 <p><b>Massachusetts General Hospital</b> <i>Translational and Clinical Research Centers</i></p>	<h1>Standard Operating Procedure</h1>	Effective Date: 7/1/2012 Updated: 9/1/2018
		Version: 3.0
<b>TCRC Indirect Calorimetry/ Metabolic Cart</b>		

## 1. RELEVANCE

- a. This SOP outlines the instructions to completing a metabolic cart including: conducting the test, software input, and saving data, to ensure safety and reliability.
- b. The majority of this SOP refers to completing “Canopy” tests to measure resting energy expenditure (REE), though the metabolic cart can be used to complete other tests as well. Additional SOPs may be made or this SOP may be edited to encompass additional tests completed using the metabolic cart.

## 2. SCOPE

- a. This SOP applies to TCRC RDs and TCRC DTs
- b. All TCRC RDs and DTs should be trained and follow the outlined procedures prior to performing metabolic carts.

## 3. DEFINITIONS/ABBREVIATIONS


- a. **Metabolic Cart (Met Cart):** The equipment used to complete indirect calorimetry.
- b. **Indirect Calorimetry:** Energy expenditure assessment using indirect calorimetry is an accurate and feasible method of measuring gas exchange: O<sub>2</sub> uptake and CO<sub>2</sub> production. Indirect calorimetry methodology calculates resting energy expenditure (REE) and respiratory quotient (RQ)\* (using Weir equation). Currently indirect calorimetry is considered the “gold standard” for resting metabolic rate (RMR). Energy expenditure reflects the rate of cellular metabolism of carbohydrate, fat and protein to produce energy (heat, kcals). Obtaining reliable measurement using indirect calorimetry is dependent on the participant’s condition.
- c. **Resting Energy Expenditure (REE):** Also, referred to as **Resting Metabolic Rate (RMR):** The amount of energy (calories) a person uses in a 24-hour period, while at rest.
- d. **Respiratory Quotient (RQ):** Ratio of carbon dioxide production to oxygen consumption, reflecting the relative contributions of fat, carbohydrate, and protein to the oxidation fuel mixture.  $RQ = VCO_2 / VO_2$ .
- e. **Weir Equation (abbreviated):**  $REE = [3.9 (VO_2) + 1.1 (VCO_2)] 1.44$

## 4. RESPONSIBILITIES

- a. TCRC RDs and trained TCRC DTs will calibrate the metabolic cart and maintain its daily functions
- b. The TCRC RD or DT will set up and input the study participant’s information and explain test to the participant. The RD and/or a trained technician will monitor the participant throughout the test and remove the canopy at the completion of the test.
- c. Indirect calorimetry competency training will be completed annually or at more frequent intervals as necessary.

## 5. PROCEDURES

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Procedures followed are in line with the instructions for VMAX 29 Encore Model and Cardiosoft 6.51 version software, VMAX Encore software.

**Note:** Based on recent research and to maintain best practice, while also keeping data collection consistent, our procedures have been transitioning regarding the test length, and data point analysis. Prior to September 2017, standard practice consisted of a 15 minute test to steady state (green box at lower right), 20 minutes if not. As of September, 2017, All new studies will run the test for 20 minutes. Studies that began prior to this change will continue with the procedure they started with to ensure consistent data collection. Protocol specific requirements are always followed when indicated.

### Daily Calibration

- a. Flow sensor calibration is completed daily prior to subject data collection.
- b. Metabolic cart should be turned on and Vmax software opened and allowed to warm up for approximately 30 minutes prior to conduction morning calibration.
- c. Calibration will be saved internally by pressing F3.

### Prior to the test

- a. Participant should:
  - o Fast (no food or beverages besides water). Each study may have a specified amount of time that is required, but generally at least 8 hours is recommended.
  - o Avoid nicotine for at least 2 hours prior to the test.
  - o Avoid moderate exercise for at least 2 hours prior to the test, and avoid vigorous activity for at least 12 hours prior to the test.
  - o Relax and sit or lie down for at least 20 minutes prior to the test.
- b. The room should be a controlled, comfortable temperature.
- c. Participant's height and weight should be recorded prior to the test.


### Performing a Canopy Test (indirect calorimetry)

- a. On the main menu of the Metabolic Cart screen, select #2: New Study and enter participant data. Once entered, press F3 to save.

NOTE: in some cases studies may be deidentified, see study specific instructions.


- o ID (SPID and Visit #)
  - o Last Name
  - o First Name
  - o Date of Birth (day/month/year)
  - o Sex
  - o Height (to the nearest cm.)
  - o Weight (to the nearest 0.1 kg.)
- b. At the main menu, select #4: Exercise/Metabolic Test. "Canopy Study" should be highlighted under Test Protocol.

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- c. Press F1 to recalibrate the gases. When green box appears in the lower right hand corner, press F3 and wait for prompts.
- d. Prepare the participant by explaining the test to them. He/she should lie in bed at a 30° angle, with head on pillow and arms at sides. Extra pillows and blankets can be provided for comfort.
- e. Connect one end of the corrugated tubing to the flow sensor adapter and the other to the canopy. Place the canopy over the participant's head.
- f. Follow the sequence of prompts. Switch the pump on (to the left) and press the space bar to continue. Click F8: Start (green box in lower right hand corner) once, then again so that "No Stage" changes to "Baseline."
- g. While test is in progress, adjust pump up or down so that "FECO<sub>2</sub>" box (farthest to the right) remains green at all times. Average value is approximately 0.85. If the box becomes yellow or red and is above that value, adjust the pump upward and wait for equalization; if it is below that value, adjust the pump downward. [\*Be sure to adjust the pump slowly (only a few percent at a time), then wait until the next time point registers before making any additional adjustments.]
- h. The TCRC RD or DT will remain in the room with the participant at all times during the metabolic cart procedure. They will adjust the metabolic cart as needed to ensure adequate airflow and accuracy of the test, and to monitor for the participant reaching steady state. The participant will be encouraged to remain awake, but in a rested, still state. Efforts will be made to ensure the participants comfort. If at any time the participant is in distress, the test will be stopped and RN/MD/NP will be consulted as needed. Documentation of any such events will be made.
- i. Run test for specified length of time (generally 15 to 20 minutes, see protocol specific instructions).
- j. At the end of the test select "Exit/Pause" from the top menu, then "Y to end test." Follow the prompts. Switch the pump off, and press space bar to continue.
- k. Remove the canopy and inform the participant that the test is complete. Disconnect and dispose of the corrugated tubing and clean/sterilize the canopy using Sani-wipes.
- l. At the next screen, select the reason for stopping the test (generally "steady state achieved" or "steady state not achieved"). Double-click and press F3 to proceed.
- m. Use mouse to select all relevant test points. Usually omitting the first 2 minutes (3 points) and last minute (last point). Check the "SS4 = Avg SS 1 – 3" box at lower right and press F3 to save.
- n. Click F8: Reports and select "Default Canopy Report," then choose "View" or "Print" to obtain results. Once completed, select "Exit" from the top menu bar.
- o. Do not allow participant to see results of test. If they have any questions about the results refer them to their study coordinator.
- p. A PDF of the participant's results will be place in the study specific RFA folder.
- q. Once the test is complete be sure to:
  - o Turn off the gases using pressure gauge and the gas tanks using the turn key.
  - o Remove the sheets and pillow case from the stretcher, clean the bed and replace linens with clean sheet and pillow case.

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- r. Completion of indirect calorimetry will be recorded in the TCRC RD's Epic progress note, but results will not be placed in the participant's medical record.
- s. Refer to "Metabolism and Nutrition Research Secure Data Storage" SOP for more details regarding data storage.

### Sanitizing

- a. After each test:
  - a. Discard corrugated tube.
  - b. Thoroughly wipe the canopy and veil with saniwipes and allow to air dry.
  - c. Remove and replace the sheets and pillow case from the bed or stretcher.
- b. Daily, after the last participant: Wipe the surface of the Mass Flow Sensor with a sani-cloth. Do not touch the inner screen.

### Quality Improvement

- a. Daily calibration reports are on file
- b. Quarterly review of metabolic cart data via chart review

## **6. OPERATIONAL DOCUMENTS**

- a. VMAX Operations Manual

## **7. REFERENCE(S)**

- a. Weir JB de V. New methods for calculating metabolic rate with special references to protein metabolism. *J Physiol.* 1949;109:1-9
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- h. TCRC SOP: "Metabolism and Nutrition Research Secure Data Storage"

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