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Title: Management of Respiratory Motion Artefacts in ^{18}F-Fluorodeoxyglucose Positron Emission Tomography Using an Amplitude-Based Optimal Respiratory Gating Algorithm

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Author Questionnaire

1. Microscopy: Does your protocol demonstrate 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**

3. 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. **Willem Grootjans**: The deteriorating effects of respiratory motion artefacts in PET imaging have long been well-recognized. Optimal respiratory gating is a method for correcting these motion artefacts in PET images **[1]**.

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

REQUIRED:

1.2. **Willem Grootjans**: Maintaining a sufficient image quality is problematic for many respiratory gating algorithms. The optimal respiratory gating algorithm allows the user to define and maintain the image quality **[1]**.

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

OPTIONAL:

1.3. **Willem Grootjans**: Respiratory motion artefacts have a significant impact on image quality and quantitative accuracy. Removal of these artefacts can significantly improve diagnostic accuracy and the ability to monitor treatment responses **[1]**.

1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera *Videographer: Can cut for time* [done]

Introduction of Demonstrator on Camera

1.4. **Willem Grootjans**: Demonstrating the procedure will be Jurrian Butter, a technologist at the department of radiology and nuclear medicine **[1][2]**.

1.4.1. INTERVIEW: Author saying the above [done]

1.4.2. The named demonstrator(s) looks up from workbench or desk or microscope and acknowledges the camera [done] NOTE: 1.4.2 take 1 includes 2.1.1

Ethics Title Card

1.5. Procedures involving human subjects have been approved by the Institutional Review Board (IRB) at the Radboud University Medical Centre.

Protocol

2. Radiotracer Administration

2.1. After explaining the preparation and imaging procedures to the Patient **[1]**, insert a peripheral venous cannula into one of the antecubital veins of the Patient **[2]** and attach a 3-way stopcock system with a Luer lock to a 20-milliliter syringe of saline **[3]**.

2.1.1. WIDE: Talent explaining procedure to Patient

2.1.2. Cannula being inserted

2.1.3. Stopcock being attached to syringe with saline NOTE: 2.1.3 and 2.2.1 filmed together

2.2. De-aerate the stopcock with saline **[1]** and attach the stopcock to the venous cannula **[2]**.

2.2.1. Stopcock being flushed with saline, with saline container visible in frame

2.2.2. Stopcock being attached to cannula

2.3. Check the patency of the cannula with 10 milliliters of saline **[1-TXT]** and attach the syringe with the radiotracer to the three way stop cock **[2]**.

2.3.1. Cannula being flushed **TEXT: Check patient for complaints during flush**

2.3.2. Syringe being attached to three way stop cock

2.4. Then turn the valves of the 3-way stopcock such that the direction of the fluid will flow from the syringe containing the radiotracer to the peripheral venous cannula **[1]**.

2.4.1. Valve(s) being turned

2.5. Place the syringe containing the radiotracer in a special tungsten shielded container. To administer the radiotracer slowly depress the syringe plunger of the container **[2]**.

2.5.1. syringe in container

2.5.2. Plunger being depressed

2.6. When all of the tracer has been delivered, turn the valves of the stopcock such that the syringe containing the saline is connected to the radiotracer syringe **[1]** and flush the syringe to capture any residual radiotracer within the syringe in the saline **[2]**.

2.6.1. Valves being turned NOTE: 2.6.1 – 2.7.2 in one shot

2.6.2. Syringe being flushed

2.7. Then turn the valves of the stopcock **[1]** and deliver the saline flush containing residual radiotracer to the patient **[2-TXT]**.

2.7.1. Valves being turned

2.7.2. Saline being delivered **TEXT: Repeat radiotracer wash and delivery x3**

2.8. After the last wash of radiotracer has been administered, remove the radiotracer syringe **[1]** and deliver 0.5 milligrams/kilogram of furosemide through the venous cannula **[2-TXT]**.

2.8.1. Talent removing syringe

2.8.2. Furosemide being delivered **TEXT: Remove and discard cannula after diuretic delivery**

3. Patient Incubation

3.1. After the furosemide has been delivered, let the Patient rest in a comfortable position for 50 minutes **[1]** before asking the Patient to void their bladder **[2]**.

3.1.1. WIDE: Talent adjusting Patient seat/bed/giving pillow or similar representative action

3.1.2. Talent helps the patient to get up and talks to the patient NOTE: There is an additional shot of the bathroom sign to illustrate that the patient has been instructed to go to the bathroom.

3.2. At 55 minutes, escort the Patient to the scanner **[1]** and have the Patient lie in the supine position with the arms up on the scanner bed **[2-TXT]**.

3.2.1. Talent gesturing toward scanner/Patient walking toward scanner

3.2.2. Patient lying down/placing arms above head **TEXT: If patient unable to elevate arms, perform scan with arms positioned alongside patient**

3.3. Use appropriate arm support to make the Patient as comfortable as possible and observe the Patient's breathing pattern **[2]**.

~~3.3.1. Talent placing arm supports~~

3.3.2. Shot of Patient's chest rising and falling

3.4. Secure the respiratory belt around the Patient's thorax or upper abdomen **[1]** with the sensor placed such that the abdominal wall excursion can be identified after visual inspection **[2]**.

3.4.1. Belt being secured *Videographer: Important step*

3.4.2. Shot of sensor placed near excursion

3.5. Then use the hook-and-loop closing system to secure the belt around the Patient **[1]** and check the scanner display to confirm that the respiratory signal remains within the bounds of the minimum and maximum range **[2-TXT]**.

3.5.1. Belt being secured *Videographer: Important/difficult step* NOTE: There are also shots of the belt being repositioned and of the scanner display, showing that the respiratory signal should remain constant without clipping

3.5.2. Shot of scanner display **TEXT: If respiratory signal clipping, fasten or tighten belt**

4. Image Acquisition and Reconstruction

4.1. At 60 minutes, after registering the patient, select the whole-body protocol on the scanner **[1]** and click the optimal gated acquisition protocol **[2]**.

4.1.1. WIDE: Talent selecting whole-body protocol

4.1.2. SCREEN: 4.1.2: 01:02-01:12

4.2. Move the scanner table to the correct position for acquisition of the topogram **[1]**.

4.2.1. SCREEN: 4.2.2. – 4.3.1: 00:16-00:28

4.3. To initiate acquisition of the topogram, press the scanner start key on the scanner control box **[1-TXT]** and click the left mouse button on the topogram to set the scan range **[2]**.

4.3.1. Talent pressing scanner key **TEXT: Press suspend to halt or stop to abort acquisition**

4.3.2. SCREEN: 4.2.2. – 4.3.1: 01:08-01:22 *Video Editor: can speed up*

4.4. Then acquire a low-dose CT scan of the patient **[1-TXT]**.

4.4.1. SCREEN: 4.2.2. – 4.3.1: 01:25-02:21 *Video Editor: please speed up* **TEXT: CT: computed tomography**

4.5. Next, set the PET (pet) bed positions to be corrected for respiratory motion and set the image recording time for the bed positions **[1-TXT]**.

4.5.1. SCREEN: 4.2.2. – 4.3.1: 01:25-01:34 **TEXT: PET: positron emission tomography**

4.6. When the acquisition parameters have been, press and hold the **Start** key **[1]** until the scanner bed has moved back to the starting position **[2]** and press **Start** again to initiate the PET scan **[3-TXT]**.

4.6.1. Talent pressing Start key

4.6.2. Scanning bed moving to position

4.6.3. SCREEN: 4.4 – 4.5.1: 01:46-02:14 *Video Editor: please speed up*

4.7. During the acquisition, regularly check on the Patient **[1]** and the quality of the respiratory signal **[2-TXT]**.

4.7.1. Talent checking Patient

4.7.2. Shot of respirator signal **TEXT: Adjust respiratory belt as necessary**

4.8. At the end of the scan, confirm that the respiratory signal has been acquired **[1]** and initiate the scan reconstruction **[2]**.

4.8.1. SCREEN: 4.7.1 – 4.7.2: 00:56-01:10 *Video Editor: please speed up*

4.8.2. SCREEN: 4.7.1 – 4.7.2: 01:11-01:16

Protocol Script Questions

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

3.4.

B. What is the single most difficult aspect of this procedure and what do you do to ensure success?
3.4., 3.5. Securing the belt around the patient's chest is very important to capture a high quality respiratory signal, given that this signal is used to rebin the PET listmode data for image reconstruction of a motion-free PET image.

Results

5. **Results: Representative Non-Gated and Optimal Gated (ORG) ^{18}F-fluorodeoxyglucose (FDG)-PET-CT Imaging**

   5.1. The use of optimal gating in PET images results in an overall reduction of respiratory-induced blurring of the images **[1]**.

      5.1.1. LAB MEDIA: Figures 8 and 9

   5.2. For example, in a clinical evaluation of patients with non-small cell lung cancer **[1]**, optimal gating resulted in the detection of more pulmonary lesions **[2]** and hilar and mediastinal lymph nodes **[3]**.

      5.2.1. LAB MEDIA: Figures 8 and 9
      5.2.2. LAB MEDIA: Figures 8 and 9 *Video Editor: please emphasize P and S texts in images and/or magnified images in Figure 9*
      5.2.3. LAB MEDIA: Figures 8 and 9 *Video Editor: please emphasize P and S texts in images and/or magnified images in Figure 8*

   5.3. These differences can have an important impact on patient management, particularly in non-small cell lung cancer patients with early disease stages **[1]**.

      5.3.1. LAB MEDIA: Figures 8 and 9

   5.4. An important advantage of the optimal respiratory gating algorithm is that image quality can be determined by the user. In this figure, two different optimally gated PET **[1]** and non-gated PET images with different statistical quality can be observed **[2]**.

      5.4.1. LAB MEDIA: Figure 11 *Video Editor: please emphasize Figures 11B and 11D*
      5.4.2. LAB MEDIA: Figure 11 *Video Editor: please emphasize Figures 11A and 11C*

   5.5. As observed, lowering the duty cycle increases the amount of noise **[1]**, while the statistical quality of the optimally gated PET image reconstructed with a duty cycle of 35% and the non-gated equivalent image is kept constant **[2]**.

      5.5.1. LAB MEDIA: Figure 11 *Video Editor: please emphasize asterisk in Figure 11A*
      5.5.2. LAB MEDIA: Figure 11 *Video Editor: please emphasize corresponding area in Figure 11B*

5.6. The trade-off between image noise and the amount of motion rejection from the PET images is determined by the duty cycle **[1]**.

5.6.1. LAB MEDIA: Figure 11

Conclusion

6. Conclusion Interview Statements

6.1. **Willem Grootjans**: Although the image quality is maintained when using optimal gating, appropriate positioning of the belt prior to scanning is important for acquiring a high-quality respiratory signal **[1]**.

6.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera (3.4.)

6.1.2. Added interview shot: "Before administrating the radiotracer, it is important to measure the patient's blood glucose level". NOTE: Please add this at the end of the video or somewhere else.

