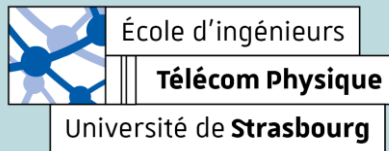


Information Sciences & Technology

for Healthcare | HealthTech

The interdisciplinary thematic institutes

of the University of Strasbourg & CNRS & Inserm



INSTITUT DE CHIRURGIE
GUIDÉE PAR L'IMAGE



Robotization of a transesophageal probe for interventional echocardiography

Friday, 13th February

Supervisors : PhD - Benoit ROSA, PhD -
Florent NAGEOTTE, PhD - Johnatan VAPPOU
Co-Investigator : Prof. Elena GALLI



Léon LEROY

Master 2 HealthTech 2025-2026

Clinical Context – Minimally invasive S.H.I.

- Catheter-based structural heart interventions
- Reduced surgical trauma, faster recovery

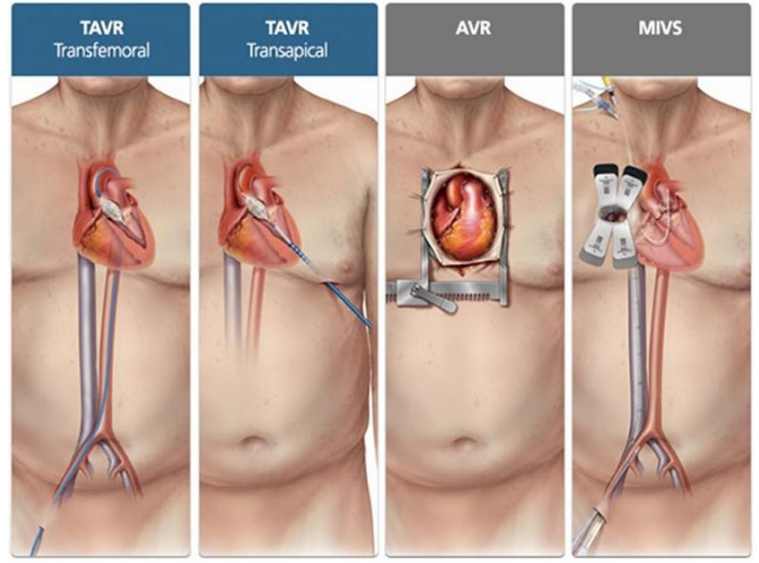


Figure : Comparison between transcatheter and surgical heart valve interventions [1]

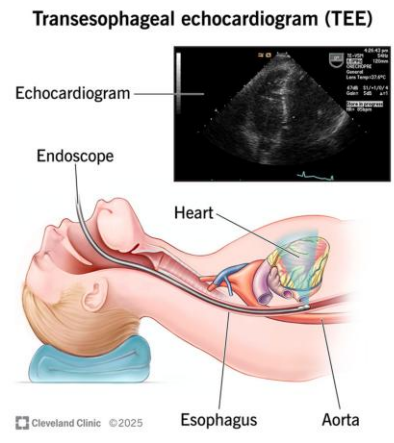


Figure : Transesophageal echocardiography TEE

Strong dependence on real-time imaging (Fluoroscopy + TEE)



Clinical Risks – Patient Risk

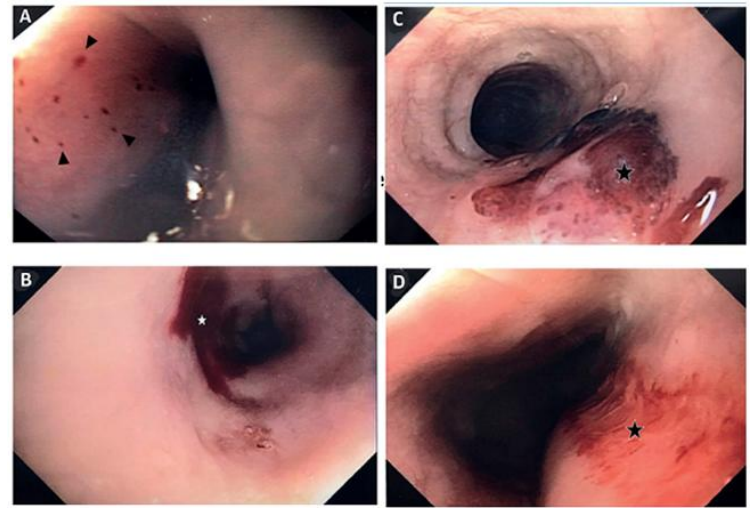


Figure : Examples of esophageal injuries associated with prolonged TEE manipulation

Why is TEE risky for the patient ?

- Invasive and prolonged procedure
- 1–4 hours
- Continuous mechanical contact with esophageal wall

Reported complications include : [2],[3],[6]

- Esophageal hematoma
- Mucosal trauma
- Complication Rate 0,2-1,4 %
- Rare but severe esophageal perforation



Clinical Risks – Operator Risk

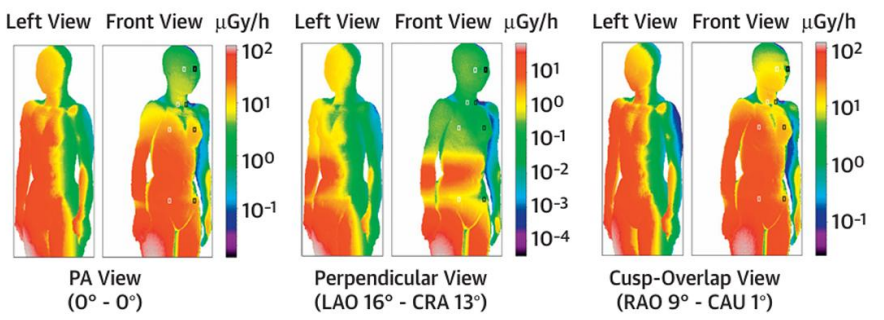
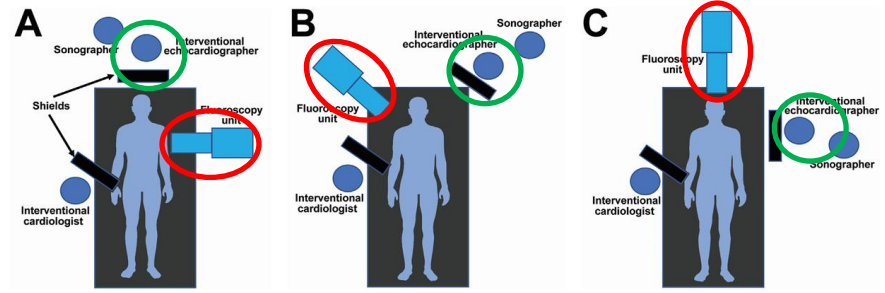


Figure : Radiation exposure of medical staff depending on C-arm configuration [14]

Figure : Spatial Distribution of Radiation Dose [5]

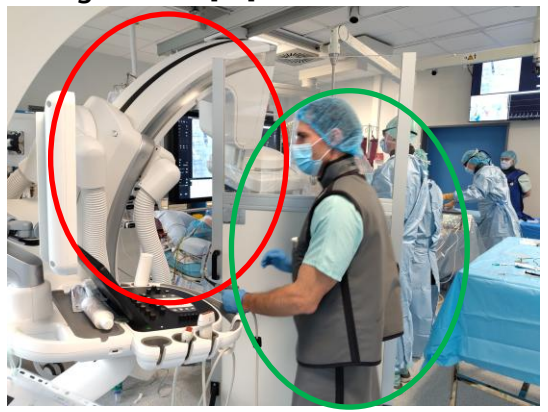


Figure : Echocardiographer operating near the fluoroscopy C-arm

- Highly constrained environment with multiple operators and devices
- Echocardiographer positioned close to X-ray source [4],[5],[6]
- Ergonomics is a major issue : Static posture - Lead aprons

Problem Definition

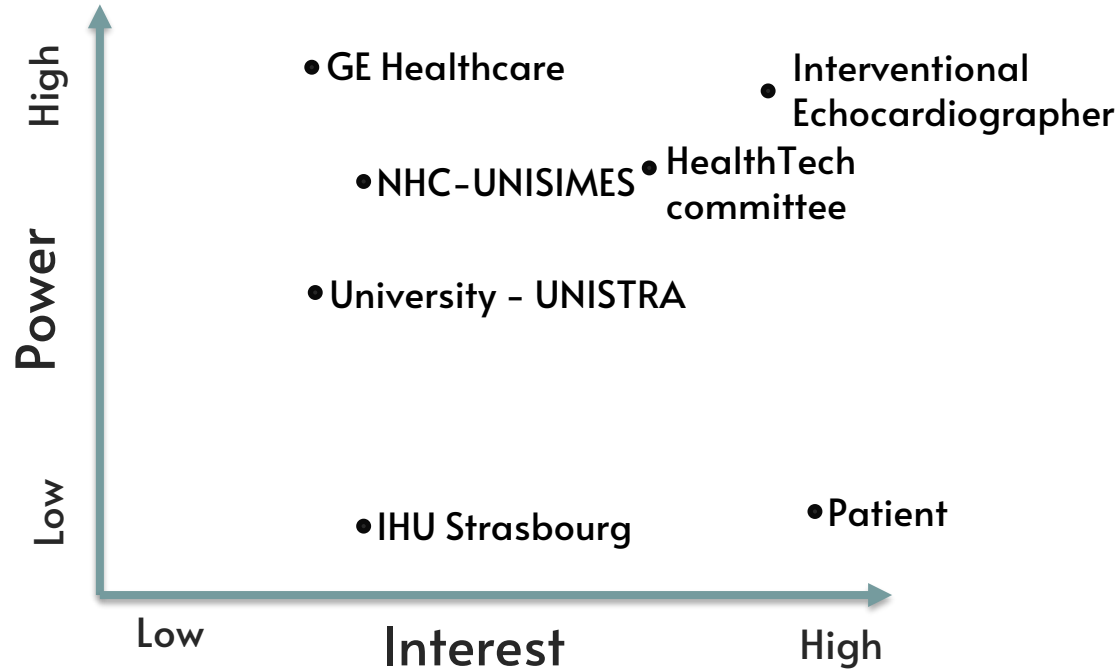
Who	Interventional Echocardiographers and Patients undergoing structural heart interventions.
What	<p>High Radiation Exposure</p> <p>Musculoskeletal Disorders</p> <p>Fatigue</p> <p>Patient Risk</p>
Where	Operating Rooms
When	During complex, long-duration procedures
Why	The current manual procedure requires the IE to stand directly next to the patient and the C-arm (X-ray source)
GOAL	Develop a teleoperated robotic system compatible with commercial TEE probes, allowing the operator to control the probe remotely from a radiation-shielded area.

Table : Problem Definition [1-6]

SWOT Analysis

Strengths	Weaknesses
<p>Direct access to surgeons for "real-world" feedback.</p> <p>Access to IHU facilities and 3D printing lab.</p> <p>Availability of Dynamixel motors with validated torque</p> <p>Opportunities</p> <p>Opportunity to discover the environment in a research laboratory</p> <p>Market Growth: Increase in complex structural heart procedures (e.g. MitraClip). [1], [6]</p> <p>Publication: Potential to publish a technical paper on the prototype.</p>	<p>Strict academic timeline (Master's thesis).</p> <p>Limited financial resources for high-end prototyping,</p> <p>3D printed parts (PLA/PETG) may lack long-term durability compared to injection molding.</p> <p>Threats</p> <p>Manufacturers (GE, Philips) may directly integrate robotic actuation</p> <p>Adoption: Clinicians resisting change or loss of "tactile feedback".</p>

Stakeholder Analysis



Toward Robotic Control of TEE

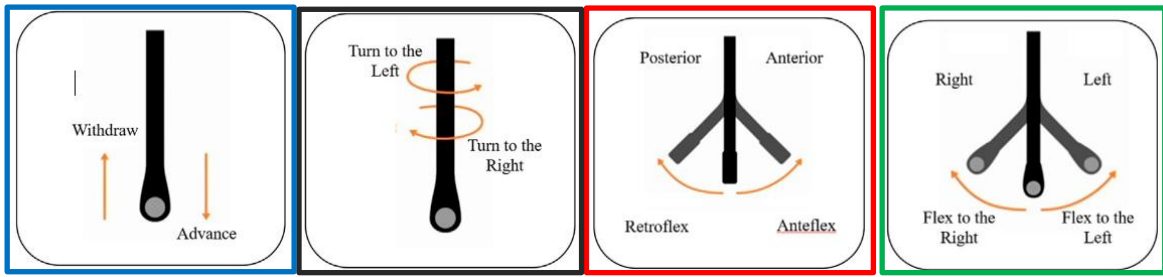


Figure : Degrees of freedom of a TEE probe

Preservation of standard clinical gestures [7],[8]

- Physical decoupling from radiation
- Improved stability
- Reduced fatigue

Degree of Freedom	Range	Actuation Interface
Pitch (Ante/Retro flexion)	180° / 90°	Large control wheel (primary flexion)
Yaw (Left/Right flexion)	±45°	Small control wheel (lateral flexion)
Roll (Axial rotation)	±180°	Rotation of the probe shaft
Translation (Insertion)	50 mm	Manual push / pull along probe axis

Figure : Degrees of freedom, ranges, and actuation interfaces of a TEE probe

