**Doctors on Riccarton**

**Spirometry Manual**

Last updated

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# Spirometry Test Flow Chart at Doctors on Riccarton

**Receptionists**

Referral given to nurses (*Andrea or Vivian only, Sharon from June 2015*)

Referral scanned into inbox. Annotate referring GP/Practice

Casual patient status created

Referral arrives via fax

**Nurses & Doctors**

Nurse to check the report has been finalised, print it out and scan to patient’s file in Medtech

Nurse to inform GP (*Dr Colin & Dr Kent only*) to report and finalise the test online

Nurse to perform and upload the test online

Nurse to contact patient for a 45 minutes appointment within 1-2 weeks after referral is received

Fax the report to referring GP and claim through Pegasus e-portal under Canterbury Initiatives. No charge to patient unless specified.

# 10 Steps Quick Guide

1. Check equipment, patient ID, NHI, weight, height and smoking status (see page 17).
2. Check for any contraindications (see list on page 14).
3. Check inhaler use prior to spirometry test (no short-acting bronchodilator within last 4-6hrs and no long-acting bronchodilator within last 12-24hrs, see detail on page 17). Record medications.
4. Explain procedure (see page 18).
5. Sit up straight (NO STANDING).
6. Inhale completely.
7. Exhale immediately as much as possible and as fast as possible into mouth piece with firm mouth grip.
8. Continue to exhale until no more air can be expelled (at least 6 seconds for adult and at least 3 seconds for under 10 years old).
9. Repeat test 3 times (No more than 8 trails).
10. Need to obtain test results with quality A or B. (Try to get FEV1 and FVC within 150ml of each test).
* Administer bronchodilator and repeat test if required (e.g. asthma, COPD or all tests for Canterbury Initiatives). Administer 4 puffs of ventolin via MDI with spacer and wait for 15 minutes before repeating the test.

# Spirometry Algorithm and Technical Comments Quick Guide

Is **FEV1/FVC** < Lower Limit

of Predicted

 **No**

Is **FVC** < Lower Limit of Predicted

 **Yes**

 **Yes** **No**

Assess Severity of **Obstruction**

Using **% Predicted FEV1**

Mild >70

Moderate 60–69

Moderately severe 50–59

Severe 35–49

Very severe <35

Spirometry within **Normal** **Limits** of Reference Values

**Restrictive pattern**

(Suggest referral for confirmation of diagnosis)

**Repeatability (best 2 acceptable results)**

* FEV1 and FVC: within 150mls if FVC > 1.0L

within 100mls if FVC < 1.0L

* Peak flow at least within 10%

**Bronchodilator Response (BDR)**

* ***Significant response: >12% and 200mls increase in FEV1 and/or FVC***

**Technical Comments**

1. Spirometry is acceptable and repeatable.
2. 400mcg Salbutamol administered via MDI and spacer.
3. Bronchodilators have been taken within 4 hours of testing, bronchodilator response may be underestimated.
4. End of test criteria not met. FVC may be underestimated.
5. All other spirometry test criteria have been met.
6. Patient unable to comply with test criteria. Unreliable results, interpret cautiously.
7. Patient unable to perform acceptable and repeatable manoeuvres. RESULTS HAVE NOT BEEN RELEASED.
8. Back extrapolation error detected indicating poor start to exhalation. FEV1 may be overestimated, interpret cautiously.
9. Normal spirometry, bronchodilator not given.
10. Reference equations are extrapolated beyond 80yrs. Interpret with caution.
11. Reference values are based on a Caucasian population, interpret with caution.

*Other comments usually relate to why a certain criteria was not achieved.*

**Interpretation Pattern**

1. Spirometry results are within the normal limits of the reference range.
2. Spirometry results indicate a mild obstructive pattern.
3. Spirometry results indicate a moderate obstructive pattern.
4. Spirometry results indicate a moderately severe obstructive pattern.
5. Spirometry results indicate a severe obstructive pattern.
6. Spirometry results indicate a very severe obstructive pattern.
7. Spirometry suggests a restrictive pattern with a normal FEV1/FVC ratio and FVC below the lower limits of normal for the reference range.
8. Spirometry results show FEV1/FVC ratio at the lower limit of normal. FEV1 is below the lower limit.

**Response**

1. No significant reversibility has been noted after bronchodilator administration.
2. A significant improvement in the FEV1 of \_\_\_\_ ml and \_\_\_\_ % has been noted after bronchodilator administration.
3. A significant improvement in the FVC of \_\_\_\_ ml and \_\_\_\_ % has been noted after bronchodilator administration.

**Clinical comments may include:**

* Smoking history
* Relevant medical history
* Pulmonary rehabilitation / sleep assessment recommendations
* Any information that is different from the referral
* Any information that may be valuable for the general practice team to follow up e.g. poor inhaler technique

**Some useful clinical interpretation comments:**

* Normal spirometry excludes clinically significant COPD
* Normal spirometry does not exclude asthma. If thought clinically important to determine, you may wish to contact the Respiratory Physiology Laboratory at Christchurch Hospital to organise a challenge test.
* Causes of restrictive spirometry can be found on the HealthPathways website
* Restrictive spirometry may be further investigated by measurement of lung volumes and diffusing capacity. Consider contacting Respiratory Physiology Laboratory at Christchurch Hospitals to arrange this.
* High BMI might be contributing to low FVC
* If asthma is considered, you may wish to give a 2-week course of oral prednisone to optimise lung function, and then repeat lung function.
* For further details on differentiating asthma from COPD, see HealthPathways website
* Spirometry is technically poorly performed, meaning that interpretation is not possible. Details of lung function have been removed from this report.
* Spirometry results should be interpreted with caution.
* For more advice about the investigation and management of chronic cough, please see HealthPathways website
* Consistent with COPD if clinical picture also consistent.
* Normal spirometry with no significant bronchodilator reversibility on this occasion of testing. This result excludes clinically significant COPD.
* Would your patient get benefit from Pulmonary Rehabilitation?
* Please see facilitator comments re possible sleep disordered breathing.
* Please note re-interpretation with correct normal values - ignore previous report
* The post-bronchodilator lung function is within normal limits.
* Based on these results, patient qualifies for funding for tiotropium.

NB: Regarding bronchodilator testing:

Normal spirometry excludes significant COPD

‘Subnormal’ spirometry results may show post bronchodilator reversibility which could indicate asthma.

# Spirometry Definition

Spirometry is the single most important test of pulmonary function. Spirometry measures how much air can be exhaled or inhaled. If the manoeuvre is forced, maximum flow volume relationships can be examined.

The forced vital capacity (FVC) manoeuvre is the most frequently used method for assessment of dynamic pulmonary function. FVC is the volume of air that can be exhaled from the lungs as rapidly and forcefully as possible after a complete inhalation to total lung capacity. The forced vital capacity manoeuvre is evaluated on the basis of both measured volume and flow. The most commonly assessed spirometric values are:

FEV1 Forced Expired Volume in 1 second (L)

FVC The volume of air that can be exhaled (L)

FEV1/FVC The ratio of FEV1/FVC (%)

The volume / time curve from an FVC manoeuvre is traced or plotted with the volume on the vertical axis and time on the horizontal axis. Figure 1 shows the required manoeuvre for recording the FVC. Figure 2 shows volume and time measurements that can be made from an FVC manoeuvre.



Figure 1. Volume / Time tracing for an FVC manoeuvre. Madama, V. C. 1998. *Pulmonary function testing and cardiopulmonary stress testing,* 2nd Edition. Delmar Publishers, Albany, NY.



Figure 2. Volume / Time tracing demonstrating the FEV1 parameters. Madama, V.C. 1998. *Pulmonary function testing and cardiopulmonary stress testing*, 2nd Edition. Delmar Publishers, Albany, NY.

In order to make accurate determinations of the FEV1, and other volume-time measurements, it is important to establish the start of the manoeuvre (time-zero) correctly. On the volume-time tracing, this is achieved by back-extrapolation. Back extrapolation is performed by drawing a line tangent to the steep, initial portion of the curve. The line should extend back to cross the volume baseline. The point at which these two lines intersect is the time-zero point (Figure 3). The extrapolated volume must not be more than 5% of the FVC or 0.15 litres, whichever is greater, if the test is to be considered acceptable.

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Figure 3. Back-extrapolation of a volume-time spirogram. Ruppel, G. 1998. *Manual of pulmonary function testing*, 7th Edition. Mosby, St Louis.

The flow-volume loop is plotted with flow on the vertical axis and volume on the horizontal axis (Figure 4). Most spirometer systems allow for plotting both the maximum expiratory flow-volume and the maximum inspiratory flow-volume curve and produce a complete flow-volume loop.

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Figure 4. Flow / Volume Loop. Madama, V.C. 1998. *Pulmonary function testing and cardiopulmonary stress testing*, 2nd Edition. Delmar Publishers, Albany, NY.

Interpretation of Spirometry results depend on good quality data. Using reference equations that are relevant to the population being tested is important. It is common practice to use an algorithm for interpretation that uses the FEV1/FVC ratio, FEV1 and FVC. Obstructive patterns will have a low FEV1/FVC ratio and a restrictive pattern will have a low FVC. The severity of an obstructive pattern can be graded using the FEV1 expressed as the percent predicted as shown in Table 2. The Interpretation procedure will be elaborated on and practiced during the spirometry training course.

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Table 2. Spirometric abnormality severity based on FEV1. ATS/ERS 2005 Interpretative strategies for lung function testing, *Eur Respir J* 2005; 26: 948–968.

**Expired and Inspired Flow / Volume Patterns**

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Figure 5.

Figure 5 shows six flow-volume curves with expected curves (dashed lines) and curves illustrating a particular disease pattern superimposed. In patients who have asthma and emphysema, the portion of the expiratory curve from the peak flow to residual volume is characteristically concave. In restrictive patterns the shape of the flow-volume curve is preserved but the FVC is decreased.

The bottom three examples depict types of large airway obstruction. Variable intra-thoracic obstruction shows reduced flows on expiration, despite near-normal flows on inspiration, resulting from flow limitation in the large airways during a forced expiration. Variable extra-thoracic obstruction shows an opposite pattern. Inspiratory flow is reduced while expiratory flow is relatively normal. Fixed large airway obstruction is characterised by equally reduced inspiratory and expiratory flows.

Comparison of the FEF50% with the FIF50% may be helpful in differentiating large airway obstructive processes. The normal ratio of FEF50/FIF50 is less than 1.0.

# Indication for Spirometry

**Diagnostic:**

 To evaluate symptoms, signs or abnormal laboratory tests

 To measure the effect of disease on pulmonary function

 To screen individuals at risk of having pulmonary disease

 To assess pre-operative risk

 To assess prognosis

 To assess health status before beginning strenuous physical activity programmes

**Monitoring:**

 To assess therapeutic intervention

 To describe the course of disease that affect lung function

 To monitor people exposed to injurious agents

 To monitor for adverse reactions to frugs with known pulmonary toxicity

**Disability/impairment evaluations:**

 To assess patients are part of a rehabilitation programme

 To assess risks as part of an insurance evaluation

 To assess individuals for legal reasons

**Public health:**

 Epidemiological surveys

 Derivation of reference equations

 Clinical research

**Some examples of indications for spirometry:**

Chest pain or orthopnea Cough or phlegm production

Dyspnea or wheezing Chest wall abnormalities

Cyanosis Decreased breath sounds

Finger clubbing Abnormal laboratory findings

Blood gases Abnormal chest radiograph

Pulmonary diseases Chronic obstructive pulmonary disease

Cystic fibrosis Interstitial lung disease

Sarcoidosis Cardiac diseases

Congestive heart failure Congenital heart disease

Pulmonary hypertension Neuromuscular diseases

Amyotrophic lateral sclerosis Guillain-Barre syndrome

Multiple sclerosis Myasthenia gravis

Risk stratification of patients for surgery Thoracic surgeries

Lobectomy Pneumonectomy

Cardiac surgeries Coronary bypass

Correction of congenital abnormalities Valvular surgery

Organ transplantation General surgical procedures

Cholecystectomy Gastric bypass

Social security or other compensation programs

# Contraindications to Use of Spirometry

**Patient Considerations**

Performing spirometry is a physical demanding test, particularly for the elderly and for patients with moderate to severe respiratory disease.

**Conditions where sub-optimal spirometry results are likely:**

* Chest or abnormal pain of any cause
* Oral or facial pain exacerbated by a mouthpiece
* Stress incontinence
* Dementia or confused state
* Acute disorders affecting test performance (e.g., vomiting, nausea, vertigo)
* Hemoptysis of unknown origin (FVC manoeuvre may aggravate underlying condition)
* Pneumothorax
* Recent abdominal or thoracic surgery
* Thoracic aneurysms (risk of rupture because of increased thoracic pressure)

***It is recommended that patients should not be tested within 1 month of a myocardial infarction or within 1 – 2 weeks after eye surgery.***

# Spirometry Parameters

* FEV1 (L): Forced Expiratory Volume in 1 second
* FVC (L): Forced Vital Capacity
* FEV1/FVC (%): Ratio of FEV1 to FVC
* PEF (L/sec): Peak Expiratory Flow (commonly used in asthma monitor)
* FEF 25-75% (L/sec): Forced Expiratory Flow between 25% and 75% of the vital capacity (commonly used for paediatric tests)
* FET (s): Forced Expiratory Time
* FEV1/FEV6: The ratio of FEV6 exhaled in 1 second (%)
* FEF 50%/FIF 50%: The ratio of FEF 50% (expired flow rate half way through the FVC manoeuvre) to FIF 50% (inspired flow rate halfway through the FIVC manoeuvre)

# Calibration of Spirometer

Attention to equipment quality control and calibration is an important part of good practice.

We use Easy on PC Spirometer which is a Flow sensing Spirometer (measures flow and integrates with time to give volume).

Syringe calibration is required **DAILY** except when the clinic is closed.

Biological calibration is required **WEEKLY** except when the clinic is closed.

**Syringe Calibration:**

* Open “Easy on-PC” on desktop.
* Plug in purple spirometer into computer USB.
* Attach grey adapter into syringe if it is not already attached.
* Put testing mouthpiece into purple spirometer and then connect to grey adapter.
* In the Easy on-PC software, click on “Utilities” 🡪 “Check calibration” 🡪 “Syringe calibration check”.
* Add trial and test 3 times at three different flow-rates, slow (0.5 L/s, pull the syringe over 6 seconds), medium (3 L/s, pull the syringe over 1 second), fast (12 L/s, pull the syringe over 0.5 second). Once successful click out (saves automatically) return to main menu.
* Sign log book daily.
* Accurate 3 L syringe (0.5%) – validated yearly.
* Spirometer accuracy within 3%.
* Overall accuracy (syringe and spirometry) 3.5% or <65 ml. Easy on-PC software will indicate this.
* Syringe and spirometry must be equilibrated to the same temperature.
* Always calibrate after cleaning or dismantling, change of equipment location or if temperature varies by > 2 degrees.

**Biological Calibration:**

* Open “Easy on-PC” on desktop.
* Plug in purple spirometer into computer USB.
* Attach grey adapter into syringe if it is not already attached.
* Put your own mouthpiece into purple spirometer and then connect to grey adapter.
* In the Easy on-PC software, click on “Utilities” 🡪 “Check calibration” 🡪 “Biological calibration check”.
* Add trial and test 3 times as per normal person. Results need to meet criteria as normal spirometry test. Once successful click (saves automatically) “return” to main menu.
* Click on Graph, check within ± 2SD (Standard Deviation).

*Warning: one result outside 2SD. Out of control: two results outside 2DS or one result outside 3SD. If any problems, refer to Troubleshooting listed below.*

* If result is within 2SD, record the best FVC and FEV1 in the EzyQC programme (set up in room 201, icon is on desk top).
* Sign log book.

**Troubleshooting**

If any calibration test fails or is outside of normal range, perform tasks below:

* Check for leaks and correct set-up.
* Verify calibration with 3-L syringe.
* Perform spirometry on 2nd biological control, if results still in doubt as sometimes the person maybe unwell.
* Refer to manufacturers manual. If all fail to fix the problem, it may need to be sent back to manufactory for servicing and repair.
* Record all troubleshooting action in a log book.

**Implementing a biological Quality Control Programme (only for initial set up)**

* Select 2 healthy volunteers.

\* Free from cardiopulmonary disease

\* Accessible for repeated testing at regular intervals

* Test biological subjects after calibration verification.
* Perform 10 initial baseline tests on ten separate days.
* Calculate mean and standard deviation of the 10 values to set limits.
* Thereafter perform regular biological tests.

\* Test each subject weekly

\* Check FEV1 and FVC are within limits

If not, troubleshoot before returning to spirometer to service.

* Update baseline mean and SD annually.

# Pre-Testing

* Verify the spirometer calibration
* Check patient ID, NHI and demographics
* Measure accurate standing height (cm) & mass (kg) – shoes off
* Check for bronchodilator use \*, smoking history, illness etc
* Ask patient to loosen tight clothing
* Explain the test (instruct and demonstrate)
* Patient must sit up straight – feet flat on floor. No standing please.
* Apply nose clip (optional)

***\* Check for recent bronchodilator use and include in technical comments***

Recommended withholding times: (To be communicated to patient prior to the test)

*Suggest patient to withhold SABA for 6hrs, LABA for 24hrs and LAM for 48, if it’s difficult for the patient, withhold the meds for minimal hours as listed below.*

* Short acting bronchodilators SABA (4 – 6 hrs)

Salbutamol (Asthalin, Ventolin, Respigen, Salamol, Salapin, Asmol, Respolin, Airomir), Ipratropium Bromide (Duolin, Atrovent, Univvent, Combivent, Duovent), Terbutaline (Bricanyl)

* Long acting bronchodilators LABA (12 – 24 hrs)

Salmeterol (Serevent, Seretide), Eformeterol (Symbicort, Vannair, Foradil, Oxis)

* Long acting medications LAM (48hrs)

Bambec, Volmax, Ventolin tablet, Nuelin R, Spiriva

# Spirometry Procedure

**Spirometry Procedure**

* Correct position, nose-clip in place (if needed), lips sealed around mouthpiece
* Inhale completely with a pause of <1s at TLC (Total Lung Capacity)
* Exhale maximally until no more air can be expelled
* Repeat instructions as necessary
* Repeat for a minimum of 3 technically acceptable manoeuvres
* Check test repeatability and perform additional manoeuvres if required; no more than 8

**There are 3 distinct phases to the FVC manoeuvre:**

1. Maximal inspiration to TLC (Total Lung Capacity)
2. A “BLAST” of exhalation
3. Complete exhalation until the end of test criteria met

**An inspiratory manoeuvre can be performed immediately following the FVC manoeuvre:**

1. Complete forced exhalation
2. Maximal forced inhalation until TLC is reached

**Inspired Spirometry Evaluation**

* Manoeuvre evaluation the same as for FVC
* No hesitation
* Same VC repeatability criterion

**Slow Vital Capacity**

If patient is unable to achieve adequate quality from an FVC manoeuvre, a slow vital capacity (SVC) can be performed to allow an FEV1/SVC measurement for interpretative purposes.

(FEV1 must come from the forced manoeuvre)

**Bronchodilator Response**

If bronchodilator response test is indicated (it is required for all tests for Canterbury Initiatives), administer bronchodilator medication as per prescription or standing order after the baseline spirometry is measured (i.e. 3 acceptable tests)

.

* Salbutamol: wait at least 15 minutes
* Ipratropium Bromide: wait at least 30 minutes

Repeat spirometry (i.e. 3 acceptable tests)

# Spirometry Results

**End of Test Criteria**

1. The volume / time curve shows no change in volume (<0.025L) for ≥ 1 S, i.e. reaches plateau, and tried to exhale for
* ≥ 3 seconds in children <10 years
* ≥ 6 seconds in patients >10 years

 Or

1. The patient cannot or should not continue further exhalation.

**Summary of Acceptable Exhalation Criteria**

1. Satisfactory start of expiration (extrapolated volume < 5% of FVC or 0.150 L)
2. No cough within the first second of exhalation
3. Reaches end of test criteria
4. Without valsalva manoeuvre (glottic closure)
5. Without a leak
6. Without an obstructed mouthpiece (tongue)
7. Without multiple breaths

**Summary of Acceptable Inhalation Criteria**

1. No hesitation at start of inhalation
2. Without flow interruption (glottic closure)
3. Without a leak
4. Without an obstruction mouthpiece (tongue)
5. Without multiple breaths

# Factors that may Influence Spirometric Results

* Age related annual decline

For males: FEV1 decreases 30mL yearly & FVC decreases 25mL yearly

For females: FEV1 decreases 25mL yearly & FVC decreases 25mL yearly

* Height: decrease in height with age
* Mass: A large gain or loss
* Smoking: The FEV1 decrease exacerbated
* Seasonal Allergies: Hayfever season
* Medications: May influence motivation or may directly affect airflow
* Illness: May reduce performance
* Change of spirometer

# Easy On-Pc Quality Messages

**FVC/FVL Quality Messages for** *Easy on-PC*

The end-of-test criterion for an FVC test is as follows: A test ends when the volume change during the last 2 seconds is <45 ml or an inspiratory volume >150 ml is detected. When this end-of-test criterion is met, the following quality messages are checked:

|  |  |  |
| --- | --- | --- |
| **Message** | **Criterion** | **Recommended action** |
| Don’t hesitate … | Back-extrapolated volume greater than 150 ml or 5% of FVC whichever is greater (for age <= 6: 80ml or 12.5% of FVC whichever is greater) | The patient must exhale all air at once and not exhale in short bursts. |
| Blast out faster … | Time until peak flow greater than 160 ms | The patient must exhale more explosively and as firmly and quickly as possible. |
| Blow out longer …  | Expiration time less than 2 seconds OR volume in the last 0.5 seconds of the expiration larger than 100 ml | The patient stopped exhaling too early. The patient must exhale still further and force as much air as possible out of his or her lungs. |
| Test Abrupt End! | FVC Test only: Expiration time less than 2 seconds OR volume during last 0.5 seconds >40 ml when expiration time is <6 seconds OR volume during last second >25 ml when end-of-test was initiated by an inspiration. | The patient stopped exhaling too early. The patient must exhale still further and force as much air as possible out of his or her lungs. |
| Good effort, do next … | Test meets above criteria. | Good trial. Only one to two more good trials and the test is complete. |
| Do not start too early! | The time to peak flow (PEFT) is less than 30 ms or flow detected before sensor was initialized (Wait until 'Start Manoeuvre …' is displayed) | Instruct the patient to wait until the baseline setting is finished and the device signals that the trial can start ('Start manoeuvre …') |
| Cough detected. Try again … | A cough has been detected (PEF or PIF > 19l/s) | Instruct the patient to avoid coughing during the first second. Repeat the test. |
| Deeper breath … | FEV1 or FVC\* not reproducible. Difference with respect to best test greater than 150 ml or 100 ml if FVC is <1.0L (for age <= 6:100 ml or 10% of FEV1 or FVC\* whichever is greater) | The test differs greatly from previous tests. The patient can inhale even more deeply and exhale even more air. |
| **Message** | **Criterion** | **Recommended action** |
| No manoeuvre detected! | No parameter calculation possible | Instruct the patient to perform the manoeuvre according to its definition. |
| Session complete! Great Job! | QC grade A or B reached. | The test is complete. An adequate number of good tests is available. |

\*When using FEV6 instead of FVC, FEV6 is also used for the determination of the quality message.

**FVC/FVL** Quality Grades for Easy on-PC

|  |  |
| --- | --- |
| **Rating** | **Criteria** |
| A | At least 3 acceptable tests (for age <= 6: 2 acceptable) AND the different between the best two FEV1 and FVC values is equal to or less than 100 mL (80 mL if FVC < 1.0 L) (got age <= 6: 80 mL or 8% of FVC whichever is greater) |
| B | At least 3 acceptable tests (for age <= 6: 2 acceptable) AND the difference betweenthe best two FEV1 and FVC values is equal to or less than 150 ml (100 ml if FVC< 1.0 L) (for age <= 6: 100 ml or 10% of FVC whichever is greater) |
| C | At least 2 acceptable tests AND the difference between the best two FEV1 and FVC values is equal to or less than 200 ml (150 ml if FVC < 1.0 L) (for age <= 6: 150 ml or 15% of FVC whichever is greater) |
| D (1) | At least 2 acceptable trials but the results are not reproducible according to 'C'. Quality message: "*Result not reproducible*" OR only one acceptable trial. Quality message: "*Only one acceptable trial*". |
| D (2) | Only one acceptable trial |
| F | No acceptable trial available |

**SVC Quality Messages for** *Easy on-PC*

The end-of-test criterion for an SVC test is the same as for an FVD test: A test ends when the volume change during the last 2 seconds is ≤ 30 ml (test time ≤ 6 s) ≤ 45 ml (test time > 6 s), or if an inspiratory volume ≥ 120 ml is detected. When this end-of-test criterion is met, the following quality messages are checked:

|  |  |  |
| --- | --- | --- |
| **Message** | **Criterion** | **Recommended action** |
| Deeper breath | VC of the two largest trials are not reproducible. Difference with respect to best test greater than 150 ml. | The test differs greatly from previous tests. The patient can inhale even more deeply and exhale even more air. |
| No Steady-Tidal breathing detected  | All end-inspiratory volumes of the last 3 breaths within 200 ml. | Instruct patient to breathe quietly and steadily. |
| Manoeuvre incomplete  | No ERV and / or no IRV could be calculated due to an incomplete manoeuvre session.  | Perform SVC test according to ERS / ATS recommendation. |
| **Message** | **Criterion** | **Recommended action** |
| Do not start too early! | Too early, flow detected.  | Instruct the patient to wait until the baseline setting is finished and the device signals that the trial can start (‘Start Manoeuvre …’) |
| Good effort, do next … | Test meets above criteria. | Good trial. Only one to two more good trials and the test is complete. |
| Do not start too early! | The time to peak flow (PEFT) is less than 30 ms or flow detected before sensor was initialized (Wait until 'Start Manoeuvre …' is displayed) | Instruct the patient to wait until the baseline setting is finished and the device signals that the trial can start ('Start manoeuvre …') |
| Session complete! Great Job! | QC grade A, VC variability ≤ 150 ml and at least 3 acceptable trials available.  | The test is complete. An adequate number of good tests is available. |

**SVC** Quality Grades for Easy on-PC

|  |  |
| --- | --- |
| **Rating** | **Criteria** |
| A | At least 3 acceptable tests AND the different between the best VC values is equal to or less than 150 ml. |
| B | At least 2 acceptable tests AND the difference between the best VC values is equal to or less than 150 ml. |
| D (1) | At least 2 acceptable trials but the results are not reproducible according to 'B'.  |
| D (2) | Only one acceptable trial |
| F | No acceptable trial available |

# Canterbury Initiative Spirometry Technical Comment Guidelines

**Technical Comments**

1. Spirometry is acceptable and repeatable.
2. 400mcg Salbutamol administered via MDI and spacer.
3. Bronchodilators have been taken within 4 hours of testing, bronchodilator response may be underestimated.
4. End of test criteria not met. FVC may be underestimated.
5. All other spirometry test criteria have been met.
6. Patient unable to comply with test criteria. Unreliable results, interpret cautiously.
7. Patient unable to perform acceptable and repeatable manoeuvres. RESULTS HAVE NOT BEEN RELEASED.
8. Back extrapolation error detected indicating poor start to exhalation. FEV1 may be overestimated, interpret cautiously.
9. Normal spirometry, bronchodilator not given.
10. Reference equations are extrapolated beyond 80yrs. Interpret with caution.
11. Reference values are based on a Caucasian population, interpret with caution.

*Other comments usually relate to why a certain criteria was not achieved.*

**Interpretation Pattern**

1. Spirometry results are within the normal limits of the reference range.
2. Spirometry results indicate a mild obstructive pattern.
3. Spirometry results indicate a moderate obstructive pattern.
4. Spirometry results indicate a moderately severe obstructive pattern.
5. Spirometry results indicate a severe obstructive pattern.
6. Spirometry results indicate a very severe obstructive pattern.
7. Spirometry suggests a restrictive pattern with a normal FEV1/FVC ratio and FVC below the lower limits of normal for the reference range.
8. Spirometry results show FEV1/FVC ratio at the lower limit of normal. FEV1 is below the lower limit.

**Response**

1. No significant reversibility has been noted after bronchodilator administration.
2. A significant improvement in the FEV1 of \_\_\_\_ ml and \_\_\_\_ % has been noted after bronchodilator administration.
3. A significant improvement in the FVC of \_\_\_\_ ml and \_\_\_\_ % has been noted after bronchodilator administration.

**Clinical comments may include:**

* Smoking history
* Relevant medical history
* Pulmonary rehabilitation / sleep assessment recommendations
* Any information that is different from the referral
* Any information that may be valuable for the general practice team to follow up e.g. poor inhaler technique

NB: Regarding bronchodilator testing:

Normal spirometry excludes significant COPD

‘Subnormal’ spirometry results may show post bronchodilator reversibility which could indicate asthma.

Quality Results

* Record 3 technically satisfactory results
* Sharp start to exhalation
* Free from excessive flow interruption
* End of test volume plateau achieved

**Repeatability (best 2 acceptable results)**

* FEV1 and FVC: within 150mls if FVC > 1.0L

within 100mls if FVC < 1.0L

* Peak flow at least within 10%

**Guideline for Spirometry Interpretation**

Is **FEV1/FVC** < Lower Limit

of Predicted

 **No**

Is **FVC** < Lower Limit of Predicted

 **Yes**

 **Yes** **No**

Assess Severity of **Obstruction**

Using **% Predicted FEV1**

Mild >70

Moderate 60–69

Moderately severe 50–59

Severe 35–49

Very severe <35

Spirometry within **Normal** **Limits** of Reference Values

**Restrictive pattern**

(Suggest referral for confirmation of diagnosis)

**Bronchodilator Response (BDR)**

* Check prior medication use
* Record pre BDR spirometry
* Administer bronchodilator (400mcg Salbutamol via MDI and spacer)
* Wait 15 minutes
* Measure post BDR spirometry
* ***Significant response: >12% and 200mls increase in FEV1 and/or FVC***

**Some useful clinical interpretation comments:**

* Normal spirometry excludes clinically significant COPD
* Normal spirometry does not exclude asthma. If thought clinically important to determine, you may wish to contact the Respiratory Physiology Laboratory at Christchurch Hospital to organise a challenge test.
* Causes of restrictive spirometry can be found on the HealthPathways website
* Restrictive spirometry may be further investigated by measurement of lung volumes and diffusing capacity. Consider contacting Respiratory Physiology Laboratory at Christchurch Hospitals to arrange this.
* High BMI might be contributing to low FVC
* If asthma is considered, you may wish to give a 2-week course of oral prednisone to optimise lung function, and then repeat lung function.
* For further details on differentiating asthma from COPD, see HealthPathways website
* Spirometry is technically poorly performed, meaning that interpretation is not possible. Details of lung function have been removed from this report.
* Spirometry results should be interpreted with caution.
* For more advice about the investigation and management of chronic cough, please see HealthPathways website
* Consistent with COPD if clinical picture also consistent.
* Normal spirometry with no significant bronchodilator reversibility on this occasion of testing. This result excludes clinically significant COPD.
* Would your patient get benefit from Pulmonary Rehabilitation?
* Please see facilitator comments re possible sleep disordered breathing.
* Please note re-interpretation with correct normal values - ignore previous report
* The post-bronchodilator lung function is within normal limits.
* Based on these results, patient qualifies for funding for tiotropium.

# Common Spirometry Patterns

**Predicted Spirometry**

Flow

 1 1. Rapid rise to peak flow

 2. Flow reduces steadily to zero

2 3. Forced inspiratory manoeuvre to complete the flow-volume loop

Volume

 3

**Normal Spirometry**

Flow

 1 1. Rapid rise to peak flow

 2. Flow reduces steadily to zero

2 3. Forced inspiratory manoeuvre to complete the flow-volume loop

Volume

 3

**Mild Obstruction**

Flow

 1 1. Peak flow may be reduced or normal

 2. Concave shape to expired flow

2 3. Normal inspiratory loop

Volume

 3

**Moderate Obstruction**

Flow

 1 1. Peak flow usually reduced

2. Concave shape to expired flow more pronounced as obstruction worsens

 2 3. FVC may be normal or reduced (due to hyperinflation and gas trapping)

4.Normal shape to inspiratory loop

3 Volume

 4

**Very Severe Obstruction**

Flow

 1. Peak flow usually reduced

2. Low flow rate for majority of expiration

 3. Normal shape to inspiratory

1

 2

 Volume

 3

**Restricted Spirometry**

Flow

 1. Still sharp rise to peak

 1 2. Flow reduces steadily to zero

 3. FVC is reduced

 4. Normal shape to inspiratory loop

 2

 3 Volume

 4

**Extra-thoracic Obstruction**

Flow

 1. Expired spirometry may be normal or reduced

 2. Inspired flow will be reduced and appear flattened

 1

 Volume

 2

# Common Problems - FVC

Flow Flow Flow

( 1 ) ( 2 ) ( 3 )

Flow

( 1 ) Lack of understanding

( 2 ) Coughing

( 3 ) Glottic closure

( 4 ) Slow start

( 4 )

# Standing Order – Salbutamol for Spirometry Reversibility Testing

|  |
| --- |
| Issued: 13/01/2014 Review date: 13/01/2015 |
| **Organisations** | Approved Providers of Spirometry |
| **Rationale** | To allow diagnostic information for spirometry |
| **Scope (condition & pt group)** | Those over the age of 15 years presenting for spirometry testing following an appropriate referral.Clinically stable |
| **Indication/circumstances for activating the standing order** | Following receipt of referral for spirometry and appointment made. |
| **Medicine/s** | Salbutamol 100mcg MDI (Metered dose inhaler) |
| **Dosage instructions**  | Salbutamol 400mcg (x4,100mcg actuations)) via MDI and spacer following initial spirometry testing. Wait 15 minutes following administration before initiating post bronchodilator spirometry testing   |
| **Route of administration** | Salbutamol MDI and single use spacer.Demonstrate technique for using MDI and spacer. 4 single actuations with 4-5 tidal breaths to clear each dose. Shake the MDI between actuations.Dispose of, or give spacer to patient following procedure |
| **Exclusions applying to this standing order** | * Known hypersensitivity to Salbutamol or inhaler components
* Severe Cardiac Arrhythmias
* Uncontrolled Thyrotoxicosis
 |
| **Persons authorised to administer the standing order** | Registered nurses (RNs) or those with a relevant science qualification, having completed Spirometry certification and maintaining continuing quality processes. Performing spirometry as an Approved Provider* Versed with emergency procedures within the environment.
 |
| **Management if patient excluded** | * Discuss/refer to referring doctor.
* Discuss with Community Respiratory Physician or Approved Provider GP
* Consider mobilising local emergency procedures in the case of adverse event
 |
|  **Further information/ Special considerations** | * + It is preferable that the patient withholds the following medications:
	+ 6 hours before testing - SABA (relievers)
	+ 24 hours before testing - LABA for 24 hours
	+ 48 hours before testing – Long acting medication

Refer to Healthpathways* + Patients should always be asked about their medication use and any pertinent comments are then made in the comments section of the spirometry report.
 |
| **Reported Adverse Effects**  | * Coughing
* Fine tremor (particularly in the hands)
* Nervous tension
* Headache and/or peripheral vasodilatation
* Tachycardia, arrhythmias, palpitations
* Hypersensitivity reactions: paradoxical bronchospasm, urticaria, and angiodema have been reported.
 |
| **Action if pt declines medication** | * Document reason for decline and action taken within spirometry report
 |
| **Written/Verbal advice for pt before/after treatment** | * Enquire and document current use of inhaled medication if appropriate
* Provide advice on inhaler technique and use if appropriate.
 |
| **Records to be kept*** Supply/Administration
* Patient identifiers (sufficient for audit trail)
 | * Spirometry referrals are scanned into a PMS (Medtech)
* Spirometry reports include relevant information for interpreter and Quality checks.
 |
| **Follow-up** | * Any adverse events are reported in writing to the referring GP and the Community Respiratory Physician.
* If an adverse event occurs, complete an incident report and follow local procedures.
* Patients are encouraged to follow up results with their GP.
 |
| **Competency/training requirements for the person(s) authorised to administer** | * Authorised staff are required to have undergone in-house training on the *policy,* *procedure*, and *documentation* requirements for standing orders. A record of this training is to be kept.
* The RN/scientist is competent in all aspects of Salbutamol via MDI administration, including contraindications to treatment.
* Training has been given in the recognition and management of anaphylaxis.
* The RN/scientist is professionally accountable for his/her practice. There is a requirement for the nurse/scientist to maintain and improve his/her professional knowledge and competence, including attending annual resuscitation, training and regular relevant drug updates.
 |
| **Countersigning and audit** | Countersigning of Standing Order is not required.20% of Standing Order treatments are audited monthly. |
| **Additional information** | Standing Orders policy and procedure documentInfection Control, Policy and procedure documentPractice Procedure Manual,CISS spirometry Service Specifications/ContractMOH Standing Order Guidelines (2012)  |
| **References** | Mims, 2012 Medsafe Data Sheet, June 2012 |
| **Signed by issuer:** |
| Name: | *Dr Colin Chin & Dr Kent Johnston* | Date: |  |
| Title: |  |

This medicine standing order is not valid after the Review date which is one year after the date that the order was signed by the issuer. The Standing Order must be read, agreed to and signed by the Registered Nurse/Scientist and the Medical Director working within this standing Order. Both professionals must act within their appropriate Code of Professional Conduct.

# Infection Control Considerations Associated with Spirometry Testing

**Associated documents**

* *Hand washing technique poster*
* *Practice infection control policies and procedures*

**Aim**: *To provide guidance on practice in relation to infection control for staff performing spirometry testing with the Easy- On spirometer in a primary care/practice setting*

**Background**

**Hygiene and Infection Control**

The goal of infection control is to prevent the transmission of infection to patients and staff during pulmonary function testing. The documented number of cases of infection transmission is small but the potential is real. Universal precautions should be applied in all instances in which there is the potential for exposure to blood and body fluids.

**Direct Contact**

There is potential for transmission of upper respiratory diseases, enteric infections and blood borne infections through direct contact. Although hepatitis and HIV contagion are unlikely via saliva, transmission becomes a possibility with open sores on the oral mucosa or bleeding gums. The most likely surfaces for contact are mouth pieces.

**Indirect Contact**

There is potential for transmission of TB various viral infections, opportunistic infections and nosocomial pneumonia through aerosol droplets. The most likely surfaces for possible contamination by this route are mouthpieces and proximal tubing if used.

**Prevention**

***Transmission to technicians***

Prevention of infection transmission to staff exposed to contaminated spirometer surfaces can be accomplished through proper hand washing and use of barrier devices, such as suitable gloves. To avoid technician exposure and cross contamination, hands should be washed immediately after direct handling of mouth pieces. Gloves should be worn when handling potentially contaminated equipment if the technician has any open cuts or sores on their hands. Hands should always be washed between patients.

***Cross Contamination***

To avoid cross contamination, mouth pieces, nose clips and any other equipment that comes into direct contact with mucosal surfaces should be disinfected, sterilised or if disposable, discarded after each use. The body of the spirometer should be wiped between patients. Special precautions may need to be taken for immunocompromised patients (preferable at the beginning of the day/session).

When an open circuit technique is used (Easy-on), the risk of infection is reduced to the patient but not the technician. Bacterial/viral filters are widely used in pulmonary function laboratories although the need for such filters and their effectiveness is not well documented. These filters impose added resistance. If in line filters are used during spirometry it is recommended that the equipment be calibrated with the filter installed. The use of inline filters does not guarantee that transmission of disease cannot occur. Filters should be considered single patient use.

***Other Known transmissible infectious diseases***

Extra precautions should be taken for patients with known transmissible infectious disease. Possible precautions include 1. Test such patients at the end of the day. 2. Test patients in their own home with adequate ventilation and appropriate barrier protection for technician.

*References*:

ATS-ERS Task Force. *European Respiratory Journal* (2005), Series ‘Standardisation of lung function testing’. General considerations for lung function testing.

www.medskills.eu/respiratory/spirometry

**Infection Control Procedure for Spirometry testing in a Primary Care setting.**

Procedure

|  |  |
| --- | --- |
| Step | Action: Standard Precautions for staff |
| The following precautions are applied by all staff as routine protective precautions when performing spirometry testing on patients regardless of their diagnosis or presumed infectious status. |
|  | Hand hygiene is the most important infection control practice |
|  | Washing of hands must be carried out prior to spirometry procedure and immediately following the procedure including handling the spirettes. |
|  | Any broken skin areas must be covered with adhesive water resistant dressings. |
|  | Consider wearing gloves when handling potentially contaminated equipment. Perform hand hygiene before putting gloves on and after gloves are removed. Fresh gloves must be used for each patient. |
|  | Ensure good respiratory hygiene and cough etiquette is performed |

Procedure

|  |  |
| --- | --- |
| Step | Action: Standard Precautions for Patients |
| To prevent patients from infecting staff and other patients, standard precautions must be adhered to. It is important to ensure that the risk of disease transmission is minimal. |
|  | Clean equipment must be used for every patient |
|  | Single use spirettes and spacers are used for spirometry testing |
|  | Non disposable equipment must be cleaned as per the guidelines below. |
|  | Consider using inline single patient use filters. |
|  | Dispose of spirettes into general waste bag |

Procedure

|  |  |
| --- | --- |
|  Step | Action: General Equipment Cleaning Guidelines |
|  |
|  | Wipe the hand held part of the spirometer with approved product between patients |
|  | Wipe proximate surfaces with azo wipes at the end of each session |

# Some Software Troubleshoot Tips

**Current contact for Spirometry IT support:**

Rob at Pegasus Health. Phone: 3539915 Email: techsupport@pegasus.org.nz

**How to merge database in Easy on-PC software (example in Room 401)**

Here are the instructions for merging the spirometry data that was on the local (C:\) drive in the front room. Rob had copied that database over to the server, M:\spirometry\firstroom\EasyWarepro.mdb (or something like that)

First you need to load the old database as the current storage so that it can be promoted to the correct version.

In Easy on-PC software, go to utilities-configuration-storage.

Push [select] and find the location of the old database (M:\spirometry\firstroom\EasyWarepro.mdb)

Hit [OK]

This will reopen Easy on-PC and promote the old database to the new version.

Next, reset the current storage location to M:\spirometry\EasyWarepro.mdb

In Easy on-PC software, go to utilities-configuration-storage.

Push [select] and find the location of the old database (M:\spirometry\firstroom\EasyWarepro.mdb)

Now import the data from the other database:

In the utilities-configuration-storage section

In here there is an import button, select this and find the first database M:\spirometry\firstroom\EasyWarepro.mdb

You will get an hour glass appear while it thinks and imports the data. Once this is completed the old data will be in the proper database.

**How to debug spirometry**

If won’t connect. In CI spirometry go to options-Test-SOAP-certificate. Certificate must be in health link (M:hlk/erms install)

Sometimes ERMS been moved into different pathway. Also check original spirometry has all parameters filled in (e.g. wt, BMI, smoking status as it won’t upload if not filled in properly).

Also Delete all comments in spirometry test where failed.

# References

nnd Medical Technologies. (2013). *Easy on-PC: Operator’s manual.* Andover, USA: ndd Medical Technologies.

Respiratory Physiology Laboratory (2013), *Christchurch Spirometry Course.* Christchurch, NZ: Respiratory Physiology Laboratory.

# Canterbury Initiative Spirometry Audit

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Name** | **NHI** | **Timeframe from receipt of referral to test** | **Timeframe from test to interpretation** | **Timeframe from receipt of referral to claim** | **Timeframe from receipt of referral to GP notified** | **What type of referral form has been used? ERMS or other?** |
|  |  |  |  |  |  |  |
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# Exporting Spirometry Tests

Start from next page