Translation of Virtual Physiological Human concepts into clinical systems and services for disease understanding and interventional planning

Jürgen Weese & Olivier Ecabert
Philips Research

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euHeart – Integrated Cardiac Care Using Patient-specific Cardiovascular Modeling

**euHeart** is about the development, personalization and validation of computational models of the heart to improve:
- Diagnosis,
- Treatment planning,
- Interventions and
- Design of implantable devices

5 clinical focus areas:
- Cardiac Resynchronization Therapy
- Radiofrequency Ablation
- Heart Failure
- Coronary Artery Diseases
- Valves and Aorta

**Project coordination:** Philips Research
**Scientific coordination:** The University of Oxford
**Clinical coordination:** King’s College London

17 partners (6 companies, 6 universities, 5 clinics)

Budget ~19M€ (~14M€ EU funding)
List of Partners

Universities and research institutes
- INRIA, Sofia Antipolis, FR
- INSERM, Rennes, FR
- University of Karlsruhe, DE
- UPF, Barcelona, SP
- University of Sheffield, UK
- University of Oxford, UK
- Amsterdam Medical Center, NL

Industrial partners
- Berlin Heart, Berlin, DE
- HemoLab, NL
- Philips Healthcare, NL & SP
- Philips Research, DE
- PolyDimension, DE
- Volcano, BE

Hospitals and clinics
- KCL, London UK
- DKFZ, Heidelberg, DE
- INSERM, Rennes, FR
- HSCM, Madrid, SP
- Amsterdam Medical Center, NL
Project Objectives

1. To develop, share and integrate multi-physics and multi-level models of the heart and great vessels in normal and pathological conditions to address the clinical challenges targeted in euHeart.

2. To develop and validate automated methods for the consistent interpretation of multi-modal clinical images.

3. To develop and apply specific and general strategies for model personalisation.

4. To integrate the multidisciplinary results into prototypes and to carry out validation at clinical sites.

5. To optimise catheter and surgical interventions and tuning of devices for better treatment delivery and clinical outcome.

6. To collect evidence of and to quantify the clinical benefit of the approaches developed above for prediction, accurate diagnosis, and disease quantification as well as improved therapy of CVD.
Need for Demonstration of VPH Added Value

VPH new to end user communities (i.e., clinicians and industry)

Strong interests and high expectations but
- Translation has not taken place yet
- Predictive value has still to be demonstrated
- We need to convince through success stories

What do we do in euHeart?
- High focus on clinical applications with large parts of the project dedicated to prototype development and clinical validations
- Collect evidence of benefit compared to current clinical practice
- Close collaboration with clinicians and industry to improve buy in
- See next slide
Project Structure

VPH

ICT Technology
- Integrated Multi-scale Cardiac Modelling
- Modelling Standards and Software Tools
- Anatomical Model Personalisation
- Biophysical Personalisation

Cardiac Radiofrequency Ablation
Cardiac Resynchron. Therapy
Heart Failure
Coronary Artery Disease

Valvular and Aortic Disease

Patient-specific Simulator

Valve + Aorta

CRT
CRF
HF
CAD

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Integration into Clinical Workflow

To be successful, VPH technologies must fit the established workflows

- **Ease of use**
- Seamless integration
- **Should work with as few input as possible** (ideally not more or even less than today)
- Needed clinical data as standard as possible
- If data are available, then make the most of it

What do we do in euHeart?

- We are still in the validation / demonstration phase but…
- … we will have intensive discussions with clinicians / industry
Technical requirements (1/2)

The VPH will not be finalized with the next 5 years!
- First, demonstrate benefits on some clinical applications
- Then, incrementally extend and generalize concepts

VPH tools should be
- Highly automated
- Robust
- “Fast”
- Easy to use (for clinicians) and to integrate (for industry)
- Well documented
  - Up-to-date quality documentation
  - Verification
  - Responsibility?
Technical requirements (2/2)

VPH tools should be (continued)

- Adaptable
- Extendable
- **Modular**
  - Exchange of components should be controllable
  - “Limited effect of changing one line of code”.
- Need for well-defined interfaces and standards
  - Models: CellML, FieldML, etc
  - Images: DICOM, etc.
Open Source?

- Depend on license types
  - Industry would like as few constraints as possible

- Who should care of legal approval for clinical use / certification?

- Intellectual Property
  - who is responsible if IPs are violated?
  - who will check?

- Quality requirements vs. quantity of tools

- How to deal with industrial timelines, release of products?
Disease Understanding

- Thorough disease understanding requires the personalization of numerous model parameters.

- More information will be available but
  - **Less is more**
  - Focus on the clinical relevance
  - Provide all information on demand
  - Clinicians like go/no go statements
    - Make use of a improved understanding to ascertain decisions.

- Numerous and large clinical studies will be needed for validation.
Disease Understanding (2/2)

What do we do in euHeart?

– Why does the heart sometimes (~5%) recover after the implant of a LVAD?

– Should a patient be stented in case of CAD (stented patients have shown to have poor survival rate after 3/5 yrs)?

– Why 30% of the patients selected for CRT do not respond or worsen?