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Sex-Based Differences in Heart Failure: A Retrospective Analysis of Clinical Management and Outcomes in a Portuguese Cardiology Department

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SOUHRN

Cíl: Zjistit rozdíly mezi pohlavími při srdečním selhání (heart failure, HF) se zaměřením na vliv těchto rozdílů na strategie léčby a výsledný stav pacientů v klinické praxi.
Metody: Do této retrospektivní monocentrické kohortové observační studie byli zařazováni všichni pacienti přijatí na jednu portugalskou kardiologickou kliniku v průběhu roku 2022. Pacienti byli rozděleni do dvou skupin podle pohlaví. Primárním sledovaným parametrem byla kombinace mortality z kardiovaskulárních příčin, celková mortalita, hospitalizace pro HF, zvyšování dávek (uptitrace) perorálně užívaného diuretika a neplánované návštěvy lékaře pro intravenózní aplikaci diuretika. Mezi sekundární sledované parametry patřily předepsání kompletní farmakoterapie podle doporučených postupů (guideline-directed medical therapy, GDMT) při propuštění a změny v ejekční frakci levé komory (EF LK) do jednoho roku od propuštění.
Výsledky: Do studie bylo zařazeno celkem 265 osob (68 % muži, 32 % ženy) s mediánem věku 70 ± 12 let. Prevalence *de novo* HF byla vyšší u mužů, zatímco procento příjmů pro akutní dekompenzaci chronického HF bylo vyšší u žen (p = 0,009). Z hlediska etiologie byla u mužů příčinou číslo jedna ischemie, přičemž u pacientek bylo hlavní příčinou chlopenní vada (p < 0,001). U téměř poloviny žen (46,3 %) bylo přítomno HF se zachovanou ejekční frakcí. Do této kategorie spadalo pouze 13,3 % mužů; u převážné většiny z nich (76,1 %) byla při příjmu zjištěna snížená ejekční frakce. Při propuštění užívaly ženy méně často všechny čtyři základní lékové skupiny podávané při HF (p = 0,041). Ženské pohlaví bylo rovněž spojeno se zhoršením EF LK do jednoho roku od propuštění z nemocnice (p = 0,03). Incidence kombinovaného sledovaného parametru se mezi muži a ženami statisticky významně nelišila (p = 0,588).
Závěry: Tato studie potvrzuje, že rozdíly mezi muži a ženami při HF, zvláště pokud se týče projevů, etiologie a odpovědi na léčbu, jsou reálné a v klinické praxi je třeba jim věnovat větší pozornost. I když v souhrnném primárním sledovaném parametru nebyly pozorovány žádné statisticky významné rozdíly, existovala u žen nižší pravděpodobnost, že se u nich bude provádět kompletní GDMT, a častěji u nich docházelo k postupnému zhoršování EF LK. Je naprosto nezbytné zmenšovat rozdíly v léčebných strategiích a v léčbě srdečního selhání zajistit mužům i ženám rovnocennou péči.

Keywords:
Comorbidities
Guideline-directed medical therapy
Heart failure
Left ventricular ejection fraction
Sex difference

ABSTRACT

Aim: Understand sex-specific differences in heart failure (HF) with a focus on their implications for clinical management strategies and patient outcomes.
Methods: This retrospective single-center observational cohort study included all patients admitted with a diagnosis of heart failure to a Portuguese cardiology department during the year of 2022. Patients were divided into two groups based on sex. The primary endpoint was a composite of cardiovascular mortality, all-cause mortality, HF hospitalization, oral diuretic up-titration, and unplanned visits for intravenous diuretic therapy. Secondary outcomes included the prescription of complete guideline-directed medical therapy (GDMT) at discharge and changes in left ventricular ejection fraction (LVEF) one-year post-discharge.

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Results: A total of 265 patients were included, 68% male and 32% female, with a median age of 70 ± 12 years. *De novo* HF was more prevalent in male patients, while female patients showed a higher percentage of admissions for acute decompensated chronic HF ($p = 0.009$). Regarding HF etiology, ischemic etiology was the number one cause in male patients whereas valvular etiology was more prevalent in female patients ($p < 0.001$). Almost half of female patients (46.3%) had HF with preserved ejection fraction. Only 13.3% of male patients fell into this category, with the vast majority (76.1%) presenting with reduced ejection fraction at the time of admission. At discharge, compared with male patients, female patients were less frequently treated with all four pharmacological pillars for HF ($p = 0.041$). Female sex was also associated with worsening of left ventricular ejection fraction (LVEF) after one year of hospital discharge ($p = 0.03$). The combined endpoint was not significantly different between men and women ($p = 0.588$).
Conclusions: This study highlights that sex-related differences in HF, particularly in terms of presentation, etiology, and response to therapy, are real and warrant greater attention in clinical practice. Although no significant disparities were observed in the composite primary outcome, female patients were less likely to receive complete GDMT and more frequently experienced worsening of LVEF over time. Moving forward, it is crucial to bridge disparities in treatment strategies and ensure equitable care for both men and women in heart failure management.

Introduction

Heart failure (HF) is one of the leading causes of hospitalization in Europe, especially in individuals over 65 years of age, with a high mortality and morbidity rate associated. In Europe, it has an estimated prevalence of 1.72%,[1] accounting for approximately 1.5–2.0% of direct healthcare expenditure.[2] The Portuguese Heart Failure Prevalence Observational Study (PORTHOS),[3] conducted between 2021 and 2023, aimed to determine heart failure (HF) prevalence in mainland Portuguese population over 50 years old, and reported an estimated prevalence of 16.5% in that age group, with a significant economic impact associated, accounting for around 2% of the total budget allocated to the National Health Service.[4] The study also concluded that 90% of HF patients were unaware they had the disease, mostly among women and those over 70 years old.[3,5] In terms of sex, like many other syndromes, HF differs in terms of pathophysiology, pharmacodynamics, genetic and hormonal influences, among others. This is due to the different prevalences of cardiovascular risk factors and autoimmune diseases, the impact of sex hormones on metabolism and the systemic inflammatory response of the body, lifestyle, or even the sociocultural perception of the concept of disease associated with each group.[6–10] These differences influence the underlying causes, clinical presentations, response to treatments, and outcomes.

Material and methods

The primary goal of this study was to assess sex-related differences in the mechanisms underlying HF development, the application of medical therapy, and patient prognosis. To achieve this, a retrospective observational cohort study was conducted, including all patients admitted with a diagnosis of HF during the year 2022 in a Cardiology ward at a Portuguese hospital. Eligible participants were aged 18 years or older, resulting in a total sample of 265 patients. Clinical data were collected through a systematic review of electronic medical records, based on ICD-11 codification, including demographic characteristics, comorbidities, treatment regimens, and outcomes, with a specific focus on possible discrepancies between male and female patients.

The primary endpoint for this study included the combined endpoint of cardiovascular mortality, all-cause mortality, HF hospitalization, oral diuretic up-titration, and unplanned hospital visits for intravenous diuretic therapy. As secondary outcomes, the authors assessed the prescription of complete guideline-directed medical therapy (GDMT) for HF at the time of hospital discharge, as well as changes in left ventricular ejection fraction (LVEF) one year after discharge, specifically evaluating improvement or deterioration. A variation of ±5% or more in LVEF was considered clinically relevant to define improvement or deterioration.

Descriptive statistical methods were employed to summarize the data. Categorical variables were expressed as frequencies and percentages, while continuous variables were reported using appropriate measures of central tendency and dispersion. Group comparisons were conducted to identify potential differences according to sex.

For continuous variables, Student's t-test for independent samples was used to compare means between both groups when the assumption of normality and homogeneity of variances was met, as assessed by the Levene's test. For variables that did not meet these assumptions, the non-parametric Mann–Whitney U test was used to compare distributions between the two groups. Normality was assessed visually using histograms and quantitatively using the Shapiro–Wilk test.

All statistical analyses were conducted using IBM SPSS Statistics, version 29, with a significance level set at $p < 0.05$. All patient data were anonymized prior to analysis to ensure confidentiality and compliance with ethical standards for research involving human subjects.

Results

A total of 265 patients hospitalized with HF were included: 68% were men (N = 180) and 32% were women (N = 85). Women were significantly older than men at the time of admission (median age, 74 vs 70 years; $p = 0.009$). No significant differences were observed between the two in terms of hypertension, diabetes, and dyslipidemia. However, alcohol and tobacco consumption were more

common among men (p <0.001), whereas atrial fibrillation was more frequently observed in women (p = 0.023). The prevalence of chronic coronary syndrome (CCS) was similar between sexes (21.7% in men vs 16.5% in women, p = 0.324) (**Table 1**).

A significant difference was observed in the type of heart failure presentation between sexes. *De novo* HF was more frequent in male patients (62.8%) compared to female patients (45.9%) (p = 0.009), whereas acute decompensated chronic HF was more prevalent among female patients (54.1%) (**Table 2**).

Regarding etiology, ischemic HF was significantly more prevalent in male patients (47.8% vs. 22.4%, p <0.001), while valvular etiology was more frequently observed in female patients (36.5% vs. 21.7%, p = 0.011). Notably, alcoholic cardiomyopathy was identified exclusively in male patients (10.6%, p = 0.002).

Heart failure with reduced ejection fraction (HFrEF) was substantially more prevalent in male patients compared to female patients (76.1% vs. 45.1%, p <0.001). In contrast, heart failure with preserved ejection fraction (HFpEF) was significantly more frequent among female patients (46.3% vs. 13.3%). The proportion of patients with heart failure with mildly reduced ejection fraction (HFmrEF) was similar between the two groups (**Table 2**).

In terms of laboratory parameters (**Table 3**), significant differences were observed between male and female patients for several variables. Hemoglobin levels were higher in male patients compared to female patients (13.13 ± 2.11 vs. 12.04 ± 2.05 g/dL, p <0.001). Male patients also had higher estimated glomerular filtration rate (eGFR) values, suggesting better renal function (66.0 [IQR: 43.0] vs. 46.5 [IQR: 39.0] mL/min/1.73 m², p < 0.001). Conversely, total cholesterol and low-density lipoprotein (LDL) levels were lower in male patients (134.0 vs. 153.0 mg/dL, p = 0.012 and 69.0 vs. 80.0, p = 0.050, respectively). High-density lipoprotein (HDL) was higher in female patients (45.0 vs. 41.0 mg/dL, p = 0.008). No significant differences were found in triglyceride levels (p = 0.863) or HbA_{1c} value (p = 0.815). Uric acid levels were higher in male patients (8.28 ± 2.39 vs. 7.62 ± 2.55 mg/dL, p = 0.027). Regarding HF biomarkers, NT-proBNP levels at admission did not differ between the two groups (p = 0.906).

Regarding the primary endpoint (**Table 4**), no statistically significant differences were observed between sexes (p = 0.588). The rate of unplanned hospital visits was similar in both groups (p = 0.474), as was the rate of oral diuretic up-titration (p = 0.942). Likewise, HF hospitalization occurred in 15.0% of male patients and 16.5% of female patients (p = 0.757). Although the rate of cardiovascular death was numerically higher in male patients (8.9% vs. 4.7%), the difference was not statistically significant (p = 0.229). Similarly, all-cause mortality did not differ significantly (p = 0.327).

In terms of secondary outcomes (**Table 5**), significant sex-related differences were identified. Male patients

Table 1 – Baseline demographic and clinical characteristics

	Total	Male	Female	*p*-value
Age		70 ± 21	74 ± 16	**0.009**
Comorbidities				
Hypertension	80.4	77.8	85.9	0.121
Diabetes	42.6	39.4	49.4	0.126
Dyslipidemia	67.5	65.0	72.9	0.197
Cigarette smoking	17.0	22.8	4.7	**<0.001**
Atrial fibrillation	31.7	27.2	41.2	**0.023**
Alcohol drinking	21.1	30.0	2.4	**<0.001**
Chronic coronary syndrome	20.0	21.7	16.5	0.324

Table 2 – Sex-based comparison of HF characteristics

	Total	Male	Female	*p*-value
De novo HF	57.4	62.8	45.9	**0.009**
Acute decompensated chronic HF	42.6	37.2	54.1	
HF etiology				
Ischemic	39.6	47.8	22.4	**<0.001**
Valvular	26.4	21.7	36.5	**0.011**
Alcoholic	7.2	10,6	0	**0.002**
Types of HF				
HFrEF	66.4	76.1	45.1	**<0.001**
HFmrEF	9.9	10.6	8.5	
HFpEF	23.7	13.3	46.3	

Table 3 – Laboratory parameters

	Male	IQR	Female	IQR	*p*-value
eGFR	65.0	44.0	45.0	35.0	**<0.001**
Total cholesterol	134.0	59.0	153.0	47.25	**0.012**
LDL	69.0	49.5	80.0	45.75	**0.050**
HDL	41.0	15.0	45.0	18.75	**0.008**
Triglycerides	104.0	59.0	103.0	46.5	0.863
HbA_{1c}	6.1	1.1	6.0	1.08	0.815
NT-proBNP	6430.0	9720.0	5000.0	13012.5	0.906
	Male	σ	**Female**	σ	***p*-value**
Hemoglobin	13.13	2.11	12.04	2.05	**<0.001**
Uric acid	8.28	2.39	7.62	2.55	**0.027**

Table 4 – Primary endpoint and associated clinical outcomes

	Total	Male	Female	*p*-value
Primary endpoint				0.588
Unplanned hospital visit	10.9	10.0	12.9	0.474
Oral diuretic up-titration	6.0	6.1	5.9	0.942
Heart failure hospitalization	15.5	15.0	16.5	0.757
Cardiovascular death	7.5	8.9	4.7	0.229
All-cause death	8.3	9.4	5.9	0.327

Table 5 – Secondary outcomes

	Total	Male	Female	*p*-value
Discharge with complete GDMT	50.4	55.4	41.3	**0.041**
LVEF improvement 1 year after discharge	56.0	66.0	34.1	**<0.001**
LVEF worsening 1 year after discharge	13.5	9.3	22.7	**0.030**

were more frequently discharged on complete GDMT ($p = 0.041$). Additionally, LVEF improvement one year after discharge was significantly more common among male patients ($p < 0.001$), whereas LVEF worsening was more frequently observed in female patients ($p = 0.030$).

Discussion

This study aimed to explore sex-related differences in the clinical presentation, management, and outcomes of HF patients. Our findings demonstrate significant differences between male and female patients in terms of age, etiology, and clinical characteristics, with both genders exhibiting distinct patterns in response to treatment and disease progression. However, regarding primary outcomes, no significant sex-related differences were observed.

Consistent with previous literature, female patients in our cohort were older and more frequently presented with HFpEF, while male patients more commonly had ischemic heart disease as the underlying etiology.[11–14] Although no significant differences were found in the prevalence of cardiovascular comorbidities, female patients exhibited a higher incidence of atrial fibrillation. These observations align with current epidemiological studies suggesting that HFpEF is often linked to chronic comorbidities and a more gradual deterioration of cardiac function over time.[15,16]

This study also found that male patients had higher rates of smoking and alcohol intake, which are well-known risk factors for ischemic heart disease.[13,17] The higher prevalence of ischemic heart failure among male patients may be attributed to these lifestyle factors, which play a crucial role in the development of coronary artery disease and thereby predispose individuals to HF development. These findings underscore the distinct lifestyle and clinical profiles between men and women with HF – men being more likely to exhibit behaviors associated with traditional cardiovascular risk factors, while women may face a higher prevalence of arrhythmias and other complications, such as depression and anxiety.[8,9,18]

Regarding HF presentation, male patients more frequently presented with new-onset HF, while female patients were more prone to experiencing acute decompen-

sation of pre-existing chronic HF. This trend is consistent with findings in the literature, suggesting that women are more likely to experience acute decompensation in the context of chronic HF, potentially due to the more complex and progressive nature of the disease in this population.[19,20] These sex-related differences have important clinical implications for an earlier detection and management of this syndrome in both sexes, reinforcing the need for tailored approaches that account for the sex-specific pathophysiology of the disease.

Interestingly, NT-proBNP levels ate admission did not differ significantly between sexes. This suggests that while NT-proBNP remains a valuable prognostic tool, its interpretation as a single isolated measure may be insufficient to capture sex-specific differences in heart failure severity. These findings underscore the necessity for integrative analyses encompassing additional biomarkers and relevant clinical variables.

When assessing metabolic parameters, although female patients are typically reported to have lower cholesterol and LDL levels,[21,22] our study found the opposite. One possible explanation are the hormonal changes that occur after menopause, which are known to reduce the protective effects of estrogen on lipid metabolism, thereby contributing to a more atherogenic profile in older women.[7,17,21,22] Additionally, female patients had higher HDL cholesterol levels, which is typically considered protective; however, its clinical relevance in the context of HF remains uncertain.

Renal function, as assessed by eGFR, was significantly lower in female patients, supporting previous observations that women with HF often present with a greater burden of comorbidities, including chronic kidney disease.[20] Surprisingly, there were no significant differences in terms of HbA_{1c} or triglyceride levels between sexes, suggesting similar glycemic control and lipid metabolism in these specific parameters. Together, these results emphasize the importance of considering sex-specific metabolic and renal profiles when assessing and managing patients with HF, as these factors may influence disease trajectory and therapeutic response.

Despite the numerous sex-related differences described above, no statistically significant differences were found in the primary composite endpoint, which included unplanned hospital visits for intravenous diuretic therapy, oral diuretic up-titration, HF hospitalizations, cardiovascular death, and all-cause mortality. Numerous studies[11,23] indicate that women with HF present with lower hospitalization rates and a better survival rate than men. However, despite the distinct clinical characteristics and treatment patterns observed between both groups, male and female patients responded similarly in terms of the predefined primary outcomes in this study. One possible explanation for this discrepancy is the relatively small sample size and limited number of events in each subgroup, which may have reduced the statistical power to detect modest yet clinically meaningful differences between groups. Additionally, as this study reflects the experience of a cardiology department in a Portuguese hospital, the exclusion of older patients with more comorbidities or acute decompensation due to non-cardiac causes, such as acute infection, who were admitted to internal medicine wards, may not fully represent the broader heart failure population, potentially introducing selection bias. This context may limit the generalizability of our findings and influence comparisons in clinical outcomes.

Longitudinal data revealed another key difference: men showed significantly greater improvement in LVEF one year after discharge, whereas women experienced more frequent cardiac function deterioration during the same period.[10,24] This discrepancy may be partially explained by the differing HF profiles between sexes — with men more commonly presenting with *de novo* HF and HFrEF which typically responds better to pharmacological therapy, while women more frequently exhibited acute decompensated chronic HF and preserved ejection fraction, a heterogeneous condition for which therapeutic options remain limited, and outcomes are generally less favorable.[9,18,25]

Although current guidelines do not differentiate treatment based on sex, latest evidence suggests that women may require different dosages of certain medications and may experience varying levels of benefit from certain drugs compared to men.[14,26,27] The underrepresentation of women in clinical trials has contributed to gaps in knowledge regarding their disease mechanisms and responses to treatment, with therapeutic recommendations largely developed based on male-dominant data.[12,14]

Limitations

These findings contribute to the growing evidence of sex-related differences in HF management and outcomes. However, this study has some limitations that should be considered when interpreting the results. First, the retrospective and observational design of the study limits causal inference and may be subject to residual confounding. The single-center design, focused on patients admitted to a cardiology unit, may reduce the generalizability of the findings to other patient populations or care settings. The study analyzed outcomes over a two-year period, which may not fully capture the long-term evolution and prognosis of chronic HF, particularly in women. Additionally, missing or incomplete data, along with the unavailability of variables such as medication adherence and socioeconomic factors, may introduce bias and limit the understanding of factors influencing outcomes like hospitalization rates. Lastly, the study was based on a relatively small sample size from a single institution, which may limit the ability to detect subtle differences between groups and reduce the external validity of the findings.

Conclusions

This study highlights that sex-related differences in HF, particularly in terms of presentation, etiology, and response to therapy, are real and warrant greater attention in clinical practice. Although no significant disparities were observed in the composite primary outcome, women were less likely to receive complete GDMT and more frequently experienced worsening of LVEF over time. Moving forward, it is crucial to bridge disparities

in treatment strategies and ensure equitable care for both men and women in HF management. Therefore, understanding sex-specific differences is not only important but imperative for the formulation of targeted preventive and therapeutic interventions. Incorporating these distinctions into routine clinical decision-making will enhance diagnostic precision, improve adherence to evidence-based care, and ultimately optimize outcomes. Future research must prioritize sex-based analyses and adopt more inclusive research designs to better elucidate the biological, clinical. and systemic mechanisms driving these disparities.

Conflicts of interest
The authors have nothing to declare.

Funding
The authors have nothing to declare.

Ethical statement
The study was conducted in accordance with the Declaration of Helsinki.

Informed consent
Informed consent was obtained from all subjects involved in the study.

References

1. Seferović PM, Vardas P, Jankowska EA, et al. The Heart Failure Association Atlas: Heart Failure Epidemiology and Management Statistics 2019. Eur J Heart Fail 2021;23:906–914.
2. Delgado JF, Bueno H. Heart failure: health is priceless… but still expensive. Eur J Heart Fail 2016;18:1141–1143.
3. Baptista R, Silva Cardoso J, Canhão H, et al. Portuguese Heart Failure Prevalence Observational Study (PORTHOS) rationale and design – A population-based study. Rev Port Cardiol 2023;42:985–995. English, Portuguese.
4. Fonseca C, Brás D, Araújo I, Ceia F. Heart failure in numbers: Estimates for the 21st century in Portugal. Rev Port Cardiol 2018;37:97–104.
5. DN/Lusa. 2024. Alentejo é a região do país com maior prevalência de insuficiência cardíaca. Online. Available from: https://www.dn.pt/sociedade/alentejo-e-a-regiao-do-pais-com-maior-prevalencia-de-insuficiencia-cardiaca. [cited 2025-09-14].
6. Fazzini L, Casati M, Martis A, Perra F, Rubiolo P, Deidda M, et al. Gender Effect on Clinical Profiles, Pharmacological Treatments and Prognosis in Patients Hospitalized for Heart Failure. J Clin Med 2024;13:881.
7. Rossouw JE. Hormones, genetic factors, and gender differences in cardiovascular disease. Cardiovasc Res 2002;53:550–557.
8. Savarese G, D'Amario D. Sex Differences in Heart Failure. In: Kerkhof PLM, Miller VM, eds. Sex-Specific Analysis of Cardiovascular Function. Online. Cham: Springer International Publishing; 2018. p. 529–544. Available from: https://doi.org/10.1007/978-3-319-77932-4_32. [cited 2025-09-14].
9. Kawai A, Nagatomo Y, Yukino-Iwashita M, et al. Sex Differences in Cardiac and Clinical Phenotypes and Their Relation to Outcomes in Patients with Heart Failure. J Pers Med 2024;14:201.
10. Lala A, Tayal U, Hamo CE, et al. Sex Differences in Heart Failure. J Card Fail 2022;28:477–498.
11. Kim HM, Kim HL, Kim MA, et al. Sex differences in clinical characteristics and long-term outcome in patients with heart failure: data from the KorAHF registry. Korean J Intern Med 2024;39:95–109.
12. Bozkurt B, Khalaf S. Heart Failure in Women. Methodist Debakey Cardiovasc J 2017;13:216–223.
13. Hopper I, Kotecha D, Chin KL, et al. Comorbidities in Heart Failure: Are There Gender Differences? Curr Heart Fail Rep 2016;13:1–12.
14. Lam CSP, Arnott C, Beale AL, et al. Sex differences in heart failure. Eur Heart J 2019;40:3859–3868.
15. Borlaug BA, Paulus WJ. Heart failure with preserved ejection fraction: pathophysiology, diagnosis, and treatment. Eur Heart J 2011;32:670–679.
16. Bozkurt B, Ahmad T, Alexander K, et al. HF STATS 2024: Heart Failure Epidemiology and Outcomes Statistics An Updated 2024 Report from the Heart Failure Society of America. J Card Fail 2025;31:66–116.
17. Regitz-Zagrosek V. Sex and Gender Differences in Heart Failure. Int J Heart Fail 2020;2:157–181.
18. Sumarsono A, Xie L, Keshvani N, et al. Sex Disparities in Longitudinal Use and Intensification of Guideline-Directed Medical Therapy among Patients with Newly Diagnosed Heart Failure with Reduced Ejection Fraction. Circulation. 2024;149:510–520.
19. Patel RB, Fonarow GC, Greene SJ, et al. Kidney Function and Outcomes in Patients Hospitalized With Heart Failure. JACC 2021;78:330–343.
20. Melsom T, Norvik JV, Enoksen IT, et al. Sex Differences in Age-Related Loss of Kidney Function. J Am Soc Nephrol 2022;33:1891–1902.
21. Holven KB, Roeters van Lennep J. Sex differences in lipids: A life course approach. Atherosclerosis 2023;384:117270.
22. von Hafe P. Gender differences in lipid profile and therapy Rev Port Cardiol 2019;38:571–572.
23. Deng Y, Zhang J, Ling J, et al. Sex differences in mortality and hospitalization in heart failure with preserved and mid-range ejection fraction: a systematic review and meta-analysis of cohort studies. Front Cardiovasc Med 2024;10:1257335.
24. Schulz A, Lange T, Evertz R, et al. Sex-Specific Impairment of Cardiac Functional Reserve in HFpEF. JACC: Advances 2023;2:100327.
25. Becher PM, Fluschnik N, Blankenberg S, Westermann D. Challenging aspects of treatment strategies in heart failure with preserved ejection fraction: "Why did recent clinical trials fail?" World J Cardiol 2015;7:544.
26. Santema BT, Ouwerkerk W, Tromp J, et al. Identifying optimal doses of heart failure medications in men compared with women: a prospective, observational, cohort study. The Lancet 2019;394:1254–1263.
27. Seeland U, Regitz-Zagrosek V. Sex and Gender Differences in Cardiovascular Drug Therapy. In: Regitz-Zagrosek V, ed. Sex and Gender Differences in Pharmacology. Online. Berlin, Heidelberg: Springer Berlin Heidelberg; 2012. p. 211–236. Available from: https://doi.org/10.1007/978-3-642-30726-3_11. [cited 2025-09-14].