A population kinetic model for $^{18}$F-choline in prostate cancer patients

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AIM
The MADEIRA Project (Minimizing Activity and Dose with Enhanced Image quality by Radiopharmaceutical Administrations) aims to improve the efficacy and safety of 3D functional imaging by optimizing, among others, the knowledge of the temporal variation of the radiopharmaceuticals’ uptake in and clearance from tumor and healthy tissues. The aim of the present study was to optimize the time schedule for data collection and improve the evaluation of the organ doses to prostate cancer patients undergoing investigation with $^{18}$F-choline.

MATERIALS AND METHODS
Biokinetic data were collected at Malmö University Hospital in 10 patients undergoing screening with $^{18}$F-choline for recurrence or metastasis after prostate cancer. Activity concentrations in liver, kidneys, spleen, and (if present) tumour were quantitatively determined up to four hours post-administration by means of PET and PET/CT imaging. Additionally blood and urine samples were collected at different times post-administration and the activities in those samples were measured with a gamma counter. Starting from these data, a compartmental model was developed using the forcing function method and the population kinetic approach with the pharmacokinetic/pharmacodynamic modelling software ADAPT 5, and reference radiation dose values for a typical patient were estimated.

RESULTS
The developed model structure consists of one central compartment, representing the blood, and seven compartments, which describe the peripheral organs and the elimination pathways. The population standard deviation was found to be lower than 60% for all model parameters, indicating that this general structure is able to describe successfully the biodistribution of the radiopharmaceutical in a typical patient. The organ receiving the highest radiation dose is the kidney (0.083 mGy/MBq). Doses to liver and spleen were estimated at 0.062 mGy/MBq and 0.042 mGy/MBq respectively. On the basis of the model calculations, it was also shown that PET scans taken later, between 90 and 120 minutes after injection of $^{18}$F-choline, have the potential to improve the detection of malignant lesions during diagnostic examinations.

CONCLUSIONS
The population kinetic model developed in this study was successfully used to describe the biodistribution of $^{18}$F-choline in prostate cancer patients. With the help of the model, reliable estimates of the organ doses to the patients were calculated, and suggestions for an improved diagnostic protocol introduced.

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