**CIFRE PhD position IGL/CREATIS**

# OPTICAL EVALUATION OF ORGAN VIABILITY FOR TRANSPLANTATION

Organ transplantation is facing a growing shortage of grafts. Advances in surgical techniques have made transplantation a reference treatment for end-stage diseases, leading to an increase in the number of patients on waiting lists. This growing demand is not matched by an equivalent rise in donor numbers, which extends waiting times and increases patient mortality.
To address this shortage, so-called "marginal" organs from expanded criteria donors represent one avenue for broadening the pool of available grafts. These organs carry a higher risk of post-transplantation complications, however, which makes their assessment all the more important. Currently, organ viability is evaluated through biopsy followed by histological analysis. This method has several limitations: results are sometimes obtained after the transplant has already taken place, pathological interpretation remains subjective, and the procedure is invasive by nature. There is therefore a need to develop an objective and faster assessment method, enabling surgeons to better select transplantable organs.

## Keywords :

Organ transplantation, biomedical optics, fluorescence spectroscopy, infrared spectroscopy, optical medical devices, artificial intelligence

## PhD objectives :

Optical methods have the potential to address this challenge. Non-invasive, rapid, and compatible with intraoperative use, they allow continuous and quantitative monitoring of tissue condition without disrupting the transplantation protocol. The aim of this thesis is to develop such objective methods for assessing organ viability, in order to broaden the pool of transplantable organs and reduce rejections and graft failures linked to poor selection (illustrated in Figure 1).

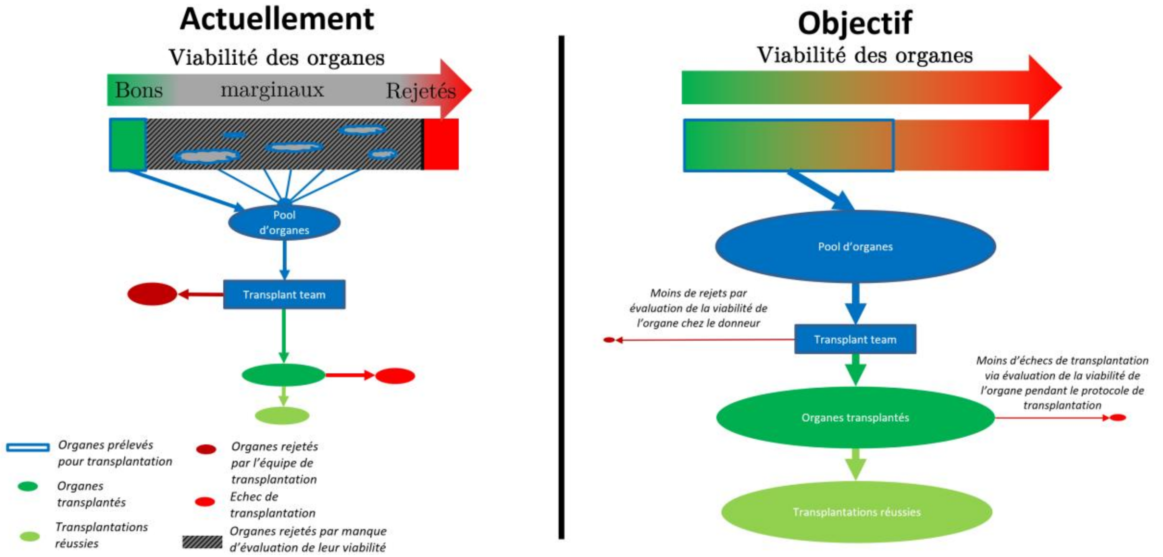


Figure 1 Schéma de l'augmentation de la pool d'organes et du nombre de transplantation réussies grâce à une évaluation objective de la viabilité des organes

This work will directly follow on from the thesis of Antoine Uzel (IGL/CREATIS, 2026), which laid the first groundwork for this type of assessment on the liver by developing two complementary approaches: near-infrared diffuse reflectance spectroscopy (NIR-DRS) for quantifying hepatic steatosis, with a particular focus on differentiating micro- and macrovesicular steatosis [Chopinet,et al., Diagnostics 2024 ; Uzel et al., ECBO 2025], nd fluorescence spectroscopy for metabolic tissue monitoring through the study of endogenous fluorophores such as NADH, FAD, and vitamin A [Uzel et al, 2025 ; Croce et al, 2018]. Attention will also be given to implementing artificial intelligence methods to score organs based on optical measurements.

### Scientific challenges

Real-time evaluation of graft viability depends on the ability to robustly measure biomarkers of mitochondrial energy metabolism and tissue oxygenation [Mayevsky et al. 2003 ; Bellini et al. 2021]. Optical methods such as NIR-DRS and fluorescence spectroscopy are well suited for this continuous monitoring, but their clinical deployment faces several obstacles. Quantification models for optical biomarkers must be robust to the significant variations in optical properties encountered across the different stages of transplantation, depending on the perfusion state and temperature of the organ [Nogueira et al. 2021]. Furthermore, organ viability is complex and multiparametric: complementary biomarkers and multimodal probes are needed to build a reliable indicator. The link between optically measured biomarkers and the functional outcome of the graft after transplantation still needs to be established on sufficiently representative cohorts. Finally, various AI methods will be explored to translate optical measurements into a viability "score" that can be provided to surgeons to assist decision-making during a transplantation protocol.

### Expected original contributions :

We propose to continue developing the multimodal probe (NIR-DRS, fluorescence spectroscopy) initiated in previous work, along three main lines :

- Organ assessment at the donor site: the probe must enable rapid, non-invasive measurement of the degree of macrovesicular steatosis and the metabolic state of the tissue without requiring the donor to be opened.
- Continuous monitoring during the transplantation protocol on a perfusion machine: optical measurements will be integrated into the hypothermic and normothermic perfusion machines developed by one of the project partners (Institut Georges Lopez), in order to track the evolution of metabolic and hemodynamic biomarkers throughout the machine perfusion protocol.
- Development of optical quantification models for biomarkers from the spectroscopic measurements obtained with the various optical systems developed, and implementation of AI models (machine learning) for organ scoring based on spectroscopic measurements and the optical models developed. Several datasets from animal models and human biopsies have already been acquired during Antoine Uzel's thesis and will be available to define the optical models, alongside the optical systems development work.

Finally, a study of the relationship between optical biomarkers and organ viability will need to be conducted: particular attention will be paid to the correlation between indicators measured by optical methods (optical redox ratio, macrovesicular steatosis rate, tissue oxygen saturation) and reference biological markers as well as post-transplantation functional outcomes, in order to define objective decision criteria for graft acceptance.

The optical devices developed will be characterized on various laboratory phantoms. Measurements will be carried out on porcine livers during hypothermic and normothermic machine perfusion protocols from the start of the thesis, with the ambition of moving towards measurements on human livers in collaboration with the Hospices Civils de Lyon.

### Supervision :

Three structures will be involved in the scientific supervision of this project :

- Institut Georges Lopez (IGL) is a company specializing in the design, manufacture, and commercialization of technologies for the preservation and transport of human organs for transplantation, developing products ranging from static preservation solutions (used primarily for the liver, kidney, and pancreas) to hypothermic perfusion machines (used mainly for the kidney).
- CREATIS laboratory is an applied research laboratory in medical imaging, affiliated with the CNRS, INSERM, INSA de Lyon, and Université Lyon 1.
- Clinical partners including in particular the Hospices Civils de Lyon (HCL)

The supervision committee will bring together specialists from each component of this PhD project :
- clinical medical optics setup (Bruno Montcel, MAGICS team, CREATIS)
- Machine Learning for optics (Cédric Ray-Garreau, MAGICS team, CREATIS)
- Data analysis (Michaël Sdika, MYRIAD team, CREATIS)
- as well as the company representative specializing in biomedical optics, who carried out the initial work on the subject (Antoine Uzel, IGL engineer)

This work is part of the ITI Labcom project (Imaging for Transplantation Assisted by Artificial Intelligence), funded by the ANR, which structures the IGL/CREATIS collaboration over 5 years with the ultimate goal of commercializing organ viability assessment devices.

### Candidate profile :

The person recruited will work on both the development and modelling of optical setups, signal processing, and data analysis. They will conduct laboratory characterization experiments as well as in vivo experiments on animal models, humans, and human organs under surgical conditions. The prerequisites are therefore those of a physicist and/or engineer with a specialization in modelling and/or data analysis, and a strong interest in interdisciplinary work in the medical and biomedical field.

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