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## Publishable Summary for 19SIP04 TracPETperf

### Software for evaluating PET cardiac perfusion imaging uncertainties for more accurate diagnosis

#### Overview

The aim of the project is to maximise awareness and minimise the effect of the uncertainties in cardiac PET (Positron Emission Tomography) perfusion imaging in the research and clinical environment. This will be achieved by: incorporating the 15HLT05 project results into a Monte Carlo add-on for the Carimas software (<https://turkupetcentre.fi/carimas/>) used for perfusion quantification and by developing a semi-automatic classification software that highlights the suspected regions of ischemia in the perfusion maps, to assist clinical decision-making. In addition, relevant documentation explaining the implemented uncertainty quantification for the software package will be provided and disseminated to the wider PET perfusion community.

#### Need

The quantification of perfusion in PET images is highly sensitive to acquisition parameters. However, even though this is known to be the case, the uncertainties associated with these parameters are not currently provided in software implementations of perfusion analysis. This limits the usefulness of such measures as they are not easily comparable between centres, or even between different acquisition types at a single centre. Additionally, this means that uncertainty exists in the source of variations between measurements, where it is not known whether variations in perfusion measurements come from variations within the patient or variations due to scanner parameters.

To be fully quantitative, perfusion measurements require associated uncertainty measurements, as highlighted in the EMPIR project 15HLT05 PerfusImaging. This also allows for more confident comparison of results across centres and within centres over time. Therefore, there is a need for improved access to uncertainty quantification tools; that can enable clinicians to better understand their decisions; as variations could be more accurately attributed to: either true underlying changes in patient physiology or scanning parameters.

Validated, easy to use and accessible software would provide clinicians with associated uncertainty information that would improve image interpretation and hence, quantification. The project will address this need by developing a uncertainty package based on a Monte Carlo model as described in Supplement 1 to the Guide to the Expression of Uncertainty in Measurement (GUM); to simulate errors due to the factors identified in 15HLT05 PerfusImaging. The software will also come with an associated protocol for calibration using a phantom (physical test object). This will enable the end user to understand key sources of uncertainty in their measurement systems. A clinical interpretation of the uncertainty will be derived from an existing dataset of patient scans.

#### Objectives

The overall aim of the project is to create clinical and research impact from the results of the EMPIR project 15HLT05 PerfusImaging, for cardiac perfusion PET imaging. The project addresses the following objectives:

1. To develop a Monte Carlo add-on for the Carimas software which can evaluate measurement uncertainties in a cardiac PET perfusion pipeline.
2. To establish technical validation and calibration protocol using information from a multi-centre phantom study between partners, and to produce documentation relating to the relevant acquisition protocols to extract the necessary information about the gantry used.
3. To develop a semi-automatic classification software based on the results of 15HLT05 PerfusImaging, which will consider associated uncertainties in perfusion classification.
4. To produce a recommended clinical guideline (CG) whereby the disease classification results have an associated uncertainty that will provide clinicians and researchers with more information upon which to decide treatment paths.

## Results

The expected outputs in relation to the objectives of the project are:

1. A software add-on to the Carimas package, which propagates the uncertainties associated with cardiac PET perfusion measurements for improved quantification. In addition, knowledge transfer to the primary supporter through the application of the software to clinical data obtained at the Turku PET centre (*Objective 1*)
2. Protocol from a multi-centre phantom study used to validate the software and provide research centres with enough information to carry out their own validations. (*Objective 2*)
3. A semi-automatic classifier along with associated clinical guidelines that will provide information and improve diagnostic confidence on how the uncertainties affect the classification of patients as ischemic/non-ischemic. (*Objectives 3 and 4*)

## Impact

### *Impact on the Primary Supporter, end-users and the wider PET community*

Immediate impact is expected through the distribution of the software, to all current users of Carimas as well as the Primary Supporter. This will ensure awareness of the importance of uncertainty quantification within a wide section of the PET perfusion community. Moreover, beyond the usage base of Carimas users, the results could be implemented in the future as a standalone package or implemented into various imaging software packages. Eventually, after the initial validation with the Carimas user base, the package will then be disseminated to the wider PET perfusion community. By providing a visual and quantitative estimate of the uncertainties related to a perfusion scan, the end user will be informed of the errors within modelled perfusion images. This will aid in the interpretation of how errors in the acquisition and reconstruction processes affect the calculation of perfusion values. The results of the error modelling can also be used to reduce the variability due to technical factors and thus increase the repeatability and reproducibility of the subsequent perfusion scans. In this manner, the comparability of perfusion values across different imaging systems or sites in multi-centre studies will be greatly improved.

There are currently no widely available reference standards or software solutions to assess and minimise the effects of measurement uncertainties across various imaging devices or sites in myocardial PET perfusion measurements. As a result of this project, a standard software, acquisition protocol with the corresponding calibration sheet could be provided for harmonisation and quality control purposes which will also benefit the wider PET community

### *Long term socio-economic impact*

Longer term impact is expected to be clinical, once uncertainties become part of the diagnostic pipeline. There is currently no diagnostic software which would display the quantified perfusion value with an associated uncertainty. Displaying associated uncertainties with automatic classification of suspected regions would greatly enhance the reliability of the diagnosis in cases which are borderline between healthy and ischemic states whilst also allowing clinicians to determine whether further tests are necessary to make a reliable diagnosis.

The enhanced quantification is expected to modify practice as clinicians will have more information available when deciding whether further tests are needed. This will lead to improved and cost-effective healthcare for patients thus creating social and economic impact across Europe.

Project start date and duration:		01 July 2020, 24 months	
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