Practice Quality Improvement Project for Lung CT
A Patient and Staff Training Program to Reduce Motion Artifacts
(Resubmitted December 2008)

Background and Purpose

The contrast between the low attenuation of air and the higher attenuation of interstitial structures makes CT imaging of the lungs possible and useful. In turn, it is that inherent contrast that makes suspension of respiration by the patient during examination so important.

Accurate visualization of lung parenchyma is dependent on cessation of respiration by the patient. Although the standard procedure is to scan the thorax in full inspiration (total lung capacity), CT scanning in full expiration (residual volume) or during other respiratory maneuvers is occasionally required. Failure to properly educate technologists or failure of patients to understand instructions or cooperate with the technical staff may lead to a multitude of interpretation difficulties, including motion artifact(s) and distorting influence in lung attenuation. These complications can be avoided if simple steps are consistently taken to train and assist patients in breathing maneuvers.

The purpose of this project is to:

1) **develop** a program to train patients and staff in effective breathing cessation and maneuvers
2) **implement** that program in the radiology practice
3) **institute** a means of measure to assure that the program is followed consistently
4) **assess** the effectiveness of the program in reducing motion artifacts.

For more detailed discussion of the principles and premise of this program, and more information about lung CT procedures, we recommend the following resources:

- Alexander A. Bankier, Carl R. O'Donnell, and Phillip M. Boiselle. Respiratory instructions for CT examinations of the lungs: a hands-on guide. *RadioGraphics* 2008; 28: 919-931.
- Alexander A. Bankier, Sheida Mehrain, Daniela Kienzl, Michael Weber, Marc Estenne, and Pierre Alain Gevenois. Regional heterogeneity of air trapping at expiratory thin-section CT of patients with bronchiolitis: potential implications for dose reduction and CT protocol planning. *Radiology* 2008; 247: 862-870.
- Yeon Joo Jeong, Kun-Il Kim, Im Jeong Seo, Chang Hun Lee, Ki Nam Lee, Ki Nam Kim, Jeung Sook Kim, and Woon Jung Kwon. Eosinophilic lung diseases: a clinical, radiologic, and pathologic overview. *RadioGraphics* 2007; 27: 617-637.

PLAN

Step One--Assess

For a quality study, one has to have baseline data that measures as accurately as possible the extent of the problem in question. In this case, the information will come from radiology report review to determine how many CT examinations of the lungs are currently being influenced by possibly incorrect breathing maneuvers, resulting in motion artifacts. Follow-up will then measure improvement in imaging over time.

Such a retrospective study will present difficulty for many radiology practices. The first and most obvious barrier is not knowing whether breathing errors were consistently noted on each radiology report. Without being certain of reporting consistency, obtaining a truly accurate baseline is impossible. Completing the preliminary review, however, will afford some information about current practice and will provide a 'dry run' for future data collection.

The main purpose of the initial data collection process is to establish a baseline level of images with motion artifacts. No imaging acquisition system will be perfect, but based on patient population, staffing, acquisition protocols, and clinical judgment and expertise, the radiologist will be able to set a threshold number of compromised images above which the practice should not rise.

Choose a number of radiology reports for review. This number will be influenced by the volume of CT lung examinations performed by the practice but should be no fewer than 50 per month. A potential target might be 10% of the studies performed in one month, selected randomly. Say, based on volume that you decide to examine 75 studies. Choose a strategy for collecting your study sample--it could be the first 75 studies done in the month, the first 19 studies done each week, every third study performed until 75 have been selected, etc. Whatever sampling approach you decide, stick to the plan.

The review should result in the following data: 1) the total number of CT studies of the lung conducted during the study period, 2) the number radiology reports reviewed, 3) the number of reports on which motion artifacts were noted, 4) the number of studies in which patient training was documented (this may or may not be available through reviewing the report; if not, another means--such as a protocol checklist--may be used to document patient training), and 5) the number of incorrect breathing maneuvers noted. You can decide if you want to make this last tally a simple yes/no or keep subtallies of the types of breathing problems noted. If the latter, make sure that guidelines are developed about how to categorize the entries and that the guidelines are applied consistently. **See Appendix 1 for a sample spreadsheet that can be used for the review--note that when collecting baseline data the "number of radiology reports with completed checklists" row will remain empty**.

This data collection is made easier, more reliable and more valid when a department or practice has an expectation that reports will include information about patient training, artifacts, and patience adherence to breathing instructions. If you and your colleagues utilize a structured report, make sure that this information is included in the report elements. If not, involve your colleagues in the project by telling them what you are doing and asking them to be conscientious about noting relevant information in their dictations. Because this is a systems-based project, consider making it a group activity with buy-in and participation from everyone.

DO

Step Two - Intervene

For radiology technologists, CT imaging of the lung is routine. To them, the necessity of properly timed inspiration, breath-hold and expiration (when obtained) is self-evident. However, the environment and these procedures are stranger and more mysterious for patients. For this reason, and because the circumstances necessitating imaging are often stressful, pre-imaging instructions and training for patients is a good strategy for reducing motion artifacts and subsequent interpretation difficulties.

► *First, determine which member(s) of staff will provide the instruction for patients.* Often, a busy practice will not allow the radiologist to do this, and more than one person can be designated "coach." To ease stress and provide consistency, however, it is often best that the same person who will be performing a particular imaging procedure be the one to instruct the patient before imaging. It is also helpful if a coaching space is identified or if the space around the CT table is cleared of distraction. (If it can be done in a quiet, dedicated space with no distractions for the patient, coaching results are often better.)

► *Second, together with other staff who frequently perform and interpret lung imaging studies, develop a list of key elements that must be covered with each patient.* In developing this list, here are some important things to keep in mind.

1. Provide a simple, concrete explanation of the procedure to be done. Include what will happen, why the patient's cooperation is necessary, and what exact maneuvers the patient will have to perform. Encourage questions at any point in the explanation.

2. If the patient is not already on the CT table during training, try to put the patient in the same body position s/he will experience during CT imaging, and allow for some shifting and practice.

3. Remember the old teaching credo of Tell-Show-Do. First *tell* a patients what he/she will have to do, *show* how to do it, then have the patient *do* it. When practicing, encourage the patient to cough if needed. Often, this will reduce the instinct to cough during actual imaging.

4. When describing the maneuvers, try to give concrete examples and use demonstrative language. For example, when instructing a patient to perform maximum expiration, explain that it should be like squeezing a bottle. Observe the patient's response during practice, and be ready to provide alternative examples. Again, let the patient practice and allow for rest.

► *Third, use this list to develop a standardized form for use with each patient undergoing lung CT image acquisition.* It will serve as a checklist for staff providing consistent training. Items on the checklist should be informed by what was learned during baseline data analysis. **See Appendix 2 for an example of a patient training checklist.**

► *Finally, emphasize with staff two important things that should be done during CT imaging.* First, observe the patient response and behavior closely during training. Second, if there is any evidence that a maneuver may not been performed correctly, document the occurrence. This can be done on the technical note sheet or the radiologic report, but ideally it should be noted by all staff in the same manner. Regardless of where the notation is made, making it will emphasize to staff the influence an imperfect breathing maneuver can have on diagnostic results.

STUDY

Step Three - Interval Review and Analysis

After establishing these patient training procedures, radiology report reviews should be done at regular intervals. The frequency of those intervals will be influenced by considerations such as patient volume, staff availability, and staff turnover. The example spreadsheet in Appendix 1 assumes a monthly review. Once an interval has been selected, however, it is important to be conscientious in performing report reviews as scheduled. Each review should follow the same data collection procedures with regard to number of randomly selected reports and methods for counting and recording results. Where possible, it is desirable that the same person(s) perform data collection each time.

Review of the spreadsheet over time will provide some simple but important insights. First, it will take measure of how often patient training is taking place. Second, it will reveal if that training is having a positive effect on imaging. Third, it will show where the most common deficiencies are occurring.

ACT

Step Four - Re-measure and Adjust

A look at the numbers over an extended time is especially useful. It might reveal over the course of, say, three quarters, that breath maneuver errors are creeping up. In that case, the radiologist must take a closer look at the circumstances. Is it a matter of training growing less effective as it "becomes rote" for technology staff. In that case, a staff in-service program to reinvigorate the training might help. Have there been staffing changes? Training for new technologists as part of their employee orientation might be warranted. Has the place where patient education was taking place been changed to a supply closet? Time for Plan B. Or, is it a matter of a changing patient population? If so, perhaps entirely new approaches to training are warranted.

Adjust the intervention as necessary to address what you learn on your periodic data reviews. If the system breaks down, most often at a single step, can you modify your staff or patient training instructions to bolster procedure in that area?

Having these numbers and reviewing them regularly will help to grow and maintain a high level of quality CT lung imaging.

Appendix 1

Thoracic CT Examination Patient Training

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of Total Procedures												
Number of Radiology Reports Reviewed for Lung CT												
Number of Radiology Reports for Lung CT with Corresponding Completed Checklists/ Documentation												
Number of Motion Artifacts Noted												
Percentage of Errors **(Number of Errors/Radiology Reports Reviewed)**												

Appendix 2

Thoracic CT
Patient Training Guide/Checklist

1) Patient ID/name _____

2) Date _____

3) Scheduled Exam _____

4) Trainer _____

Initial each item below as completed.

____ 1. Explain procedure based on the following format.
We're going to perform a CT of your lungs when they're completely filled with air (and when they're empty, if appropriate for the patient). Just as with a snapshot, the less your lungs move while we're taking pictures, the better the pictures will be. We will need your help in doing that properly.

First, I'm going to ask you to take as big a breath in as you can and hold it and then hold still for 5 - 7 seconds. After that I'll ask you to empty your lungs as much as you can, and then hold still again for another 5 - 7 seconds. I'll be there to tell you when to do these breaths during your scan. And while we're practicing, you can stop and ask me any question you like. [During this session, the patient should be told whether the technologist or a remote electronic voice system will be giving them the instructions on breathing.]

____ 2. Place patient in body position(s) that will be used.

____ 3. Explain/demonstrate maneuver(s).
__ Inspiratory breathing __ Expiratory breathing
__ Breath hold
__ Other: _____

____ 4. Practice maneuver(s)
__ Inspiratory breathing __ Expiratory breathing
__ Breath hold
__ Other: _____

Note particular difficulty: _____