In vitro study of the therapeutic technique of vessel embolization by glue injection

Research laboratory
Université de Technologie de Compiègne
Biomechanics & Bioengineering Laboratory (BMBI), UMR CNRS 7338
“Biological Fluid Structure Interactions” Team (http://www.utc.fr/bmbi/spp.php?article378)

Thesis supervisors
Dr Anne-Virginie Salsac, CR CNRS (HDR)
Prof. Dominique Barthès-Biesel, Emeritus Prof.

Scientific domains
Biomedical and health science engineering, Science and technology

Research work
Endovascular embolization is a minimally invasive treatment used to stop or reduce the blood flow to specific parts of the body by introducing embolic agents that occlude vessels [1]. The procedure is guided under X-ray by navigating a guidewire and a catheter through the vasculature to reach the targeted location of delivery of the embolic agent. Liquid embolic glues are particularly well suited to vascular embolization: they are characterized by a low viscosity, rapid polymerization and low tissue toxicity, as well as a good penetration ability, which enables a complete and permanent occlusion of small vessels. Embolization with glue also shows a lower complication rate than particulate agents or coils [2,3]. It is widely used to manage vascular abnormalities, such as vessel dilatations (aneurysms, varices), arteriovenous malformations (AVM) and tumours [4,5], but its use as embolic agent could be even further generalized, if the injection and polymerization processes were better quantified and controlled.

The clinical practice of glue embolization is still largely based on empiricism, due to the lack of understanding of the phenomena of glue convection and polymerization in a surrounding blood flow. The project aims at providing precise and reproducible assessment of the mechanical and physico-chemical processes at play during the medical procedure of glue embolization. This will be achieved with dedicated in vitro experiments, where the different physical parameters governing embolization can be well controlled. The objectives of the project will be to study the glue polymerization reaction as well as the interactions between glue injection, convection and polymerization kinetics. This will be achieved by performing experiments in vessel phantoms under static and dynamic conditions [6-8], the latter consisting in injecting glue mixtures in an external flow mimicking the blood flow. The study will be conducted in close collaborations with clinician and industrial partners.

The study will aim at providing answers to the following questions that are key to interventional radiologists: Where should the glue be injected in the vasculature? Which concentrations, temperatures and mixing procedure should be used for optimal results? Does the entire glue volume get solid? When is the adequate moment to withdraw the catheter? The answers to these questions will enable to propose optimizations to the clinical use of glue injection.

Keywords
Vessel embolization, glue polymerization, injection dynamics, mechanical characterization, chemical reaction

References
Research team
The project will take place within the Biological Fluid-Structure Interaction Group, directed by A.V. Salsac, which is one of the 3 research teams of the UTC Biomechanics & Bioengineering Laboratory (BMBI). The team is one of the leading groups specialized in the fields of biofluids and hemodynamics at both the microscopic and macroscopic scales. The strength of the group is the long-standing expertise in numerical and experimental modeling of the fluid-structure interactions associated with blood flows and of innovative endovascular techniques.

Supervisors
After having graduated from UCSD & Ecole Polytechnique with a PhD in Biofluids, Anne-Virginie Salsac spent two years at University College London as a Lecturer and was recruited by the CNRS in 2007. She is CNRS Researcher (CR1, with habilitation) at BMBI and Visiting Professor at Queen Mary University of London. She has been awarded various prizes, including the CNRS bronze medal in 2015 and National Order of Merit in 2016, for her research on vascular mechanics, the microcirculation and biomedical engineering applications. She has authored over 200 papers and conferences and is co-inventor of one patent. She is strongly involved in dissemination of scientific activities (Femmes en Or, Ma thèse en 180s …) and has a strong involvement in institutional activities (member of the interdisciplinary section 54 of CoCNRS, elected member of the Scientific Council at UTC).

Dominique Barthès-Biesel, Emerit Professor, is internationally renowned for her pioneering work on the study of capsule dynamics. She is specialized in microhydrodynamics and complex fluids under low Reynolds number flows. She has conjointly held a Professorship at Ecole Polytechnique (Palaiseau, France) for 25 years. She is currently Chair of the World Council for Biomechanics.

Material resources
All of the tools and equipment are available for the project:
- Experimental benches to study glue polymerization under static and dynamic conditions
- Biofluids platform equipped with pressure flow controllers, flowmeters, high-speed cameras
- RMN

Human resources
The Biomechanics & Bioengineering laboratory is composed of:
- 40 permanent staff members (27 academic staff, 13 technical and administrative staff)
- 31 PhD students
- 8 Postdocs
- 7 associated researchers
- 15 Master students

Related collaborations
- University hospitals:
  - Caen Research Hospital, Caen (France)
  - Amiens Research Hospital, Amiens (France)
  - Lariboisière Hospital, Paris (France)
- Scientific collaborators:
  - Enzymatic and Cellular Engineering Laboratory, UTC, Compiègne (France)
  - Cervoxy, CEA Caen (France)
- Compagnies:
  - Guerbet, Aulnay-sous-Bois (France)
  - GEM srl, Viarregio (Italy)

Requirements
- Knowledge in fluid/solid mechanics
- Notions of biomechanics and bioengineering
- Ability to work in team in an interdisciplinary context
- Rigor, conscientiousness, motivation, dynamism
- Good English skills
Contact

To apply please send a complete CV, a letter of motivation, 2 letters of recommendation or the contact details of 2 referring persons, as well as the result transcripts for all the courses followed at university to:

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