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Prospective Observational Study of a Telemedicine-Based Transitional Care Pathway for Patients Hospitalized with Acute Heart Failure

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Abstract

The transition phase after hospital discharge for acute heart failure represents a vulnerable period that requires careful management to optimize guideline-directed medical therapy (GDMT) and reduce the risk of early adverse events. For this reason, we planned a 30-day post-discharge follow-up including weekly tele-visits and the assessment of biohumoral and heart–lung ultrasound parameters at discharge (T1) and after 4 weeks of post-hospitalization (T5).

The Kansas City Cardiomyopathy Questionnaire (KCCQ), a structured clinical monitoring form, a heart-lung point-of-care ultrasound (HLPOCUs) diagram, and a dedicated database were used to support therapy titration and to record prognostic parameters.

Four weeks after discharge, the proportion of patients receiving GDMT increased (T0 vs T5: ARNI 22 vs 80%, beta-blockers 63 vs 92%, MRA 40 vs 96%, SGLT2i 24 vs 100%). Clinical signs of heart failure resolved, and echocardiographic parameters of systolic and diastolic function as well as pulmonary congestion showed consistent improvement (T0 vs T5: EF 32 vs 47%, p=0.000; E/e' 21 vs 14, p=0.013; indexed LA volume 56 vs 45 ml/m², p=0.008; PAPS 39 vs 25 mmHg, p=0.001; IVC diameter 17 vs 11 mm, p=0.000; B-lines/8 zones 17 vs 4, p=0.000). Biohumoral markers also decreased (BNP 1141 vs 420 pg/ml, p=0.009; CA-125 101 vs 15 U/ml, p=0.012). Quality of life improved as assessed by the KCCQ score (55 vs 86, p=0.000). A reduction in emergency department visits and hospitalizations for heart failure was observed during short-term follow-up. In conclusion, a structured telemedicine-supported transitional care pathway appears feasible in the post-hospitalization phase after acute heart failure and may support optimization of therapy and short-term clinical stability.

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Introduction

Numerous scientific evidence documents the importance of an early taking of care about the patient discharged after an episode of acute heart failure [1-5]. Accurate prognostic identification, complete information-training of the patient and his caregiver, optimization of therapy according to the guidelines (guideline-directed medical therapy, GDMT) are factors that favourably modify disease outcomes such as mortality and hospital readmissions [6-7]. These objectives are pursued at heart failure ambulatories (clinics), that are mainly directed by multi-professional/multi-disciplinary teams with the aim of assisting the general practitioner (family doctor) in managing the disease [8-9]. During the recent pandemic phase, telemedicine has also come into use in heart failure clinics in the forms of tele visit, telemonitoring and teleconsultation [10-18]. In the Department of Medicine of the Angel's Hospital in Mestre (Venice) there isn't a dedicated ambulatory, so the patient is followed for approximately 30 days with scheduled visits inside the ward (defined "post-hospitalization" visits). The follow-up visit is however made difficult by some critical issues related to the patient (age, comorbidity), logistics (distance, transportation, waiting, risk of contagion) and the healthcare professional (shift work). Telemedicine finds its place in this context and in lieu of a visit. Through tele visits and teleassistance the health professional is able to: a) carry out a virtual post-discharge visit at the patient's home, b) make a clinical monitoring using the tools already in possession to the patient (oximeter, sphygmomanometer), c) verify the complete and correct intake of the therapy (compliance), d) recommend any changes in order to optimize the therapy (according to GDMT) and adapt it to the clinical needs, e) administer questionnaires to evaluate daily activities (the Barthel scale) and perceived quality of life (the Kansas City Cardiomyopathy Questionnaire, KCCQ) [19].

For all this reason it was decided to implement an observational study in the post hospitalization transition phase after an episode of acute congestive heart failure (P.E.A.C.H program). The patients will be followed with tele visit for the first 3 weeks and with a final visit at the 4th week after discharge (tele P.E.A.C.H). During this time interval, therapy will be optimized according to GDMT, and clinical, biochemical and instrumental data will be recorded to build a database to identify outcomes and prognostic factors (data P.E.A.C.H.). The study began in March 2024 and is scheduled to end in December 2025. Here we report the results recorded so far.

Materials and Methods

Patients

The study aims to enrol patients discharged from the Internal Medicine Department of the Angel's Hospital in Mestre (Venice) during 2024-2025 according to the following criteria:

Inclusion Criteria: Hospitalization for acute heart failure episode. Diagnosis of heart failure with reduced ejection fraction (EF<40%, HFrEF). Not in optimally therapy (sec. GDMT). Age between 40 and 90 years. Signed informed consent

Exclusion Criteria: Patients who, due to clinical or laboratory conditions, cannot optimize therapy as GDMT (e.g., due to adverse drug reactions, systolic blood pressure values <100 mmHg, renal failure with eGFR <30 mL/min/1.73 m2). Patients terminally ill due to neoplastic disease and/or advanced organ disease. Advanced dementia. Patients unable to perform tele visit and/or without an effective caregiver.

Study Design and Data Collections (Fig.1a, 1b, 1c)

Pre-discharge visit (T1): The physician identifies the eligible patient and, upon discharge, fills out the database. Clinical data, symptoms, laboratory tests, therapies and point-of-care heart and lungs ultrasound (HLPOCUs) are recorded in the database. The nurse records the KCCQ and the clinical monitoring form.

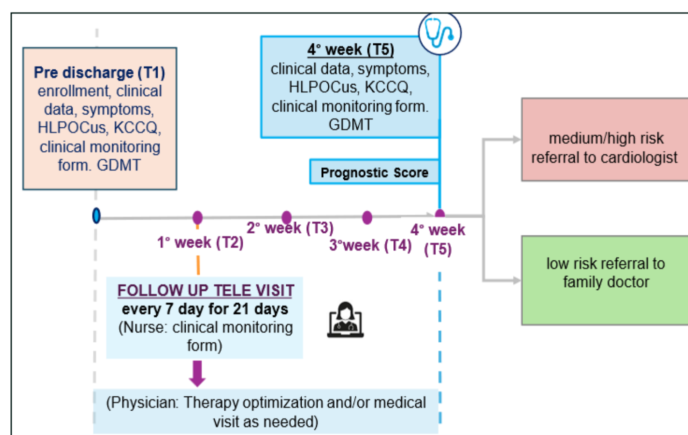

Figure 1a: Study Design : P.E.A.C.H. Program

PEACH: Post-hospitalization transition phase program after an Episode of Acute Congestive Heart Failure
HLPOCUs: point-of-care heart and lungs ultrasound; **KCCQ:** Kansas City Cardiomyopathy Questionnaire

Point of care Heart and Lungs Ultrasounds (HLPOCUs)

	EF (%)	Pattern diast.	TR velocity (m/sec)	PAPS (mmHg)	E/e’	e’ (msec)	LA vol i (ml/mq)	TAPSE (mm)	VCI (mm)	Line B 8 fields (n)
Pre-dimisson (T1)	x	X	x	x	x	x	x	x	x	x
4 week (T5)	x	X	x	x	x	x	x	x	x	x

Figure 1b: EF: ejection fraction; Pattern diastolic: E/A; TR: CW doppler TR systolic jet velocity; PAPS: pulmonary artery systolic pressures; E/e’: mitral E/e’; e’: pulsed wave TDI e’ velocity; LA: left atrium maximum volume index; TAPSE: tricuspid annular plane systolic excursion; VCI: inferior cava vein diameter; Line B: n. line B/8 zone(fields)

	KCCQ (n)	Weight (kg)	PAS/ PAD (mmHg)	SatO2 (%)	Heart rate (bpm)	Orthopnea (yes/ no)	Dyspnea at rest (yes/ no)	Exertional dyspnea (yes/ no)	Edema (yes/ no)	Compliance (yes/ no)	Measures
Pre-discharge (T1)	X	x	X	x	x	x	x	x	X	X	x
1°week (T2)		x	X	x	x	x	x	x	X	X	x
2°week (T3)		x	X	x	X	x	x	x	X	X	x
3°week (T4)		x	X	x	X	x	x	x	X	X	x
4°week (T5)	x	x	X	x	X	x	x	x	X	X	x

Figure 1c: The Clinical Monitoring form (Telenursing)
KCCQ: Kansas City Cardiomyopathy Questionnaire; PAS: systolic arterial pressure; PAD: diastolic arterial pressure; Sat O2: oxygen saturation.

First week tele visit (T2): The nurse makes a tele visit and fills out the clinical monitoring form. The physician reviews the form and, if necessary, adjusts the therapy, fills out the database.

Second week tele visit (T3): The nurse makes a tele visit and fills out the form for clinical monitoring. The doctor examines the form and possibly adjusts the therapy, fills out the database.

Third week tele visit (T4): The nurse makes a tele visit and fills out the form for clinical monitoring. The doctor examines the form and possibly adjusts the therapy, fills out the database.

Fourth week visit (T5): The patient is received for

a check-up. On this occasion the nurse fills out the form for clinical monitoring and the KCCQ. The doctor evaluates the patient with clinical data, symptoms, laboratory tests, therapies, and HLPOCUs. Finally, he closes the discharge report-letter (with addendum) and fills in the database.

Instruments

Training: To carry out this project we decided to use the training tool training improvement project. By doing so, we responded to the national training objective of introducing innovations and technologies and to the regional training objective of introducing new healthcare organizational models with telemedicine. The course program consisted of 4 steps. The first step was a frontal lesson on the theoretical aspects of the pathology (heart failure) and on the telemedicine tool. Furthermore, the project and the operational methods were presented. The second step consisted in the joint work doctor/nurse who carried out tele visits. In the third step the nurse, having achieved decision-making and management autonomy, was able to carry out tele visits independently. The fourth step was characterized by the analysis of the results and identification of any corrective proposals.

Database: The database is built on Google Excel sheets and reports the clinical, bio humoral, pharmacological and instrumental measurements of the patients enrolled from entry (T0) to the fourth week of post-hospitalization (T5). Registration takes place in real time and the data will be used for statistical purposes following the indications of the Ethics Committee.

Nursing clinical monitoring form and KCCQ: Directly collected by the nurse via tele visit and with the contribution of the caregiver (T1-T5) (Fig 1c).

Point of care heart and lungs ultrasounds (HLPOCUs): The echography examination will carry out at admission (T0), at pre-discharge (T1) and at the 4th week of post-hospitalization (T5) (Fig 1b). The parameters measured are those indicated by the guidelines [20-23]. In particular, the indicators of systolic function (ejection fraction), the assessment of diastolic function (diastolic pattern, mitral valve E/A ratio, pulsed wave TDI e' velocity, mitral E/e', left atrial maximum volume index, CW doppler TR systolic jet velocity, pulmonary artery systolic pressure (PAPS), tricuspid annular plane systolic excursion (TAPSE), inferior cava vein diameter), and the lungs congestion (B lines in 8 fields). Two doctors with proven experience and with certification from the Società Italiana di Ecocardiografia e CardioVascular Imaging (SIECVI) will alternate in carrying out the exams.

Blood chemistry tests: Among the blood chemistry tests that will be compared at times T0, T1, T5 we have identified those with prognostic significance, like brain natriuretic peptide (BNP), creatinine clearance (GFR), hemoglobin, transferrin saturation, carbohydrate antigen (CA 125), et al [24,25].

Endpoints

Primary Study Endpoints:

- Improvement of the patient's perceived quality of life, comparing the pre-discharge and at 4 weeks of post-hospitalization KCCQ (T1 vs T5)
- Verification of therapeutic adherence and the possibility of optimizing heart failure therapy up to the maximum tolerated according to GDMT, comparing pre-discharge and at 4 weeks of post-hospitalization therapies (T1 vs T5)
- for each individual drug, comparison of the maximum tolerated dose with the optimal dose (GDMT)
- evaluation of the effectiveness of therapeutic changes based on clinical and instrumental data recorded before discharge and at 4 weeks of post-hospitalisation (T1 vs T5)
- correlation of therapy, clinical and instrumental data before discharge and at 4 weeks of post-hospitalization (T1 and T5) with the most common outcomes at 3-6-12 months (Emergency Department (ED) admissions, hospitalizations, mortality)
- Recording of adverse events

Secondary Endpoints:

- construction of a digital clinical monitoring form (Fig 1 c, telenursing) and its administration to enrolled patients (patients enrolled/clinical monitoring form administered >80%)
- construction of a follow-up path with the use of ultrasound focused on the heart and lungs (Fig 1 b, HLPOCUs) (patients enrolled/HLPOCUs performed >80%)
- construction of a predictive re-hospitalization score based on a combination of multiple vari-

ables (anamnestic, clinical, bio humoral, functional, instrumental), descriptive of "response performance" to pharmacological treatment during hospitalization

Statistical Analysis

All data will be entered into an electronic database in anonymous form. The data will be checked to verify its consistency and completeness; therefore, the database will be used for statistical analysis. Results will be presented as mean ± standard deviation for continuous variables with normal distribution or as median and interquartile range (IQR) for variables with non-normal distribution. Percentages for categorical variables will be used. Comparison of groups and subgroups with continuous variables will be calculated using the Student's T-test or Mann-Whitney U test when appropriate, and the Chi-square test or Fischer's exact test for categorical variables. For comparison of pre- and post-discharge variables, the Paired T-test or the Wilcoxon test for paired data will be used, when appropriate. Variables found to be predictors of hospital readmission, emergency department visits and survival, with a p-value less than 0.1 on univariate analysis, will be included in a multivariable Cox regression model and the results will be presented as Hazard Ratio (HR) with a 95% confidence interval (CI). All tests will be two-tailed. A $p < 0.05$ will be considered significant. Statistical analysis of the data will be performed using SPSS 28 statistical software (SPSS Inc. and Microsoft Corp., Chicago, IL, USA).

Results

In March 2024 the observational study received authorization from the Ethics Committee for Clinical Trials. From then until today, 35 patients have been enrolled, of these 27 have completed the post-hospitalization follow-up (4 weeks, T5) and are the subject of our statistics. The average age was 77 years (+ 8). Men were 59%. The average hospital stay was 9 days (+ 4). Each patient presented on average 3 chronic pathologies. In order of frequency: Hypertensive heart disease (82%), chronic kidney disease (CKD, 52%), anemia (41%), ischemic heart disease (41%), diabetes (37%), atrial fibrillation (37%) et al. Therapy at admission (T0) consisted of: Furosemide (65%), Beta blockers (63%). Less represented were MRA (40%), ARNI (22%), ACEi (23%), and SGLT-2i (24%) (Fig. 2).

Patients (number)	**Age** (years)	**Hospital stay** (days)	**Men/Women** (%)					
27	77	9	59/41					
Hypertensive heart disease (%)	**Ischemic heart disease** (%)	**Primary dilated cardio myopathy** (%)	**Diabetes** (%)	**Atrial fibrillation** (%)	**Chronic obstructive pulmonary disease** (%)	**Kidney chronic disease** (%)	**Anemia** (%)	
82	41	15	37	37	26	52	41	
Heart failure admission/ 12 months	**0**	**1**	**2**					
(%)	66	11	22					
Therapies at admission (T 0)	**Sacubitril /Valsartan**	**ACEi**	**Sartani**	**Beta bloccanti**	**Ivabradina**	**MRA**	**SGLT-2i**	**Furosemide**
(% patients)	22	23	7	63	3	40	24	65

Figure 2: General Data

Sacubitril/Valsartan o ARNI angiotensin receptor/neprilysin inhibitor

ACEi angiotensin-converting enzyme (ACE) inhibitors

Sartani or AT1 antagonist

MRA mineralocorticoid receptor antagonist

SGLT2i sodium-glucose cotransporter-2 inhibitors

All 27 patients completed the KCCQ format in pre dismission (T1) and in the 4th week post hospitalization (T5) allowing us to record how both the perception of the disease, the symptoms and the quality

of life changed. The mean score improved significantly from T1 to T5 (55 vs 86, p =0.000) and 60% of the patients had a change of more than 30 points (Fig. 3). The evaluation of the individual items of the KCCQ confirmed the trend towards an improvement at the 4th week post hospitalization (T5). All symptoms (daily activity, edema, tiredness, shortness of breath), knowledge of the pathology, pleasure in living had improved at T5. An analysis parallel to the KCCQ also recorded the importance of continuity of care and the ease in learning the new technology (tele nursing).

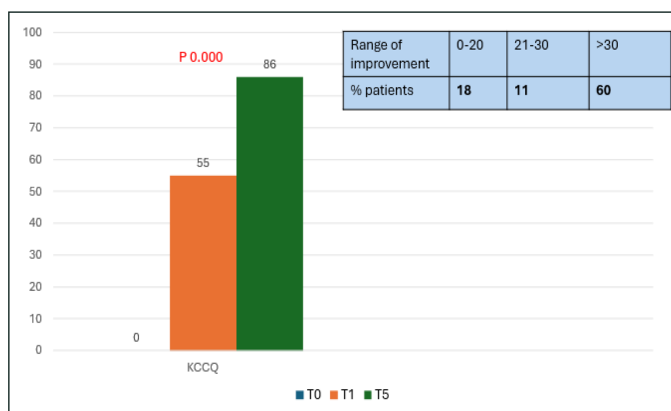

Figure 3: Improvement in perceived quality of life: The KCCQ (T1 vs T5)

We compared the therapy at the time of admission (T0) with the pre-discharge (T1) and the 4th week post-hospitalization (T5) therapy. Compared to entry (T0), the percentage of patients taking ARNI, Beta blockers, MRA, SGLT-2i had significantly increased at pre-discharge (T1) (22 vs 55%, 63 vs 92%, 40 vs 96%, 24 vs 96% respectively). At the 4th week of post-hospitalization (T5), the percentage of patients on therapy with ARNI and SGLT-2i continued to increase (80% and 100% respectively) while diuretics decreased (T1 77% vs T5 68%) (Fig. 4a). An analysis of the dosage reached for the single drug revealed that SGLT-2i and MRA achieved the maximum recommended dose sec. GDMT (10mg and 50mg) in the 4th week of post hospitalization (T5 vs T0 p=0.000 and p=0.003 respectively). The dosage of ARNI and Beta blocker was increased during follow-up (T5 vs T0, ARNI p=0.001, Bisoprolol p=0.03) without, however, reaching that recommended by the guidelines (Fig. 4b). In fact, most patients maintained a low dosage of ARNI (50mg in 40%), Metoprolol (100mg in 15%), Bisoprolol (2.5mg in 30%) at the 4th week of post hospitalization (T5) (FIG. 4c). The dosage of the diuretic at the 4th week of post hospitalization decreased significantly (T5 vs T1 Furosemide p= 0.02).

The symptoms at the admission such as orthopnea and dyspnea at rest had already disappeared at the time of pre-discharge (T0 vs T1 p=0.000). Exertional dyspnea and edema almost completely disappeared in the 4th week post-hospitalization (T1 vs T5 p=0.000 and p=0.005 respectively) (Fig. 5). The NYHA class also improved continuously from discharge to the end of post-hospitalization (T0 vs T5 p =0.000). Thanks to the clinical nursing monitoring form we recorded a drop in weight (T0 vs T5 p 0.002), in systolic blood pressure (p= ns) and in diastolic blood pressure (p= ns) over the 4 weeks.

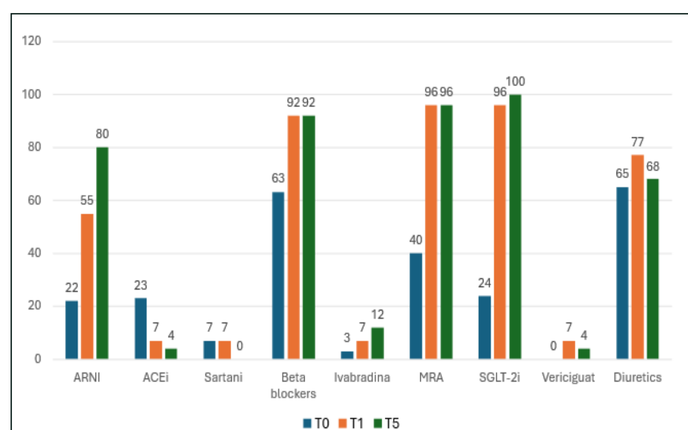

Figure 4a: Optimization of therapy sec. GDMT. Therapy from T0 to T5. % Patients

ARNI angiotensin receptor/neprilysin inhibitor
ACEi angiotensin-converting enzyme (ACE) inhibitors
Sartani or AT1 antagonist
MRA mineralocorticoid receptor antagonist
SGLT2i sodium-glucose cotransporter-2 inhibitors

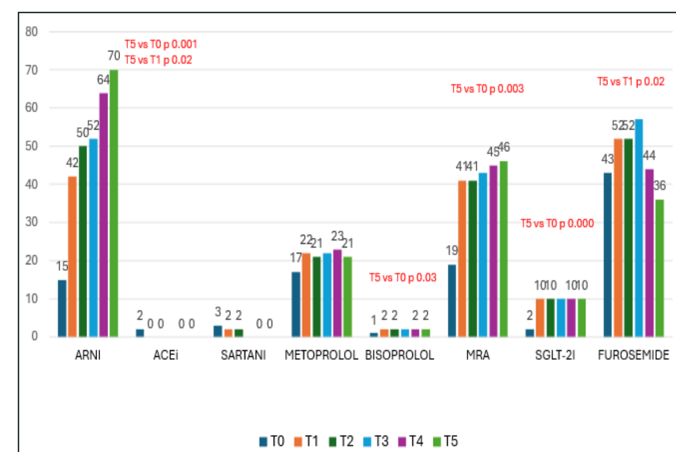

Figure 4b: Therapy: maximum tolerated dose (mg). From T0 to T5

ARNI angiotensin receptor/neprilysin inhibitor
ACEi angiotensin-converting enzyme (ACE) inhibitors
Sartani or AT1 antagonist
MRA mineralocorticoid receptor antagonist
SGLT2i sodium-glucose cotransporter-2 inhibitors

ARNI	50mg	100mg	200mg
% patients	**40**	22	11
METORPOLOL	**50mg**	**100mg**	**200mg**
% patients	7	**15**	0
BISOPROLOL	**1.25mg**	**2.5mg**	**5mg**
% patients	15	**30**	15
MRA	**25mg**	**50mg**	**100mg**
% patients	18	**63**	3
SGLT-2i			**10mg**
% patients			**92**

Figure 4c: Percentage of patients in optimal dose of therapy (mg) sec. GDMT at T5

ARNI angiotensin receptor/neprilysin inhibitor
MRA mineralocorticoid receptor antagonist
SGLT2i sodium-glucose cotransporter-2 inhibitors

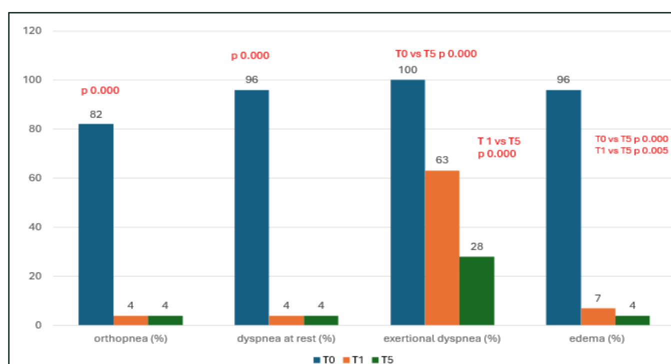

Figure 5: Clinical data recorded at admission (T0), pre-discharge (T1) and at 4th week of post-hospitalization (T5)

From time T0 to T5 we recorded a continuous decrease in the Brain Natriuretic Peptide (BNP) (1141 vs 420 pg/ml, p=0.009) and in the carbohydrate antigen (CA 125) (101 vs 15 u/ml, p=0.012). Differently, in the same period, hemoglobin (HB) and the percentage of transferrin saturation improved (12 vs 13 mg/dl, p=0.008 e 10 vs 23 %, p=0.05 respectively). There were no significant changes in the creatinine clearance.

The HLPOCUs examination was carried out on admission (T0), before discharge (T1) and in the 4th week of post-hospitalization (T5). We recorded a continuous improvement of all useful parameters (Fig.6). The ejection fraction (EF) increased on average from 31% to 47% (T1 vs T5, p=0.001). Diastolic function, measured with the diastolic pattern and with the E/e' ratio, improved significantly from T1 to T5 (3 vs 2, p=0.013 and 20 vs 14 p=0.012 respectively). The indexed atrial volume, an indicator of intra atrial pressure, also improved in follow up (T1 54ml/m2 vs T5 45ml/m2 p=0.005). We therefore recorded, from T1 to T5, an improvement in all indicators of right ventricular function and systemic congestion. The TAPSE (17 vs 23mm, p=0.000), the PAPS (38 vs 25mmHg, p=0.000), the VCI diameter (17 vs 11mm, p=0.001). Finally, the measurement of pulmonary congestion with the search for B lines in 8 zone confirmed the effectiveness of the interventions from T1 to T5 (10 vs 4, p=0.000) which had already begun after admission (T0 vs T1).

Data	T0	T1	T5	*p T5 vs T0*	*p T5 vs T1*
EF (%)	32	31	47	*0.000*	*0.001*
Pattern dyastolic	3	3	2	*0.005*	*0.013*
E/è	21	20	14	*0.013*	*0.012*
LAvol (ml/mq)	56	54	45	*0.008*	*0.005*
TRV (m/sec)	3	3	2	*0.001*	*0.004*
TAPSE mm	17	17	23	*0.002*	*0.000*
PAPS mmHg	39	38	25	*0.001*	*0.000*
VCI mm	17	17	11	*0.000*	*0.001*
Line B n/8 zone	17	10	4	*0.000*	*0.000*

Figure 6: Instrumental data: Heart and Lungs point of care ultrasound (HLPOCUs). T0, T1, T5

EF: ejection fraction; Pattern diastolic: E/A; TR: CW doppler TR systolic jet velocity; PAPS: pulmonary artery systolic pressures; E/e': mitral E/e'; e': pulsed wave TDI e' velocity; LA: left atrium maximum volume index; TAPSE: tricuspid annular plane systolic excursion; VCI: inferior cava vein diameter; Line B: n. line B/8 zone(fields)

A recording of the strongest outcomes has not yet been possible due to the short observation period (from March to December 2024) and the small population size. However, thanks to the Hospital Management Control Service and the confirmation phone

calls to the care givers, we recorded the following events due to heart failure (HF) occurred up to the 7th month after the 4th week of post hospitalization (T5). HF Hospitalizations: 2 in the first month, 1 in each third, fourth, fifth month. HF Deaths: 1 in each first and second month (Fig. 7).

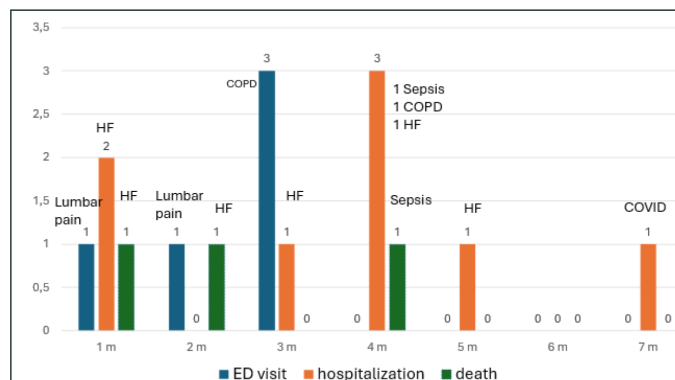

Figure 7: Outcome: Emergency Department (ED) visits, hospitalizations, deaths at the end of the PESCA program (divided by cause).

HF= heart failure, COPD = chronic obstructive pulmonary disease
m= months

The following adverse events were recorded during follow-up: Erythema (1 patient), hypokalaemia (1 patient), hypotension (3 patients), acute renal failure (1 patient). None of these events required hospitalization.

As regards the secondary endpoints and thanks to the training, it was possible to administer both the digital clinical monitoring form (telenursing in T1-5) and the HLPOCUs path (in T0, T1, T5) to all 27 patients (100%).

Now, considering the low number of patients enrolled and the short follow up time, it is not possible to construct a prognostic score with clinical, instrumental and biochemical parameters (Delta T1-T5)

Discussion

This study was not designed to demonstrate clinical efficacy or to establish causal relationships. Its primary aim was to explore the feasibility and implementation of a structured, telemedicine-supported transitional care pathway in a real-world internal medicine setting. The observational design, limited sample size, and short follow-up period preclude definitive conclusions on long-term clinical outcomes. Therefore, the observed changes in clinical, biohumoral, and instrumental parameters should be interpreted as short-term signals supporting the potential role of structured post-discharge management rather than as evidence of effectiveness.

The transition phase, immediately after discharge from an episode of heart failure, is known to be a critical phase. In fact, the patient passes from a place protected by the supervision of health workers to a less controlled site at home [26]. In this same period the neurohormonal factors that led to the decompensation are not yet completely controlled so that the hemodynamic balance is still unstable. For these reasons and in the first 30 days after discharge the risk of a second hospitalization and/or access to the emergency room is very high (30%) [27]. To better manage this transition phase, it is necessary to titrate the therapy according GDMT to be started already during hospitalization, once the acute phase has passed, and in the days before discharge [28].

Heart failure clinics are set up in various hospitals and territories to provide continued therapeutic care immediately after hospitalization. Health professionals work in these and form a multidisciplinary and multi-professional group (doctors and nurses) [4,5]. However, not all public health government entities have economic resources, nursing staff and equipment to dedicate to a clinic set up in this way. The P.E.A.C.H. program wants to verify whether the patient hospitalized for an episode of acute heart failure can be taken care of post-hospitalization, in the transition phase, by the healthcare professionals who treated him during the hospitalization phase (doctors and nurses). The advantages are various: healthcare workers already know the patient's health, welfare and social problems; follow-up exams are scheduled in advance and quickly compared with those of the hospital stay; the therapy is titrated and recorded in the same medical record; if necessary it is easy to prescribe specialist advice; any hospitalization can be planned without going to the emergency room; the expense is covered by the department's work, carried out by professionals and instruments already in possession.

To achieve these goals, we have used tools that are easily available, economical and can be shared among all healthcare professionals. The first is training accord-

ing to an improvement project. This allowed doctors and nurses to be trained during working hours and until the required skills are achieved. The second tool is telemedicine understood as tele visit and telenursing. Thanks to this and for the transition phase we have remotely followed the patient discharged after an episode of acute heart failure. Also interacting with the care giver, if necessary, we recorded the clinical data on a specific clinical monitoring format and titrate the therapy, when possible, according to the guidelines (tele P.E.A.C.H.) [10, 11]. The third tool is ultrasound focused on the heart and lung (HLPOCUs). We have measured the change in parameters for systolic, diastolic function, and pulmonary congestion before discharge and after the fourth week of post-hospitalization. These values also allowed us to adequately modify the therapy according to guidelines [21-23]. All clinical, blood chemistry and instrumental parameters were recorded in a special database. Thanks to this, all patient information was easily available, and the data could also be used for scientific purposes (data P.E.A.C.H.).

After obtaining the favourable opinion of the Ethics Committee for Clinical Trials (March 2024) and to date (December 2024) we have enrolled 35 patients hospitalized for an episode of acute heart failure with reduced ejection fraction (HFrEF). We currently have the results of the first 27 patients. Such a low number can be explained by the type of patient admitted to the medical department: characterized by age, multi-pathology, dementia, fragility (including social).In fact the patients enrolled have an average age of 77 years and a high percentage of pathologies associated with heart failure (renal failure in 52%, anaemia in 41%, diabetes and atrial fibrillation in 37%, et al) and a Barthel index of 60 points. Most of the patients were helped by care givers (80%). At admission (T0) the therapy was inadequate respect to guidelines (ARNI in 22%, SGLT2i in 24 %, Beta blockers in 60%, MRA in 40%). This could be explained both because at least 60% had not had a hospitalization for heart failure in the previous 12 months, and because of the comorbidities as already described.

All patients were able to use the tool to connect to the tele visit, recorded the clinical data as per the format for clinical monitoring, and maintained good compliance with the therapy. All patients concluded the P.E.A.C.H program with the visit and the HLPOCUs at the 4th week of post-hospitalization (T5).

The use of the KCCQ, also in digital format, allowed us to record the delta in perceived quality of life and clinical outcomes during follow up (from pre-discharge T1 to the 4th week of post-hospitalization T5). At the end of the post-hospitalization period, we registered an improvement in the score in all patients, and 60% increased it by more than 30 points. Among the items that clearly improved there were: activities of daily living, tiredness, oedema, dyspnoea, awareness of the disease, pleasure in living and recreational activities. An analysis parallel to the KCCQ, with a specific questionnaire, confirmed and reinforced the effectiveness of tele nursing (tele P.E.A.C.H.). All patients perceived and appreciated the healthcare support and used the new technology without difficulty.

The tele visit also allowed the therapy to be modified during follow-up. In fact, thanks to the recording of clinical, bio humoral and instrumental data, the percentage of patients treated with GDMT increased significantly (from T0 to T5): ARNI from 22 to 80%, beta blockers from 63 to 92%, MRA from 40 to 96%, SGLT2i from 24 to 100%. At the same time, the use of diuretics decreased. This trend already occurred in the days before discharge, once the acute phase had passed, as recommended by recent scientific evidence [20]. At pre-discharge (T1) the percentage of patients on SGLT2i and MRA was 96%, on beta blockers 92%, on ARNI 55%.

The optimal dose recommended by the guidelines was reached at T5 for SGLT2i and for MRA only (10mg in 92% and 50mg in 63% of patients respectively). Otherwise, that for ARNI and for beta blockers remained low at T5 (Sacubitril/Valsartan 50mg in 40%, Bisoprolol 2.5mg in 30% and Metoprolol 100mg in 15% of patients). In fact, we have intercepted the tendency towards hypotension and bradycardia via tele nursing. The data is common and due to the multi-pathologies and multi-therapies in use in patients admitted in internal medicine ward [29, 30].

During the 4 weeks of follow up, thanks to the titration of the therapy, we recorded progressive clinical improvement via telenursing. At time T1 the orthopnoea and dyspnoea at rest, at time T5 the dyspnoea on exertion and the oedemas disappeared. The NYHA class

also improved at time T5. In parallel we recorded at T5 time an improvement in bio humoral and instrumental data. The BNP value went from 1141 in T0 to 420 pg/ml in T5 (p=0.009), the CA 125 from 101 in T0 to 15 u/ml in T5 (p=0.012). While the former decreased more rapidly, the latter normalized after 4 weeks confirming their pathogenetic significance as a marker predominantly of left and right ventricular dysfunction respectively [24, 25]. The improvement from T0 to T5 in the percentage of transferrin saturation and haemoglobin, due to ferric carboxy-maltose transfusions, contributed to get better the clinical and the decongestion status as already described in the literature [31]. The most evident result, thanks to the titration of the therapy, was recorded for the change in instrumental data (HLPOCUs). The HLPOCUs algorithm includes a few easy-to-learn parameters, it is quick and repeatable by the same operator and between different operators. Its information is important not only to diagnose HF but also to better appreciate its severity, response to treatment and prognosis [22]. In our study the delta began already in the predischarge phase (T0 vs T1) and continued until the 4th week of post-hospitalization (T1 vs T5). We registered an increase in the EF (31 vs 47%), an improvement in the left ventricular filling pressure (E/e' 20 vs 14, LA vol index 54 vs 45 ml/mq, et al) a reduction in the pulmonary congestion (VCI 17 vs 11mm, line B n/8zone 10 vs 4, et al).

To date, due to the low number of participants and the short time that has elapsed, it is difficult to record the major outcomes. However, what we can register is that P.E.A.C.H. program via tele nursing has protected patients in the transition phase. Ninety days after the end of tele P.E.A.C.H. there were 3 hospitalizations (11% of patients) and 2 deaths (7% of patients) due to heart failure. Visits to the Emergency Room (E.R.) in the first 3 months were due to causes other than exacerbation of heart failure (Fig. 7). Adverse events recorded from T1 to T5 were few and did not lead to hospitalization or to visit E.R. Cases of erythema and hypotension were intercepted thanks to tele nursing and resulted in the suspension and/or reduction of Sacubitril/Valsartan. The blood tests carried out at time T5 recorded hypokalaemia in one patient and exacerbation of chronic renal failure in one other patient which were corrected without the need for hospitalization. To date it is not possible to define a definitive prognostic score. In the coming months and until the end of the study (December 2025) the recording of clinical, bio humoral and HLPOCUs data in the transition phase will allow us to better identify the patient who, due to the severity of the disease, will need to be referred to the cardiologist specialist rather than to the general practitioner (Fig. 8). During the follow up we recorded some critical issues of the P.E.A.C.H. program. Training is time consuming and not all healthcare professionals (nurses and physicians) joined the program, burdening the volunteers with work. The patient enrolled, due to age and comorbidities, needed care givers at home for the measurement of parameters and for the connection to the tele visit. At the beginning of the study the digital devices were not performing and some tele communication problems occurred [32].

Parameters score (Delta T1 -T5)

KCCQ n. (increase)	Values	PAPS mmHg (reduction)	Values	BNP pg/ml (reduction)	Values
< 10	3	0	3	<500	3
11-30	2	1-10	2	500-100	2
>30	1	>10	1	>1000	1
EF % (increase)		**VCI mm (reduction)**		**Score total**	
0	3	0	3	**High risk**	>14
1-10	2	1-10	2	**Medium risk**	8-14
>10	1	>10	1	**Low risk**	<8
E/e' n. (reduction)		**Linee B n/8 zone (reduction)**			
0	3	0	3		
1-5	2	1-10	2		
>5	1	>10	1		

Figure 8: A hypothetical prognostic score using clinical, HLPOCUs and laboratory parameters (Delta T1-T5)

EF: ejection fraction; PAPS: pulmonary artery systolic pressures; E/e': mitral E/e'; VCI: inferior cava vein diameter; Line B: n. line B/8 zone(fields); KCCQ: Kansas City Cardiomyopathy Questionnaire; BNP: Brain Natriuretic Peptide

Conclusions

In this short period of observation, the P.E.A.C.H. program allowed us to draw some conclusions. Tele medicine (tele visit and tele nursing) has proven to be an easy-to-use tool in the post-hospitalization transition phase after an acute heart failure episode. The same tool allows healthcare professionals (nurses and physicians) to verify therapeutic adherence and optimize therapy according to GDMT. Telenursing in post-hospitalization is appreciated and easily used by

patients. The digital format for clinical monitoring, the use of ultrasound focused on the heart and lungs (HLPOCUs) are quickly learned by healthcare professionals, they can monitor the state of congestion and record the prognostic parameters of the patient. The 30-day follow-up served to protect the patient in the transition phase. An internal medicine clinic dedicated to heart failure in the elderly would guarantee better care after one month of the tele nursing monitoring.

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