A.C.C.A. Amicale des Cardiologues de la Côte d'Azur

Intelligence Artificielle dans les Maladies Vasculaires

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I/ Qu'est-ce que l'Intelligence Artificielle (IA) ?

L'Intelligence Artificielle (IA) correspond à une discipline très vaste dont le but est de développer des technologies ou des applications qui reproduisent certaines caractéristiques de l'intelligence humaine, comme la capacité de raisonner, d'apprendre, de s'adapter, d'interagir, de communiquer ou encore de percevoir.

L'IA est ainsi une discipline qui va toucher de nombreux domaines dont par exemple les mathématiques, l'informatique, la mécanique, la physique ou encore la biologie.

Donner une définition unique à l'IA est extrêmement difficile et la Commission Européenne a proposé de la définir comme l'ensemble des systèmes qui font preuve d'un comportement intelligent en analysant leur environnement et en prenant des mesures – avec un certain degré d'autonomie – pour atteindre des objectifs spécifiques.

Historique ?

ELSEVIER
Annals of Vascular Surgery
Volume 65, May 2020, Pages 254-260

General Review

Fundamentals in Artificial Intelligence for Vascular Surgeons

Juliette Raffort [1,2], Cédric Adam [3], Marion Carrier [3], Fabien Lareyre [2,4]

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https://doi.org/10.1016/j.avsg.2019.11.037

Artificial intelligence (AI) corresponds to a broad di
which display properties of human intelligence. W
applications in daily life, its introduction in medi
interesting perspectives for medical research and
sometimes associated with hype leading to a mis
Here, we aim to introduce the fundamental notio
potential applications for medical and surgical pr
knowledge, limits and challenges to face as well a

II/ Quelles applications grâce à l'IA dans le domaine de la santé ?

INTELLIGENCE ARTIFICIELLE

Machine Learning
- Supervised
- Unsupervised
- Re-inforcement

Deep Learning
- *Artificial Neural Network*
- *Convolutionnal Neural Network*

Natural Language Processing

Robotique

Vision

RECHERCHE MEDICALE

Branche physique: robotique, dispositifs médicaux

Branch virtuelle: programme informatique, système support

PRATIQUE CLINIQUE

Adapted from Park et al. Methodologic Guide for Evaluating Clinical Performance and Effect of Artificial Intelligence Technology for Medical Diagnosis and Prediction. Radiology. 2018;286(3):800-9. Krittanawong et al. Artificial Intelligence in Precision Cardiovascular Medicine. J Am Coll Cardiol. 2017;69(21):2657-64.

III/ Données médicales et champ d'application

Données Médicales

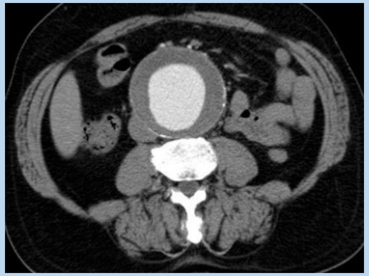
Dossiers médicaux

Electroniques

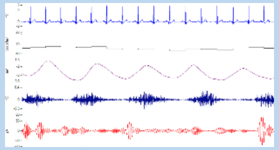
Manuels

Données "digitales"

Imagerie - vidéo



Données physiologiques



Données biologiques

Données environnementales

III/ Données médicales et champ d'application

Système d'information en Santé

- Optimiser la gestion et l'analyse des données de santé
- Utilisation du NLP

Santé Publique

- Nouveaux outils pour des actions de prevention (objets connectés, télémedcine)
- Identification de population à risque

Un grand champ d'applications

Education – enseignement médical

- Simulateurs
- Réalité virtuelle - augmentée

Pratique clinique

- **Diagnostic:** amelioration de l'analyse de l'imagerie, interpretation des résultats de biologie
- **Pronostic**: développement de modèles prédictifs
- **Thérapeutique**: développement de nouveaux dispositifs médicaux

→ Aide pour la prise de decision : **médecine personnalisée**

Recherche Médicale

- Faciliter l'analyse de la littérature scientifique
- Optimiser la conception des essais cliniques
- Identifier de nouvelles cibles thérapeutiques
- Data mining: identifier des patterns (signatures, profiles)

→ Meilleure connaissance des mécanismes physiopathologiques

IV/ IA et maladies vasculaires : où en est-on ?

Original Manuscript

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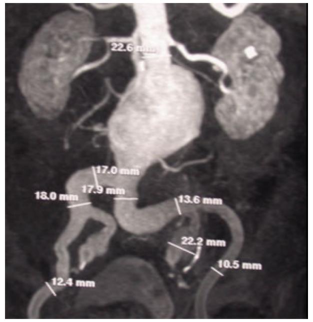
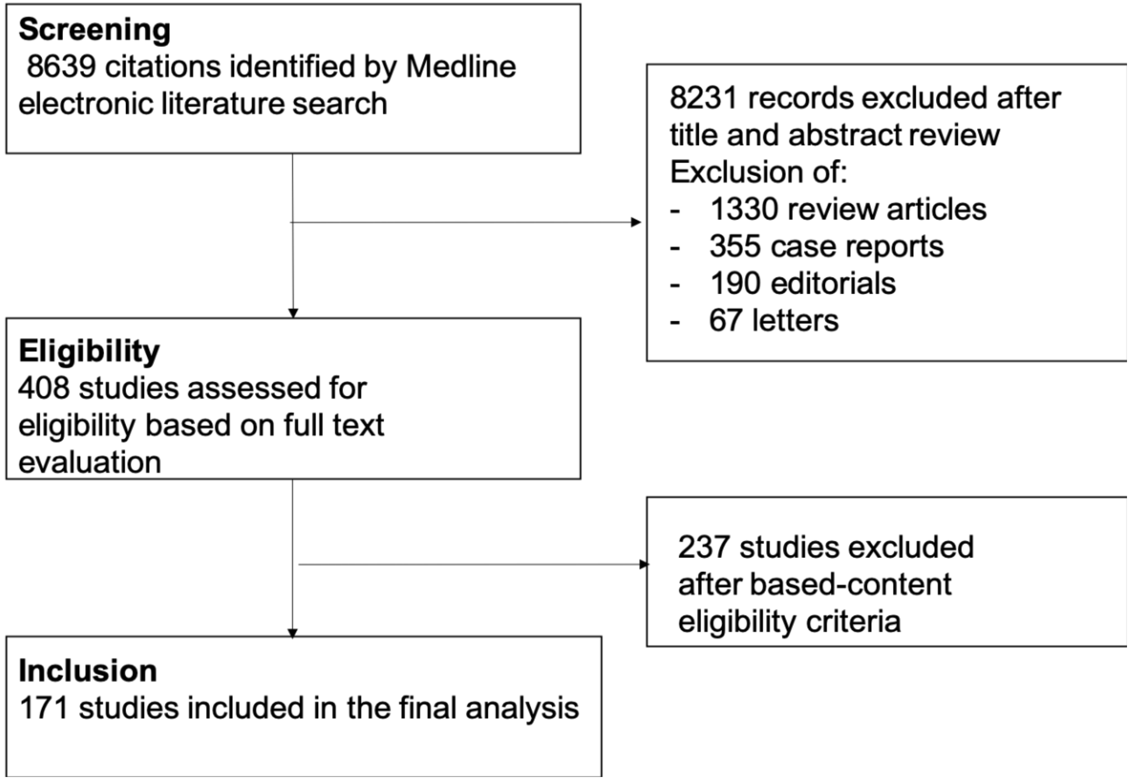
Applications of Artificial Intelligence in Non-cardiac Vascular Diseases: A Bibliographic Analysis

Fabien Lareyre[1,2,3], Cong Duy Lê[1,3], Ali Ballaith[4], Cédric Adam[5], Marion Carrier[5], Samantha Amrani[1], Caroline Caradu[6], and Juliette Raffort[2,3,7]

Abstract
Research output related to artificial intelligence (AI) in vascular diseases has been poorly investigated. The aim of this study was to evaluate scientific publications on AI in non-cardiac vascular diseases. A systematic literature search was conducted using the PubMed database and a combination of keywords and focused on three main vascular diseases (carotid, aortic and peripheral artery diseases). Original articles written in English and published between January 1995 and December 2020 were included. Data extracted included the date of publication, the journal, the identity, number, affiliated country of authors, the topics of research, and the fields of AI. Among 171 articles included, the three most productive countries were USA, China, and United Kingdom. The fields developed within AI included: machine learning (n = 90; 45.0%), vision (n = 45; 22.5%), robotics (n = 42; 21.0%), expert system (n = 15; 7.5%), and natural language processing (n = 8; 4.0%). The applications were mainly new tools for: the treatment (n = 52; 29.1%), prognosis (n = 45; 25.1%), the diagnosis and classification of vascular diseases (n = 38; 21.2%), and imaging segmentation (n = 38; 21.2%). By identifying the main techniques and applications, this study also pointed to the current limitations and may help to better foresee future applications for clinical practice.

Keywords
Artificial intelligence, vascular diseases, machine learning, deep learning, bibliometry, bibliographic analysis

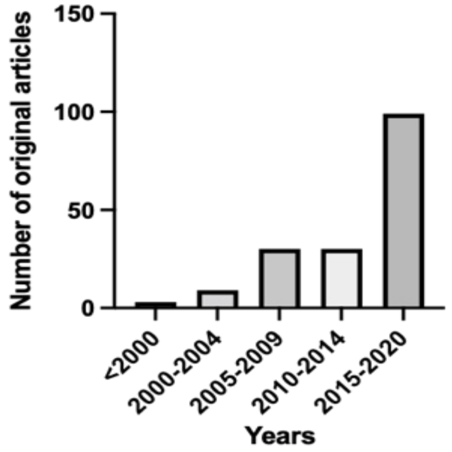




IV/ IA et maladies vasculaires : où en est-on ?

Characteristics	Categories	Data (n=171 original articles)
Year of publication	<2000	3 (1.8)
	2000- 2004	10 (5.8)
	2005- 2009	29 (17.0)
	2010-2014	30 (17.5)
	2015- 2020	99 (57.9)
Scope of the journal	Cardiovascular diseases	45 (26.3)
	Other (medicine, imaging, engineering, informatics)	126 (73.7)
Number of authors	1 to 3	33 (19.3)
	4 to 6	75 (43.9)
	7 to 9	38 (22.2)
	10 or more	25 (14.6)
Number of countries in authorship	1	139 (81.3)
	2	27 (15.8)
	3 or more	5 (2.9)

→ Augmentation exponentielle des publications

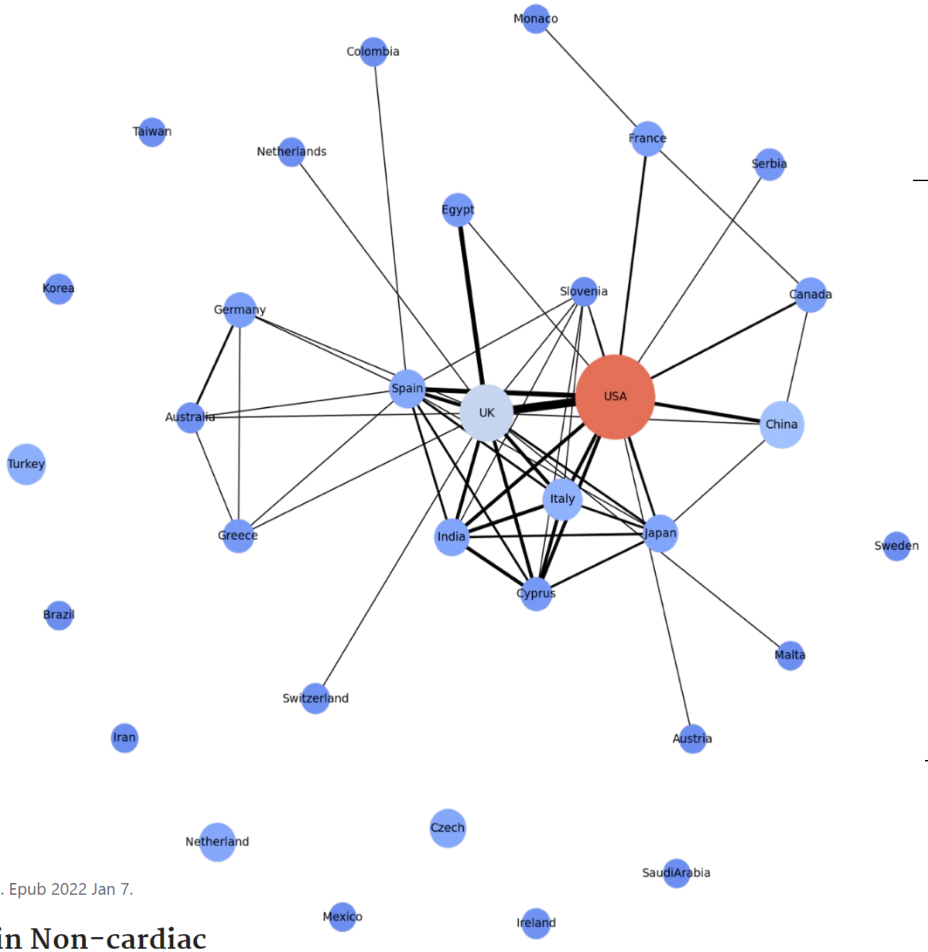


Angiology. 2022 Aug;73(7):606-614. doi: 10.1177/00033197211062280. Epub 2022 Jan 7.

Applications of Artificial Intelligence in Non-cardiac Vascular Diseases: A Bibliographic Analysis

Fabien Lareyre [1 2 3], Cong Duy Lê [1 3], Ali Ballaith [4], Cédric Adam [5], Marion Carrier [5], Samantha Amrani [1], Caroline Caradu [6], Juliette Raffort [2 3 7]

IV/ IA et maladies vasculaires : où en est-on ?



Angiology. 2022 Aug;73(7):606-614. doi: 10.1177/00033197211062280. Epub 2022 Jan 7.

Applications of Artificial Intelligence in Non-cardiac Vascular Diseases: A Bibliographic Analysis

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Principaux pays: **USA**, Chine, UK, pays européens

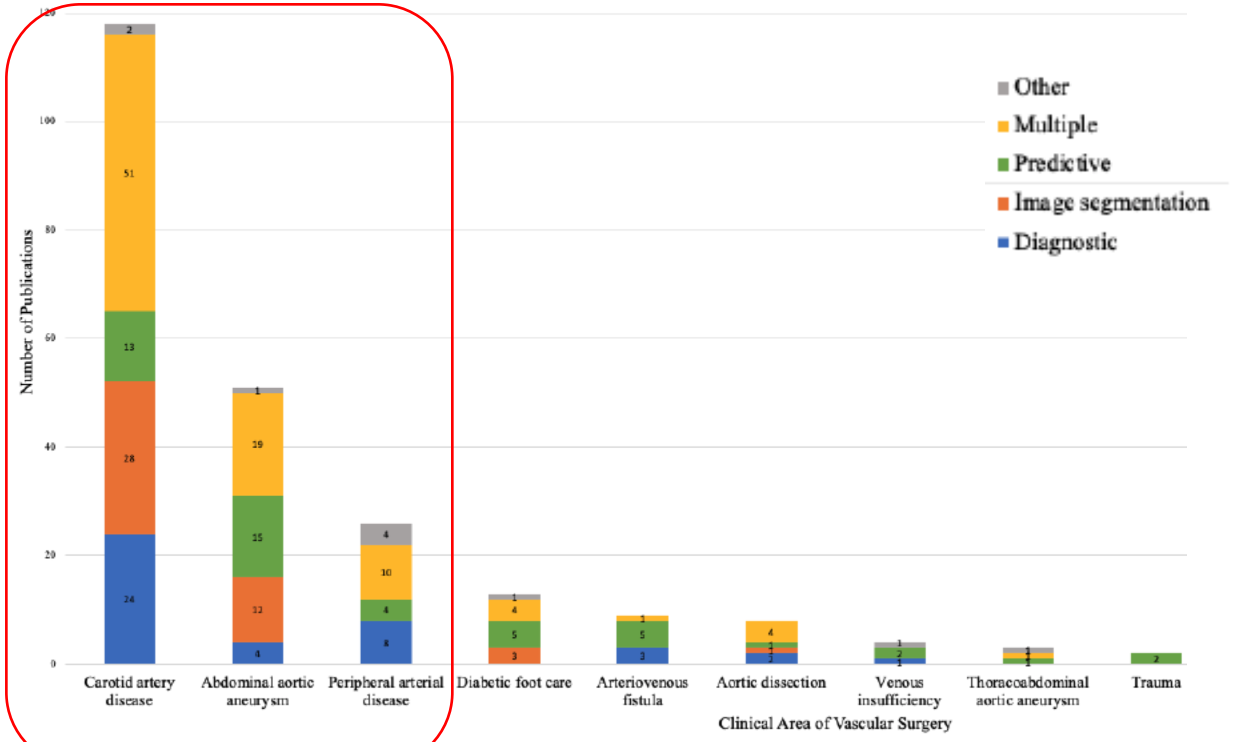
Collaboration internationale: 19.7 % des articles

IV/ IA et maladies vasculaires : où en est-on ?

A Systematic Review and Bibliometric Analysis of Applications of **Artificial Intelligence** and Machine Learning in Vascular Surgery.
Javidan AP, Li A, Lee MH, Forbes TL, Naji F.
Ann Vasc Surg. 2022 Mar 24:S0890-5096(22)00148-0. doi: 10.1016/j.avsg.2022.03.019. Online ahead of print.
PMID: 35339595 Review.

- Inclusion: original articles on Medline, Embase, Ovid Healthstar until February 2021
- Combination of keywords: AI in vascular surgery

→ 249 articles finally included



Clinical areas of vascular surgery

IV/ IA et maladies vasculaires : où en est-on ?

Range of applications

ARTIFICIAL INTELLIGENCE

NATURAL LANGUAGE PROCESSING

Automatic identification of patients with vascular diseases in medical records

→ Improve screening and facilitate large scale search in vascular registries

VISION

Automatic detection, characterization and classification of vascular diseases on medical images

→ Improve screening, diagnosis, pre-surgical planning and follow-up

MACHINE LEARNING

Use of ML development of predictive models

→ Propose personalized therapeutic approach and support clinical decision making

Artificial intelligence in abdominal aortic aneurysm.
Raffort J, Adam C, Carrier M, Ballaith A, Coscas R, Jean-Baptiste E, Hassen-Khodja R, Chakfé N, Lareyre F.
J Vasc Surg. 2020 Jul;72(1):321-333.e1. doi: 10.1016/j.jvs.2019.12.026. Epub 2020 Feb 21.
PMID: 32093909

Artificial intelligence and machine learning in **aortic** disease.
Hahn LD, Baeumler K, Hsiao A.
Curr Opin Cardiol. 2021 Nov 1;36(6):695-703. doi: 10.1097/HCO.0000000000000903.
PMID: 34369401 Review.

Machine learning in vascular surgery: a systematic review and critical appraisal.
Li B, Feridooni T, Cuen-Ojeda C, Kishibe T, de Mestral C, Mamdani M, Al-Omran M.
NPJ Digit Med. 2022 Jan 19;5(1):7. doi: 10.1038/s41746-021-00552-y.

Applications of artificial intelligence for patients with **peripheral artery disease**.
Lareyre F, Behrendt CA, Chaudhuri A, Lee R, Carrier M, Adam C, Lê CD, **Raffort J.**
J Vasc Surg. 2022 Jul 31:S0741-5214(22)02088-2. doi: 10.1016/j.jvs.2022.07.160. Online ahead of print.
PMID: 35921995 Review.

I. Machine Learning to develop predictive models

Seminars in Vascular Surgery
Volume 36, Issue 3, September 2023, Pages 440-447
Review article

Artificial intelligence–based predictive models in vascular diseases

Fabien Lareyre [a b], Arindam Chaudhuri [c], Christian-Alexander Behrendt [d e], Alexandre Pouhin [f], Martin Teraa [g], Jonathan R. Boyle [h], Riikka Tulamo [i], Juliette Raffort [b j k]

Seminars in Vascular Surgery
Volume 36, Issue 3, September 2023, Pages 448-453
Review article

Artificial intelligence in vascular surgical decision making

Fabien Lareyre [a b], Kak Khee Yeung [c], Lisa Guzzi [d e], Gilles Di Lorenzo [a], Arindam Chaudhuri [f], Christian-Alexander Behrendt [g h], Konstantinos Spanos [i], Juliette Raffort [b d j]

ML-based predictive models

Prediction of the progress of the disease and associated complications

- **AAA** : growth, rupture
- **LEAD** : amputation, wound healing, MACE
- **Carotid stenosis**: stroke risk, plaque vulnerability

Prediction of survival and re-hospitalization

Prediction of complications related to treatment

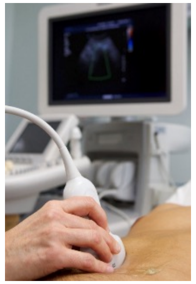
- **AAA** : endoleak, EVAR-related severe adverse events
- **LEAD** : bleeding risk, post-operative complications
- **Carotid stenosis**: ischemic stroke, MACE, hemodynamic depression

Aid decision-making
Precision medicine

II. Computer vision: DL to enhance imaging analysis in vascular diseases

1- Advanced imaging analysis

Imaging takes a central role in the management of vascular diseases



- Several imaging techniques available: **ultrasound**, computed tomography angiography (**CTA**) and magnetic resonance imaging (**MRI**)

→ CTA is one of the most commonly used

Commercialized software are **semi-automatic** and require human intervention

This is **tedious** and **time-consuming**. It depends on the expertise and training of the operators and **lacks reproducibility.**

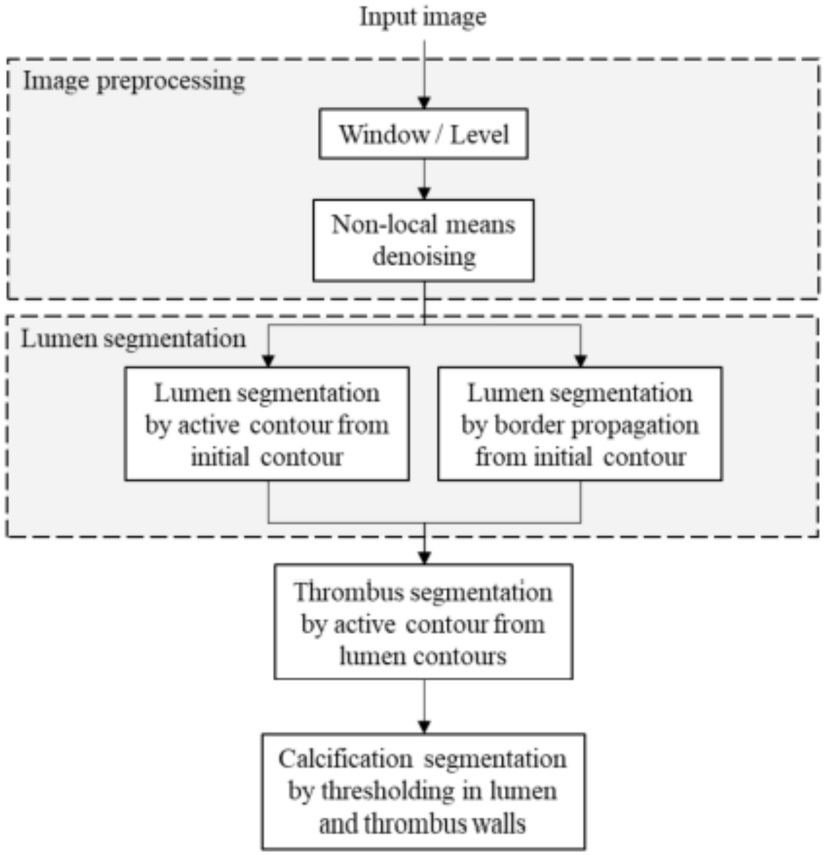
Can AI be of interest to develop advanced imaging analysis?

II. Computer vision: DL to enhance imaging analysis in vascular diseases

2. Example of aortic aneurysm

2.1. Characterization of AAA using Deep Learning

Automatic pipeline for automatic segmentation of AAA from CTA images



Pipeline using Expert system method:

- Developed from CTA from patients with aortic aneurysms
- 4 main steps:
  → Image pre-processing
  → Lumen segmentation
  → Thrombus segmentation
  → Calcifications segmentation

A **fully** automated pipeline for mining abdominal aortic **aneurysm** using image segmentation.
Lareyre F, Adam C, Carrier M, Dommerc C, Mialhe C, **Raffort J.**
Sci Rep. 2019 Sep 24;9(1):13750. doi: 10.1038/s41598-019-50251-8.
PMID: 31551507 Free PMC article.

natureresearch

A fully automated pipeline for mining abdominal aortic aneurysm using image segmentation

Fabien Lareyre[1,2], Cédric Adam[3], Marion Carrier[3], Carine Dommerc[1], Claude Mialhe[1] & Juliette Raffort[2]

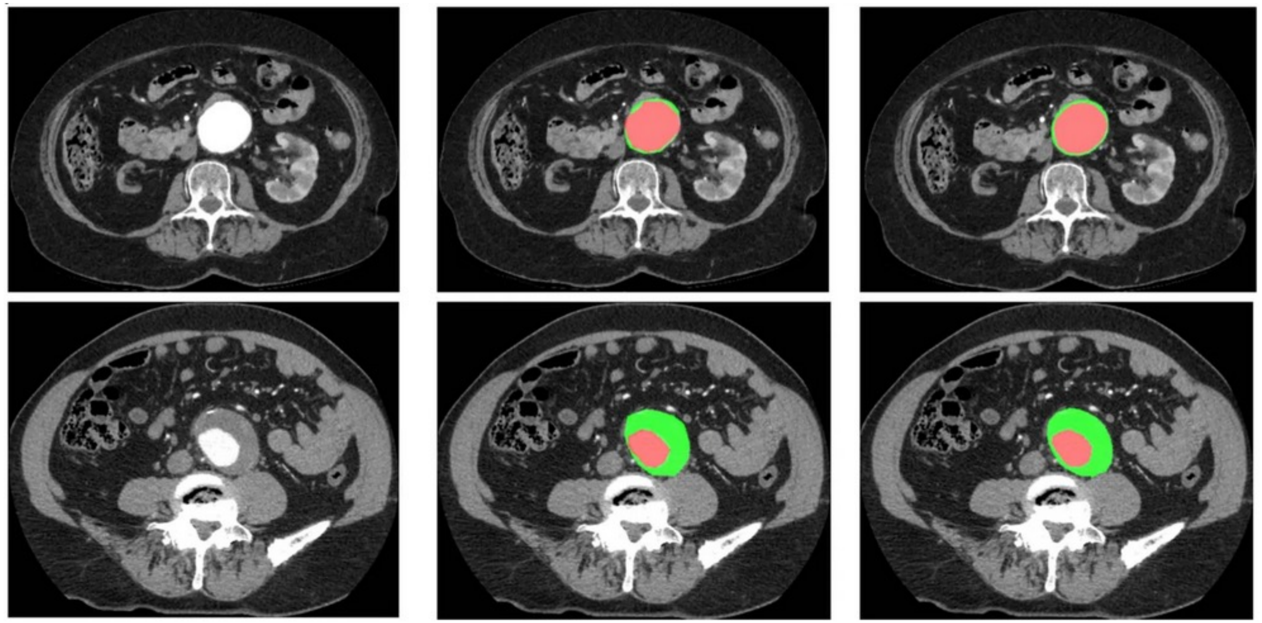
Imaging software have become critical tools in the diagnosis and the treatment of abdominal aortic aneurysms (AAA). The aim of this study was to develop a fully automated software system to enable a fast and robust detection of the vascular system and the AAA. The software was designed from a dataset of injected CT-scans images obtained from 40 patients with AAA. Pre-processing steps were performed to reduce the noise of the images using image filters. The border propagation based method was used to localize the aortic lumen. An online error detection was implemented to correct errors due to the propagation in anatomic structures with similar pixel value located close to the aorta. A morphological snake was used to segment 2D or 3D regions. The software allowed an automatic detection of the aortic lumen and the AAA characteristics including the presence of thrombus and calcifications. 2D and 3D reconstructions visualization were available to ease evaluation of both algorithm precision and AAA properties. By enabling a fast and automated detailed analysis of the anatomic characteristics of the AAA, this software could be useful in clinical practice and research and be applied in a large dataset of patients.

II. Computer vision: DL to enhance imaging analysis in vascular surgery

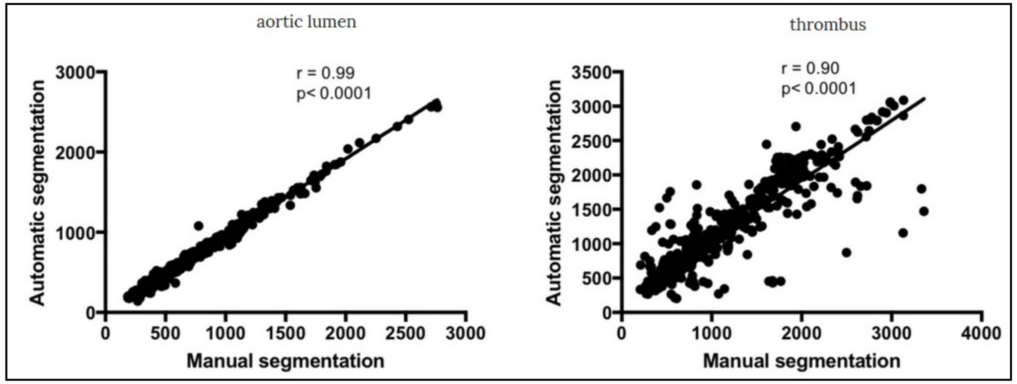
2. Example of aortic aneurysm

2.1. Characterization of AAA using Deep Learning

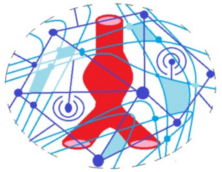
Development of the automatic pipeline for AAA and vascular segmentation from CTA images



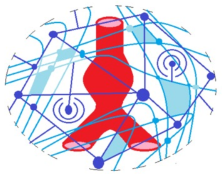
CT-scan Manual segmentation Automatic segmentation



Automatic method: initiate the localization of the aorta and discriminate contrasted arterial system from surrounding tissues.

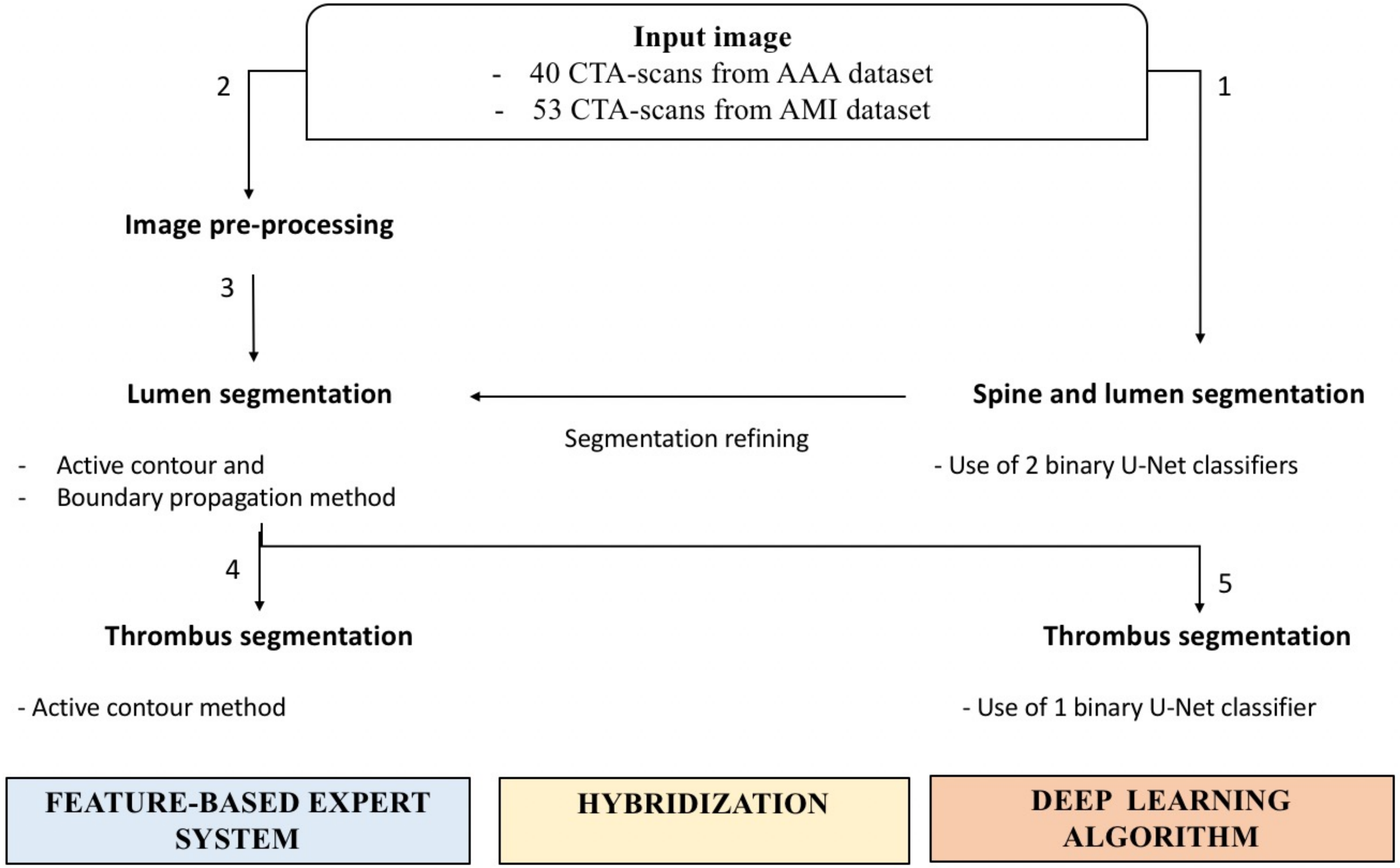


II. Computer vision: DL to enhance imaging analysis in vascular diseases



2. Example of aortic aneurysm

2.1. Characterization of AAA using Deep Learning



Journal of Clinical Medicine MDPI

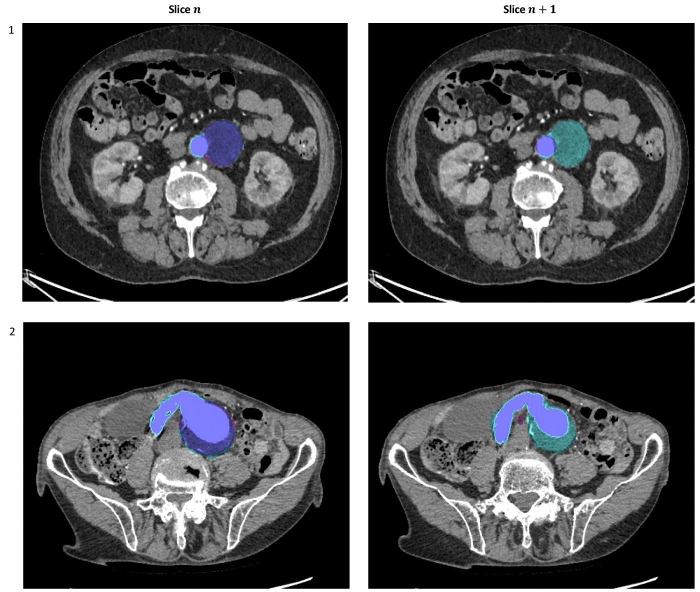
Article

Automated Segmentation of the Human Abdominal Vascular System Using a Hybrid Approach Combining Expert System and Supervised Deep Learning

Fabien Lareyre [1,2,*], Cédric Adam [3], Marion Carrier [3] and Juliette Raffort [2,4,5]

1 Department of Vascular Surgery, Hospital of Antibes Juan-les-Pins, 06600 Antibes, France
2 Université Côte d'Azur, Inserm U1065, C3M, 06204 Nice, France; juliette.raffort@hotmail.fr
3 Laboratory of Applied Mathematics and Computer Science (MICS), CentraleSupélec, Université Paris-Saclay, 91190 Gif-sur-Yvette, France; cedric.adam2@gmail.com (C.A.); marion.carrier&@gmail.com (M.C.)
4 Clinical Chemistry Laboratory, University Hospital of Nice, 06003 Nice, France
5 AI Institute 3IA Côte d'Azur, Université Côte d'Azur, 06204 Nice, France
* Correspondence: fabien.lareyre@gmail.com

Fully automatic software using
Expert System *and* ***Supervised Deep Learning***

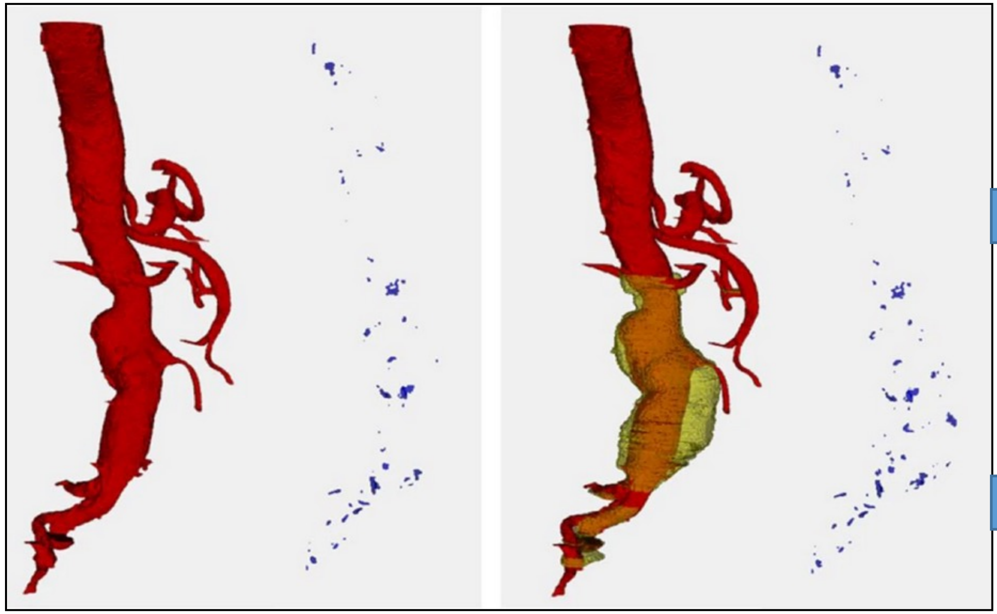


II. Computer vision: DL to enhance imaging analysis in vascular diseases

2. Example of aortic aneurysm

2.1. Characterization of AAA using Deep Learning

*Automatic segmentation of the vascular system using **Expert System** and **Supervised Deep Learning***



This software allows an automatic detection of the **main characteristics** of AAA: the aneurysmal localization in the aorta, diameters and volume, the presence of calcifications and intraluminal thrombus.

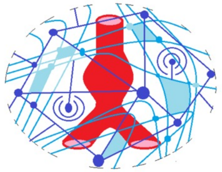
Generate automatic measurement of the vessels (length, diameters and volume)

Automated Segmentation of the Human Abdominal Vascular System Using a Hybrid Approach Combining Expert System and Supervised Deep Learning.
Lareyre F, Adam C, Carrier M, Raffort J.
J Clin Med. 2021 Jul 29;10(15):3347. doi: 10.3390/jcm10153347.

A **fully** automated pipeline for mining abdominal aortic **aneurysm** using image segmentation.
Lareyre F, Adam C, Carrier M, Dommerc C, Mialhe C, **Raffort J.**
Sci Rep. 2019 Sep 24;9(1):13750. doi: 10.1038/s41598-019-50251-8.
PMID: 31551507 **Free PMC article.**

II. Computer vision: DL to enhance imaging analysis in vascular diseases

3. Conclusion



Automatic segmentation of the vascular system using AI

- **Perspectives for clinical practice**

→ Improve the detection and the diagnosis of the disease
→ Facilitate the anatomical characterization
→ Improve reproducibility of measurements
→ Decrease computational time
→ Facilitate pre-operative planning
→ Better detect post-operative complications

- **Use of automatic segmentation for clinical research:**

→ Provide a fast and detailed analysis of the characteristics of the vessels.
→ Identify imaging patterns
→ Develop predictive models

→ **Personalized therapeutic approach** for patients with vascular diseases

III. Natural language processing (NLP) in vascular diseases

1. Identification and automatic data extraction from health records

Examples: **aortic aneurysm, PAD, carotid stenosis**

Successful implementation of a nurse-navigator-run program using natural language processing identifying patients with an abdominal aortic aneurysm.
Boitano LT, DeVivo G, Robichaud DI, Okuhn S, Steppacher RC, Simons JP, Aiello FA, Jones D, Judelson D, Nguyen T, Sorensen C, Schanzer A.
J Vasc Surg. 2023 Mar;77(3):922-929. doi: 10.1016/j.jvs.2022.10.034. Epub 2022 Oct 31.

Validation of **natural language processing** to determine the presence and size of **abdominal aortic aneurysms** in a large integrated health system.
McLenon M, Okuhn S, Lancaster EM, Hull MM, Adams JL, McGlynn E, Avins AL, Chang RW.
J Vasc Surg. 2021 Aug;74(2):459-466.e3. doi: 10.1016/j.jvs.2020.12.090. Epub 2021 Feb 4.

Use of **Natural Language Processing** to **Improve Identification** of **Patients** With **Peripheral Artery Disease**.
Weissler EH, Zhang J, Lippmann S, Rusincovitch S, Henao R, Jones WS.
Circ Cardiovasc Interv. 2020 Oct;13(10):e009447. doi: 10.1161/CIRCINTERVENTIONS.120.009447. Epub 2020 Oct 12.

Establishing a **carotid artery stenosis disease cohort** for comparative effectiveness research using **natural language processing**.
Chang RW, Tucker LY, Rothenberg KA, Lancaster EM, Avins AL, Kuang HC, Faruqi RM, Nguyen-Huynh MN.
J Vasc Surg. 2021 Dec;74(6):1937-1947.e3. doi: 10.1016/j.jvs.2021.05.054. Epub 2021 Jun 25.

- Facilitate analysis in large datasets to evaluate current practice
- Develop tools to optimize prevention and public health surveillance programs (alerts generated from medical records)
- Optimize orientation, triage of patients and reference to vascular specialists when needed

III. Natural language processing (NLP) in vascular diseases

2. NLP as virtual assistants (chatbots)

ChatBot

REVIEW

Comprehensive Review of Natural Language Processing (NLP) in Vascular Surgery

Fabien Lareyre [a,b,*], **Bahaa Nasr** [c,d], **Arindam Chaudhuri** [e], **Gilles Di Lorenzo** [a], **Mathieu Carlier** [f], **Juliette Raffort** [b,g,h]

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[b] Université Côte d'Azur, Inserm, U1065, C3M, Nice, France
[c] Department of Vascular and Endovascular Surgery, Brest University Hospital, Brest, France
[d] INSERM, UMR 1101, LaTIM, Brest, France
[e] Bedfordshire - Milton Keynes Vascular Centre, Bedfordshire Hospitals, NHS Foundation Trust, Bedford, UK
[f] Department of Urology, University Hospital of Nice, Nice, France
[g] Institute 3IA Côte d'Azur, Université Côte d'Azur, France
[h] Clinical Chemistry Laboratory, University Hospital of Nice, France

ELSEVIER
Journal of Vascular Surgery
Volume 72, Issue 2, August 2020, Pages 772-773

Virtual assistants for vascular surgeons

Fabien Lareyre MD, PhD, Cédric Adam PhD, Marion Carrier PhD, Juliette Raffort MD, PhD

Potential use for clinicians

- Writing assistance and administrative work
- Research and academic work
- Medical and surgical education

Potential use for patients

- Source of information
- Assistance for planning and follow-up
- NLP embedded in applications for telemedicine (telecoaching, telemonitoring)

III. Natural language processing (NLP) in vascular diseases

3. Example: NLP for literature search

ELSEVIER

EJVES Vascular Forum
Volume 60, 2023, Pages 48-52

Technical Note

Natural Language Processing for Literature Search in Vascular Surgery: APilot Study Testing an Artificial Intelligence Based Application

Robin Roumengas [a ‡], Gilles Di Lorenzo [b ‡], Amel Salhi [a], Paul de Buyer [a], Arindam Chaudhuri [c], Fabien Lareyre [b d], Juliette Raffort [d e f]

Introduction

The use of natural language processing (NLP) for a literature search has been poorly investigated in vascular surgery so far. The aim of this pilot study was to test the applicability of an artificial intelligence (AI) based mobile application for literature searching in a topic related to vascular surgery.

Technique

A focused scientific question was defined to evaluate the performance of the AI application for a literature search and compare the results with the ground truth provided via a traditional literature search performed by human experts. Using pre-defined keywords, the literature search was performed automatically by the AI application through different steps, including quality assessment based on evaluation of the information available and quality filters using indicators of level of evidence, selection of publications based on relevancy filters using NLP, summarisation, and visualisation of the publications via the mobile app. A traditional literature search performed by human experts required 10 hours to check 154 original articles, among which 26 (16.9%) were truly related to the question, 63 (40.9%) related to the field but not to the specific question, and 65 (42.2%) were unrelated. The AI based search was performed in less than one hour, and, compared with traditional search, the method identified 17 original articles (48.6%) truly related to the question ($p < .010$), 18 (51.4%) related to the field but not to the specific question ($p = .26$), and no unrelated publications ($p < .001$). Fifteen truly related articles (88.2%) were identified jointly by the two methods. No significant difference was observed regarding the median number of citations, year of publications, and impact factor of journals.

Discussion

The AI based method enabled a targeted, focused, and time saving literature search, although the selection of publications was not completely exhaustive. These results suggest that such an AI driven application is a complementary tool to help researchers and clinicians for continuous education and dissemination of knowledge.

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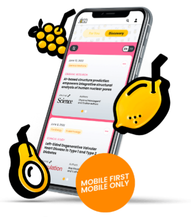

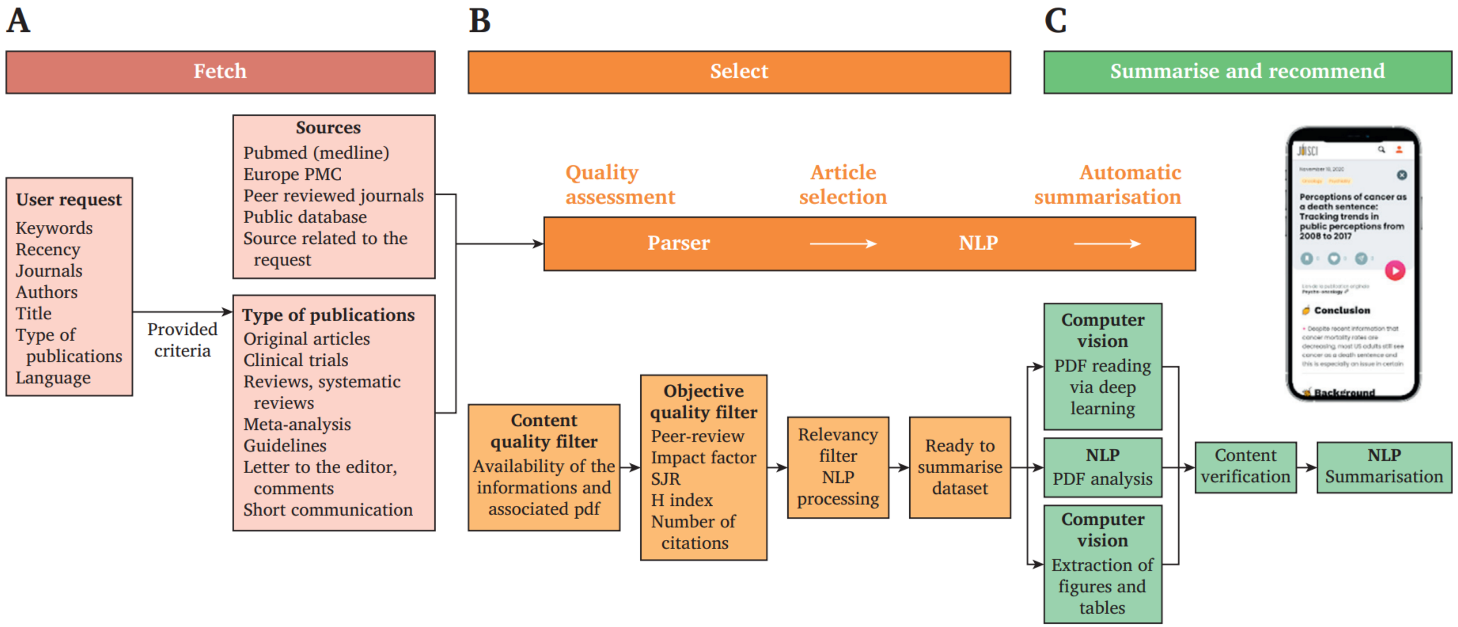

III. Natural language processing (NLP) in vascular diseases

3. Example: NLP for literature search

Aim of the study:

→ Test the applicability of an AI-based mobile application for literature search in a topic related to vascular surgery

→ Compare to the ground truth provided via traditional literature search performed by human experts

Scientific question to serve as a use case:

"What studies have been published on the use of AI/ML to evaluate the prognosis of patients with aortic aneurysm?"

AI-based method (Juisci application)

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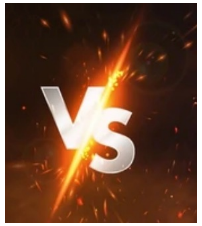
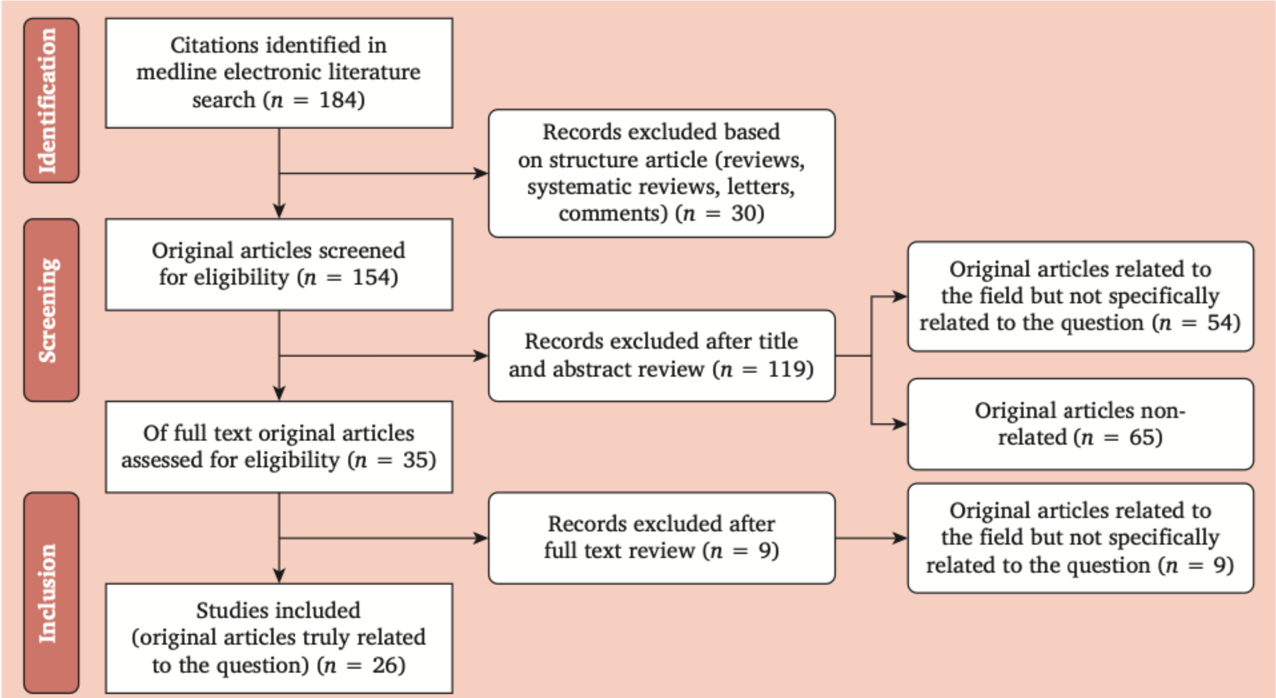


Traditional search (human experts)



III. Natural language processing (NLP) in vascular diseases

3. Example: NLP for literature search

	AI based method (Juisci application)	Traditional search (Human experts)	*p* value
Quantitative analysis			
Total number of papers identified in the search results	45	184	NA
Number of original articles in the search results	35	154	NA
Number of original articles truly related to the question	17/35 (48.6)	26/154 (16.9)	<.001
Number of original articles related to the field but not to the question	18/35 (51.4)	63/154 (40.9)	.26
Number of unrelated papers	0 (0)	65/154 (42.2)	<.001
Estimation of computational time	Approximately <1 hour	Approximately 10 hours	NA
Qualitative analysis of truly related articles			
Impact factor of the journal	3.6 (2.5, 4.7)	2.7 (1.8, 3.7)	.13
Number of articles with impact factor >3.0	13/17 (76.5)	12/26 (46.2)	.060
Number of articles published in journals related to cardiovascular disease	6/17 (35.3)	13/26 (50)	.37
Number of articles published in other journals (general journal or related to engineering and bio-informatics)	11/17 (64.7)	13/26 (50)	.37
Number of citations of the articles	21 (4.5, 48.0)	13 (4.0, 34.0)	.47
Year of publication of the articles	2020 (2017, 2021)	2020 (2017, 2022)	.54
Qualitative analysis of truly related articles identified jointly by the two methods			
Number of original articles	15/17 (88.2)	15/26 (57.7)	NA
Impact factor of the journal	3.6 (1.9, 4.3)		NA
Number of articles with impact factor >3.0	11/15 (73.3)		NA
Number of citations of the articles	24 (4.8, 50.5)		NA
Year of publication of the articles	2020 (2016, 2020)		NA
Qualitative analysis of truly related articles identified by only one of the methods			
Number of original articles	2/17 (11.8)	11/26 (42.3)	NA
Impact factor of the journal	5.6	1.9 (1.2, 2.5)	NA
Number of articles with impact factor >3.0	2/2 (100)	1/11 (9.1)	NA
Number of citations of the articles	23.5	7.5 (1, 19)	NA
Year of publication of the articles	2020	2021 (2018, 2022)	NA

→ AI-based method:
. Sélection de 17 articles (vs 26 for human search)
. Sélection plus ciblée sur la question
. Gain de temps++

→ Analyse qualitative:
. AI-based method: sélection appropriée des articles avec IF élevé
. Environ 90% des articles communs, retrouvés par les 2 méthodes

→ Conclusion:
. AI-based method: selection rapide et ciblée (overview) même si non complètement exhaustive
. Outil complémentaire de l'expertise humaine

IV. Innovative Devices

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L'AVENIR DE VOS ARTÈRES

La réalité étendue

La réalité étendue est un terme générique qui réfère aux environnements virtuels et réels générées par la technologie.
Elles incluent trois grandes catégories :

→ La réalité virtuelle : Il s'agit d'un ensemble de technologies qui permet à l'utilisateur d'être plongé dans un monde complètement artificiel, dit « virtuel ». Ce monde peut être totalement fantastique, imaginatif ou mimer et reproduire le monde que nous connaissons.

→ Dans la réalité augmentée, l'opérateur va visualiser des objets virtuels qui vont être projetés dans le monde réel (ou « physique ») sous la forme d'hologrammes. L'utilisateur est ainsi capable de visualiser les objets virtuels, tout en gardant une vision sur le monde réel.

→ La réalité mixte va en plus permettre à l'opérateur de pouvoir interagir avec les objets virtuels et le monde réel.

IV. Innovative Devices

What is the difference between **Virtual (VR), Augmented (AR) and Mixed Reality (MR)?**

Applications of **Head-Mounted Displays** and **Smart Glasses** in Vascular Surgery.
Lareyre F, Chaudhuri A, Adam C, Carrier M, Mialhe C, **Raffort J.**
Ann Vasc Surg. 2021 Aug;75:497-512. doi: 10.1016/j.avsg.2021.02.033. Epub 2021 Apr 3.
PMID: 33823254 Review.

- **Education and training**: use of simulators
- **Pre-surgical planning:** 3D-visualization
- **Image-guided surgery:** endovascular repair

TECHNOLOGY

Extended reality

Virtual reality	**Augmented** reality	**Mixed** reality
Artificial world fully immerses users into a digital environment	Blending **virtual objects** (holograms) into the **real world**.	Merging of **virtual** and **real worlds** Virtual and real objects co-exist in space and can interact in real time.

APPLICATIONS

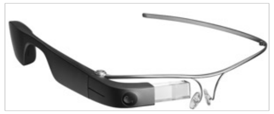
Wearable technologies


*

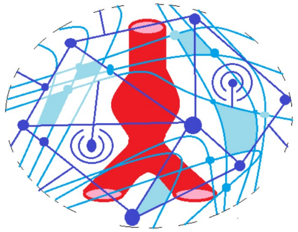
Head Mounted Display

Smart Glasses

**



Education and **Training** | **Presurgical planning** | **Image guided surgery**



Nos Projets (en cours et à venir)

1. PREDICTA project

Système support d'aide à la décision thérapeutique pour mieux prédire le devenir des patients atteints d'anévrisme de l'aorte abdominale (AAA)

"PREDICT Abdominal aortic aneurysm outcomes"

Financement
ANR JCJC

Limites en pratique clinique

- **Biologie:** Aucun biomarqueur ayant démontré une sensibilité et une spécificité suffisante pour le diagnostic, le pronostic ou le suivi des patients.

- **Imagerie:** Très peu d'outils pour évaluer et prédire le risque de croissance et de rupture de l'AAA. Ce risque est évalué par la simple mesure du diamètre maximal de l'AAA à partir de l'imagerie.

Limites: Certains patients dont l'AAA est en dessous du seuil indiqué pour un traitement chirurgical, peuvent évoluer vers une rupture potentiellement mortelle.

Besoins: -d'identifier de **nouveaux biomarqueurs**, - de **perfectionner l'analyse de l'imagerie médicale,** - d'intégrer les données cliniques, biologiques et d'imagerie pour developer de nouveaux **modèles prédictifs**

→ **Développer de nouveaux outils pour mieux guider la décision thérapeutique.**

1. PREDICTA project

Machine Learning and Omics Analysis in Aortic Aneurysm

Fabien Lareyre, MD, PhD, Arindam Chaudhuri, MD, [...], and Juliette Raffort, MD, PhD (+1) View all authors and affiliations

OnlineFirst | https://doi.org/10.1177/00033197231206427

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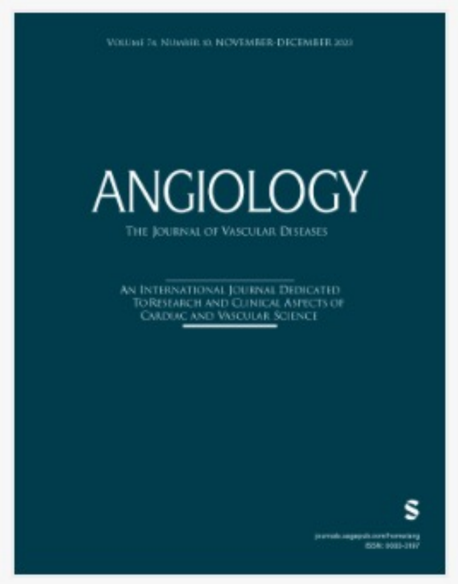

Abstract

Aortic aneurysm is a life-threatening condition and mechanisms underlying its formation and progression are still incompletely understood. Omics approach has brought new insights to identify a broad spectrum of biomarkers and better understand cellular and molecular pathways involved. Omics generate a large amount of data and several studies have highlighted that artificial intelligence (AI) and techniques such as machine learning (ML)/deep learning (DL) can be of use in analyzing such complex datasets. However, only a few studies have so far reported the use of ML/DL for omics analysis in aortic aneurysms. The aim of this study is to summarize recent advances on the use of ML/DL for omics analysis to decipher aortic aneurysm pathophysiology and develop patient-tailored risk prediction models. In the light of current knowledge, we discuss current limits and highlight future directions in the field.

Next steps: International Consortium

EVRC Eur | esvs VASCUNET | SVS | VQI VASCULAR QUALITY INITIATIVE | ICVR | MDEpiNet

- Development **large-scale prospective studies**
- Development of **International data lakes**
- **International vascular registries**

Time for **multidisciplinary cross-border collaboration**

Big Data and **Artificial** Intelligence in Vascular Surgery: Time for Multidisciplinary Cross-Border Collaboration.
Lareyre F, Behrendt CA, Chaudhuri A, Ayache N, Delingette H, Raffort J.
Angiology. 2022 Sep;73(8):697-700. doi: 10.1177/00033197221113146. Epub 2022 Jul 10.
PMID: 35815537 No abstract available.

e-Health in Vascular Diseases: Integrating Digital Innovation in Everyday Clinical Practice.
Lareyre F, Behrendt CA, Raffort J.
J Clin Med. 2022 Aug 15;11(16):4757. doi: 10.3390/jcm11164757.

Artificial Intelligence in Vascular Surgery: Moving from Big Data to Smart Data.
Lareyre F, Adam C, Carrier M, Raffort J.
Ann Vasc Surg. 2020 Aug;67:e575-e576. doi: 10.1016/j.avsg.2020.04.022. Epub 2020 Apr 24.

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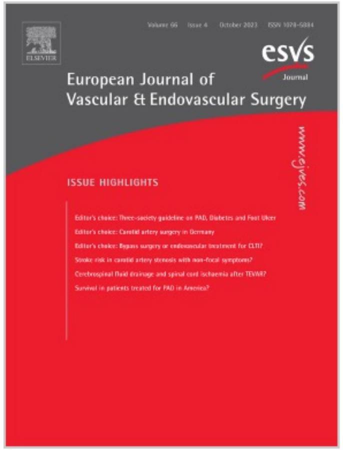
Editor's Choice – Impact of Sex on the Outcomes of Patients Undergoing Repair for Lower Extremity Peripheral Arterial Disease in France

Juliette Raffort ‡ • Fabien Lareyre ‡ • Christian Pradier • Roxane Fabre • Christian-Alexander Behrendt • Laurent Bailly • Show footnotes

Published: February 27, 2023 • DOI: https://doi.org/10.1016/j.ejvs.2023.02.071

European Journal of Vascular & Endovascular Surgery

esvs Journal



Impact of Sex on the outcomes :

- AOMI
- Thoracic Endovascular Aneuysm repair (TEVAR)

Journal of *Clinical Medicine*

MDPI

Article

Impact of Female Sex on Outcomes of Patients Undergoing Thoracic Endovascular Aortic Aneurysm Repair: A Ten-Year Retrospective Nationwide Study in France

Fabien Lareyre [1,2,3,*,†], Juliette Raffort [2,3,4,†], Christian-Alexander Behrendt [5], Arindam Chaudhuri [6], Cong Duy Lê [1,2,3], Roxane Fabre [7,8], Christian Pradier [8] and Laurent Bailly [8,9]

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6 Bedfordshire-Milton Keynes Vascular Centre, Bedfordshire Hospitals NHS Foundation Trust, Bedford MK42 9DJ, UK; a.chaudhuri@ntlworld.com
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† These authors contributed equally to this work.

check for updates

Citation: Lareyre, F.; Raffort, J.; Behrendt, C.-A.; Chaudhuri, A.; Lê, C.D.; Fabre, R.; Pradier, C.; Bailly, L. Impact of Female Sex on Outcomes of Patients Undergoing Thoracic Endovascular Aortic Aneurysm Repair: A Ten-Year Retrospective Nationwide Study in France. *J. Clin. Med.* **2022**, *11*, 2253. https://doi.org/10.3390/jcm11082253

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Published: 18 April 2022

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Abstract: The impact of sex on the outcomes of patients with cardiovascular disease is still incompletely understood. The aim of this nationwide multicenter observational study was to investigate the impact of sex on post-operative outcomes in patients undergoing thoracic endovascular aortic repair (TEVAR) for intact thoracic aortic aneurysm (iTAA). The French National Health Insurance Information System was searched to identify these patients over a ten-year retrospective period. Post-operative outcomes, 30-day and overall mortality were recorded. Among the 7383 patients included (5521 men and 1862 women), females were significantly older than males (66.8 vs. 64.8 years, $p < 0.001$). They were less frequently diagnosed with cardiovascular comorbidities. Post-operatively, women had less frequently respiratory (10.9 vs. 13.7%, $p = 0.002$) as well as cardiac complications (34.3 vs. 37.3%, $p = 0.023$), but they had more frequently arterial complications (52.8 vs. 49.8%, $p = 0.024$). There was no significant difference on overall mortality for a mean follow-up of 2.2 years (26.9 vs. 27.6%, $p = 0.58$). In the multivariable regression model, female sex was not associated with 30-day or overall mortality. Although women had a favorable comorbidity profile, the short-term and long-term survival was similar. The significantly higher rate of arterial complications suggests that women may be at higher risk of access-vessel-related complications.

Keywords: thoracic aortic aneurysm; thoracic endovascular repair; TEVAR; outcomes; nationwide study; sex

Conclusion

- <u>Accessibilité et protection des données médicales</u>

- Nécessité d'un gros volume de données (Big Data)
- Hétérogénéité et diversité des données
- Représentativité des données
- Sécurité et protection des données, éthique

→ Nécessité de standardisation
→ Nécessité de développer des études multicentriques au niveau national et international
→ Réglementation et respect de l'éthique

- <u>Soutien financier et institutionnel</u>

- Nécessité de plateformes et infrastructures adaptées
- Inter-opérabilité des systèmes
- Coût à la mise en place mais potentielles retombées médicales

→ Nécessité d'un soutien financier et institutionnel

Conclusion

- <u>Etapes avant application en pratique clinique</u>

- Validation externe et généralisation des résultats
- Interprétation des algorithmes d'IA

- Etudes médico-économiques

→ Besoin d'une expertise médicale pour évaluer l'efficacité, la sécurité et les bénéfices pour la pratique

→ Collaboration transdisciplinaire +++

- <u>Considérations éthiques et culturelles</u>

- Perception de l'IA par les patients et les professionnels de la santé
- Impact sur la relation médecin/malade ?

→ Standardisation et élaboration de guidelines

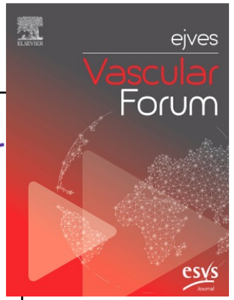
Conclusion

Ethics and Legal Framework for Trustworthy Artificial Intelligence in Vascular Surgery.

Lareyre F, Maresch M, Chaudhuri A, **Raffort J.**

EJVES Vasc Forum. 2023 Sep 2;60:42-44. doi: 10.1016/j.ejvsvf.2023.08.003. eCollection 2023.

PMID: 37790247 **Free PMC article.** No abstract available.



→ **Ethic principles:**

Key-requirements, **EU's AI high level group of experts**

→ **Legal framework:**

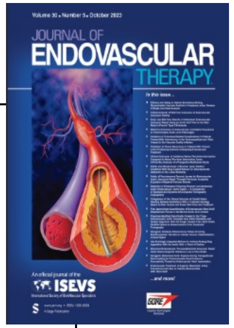
. Europe: GDPR, CE mark, EU'S AI Act

. USA: HIPAA, FDA, Algorithmic Act (?)

Editorial

Artificial Intelligence–Powered Technologies for the Management of Vascular Diseases: Building Guidelines and Moving Forward Evidence Generation

Fabien Lareyre, MD, PhD [1,2], Anders Wanhainen, MD, PhD [3,4], and Juliette Raffort, MD, PhD [2,5,6]



→ Several **AI extensions** have been added or are being built **to existing guidelines** to help investigators to evaluate AI-research outpout.

. SPIRIT-AI, CONSORT- AI (trials)

. STARD-AI, QUADAS-AI (diagnostic test accuracy)

. TRIPOD-AI, PROBAST-AI (prediction tools)

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