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Modeling PET tracer uptake kinetics in inflammation and infection imaging using a porcine osteomyelitis model – preliminary results

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Introduction
Bone marrow infection (osteomyelitis) is a severe condition that can result in degradation of the affected bone and disability, as well as systemic infection originating from the osteomyelitic focus. Osteomyelitis is often hard to treat with antibiotics, and surgery is frequently needed.

The present study investigates PET scanning (Positron Emission Tomography) of pigs with experimental osteomyelitis, modeling the human condition, and permitting testing of new diagnostic tracers. PET uses short-lived radioactive tracers to reveal physiological and pathophysiological events in the living body. Using dynamic (rather than static) PET scans allows kinetic analysis of the results. This can reveal details of the uptake process, thereby giving more information on the advantages and disadvantages of the studied tracers.

Kinetic modeling
To study the uptake and release of the tracers, kinetic modeling was performed. Volumes-of-interest (VOI) were drawn on lesion sites in the right limb. To compare with non-infected sites, similar VOIs were drawn at the same anatomical position in the non-infected left limb. In this preliminary analysis, all considered volumes were spheres of approximately the same size as the lesions as seen on the CT scans.

For a given VOI, the mean PET signal (Bq/mL) over time was analyzed as follows:

Water

Kwater

\[ \frac{N_water}{C_water} \]

\[ \frac{1}{t} \]

Equation 1

The possible infection/inflammation tracers were analyzed with the compartment model shown in Figure 2b. This model describes the reversible uptake from a compartment to the blood.

Briefly, the Patlak model assumes that after some time, blood and tissue concentrations are in equilibrium. The ratio K describes the irreversible uptake from this compartment.

Figure 2. Models for kinetic analysis

Discussion and outlook
Inflammation and infection usually results in increased blood flow, at least in the acute state, and it is therefore surprising that these two lesions had uptake (blood flow) at the same level as the corresponding non-infected positions in the opposite leg. Further analysis of these and other lesions are to be made to see if this finding is general for osteomyelitic lesions, which could be a part of the inability of systemic antibiotic therapy.

Of the possible infection/inflammation tracers, FDG uptake was found to have the highest uptake ratio relative to the non-infected side. A high ratio was expected since it is a glucose analogue and can accumulate in the affected tissue in the presence of high glucose levels.

The series of pig scans continues, but without PK11195 as a tracer. Knowledge of which tracers are taken up by osteomyelitic lesions can hopefully lead to improved scanning of patients with suspicion of osteomyelitic infections.

References

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