Driving Surgical Insights: Automating Quality Improvement in Cardiac Care

HDR UK Black Internship Programme 2025 | Host: European Association for Cardio-Thoracic Surgery (EACTS)

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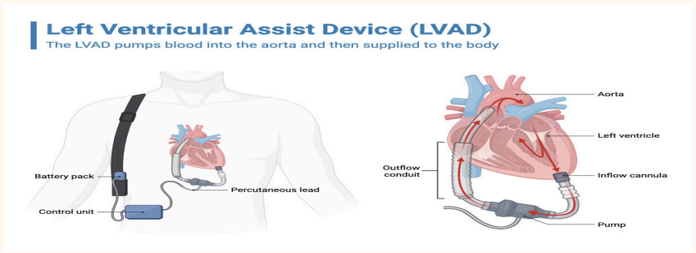
The EUROMACS Registry

Background & Context: The Critical Role of VADs in Heart Failure

Heart failure remains a significant global health challenge, often requiring advanced interventions. For many patients, Left Ventricular Assist Devices (LVADs) offer a lifeline, providing crucial mechanical support to the failing heart. These devices significantly improve quality of life and extend survival for individuals awaiting transplant or those ineligible for it.

The **EUROMACS registry** stands as a cornerstone in this field, systematically collecting comprehensive data on the implantation and outcomes of mechanical circulatory durable support devices, including LVADs, across numerous European centres. This rich dataset provides an invaluable resource for understanding real-world performance and identifying areas for improvement.

Leveraging this data, EACTS's **Quality Improvement Programme (QUIP)** plays a pivotal role. QUIP translates raw registry data into insightful reports. The ultimate goal is to provide hospitals with tailored feedback that directly informs clinical practice, thereby improving surgical outcomes. This data can also support ongoing research in mechanical circulatory support, helping to guide the management of heart failure patients.



Jiang, W. (2025) BioRender.https://app.biorender.com/biorender-templates/details/t-661307d65a1b5d0d5e6238fe-left-ventricular-assist-device-lvad

What is an LVAD?

An LVAD is a mechanical pump implanted in patients with heart failure to help their heart pump blood from the lower left chamber (left ventricle) to the rest of the body. It's used as a bridge to transplant, or as a long-term therapy.

European Association for Cardio-Thoracic Surgery (EACTS)

EACTS is a leading international membership organisation, founded in 1986, that advances education, research, and quality improvement in heart and lung surgery. It supports surgeons, hospitals, and researchers across Europe through training programmes, journals, clinical registries such as **EUROMACS**, and collaborative networks.

One of EACTS' initiatives is the **Quality Improvement Programme (QUIP)**, which transforms registry data into meaningful feedback for hospitals. These insights help clinical teams enhance care and improve outcomes in cardiothoracic surgery. In addition to informing clinical practice, data from EUROMACS are regularly used in quality research and have contributed to numerous scientific publications in the field of mechanical circulatory support.

Project Goal: Automating Insights for Better Patient Care

This project aims to turn complex EUROMACS data into tailored reports for surgeons in participating hospitals, helping to identify data gaps, improve data collection and recording practices, and ultimately enhance both data quality and patient outcomes.

1

Automated Reporting Pipeline

Develop a reproducible system using **R Markdown** to generate hospital reports.

2

Outlier Detection & Performance

Identify potential data and clinical outliers, highlighting key performance indicators for each hospital.

3

Clinically Accessible Data

Present complex data clearly so clinicians and quality teams can use it to improve care.

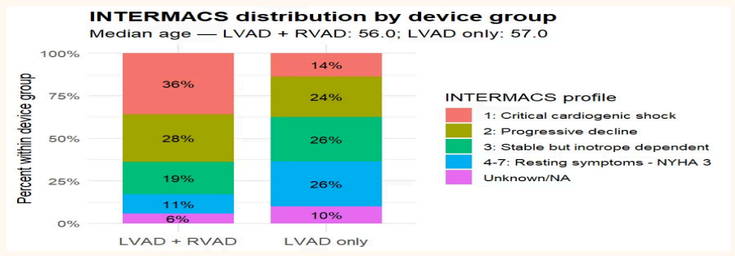
Methods & Key Findings

Methods

- **Dataset Overview:** The analysis was based on 8,524 patient records from the EUROMACS registry, including cases with durable LVAD support, with or without temporary RVAD.
- **Automated Reporting Workflow:** Built a reproducible pipeline using R Markdown.
- **Template Report Developed:** A flexible report format for hospital data.
- **Data Cleaning:** Addressed format inconsistencies, missing values, and harmonisation across variables.
- **Outlier Detection:** Applied statistical thresholds (e.g. IQR) to flag potential clinical or data anomalies.
- **Visualisation:** Used ggplot2 to generate interpretable charts (e.g., age distribution, ICU stay).
- **Documentation & Reproducibility:** Version controlled via Git and documented in R Markdown.

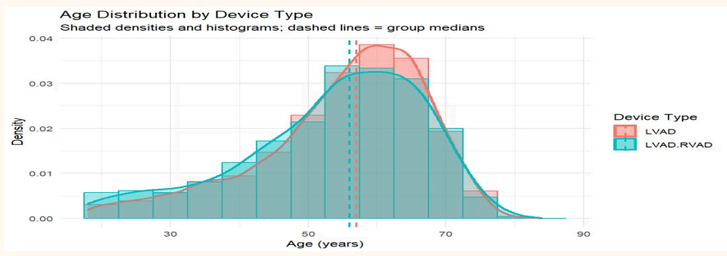
Key Findings

- **Data Quality Identified:** Common issues included inconsistent formats and missing outcome data.
- **Potential Outliers Flagged:** ICU length of stay highlighted for further review.
- **Improved Usability:** Clear visuals and narrative enhanced clinician interpretability.
- **Clinical Insight Gained:** Variations by age, gender, and device type revealed population differences.
- **Supports Quality Improvement:** Outputs aligned with benchmarking goals of EACTS QUIP.



INTERMACS Profile Distribution by Device Group

Stacked bar chart showing the distribution of INTERMACS profiles among patients receiving either LVAD only or combined LVAD + RVAD support. The **LVAD + RVAD group** includes a higher proportion of patients in **critical cardiogenic shock (INTERMACS 1)**, while the **LVAD-only group** has a larger share of patients with **less severe profiles** (INTERMACS 3–7).



Age Distribution by Device Type (Combined Plot)

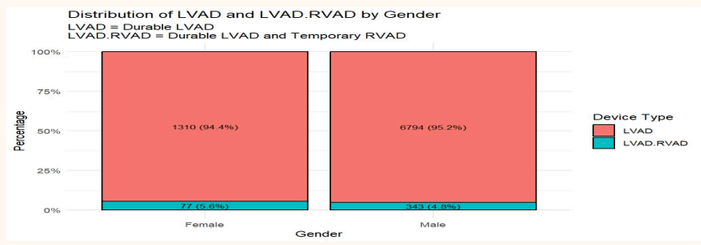
Patient age distributions vary by device type, with slightly younger profiles in patients receiving combined LVAD+RVAD support. Median age of 57 for LVAD patients and 56 for LVAD+RVAD

What is an RVAD?

A mechanical pump that supports the right side of the heart . It's often used temporarily alongside an LVAD in cases of biventricular heart failure.

Limitations - Data Skewness

While LVAD.RVAD patients are typically older, the dataset analysed here includes a relatively small LVAD.RVAD subgroup, which appears skewed toward younger ages. This may reflect sampling bias or underrepresentation of older RVAD cases within the subset of data received from participating hospitals.



Distribution of LVAD and LVAD.RVAD by Gender

Across both male and female patients, the vast majority received durable LVADs. A small proportion received combined LVAD.RVADs, with similar patterns observed across genders.

Baseline characteristics of isolated LVAD (± temporary RVAD) implants	
Procedures	
No. of procedures	8,524
LVAD only	8,104
LVAD + temporary RVAD	420
Patient demographics	
Age, median [IQR]	57.00 [49.00, 64.00]
Male, n (%)	7,137 (83.7)%
Female, n (%)	1,387 (16.3)%
INTERMACS profile, n (%)	
1: Critical cardiogenic shock	1,259 (16.4)%
2: Progressive decline	2,046 (26.6)%
3: Stable but inotrope dependent	2,200 (28.6)%
4-7: Resting symptoms - NYHA 3	2,182 (28.4)%
History neurological event	
TIA	214 (3.2)%
ICB	49 (0.7)%
Ischaemic CVA	503 (7.4)%
Currently smoking, n (%)	64 (6.3)%
Rhythm, n (%)	
Atrial Fibrillation	1,190 (18.2)%
Atrial Flutter	100 (1.5)%
Other	135 (2.1)%
Paced	1,525 (23.3)%
Sinus	3,595 (54.9)%
Device strategy, n (%)	
Possible bridge to transplant	2,685 (33.7)%
Bridge to transplant	5,388 (67.7)%
Destination therapy	2,042 (25.6)%
Rescue therapy	325 (4.1)%
Bridge to recovery	176 (2.2)%
Others	2,073 (26.0)%
Hospital outcome	
Hospital deaths, n (%)	1,101 (14.9)%
ICU/CCU stay (days), median [IQR]	10.00 [5.00, 24.00]

Notes: Percentages use available data as denominator. ICU/CCU stay parsed to days when ranges present.

Baseline Characteristics of Patients Undergoing LVAD (± temporary RVAD) Implantation

This table presents key baseline characteristics of patients who received isolated durable LVAD support, with or without temporary RVAD support, as reported in the 4th EUROMACS annual registry report (Veen et al., 2025). It includes procedure counts, patient demographics, INTERMACS clinical profiles, neurological history, rhythm disturbances, device strategy intentions, and early hospital outcomes. The table serves as a clinical reporting standard that this project aims to replicate.

Why This Matters

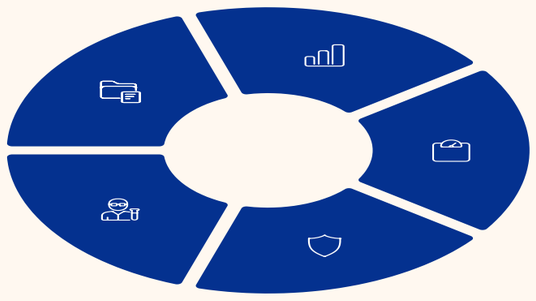
This project transforms data into real-world benefits for patients and healthcare professionals:

Improved Data Collection & Quality

Helps hospitals identify missing or inconsistent data, enabling more complete and reliable analysis.

Evidence-Based Improvements

Facilitates data-driven enhancements in surgical processes.



Better Hospital Feedback

Hospitals get actionable data to make informed decisions.

Identified Care Variation

Highlights differences in care, fostering best practice sharing.

Enhanced Quality & Safety

Supports transparency and patient safety in cardiac surgery.

This work ensures patients undergoing LVAD implantation receive the highest standard of care.

Acknowledgements

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Reference:

Veen KM, Ahmed M, et al. The fourth report of the European Registry for Patients with Mechanical Circulatory Support (EUROMACS) of the European Association for Cardiothoracic Surgery: focus on standardized outcome ratios. *Eur J Cardiothorac Surg*. 2025;67(2):ezaf016. doi:10.1093/ejcts/ezaf016

Transforming Data into Better Patient Care

By turning complex clinical data into clear insights, this project contributes to **enhanced patient outcomes** and a safer future for those living with heart failure.