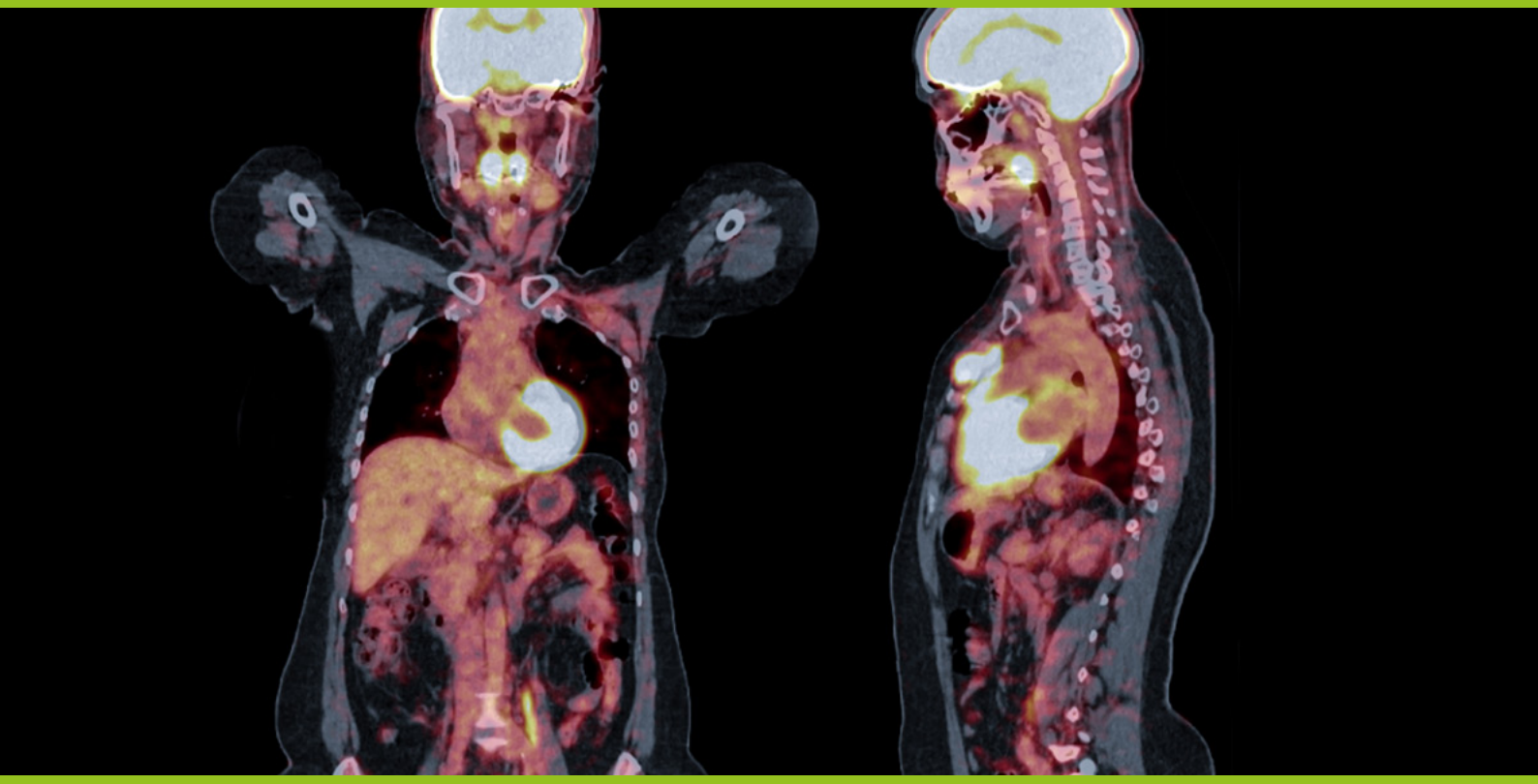
European Metrology Programme for Innovation and Research

Delivering Impact



Enabling a quantitative approach to cardiovascular disease diagnostics

Cardiovascular disease (CVD) covers a range of blood vessel and heart disorders. For many CVD-subtypes the changes of blood supply to the heart muscle plays a significant role, which would benefit from quantitative measurements. However, the 'gold standard' technique used to diagnose these conditions lacks metrological traceability and variations in interpreting results can lead to false diagnoses endangering patients.

Europe's National Measurement Institutes working together

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets future needs.

Challenge

Over a third of all deaths in the EU are caused by disorders of the heart or blood vessels collectively described as cardiovascular disease (CVD), making it the leading cause of mortality. As well as the significant social toll, CVD is also estimated to cost the EU economy around €210 billion a year. The current 'gold standard' method to diagnose CVD, and hence direct appropriate treatment, is through measuring the blood flow or 'perfusion' in affected organs and tissue using Positron Emission Tomography (PET). In this technique a radionuclide is injected into a patient and the perfusion monitored using a PET scanner. From this scan, an image or cardiac perfusion map is derived which is used to make clinical decisions. The assessment of PET perfusion is usually performed quantitatively using specific cut-off thresholds by visual inspection or by describing the image intensity, however the measurement uncertainties affecting the perfusion values are not taken into account in the interpretation of the perfusion images. The expertise of the clinicians interpreting image maps can also add an additional source of error. This can lead to significant variation in results using the imaging technique applied at different centres or between this and alternative imaging techniques. In clinical practice, these factors can lead to false diagnoses, patient distress and unnecessary treatments.

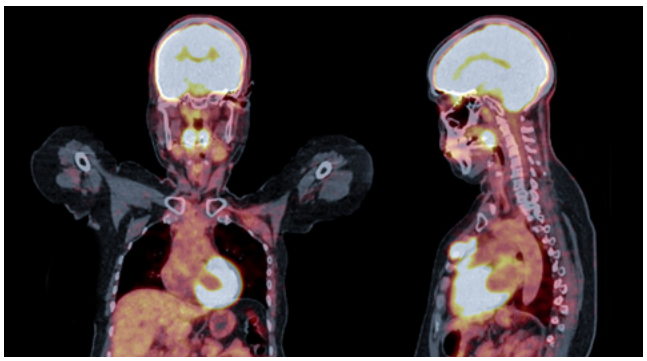
Solution

During the EMPIR project *PerfusImaging* the UK's National Metrology Institute, NPL, and Finland's Turku PET National Research Institute, TPC, examined methods for PET image quantification. To identify the most influential parameters in the perfusion quantification pipeline, a sensitivity analysis was performed and a first ever calibration standard for PET scanners was developed. Furthermore, analysis was performed on around 130 clinical PET scans from patients at TPC.

This resulted in the development of a risk-based decision-making framework, incorporating uncertainty information which allows less experienced clinicians to make better decisions regarding patient health, improving the diagnosis of CVD from PET images.

Impact

TPC is responsible for training medical experts and performs around 3500 PET studies per year in clinical and research imaging for cardiology, oncology, and other clinical areas. As well as patient images TPC brought a clinical perspective and expert experience in perfusion map analysis to the project. In return TPC is now able to model the factors that can affect scan results and assign uncertainties to them. The institute is now developing the method as an add-on to its Carimas image processing software in the follow-on EMPIR project TracPETperf with NPL. When completed this software will analyse PET perfusion images and display measurement uncertainties as an interpretable and actionable visual map in addition to the perfusion values. Not only will this allow less experienced clinicians to make better decisions regarding patient health, but it can also be used as a screening tool to ensure the most severe cases are prioritised and increase confidence in clinical reading with borderline cases. Once validated the add-on will also be offered to manufacturers using proprietary software. The outcomes developed in the project will enable more reliable diagnoses of perfusion issues, allowing clinicians to provide personalised and timely patient treatments for improved survivability and quality of life.



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New standards and tools to validate emerging techniques to identify those at risk of CVD

In the EMPIR project PerfuImaging:

- A physical standard phantom prototype was produced for quantitative medical imaging that realistically mimics spatially varying perfusion regions.
- The world's first [^{15}O]H_2O positron emitting radionuclide standard was developed to allow the calibration of equipment used for the diagnosis of heart conditions.
- The project also addressed the measurement of radiation dose, which occurs in perfusion scans, for different types of X-ray computed tomography (CT) scanners using mobile measurement equipment.
- For cardiovascular magnetic resonance imaging new analysis software was designed that can quantify perfusion values from the measured data and can assign an uncertainty to the perfusion value in each pixel of a perfusion map.
- In addition, a new analysis method was applied to perfusion maps from Positron Emission Tomography (PET) scanners to analyse images and display data as an interpretable and actionable visual map.

The new standards, instruments and software tools developed represent a first step towards applying metrology practices to the diagnosis of CVD.

EMPIR EURAMET

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www.euramet.org/project-15HLT05

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