

Cardiac POCUS in primary care

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Dissertação de candidatura ao grau de Doutor em Medicina
Faculdade de Medicina da Universidade do Porto

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Cardiac point-of-care ultrasound in primary care

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*Improving early detection and management
of cardiovascular disease*

Dissertação de candidatura ao grau de Doutor em Medicina,
apresentada à Faculdade de Medicina da Universidade do Porto

ORIENTAÇÃO

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P O R T O • 2 0 2 6

A melhor tecnologia em medicina não é a que substitui o médico, mas sim a que o aproxima do doente.

Foi na consulta que aprendi que o doente precisa de ver para crer — quando a ecografia lhe mostra o que antes apenas explicávamos, deixamos de cuidar dele para passarmos a cuidar com ele.

— Jonathan dos Santos

PART I

Preliminaries

*Acknowledgments, outline,
publications, abstract & glossary*

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Thesis outline

This thesis is organised into six chapters, followed by a discussion and conclusion.

Chapter 1 presents the Preface, contextualising the current challenges of cardiovascular disease and chronic care, and highlighting the potential of technological innovation — particularly cardiac point-of-care ultrasound (POCUS) — in family medicine.

Chapter 2 outlines the Aims of the doctoral project, including the overarching aim and the specific objectives addressed in the studies.

Chapter 3 provides the Introduction, describing the epidemiology and clinical relevance of heart failure, the challenges of early diagnosis in primary care, and the rationale for integrating cardiac POCUS into family medicine.

Chapter 4 corresponds to the core paper of this thesis, reporting the PLAN-HF study, which evaluated the clinical impact of cardiac POCUS in primary care consultations.

Chapter 5 includes the published case report that illustrates the value of POCUS in family medicine — particularly in the home setting — and its role in democratising access to echocardiography.

Chapter 6 presents the PRIMARY-HF study protocol, defining the future research framework for combining POCUS with biomarkers such as NT-proBNP in heart failure screening.

Finally, the **Discussion** integrates the main findings of the included works, explores obstacles to implementation, and reflects on the broader implications for patient-centred and value-based care. The **Conclusion** summarises the main contributions of the thesis and points towards future research directions.

List of publications

CORE PAPER

Point-of-care ultrasound can make the difference in patients with heart failure at primary care

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Other publications during this thesis

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1. dos Santos J, Fernandes PB, Gonçalves FR, Gonçalves A. Moving the needle towards the democratization of echocardiography: a case report. *Eur Heart J Case Rep.* 2019;3(4):1–5. doi:10.1093/ehjcr/ytz179.
2. dos Santos J, Gonçalves A. POCUS – Point-of-Care Ultrasound: Advanced Physical Examination. *Acta Med Port.* 2020;33(5):351. doi:10.20344/amp.13395.
3. dos Santos J, Fernandes P, Rocha Gonçalves F, Pereira Rodrigues P, Ribeiro J, Gonçalves A. P1349 POCUS by general and family physician – advancing physical examination. *Eur Heart J Cardiovasc Imaging.* 2020;21(Suppl 1):jez319.785. doi:10.1093/ehjci/jez319.785.
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5. Neves JS, Baptista R, Azevedo de Pape E, Pereira MR, Paulos R, dos Santos JP, Gavina C, Jácome de Castro J. Recommendations for the use of natriuretic peptides for early diagnosis of heart disease in patients with diabetes: a consensus report by

SPEDM, SPC, NEDM-SPMI and APMGF. *Rev Port Cardiol.* 2025;44(1):57–67. doi:10.1016/j.repc.2024.07.010.

6. dos Santos J, Nobre JP, Ferreira JP, Marques MI, Henriques M, Cardim N, Villanueva T, Gonçalves A. PRIMARY-HF: Heart failure screening in primary care using point-of-care. *Acta Med Port.* 2025;38(4):237–44. doi:10.20344/amp.22463.
7. Silva-Cardoso J, Moreira E, Tavares de Melo R, Sarmento PM, Cardim N, Oliveira M, Gavina C, Moura B, Araújo I, Santos P, Peres M, Fonseca C, Ferreira JP, Marques I, Andrade A, Baptista R, Brito D, Cernadas R, dos Santos J, Leite-Moreira A, Gonçalves L, Ferreira J, Aguiar C, Fonseca M, Fontes-Carvalho R, Franco F, Lourenço C, Martins E, Pereira H, Santos M, Pimenta J. A Portuguese expert panel position paper on the management of heart failure with preserved ejection fraction – Part I: Pathophysiology, diagnosis and treatment. *Rev Port Cardiol.* 2025;44(4):233–43. doi:10.1016/j.repc.2024.11.011.
8. Silva-Cardoso J, Moreira E, Tavares de Melo R, Sarmento PM, Cardim N, Oliveira M, Gavina C, Moura B, Araújo I, Santos P, Peres M, Fonseca C, Ferreira JP, Marques I, Andrade A, Baptista R, Brito D, Cernadas R, dos Santos J, Leite-Moreira A, Gonçalves L, Ferreira J, Aguiar C, Fonseca M, Fontes-Carvalho R, Franco F, Lourenço C, Martins E, Pereira H, Santos M, Pimenta J. A Portuguese expert panel position paper on the

management of heart failure with preserved ejection fraction –
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Resumo

INTRODUÇÃO

A doença cardiovascular continua a ser a principal causa de mortalidade a nível mundial. Em Portugal, o estudo PORTHOS, recentemente publicado, demonstrou que a insuficiência cardíaca (IC) afeta 16,5% dos indivíduos com idade ≥ 50 anos, atingindo 30,7% nos ≥ 70 anos, com mais de 90% por diagnosticar e 93,4% correspondendo a IC com fração de ejeção preservada (HFpEF). Esta realidade evidencia uma lacuna crítica no diagnóstico precoce, particularmente desafiadora em cuidados de saúde primários, dado que os sintomas iniciais são inespecíficos e a acessibilidade à ecocardiografia é limitada. O ecocardiograma point-of-care (POCUS), realizado pelo médico de família, surge como ferramenta promissora para colmatar esta lacuna, ao expandir o exame físico e aproximar a decisão clínica do momento da consulta.

OBJETIVOS

Explorar o papel do POCUS cardíaco na prática da Medicina Geral e Familiar, avaliando o seu impacto no diagnóstico e estadiamento da IC, no processo de decisão clínica e na utilização de recursos de saúde, bem como refletir sobre os desafios da sua implementação.

MÉTODOS

Foi conduzido o estudo observacional prospectivo PLAN-HF em contexto de cuidados de saúde primários, avaliando doentes com fatores de risco cardiovascular. Um médico de família, após formação estruturada em POCUS cardíaco, realizou os exames ecográficos durante a consulta, registando a influência na decisão clínica, no estadiamento da IC e na necessidade de exames complementares ou referências.

RESULTADOS

O estudo demonstrou que o POCUS permitiu reclassificar precocemente um número significativo de doentes nos estádios da IC, identificar alterações estruturais subclínicas — nomeadamente hipertrofia ventricular esquerda — com maior frequência do que o eletrocardiograma, e reduzir pedidos desnecessários de ecocardiograma e referências hospitalares.

CONCLUSÕES

O POCUS cardíaco, integrado na consulta de Medicina Geral e Familiar, é uma ferramenta viável e clinicamente relevante para a deteção precoce e gestão da IC. Para além de melhorar a precisão diagnóstica e otimizar os recursos de saúde, promove maior envolvimento do doente e fortalece a centralidade da MGF no percurso do doente cardiovascular. A investigação futura, nomeadamente o ensaio multicêntrico PRIMARY-HF, avaliará a combinação do POCUS com biomarcadores como o NT-proBNP —

uma estratégia diretamente alinhada com as recomendações do estudo PORTHOS — para o rastreio precoce de IC em populações envelhecidas.

Abstract

INTRODUCTION

Cardiovascular disease remains the leading cause of mortality worldwide. In Portugal, the recently published PORTHOS study has shown that heart failure (HF) affects 16.5% of adults aged ≥ 50 years — rising to 30.7% among those ≥ 70 — with more than 90% previously undiagnosed and 93.4% corresponding to HF with preserved ejection fraction (HFpEF). This reality reveals a critical diagnostic gap, particularly challenging in primary care, where initial symptoms are non-specific and access to echocardiography is limited. Cardiac point-of-care ultrasound (POCUS), performed by family physicians, represents a promising tool to bridge this gap, extending the physical examination and enabling immediate, patient-centred decision-making.

AIMS

To explore and evaluate the role of cardiac POCUS in family medicine, particularly in the early detection and management of HF, by assessing its impact on diagnostic accuracy, HF staging, clinical decision-making, and healthcare resource utilisation, as well as reflecting on the challenges to its implementation.

METHODS

The PLAN-HF prospective observational study was conducted in a Portuguese primary care setting among patients with cardiovascular risk factors. A single family physician, after structured training in cardiac POCUS, performed ultrasound examinations during routine consultations and recorded their impact on diagnosis, HF staging, further investigations, and referrals.

RESULTS

Cardiac POCUS enabled the earlier reclassification of a significant proportion of patients across HF stages, improved the detection of subclinical structural abnormalities — particularly left ventricular hypertrophy — compared with electrocardiography, and reduced unnecessary echocardiography requests and hospital referrals.

CONCLUSIONS

When integrated into routine family medicine consultations, cardiac POCUS is a feasible and clinically valuable tool for the early detection and management of HF. It enhances diagnostic accuracy, reduces unnecessary investigations, and promotes equity of access while reinforcing patient engagement and the central role of family medicine in cardiovascular care. Future research, including the PRIMARY-HF multicentre trial, will assess the combined use of POCUS and biomarkers such as NT-proBNP — a strategy directly aligned with the PORTHOS recommendations — for improving early HF detection in ageing populations.

GLOSSARY

Acronyms & abbreviations

AI	Artificial Intelligence
APMGF	Associação Portuguesa de Medicina Geral e Familiar
CVD	Cardiovascular Disease
HF	Heart Failure
HFpEF	Heart Failure with Preserved Ejection Fraction
HFmrEF	Heart Failure with Mildly Reduced Ejection Fraction
HFrEF	Heart Failure with Reduced Ejection Fraction
IC	Insuficiência Cardíaca
LVEF	Left Ventricular Ejection Fraction
MGF	Medicina Geral e Familiar
NT-proBNP	N-terminal pro-B-type Natriuretic Peptide
POCUS	Point-of-Care Ultrasound
RCT	Randomised Controlled Trial

PART II

Foundations & studies

*From context to evidence — the
published works of this thesis*

1

Preface

“The good physician treats the disease; the great physician treats the patient who has the disease.” (William Osler)

Over the past decades, we have witnessed a marked transition in the landscape of medicine: from an almost exclusive focus on acute illness, we have evolved towards the growing need to deal with chronic diseases. Increased life expectancy, together with advances in the treatment and cure of multiple pathologies, the development of new techniques and technologies, and the growing specialisation of health professionals, has enabled greater survival from conditions that were once fatal. This progress, though extraordinary, has inevitably led to a rising prevalence of chronic diseases, particularly of metabolic and cardiovascular nature. This reality translates into

increasing demands from citizens, requiring more differentiated and better organised responses within primary health care, which today stands as the fundamental pillar in the prevention and management of chronic illness.

Faced with this reality, it becomes clear that twenty-first century medicine cannot remain anchored to the models of the past. Technological innovation emerges not as an accessory, but as an indispensable condition to address current challenges. It is in this context that Eric Topol, as early as 2012 in his book *The Creative Destruction of Medicine*, argued that the digitalisation of health care does not merely represent successive technological advances, but rather a true revolution in the way physicians relate to information and to patients. With the incorporation of digital data, mobile devices, and big data into clinical practice, medicine becomes guided by individualised, decentralised, and permanently accessible knowledge, breaking with the traditional paradigm of paternalism towards true shared decision-making based on data and respecting patients' preferences. The democratisation of access to medical information — by both professionals and patients — radically transforms the physician's role, making it more collaborative, horizontal, and personalised. Topol compares Gutenberg's printing press to the digitalisation of health information, inaugurating the "Gutenberg Moment of Health", in which doctors and patients share decisions and protagonism in care.

In this scenario, tools such as point-of-care ultrasound (POCUS) clearly materialise this paradigm shift. Their use in primary health care illustrates how technology, when integrated carefully and with a person-centred approach, can expand diagnostic capacity, bring decision-making closer to the moment of consultation, and strengthen patient involvement in the process. More than technological innovation, it is a step toward more accessible, equitable, and truly citizen-centred care, fulfilling the promise of a medicine that unites science, technology, and humanism.

Today, the physician is no longer the sole holder of information. Its sharing among patients — whether through wearables, the internet, apps, and more recently through large language models (LLMs) — has placed the physician in a position different from the one we were used to. The doctor–patient relationship is now more horizontal, and the physician becomes a trusted guide by interpreting the information in its proper context. Technology has not come to replace the physician, but to bring them closer to the patient. POCUS, for instance, performed at the time of consultation, is not only a diagnostic tool: it represents a unique opportunity to explain to the patient what is happening within their body, to involve them in the clinical process, and to embody the principle that, in medicine, “seeing is believing”.

The organisation of health care places primary care as the first point of contact for citizens, while also ensuring continuity of care,

particularly in the management of chronic disease — which occupies much of the activity in family medicine. More than a prescription manager, the family physician is a guide who accompanies the entire process of health and illness, and who should align with hospital care whenever necessary, but never unnecessarily. Optimising care in everyday practice faces significant challenges and obstacles, namely limited time, insufficient human resources, complex patient demands, and fragmented information systems. Technology, when cost-effective, simple, and accessible, can add value. This is the case with POCUS, which has proven its worth in recent years. It is not a new concept: cardiology and gynaecology have long used it in clinical practice, but its expansion into other specialties has been limited until recently. Extending the physical exam with insonation — widely considered the “fifth pillar” — brings to the patient’s bedside, in a convenient and non-invasive way, a diagnosis or a more rapid and integrated diagnostic pathway within clinical evaluation, while also safely guiding invasive procedures, with the patient’s involvement.

Despite all the potential benefits of innovation, physicians have concerns about workload, and liability. Consultations have limited time, often perceived as insufficient by physicians and patients, leaving little room for innovation and new tools such as POCUS. Moreover, its adoption requires financial and training investment. In primary care, such investment is rarely prioritised. In the case of

POCUS, ultrasound devices, technical training, and continuous capacity-building programmes with minimum standards for correct use would be necessary. Its use would also benefit from integration with information systems and clinical workflows. A paradigm shift is difficult, as is the natural human resistance to change, yet it is expected when faced with well-established conventional medical practice.

Medicine is moving from a disease-centred model, focused on acute illness, to a patient-centred model of prevention, screening, early detection, and early intervention. The future lies in early action during subclinical phases of disease, before it manifests as greater suffering, resource expenditure, and reduced survival. Health should be measured not only by clinical management outputs — such as number of consultations or patients seen — but by outcomes that matter to patients: quality of life, autonomy, and functionality. Health systems must therefore reorganise to measure these parameters, evaluate the effectiveness and efficiency of implemented measures, and promote incentives that translate into more value and less volume.

Family medicine is uniquely positioned to integrate this change, where technology can play a crucial role as a foundation for better care, involving patients more directly in the process. POCUS is a paradigmatic example: by democratising access to diagnosis, it can reduce inequalities and avoid unnecessary patient travel. At the

same time, artificial intelligence, when allied with data and technology, has the potential to enhance POCUS and, consequently, the diagnostic pathway.

This paradigm is not merely a change in tools, but a transformation. It is the opportunity to restore time and meaning to the doctor–patient relationship, to bring science and humanity closer together, and to place the citizen at the true centre of the process. Paradoxically, it will be technology that makes medicine more human — because it allows us to look beyond disease and to care, with greater clarity and closeness, for the person in all their complexity.

*Technology has not come to replace the
physician, but to bring them closer to
the patient.*

CHAPTER

2

Aims

The overarching aim of this doctoral project is to explore and evaluate the role of cardiac point-of-care ultrasound (POCUS) in primary care, with a particular focus on the early detection and management of heart failure (HF), contributing to a more timely, accurate, and patient-centred approach to cardiovascular care.

SPECIFIC OBJECTIVES

1. To evaluate the clinical impact of cardiac POCUS in primary care consultations — through the PLAN-HF study — by assessing its influence on diagnostic accuracy, HF staging, and clinical decision-making regarding additional investigations and referrals.

2. To assess the feasibility and added value of integrating cardiac POCUS into routine family medicine practice, with special attention to its impact on consultation workflow, training requirements, patient engagement, and collaboration with other specialties in the context of cardiovascular care.
3. To develop and present the PRIMARY-HF study protocol as a framework for future research, aimed at assessing the combined role of NT-proBNP measurement and cardiac POCUS in HF screening within primary care.

3

Introduction

Cardiovascular disease (CVD) remains the leading cause of mortality worldwide, despite significant advances in prevention and treatment. The ageing of the population, together with improved survival after major cardiovascular events and the rising prevalence of chronic conditions such as hypertension and diabetes, has contributed to an increasing burden of CVD. Among these conditions, heart failure (HF) stands out as one of the most impactful, due to its high morbidity and mortality, its economic burden, and the strain it imposes on healthcare systems (1, 2). In Portugal, CVD has remained the leading cause of death over the past decade, accounting for approximately a quarter of all deaths in 2023, with heart failure identified by the national cardiovascular health programme as one of the major challenges for the coming years given its rising prevalence in an ageing population (3).

In Portugal, the recently published PORTHOS study has provided the most robust epidemiological evidence to date: heart failure affects 16.5% of community-dwelling adults aged 50 years or older, with prevalence rising sharply with age (4.0% in the 50–59 age group versus 30.7% in those aged 70 and above) and a striking female predominance (21.0% versus 10.5% in men). Even more concerning, more than 90% of those affected had not been previously diagnosed, and 93.4% corresponded to heart failure with preserved ejection fraction (HFpEF) — the phenotype most difficult to identify without echocardiographic evaluation (4). This silent epidemic underscores the need for improved strategies to identify HF earlier, when treatment is most effective. Timely recognition and intervention are particularly relevant in the current era, with the emergence of novel therapies — including SGLT2 inhibitors across the whole ejection fraction spectrum — capable of modifying the natural course of the disease (5).

*In Portugal, more than 90% of
patients with heart failure remain
undiagnosed (4).*

Primary healthcare, and family physicians in particular, play a pivotal role in this process. They are uniquely positioned to oversee the care of patients at risk for HF — those with hypertension, diabetes, atrial fibrillation, or ischaemic heart disease — while simultaneously managing multimorbidity. Their holistic view of the patient, family, and social context provides invaluable insights, yet early diagnosis of HF in primary care remains a challenge. The disease is often insidious, with symptoms such as fatigue or mild dyspnoea being non-specific and frequently attributed by patients to ageing or comorbidities. Consequently, a substantial proportion of patients experience delays in diagnosis, and natriuretic peptide testing and echocardiography remain underused in the community (6). Moreover, physical examination alone is frequently insufficient to detect early structural or functional abnormalities, limiting the capacity of family physicians to identify HF in its preclinical stages. Real-world data from Portuguese primary care illustrate this gap: in a cohort of patients hospitalised for the first time with heart failure, nearly half of those with previously recorded signs or symptoms had not undergone an adequate diagnostic work-up beforehand, highlighting missed opportunities for earlier recognition (7).

Over the past decades, advances in diagnostic technology have progressively extended the clinician's capacity to detect disease earlier and more accurately. Laboratory markers, imaging, and other complementary exams have become integral to the diagnostic

process. Among these tools, ultrasound has proven to be one of the most powerful — yet traditionally it has been restricted to specialists and performed in hospital settings, often detached from the clinical context of the patient. This gap gave rise to the concept of point-of-care ultrasound (POCUS), an approach in which imaging is performed by the treating physician as an extension of the physical examination (8).

POCUS has been growing its adoption in several specialties, including cardiology, gynaecology, emergency medicine, intensive care, internal medicine, anaesthesiology, and rehabilitation (9). In these settings, bedside ultrasound has become indispensable for decision-making and timely intervention. With the miniaturisation of devices and their increasing portability and affordability, the use of POCUS has gradually expanded to other areas, including primary care (10). A recent systematic review has confirmed that, after a brief theoretical and practical training, non-expert physicians can reliably assess left ventricular ejection fraction with cardiac POCUS in unselected primary care patients, supporting its feasibility and clinical value (11). Internationally, family physicians have begun to integrate ultrasound into their practice, mostly in acute care settings. In Portugal, however, this practice remains in its infancy.

Specifically in the context of HF, the integration of cardiac POCUS into routine family medicine consultations has the potential to bridge critical diagnostic gaps. Evidence from Spain has shown

that trained family physicians were able to acquire cardiac ultrasound images that, when interpreted remotely by cardiologists, led to earlier identification of cardiac abnormalities and more timely interventions (12). Nonetheless, the question remained whether family physicians trained in cardiac POCUS could independently perform and interpret these exams during routine consultations with patients at risk of HF, and whether this would improve clinical decision-making compared to conventional practice. These considerations laid the groundwork for the development of the PLAN-HF study – the central component of this thesis – aimed at assessing the real-world impact of cardiac POCUS in Portuguese primary care (13).

Our own experience further emphasises this potential. In one case example, during a home visit, cardiac POCUS was instrumental in diagnosing HF and guiding immediate management, later published as a case report in the *European Heart Journal – Case Reports* (14). Such scenarios highlight the unique advantages of POCUS in family medicine – not only in the office but also in the community – particularly in rural areas where access to echocardiography may be limited. Beyond geographic and logistical barriers, many patients do not undergo echocardiography even when prescribed by their family physician, due to reasons such as the cost of the exam or transportation, the need to travel outside their community, difficulties in scheduling, or simply the perception

that the test is not important if symptoms are mild or attributed to ageing. In this context, POCUS performed by the family physician represents an immediate, patient-centred solution that can overcome these barriers and promote earlier diagnosis.

Building on these insights, we conducted a prospective observational study in a Portuguese primary care setting, which demonstrated that cardiac POCUS significantly influences HF staging, reduces unnecessary echocardiography requests and hospital referrals, and improves the detection of subclinical cardiac abnormalities (13). These findings underscore the transformative role of POCUS in primary care, with the potential to change the trajectory of cardiovascular disease by enabling earlier detection, better risk stratification, and more efficient management of patients at risk of HF.

4

Point-of-care ultrasound can make the difference in patients with heart failure at primary care

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Point-of-care ultrasound can make the difference in patients with heart failure at primary care

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Abstract

Background: Primary healthcare centers (PHC) play a pivotal role in the first-line management of patients with diabetes and hypertension, major risk factors for heart failure (HF) development. Point-of-care cardiac ultrasound (POCUS), integrated as an extension of the physical examination, holds significant potential to enhance diagnostic accuracy and clinical management in this setting.

Objectives: Evaluate the impact of POCUS on clinical decision-making in patients with HF and at risk of developing HF in PHC and compare POCUS findings with clinical assessment alone, conventional echocardiography, and electrocardiogram results.

Methods: Patients with diabetes, hypertension, or HF symptoms at a PHC underwent POCUS by a trained family physician. The findings were compared with traditional clinical practice. Decisions regarding referral for an echocardiogram or hospital consultation were contrasted with those of two clinicians who do not use POCUS, and the investigator's echocardiographic results were compared with those from conventional echocardiography and electrocardiogram. Data were analyzed using SPSS.

Results: Among 196 patients (66 ± 15 years; 53.6% female), 36.2% had HF symptoms, 89.2% hypertension, and 29.7% diabetes. Investigator requested less echocardiograms (44 vs. 145 and 125) and made less hospital referral (15 vs. 16 and 24). Using POCUS, congestive patients were less than expected (18 vs. 43 cases), and stage B HF patients were more than clinically (44.9% vs. 19.4%). POCUS identified more cases with left ventricular hypertrophy than electrocardiograms (58 vs. 10).

Conclusion: These findings highlight the value of integrating POCUS into routine family physician consultations, particularly for the management of HF and effective risk stratification.

Key words: family medicine; primary healthcare; heart failure; point-of-care ultrasound; echocardiography; clinical decision-making; risk stratification

Introduction

Heart failure (HF) remains a major contributor to the global burden of cardiovascular disease, driven by increased life expectancy and a corresponding rise in its prevalence, mortality, and hospitalization rates, particularly among older populations. HF significantly impacts patients' quality of life and imposes considerable strain on healthcare systems worldwide. However, this economic and clinical burden can be mitigated through early identification and timely intervention, including the optimization of both pharmacological and non-pharmacological strategies [1–3].

According to the American Heart Association guidelines, HF is categorized into four stages [4]. Stages A and B, collectively termed "preclinical HF," include patients who do not exhibit clinical symptoms [5]. Stage A (at-risk for HF) encompasses individuals at risk of developing HF due to predisposing conditions but without evidence of structural or functional cardiac abnormalities. In contrast, Stage B (pre-HF) refers to patients with structural or functional cardiac abnormalities that remain asymptomatic and undetectable on physical examination [6]. Echocardiography serves as a critical diagnostic tool for identifying these abnormalities,

highlighting the necessity of effective comorbidity management to improve prognostic outcomes in HF [4–8].

Accurate identification of HF in its early stages is a crucial first step in effective management [5, 8, 9]. Family physicians (FP) are uniquely positioned to play a pivotal role in this process, as they frequently oversee the care of patients with HF and those at elevated risk for its development, including individuals with diabetes, arterial hypertension, atrial fibrillation, or coronary artery disease [10, 11]. However, disparities in medical and diagnostic resources across primary healthcare settings pose challenges, particularly in rural or underserved areas [12, 13].

The electrocardiogram (ECG), a standard diagnostic tool in primary healthcare centers, has limited sensitivity and specificity for detecting HF, especially in its early stages [14]. Although natriuretic peptides are an effective screening tool, their diagnostic accuracy is higher in patients presenting with symptoms of HF and those with systolic dysfunction than in asymptomatic patients or with diastolic dysfunction [15].

Echocardiography, particularly through the integration of point-of-care ultrasound (POCUS) in primary healthcare settings, performed by trained FP, could mitigate these

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Lay summary

- Cardiac point-of-care cardiac ultrasound (POCUS) potentially enhances diagnostic accuracy and clinical management in primary care
- POCUS can detect subclinical cardiac abnormalities missed by physical examination and ECG
- POCUS significantly reduces the number of echocardiograms requested and hospital referrals
- Standardized training and advanced diagnostic protocols are crucial to a consistent POCUS use

limitations by facilitating the early detection of structural abnormalities in Stage B HF. Moreover, POCUS has the potential to enhance the diagnostic capacity of physical examinations in patients with Stage A HF, offering a cost-effective and practical solution, especially in resource-constrained or rural healthcare settings [14–19]. Additionally, patients with HF frequently present with symptoms or signs of congestion, necessitating distinct treatment approaches based on the type of congestion: intravascular or interstitial. Differentiating between these forms is essential for tailoring therapeutic strategies effectively. POCUS plays a crucial part in this context, particularly by enabling the assessment of the inferior vena cava (IVC), a parameter that reflects left atrial pressure. Accurate evaluation of the IVC via POCUS aids in guiding diuretic therapy, thereby optimizing the management of intravascular congestion and the improving patient outcomes [20].

This study aimed to evaluate the utility of POCUS, performed by a trained FP, in the classification of HF patients and its role in guiding diagnostic and therapeutic decision-making in primary healthcare settings.

Methods**Standard protocol approvals, registrations, and patient consents**

The study was approved by the Ethics Committee of the Northern Regional Health Administration (ARS Norte) under reference number 50/2018. All procedures were conducted following the ICH Harmonized Tripartite Guidelines for Good Clinical Practice and with the Declaration of Helsinki. All participants provided written informed consent prior to inclusion in the study.

Study design and population

Prospective observational study, conducted between 2021 and 2022, at a rural primary healthcare center. The study population comprised patients under the care of the FP, who also served as the study investigator, during both office consultations and home visits.

Within the study period, all patients with presence of HF signs or symptoms, or HF risk factors, including diabetes and hypertension (Fig. 1) with indication to perform an echocardiogram were eligible to participate in the study. Patients receiving follow-up care at a hospital level were excluded.

Eligible patients were identified by the investigator during clinical practice and underwent POCUS at the same consultation. Prior to inclusion, patients had time to ask any question about the study procedures and gave their written informed consent to participate. In fewer than 10% of cases, POCUS was scheduled for a follow-up consultation due to time constraints.

Training and equipment

A single investigator (the FP who also served as the study investigator) performed POCUS as a complement to the patients' medical history and physical examination. Prior to conducting the study, this investigator completed structured cardiac ultrasound training, which included a theoretical component (certified 30-hour online course) and a practical component (observation of 250 echocardiographic exams and independent performance of 50 exams in a hospital echocardiography laboratory).

POCUS assessments were performed using a handheld ultrasound device (Lumify®).

Clinical and ultrasound data collection

Data collected included patient demographics (age, sex), reason for consultation, clinical signs and symptoms, and physical examination findings. Clinical history, and ECG and echocardiograms' prior results were obtained from patient medical records.

POCUS views obtained included: parasternal long axis, parasternal short axis, apical four-chamber, apical three-chamber, apical two-chamber, and subcostal views. Color Doppler imaging was used to assess valvular disease, and the following measurements were recorded: ventricular wall thickness (posterior and septal wall), left ventricular end-diastolic diameter, left atrial diameter, ascending aorta diameter, and IVC diameter. The presence of pleural and pericardial effusions was also evaluated. Ventricular function was qualitatively assessed by visual estimation ("eyeballing").

A conventional echocardiogram was asked to be performed a maximum of one month after the POCUS.

POCUS interpretation

POCUS findings were categorized into four outcomes: inconclusive, no alterations, minor alterations, and major alterations (Fig. 1). HF staging was determined according to the American College of Cardiology/American Heart Association (ACC/AHA) stages A to D [4]. Volume status was assessed based on IVC diameter and contractility.

Clinical management decisions were made by the FP who also served as the study investigator based on the patient's medical history, physical examination, and POCUS findings, particularly in cases of inconclusive or significant alterations. These decisions included therapeutic adjustments, patient education, hospital referrals, and requests for conventional echocardiography or additional diagnostic tests.

Control physician evaluation

Clinical information, namely clinical history, laboratory tests, ECG and echocardiograms' prior results, was shared with two control FP (CT1 and CT2) who, based on that information,

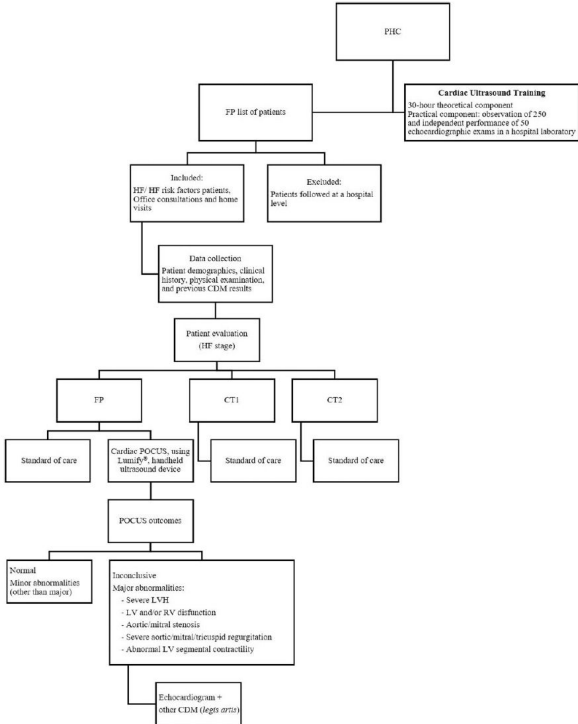


Figure 1. Study design and methodology flowchart. CDM, complementary diagnostic methods; CT1 and CT2, independent control family physicians; FP, family physician, the study investigator; HF, heart failure; LV, left ventricle; LVH, left ventricular hypertrophy; PHC, primary healthcare center; POCUS, point-of-care ultrasound; RV, right ventricle.

independently decided whether to request an echocardiogram or refer the patient to the hospital (routine consultation or emergency department). These physicians had no access to POCUS data.

Statistical analysis

Descriptive and analytical statistical analyses were performed using SPSS software. Categorical variables were summarized as absolute and relative frequencies, while continuous variables were expressed as mean $\pm$ standard deviation (SD) or median with percentiles.

Decisions and outcomes based on POCUS were compared with CT1 and CT2 decisions and with conventional methods.

For each observer and defined outcome, the proportions of overall and partial agreement were calculated, with respective Cohen's Kappa. A significance level of $\alpha = 0.05$ was used in all analyses.

No imputation of missing or incomplete values was performed.

Results

Patient characteristics

The study included a convenience, consecutive sample of 196 patients, 53.6% female, mean age 66 years old (range, 23–95). Patient characteristics are summarized in Table 1. The primary reason for consultation was routine follow-up (92.3%),

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Table 1. Patient characteristics.

	<i>n</i> = 196
Age in years, mean ($\pm$ SD)	66.1 ($\pm$ 14.5)
Female sex, <i>n</i> (%)	105 (53.6)
BMI, kg/m ² , mean ($\pm$ SD)	29.1 ($\pm$ 5.2)
Consultation, <i>n</i> (%)	
Routine/follow-up consultation	181 (92.3)
Acute consultation	15 (7.7)
Signs/symptoms, <i>n</i> (%)	
Symptomatic	71 (36.2)
Ankle swelling	32 (16.3)
Dyspnea	15 (7.7)
Orthopnea	40 (20.4)
Elevated jugular venous pressure	16 (8.2)
Fatigue	62 (31.6)
Heart murmur	37 (18.9)
Orthopnea	15 (7.7)
Pulmonary crepitations	17 (8.7)
Reduced exercise tolerance	68 (34.7)
NYHA class, <i>n</i> (%)	
NYHA I	112 (57.1)
NYHA II	57 (29.1)
NYHA III	23 (11.7)
NYHA IV	2 (1.0)
UNK	2 (1.0)
Comorbidities, <i>n</i> (%)	
Arrhythmia	17 (8.7)
Atrial fibrillation	22 (11.3)
Coronary artery disease	2 (1)
Diabetes	58 (29.7)
Hypertension	174 (89.2)

BMI, body mass index; *n*, number of patients; NYHA, New York Heart Association HF functional classification; SD, standard deviation; UNK, unknown.

with a minority occurring in acute contexts (7.7%). Most evaluations were performed in the medical office (96.4%), while seven patients were assessed during home visits. Among the study population, 63.8% were asymptomatic, 89.2% had arterial hypertension and 29.7% diabetes.

POCUS impact on echocardiography requests and hospital referrals

Among 194 patients, the investigator requested fewer echocardiograms (*n* = 44) compared to the two independent FP who did not use POCUS, CT1 (*n* = 142) and CT2 (*n* = 125; Table 2). The global level of agreement between the investigator and CT1 was low (*k* = 0.109), and no kappa calculation was able to be performed with CT2. The agreement rates between the two control physicians were higher for cases where no echocardiogram was requested (68%) compared to cases where an echocardiogram was requested (43%), although with a *k* = 0.099.

Considering the hospital referral decisions for consultation or emergency services (Table 2), the investigator referred fewer patients (*n* = 15) compared to CT1 (*n* = 16) and CT2 (*n* = 24). Agreement rates for referred cases were lower (38% for CT1 and 13% for CT2) compared to non-referred cases (95% and 93%, for CT1 and CT2, respectively).

Assessing cardiac abnormalities: POCUS vs. Conventional Echocardiography

The efficacy of POCUS was compared with a conventional echocardiogram by evaluating the presence or absence of cardiac abnormalities. The conventional echocardiogram was performed at a median of 27 $\pm$ 31 days after the POCUS. The overall concordance rate was 83%, with partial concordance of 70% for cases without abnormalities and 92% for cases with abnormalities. When findings were stratified into “no abnormalities,” “minor abnormalities,” and “major abnormalities”; the overall concordance was 64%. Partial concordance rates were 30%, 67%, and 82% for “no abnormalities,” “minor abnormalities,” and “major abnormalities,” respectively (Table 3).

Volume status assessment: physical examination alone vs. physical examination with POCUS

Patient volume status was assessed using both physical examination and POCUS. POCUS evaluation included measurement of IVC diameter, considered elevated if >20 mm (Supplementary Table S1). Concordance between physical examination and physical examination with POCUS was higher in cases without congestion (82%) compared with those with congestion (72%).

HF staging: conventional method vs. POCUS

HF stages (A–D) were assessed during the same consultation using clinical history, including prior imaging results, and physical examination, followed by the addition of POCUS data. POCUS significantly influenced the classification of HF stages, particularly in identifying stage B patients (44.9% vs. 19.4% with conventional method). Conversely, the conventional method identified more cases at stage A (43.9% vs. 17.9% with POCUS). Concordance rates between methods varied substantially: 12% for stage A, 87% for stage B, and 97% for stage C (Table 4).

Assessing left ventricular hypertrophy: ECG vs. POCUS

The ability of POCUS and ECG to detect left ventricular hypertrophy (LVH) was also compared (Supplementary Table S2). POCUS identified 58 cases of LVH, whereas ECG indicated 10. The overall agreement between the two methods was 65%, with 50% concordance for cases with LVH and 66% for cases without LVH.

Discussion

Role of cardiac POCUS in family practice

This observational study highlights the transformative potential of cardiac POCUS as a diagnostic tool in family practice consultations. By augmenting traditional clinical evaluation methods, POCUS enhances diagnostic accuracy and decision-making, particularly in detecting subclinical cardiac abnormalities that

Table 2. Proportion of agreement between investigator and control physicians on echocardiography requests and hospital referrals.

Echocardiography requests							
n = 193		Investigator (n)		Proportion of agreement			Kappa
		No	Yes	Global	No request	Request	
CT1	No	46	5	44%	90%	27%	0.109 [0–0.211]
	Yes	103	39	[37%–51%]	[79%–96%]	[21%–35%]	
n = 194		Investigator (n)		Proportion of agreement			Kappa
		No	Yes	Global	No request	Request	
CT2	No	51	18	40%	73%	21%	-
	Yes	99	26	[33%–47%]	[62%–83%]	[15%–29%]	
n = 194		CT2 (n)		Proportion of agreement			Kappa
		No	Yes	Global	No request	Request	
CT1	No	22	29	61%	43%	68%	0.099 [0–0.258]
	Yes	46	97	[54%–68%]	[31%–57%]	[60%–75%]	
Hospital referrals							
n = 194		Investigator (n)		Proportion of agreement			Kappa
		No	Yes	Global	No referral	Referral	
CT1	No	169	9	90%	95%	38%	0.334 [0.049–0.618]
	Yes	10	6	[85%–94%]	[91%–97%]	[19%–61%]	
n = 195		Investigator (n)		Proportion of agreement			Kappa
		No	Yes	Global	No referral	Referral	
CT2	No	159	12	83%	93%	13%	0.065 [0–0.356]
	Yes	21	3	[77%–88%]	[88%–96%]	[4%–31%]	

CT1, Control family physician 1; CT2, Control family physician 2; n, number of patients.

might be missed by physical examination and electrocardiography. These findings align with prior research demonstrating the effectiveness of POCUS, especially when integrated with remote expert support systems [21, 22].

POCUS is especially valuable for identifying clinically significant conditions, such as LVH and early stages of HF, and for distinguishing serious pathologies from minor abnormalities [22, 23]. However, the technical skills required for cardiac ultrasound and the time investment may hinder broader adoption, challenges that advancements in artificial intelligence (AI) could mitigate by improving image acquisition and interpretation efficiency [24].

POCUS integration in primary care has been increasingly studied. However, most of the existing research focuses on undergraduate training programs, its use in emergency settings, or feasibility and accuracy studies with remote supervision or support. To the best of our knowledge, only one study was performed in the outpatient setting, where FP performed cardiac POCUS, although specialists conducted image interpretation remotely [21]. In contrast, our study evaluates the real-life implementation of cardiac POCUS in routine family practice consultations, where the FP acted autonomously as operator, interpreter, and clinical decision-maker without

external support. This reflects the practical reality of primary care in rural settings, such as in Portugal, and highlights the potential for immediate integration of POCUS into everyday clinical workflows to improve patient care.

Impact on resource utilization

POCUS significantly reduces the number of echocardiograms requested and hospital referrals, contributing to improved healthcare efficiency. The investigator requested fewer echocardiograms and made fewer hospital referrals than the control physicians, indicating POCUS's utility in tailoring on-site management. This reduction aligns with studies demonstrating that POCUS minimizes unnecessary advanced imaging and streamlines diagnostic pathways [25–27].

Despite its benefits, variability in referral decisions among control physicians underscores the need for standardized echocardiogram referral guidelines to ensure consistency and reliability across primary care practices.

HF staging and LVH detection

POCUS enhances the classification of HF stages, with a notable increase in stage B HF diagnoses compared to conventional

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Table 3. Proportion of agreement between POCUS and conventional echocardiography in detecting cardiac abnormalities.

<i>n</i> = 72		POCUS (<i>n</i>)		Proportion of agreement			Kappa
		No	Yes	Global	No	Yes	
Conventional Echocardiography	No	3	7	83%	70%	92%	0.200 [0–0.632]
	Yes	5	57	[73%–90]	[40%–89%]	[82%–97%]	

<i>n</i> = 72		POCUS (<i>n</i>)			Proportion of agreement				Kappa
		No	Minor ^a	Major ^b	Global	No	Minor ^a	Major ^b	
Conventional Echocardiography	No	3	7	0	64%	30%	67%	82%	0.302 [0.088–0.517]
	Minor ^a	8	34	9	[52%–74%]	[11%–60%]	[53%–78%]	[52%–95%]	
	Major ^b	0	2	9					

BSA, body surface area; LV, left ventricle; LVH, left ventricular hypertrophy; *n*, number of patients; POCUS, point-of-care ultrasound; RV, right ventricle.
^aAny abnormality other than major.
^bSevere LVH—indexed LV mass/BSA ≥ 122 g/m² (women) and ≥ 149 g/m² (man), LV and/or RV dysfunction (eyeball), aortic/mitral stenosis (B mode and color mode evaluation), severe aortic/mitral/tricuspid regurgitation (B mode and color mode evaluation), abnormal LV segmental contractility.

Table 4. Proportion of agreement in HF staging between POCUS and conventional consultation.

<i>n</i> = 196		With POCUS (<i>n</i>)				Proportion of agreement				Kappa
		A	B	C	D	Global	A	B	C	
Without POCUS	A	30	55	1	0	68%	12%	87%	97%	0.542 [0.449–0.635]
	B	5	33	0	0	[61%–74]	[6%–20%]	[73%–94%]	[90%–97%]	
	C	0	0	70	2					
	D	0	0	0	0					

n, number of patients; POCUS, point-of-care ultrasound.

methods (44.9% vs. 19.4%). This improvement is critical, as early identification of stage B HF allows for timely preventive measures, such as lifestyle modifications and optimized pharmacological treatments, potentially delaying progression to symptomatic stages C and D [23].

Although the increased number of Stage B HF diagnoses with POCUS should be interpreted with caution in the absence of long-term outcome data, it is important to highlight that both Stage A and B HF patients are asymptomatic, with Stage B being characterized by structural or functional cardiac abnormalities that would otherwise remain undetected without imaging. In primary care, Stages A and B are expected to be the most frequent, but differentiating between them is challenging without echocardiography.

Our findings demonstrate that POCUS, as an extension of the physical examination, allows the detection of such abnormalities, leading to reclassification from Stage A to B. While long-term data are needed to assess outcome implications, identifying Stage B HF patients enables earlier targeted interventions and closer monitoring, which may prevent progression to symptomatic stages. This raises an important question regarding whether current follow-up strategies in primary care should be revisited to integrate tools like POCUS for improved risk stratification and disease prevention.

Additionally, POCUS demonstrated superior sensitivity for detecting LVH, identifying 58 cases compared to only 10 detected by ECG. This discrepancy emphasizes ECG's limitations, particularly in elderly patients with comorbidities [28, 29]. LVH detection is crucial for assessing cardiovascular risk and informing interventions, such as antihypertensive therapy adjustments or closer cardiac monitoring [28–30].

Congestion status evaluation

The ability to evaluate congestion status is integral to HF management. POCUS complements physical examination by assessing IVC diameter, allowing differentiation between intravascular and interstitial congestion. This distinction guides targeted therapeutic strategies [20, 31]. However, it is important to acknowledge the limitations of relying solely on IVC assessment. Factors such as chronic dilation, tricuspid regurgitation, or variations due to physical conditioning (e.g. young athletes) can influence IVC measurements, leading to potential misinterpretation [32].

To overcome these challenges, integrating advanced protocols, such as the Venous Excess Ultrasound (VExUS) score and pulmonary B-line analysis, could provide more comprehensive assessments. These tools have been shown to enhance the accuracy of congestion evaluation, offering a more robust framework for therapeutic decision-making [33, 34].

Enhancing clinician–patient engagement

From both the clinician's and patient's perspectives, the integration of POCUS enhances awareness of disease progression. Providing visual evidence of cardiac abnormalities during consultations may encourage greater adherence to preventive strategies and therapeutic regimens. Additionally, educating patients on imaging findings reinforces the importance of treatment adherence, which has been shown to improve clinical outcomes [30].

The ability to visually demonstrate abnormalities during consultations fosters patient trust and engagement, enabling a more collaborative approach to managing chronic conditions.

This aspect of POCUS can help improving outcomes by applying guideline medical directed therapy and also contribute to a more patient-centered healthcare model. Future longitudinal studies are needed to confirm any direct benefits on patient outcomes.

Challenges and future directions

Despite its considerable potential, this study has several limitations. The patient cohort, while representative of a typical FP list, is relatively small and may not reflect the diversity of the entire Portuguese population. Nevertheless, the predominantly elderly demographic provides valuable insights into a population segment where the diagnosis of subclinical disease is becoming increasingly important across Europe [3, 15]. This focus on older patients aligns with the demographic shift in many European countries, where an aging population emphasizes the need for improved detection and management of chronic conditions [3, 4].

Another challenge is the variability in ultrasonographic proficiency among FP. While the investigator demonstrated expertise in POCUS, these skills may not be generalizable to all practitioners, underscoring the need for standardized training programs and continuous professional development [18, 21]. However, evidence suggests that structured training programs, even of short duration, can significantly improve diagnostic performance. Kobal *et al.* [35] showed that first-year medical students, after only 18 hours of echocardiography training, were able to identify 75% of cardiac pathologies with handheld ultrasound, outperforming board-certified cardiologists relying on physical examination alone.

Additionally, the POCUS single-operator model might have introduced interpretation and selection bias. The investigator had all the relevant clinical information about the patients as their FP but also a significant level of confidence on POCUS data as it sole operator.

Factors such as geographic location (urban versus rural), availability of diagnostic resources, and variations in clinician skills must also be considered to determine the generalizability and scalability of these results. Future research should focus on validating these findings across diverse populations and healthcare settings, particularly in resource-limited environments. Additionally, incorporating AI into POCUS workflows could enhance efficiency and accuracy, further expanding its utility in routine care. Longitudinal studies evaluating the cost-effectiveness and long-term outcomes of POCUS integration are also warranted [24, 33].

Conclusions

Cardiac POCUS represents a significant advancement in family practice, offering enhanced diagnostic accuracy and facilitating more informed clinical decision-making. It improves the detection of cardiac abnormalities, including LVH and subclinical HF stages, and contributes to early, targeted interventions that can delay disease progression and improve patient outcomes.

The integration of POCUS into routine consultations reduces unnecessary echocardiogram requests and hospital referrals, optimizing healthcare resource utilization. Furthermore, its ability to provide visual diagnostic insights during consultations fosters patient engagement and adherence to care plans, leading to better health outcomes.

However, the study's limitations, including the small, localized sample size and variability in operator expertise, highlight the need for broader validation. Standardized training and advanced diagnostic protocols are essential to ensure consistent application. Future efforts should also explore the integration of AI technologies to address existing challenges and maximize the utility of POCUS in primary care.

POCUS has the potential to revolutionize primary care by offering a comprehensive, immediate, and patient-centered approach to cardiovascular assessment. Its widespread adoption, supported by research and innovation, will pave the way for more effective and efficient management of cardiovascular conditions in family practice.

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Supplementary data

Supplementary data is available at *Family Practice* online.

Conflict of interest

Jonathan dos Santos received an investigation grant from Philips that supported the pocket ultrasound device used in this study. José Ribeiro and Francisco Rocha Gonçalves have no conflict of interest to declare. Alexandra Gonçalves is a former Philips employee and current Philips stockholder.

Funding

The pocket ultrasound device used in this study was supported by an investigation grant from Philips.

Ethical approval

The study was approved by the ethics committee of the employing institution (ARS Norte) under reference number 50/2018. Written informed consent was obtained from all patients prior to data collection.

Data availability

Anonymized data are available by request from the corresponding author on reasonable request.

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5

Moving the needle towards the democratization of echocardiography

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CASE REPORT

Cardiac imaging

Moving the needle towards the democratization of echocardiography: a case report

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Background

Echocardiography has been traditionally performed in echo labs and the potential benefits of its use by primary care physicians (PCPs) are still unexplored. We present a case where POCUS (point-of-care ultrasound) was used as a complement of physical examination by a family doctor, allowing a prompt clinical decision in a heart failure (HF) patient.

Case summary

An 85-year-old woman, living independently, asks her family doctor for a home consultation due to increasing dyspnoea. On examination, severe dyspnoea and bilateral ankle oedema was noted and a point-of-care echocardiogram was performed by the primary care physician, who observed: severely compromised left ventricular systolic function, moderate mitral and tricuspid regurgitation, and severe dilation of the inferior vena cava. As a result, the diagnosis of HF with decreased ejection fraction was formed supporting the therapeutic decision.

Discussion

This case represents an elderly patient with dyspnoea, without previous HF diagnosis. The primary care physician, used portable ultrasound as a complement of physical examination, which confirmed a HF diagnosis, allowing a prompt decision-making on therapy. POCUS, can be a powerful tool to expedite treatment in different settings, including the home consultations by PCPs.

Keywords

Point-of-care ultrasound • Pocket ultrasound • Heart failure • Primary care physician • Case report

Learning points

- Point-of-care ultrasound, when used by primary care physicians with training, allows detection of important functional and structural cardiac abnormalities.
- A pocket ultrasound can be used as a physical examination complement, supporting the differential diagnosis of dyspnoea and efficient decision-making process.

Introduction

Echocardiography has been traditionally performed in echo labs, but in the latest years, it has been expanded to other environments, such as hospital urgent care. The advantages of the use of echocardiography by primary care physicians (PCPs) is unexplored, although PCPs are in the front line evaluation of most of the patients.¹

We present a case report of a patient with heart failure (HF) where echocardiography was instrumental for comprehensive

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patient evaluation and clinical decision, illustrating a significant improvement in the efficiency of primary healthcare.

Timeline

4 years prior to presentation	No prior history of heart failure at presentation
At presentation	85-year-old woman requests family doctor home consultation due to progressive dyspnoea Dyspnoea [New York Heart Association (NYHA) Class III–IV], orthopnoea, pulmonary rales, and bilateral ankle oedema Point-of-care ultrasound with pocket echo by family doctor: severely compromised left ventricular systolic function, severe dilation of the inferior vena cava Treatment: spironolactone 25 mg daily; increased furosemide 40 mg 3 times daily
1 month later	Dyspnoea (NYHA Class II–III) Conventional echocardiography: reduced ejection fraction (30%) Replaces ramipril to sacubitril/valsartan Heart failure symptoms relief
2 months later	Titrate sacubitril/valsartan dose

Case presentation

We present a case of an 85-year-old woman with medical history of arterial hypertension, obesity, and atrial fibrillation, living

independently in her own house. Her regular medication included ramipril 10 mg od acenocoumarol, bisoprolol 5 mg od, pantoprazole 20 mg od and furosemide 40 mg od. We speculate patient had been advised by a different healthcare provider on this high diuretic dose due to swollen legs or other signs of congestion.

The patient requests her family doctor for a home consultation by aggravated dyspnoea. She was found with fatigue, tiredness, orthopnoea and dyspnoeic at rest. Physical examination revealed a blood pressure of 100/60 mmHg, heart rate of 98 b.p.m., elevated jugular venous pressure, third heart sound, pulmonary rales in the lower third of both lungs, and bilateral ankle oedema. Her medical records showed a glomerular filtration rate of 55 mL/min and an echocardiogram performed 4 years prior showed normal biventricular function without signs of pulmonary artery hypertension and mild mitral regurgitation. In regard to the severity of the symptoms, the patient was suggested to pursue further evaluation and treatment at the local hospital, but she refused to leave her house. On-site, the PCP with echocardiography training (certified online course and a practical training in an echocardiography lab for 6 months) performed a point-of-care ultrasound (POCUS) Lumify[®]. The study showed: severely compromised left ventricular (LV) systolic function (Figure 1, Supplementary material online, Video S4), moderate mitral (Figure 2), and tricuspid regurgitation (Figure 3), severe dilation of the inferior vena cava (Figure 4), severely dilated left atrium (52 mm in long-axis view), dilated right atrium (minor axis of 49 mm in four-chamber view), normal LV size (47 mm in diastole parasternal long-axis view), normal right ventricular (RV) size (basal and mid diameter of 39 and 29 mm), and normal RV function (tricuspid annular plane systolic excursion of 19 mm). Ultrasound B-lines were not assessed at this time. The study was shared live using a real-time programme (REACTS) with a cardiologist who confirms the findings. As a result, the diagnosis of HF with decreased ejection fraction (EF) was performed supporting the therapeutic decision: furosemide 40 mg was increased to three times daily and spironolactone 25 mg was introduced once

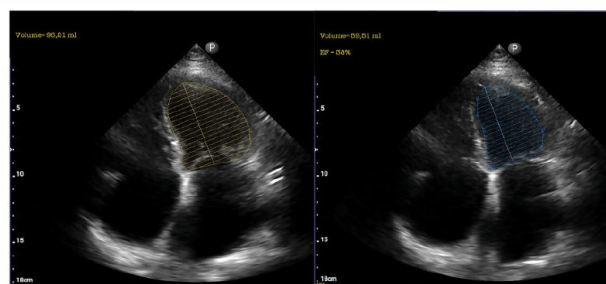


Figure 1 A four-chamber view with end-diastolic and systolic volumes. Reduced ejection fraction of 38% (Supplementary material online, Video S4).

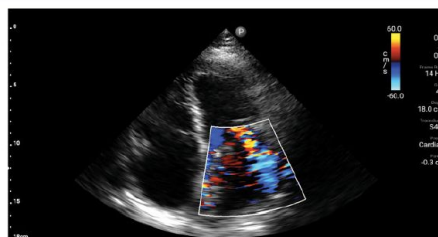


Figure 2 A four-chamber view with moderate mitral regurgitation.

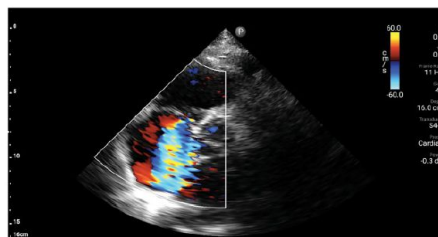


Figure 3 Parasternal short-axis view with moderate tricuspid regurgitation.

daily. The patient had weekly visits from the community nurse and one month later, a conventional echocardiogram confirmed the POCUS findings, quantifying left ventricular ejection fraction in 30% and pulmonary artery pressure in 44mmHg. At this time, ramipril was replaced by sacubitril/valsartan 24mg/26mg tid. The patient refused additional studies or hospital referral, which limited our ability to study the cause of HF. At two months, follow-up the patient was tolerating treatment and presented in Class II of New York Heart Association and the sacubitril/valsartan was titrated accordingly.

Discussion

Heart failure prevalence has been increasing in the last decades, alongside with population aging, especially in developed countries.¹ However, the diagnosis of HF, as a clinical syndrome can be challenging,

particularly in elderly patients, being the information provided by ultrasound fundamental for diagnosis and therapeutic management.²

This case represents an 85-year-old female patient with dyspnoea, without previous HF diagnosis, refusing to leave her home, to whom the PCP successfully used portable ultrasound as a physical examination complement. The comprehensive evaluation allowed a confident diagnosis of HF at patient's home and a timely and targeted therapy avoiding hospital admission, showing that the use of ultrasound by a trained primary care physician increases the efficiency of medical care for the diagnosis and treatment of HF. The available studies are very limited and no cost-effectiveness studies have been done to prove the use POCUS as a toll by PCPs; however, this technique has been proven to be a useful, reliable and fast tool in emergency department and as a bedside physical examination complement.³⁻⁶

In addition to HF recognition, HF should be monitored and medication optimized periodically. PCPs can play a critical role in this regard, in close collaboration with cardiologists, evaluating elderly

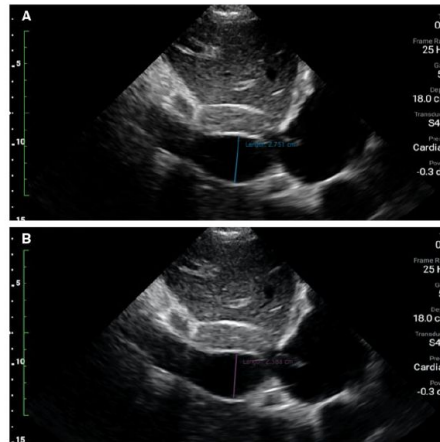


Figure 4 In subcostal view, enlarged inferior vena cava at expiration (A) and inspiration (B) shows respiratory variation >50%.

patients who require home visits. In fact, a randomized clinical trial in patients with HF with optimal medical therapy showed no differences in death and hospital admissions between patients followed by cardiologists with those followed by referral PCP.⁷

Conclusions

In summary, the crescent ageing population presents new demands to the healthcare system and chronic diseases such as HF are more commonly being diagnosed and treated by PCPs, who by using portable ultrasounds, as 'fifth pillar to bedside physical examination' will significantly improve patient care.²

Lead author biography



Jonathan dos Santos was born in Paris in 1987 and grew up in Amarante (Portugal). He's a family physician who believes that primary health care are on the mainstay of any healthcare system. He's a point-of-care ultrasound (POCUS) user so that physical examination has for him an extra

value. In 2012, Jonathan has completed the master of medicine at Coimbra Medical School (FMUC). He has been enrolled in 2016 in the PhD program of medicine at the Porto Medical School (FMUP); In 2018 he has completed the family and general medicine fellowship at 'USF Terras de Souza' in 'ACES Vale de Sousa Sul'; from February 2019 he's a clinician at "UCSP Celorico de Basto" in "ACeS Baixo Tâmega".

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as [Supplementary data](#).

Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: Pocket ultrasound of this study is an investigation grant support from Philips; Alexandra Goncalves, MD, PhD, MMSc is a Philips employee.

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PRIMARY-HF: heart failure screening in primary care using point-of-care

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PRIMARY-HF: Heart Failure Screening in Primary Care using Point-of-Care

PRIMARY-HF: Diagnóstico de Insuficiência Cardíaca em Cuidados de Saúde Primários com *Point-of-Care*

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ABSTRACT

Introduction: Heart failure is a major health challenge with high morbidity and socioeconomic burden, especially when diagnosis is delayed. In primary care, HF detection can be challenging due to symptoms overlapping with other conditions, limited access to diagnostic tools, and resource constraints. This study explores the use of natriuretic peptides (NT-proBNP) and point-of-care ultrasound (POCUS) with artificial intelligence integration as tools to improve HF screening and management in primary care. This study aims to determine whether NT-proBNP testing alone or combined with cardiac POCUS improves heart failure diagnosis and management in primary care settings, and to evaluate the cost-effectiveness of this approach.

Methods: This randomized controlled trial will involve patients aged 50 or older with suspected HF or cardiovascular risk factors, recruited across four primary care centers. Participants will be randomly assigned to one of four groups: standard of care (SoC), SoC with NT-proBNP, SoC with NT-proBNP and POCUS, and SoC with POCUS. Primary outcomes include new HF diagnosis, initiation of guideline-directed medical therapy, and improvement in health-related quality of life. Secondary outcomes include cost-effectiveness and the quality assessment of POCUS performed by trained primary care physicians. The integration of NT-proBNP and POCUS in primary care may enhance early heart failure diagnosis, optimize therapy, improve patient quality of life, and reduce healthcare costs associated with heart failure misdiagnosis and delayed treatment. This study could support the broader adoption of accessible diagnostic tools to improve heart failure management in primary care.

Keywords: Biomarkers; Echocardiography; Heart Failure/diagnosis; Heart Failure/diagnostic imaging; Natriuretic Peptide; Point-of-Care Systems; Primary Health Care

RESUMO

Introdução: A insuficiência cardíaca apresenta uma elevada morbilidade e um importante impacto socioeconómico, especialmente quando o diagnóstico é tardio. Nos cuidados de saúde primários (CSP), a deteção de insuficiência cardíaca é mais desafiante devido à sobreposição de sintomas com outras condições clínicas, ao acesso limitado a ferramentas de diagnóstico e às restrições de recursos. Este estudo explora o uso de péptidos natriuréticos (NT-proBNP) e ecografia *point-of-care* (POCUS) com integração de inteligência artificial (IA) como ferramentas para melhorar a seleção e gestão da insuficiência cardíaca nos CSP. O objetivo deste estudo é avaliar se a realização de testes de NT-proBNP combinados ou não com ecografia cardíaca POCUS melhoram o diagnóstico e a gestão da insuficiência cardíaca nos CSP, bem como avaliar a relação custo-eficácia desta abordagem.

Métodos: Este ensaio clínico controlado e randomizado incluirá pacientes com idade igual ou superior a 50 anos com suspeita de insuficiência cardíaca ou fatores de risco cardiovascular, recrutados em quatro centros de CSP. Os participantes serão aleatoriamente alocados a um de quatro grupos: *standard of care* (SoC), SoC com NT-proBNP, SoC com NT-proBNP e POCUS e SoC com POCUS. Os *outcomes* primários incluem novos diagnósticos de insuficiência cardíaca, início de terapêutica médica orientada por *guidelines* e melhoria na qualidade de vida relacionada com a saúde. Os *outcomes* secundários incluem a relação custo-eficácia e a avaliação da qualidade do POCUS realizado por médicos de CSP treinados. A integração do NT-proBNP e do POCUS em CSP poderá melhorar o diagnóstico precoce de insuficiência cardíaca, otimizar a terapêutica, melhorar a qualidade de vida dos pacientes e reduzir os custos de saúde associados ao diagnóstico incorreto e ao tratamento tardio da insuficiência cardíaca. Este estudo poderá vir a apoiar a adoção mais ampla de ferramentas de diagnóstico acessíveis para melhorar a gestão da insuficiência cardíaca nos CSP.

Palavras-chave: Biomarcadores; Cuidados Primários de Saúde; Ecocardiografia; Insuficiência Cardíaca/diagnóstico; Insuficiência Cardíaca/diagnóstico por imagem; Peptídeo Natriurético; Sistemas Automatizados de Assistência Junto ao Leito

INTRODUCTION

Background and rationale

Heart failure (HF) is a condition that poses a substantial clinical and socioeconomic burden. In Portugal, it is estimated that 16% of the population aged 50 or older suffers from

heart failure, but only 10% of them are aware of their condition.

These are preliminary findings from the Portuguese Heart Failure Prevalence Observational Study (PORTHOS), the largest and most recent epidemiological study on heart

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failure in Portugal.¹ In primary care, early identification of HF is challenging due to the overlap of symptoms with other conditions such as obesity, pulmonary disease, and general fatigue, which can obscure the clinical presentation. While recent policy changes have improved access to natriuretic peptide testing (NT-proBNP) in primary care, the use of advanced diagnostic tools, such as point-of-care ultrasound (POCUS), remains limited. Although echocardiography is accessible through conventional referral pathways, POCUS, as an immediate and practical tool for enhancing diagnostic precision in primary care, is not routinely available.^{2,3}

Point-of-care ultrasound is already considered an extension of the physical examination presently carried out by family physicians in several countries, such as Norway, Canada, Germany, and Spain, where there is evidence of the utility of POCUS performed by family physicians for detecting cardiac abnormalities, such as left ventricular hypertrophy and structural anomalies.⁴⁻⁶ These tools provide complementary information: NT-proBNP aids in the biochemical identification of heart failure, while POCUS offers real-time visualization of cardiac function and structure, helping in the confirmation or exclusion of heart failure, as well as in the identification of cardiac abnormalities that may require a prompt referral (e.g., severe valvulopathy, marked hypertrophy, segmental alterations, indirect signs of pulmonary hypertension or reduced left ventricular ejection fraction).

The primary objective of this study is to assess whether the integration of NT-proBNP testing and POCUS in primary care improves the diagnosis of HF, while improving HF guideline-directed medical treatment (GDMT), and patient's health status.

Trial design

This is a randomized controlled interventional trial, with four arms and an open-label design. The allocation ratio is 1:1:1:1, comparing different combinations of NT-proBNP testing and POCUS in heart failure diagnosis.

METHODS

Study setting

The study will be conducted across several primary care units in Portugal.

Training program for investigators in echocardiography

The training program will consist of theoretical and practical components, along with assessments to ensure proficiency:

1. Theoretical training:
 - Pre-test: Investigators will take a brief pre-test to assess their baseline knowledge of cardiac

anatomy and echocardiographic principles.

- Self-study: Investigators will complete four hours of self-study at home, focusing on cardiac anatomy, fundamental ultrasound concepts, and basic echocardiographic windows.
 - In-person learning: Following self-study, investigators will participate in four hours of in-person theoretical training led by two experienced family medicine physicians to reinforce the acquired knowledge and address any knowledge gaps identified in the pre-test.
2. Practical training:
 - Investigators will observe five POCUS echocardiographic tests performed by two trained family physicians (each with four months of practical training at a certified echocardiography laboratory, where they observed 200 echocardiograms and independently performed 50 complete echocardiograms, followed by the execution of over 400 cardiac POCUS during clinical practice).
 - Supervised tests: Investigators will perform five tests under supervision, with feedback sessions after each to identify and address areas for improvement.
 - Independent tests: Investigators will then conduct 10 tests independently. The images obtained will be reviewed by an expert cardiologist (European Association of Cardiovascular Imaging - EACVI accredited) to assess quality and accuracy.
 - Mentorship: Investigators will be assigned mentors (the family medicine physicians) who will provide continuous support during their independent phase.
 3. Final assessment:
 - A theoretical examination will be conducted to assess knowledge retention and understanding.
 - Upon validation of both theoretical and practical skills, investigators will be certified as proficient in cardiac POCUS.

Eligibility criteria

- Inclusion criteria: Patients aged 50 years or older with suspected heart failure (based on signs and symptoms) or known cardiovascular risk factors (at least two of: diabetes *mellitus*, arterial hypertension, eGFR CKD-EPI < 60 mL/min, albuminuria, coronary artery disease or history of myocardial infarction or coronary revascularization, stroke or transient ischemic attack, atrial fibrillation or flutter, left ventricular hypertrophy (LVH) or Q waves on ECG, obesity with a BMI of 30 or greater).⁷
- Exclusion criteria: Patients with known heart failure

already under hospital management, terminal disease, severe comorbidities with life expectancy of less than one year, or inability to provide informed consent.

Interventions

The study involves four groups (Fig. 1):

- Group 1: Standard care (no NT-proBNP, no POCUS).
- Group 2: Standard care and NT-proBNP.
- Group 3: Standard care and NT-proBNP and POCUS.
- Group 4: Standard care and POCUS.

Initial assessment

Supervising physicians will carry out the initial assessment. Patients with suspected HF will be re-evaluated by investigators.

NT-proBNP Testing:

- If NT-proBNP < 100 pg/mL: HF is excluded.
- If NT-proBNP ≥ 100 pg/mL:
 - Physicians without POCUS: Request a conventional echocardiogram.
 - Physicians with POCUS: Perform POCUS and follow these criteria:
 - LVEF* < 50% or LVEF ≥ 50% with structural abnormalities (e.g., LVH** or LA enlargement***): Confirms HF.
 - Absence of these criteria: HF is excluded.
 - If uncertain, an echocardiogram is requested.

* LVEF obtained with the ultrasound AI generation;

** LV mass index ≥ 95 g/m² (female), ≥ 115 g/m² (male), or relative wall thickness > 0.42;

*** LA volume index > 34 mL/m² (sinus rhythm) or > 40 mL/m² (atrial fibrillation).

Monitoring adherence

Enrolled patients will be contacted at baseline, three, six, nine and 12 months (study close-out) for the application of the Kansas City Cardiomyopathy Questionnaire (KCCQ12)¹⁵ and the *Medidas de Adesão ao Tratamento* (MAT) scale¹⁶ to monitor their health status, quality of life, and treatment adherence. Physicians involved in the study will ensure adherence to the diagnostic and follow-up protocols. If a patient begins hospital follow-up for heart failure or requests to leave the study of their own free will, they will be excluded from the study.

Outcomes

- Primary outcomes:
 - New heart failure diagnosis.

- Initiation of GDMT.
- Improvement in health-related quality of life (measured by KCCQ12).
- Secondary outcomes:
 - Cost-effectiveness of NT-proBNP and POCUS in primary care.
 - Assessment of the quality of cardiac POCUS performed by trained family physicians.

Participant timeline

Explanation (Table 1):

- Enrolment phase (-t1):
 - Eligibility screening and informed consent will be conducted before the allocation.
- Allocation (timepoint 0):
 - Participants are randomly assigned to one of the four groups.
- Post-allocation assessments (t1 - t4):
 - At each timepoint (every three months), the KCCQ12 and MAT scale will be applied to monitor quality of life and adherence to treatment.
 - Outcome variables related to heart failure diagnosis, hospitalization, and other clinical outcomes will also be assessed at these intervals.

Sample size

The primary pragmatic comparison will be between Group 4 (Standard of Care + POCUS alone) and Group 1 (Standard of Care). Based on the following assumptions:

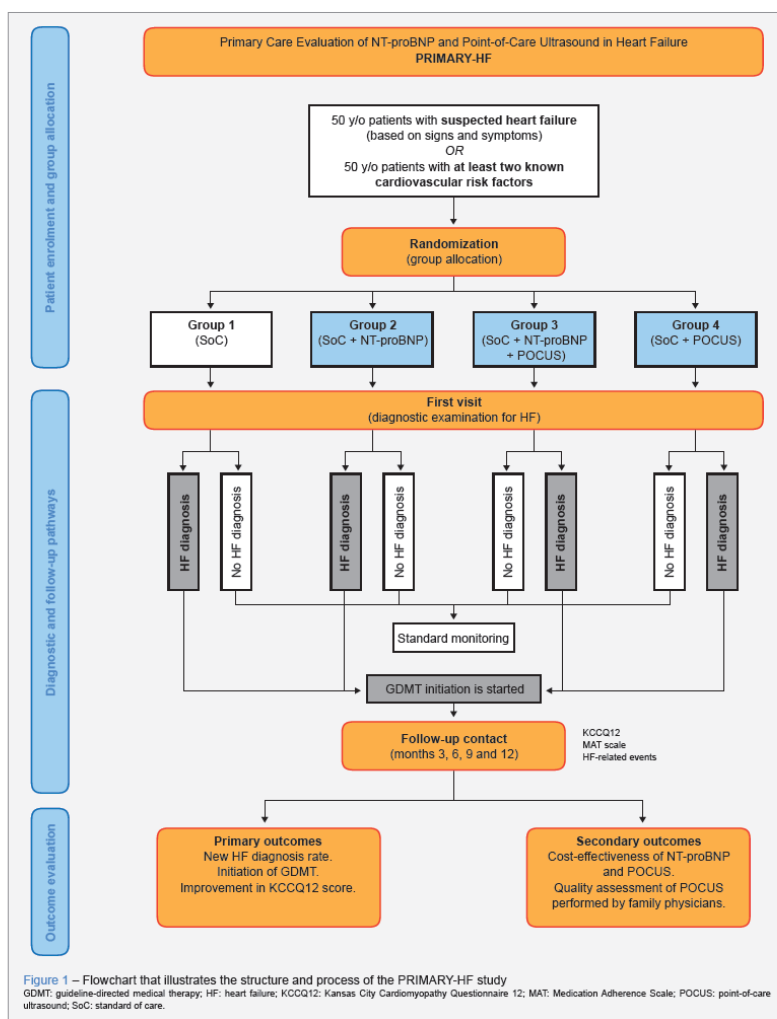
- An expected new HF diagnosis rate of 30% in Group 1 (Standard Care).
- An expected increase to 60% in new HF diagnosis with the addition of POCUS in Group 4.

To detect a doubling in the HF diagnosis rate with 80% power and an alpha level of 0.05, a minimum of 40 patients per group (160 total) is required. Randomization will be conducted in a 1:1:1:1 ratio, ensuring an even distribution of approximately 40 patients per group. The follow-up period will be 12 months, allowing clinicians sufficient time to optimize HF therapies or refer patients for hospital appointments if needed.

Comparisons between Group 4 and Groups 2 (Standard Care + NT-proBNP) and 3 (Standard Care + NT-proBNP + POCUS) will be exploratory, with the aim of determining non-inferiority. Since the proportions of GDMT initiation, specialty referral, and KCCQ-12 changes are dependent on new HF diagnoses, the power calculation is based exclusively on new HF diagnosis rates.

Recruitment

Recruitment will be carried out across multiple primary care units in Portugal. The strategy includes:



1. Target population and enrolment:
- Patients aged 50 or older with clinical suspicion of heart failure or known cardiovascular risk factors will be identified and recruited during routine visits by family physicians working at the participating primary care units.
2. Awareness campaigns:
- Educational sessions will be organized at participating clinics to inform potential participants about the study's benefits and the role of NT-proBNP and POCUS in diagnosing heart failure.
3. Sustained recruitment efforts:
- Recruitment is planned for a period of three months to ensure that the target sample size of 160 participants is achieved.
4. Retention measures:
- Participants will be contacted regularly every three months for follow-up assessments (KCCQ12 and MAT scale). Flexible scheduling and reminder systems will be implemented to maximize retention and minimize dropout rates.

Methods: assignment of interventions

Sequence generation: The randomization sequence will be generated using a computer-based random number generator. The allocation ratio will be set to 1:1:1:1, ensuring an equal distribution of approximately 40 participants per group.

Allocation concealment mechanism: To maintain allocation concealment, sequentially numbered opaque sealed envelopes will be used. Each envelope will contain the assigned intervention group and will be opened only after the participant has provided informed consent and met all eligibility criteria.

Implementation: The randomization sequence will be generated centrally by the coordinating team at the Faculty of Medicine, University of Porto. Family physicians at each participating primary care site will be responsible for enrolling participants. Once eligibility is confirmed and informed consent is obtained, the assigned intervention group will be revealed by the site physician using the sealed envelope corresponding to the patient's sequence number.

Blinding: This is an open-label study, and neither the participants nor the physicians will be blinded to the intervention groups. Since the interventions (use of NT-proBNP testing and/or POCUS) are not amenable to blinding, all parties involved will be aware of the group assignments. No unblinding procedures are required.

Methods: data collection, management, and analysis

Data collection methods: data will be collected at baseline and during each follow-up visit (every three months for up to 12 months) using standardized electronic forms. The following measures will be taken to ensure data quality and consistency across all sites:

Table 1 – Timeline for the PRIMARY-HF study, detailing the enrollment, allocation, and follow-up assessments over a 12-month period. It includes eligibility screening, informed consent, intervention allocation, and evaluations such as KCCQ12 and MAT scale to monitor patient quality of life and adherence.

TIMEPOINT	STUDY PERIOD					
	Enrolment	Allocation	Post-allocation			Close-out
	-t1	t0	t1 (3 months)	t2 (6 months)	t3 (9 months)	t4 (12 months)
Enrolment						
Eligibility screen	X					
Informed consent	X					
Allocation		X				
INTERVENTIONS						
Group 1 (SoC)		X				
Group 2 (SoC + NT-proBNP)		X				
Group 3 (SoC + NT-proBNP + POCUS)		X				
Group 4 (SoC + POCUS)		X				
ASSESSMENTS						
Baseline variables		X				
KCCQ12 and MAT Scale			X	X	X	X
Outcome variables			X	X	X	X

GDMT: guideline-directed medical therapy; HF: heart failure; KCCQ12: Kansas City Cardiomyopathy Questionnaire 12; MAT: Medication Adherence Scale; POCUS: point-of-care ultrasound; SoC: standard of care

- Baseline assessment: Includes demographic and clinical variables such as age, medical history, NT-proBNP levels, and baseline KCCQ12 and MAT scores.
- Follow-up assessments: Conducted every three months using the KCCQ12 to monitor health-related quality of life and the MAT scale to evaluate treatment adherence.
- Additional variables: Any new heart failure diagnoses, changes in therapy, or hospitalizations will be recorded during follow-up.

To maintain data quality, physicians and study staff will receive training on data collection procedures. Regular monitoring visits by the coordinating team will verify the accuracy and completeness of collected data. Participants who discontinue the study will have their data analyzed up to the last follow-up point.

Economic impact assessment

Metrics

- Direct costs: Assess the reduction in the number of traditional echocardiograms performed.
- Indirect costs:
 - Patient time savings: Calculate the average time saved per patient by avoiding traditional echocardiograms and extrapolate this to the total number of patients in the study.
 - Opportunity costs: Assess opportunity costs related to lost work or daily activities due to additional tests and consultations, calculating the average cost per patient.

Data management: Data will be securely entered into a password-protected electronic database designed for clinical research. Key data management procedures include:

- Double data entry: To minimize errors, all data entries will undergo a double-entry process.
- Range checks and validations: Automatic range checks and data validation algorithms will ensure data consistency and accuracy.
- Data anonymization: all participant data will be anonymized before analysis, with unique identifiers stored separately in an encrypted file accessible only to authorized personnel.

Data will be stored on a secure server, with regular backups and restricted access. The study will comply with GDPR and local data protection regulations.

Statistical methods

Primary and secondary outcomes will be analyzed using the win ratio method as follows:

- Win ratio command: The hierarchical primary outcome will be tested using the 'winratio' package

in Stata® with the command `winratio id group, outcomes (newhf c > hftrt c > qol c >)`.

- `id`: Unique patient identifier.
- `group`: Dummy variable where '0' represents Group 1 (Standard Care) and '1' represents Group 4 (Standard Care + POCUS).
- `outcomes`:
 - `newhf`: Categorical variable for new heart failure diagnosis, testing the hypothesis of a higher proportion of new diagnoses in Group 4 versus Group 1 at 12 weeks.
 - `hftrt`: Categorical variable assessing GDMT initiation or specialty referral at 12 weeks.
 - `qol`: Continuous variable representing the change in health status using KCCQ-12 scores from baseline to 12 weeks.

Subgroup analyses and additional tests

- Exploratory analyses will compare Groups 2 and 3 to Group 4 for non-inferiority, focusing on the effects of NT-proBNP and POCUS combined.
- Subgroup analyses will explore differential effects based on age, sex, and comorbidities.

Handling of missing data

- Missing data will be addressed using multiple imputation techniques to minimize bias. Sensitivity analyses will be conducted to compare outcomes with and without imputed data, ensuring robustness.

Methods: monitoring

Data monitoring: A formal data monitoring committee (DMC) is not required due to the low-risk nature of the study. The coordinating team at the Faculty of Medicine, University of Porto, in collaboration with the ethics committees, will oversee the study and conduct internal reviews.

Harms: All adverse events related to NT-proBNP testing and POCUS will be recorded during follow-up visits. Physicians will report any unintended effects to the coordinating team within 24 hours. The coordinating team will evaluate these events and decide on further action in consultation with ethics committees if necessary.

Auditing: No external audits are planned. However, the coordinating team will perform periodic internal audits to ensure compliance with the protocol and verify data accuracy.

Ethics and dissemination

Research ethics approval: The study protocol will be reviewed by the ethics committees of the health institutions where the intervention and data collection will take place and the ethics committee of the Faculty of Medicine, University of Porto. All procedures will comply with the Declaration

of Helsinki

Consent or assent: Informed consent will be obtained from all participants before any study procedures begin.

Confidentiality: Participant data will be anonymized and stored in a secure, password-protected database.

Access to data: Access to the final dataset will be limited to the principal investigator and authorized personnel

Ancillary and post-trial care: There are no specific provisions for ancillary or post-trial care.

Informed consent materials: A detailed informed consent form will be developed and provided to participants, outlining the study's purpose, procedures, risks, and benefits. The form will be available in Portuguese and reviewed by ethics committees for approval.

Biological specimens: If the study involves the collection of biological specimens (e.g., blood for NT-proBNP testing), procedures for collection, storage, and analysis will be established.

The aim of this clinical trial is to identify the most effective strategy for diagnosing HF and the most efficient approach to managing this condition. Recently published data from the PORTHOS study¹ found that 90% of patients with HF were unaware they had the disease, highlighting a significant gap in early diagnosis in Portugal.

The introduction of NT-proBNP and POCUS as diagnostic tools in primary care offers a practical and accessible solution, enabling more accurate screening and the early initiation of treatments. This study will not only test the clinical efficacy of these interventions but also their economic feasibility.

Additionally, the development of POCUS skills among family physicians represents an investment in continuous

training, supporting faster diagnosis not only of HF but also of other conditions in the future.

In summary, this clinical trial has the potential to redefine the approach to HF diagnosis and management in Portugal. The results may serve as a foundation for adopting a more integrated, cost-effective, and patient-centered approach, which could be replicated in other primary healthcare settings.

Unique Protocol Identification Number: PRIMARY-HF2024-NTBNP01. Trial Registration: To be submitted at [ClinicalTrials.gov](https://clinicaltrials.gov). Version 1.0 dated October 15, 2024.

JS, JPN, JPF, NC: Study conception and design, critical review of the manuscript

MIMM, MC, TV, AG: Critical review of the manuscript

All authors approved the final version to be published.

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All other authors have declared that no competing interests exist.

Roche provided NT-proBNP test kits. There was no direct financial support.

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PART III

Synthesis

Discussion, conclusion & references

7

Discussion

The best care is the one that happens while the patient is still in the consultation room. This principle guided the journey of this doctoral work and underpins its central message: that timely and patient-centred diagnosis of heart failure in primary care is both feasible and necessary when novel tools such as point-of-care ultrasound (POCUS) are integrated into routine consultations. Beyond the technical aspects of imaging, the studies included in this thesis highlight a broader reflection — innovation in primary care is not only about improving diagnostic accuracy, but about improving the patient journey, reducing delays, and restoring confidence in family medicine as the cornerstone of cardiovascular care.

The main findings of this work can be summarised as follows: (i) cardiac POCUS performed by trained family physicians reclassified a substantial proportion of patients into earlier stages of heart failure and detected left ventricular hypertrophy more frequently than electrocardiography, while reducing unnecessary echocardiography requests and hospital referrals (13); (ii) a case report illustrated that POCUS at the point of care can enable immediate diagnosis and on-site management during a home visit, in a clinical context where conventional pathways would have delayed the diagnosis (14); and (iii) these findings informed the design of the PRIMARY-HF trial, a multicentre, randomised study testing the combination of NT-proBNP and POCUS for heart failure screening in primary care, currently enrolling participants (15).

These findings are consistent with the framing of cardiac POCUS as the “fifth pillar” of physical examination (8) and with the broader literature describing its diagnostic value in primary care (9,11).

Obstacles to implementation

While the vision of bringing POCUS into family medicine consultations is compelling, the journey is challenging. Resistance arises from multiple fronts, and understanding these barriers is key to designing meaningful change.

There are valid concerns about the training and consistent practice required and the format to bring this practice to a medical

speciality area where it isn't consistently embedded. However, we have shown that this is feasible and with the broader implementation of artificial intelligence in image acquisition and interpretation it is expected that this hurdle will become meaningless over time.

Concerns regarding consultation time and scope of practice within family medicine are legitimate and warrant pragmatic responses. The PLAN-HF data suggest that the additional time required for POCUS during the consultation is partially offset by reductions in subsequent referrals and complementary investigations, although this trade-off requires confirmation in prospective designs such as PRIMARY-HF. Structured training programmes, accreditation pathways and clearly defined scopes of practice — as proposed by the national POCUS working group of APMGF — are essential to translate the observed benefits into routine care.

Financial barriers are also significant, as without proper integration there is a lack of budget allocation for the devices, which in some cases might be purchased by physicians themselves, who struggle to see a direct return on investment. In countries such as Norway, however, reimbursement systems already allow family physicians to bill for POCUS examinations: a register-based study covering 2009, 2012 and 2016 documented a six-fold increase in scans over this period, with approximately one third of Norwegian

family physicians submitting POCUS claims in 2016 (16). These examples demonstrate that sustainable models exist and can be adapted to other contexts, ensuring that innovation is not stifled by financial disincentives.

By contrast, patients frequently receive POCUS with surprise and enthusiasm, delighted by the immediacy of diagnostic insight and the comfort of having guidance in real time. For them, the convenience and transparency of seeing the condition “on the screen” bridges a gap between technology and understanding, reinforcing trust and shared decision-making.

Importantly, technological evolution is on our side. Portable ultrasound devices are increasingly intuitive, offering presets tailored to anatomical areas and built-in artificial intelligence for automatic measurements, such as left ventricular ejection fraction. They now provide real-time guidance to optimise image acquisition, lowering the barrier for broader adoption. Similarly, AI-powered platforms, currently capable of detecting HFpEF from a single apical four-chamber view with high sensitivity and specificity, exemplify how machine learning can complement the physician’s eye — extending rather than replacing clinical judgement (17).

Patient centricity & value

These obstacles are not abstract. Each one represents a potential delay, a barrier, or a gap in care for individuals at risk of heart

failure. Overcoming them requires not only evidence, but also strategic leadership — by offering training, demonstrating cost-effectiveness, advocating for reimbursement, and fostering a culture where innovation serves the patient.

In the conventional diagnostic pathway for suspected heart failure in primary care, the diagnosis is typically distributed across multiple consultations and external examinations, with documented delays of weeks to months between symptom onset and confirmed diagnosis in published European cohorts (2). The integration of POCUS into the index consultation offers a structurally different model, in which diagnostic uncertainty may be reduced immediately and management decisions taken on site, with potential downstream effects on referral rates, repeated visits, and equity of access for patients in rural or underserved settings (13).

This vision aligns with the broader movement towards value-based healthcare. Outcomes that matter to patients and to society, such as life span, quality of life and autonomy must replace volume-based metrics such as the number of consultations or tests performed. In this regard, POCUS represents more than an imaging tool: it is a strategy to reduce delays, avoid unnecessary investigations, and increase patient engagement by allowing patients to “see” their disease. Such an approach not only improves individual care but also optimises the use of healthcare resources — a critical need in systems under constant strain.

The future of family medicine — and Medicine 3.0

Looking ahead, the future of family medicine must embrace what could be termed “Medicine 3.0”: a model that is preventive, personalised, and technology-enabled, but firmly anchored in humanism. Artificial intelligence will likely play an increasing role, automating image acquisition and interpretation and supporting decision-making. Recent technological solutions exemplify how AI could complement the clinical judgement of family physicians, particularly in conditions that are subtle and often overlooked. For example, Akerman et al. demonstrated that a convolutional neural network applied to a single apical four-chamber video clip could detect heart failure with preserved ejection fraction with high sensitivity and specificity, and correctly reclassified approximately 73% of patients with indeterminate HFA-PEFF or H2FPEF scores (17). Such tools illustrate the potential of AI to support family physicians in detecting phenotypes that are particularly challenging at the point of care, although their generalisability across primary care populations and devices still requires prospective evaluation. At the same time, the concept of the “doctor in your pocket” — telemedicine, wearables, and connected devices — will bring care closer to the patient, transforming the way chronic disease is monitored. These opportunities, however, must be balanced against new risks: inequity of access, digital exclusion, algorithmic bias, and

the erosion of the doctor–patient relationship if technology is not implemented with care.

Research continuity

The PRIMARY-HF trial, which began in September 2025, represents the next step in this journey. Designed to test NT-proBNP and POCUS in a pragmatic, randomised framework, it will address several of the limitations identified in previous work such as the PLAN-HF study, namely: (i) its single-centre, observational design, which constrained generalisability and precluded causal inference about the impact of POCUS on referral patterns; (ii) the absence of a biomarker arm, which limited assessment of how NT-proBNP and POCUS perform in combination; and (iii) the lack of formal cost-effectiveness and patient-reported outcome data. Importantly, it will not only assess clinical efficacy but also cost-effectiveness, training quality, and patient-reported outcomes — providing evidence that could support broader adoption of these tools in primary care (15). This continuity of research underlines that this thesis is not an endpoint, but a foundation for future innovation.

A transformative journey

On a personal level, this doctoral journey has been transformative. It has provided advanced technical skills in echocardiography, fostered the creation of the national working

group on POCUS in family medicine, stimulated collaborative research and consensus documents, and enabled integration into medical education. More than data, it has been about building capacity, inspiring colleagues, and contributing to cardiovascular care innovation in Portugal. Crucially, this path was not taken in isolation: progress was only possible through building bridges across the various disciplines, including cardiology, internal medicine, radiology, and other specialties, whose expertise and collaboration were fundamental.

8

Conclusion

This doctoral work demonstrates that cardiac point-of-care ultrasound (POCUS), when integrated into routine family medicine consultations, has the potential to transform the early detection and management of heart failure. The findings of the PLAN-HF study show that trained family physicians can independently perform and interpret cardiac POCUS, leading to earlier staging of heart failure, improved recognition of subclinical disease, and a reduction in unnecessary referrals and complementary exams. These results provide robust evidence that POCUS adds significant clinical value — not only by increasing diagnostic accuracy, but also by promoting equity of access, accelerating diagnosis and bringing decision-making closer to the patient.

The research further highlights that innovation in primary care must be aligned with patient-centred and value-based healthcare. POCUS exemplifies a strategy that bridges technology and humanism: by enabling patients to see and understand their own condition in real time, it strengthens trust, supports shared decision-making, and enhances the quality and timeliness of care. At the same time, the barriers identified — limited consultation time, financial constraints, training requirements, and resistance to change — must be acknowledged and addressed through structured education, sustainable reimbursement models, and interdisciplinary collaboration.

This thesis also emphasises that POCUS is not an isolated solution, but a catalyst for broader transformation. Its combination with biomarkers such as NT-proBNP, as proposed in the forthcoming PRIMARY-HF trial, may further refine screening strategies and contribute to more effective and efficient healthcare delivery. Ultimately, by embracing accessible, cost-effective, and person-centred innovations, family medicine can strengthen its central role in the fight against cardiovascular disease.

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