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### What is the VASCUL-AID platform which uses AI to predict cardiovascular disease progression in AAA and lower extremity lesion patients (PAD): Interesting findings to date

Project coordinator: Kak Khee Yeung

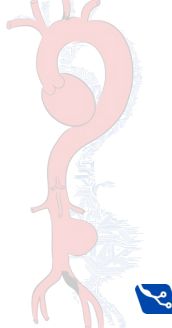




## Disclosures

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Project number 101080947




### VASCULAID consortium

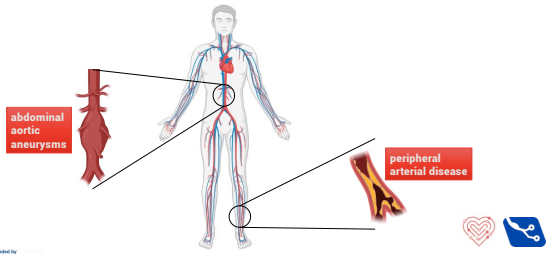
Nr	Short	Full name	Country
1	VUMC	Amsterdam UMC, location VUmc	NL
2	AMC	Amsterdam UMC, location AMC	NL
3	BFS	Brightfish B.V.	BE
4	UOT	University of Twente	NL
5	FMUP	University of Porto	PT
5.1	UAVE	University of Aveiro (AE)	PT
5.2	HSJ	Hospital São João (AE)	PT
6	CHUN	Nice University Hospital	FR
7	ALLAI	Alliance for Responsible AI	NL
8	UOB	University of Belgrade	RS
9	HUS	Helsinki University Hospital	FI
10	VINS	Vinča Institute of Nuclear Sciences	RS
11	UIB	University of Bergen	NO
12	MHB	Brandenburg Medical School	DE
13	OX	University of Oxford (AP)	UK
14	AKH	Asklepios Kliniken Hamburg (AP)	DE

16 partners: 12 beneficiaries, 2 affiliated entities (AE), 2 associated partners (AP), 9 EU countries




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### Cardiovascular diseases (CVDs) are the leading cause of death globally, taking an estimated 17.9 million lives each year




abdominal aortic aneurysms


peripheral arterial disease


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### Aortic aneurysms


Asymptomatic  
2-8% male population >60 yrs <sup>[1]</sup>  
1-2% female population >60 yrs <sup>[2]</sup>

90%  
Chance of mortality if ruptured 

40%  
Will not reach the hospital 

50%  
Chance surviving surgery 


→ Prevent rupture


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[1] Danish Surgical Aneurysm Audit - jaargang 2018  
[2] Wanhainen, A., et al. Eur. J. Vasc. and Endovasc. Sur. (2019)


### Peripheral arterial disease

Symptomatic  
5,6% global prevalence of people aged >29yrs <sup>[1]</sup>

High-risk for cardiovascular ischemic events <sup>[2]</sup> 

Adverse limb events associated with a 1-year mortality rate of 20% <sup>[3]</sup> 

→ Prevent adverse limb events

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[1] Song, P., et al. Lancet Glob Health (2019)  
[2] Geisenhartler, A., et al. Vasc Health Risk Manag 16, 417 (2014)

## Unmet need

**Need for technology to predict the disease progression and cardiovascular events**

**Personalized diagnosis & treatment**

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# VASCUL-AID

## Prediction of vascular disease progression and the risk of cardiovascular events in AAA and PAD patients

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### VASCUL-AID platform

**CLINICAL DATA**

- Genomics
- Proteomics
- Lipidomics
- Medical imaging

**MEDICAL & PATIENT REPORTED DATA**

- Blood pressure
- Smoking habit
- Medication
- Quality of life

**LIFESTYLE DATA**

- Physical activity (walking distance/steps)
- Heart rate

**PATIENT SPECIALIST**

**VASCUL-AID**  
Personalized cardiovascular and disease progression risk predictive platform

**PERSONALIZED PREVENTION STRATEGIES**

**LOW-RISK**

- Spacing medical follow-up
- Medication and lifestyle adjustments (if needed)

**HIGH-RISK**

- Early referrals to cardiologist or vascular internal medicine specialist for strict CV risk management
- Medication and lifestyle adjustments
- Early vascular intervention

Automatic image-analysis tool  
Risk-prediction clinical tool  
Patient communication tool  
Lifestyle data collection tool

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## The clinical studies

RETROSPECTIVE DATA	PROSPECTIVE DATA	
5,000 AAA patients	350 AAA patients	150 AAA patients
6,000 PAD patients	420 PAD patients	180 PAD patients
Existing biobanks (> 20,000 patients) FinnGen project, Parel AAA, Oxford biobank, MAAAGI-trial, HUSVASC, DREAM-trial, AJAX-trial, UOB Biobank, SUPER-study and GermanVasc cohort	Discovery cohort	Validation cohort

Personalized cardiovascular and disease progression risk predictive platform

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### VASCUL-AID will combine extensive datasets and prospectively collected data

RETROSPECTIVE DATA	Data-infrastructure
5,000 AAA patients	Extensive data-dictionary
6,000 PAD patients	Patient reported data: Castor EDC
Existing biobanks (> 20,000 patients) FinnGen project, Parel AAA, Oxford biobank, MAAAGI-trial, HUSVASC, DREAM-trial, AJAX-trial, UOB Biobank, SUPER-study and GermanVasc cohort	XNAT Health-RI imaging server

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## Workpackages

**WP 2 Data collection and standardization**

- Standardization
- Virtual repository
- Data collection

**WP 3 & 4 AI-based tools for predicting risk of disease progression for AAA (WPs) and PAD (WPs)**

- Automatic image-analysis tools (integrating -omics)
- Risk prediction clinical tool
- Patient communication tool
- Lifestyle data collection tool

**WP 5 Real world data collection via a patient app**

- Patient app
- Client decision support dashboard
- Visualization tools
- Support for engineers and healthcare professionals

**WP 6 VASCUL-AID Clinical validation**

- Prospective validation studies
- Cost savings
- Quality improvements

**WP 7 Regulatory and ethics - AI**

- Mapping regulations for AI in healthcare
- Developing guidelines
- Ensuring legal and ethical alignment of the platform
- Rating Assessment

**WP 8 Communication, dissemination and exploitation**

- Optimization of the platform

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### Current updates


- Started in May 2023, hiring people
- Website
- Data dictionaries for PAD and AAA (HAI)
- Conducting the Delphi studies about the core outcome sets with KOL and patients
- Data infrastructure building and collecting the data
- Aligning Protocols, Data sharing agreements
- AI image analysis started
- Ethical approval gained for retrospective data collection, prepared for prospective study
- Omics: proteomics data study, genomics data study → starting pilots

AI Act → workshop ethics & legal framework

Faculty of the University of Twente

### WP3&4

## Examples of ongoing studies/results



Associate Prof. Dr. Jelmer Wolterink

Faculty of the University of Twente

### Medical image analysis

We will extract information from

- >12,000 AAA and PAD patients
- CT, US, MRI acquisitions

RETROSPECTIVE DATA	PROSPECTIVE DATA
5,000 AAA patients	350 AAA patients
6,000 PAD patients	420 PAD patients
	150 AAA patients
	180 PAD patients
	Discovery cohort
	Validation cohort

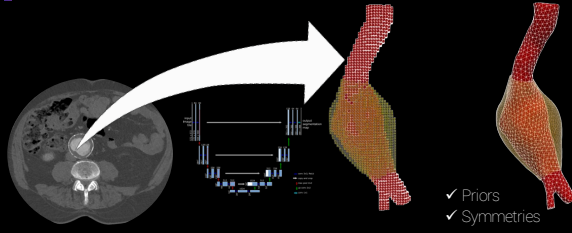
Quantitative biomarkers

- Areas, volumes, diameters
- Shape
- Function

! Need for automatic processing pipelines

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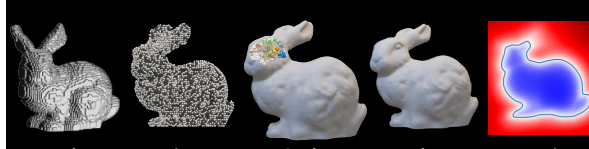
### Segmentation



✓ Priors  
✓ Symmetries

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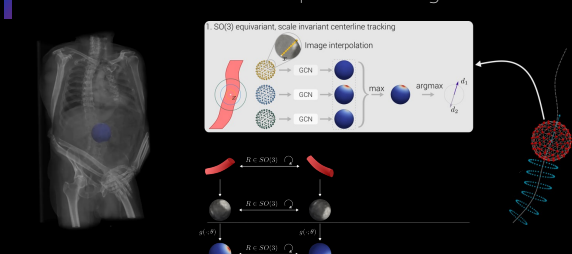
### Geometric deep learning



Voxels Points Graphs Meshes Functions

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### Scale-invariant rotation-equivariant segmentation



SO(3) equivariant, scale-invariant centerline tracking  
Image interpolation  
GCN  
GCN  
GCN  
argmax

Abbas et al. Medical Image Analysis (Under review)  
Pygmal, Abbas et al. MICCAI STACOM (2024)

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### Fully automated AAA segmentation

First prize STACOM workshop

Rygiel, P., Albiol, D., Brunz, C., Yeung, K. K., & Holinski, J. M. (2020). Global Control for Local SD (2). Experimental Scale-Invariant Vessel Segmentation, STACOM 2020. Rygiel, P., Albiol, D., Brunz, C., Smorensburg, S., Yeung, K. K., & Wolinski, J. M. AAA-100: A Quoted Dataset of 3D Waterright Abdominal Aortic Aneurysm Models. Zenodo

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### Blood flow estimation

CFD Computational Fluid Dynamics

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### Wall shear stress estimation

CFD (8 h)

SNELLIUS

WSS (CFD)

0.0e+00 1 2 3 4 5.0e+00

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### AAA growth prediction

Input: mesh & features, time step condition

GEM-GCN: short-range interactions, long-range interactions, residual block, copy & concatenate, pooling, unpooling

Output: deformation vectors

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### First pilot for lipidomics from the group of Porto Marina Neto

1<sup>st</sup> step 2<sup>nd</sup> step 3<sup>rd</sup> step 4<sup>th</sup> step

Demographic information

	AAA	PAD
N° of patients	9	15
Age (years)*	70.2 ± 7.4	66.9 ± 11.1
Gender	100% M	100% M

\*Value represented by mean ± standard deviation

Lipid extract

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### Results of Pilot studies

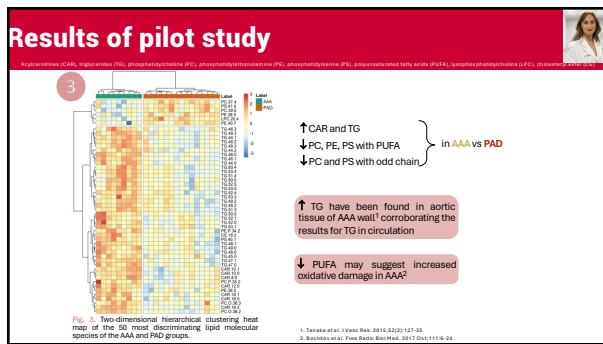
1 Plasma lipidomic signature of AAA is significantly different from that of PAD

2 Acylcarnitines (CAR) and triglycerides (TG) are the most significant to differentiate AAA from PAD

Fig. 1. PCA of the plasma lipids from AAA and PAD patients. PCA in a two-dimensional score scatter plot of lipid profiles obtained in both positive and negative modes from AAA and PAD groups.

Fig. 2. Box plots of lipid molecular species with the lowest 16 p-values of the ANOVA test followed by the Tukey test of AAA and PAD groups. \*\*p < 0.001, and \*\*\*p < 0.0001.

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### WP 5

Activities Timeline

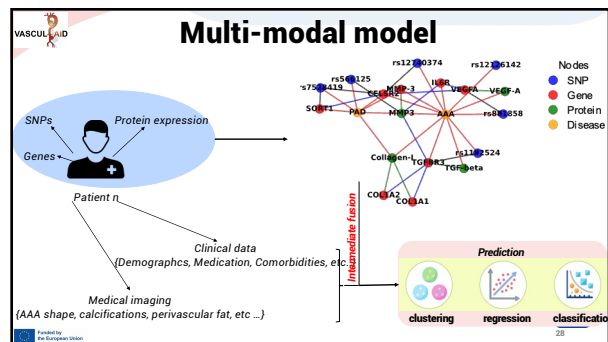
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### WP7 Legal & Ethics

- Ethical and legal framework
- The Ethics Guidelines and resulted in "7 Requirements for Trustworthy AI" that were consequently endorsed by the European Commission:
  - Human agency and oversight
  - Technical robustness and safety
  - Privacy and data governance
  - Transparency
  - Diversity, non-discrimination and fairness
  - Societal and environmental wellbeing
  - Accountability

Unacceptable impact → prohibited  
 Substantial impact → high risk, allowed with stronger requirements  
 Some impact → medium risk, allowed with minimal requirements  
 No impact → unrestricted

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### Thank you!

Amsterdam UMC | BRIGHTFISH | UNIVERSITY OF OXFORD | UNIVERSITY OF TWENTE | PORTO  
 universidade de aveiro | SAO JOAO | Centre Hospitalier Universitaire de Nice | ALLAI | UNIVERSITY OF BELGRADE | HUS  
 VINCA | UNIVERSITY OF NICOLAUS KOPERNIKUS | UNIVERSITY OF BERGEN | MH3 | MEDICINSKE FAKULTETA SAGREB | ASKLEPIOS

<https://vascul-aid.eu>

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