IL MONITORAGGIO CONTINUO E REMOTO DELLA PAP PER RIDEFINIRE LA GESTIONE DELLO SCOMPENSO CARDIACO

Dott. Gaetano Senatore
SC CARDIOLOGIA
OSPEDALE DI CIRIE'

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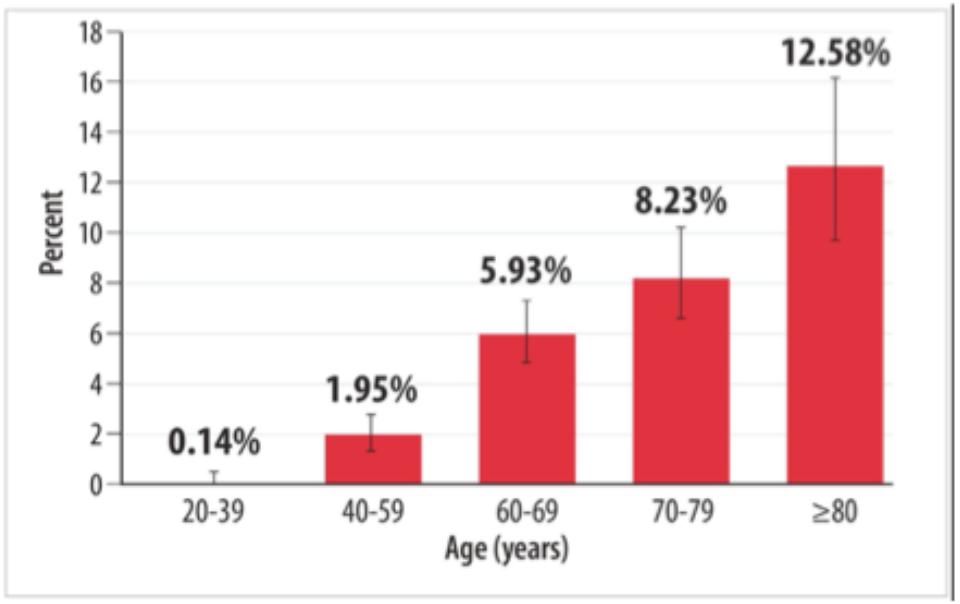
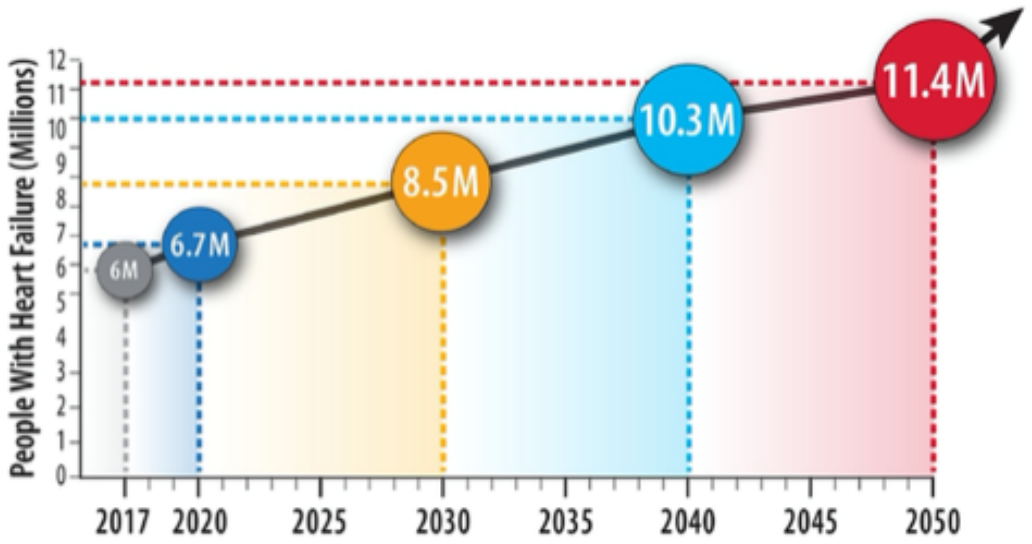
Cardiologia Cirié

Prevalenza HF

HF STATS 2025: Heart Failure Epidemiology and Outcomes Statistics An Updated 2025 Report from the Heart Failure Society of America





Journal of Cardiac Failure 32 (2026) 439–498

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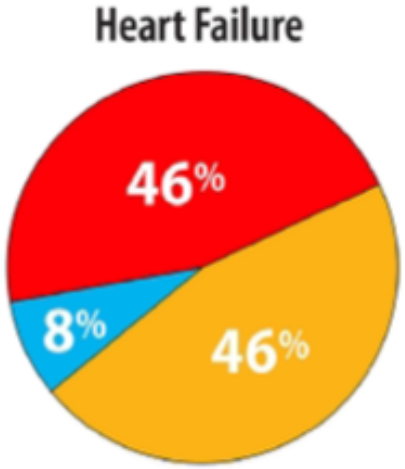
Mortalità



HFpEF (EF ≥50%) HFbEF (EF 41-49%) HFrEF (EF ≤40%)

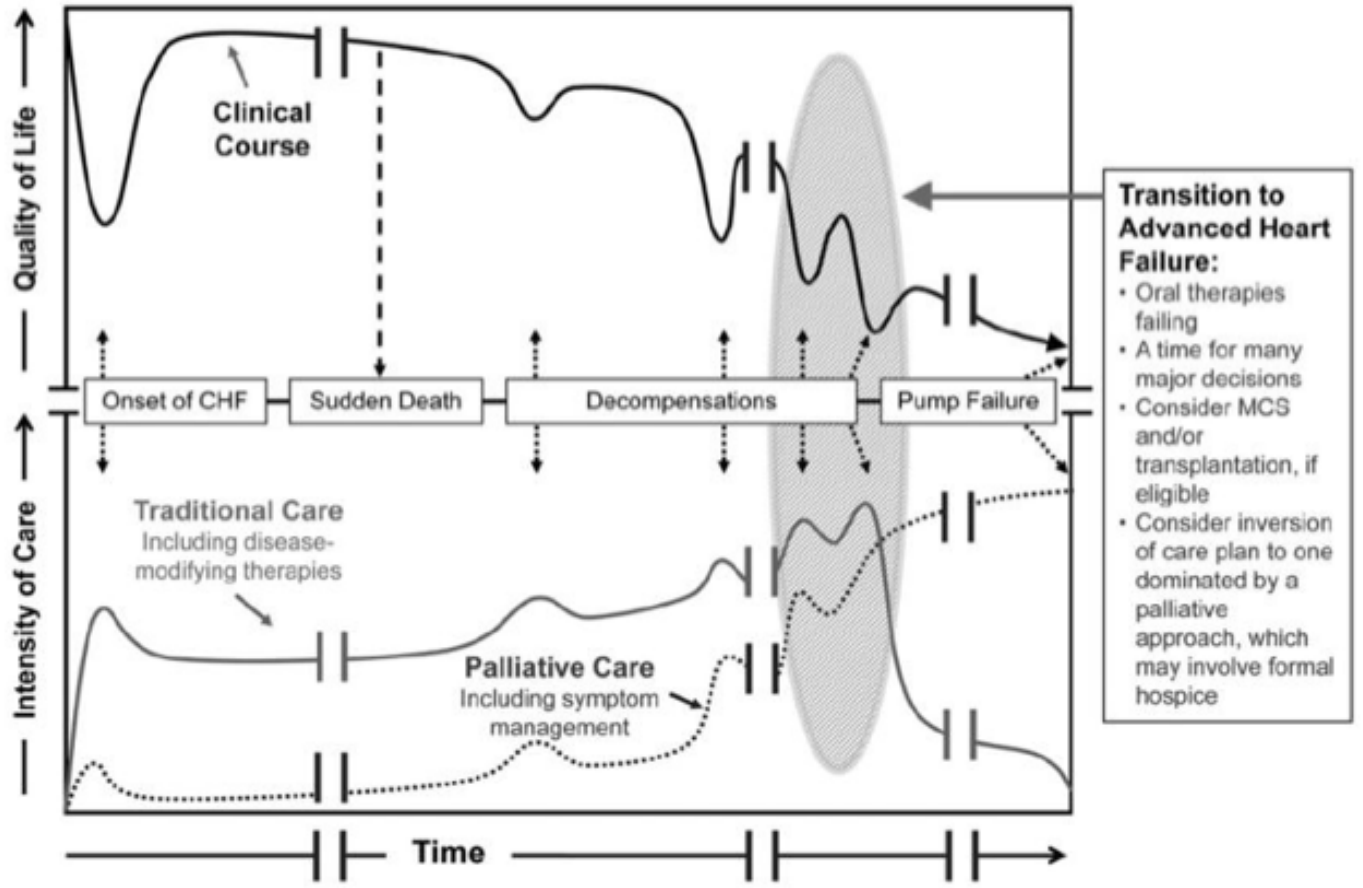
Outcomes: 5-Year Event Rates (%)

	Mortality	Readmission	CV Readmission	HF Readmission	Mortality/Readmission
HFrEF	75.3	82.2	63.9	48.5	96.4
HFbEF	75.7	85.7	63.3	45.2	97.2
HFpEF	75.7	84.0	58.9	40.5	97.3

Journal of Cardiac Failure 32 (2026) 439–498

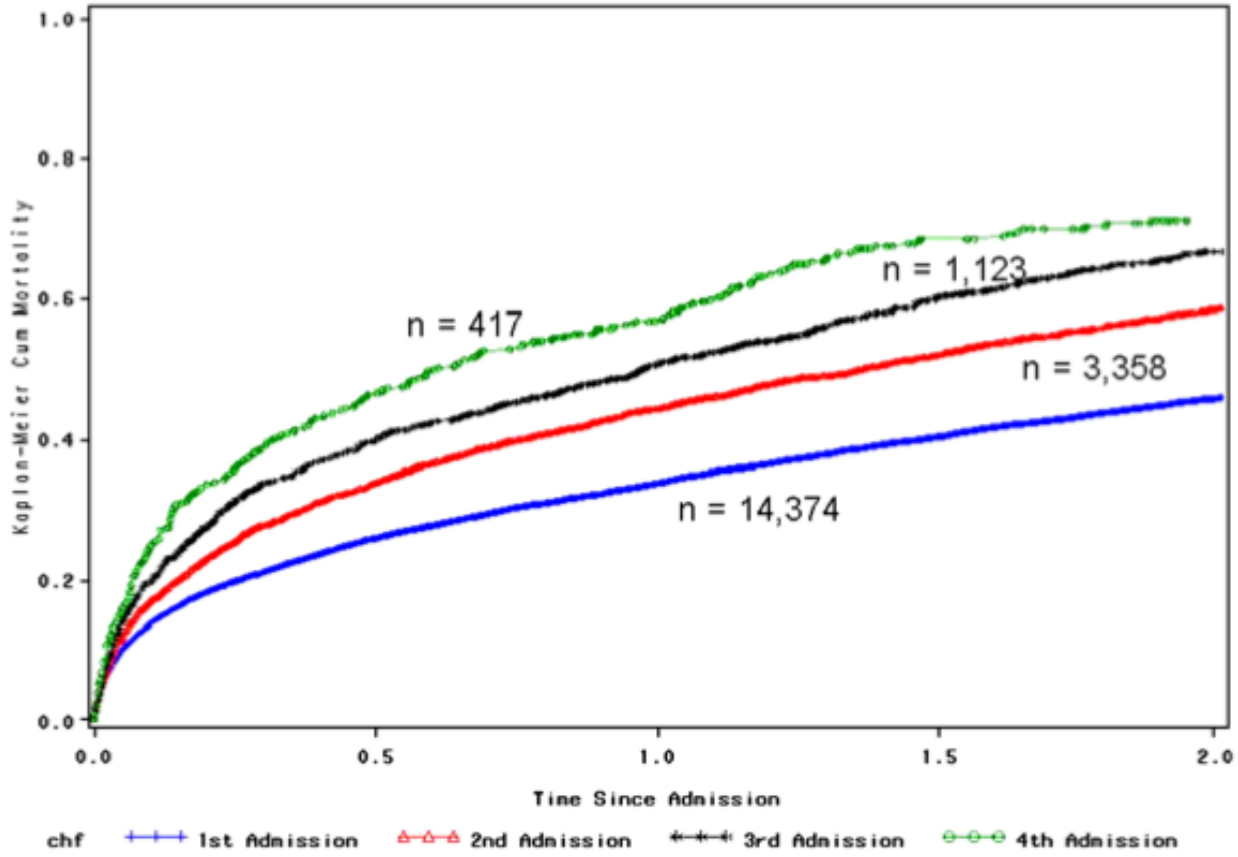
Decision Making in Advanced Heart Failure

A Scientific Statement From the American Heart Association



Circulation. 2012;125:1928-1952

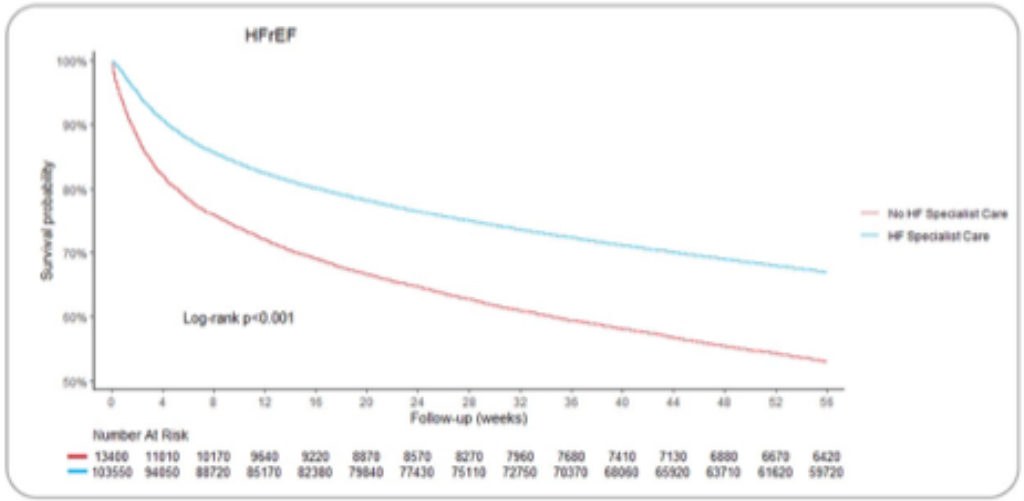
Repeated hospitalizations predict mortality in the community population with heart failure

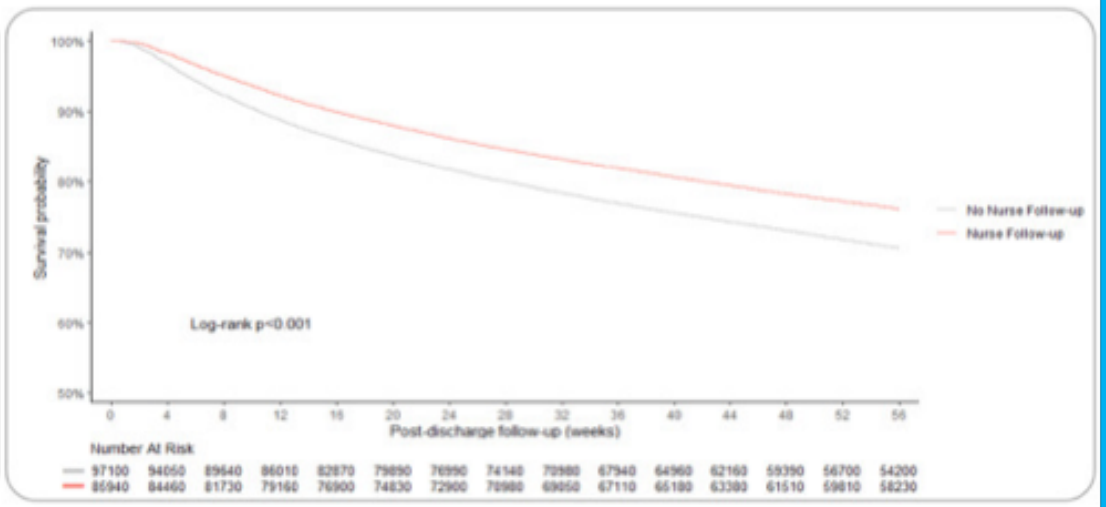


Am Heart J 2007;154:26026

Heart Failure Specialist Care and Long-Term Outcomes for Patients Admitted With Acute Heart Failure

Antonio Cannata, MD,[a,b] Mehrdad A. Mizani, PhD,[c] Daniel I. Bromage, PhD,[a,b] Susan E. Piper, MD,[a,b] Suzanna M.C. Hardman, PhD,[d] Cathie Sudlow, PhD,[c] Mark de Belder, MD,[e] Paul A. Scott, MD,[a,b] John Deanfield, FRCP,[e] Roy S. Gardner, MD,[f,g] Andrew L. Clark, MD,[h] John G.F. Cleland, MD,[i] Theresa A. McDonagh, MD,[a,b] the CVD-COVID-UK/COVID-IMPACT Consortium





JACC Heart Fail. 2025;13:402–413

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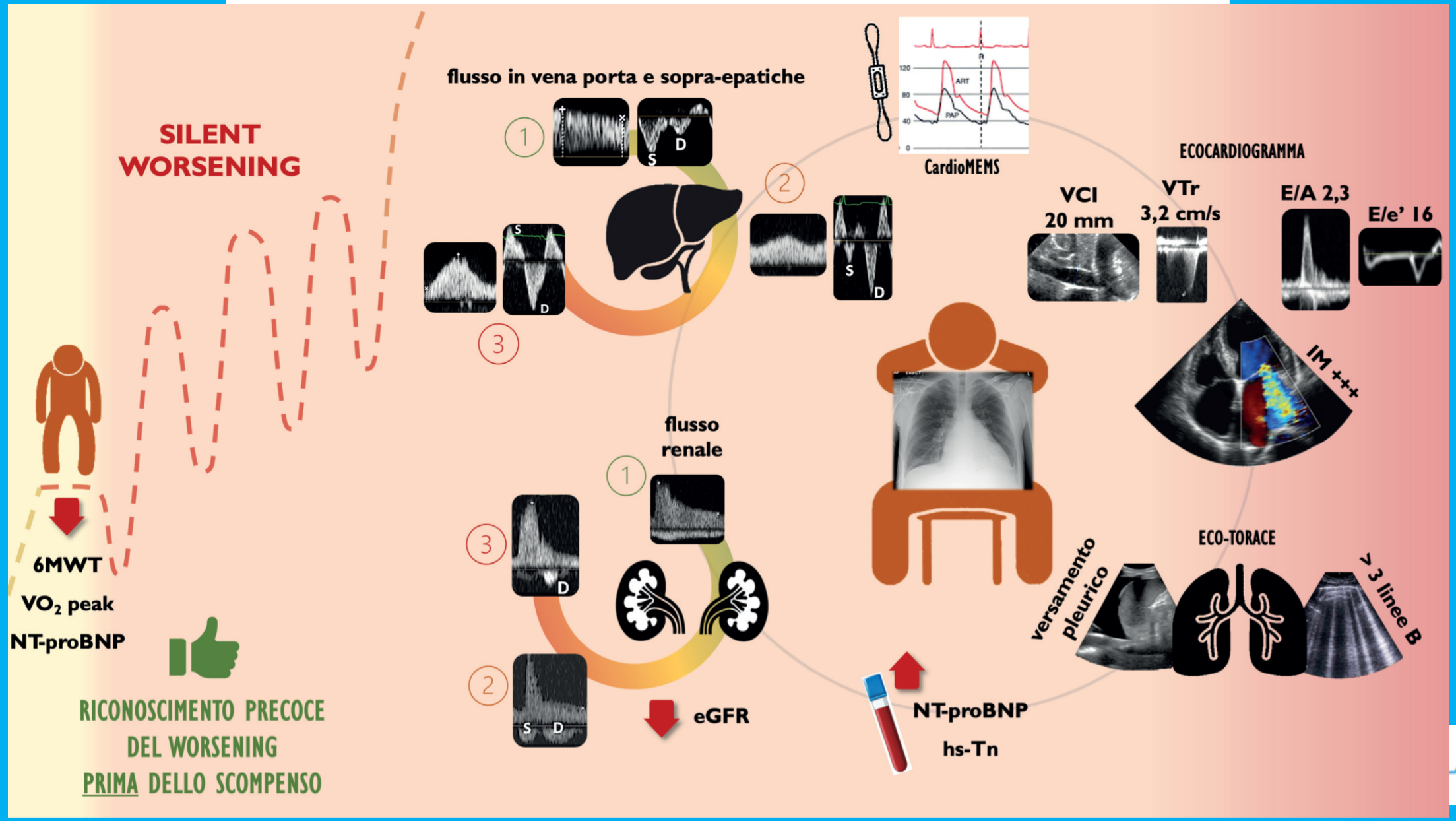
Worsening of chronic heart failure: definition, epidemiology, management and prevention. A clinical consensus statement by the Heart Failure Association of the European Society of Cardiology

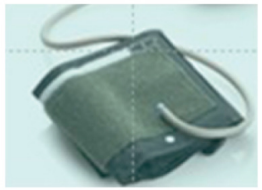
European Journal of Heart Failure (2023) **25**, 776–791

Worsening heart failure: definizione, gestione e trattamento



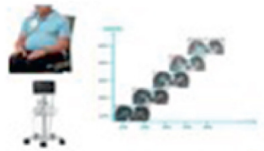
Weights and Vital Signs

Symptoms

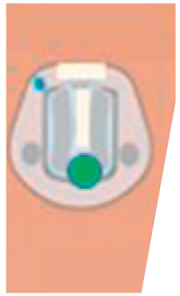


Lung Congestion

Dielectric Sensing through vest



Radiofrequency through adhesive patch



Thoracic Impedance through device lead

Multi-parameter scoring of risk through implanted rhythm devices

ICD

CRT

Proprietary algorithms with different components

Direct measurement of cardiac pressures

Pulmonary artery pressures

Left atrial pressures

Dynamic signals

reflecting the physiology of decompensation

Type of Signal	Specific Product	Patient Site	Representative Trials (Year)	Impact on Heart Failure Hospitalizations
Weights, vital signs, and other				
Traditional telemonitoring with combinations of weights, vital signs, reported symptoms + rhythm strips	Various	Home	TELE-HF (2010)[4] BEAT-HF (2016)[6] TIM-HF I (2010)[5] TIM-HF II (2018)[79]	No benefit No benefit, small signal for better quality of life No benefit Benefit for mortality with 24/7 emergency medical HF phone access
Fluid in the lung				
Thoracic impedance with Impedance cardiography	BioZ	Clinic Hospital	PREDICT (2006)[43] BIG substudy of ESCAPE (2009)[44]	Predictive of outcomes in clinic outpatients Poor correlation with hemodynamics or outcomes for inpatients
Thoracic impedance with ICD	OptiVol OptiVol or CorVue	Home	DOT HF (2011)[41] OptiLink-HF (2016)[119] MORE-CARE (2017)[120] LIMIT-CHF (2016)[121]	Alerts increased patient visits with no decrease in HF hospitalizations More HF hospitalizations with intervention than in control No benefit
Thoracic impedance and other measures from ICD		Home	IN TIME (2014)[122]	No benefit
Thoracic impedance with ICD		Home	EVOLVO (2012)[123]	No benefit
Remote dielectric sensing of lung water (ReDS)	Sensivest	Home Hospital before discharge	SMILE trial (2016)[49] ReDS-pilot SAFE-HF (2021)[47]	Validated against CT-measured lung water content Preliminary results in discharged patients showed reduction in HFH with ReDS when managed per protocol Pilot trial before discharge showing 32% needed further diuresis
Radiofrequency sensor: wearable patch on chest	Microcor	Home	BMAD Trial (2023)[50]	Pair of single-arm trials suggesting decreased HFH using patch to guide therapy
Multiparameter scores with rhythm devices				
ICD with impedance,[a] heart rate and variability, activity		Home	Cowie (2013)[53] REM-HF (2017)[54]	High risk score conferred 10X risk for events compared with low risk Remote monitoring to guide therapy had no impact to decrease HFH or death
ICD with impedance,[a] minute ventilation, activity		Home	CLEPSYDRA (2014)[125]	Alert score with 34% sensitivity False-positive rate of 2.4 alerts per patient-year
CRTD with impedance, HR, RR, activity, and heart sounds	HeartLogic	Home	MultiSENSE Trial (2017)[5] (2018)[57]	Alert score validated with 70% sensitivity, specificity 85.7% Alert zone conferred 10X risk of HF event.
CRTD or ICD with impedance, HR + HRV, atrial arrhythmias and PVCs, activity		Home	SELENE-HF (2022)[58]	Alert score with sensitivity of 65.5%; false-positive rate of 0.7/patient-year Improved by adding Seattle HF Model score before device implantation
CRTD and ICD with impedance, HR, HRV, arrhythmias, pacing		Home Early after discharge	TRIAGE-HF (2018)[126] (2023)[16]	Risk metric became predictive 60 days before HF event, continued rising until discharge Fell by a week after discharge in patients with low risk of readmission
Hemodynamic pressure monitoring				
PA pressure monitor	CardioMEMS	Home	CHAMPION (2011)[32] GUIDE-HF (2021)[20,33] Nonrandomized 2,000 Medicare patients (2017)[37] 234 Europe-MEMS (2020)[38] FDA Postapproval U.S. 1,200 patients (2023)[37]	Benefit for HFH and total hospitalizations, QOL Benefit in prespecified pre-Covid 19 analysis Compared with preimplantation: Benefit to reduce PA pressures and HF hospitalizations at 6 months Benefit to reduce PA pressures and HF hospitalizations at 1 year Sustained reduction in PA pressures and HF hospitalizations over 2 years
LA lead for pressure monitoring enabled for self-management with personalized algorithm	HeartPOD monitor alone or with CRTD	Home	LAPTOP (2016)[54,124]	Benefit to reduce HFH was comparable to CHAMPION trial discontinued because of complications of device insertion across septum
LA pressure monitoring tube anchored across atrial septum	V-LAP	Home	VECTOR-HF(2022)[36]	Correlates with pulmonary wedge pressure at 3 months
PA pressure data integrated with HF package of vital signs and symptoms	Cordella with Heart Failure System	Home	PROACTIVE-HF III[75]	450 patients in PROACTIVE class III—ongoing follow-up

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CardioMEMS™ HF System

Il **Sistema CardioMEMS™ HF** fornisce la misura accurata della pressione dell'arteria polmonare (PAP).

Sensore
per il rilevamento della pressione polmonare.

Unità Ospedaliera
per l'impianto e la calibrazione del sensore

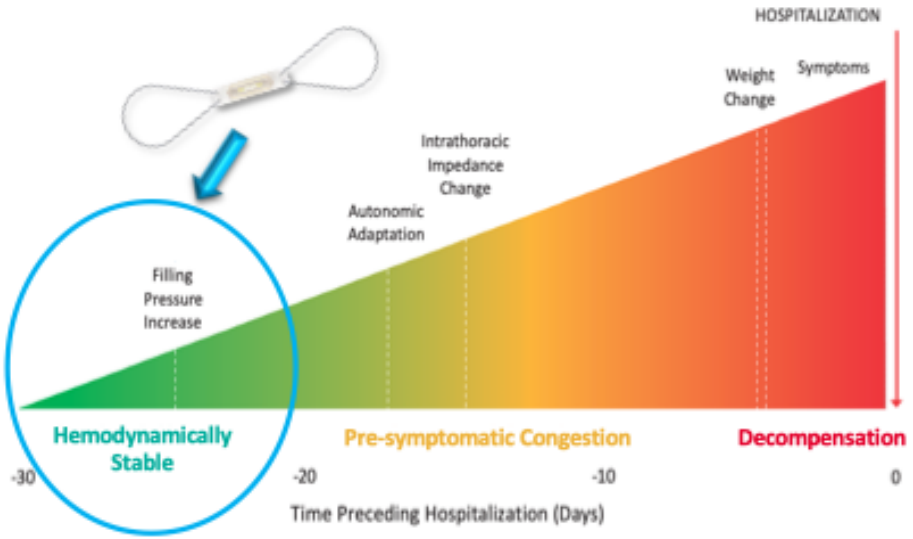
Unità Paziente
da casa il paziente effettua la lettura della pressione polmonare.

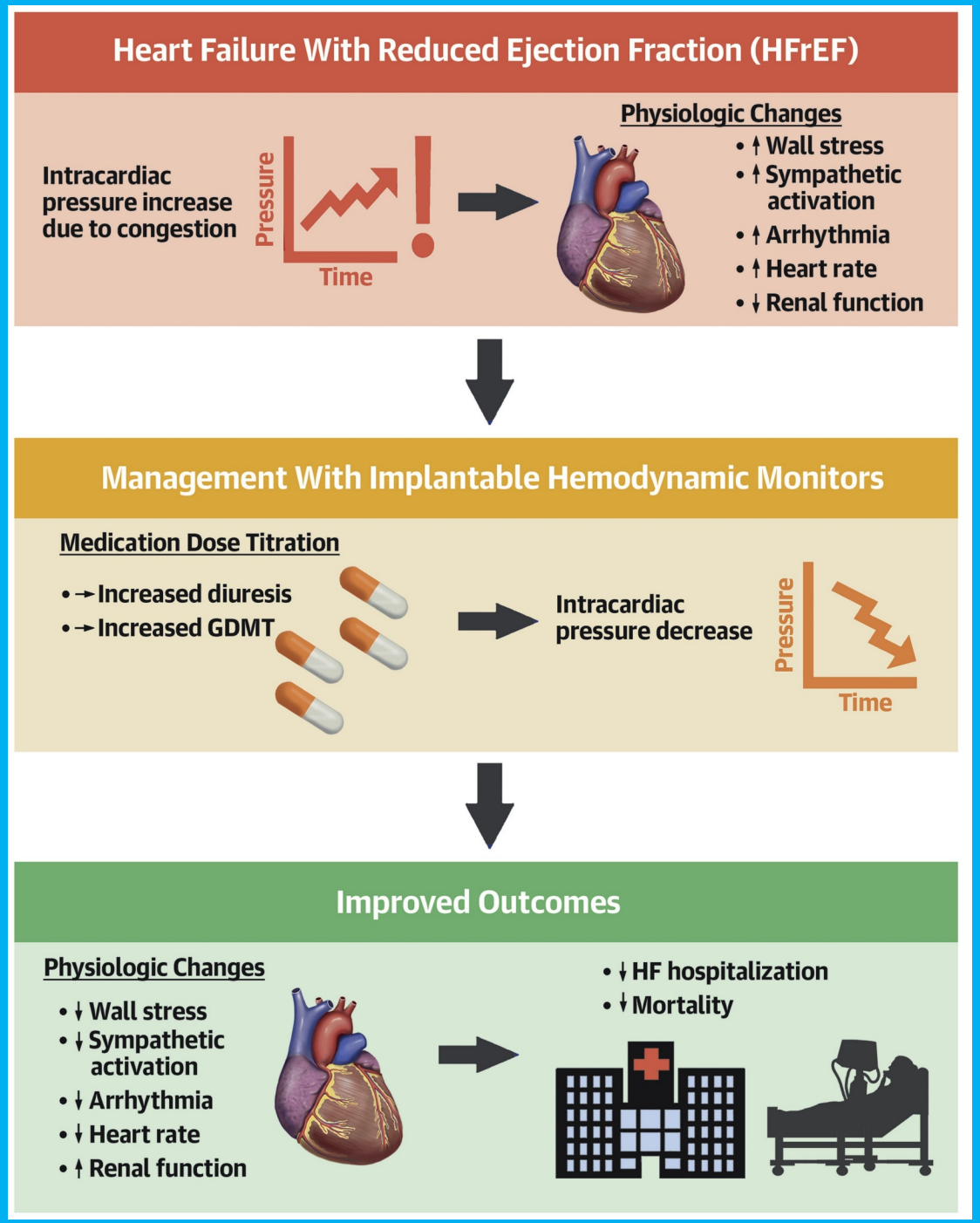
CardioMEMS™ HERO Device

Controllo Remoto
le letture vengono trasmesse alla piattaforma Merlin.net™.

La prevenzione della fase acuta

- La pressione di riempimento di LV è uno dei parametri su cui si basa la gestione dello scompenso cardiaco.
- La pressione dell'arteria polmonare (PAP) è correlata alla pressione di riempimento di LV.
- Misurazione di un **PARAMETRO DIRETTO** monitorabile da remote.





Lindenfeld JoAnn et al.
J Am Coll Cardiol 2024

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Cardiologia Cirié

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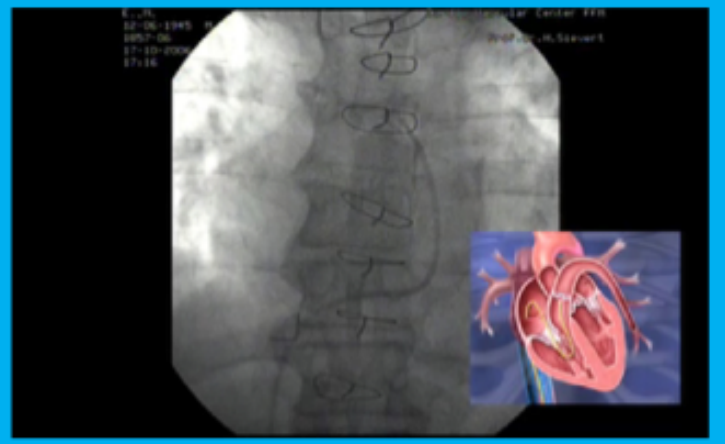
STEP 1 Accesso in arteria polmonare

- Accesso femorale tramite introduttore 12 Fr
- Avanzare catetere PA nel ramo sx dell'arteria polmonare
- Gonfiare il palloncino dello Swan Ganz nella potenziale landing zone
- Eseguire RHC e rilevare le misurazioni di PA e CO.

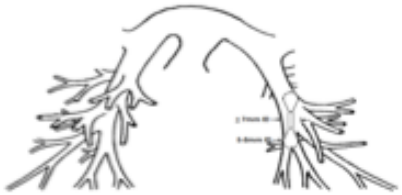


STEP 2 Identificazione vaso target

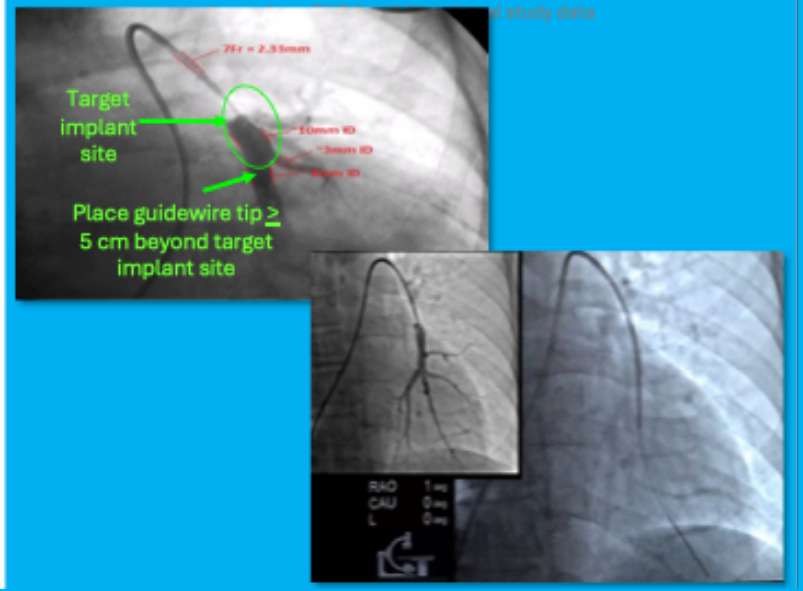
- Procedendo con angiografia ricercare un vaso discendente posteriore della PA

Diametro vaso target

7 – 10mm per il **corpo** del sensore
5-8 mm per il **loop** distale



- Introdurre la guida (**NO J**)
- Rimuovere PAC mantenendo la guida in posizione



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STEP 3

Inserimento e rilascio del sensore

- Preparare il sensore
  - lavarne il lume
  - Agitare il sensore in soluzione fisiologica per attivare la copertura idrofilica
- Introdurre sensore e delivery sulla guida (0,018") fino al sito target.
- Rilasciare il sensore **svitando** il tappo blu e ritirarlo lentamente

Inserire il video

STEP 4

Rimozione del sistema

- Ritirare il delivery in PA assicurandosi che il sensore sia rimasto in posizione
- Ritirare la guida
- Rimuovere il delivery mantenendo la guida in PA

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STEP 5 Calibrazione del sensore

- Reintrodurre PAC in PA e avanzarlo nel ramo opposto a quello in cui è stato rilasciato il sensore
- Posizionare CardioMEMS™ Hospital System Antenna sotto la spalla del pz

Attraverso il catetere in PA:

- Misurare PA media
- Verificare la correlazione con quanto visualizzato sul poligrafo (ammessa variazione di 1–2 mmHg)
- Inserire il valore di CO ottenuto da RHC (metodo Fick o Termodiluizione).

NB: Algoritmo CO non ancora validato e non visualizzabile al momento su Merlin.net

STEP 6 Misurazione, Upload, e Shutdown

Inserire 2/3 misurazioni di PA sys, PA Dias e PA Mean e chiudere la procedura di impianto.

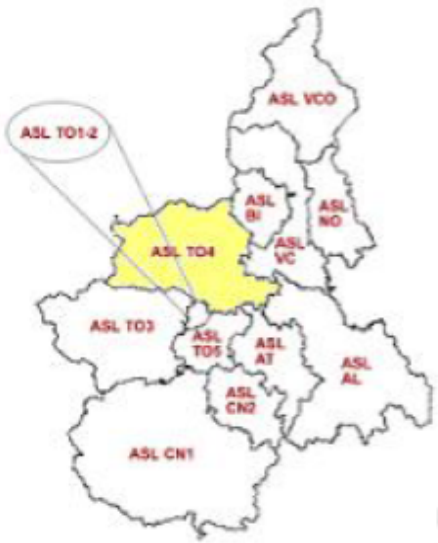
Cardiologia Cirié

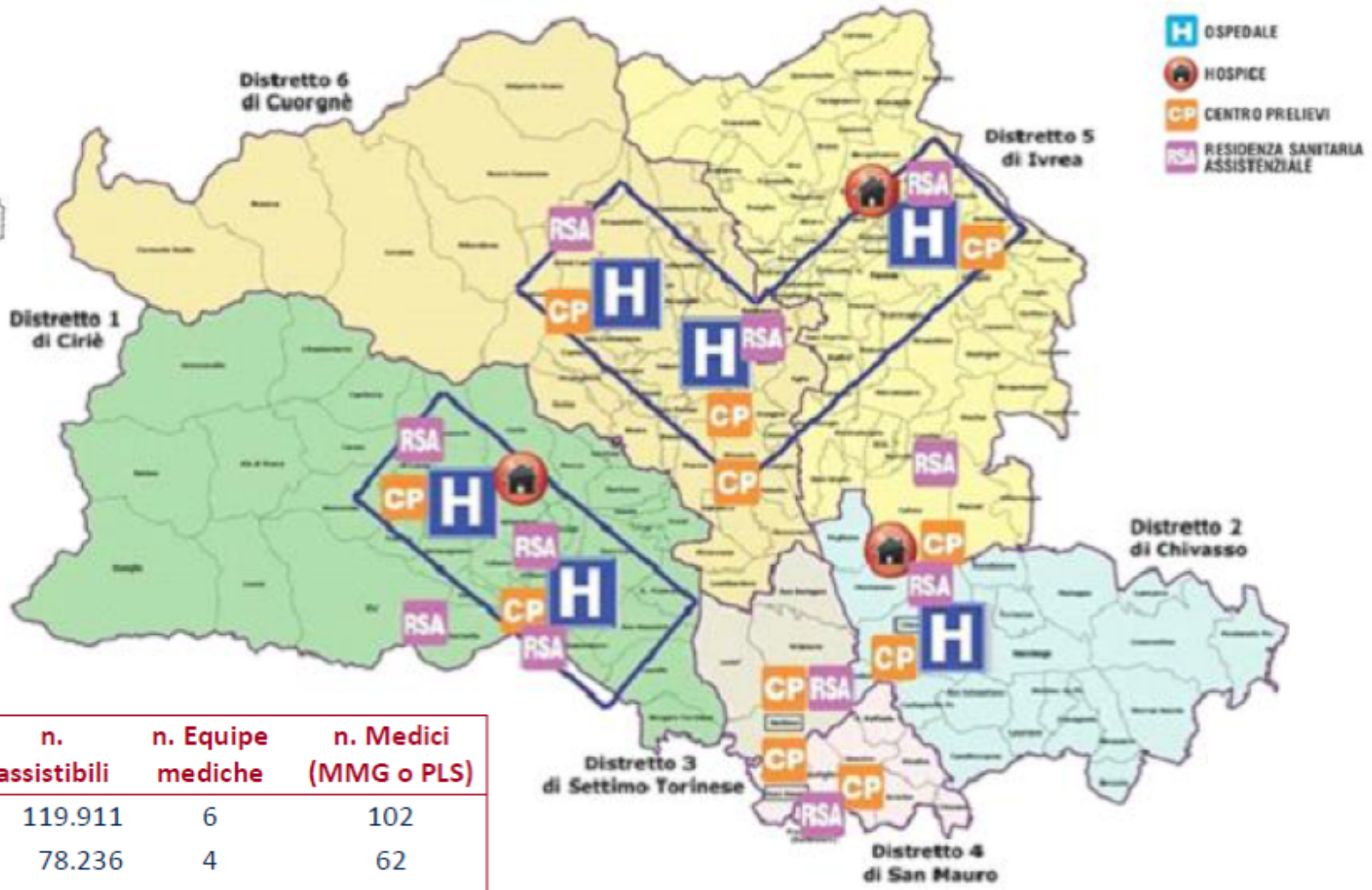
Perchè il telemonitoraggio

Consente ai pazienti di fornire in remoto informazioni sul loro stato di salute così da **sostenere ed ottimizzare la loro assistenza**:

- Aumentando la **sicurezza** del paziente
- Garantendo un **rapido accesso all'assistenza**
- Aumentando la **qualità di vita** del paziente
- Migliorando la **gestione clinica** del paziente
- Riducendo la frequenza delle **visite ambulatoriali**
- Riducendo i **ricoveri** per aventi acuti

ASL TO4 - Piemonte





Distretti	n. comuni	n. assistibili	n. Equipe mediche	n. Medici (MMG o PLS)
1 Ciriè	38	119.911	6	102
2 Chivasso	20	78.236	4	62
3 Settimo T.se	4	85.673	5	74

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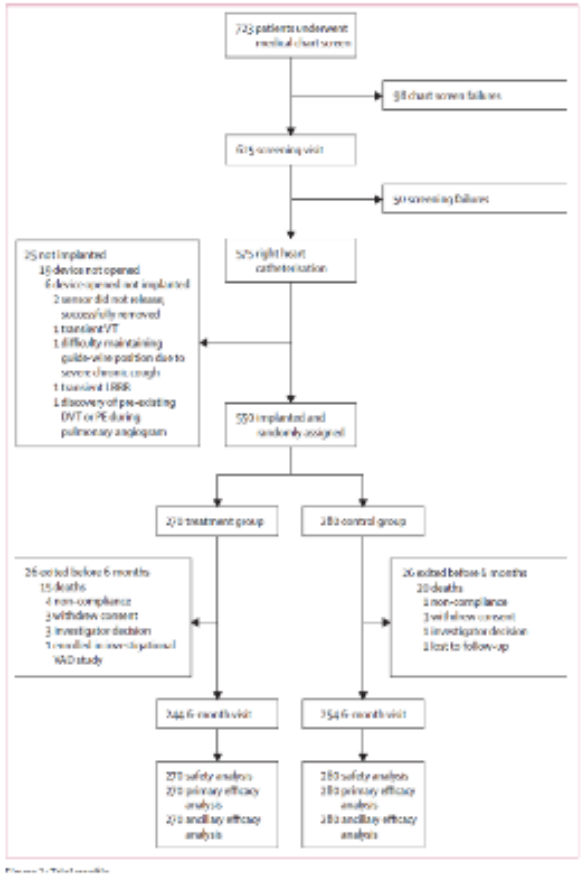
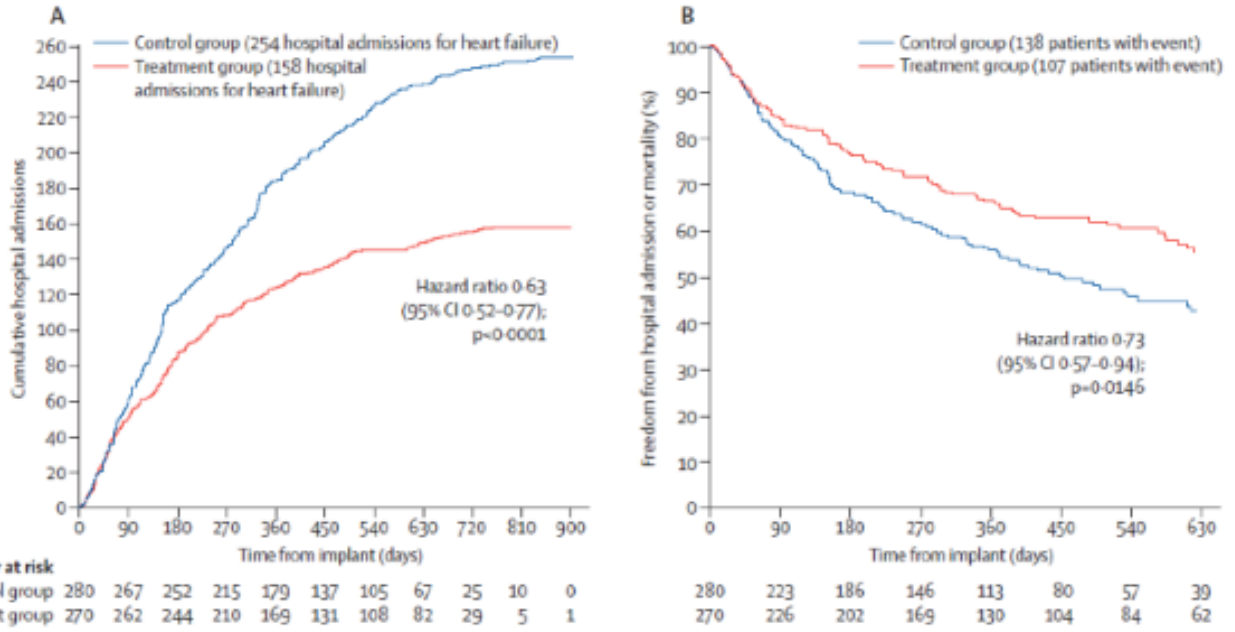
Cardiologia Cirié

Wireless pulmonary artery haemodynamic monitoring in chronic heart failure: a randomised controlled trial

William T Abraham, Philip B Adamson, Robert C Bourge, Mark F Aaron, Maria Rosa Costanza, Lynne W Stevenson, Warren Strickland, Suresh Neelagaru, Niraj Raval, Steven Krueger, Stanislav Weiner, David Shavelle, Bradley Jeffries, Jay S Yadav, for the CHAMPION Trial Study Group*



Population: NYHA III irrespective of LVEF+ prior HF hospitalization
Primary efficacy endpoint: HF hospitalization at 6 months



NNT to prevent 1 HF hosp: 8 at 6 months, 4 at 15 months

Lancet 2011; 377: 658–66

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Cardiologia Cirié

ESC
European Society of Cardiology

European Heart Journal (2021) **42**, 3599–3726
doi:10.1093/eurheartj/ehab368

ESC GUIDELINES

2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

Recommendations	Class	Level
Monitoring of pulmonary artery pressure using a wireless haemodynamic monitoring system may be considered in symptomatic patients with HF in order to improve clinical outcomes.	IIb	B

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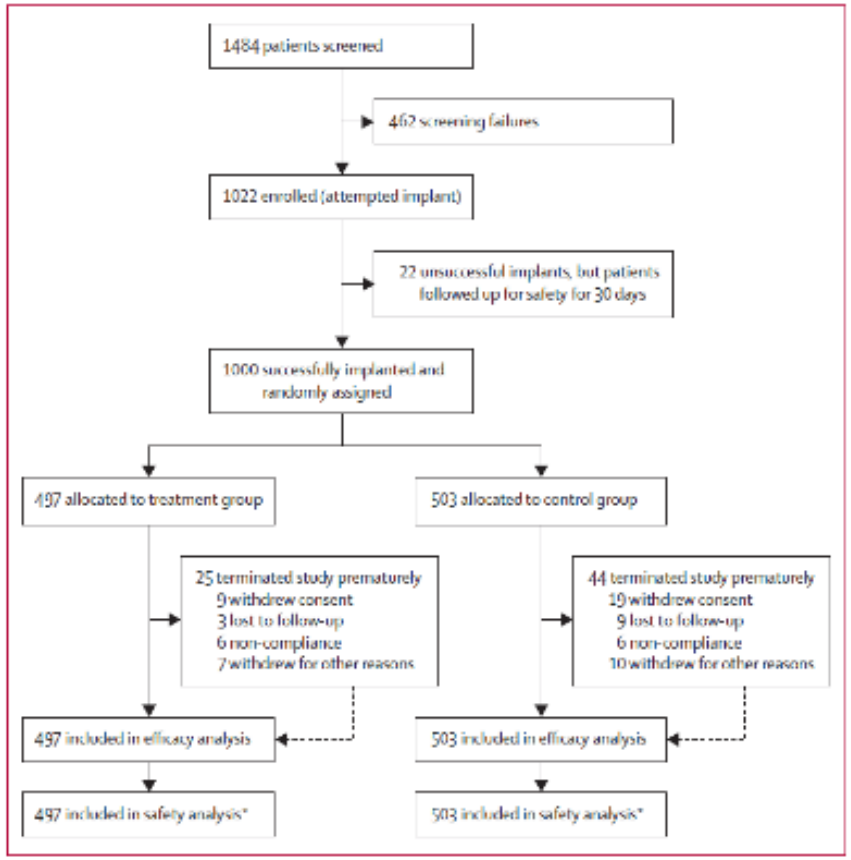
Cardiologia Cirié

Haemodynamic-guided management of heart failure (GUIDE-HF): a randomised controlled trial

JoAnn Lindenfeld, Michael R Zile, Akshay S Desai, Ruxjan Bhatt, Anique Ducharme, Georgios Filandrianos Prof, Salim R Kirr, Alan Maisel, Mandeep R Mehra, Sean Paul, Samuel J Sears, Andrew J Sauer, Frank Snyder, Marcel Zaghloul, Paige Cockrell, Jean Kelly, Alissa Johnson, Poornima Sood, Greg G Ginn, Julie Del Jasper, Philip B Adamson, Mario Rosa Costanzo



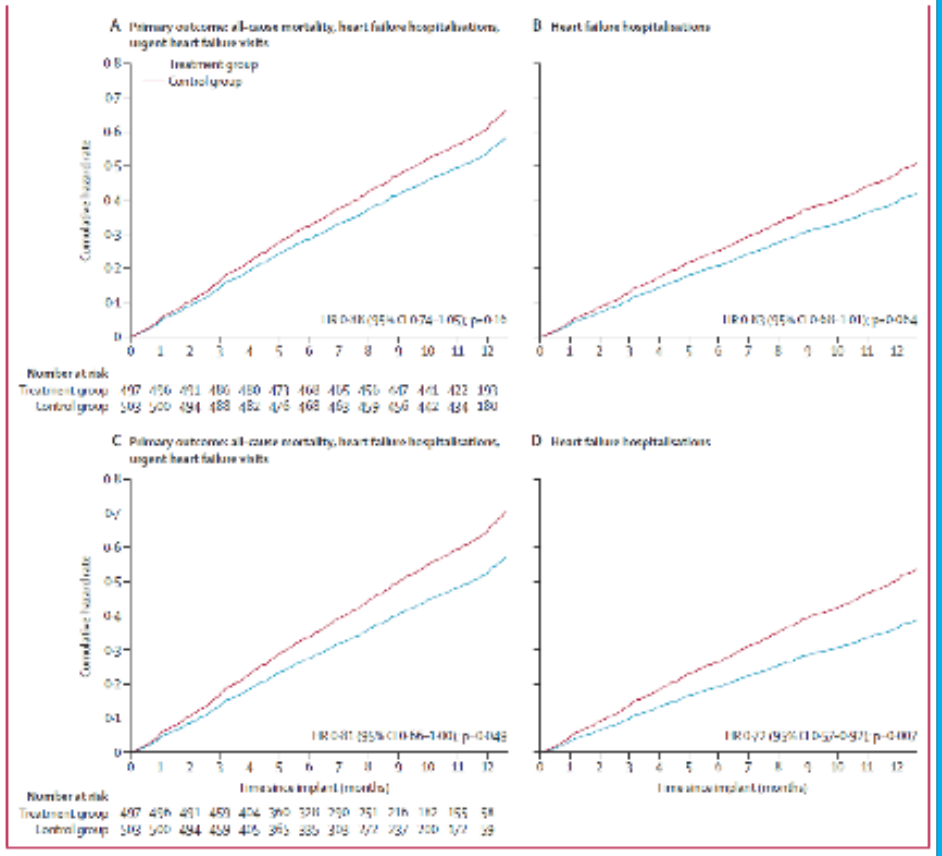


Figure 2: Cumulative hazard rate curves and 95% CIs for the primary composite endpoint and heart failure hospitalisations
(A) Overall analysis—primary outcome of all-cause mortality, heart failure hospitalisations, and urgent heart failure hospital visits. (B) Overall analysis—heart failure hospitalisations. (C) Pre-COVID-19 impact analysis—primary outcome of all-cause mortality, heart failure hospitalisations, and urgent heart failure visits. (D) Pre-COVID-19 impact analysis—heart failure hospitalisations. HR=hazard ratio.

Lancet 2021; 398: 991–1001

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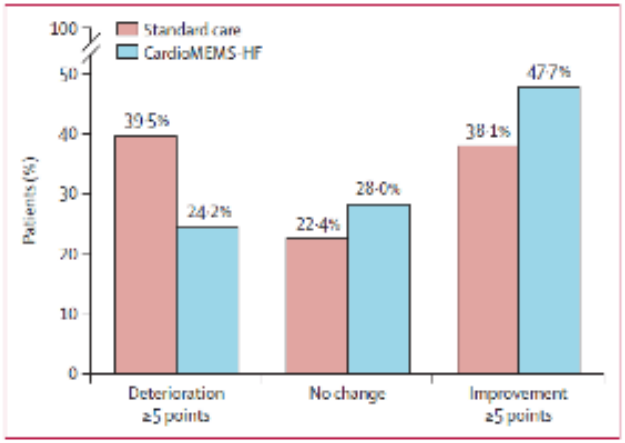
Cardiologia Cirié

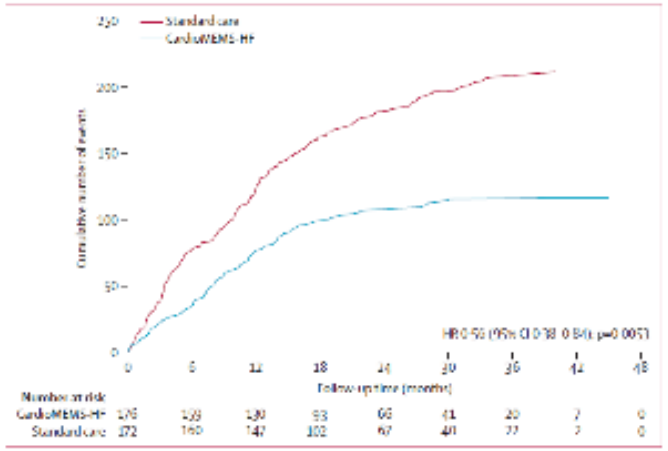
Remote haemodynamic monitoring of pulmonary artery pressures in patients with chronic heart failure (MONITOR-HF): a randomised clinical trial

Jasper J Brugts, Sumant P Radhoe*, Pascal R D Clephas†, Dilan Aydin†, Marco W F van Gent, Mariusz K Szymanski, Michiel Rienstra, Mieke H van den Heuvel, Carlos A da Fonseca, Gerard C M Linssen, C Jan Willem Borleffs, Eric Boersma, Folkert W Asselbergs, Arend Mosterd, Hans-Peter Brunner-La Rocca, Rudolf A de Boer for the MONITOR-HF investigators*

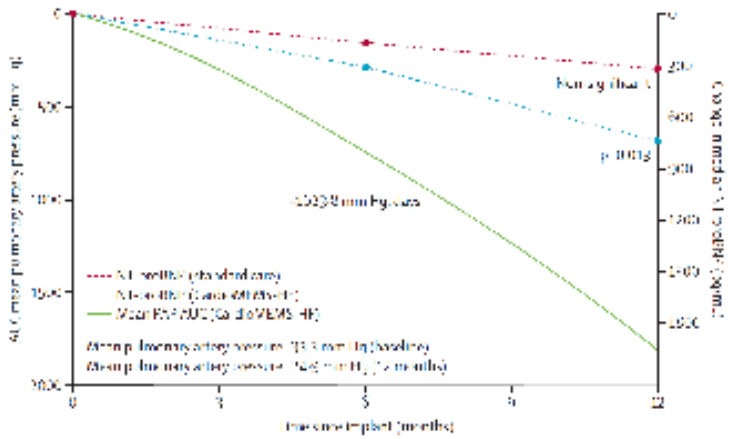
Primary endpoint: mean difference in the Kansas City Cardiomyopathy Questionnaire overall summary score at 12 months



Migliore QOL



Ridotte ospedalizzazioni



Ridotta PAP

Lancet 2023; 401: 2113–23

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Cardiologia Cirié

Implantable Hemodynamic Monitors Improve Survival in Patients With Heart Failure and Reduced Ejection Fraction

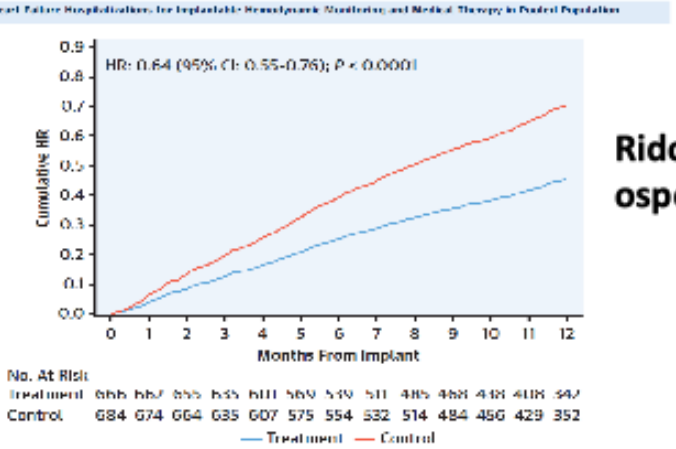
JoAnn Lindenfeld, MD,[a] Maria Rosa Costanzo, MD,[b] Michael R. Zile, MD,[c] Anique Ducharme, MD,[d] Richard Troughton, MD,[e] Alan Maisel, MD,[f] Mandeep R. Mehra, MD, MS,[g] Sara Paul, DNP,[h] Samuel F. Sears, PsD,[i] Frank Smart, MD,[j] Nessa Johnson, PhD,[k] John Henderson, MS,[k] Philip B. Adamson, MD,[k] Akshay S. Desai, MD,[g] William T. Abraham, MD,[l] on behalf of the GUIDE-HF, CHAMPION, and LAPTOP-HF Investigators

TABLE 1 Summary of Studies

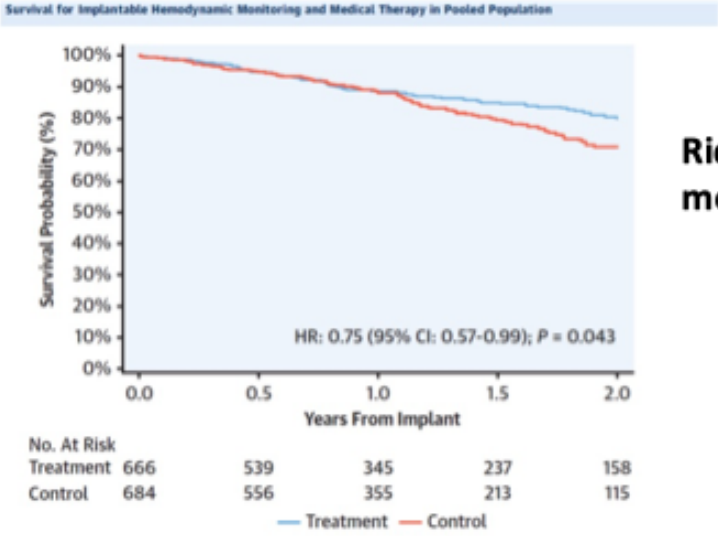
	GUIDE-HF Randomized Arm[20,21]	CHAMPION[19,34,35]	LAPTOP-HF[33,35]
Design	Prospective, multicenter, randomized, controlled, single-blinded evaluation of the CardioMEMS HF System	Prospective, multicenter, randomized, controlled, single-blinded evaluation of the CardioMEMS HF System	Prospective, multicenter, randomized, controlled evaluation of the LAP Monitoring System (HeartPOD and PAM)
Pressure sensor	Hemodynamic management using PAP via implanted sensor	Hemodynamic management using PAP via implanted sensor	Hemodynamic management using LAP via a transseptal lead
Patient engagement	• Blinded to treatment group; implanted control group • Daily PAP measurements • Interventions communicated by phone through blinded caller, minimum contact frequency for both groups	• Blinded to treatment group; implanted control group • Daily PAP measurements • Interventions communicated by phone; matched contact frequency between groups	• Unblinded to treatment group; unimplanted control group • Twice daily recording of symptoms, weights, and blood pressure; continuous measurement of LAP • Interventions communicated through handheld PAM
Trial dates	March 2018 to January 2021	September 2007 to December 2014	June 2010 to April 2015
Duration of follow-up—HFrEF, mo	12 mo Median 8.2 mo (Q1, Q3: 4.6, 11.4 mo) (pre-COVID-19)	Continued until last subject reached 6 mo Median 17.0 mo (Q1, Q3: 11.5, 23.0 mo)	Continued until last subject reached 12 months Median 22.8 mo (Q1, Q3: 14.6, 34.8 mo)
Primary endpoint	Composite of HF hospitalizations, urgent HF visits, and all-cause mortality at 12 mo	HF hospitalizations at 6 mo	HF major acute cardiovascular and neurological events at overall follow-up
Major inclusion	NYHA functional class II/III/IV with prior HF hospitalization or elevated BNP/NT-proBNP	NYHA functional class III with prior HF hospitalization	NYHA functional class III with prior HF hospitalization or persistently elevated BNP
Sample size (>HFrEF)	Baseline: 531 12 mo: 63 24 mo: not applicable	Baseline: 456 12 mo: 332 24 mo: 104	Baseline: 363 12 mo: 305 24 mo: 109
Safety outcomes	DSRDs: 0.8% (8/1,037)	DSRDs: 1.4% (4/275) Sensor Failure: 0% (0/575)	Not reported previously (see Supplemental Table 1)
Notes	Study affected by COVID-19 pandemic; pre-COVID-19 follow-up utilized (before March 13, 2020).		Study stopped because of implant-related complications; follow-up continued in therapy-initiated patients

BNP = brain natriuretic peptide; DSRD = device or system-related complications; HFrEF = heart failure with reduced ejection fraction; LAP = left atrial pressure; NT-proBNP = N-terminal pro-brain natriuretic peptide; PAM = Patient Advisory Module; PAP = pulmonary artery pressure.

J Am Coll Cardiol 2024;83:682-694



Ridotte ospedalizzazioni



Ridotta mortalità

Survival through 24 months, with implantable hemodynamic monitoring (treatment) in blue and medical therapy (control) in red. A significant 25% reduction in mortality was observed at 24 months in the pooled population. Survival estimated using Kaplan-Meier estimates; HR, 95% CI, and *P* values estimated using Cox Proportional Hazards model.

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ESC European Society of Cardiology

European Journal of Heart Failure (2024) 26, 483–501
doi:10.1002/ejhf.3150

POSITION PAPER

Integration of implantable device therapy in patients with heart failure. A clinical consensus statement from the Heart Failure Association (HFA) and European Heart Rhythm Association (EHRA) of the European Society of Cardiology (ESC)

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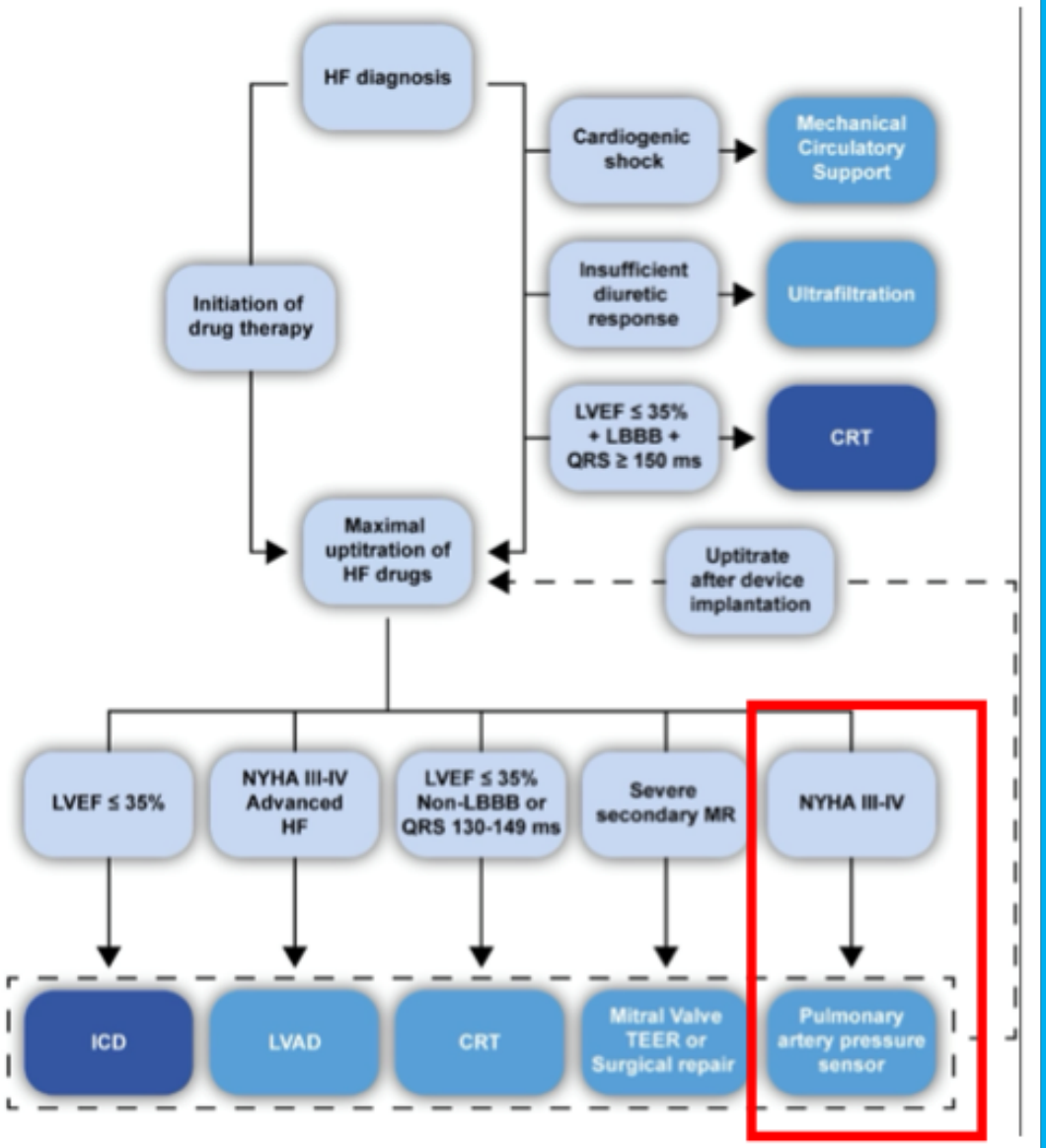


ESC European Society of Cardiology
European Heart Journal (2025) 00, 1–2
https://doi.org/10.1093/eurheartj/ehaf720
CardioPulse

Braunwald's Corner

The management of heart failure: a brief look into the future

Eugene Braunwald [1,2,*]

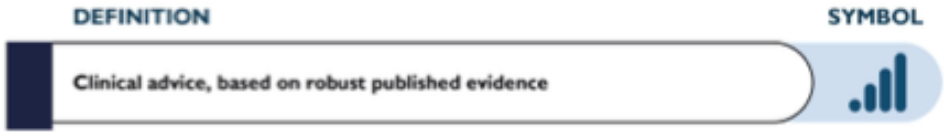
It is likely that non-invasive monitoring and telehealth will play increasingly important roles in patients with HF, especially in rural areas.

CardioMEMS system of implantable monitors provides continuous pulmonary artery pressure remotely. This can guide pharmacologic therapy and thereby enhance survival and HF hospitalization in patients with HF and reduced ejection fraction (HFrEF).[10]

Remote pulmonary artery pressure-guided management of patients with heart failure: A clinical consensus statement of the Heart Failure Association (HFA) of the ESC

Antoni Bayes-Genis[1†], Matteo Pagnesi[2†], Pau Codina[1], William T. Abraham[3], Offer Amir[4], Rudolf A. de Boer[5], Jasper J. Brugts[5], Ovidiu Chioncel[6], Finn Gustafsson[7], JoAnn Lindenfeld[8], Wilfried Mullens[9], Mark C. Petrie[10], Giuseppe Rosano[11], and Marco Metra[2*]

Advice TO DO	Evidence	Strength
CardioMEMS is useful in patients with symptomatic HF at moderate to high risk of new worsening HF events as shown by a hospitalization for HF in the previous year	RCT	



European Journal of Heart Failure (2025) **27**, 1644–1657

Indicazioni e Controindicazioni

Remote pulmonary artery pressure-guided management of patients with heart failure: A clinical consensus statement of the Heart Failure Association (HFA) of the ESC

Indications

- NYHA class II or III
- 1 HFH or HFE in the previous year and/or elevated natriuretic peptides

Contraindications

- Contraindication to antithrombotics
- Active infection
- History of recurrent PE or DVP
- Major CV event in the last 2 months
- CRT implant < 3 months
- Intolerance to a RHC
- eGFR<25ml/min
- Congenital heart disease or mechanical right heart valve
- Coagulation disorders
- BMI > 35 or chest circumference > 165 cm

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Remote pulmonary artery pressure-guided management of patients with heart failure: A clinical consensus statement of the Heart Failure Association (HFA) of the ESC

Ideal candidate for remote invasive PAP monitoring

Symptomatic HF irrespective of LVEF (NYHA III > II)

Optimal medical / device treatment

At least 1 unplanned HF hospitalization in the last year
and/or
clear signs of congestion (imaging / elevated NTproBNP)

Optimal compliance to treatment

Without end-stage HF or severe primary lung disease

European Journal of Heart Failure (2025) **27**, 1644–1657

Remote pulmonary artery pressure-guided management of patients with heart failure: A clinical consensus statement of the Heart Failure Association (HFA) of the ESC

Pre-Implant: Patient selection

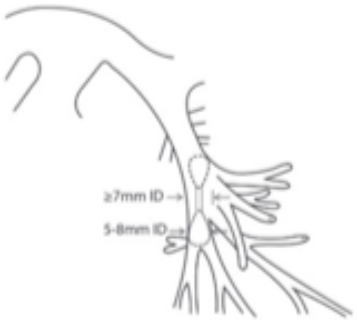
Indications
- NYHA class II or III
- 1 HFH or HFE in the previous year and/or elevated natriuretic peptides

Contraindications
- Contraindication to antithrombotics
- Active infection
- History of recurrent PE or DVP
- Major CV event in the last 2 months
- CRT implant < 3 months
- Intolerance to a RHC
- eGFR<25ml/min
- Congenital heart disease or mechanical right heart valve
- Coagulation disorders
- BMI > 35 or chest circumference > 165 cm

Optimal GDMT and ICD/CRT if indicated

During implant

Target implant site



RHC measurements
- PCWP
- PAP
- CO
- Vascular resistances

Calculate DPG (dPAP-PCWP)
- Stablish dPAP goal and thresholds

1 month DAPT / anticoagulation (if indicated) → Chronic ASA / anticoagulation

Post-implant

1. Optimization phase

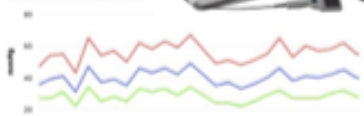
Physical exam, TTE, RHC

↓

Optimize volume status and vascular resistance

2. Maintenance phase

Daily PAP readings



Adjust treatment if persistent elevated/low PAP for ≥ 3 days
- Diuretics
- Vasodilators or GDMT

Reevaluate in 2-3 days

European Journal of Heart Failure (2025) **27**, 1644–1657

Table 3 How to monitor and treat patients during follow-up after pulmonary artery pressure monitoring device implantation

Telemonitoring with daily check (5/7 days) by HF personnel[a]

Carefully establish baseline values corresponding to absence of congestion and clinical stability in the first weeks after implantation

Monitor trends over 3–5 days

Have telephone calls when meaningful increase in trend

Treat targeting the cause of increase

- Pressure without volume increase
  - Titrate neurohormonal modulators, vasodilators, SGLT2 inhibitors
- Pressure with volume increase
  - Titrate neurohormonal modulators, vasodilators, SGLT2 inhibitors
  - Titrate loop diuretics (×2 for 3 days)
  - Adopt combined diuretic therapy (metolazone, thiazides, acetazolamide, etc.)
- Persistent pressure increase
- Consider additional therapies when indicated (valve interventions, PV isolation for AF, LVAD, etc.)

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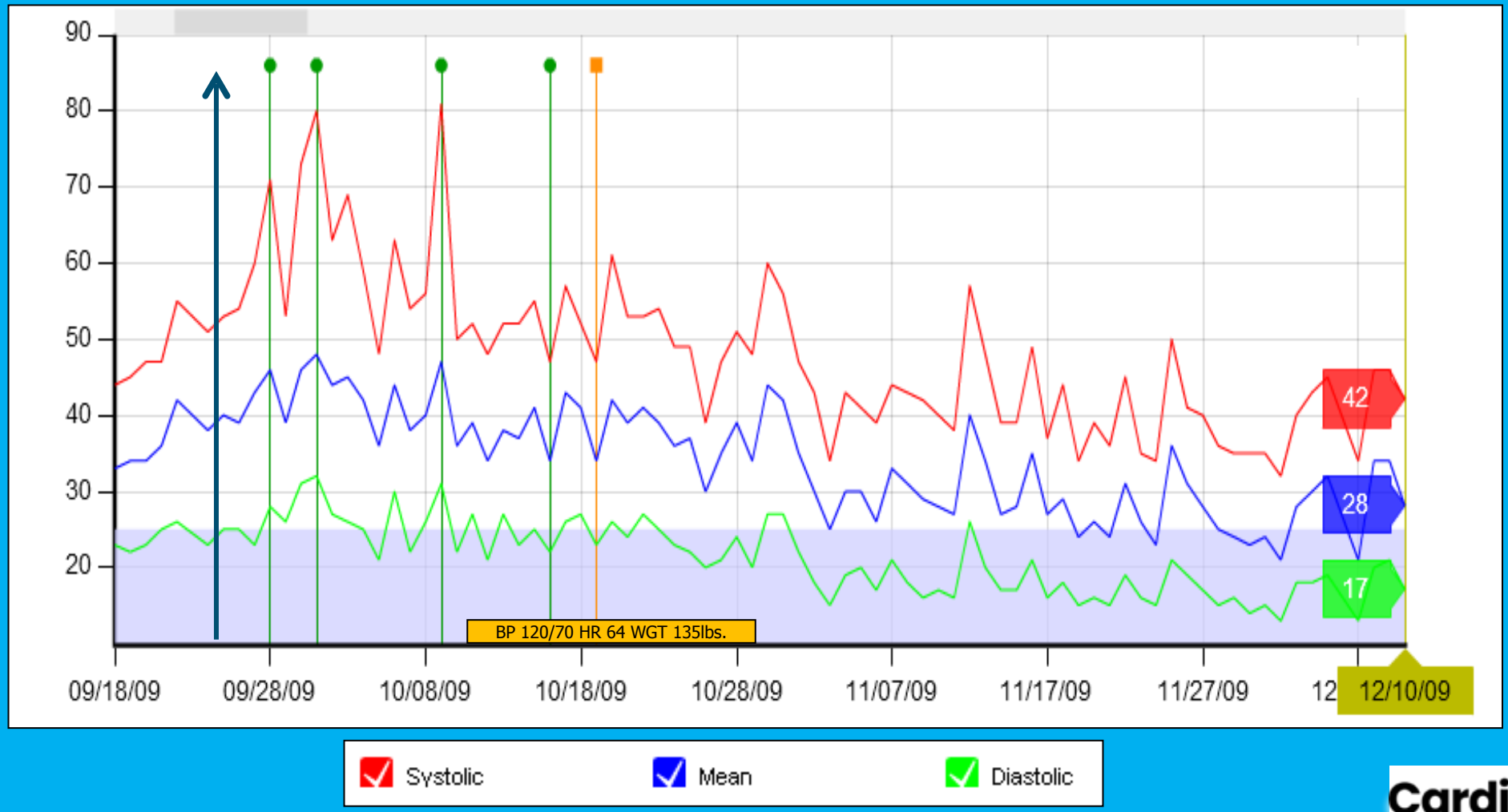

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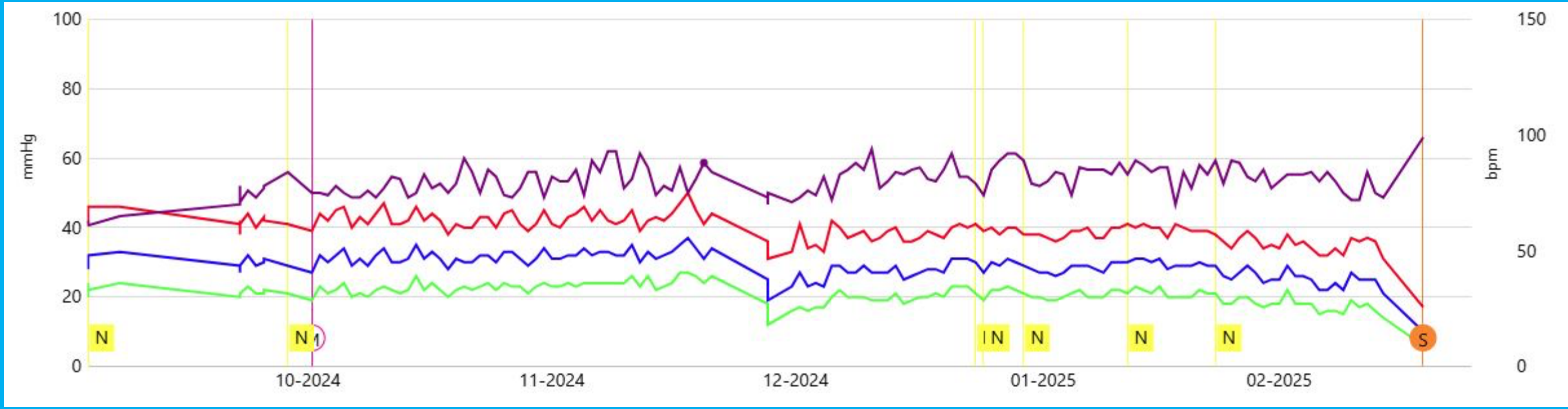

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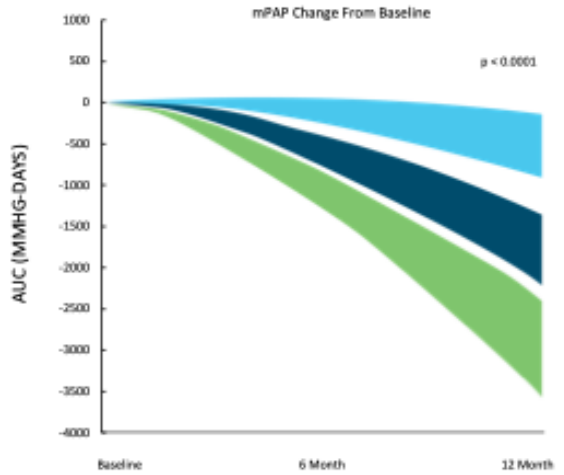
Cardiologia Cirié

Evidenze Cliniche

E’ dimostrato che il monitoraggio remoto della pressione arteriosa polmonare:

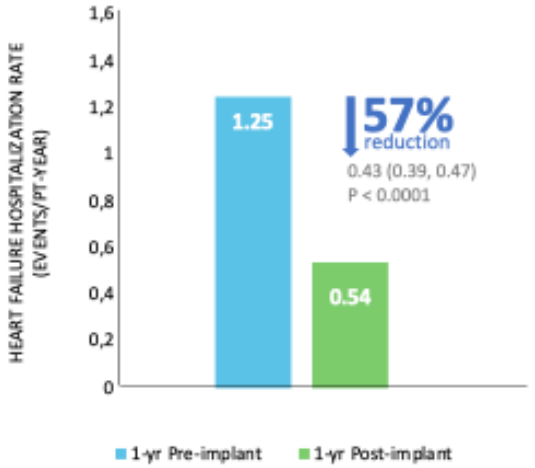
MIGLIORA
QUALITA’ DELLA VITA E CAPACITA’ FUNZIONALE

MEMS-HF European Study[1]



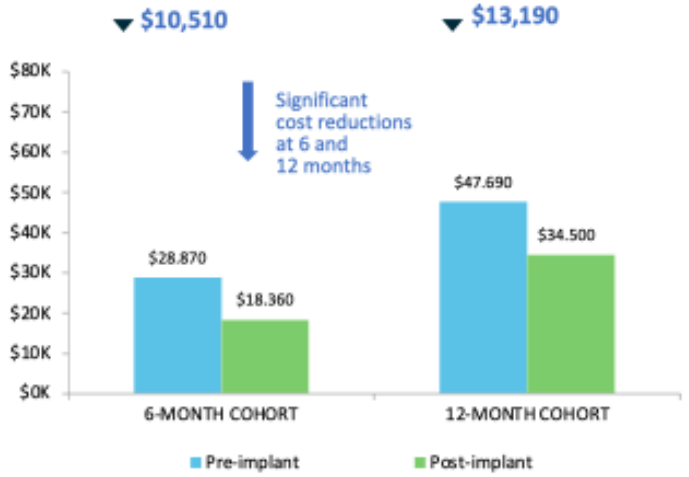
RIDUCE
RICOVERI PER SCOMPENSO CARDIACO

U.S. Post-approval Study[2]



ABBATTE
COSTI DI OSPEDALIZZAZIONE PER SCOMPENSO CARDIACO[3]

Economic Impact[3]



1. Angermann C, et al. *European J of Heart Failure*. 2020
2. Shavelle D, et al. *Circulation: Heart Failure*. 2020.
3. Desai AS, et al. *J Am Coll Cardiol*. 2017

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