Reducing Breath-hold Artifacts on Abdominal MR

Primary Authors: C. Daniel Johnson, MD
James Ellis, MD
Mark Baker, MD
Joe Veniero, MD, PhD

Purpose and Rationale

This project aims to reduce the incidence of moderate to severe artifacts in adominal MRI studies related to inadequate breath-hold by the patient.

Breath-hold artifacts in upper abdominal MRI, when moderate to severe in quantity, can reduce diagnostic effectiveness. Despite breath-hold sequences that are widely available with all commercial MR equipment today, these artifacts are common. The goal is to have moderate or severe breath-hold artifact occur in 5% or fewer patient examinations.

Resources

Robson PM, Madhuranthakam AJ, Dai W, Pedrosa I, Rofsky NM, Alsop DC. Strategies for reducing respiratory motion artifacts in renal perfusion imaging with arterial spin labeling. Magn Reson Med, 2009. Jun 61(6):1374-87.

Lee VS, Lavelle MT, Rofsky NM, Laub G, Thomasson DM, Krinsky GA, Weinreb JC. Hepatic MR imaging with a dynamic contrast-enhanced isotropic volumetric interpolated breath-hold examination: feasibility, reproducibility, and technical quality. Radiology, 2000 May 215(2):365-72.

Rofsky NM, Lee VS, Laub G, Pollack MA, Krinsky GA, Thomasson D, Ambrosino MM, Weinreb JC. Abdominal MR imaging with a volumetric interpolated breath-hold examination. Radiology, 1999 Sep 212(3):876-84.

Wilson SJ, Brereton IM, Hockings P, Roffmann W, Doddrell DM. Respiratory triggered imaging with an optical displacement sensor. Magn Reson Imaging, 1993 11(7):1027-32.

Measure

Numerator # of exams with moderate to severe artifact
Denominator total # of exams

Collecting baseline data

Select a strategy for data collection. Radiologists can be asked to report the amount of respiratory artifact when dictating their study report, but this strategy depends on their training and good will. Alternatively, a single individual—radiologist, physicist, technologist, etc.—can be assigned to review a specified number of consecutive cases retrospectively. A third strategy would be to distribute and collect a respiratory artifact data collection form with each case; these would be collected daily and aggregated at the end of the data collection period.

In order to exclude bias in data collection, all consecutive cases up to a predetermined number, all cases between selected dates, or cases selected at a specified interval (e.g., first week of every month) should be used.

Determine how many cases you will collect in advance. Depending on the volume of abdominal MRI studies in your practice, a reasonable number would be something between 25 and 50.

A data collection form is attached for your consideration; you may wish to create your own, however.

If more than one individual is reviewing the cases, they should get together for a practice session where they look at cases and discuss how they should be graded until a consensus appears to be emerging.

Baseline Data Analysis

To look at the overall issue of breath-hold artifact, no further data analysis is required. The rate of moderate to severe artifact should be considered to determine whether it is acceptable. If improvement can or should be made, additional analyses can be done. For example, you may wish to look at other variables that seem to be related to the incidence of artifact, like underlying lung disease, age, general disability, presence of ascites, etc.

Factors that Can Influence Performance

After analyzing the baseline data, determine whether there is room for improvement. Reflect on your setting and practice, and identify factors that may have influenced your results. Design an intervention to address these factors. Possible contributors may include patient characteristics, such as age, history of lung disease, ascites, general disability, etc. Potentially, these higher risk patients could be identified prospectively for intervention.

- Involve the technologist in the issues they are encountering that result in breath-hold artifact. consider adopting changes in procedure for patients at risk for artifact. For example,
  Assess each patient's breath-holding capacity when setting up.

- Coach the patient on breath -holding.
- Time the breath-holding ability of the patient using a stopwatch or wall clock.
- Try nasal cannula oxygen if patients cannot breath-hold.
- Next, try to run the normal sequences on inspiration
- Next, try to run shorter sequences on inspiration
- Try to run very short breath- hold sequences on inspiration. This may require significant sacrifice in resolution.
- Finally, if all else fails run non breath-hold sequences.

Other potential interventions might be:

- Patient training using a video in the waiting area or a handout.
- Triaging patients to CT if patient is deemed to be a poor candidate for MRI
- Adjusting sedation levels if patients are somnolent or severely drowsy.

Shortening acquisition times can be achieved by:

1. Decreasing the slice number on some 2D sequences, allowing for decreases in TR
2. On 3D sequences, minimize slab thickness in order to reduce the number of partitions while maintaining a reasonable effective thickness.
3. Enlarge FOV and increase the rectangular FOV
4. Try to use an alternative plane (saggital may allow better use of rectangular FOV)
5. Decrease matrix size (# of phase encoding steps), but resolution will decrease.
6. Try sequence increasing the bandwidth. This will allow a shorter TR but will decrease the SNR.

In selecting an intervention, pick one to implement that you think has the best likelihood of positive effect. Do not perform multiple interventions at once, as if you do you will not be able to determine which one had an effect.

Technologists should be included in the improvement process to engender ownership.

Post-Intervention Data Collection and Analysis

Plan to collect data again at a set interval—three to six months after baseline and then at specified intervals thereafter for the duration of the project (one to three years is typical).

Make sure that cases are collected, tallies are performed and metrics are analyzed the same way as at baseline. The only exceptions to this would be to adjust the number of cases collected if more cases are needed for analysis or to correct a problem identified with the baseline data collection procedure. If so, once the procedure has been corrected use it consistently going forward.

Data should continue to be collected over time. If improvement is continuing, the same intervals for data collection should be recommended. As improvement plateaus the interval for measuring and the number of exams that are measured can be reduced—as long as the metrics are stable. If

a significant decrease in performance is seen (5 or more consecutive measures), the project should start anew with analysis as to cause and potential fix.

You may want to make a chart or graph of your performance over time to identify trends and patterns. Review the data with your project team after every data collection period.

At least a 20% improvement over the baseline percentage would be expected if the intervention is deemed worthwhile. This gain of 20% should be demonstrated for at least 4-5 consecutive cycles of measures.

If you are meeting your goals, no further changes may be necessary. However, you should plan to take steps to institutionalize whatever changes contributed to successful performance. If additional improvement is possible, look at your processes again and design additional interventions. It is likely that more than one technique will be needed in order to provide the highest level of artifact reduction in most patients. It is generally best to only make one intervention per study cycle so that conclusions can be drawn about what caused the observed effect.

At some point it is recommended that technologist-specific data be analyzed, as there may be technologists that are best performers and others that are low performers. Best performers should provide instructions and tips to the group as a whole about their successful techniques. Low performers should be identified and specific improvement plans created.

Once performance has stabilized or you feel the project is well underway, consider selecting and launching another PQI project.

DATA COLLECTION FORM

Pt. name:
ID number:
Pt. age:
Date of examination:
Technologist:

Respiratory artifact rating: _____on dynamic breathhold sequence (ultrafast gradient echo)

0 = no artifacts
1 = mild artifacts (no appreciable degradation of diagnostic ability)
2 = moderate artifacts (diagnostic ability is affected, but repeat examination is not required)
3 = severe artifacts (nondiagnostic examination)