Improving Myocardial Quantitation of Cardiac PET Using Data-Driven Gated PET/CT

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Introduction

- PET/CT registration is critical for quantitative cardiac PET.
- Manual rigid registration (MRR) of CT to PET, and average CT (ACT) derived from cine CT can mitigate misregistration caused by respiratory motion in thoracis region.
- However, CT images taken at deep inspiration are challenging cases to register with PET.
- More recently, end-expiration CT (EECT), also derived from cine CT, combined with data-driven gated PET, (DDG PET/CT), has demonstrated improved PET registration.
- We compared MRR, ACT, and DDG correction methods in cardiac PET in registration performance and quantitative accuracy.

Method

- ❑ Thirty Whole-Body FDG PET/CT examinations with significant myocardial uptake were included in the study.
- ❑ Cine CT was performed in the thoracic region of misregistration to generate ACT and EECT images. Attenuation-corrected (AC) PET images were reconstructed using MRR, ACT, and DDG methods.
- ❑ Shift of liver's superior point between PET and End Inspiration CT (EICT) and the one between PET and helical CT were measured to demonstrate that the patients are in deep breathing phase, and that's the cause of misregistration.
- ❑ Standardized 17-segments polar maps were obtained from the three AC methods and compared with default scanner's AC PET as the baseline, using Standard Uptake Value (SUV) percent change (SUV%Ch):

$$SUV\%Ch = \frac{SUV_{method} - SUV_{baseline}}{SUV_{baseline}}.$$

Results

- ➢ Figure 1.A and B compares the range of diaphragm motion in deep and shallow breathing. Part C displays these ranges over the dataset, and D shows the top point of diaphragm's downward shift between end expiration and PET is twice as that of the heart.

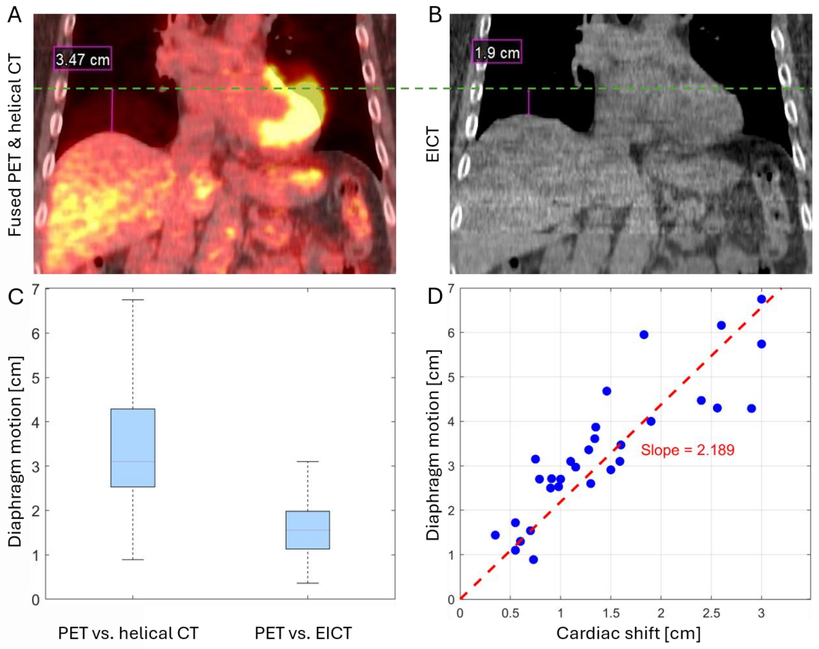

Figure 1 Displacement measurement of diaphragm's superior point in PET to equivalent locations in helical CT (A) and EICT (B). Box plots on the right show these ranges for the entire dataset (C). Diaphragm caudocranial shift vs. cardiac shift between EECT and PET uptake is shown in (D).

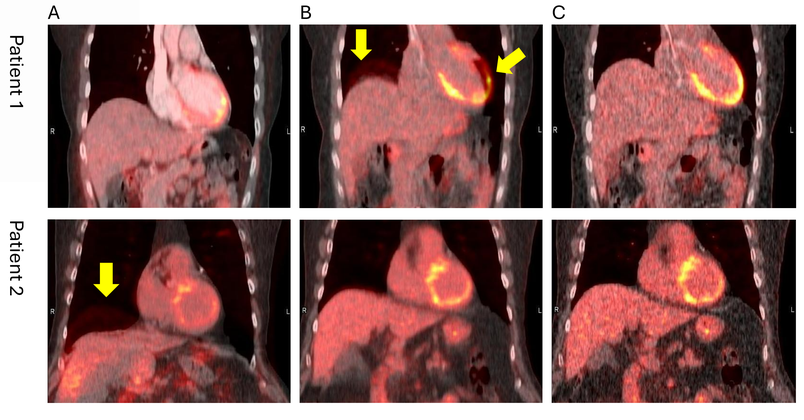

Figure 2 Examples of cardiac PET images corrected for attenuation using MRR (A), ACT (B), and DDG (C) methods, highlighting the effects of respiratory motion and organ misregistration on image quality and quantitative accuracy.

- ➢ Examples of issues with MRR and ACT in Figure 2, shows the limitations of each method:
  - ➢ MRR can't register the liver in deep inspiration.
  - ➢ ACT – but not DDG – was affected by irregular respiratory cycles or inconsistent inhalation.
- ➢ DDG method achieves SUV%Ch values that are about **6% higher** than ACT and **15% higher** than MRR on average (Figure 3).

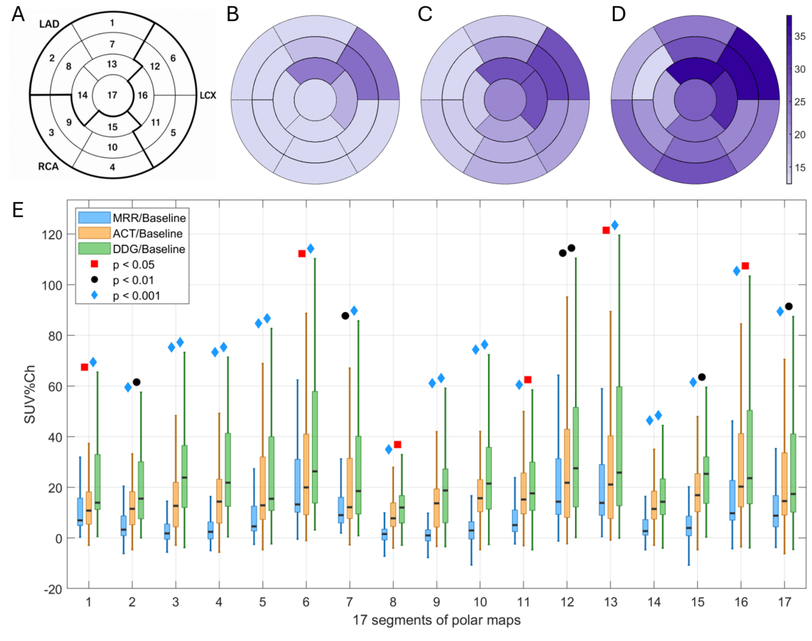

Figure 3. Standardized 17-segment polar map with major arteries (A). Median SUV%Ch by MRR (B), ACT (C), and DDG (D) methods. Segmental SUV%Ch range and relative statistical significance for the three correction methods (E).

Conclusions

- ❖ Diaphragmatic misregistration results in underestimation of myocardial uptake that cannot be compensated for by MRR.
- ❖ EECT, along with respiratory gated PET, provides more accurate registration in cardiac PET/CT, without requiring manual registration, and is more robust against irregular respiration.