# Respiratory Motion No Challenge for HD•Chest

## Full HD Lesion Detection for Every Patient, Every Day

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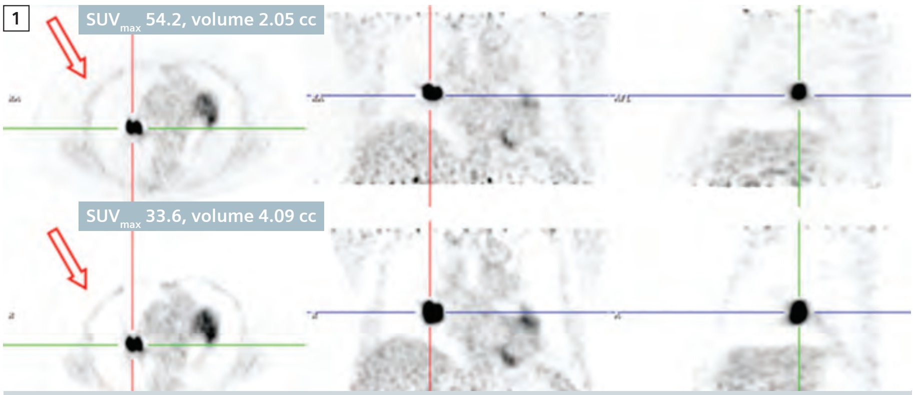
The visualization and quantification of thoracic lesions by PET is complicated by respiratory motion, which often causes lesion blurring. This can lead to an over-estimation of lesion volume, as well as under-estimation of radionuclide uptake by the lesion (expressed as the PET standardized uptake value or SUV). Motion-related blurring is commonly seen in lung nodules, as well as in liver and pancreatic tumors. Lung tissue, especially in the lower lung, moves mainly in the superior-inferior direction. Respiratory motion can be as large as 3 cm for lesions in lung bases. One study (1) reported that the range of tumor motion varied from 8 mm to 25 mm among 5 lung cancer patients. In addition to the advancements in PET technology like improved spatial resolution, point-spread function techniques and Time of Flight, HD•Chest from Siemens has considerably improved the ability of small lesions to be visualized by eliminating the impact of motion related blurring on visualization and quantification. Conventional phase-based respiratory gating of PET acquisition decreases motion artifacts and partial volume effects and delivers accurate estimation of tumor motion and more precise measurement of the maximum SUV (SUVmax). However, traditional gated PET techniques are associated with considerably increased acquisition and post-processing time as well as high noise levels in individual gate images. Due to complex patient setup and the needed increase in acquisition time, conventional phase-based respiratory gating during PET acquisition has not yet become routine. Lower count levels in individual gates necessitate longer scan times in order to achieve adequate count statistics. A respiratory-gated acquisition for a lung lesion in a single PET bed position my require 10 minutes, while standard non-gated PET images can be acquired in two to three minutes. In patients with irregular patterns of respiration, gated PET can lead to errors because of incorrect timing of data acquisition in the phase bins. Amplitude-based PET gating, which is a novel approach for gated PET acquisition, is a good method for respiratory motion reduction without the penalty of longer acquisition times and high image noise as seen in phase-based respiratory gating.




1 This comparison of non-gated PET (bottom) and HD•Chest (top) in a large lung tumor at the hilar level shows significant increase in SUVmax and almost 50 percent reduction in tumor volume with HD•Chest due to elimination of motion related blurring. Such improved quantification especially of tumor volume has implications in radiation therapy planning and can potentially help decrease GTV in radiation planning similar to what has been demonstration by 4D gated PET. (Data courtesy of National Jewish Hospital, Denver, CO, USA)

### Siemens Amplitude-Based Gating: HD•Chest

Siemens amplitude-based gating, HD•Chest, emphasizes that this approach delivers a high-definition PET image of the chest even though the patient breathes freely during the acquisition. HD•Chest integrates amplitude-based gating as an integral part of the whole-body PET acquisition and shortens the overall acquisition time compared to phase-based gating. This ensures images with minimum motion can be obtained for the relevant PET bed positions as part of the routine PET acquisition without undue increase in acquisition time as well as image noise as in 4D gated PET.

### HD•Chest—Initial Results

Early work using HD•Chest has been performed at the MAASTRO clinic in Maastricht, Netherlands. In 26 patients with lung tumors, non-gated PET, amplitude-based (HD•Chest) and 4D gated PET was compared. In general, SUVmax values calculated with HD•Chest and PET-4D were significantly higher than values calculated with non-gated PET. Average SUVmax values for 26 primary tumors were 12.9 ± 5.6

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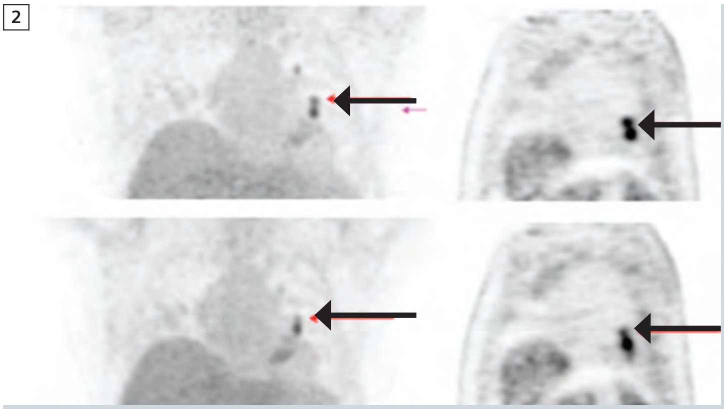

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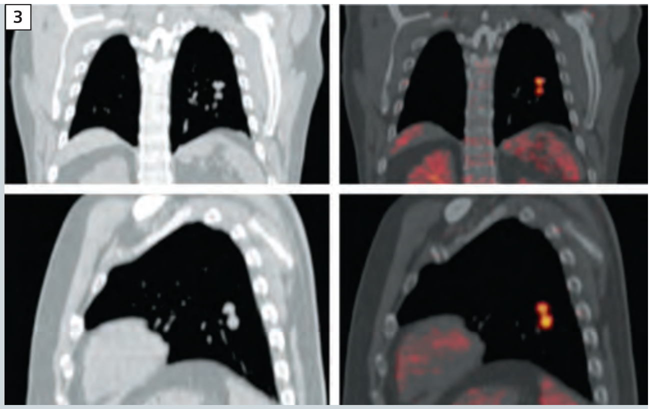

**2** This case example shows improved separation of two malignant nodular lung lesions close to each other with HD•Chest (top) while blurring due to respiratory motion is apparent from the non-gated study (bottom) with poor visualization of the upper nodule.

**3** Fusion of HD•Chest PET images with breathold CT in the same patient shows exact fusion of the two distinct hypermetabolic nodules with the nodules demonstrated on CT. Note the upper nodule is of similar size to the lower one. The upper nodule was however poorly visualized on non-gated image due to respiratory motion related blurring. Data courtesy of University of Michigan, Ann Arbor, MI, USA.

for non-gated PET, 13.5 ± 5.8 for PET-4D, and 13.9 ± 6.7 for HD•Chest. SUVmax derived from HD•Chest was 6.6±9.1 percent higher than from non-gated PET but were similar to values generated by 4D gated PET. Calculation of SUVmax by PET-4D was associated with substantial variation between different gates. Intragate variation of SUVmax ranged from 2 percent to 13 percent, which demonstrates the potential for error in calculating SUV values from 4D gated studies. The authors concluded that HD•Chest provides a reproducible solution for accurate SUV calculation for tumors that move during the respiratory cycle.

Tumor volumes measured by HD•Chest and 4D gated PET were significantly less than tumor volumes measured with non-gated PET, probably because tumor margins were less blurred by motion. However, calculated tumor volumes were similar between HD•Chest and averaged 4D gated PET. Visually, HD•Chest images were sharper than 4D gated PET images, with higher signal to noise ratios. Visual evaluation by radiologists confirmed that tumor margins were more easily visualized by HD•Chest than by non-gated PET, because there was less intrinsic motion blurring.

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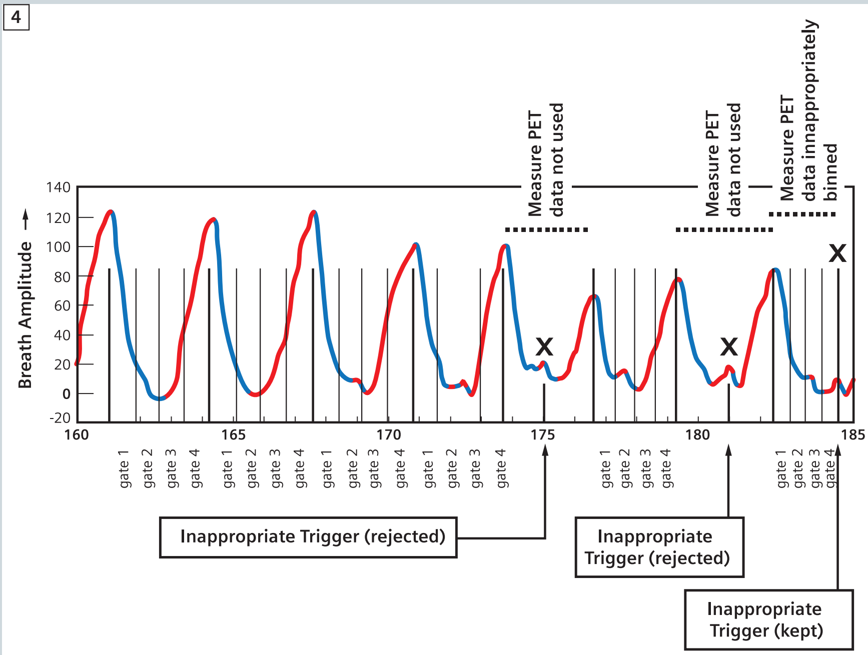


**4** Phase-based respiratory gating: Phase-based gatting with four gates, based on triggers at the end of inspiration.

Recommended Reading

1 Hamill JJ, Bosmans G, Dekker A. Respiratory gated CT as a tool for the simulation of breathing artifacts in PET and PET/CT. Med Phys. 2008 Feb;35(2):576-85.

2 Nehmeh SA, Erdi YE, Ling CC, Rosenzweig KE, Squire OD, Braban LE, Ford E, Sidhu K, Mageras GS, Larson SM, Humm JL. Effect of respiratory gating on reducing lung motion artifacts in PET imaging of lung cancer. Med Phys. 2002;29(3):366-71.

3 Lupi A, Zaroccolo M, Salgarello M, Malfatti V, Zanco P. The effect of 18F-FDG-PET/CT respiratory gating on detected metabolic activity in lung lesions. Ann of Nucl Med 2009;23(2):191-6.

4 Werner MK, Parker JA, Kolodny GM, English JR, Palmer MR. Respiratory gating enhances imaging of pulmonary nodules and measurement of tracer uptake in FDG PET/CT. AJR Am J Roentgenol. 2009;193(6):1640-5.

5 Chang G, Chang T, Pan T, Clark JW, Mawlawi OR. Implementation of an Automated Respiratory Amplitude Gating Technique for PET/CT: Clinical Evaluation J. Nucl. Med. 2009;51:16-24.

6 Wouter van Elmpt, James Hamill, Judson Jones, Dirk De Ruysscher, Philippe Lambin, and Michel Öllers Optimal gating compared to 3D and 4D PET reconstruction for characterization of lung tumours. European Journal of Nuclear Medicine Published online 11th January 2011.