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Title: Evaluation of Capnography Sampling Line Compatibility and Accuracy when Used with a Portable Capnography Monitor

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Author Questionnaire

1. Microscopy: Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or similar? **N**

2. Software: Does the part of your protocol being filmed demonstrate software usage? **Y**

Videographer: All screen captures provided; do not film

3. Interview statements: Considering the Covid-19-imposed mask-wearing and social distancing recommendations, which interview statement filming option is the most appropriate for your group? **Please select one**.

☒ Interviewees wear masks until the videographer steps away (≥6 ft/2 m) and begins filming. The interviewee then removes the mask for line delivery only. When the shot is acquired, the interviewee puts the mask back on. Statements can be filmed outside if weather permits.

4. Filming location: Will the filming need to take place in multiple locations (greater than walking distance)? **N**

Protocol Length
Number of Shots: **49**

Introduction

1. Introductory Interview Statements

REQUIRED:

1.1. **Ido Karpenkop**: These bench tests, performed in combination with a portable bedside capnography monitor, allow us to determine the accuracy of matched and cross-paired capnography sampling lines **[1]**.

1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

REQUIRED:

1.2. **Ido Karpenkop**: The main advantage of this technique is that it can be used to directly compare the accuracy of multiple capnography sampling lines under consistent, controlled testing conditions **[1]**.

1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

Protocol

2. Sampling Line Tensile Strength Measurement

2.1. To calibrate the tensile testing jig, in the tensile testing jig software **[1]**, set the load cell selection to 100 kilograms and the load parameter to 10 kilograms **[2]**.

2.1.1. WIDE: Talent opening software, with monitor visible in frame
2.1.2. Talent setting load cell selection and load parameter

2.2. Attach the sampling line components to the calibrated tensile testing jig **[1]** and, starting with a mass of 0 kilograms, initiate tension on the sampling line component **[2]** while observing whether the sampling line connection remains intact **[3]**.

2.2.1. Talent attaching sampling line component
2.2.2. Talent initiating tension
2.2.3. Shot of sampling line connection

2.3. If the connection remains intact, automatically and continuously increase the **[1]** until the subparts break or disconnect **[2]**, recording the maximum tension exerted before the break occurred **[3-TXT]**.

2.3.1. Talent adding mass to jig
2.3.2. Subparts breaking/disconnecting Author NOTE: Please use Take 6
2.3.3. Talent recording maximum tension **TEXT: Repeat for all potential sampling line subparts**

3. Rise Time and Sampling Line Accuracy Measurement

3.1. To calibrate the rise time measurement device, first cut a standard 0.95-millimeter internal diameter carbon dioxide PVC (P-V-C) tube into ten 15-centimeter pieces **[1-TXT]**.

3.1.1. WIDE: Talent cutting tube **TEXT: PVC: polyvinyl chloride**

3.2. Next, turn on the air compressor, jig controller, and power supply **[1]** and open the carbon dioxide gas flow **[2]**.

3.2.1. Talent turning on instruments NOTE: This and next shot together
3.2.2. Talent opening gas flow

3.3. Attach one of the 15-centimeter pieces of PVC directly to the measurement chamber as a sampling channel **[1]** and use a mass flow meter and a dedicated restrictor to calibrate the air flow to 10 liters/minute and the carbon dioxide sampling rate to 50 milliliters/minute **[2]**.

3.3.1. Talent attaching channel to chamber
3.3.2. Talent calibrating air/gas flow

3.4. In the jig software, set the air to carbon dioxide ratio to 1:1, the air time to 3 seconds, the carbon dioxide time to 3 seconds and 10 cycles, and the rise time measurement length to none **[1]**.

3.4.1. SCREEN: screenshot_1: 00:04-00:10

3.5. Open the carbon dioxide valve **[1]** and click **Finish Calibration**. Confirm that the button has turned green **[2]**.

3.5.1. Talent opening valve
3.5.2. SCREEN: screeshot_2: 00:02-00:05

3.6. Click **Measure** and wait for the gas flow cycles to end **[1]** before closing the carbon dioxide valve **[2]**.

3.6.1. SCREEN: screenshot_3: 00:12-01:52 *Video Editor: please speed up to 01:48*
3.6.2. Talent closing valve

3.7. Record the background rise time and confirm that the result is less than 60 milliseconds **[1-TXT]**.

3.7.1. SCREEN: screenshot_4: 00:00-01:48 *Video Editor: please speed* **TEXT: If > 60 ms, clean optical chamber with air flow and reconnect y-piece/airway adapter**

3.8. Open a new commercial sampling line **[1]** and connect the sampling line to the rise time measurement device **[2]**.

3.8.1. Talent opening sampling line *Videographer: Important step*
3.8.2. Talent connecting sampling line to device *Videographer: Important step*

3.9. Then click **Start** in the rise time measurement device software and wait for the device to measure the rise time **[1]**.

3.9.1. SCREEN: screenshot_5: 00:11-01:52 *Video Editor: please speed to 01:48*

4. End-Tidal Carbon Dioxide ($ETCO_2$) Accuracy Measurement

4.1. To measure the end-tidal carbon dioxide accuracy as a function of the respiratory rate, place a mannequin in the supine position **[1]** and connect the sampling line to the mannequin according to the manufacturer's instructions **[2]**.

4.1.1. WIDE: Talent placing mannequin into position
4.1.2. Talent connecting sampling line to mannequin

4.2. **[1] [2]**.

~~4.2.1. Talent attaching line to monitor~~
~~4.2.2. Talent changing settings to cancel gold ring identification~~

4.3. To control the simulated respiratory rate, use a flow meter to measure the gas flow **[1]** and calibrate the flow to 10 liters/minute as demonstrated **[2]**.

4.3.1. Talent measuring gas flow
4.3.2. Talent calibrating flow to 10 L/min

4.4. In the breath simulator jig software, set the duty cycle to 50% and use a leak testing jig to test for leaks in the system **[1]**.

4.4.1. SCREEN: screenshot_6: 00:17-00:25
~~4.4.2. Talent testing leaks~~

4.5. **[1] [2]**.

~~4.5.1. Talent connecting sampling line~~
~~4.5.2. Kink being created~~

4.6. **[1] [2]**.

~~4.6.1. Talent allowing pressure in line to increase~~
~~4.6.2. Talent closing valve/stopping flow~~

4.7. **[1] [2]**.

~~4.7.1. Talent observing pressure measurement displayed on leak testing jig~~

~~4.7.2. Talent replacing sampling line~~

4.8. When the patency of the sampling line has been confirmed, connect the breath simulator jig to the mannequin **[1]** and use the simulator to increase the 5% carbon dioxide flow rate to 10 liters/minute and the nitrogen flow rate to 10 liters/minute **[2]**.

4.8.1. Talent connecting breath simulator jig to mannequin *Videographer: Important step*
4.8.2. Talent increasing flow rate *Videographer: Important step*

4.9. Wait 30 seconds to allow a steady capnography waveform to be established **[1]** before recording the end-tidal carbon dioxide value **[2]**.

4.9.1. Talent checking watch or setting timer
4.9.2. Talent observing ETCO2 value

4.10. After measuring a total of 10 end-tidal carbon dioxide values over 180 seconds **[1]**, use the breath simulator jig to change the respiration rate **[2]** and allow the capnography waveform to normalize for 30 seconds before recording 10 additional end-tidal carbon dioxide readings over 180 seconds **[3]**.

4.10.1. Talent recording 10 ETCO2 values *Videographer: Important step*
4.10.2. Talent changing respiration rate NOTE: This and next shot together *Videographer: Important step*
4.10.3. Shot of waveform normalizing then readings being acquired on capnography monitor *Videographer: Important step*

5. $ETCO_2$ Accuracy Measurement in the Presence of Supplemental Oxygen

5.1. To measure the end-tidal carbon dioxide accuracy in the presence of supplemental oxygen, set the breath simulator jig to 10 breaths per minute **[1]** and connect the oxygen line to 100% oxygen **[2]** and carbon dioxide output **[3-added]**.

5.1.1. WIDE: Talent setting jig to 10 BPM *Videographer: Important/difficult step*
5.1.2. Talent connecting line to oxygen *Videographer: Important/difficult step*
5.1.3. Added: Talent connecting line to co2 output

5.2. Increase the carbon dioxide flow rate to 6 liters/minute and the oxygen flow rate to 0 liters/minute for use as a reference measurement **[1]**.

5.2.1. Talent increasing flow rate(s)

5.3. Wait 30 seconds to allow the capnography waveform to stabilize before recording the end-tidal carbon dioxide value 10 times over 180 seconds **[1]**.

5.3.1. Waveform stabilizing, then values being recorded on capnography monitor

5.4. Then change the flow rate of the carbon dioxide and oxygen **[1-TXT]**, allow the capnography waveform to normalize for 30 seconds and repeat 10 additional end-tidal carbon dioxide measurements over 180 seconds **[2]**.

5.4.1. Talent changing flow rate(s) *Videographer: Important/difficult step* **TEXT: See text for suggested CO_2 and O_2 L/min combinations**

5.4.2. Waveform stabilizing, then values being recorded on capnography monitor *Videographer: Important/difficult step*

Protocol Script Questions

A. Which steps from the protocol are the most important for viewers to see?

3.8., 4.8., 4.10., 5.1., 5.4.

B. What is the single most difficult aspect of this procedure and what do you do to ensure success?

5.1., 5.4. To ensure success, it is important to check to make sure all tubing is connected properly, confirm the flow rates are set accurately, and allow the waveform to normalize before recording the ETCO2 measurements.

Results

6. Results: Representative $ETCO_2$ Measurement and Accuracy

6.1. While a majority of the sampling lines in this representative analysis exhibited accuracy at 150 breaths per minute for both breathing ratios **[1]**, some lines failed to maintain accuracy **[2]**, while others maintained accuracy under all of the tested conditions **[3]**.

6.1.1. LAB MEDIA: Table 2
6.1.2. LAB MEDIA: Table 2 *Video Editor: please emphasize N's in Accurate after 150 BPM columns*
6.1.3. LAB MEDIA: Table 2 *Video Editor: please emphasize sampling lines 1, 4, 5, 8, 9, 10, 11, 14, 15, and 16 Y's in Accurate after 150 BPM columns*

6.2. Among the adult sampling lines tested, at 10 breaths per minute **[1]**, sampling lines 1, 2, 5, 6, 7, 8, and 9 read end-tidal carbon dioxide within an acceptable range at the lowest respiration rates **[2]**.

6.2.1. LAB MEDIA: Figure 3A
6.2.2. LAB MEDIA: Figure 3A *Video Editor: please emphasize sampling lines 1, 2, 5, 6, 7 and 10-20 BPM and 8 and 9 data lines at 10 BPM*

6.3. In contrast, sampling lines 3 and 4 reported low end-tidal carbon dioxide levels at the lowest respiration rate **[1]**, which decreased to 0 millimeters of mercury when the respiration rate increased to 80 breaths per minute or higher **[2]**.

6.3.1. LAB MEDIA: Figure 3A *Video Editor: please emphasize sampling lines 3 and 4 at 10 BPM*
6.3.2. LAB MEDIA: Figure 3A *Video Editor: please emphasize sampling lines 3 and 4 at ≥80 BPM*

6.4. Only sampling lines 1, 8, and 9 continued to capture readings at very high respiration rates **[1]**.

6.4.1. LAB MEDIA: Figure 3A *Video Editor: please emphasize sampling lines 1, 8, and 9 at 120-150 BPM*

6.5. In the presence of 2, 4, or 6 liters/minute of supplemental oxygen, the expected end-tidal carbon dioxide was 34 millimeters of mercury **[1]**.

6.5.1. LAB MEDIA: Figure 5 *Video Editor: please add/emphasize Expected value text and arrow in Figures 5B, 5C, and 5D*

6.6. Upon the addition of 2 liters/minute of supplemental oxygen, a majority of the sampling lines exhibited a decrease in the observed end-tidal carbon dioxide values **[1]**.

6.6.1. LAB MEDIA: Figure 5 *Video Editor: please emphasize black sample line data bars except sample lines 7, 8, and 9 in Figure 5B*

6.7. Similar decreases were also obtained in the presence of 4 or 6 liters/minute of supplemental oxygen **[1]**.

6.7.1. LAB MEDIA: Figure 5 *Video Editor: please emphasize black sample line data bars except sample lines 7, 8, and 9 in Figures 5C and 5D*