Summary

Introduction

Accurate determination of patient-specific attenuation correction (AC) maps in simultaneous PET-MR imaging poses a significant challenge, primarily due to the lack of contrast between bone and air in MRI structural images. The pelvic region, with its high bone content, presents an even greater challenge for AC map estimation compared to the brain. Dixon imaging offers improved spatial resolution and soft tissue contrast, but current segmentation methods often misclassify bone as soft tissue. Recent advancements in PET-MR technology, combining PET, diffusion-weighted imaging (DWI), and high-resolution T_2-weighted prostate imaging, have enabled accurate detection of primary prostate lesions. Histogram analysis of PET and ADC parameters provides additional tumor data.

Aim of the Study

In this research, we aimed to improve PET image reconstruction for the prostate by utilizing accurate AC maps generated from Dixon-MR and CT images we aimed to leverage the benefits of both modalities. We enhanced the accuracy of PET images by employing a supervised augmented generative adversarial network (GAN), ensuring reliable and precise PET image reconstruction. Additionally, we explored the correlation between augmented deep learning methods for ^{68}Ga-PSMA-11 PET scans and MR ADC maps, comparing them to conventional PET-MR approaches.

Materials and Methods

Our study involved collecting CT and PET-MR images from patients with prostate cancer. Our evaluation focused on assessing errors in bone and soft tissue regions in AC maps and reconstructed PET images. In addition, we employed K-fold cross-validation and data augmentation for deep learning. By employing these methodologies, our goal was to enhance our understanding of prostate cancer imaging and advance the application of deep learning techniques in this field.

Results

We evaluated the performance of PET reconstruction using ROI analysis. The deep learning (DL) method effectively classified and identified bone throughout the entire body, exhibiting higher accuracy as indicated by Dice coefficients. We calculated the average relative absolute errors for the reconstructed PET images and observed significant improvements compared to other techniques. The DL-based MR methods showed a 4.5% increase in accuracy for pseudo-CT AC maps compared to standard MR techniques. Regarding the correlation between ADC and SUV values, we successfully registered the ADC maps from 27 out of 32 patients to T_2 images. The results revealed an inverse correlation (-0.20 to -0.51) between ADC and SUV values in prostate cancer zones.

Conclusions

We presented a deep learning-based MRAC pipeline that has the potential to outperform conventional approaches and significantly improve bone segmentation. The reconstructed PET images exhibited remarkable similarity between CT-based μ-maps and DL-based μ-maps compared to MR-based μ-maps. Furthermore, the DL-based SUV values demonstrated a considerably stronger correlation with ADC values compared to values derived from PET-MR. Bit a considerably stronger correlation with ADC than values derived from PET-MR.

Key words: PET-MR, PET-CT, PSMA, prostate cancer, ^{68}Ga-PSMA-11 and ADC maps, DWI (Diffusion-Weighted Image)