Type of spirometry equipment.
Performing reversibility tests.
Problem solving.
Interpretation.

**Standards** Spirometry should be designed in accordance with nationally recognised guidance, adapted for use with children and young people. The intention of the procedure should be in accordance with the guidelines of the ARTP (2003) and the recommendations of the British Thoracic Society and Scottish Intercollegiate Guidelines Network (2012) for measuring respiratory function. The basic equipment for lung function testing is largely the same for children and adults because the end objective is the same.

It is true that lung function tests can be performed with children of any age, although with very young children tests are usually carried out in specialist laboratories and have historically been undertaken for research purposes. Preschool children generally find the process a challenge, so an assessment of the child’s cognitive and physical abilities is required. The procedure discussed in this article is designed for children more than five years of age and young people under 18 years.

The process for lung function testing needs to be clearly outlined in a procedure, for example entering correct patient details – including name, identification number, height, age, sex, weight and ethnic origin - to validate test results when these are compared with ‘normal’ predicted values that have been obtained from population studies. Historically, normal values refer to the European population, and there remains variability in the range of predicted values for people of different ethnic origin. There is a plethora of literature emphasising the significance of correcting ethnic factors, which differ in different ethnic groups (Cotes et al 2006).

The consequence of uncorrected data input would be that the difference in lung values would not be reflected on the report and the test would be invalid. All this needs to be recorded in a systematic manner in any procedure, to reflect the diverse population using services, and a combination of reference values from different studies can be used. Paton (2000) highlights the difficulties associated with using reference values in children, and further research is in progress (Quanjer et al 2012a, 2012b).

**Contraindications** With children and young people, contraindications to spirometry are similar to those for adults (Box 2) and may pose a relative danger to the patient or affect the validity of the results. Cooper (2011) suggests that the waiting time between a child’s experience of certain conditions (Box 2) and lung function testing can be reduced as follows. If a child or young person has experienced any of the identified contraindications in the previous month, a discussion with the doctor requesting lung function testing should occur before spirometry is attempted. If there are any contraindications to performing spirometry, the benefits to the patient’s health and general management should outweigh the risks of performing the test. These elements need to be highlighted in every individual case.

**Calibration** Each individual spirometer may have its own recommended calibration method, but the principles remain the same. It is imperative that the strict guidelines for calibration and quality control are adhered to, otherwise the lung function tests cannot be used as an objective measure (Miller et al 2005).

All staff who perform spirometry should be aware of the importance of calibration. This should be done each day the spirometer is used. Furthermore, a log should be kept of when the spirometer is calibrated. A spirometer should not be used without passing a calibration check. If the equipment does not pass the check, it must be adjusted until a successful outcome is achieved, before undertaking lung function testing. If the process continues to fail, refer to the manufacturer’s guidelines for further information.

**Procedure for testing** The advice offered to patients before testing is as pertinent to children as it is to adults. It is important to ensure that professionals less familiar with spirometry fully appreciate why children and young people should be asked, for example, about smoking, eating a heavy meal and vigorous exercise. It is well documented that smoking is associated with adolescents, and eating a heavy meal and vigorous exercise is associated with adolescents, and eating a heavy meal.

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**Box 1 **Conditions that may require spirometry
- Asthma.
- Bronchiectasis.
- Cystic fibrosis.
- Pulmonary fibrosis.

**Box 2** Contraindications to spirometry
- Haemoptysis.
- Pneumothorax.
- Unstable cardiovascular status.
- Recent eye surgery.
- Acute disorders such as nausea and vomiting.
- Thoracic or abdominal surgery.
Art & science | respiratory conditions

Box 3 Competencies for performing spirometry

- Clear explanation about why the test is required.
- Pre-test quality control and maintenance checks of equipment.
- Provision of a suitable and safe environment.
- Achievement of three technically acceptable and at least two reproducible readings.
- Understanding of the rationale and application of and treatment options for reversibility testing.
- Documentation of results in client notes.

(National Institute for Health and Care Excellence 2010)

Box 4 Problem solving

<table>
<thead>
<tr>
<th>Possible problems</th>
<th>Possible solutions</th>
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<tbody>
<tr>
<td>Poor blow, due to:</td>
<td>Encourage the active cycle of breathing to clear secretions, if appropriate, and offer the patient some water.</td>
</tr>
<tr>
<td>Cough.</td>
<td>Clarify instruction at appropriate level and repeat demonstration. Ask patient to repeat blows.</td>
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<tr>
<td>Air leak at the mouth.</td>
<td></td>
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<tr>
<td>Submaximal inspiration.</td>
<td></td>
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<tr>
<td>The start of blow is poorly co-ordinated.</td>
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</tr>
<tr>
<td>Submaximal effort on expiration.</td>
<td></td>
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<tr>
<td>Mouthpiece is obstructed by tongue and/or teeth.</td>
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meal increases the risk of vomiting due to increased pressure on the diaphragm when blowing out.

Generally children are very active, and it is good practice to advise against vigorous exercise before lung function testing and against wearing restrictive clothes, such as a school blazer, which can restrict full chest and abdominal muscle expansion. The name of any inhaled medication and when it was last taken should be documented. Medication inhaled before spirometry could invalidate the results.

A noted difference is that children usually stand, whereas most adults sit when performing spirometry. The work of Lane (2003) and Miller et al (2005) reinforces this point; they suggest that either the sitting or standing position may be used, but stress the importance of recording this on the report. All the evidence emphasises the importance of safety and consistency in any procedure.

Studnicka et al (1998) note the variability among children and young people, particularly those who are new to lung function measurement, so correct adaptation of technique is essential. In addition, Rosenthal et al (1993) describe the impact that puberty has on lung function. For example, girls who enter puberty earlier than boys have greater lung volumes. Such information requires consideration during interpretation of results.

Competence It is clear from the literature that healthcare professionals should be properly competent to perform spirometry. The person carrying out the tests also needs to be proficient in managing the particular requirements of children of different ages (Paton 2000). Miller et al (2005) insist that individuals performing spirometry should have the education and training not only to carry out the test but to understand the basic principles of spirometry also.

There are recognised spirometry courses available in the UK but these are adult focused. Training can be provided by nurses who are competent in the technique, in conjunction with local lung function departments. Skills should be reviewed at least annually (NICE 2010) (Box 3).

Environment and equipment The environment where the tests are performed should be child friendly and non-threatening. Lane (2003) describes the measurement of lung function in children as an art and a science. The principles of lung function testing are the same for adults and children (the science), but the practicalities of obtaining valid tests with children requires a different set of skills (the art). The nurse must be used to dealing with children and their families, and be able to gain the co-operation and confidence of the child or young person and parent or carer, explaining the procedure in an understandable way, while being competent in the science of testing.

There are different components of the spirometry test and children may perform one aspect correctly, but sometimes lack co-ordination or understanding, and have difficulty in putting everything together. Therefore practice is an important element in achieving technically acceptable results (Arets et al 2001). It may be helpful to cajole and coach the child to perform good blows (Arets et al 2001), for example by asking them to imagine that they are blowing out lots of candles on a birthday cake in one long blow until all the candles are out (Vyas and Youle 2013).

Modern equipment offers the use of computer-animated programs to assist and encourage the child. These may be useful but, as Gracchi et al (2003) found, can also make things worse. It is up to the individual expert practitioner to judge whether a program will be helpful or not.

Equally important is the ability to assess the child’s process of expiration. Child lung volumes are smaller, and emptying of the lungs can often occur in the first second (Arets et al 2001). This can affect the interpretation of airway obstruction.

Care and cleaning The NHS infection control policy (Department of Health 2007) underpins the basic principles of infection control. The literature...
suggests that the risk of cross-infection from spirometry is minimal. Dautzenberg (2001) emphasises the importance of correct procedures in spirometry with the intention of reducing risk, including correct cleaning methods according to the manufacturer’s guidelines.

A child, young person or adult whose immunity is compromised should undergo testing first, after equipment has been thoroughly sterilised. In addition, it is important to consider the use of bacterial/viral filters that help protect not only the patient but also the equipment from cross-contamination (Miller et al 2005).

Wherever possible, spirometry should be delayed for people with a known infection until this has resolved. However, in exceptional circumstances where it is important to carry out spirometry, the infected person should undergo testing at the end of the session so that equipment can be thoroughly cleaned immediately afterwards. For example, those with known tuberculosis not only require assessment by their doctor but should have completed treatment before they are considered non infectious. If the test is deemed as essential in any case, there needs to be a discussion with the relevant infection prevention department before a decision can be made about whether the machine will need to be removed for full sterilisation.

Types of equipment The spirometer should conform to American Thoracic Society/European Respiratory Society standards (Miller et al 2005). Refer to manufacturers’ guidelines to ensure standards are achieved. The aim is to provide a basic assessment of lung function by measuring forced expiratory volume in one second (FEV₁) and forced vital capacity (FVC) using fully calibrated and regularly maintained equipment.

Performing reversibility tests A technically acceptable baseline test result must be obtained before starting reversibility tests. If this cannot be achieved, the bronchodilator should not be given, as the response cannot be reliably assessed.

Problem solving There may be reasons why a child or young person is not able to perform a good blow, and a number of approaches can be tried to overcome the problem (Box 4).

Interpretation Unless individuals have had appropriate training, interpretation of spirometry results should be undertaken only by the requesting clinician.

When devising a procedure, it is important to give consideration to the interpretation tool or tools used. Most spirometers follow NICE guidelines for COPD (2010) in adults, but there are slight variations in the classification of obstructive disease in children that can lead to confusion. It is important to remember that spirometry results can only suggest an interpretation, and each test should be analysed in the context of the history and symptoms of the patient and the clinician’s knowledge of other conditions relevant in each case.

Conclusion It is important to provide a structured spirometry procedure appropriate for each practice area. However, the practicalities of obtaining technically acceptable results with children and young people must be acknowledged and addressed to ensure that a service achieves the high standards of care that a modern health service demands. A paediatric protocol for everyday spirometry is of paramount importance for correct interpretation of results and subsequent clinical decision making in the care of children and young people.

References


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Conflict of interest

None declared