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Evolution of CA 125 and NT-proBNP in stable patients with Fontan circulation: longitudinal analysis with sex perspective

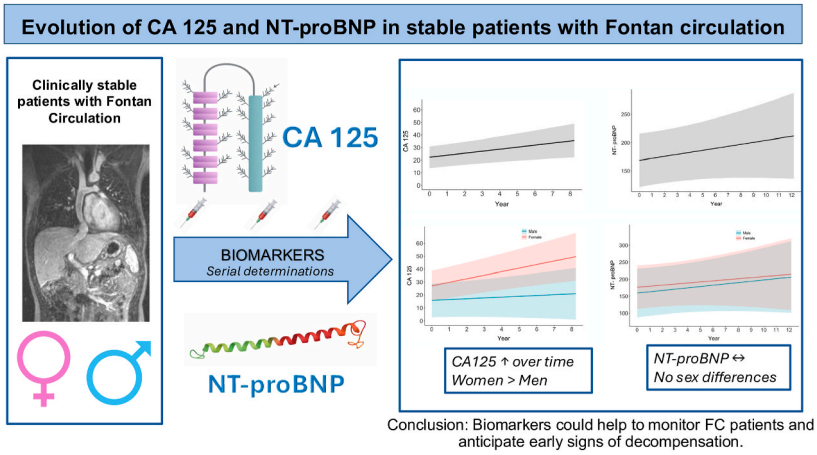
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HIGHLIGHTS

- For the first time, a temporal analysis of the evolution of CA125 and NT-proBNP in clinically stable patients with Fontan circulation is presented.
- In clinically stable adult patients with Fontan circulation, CA-125 levels increased significantly during the follow-up period, especially among women.
- In this population, NT-proBNP levels remained stable, showing no differences between the sexes.

GRAPHICAL ABSTRACT



Conclusion: Biomarkers could help to monitor FC patients and anticipate early signs of decompensation.

ARTICLE INFO

Keywords:
Fontan circulation
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ABSTRACT

Background: Monitoring heart failure in patients with Fontan circulation (FC) remains challenging due to the unique hemodynamic features of this physiology. Conventional heart failure biomarkers are not well validated in this population. We evaluated longitudinal changes in CA125 and NT-proBNP in clinically stable FC patients, with particular attention to sex-based differences.

Methods: We performed a retrospective longitudinal study including clinically stable FC outpatients with ≥2 biomarker measurements separated by ≥ 2 months. Temporal trends of CA125 and NT-proBNP were analyzed using repeated measurements and stratified by sex.

Each and every author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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Results: Sixty-six outpatients were included, with a median of five determinations per patient. The extracardiac conduit was the most frequent Fontan type (72.7%). Baseline CA125 was 22.73 ± 46.26 U/mL and demonstrated a significant upward trend over time (+1.63 U/mL/year; p = 0.008). Baseline NT-proBNP was 165.13 ± 161.62 pg/mL, with a non-significant increase during follow-up (+3.5 pg/mL/year; p = 0.163). Baseline CA125 levels did not differ between sexes. During follow-up, CA125 remained stable in men (0.63 U/mL/year; p = 0.419) but increased significantly in women (2.75 U/mL/year; p < 0.001). NT-proBNP showed no significant sex differences either at baseline or longitudinally.
Conclusions: In clinically stable patients with Fontan circulation, CA125 levels increased significantly over time, particularly in women, whereas NT-proBNP levels remained largely stable. Serial biomarker assessment may provide complementary information for long-term clinical monitoring in this population.

1. Introduction

The Fontan circulation (FC) is a palliative surgical technique for patients with congenital heart disease and univentricular physiology [1, 2]. Although this intervention has greatly improved survival, long-term morbidity remains substantial, and many patients eventually develop a complex clinical entity commonly referred to as Fontan failure [3]. Fontan failure differs fundamentally from heart failure (HF) in biventricular circulation and represents a heterogeneous, multisystem condition. Not all patients exhibit classic HF symptoms such as fluid retention and exercise intolerance, which complicates both diagnosis and monitoring of disease progression [4].

Biomarkers commonly used in acquired HF may also be useful in Fontan circulation; however, the role of NT-proBNP remains controversial due to the distinctive Fontan physiology, characterized by elevated venous pressure and limited ventricular dysfunction [4–7]. On the other hand, Carbohydrate antigen 125 (CA125) has emerged as a biomarker closely associated with systemic congestion, serosal inflammation and adverse outcomes in patients with acquired HF [8–10]. These characteristics make CA125 an attractive candidate biomarker in the Fontan population. However, evidence supporting its clinical utility in FC is currently scarce. In addition, further research is needed to elucidate the longitudinal course of CA125 and NT-proBNP in clinically stable patients with FC [7].

Therefore, the primary objective of this study was to analyze the temporal evolution of CA125 and NT-proBNP levels in clinically stable patients with FC, as well as to explore possible sex-related differences.

2. Methods

2.1. Study design and population

A longitudinal, retrospective, single-centre study was conducted in a cohort of patients undergoing outpatient follow-up after Fontan surgery at a tertiary Adult Congenital Heart Disease Unit.

Eligible patients were required to meet the following inclusion criteria: (A) age >15 years, (B) clinical stability compared to the previous visit, defined by all the following: (1) New York Heart Association (NYHA) functional class I or II without changes since the last visit, (2) no changes in physical examination, including signs of congestion, (3) no hospital admissions or unplanned urgent medical visits, (4) stable medical treatment and (C) availability of serial CA-125 and NT-proBNP measurements obtained at intervals of at least 2 months.

Patients who did not meet the inclusion criteria or who did not provide written informed consent were excluded.

2.2. Biomarker assessment

Biomarker assays were performed in the hospital's central laboratory using Abbott Alinity® chemiluminescent microparticle immunoassay system (Abbott Laboratories©, USA). Only CA125 and NT-proBNP measurements obtained during clinically stable periods were included in the analysis.

Demographic and clinical variables were collected, including underlying congenital heart disease diagnosis, type of Fontan procedure, age at Fontan completion and at last follow-up, sex, NYHA functional class, resting oxygen saturation, ventricular ejection fraction, and ongoing medical treatment.

2.3. Statistical analysis

Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as absolute frequencies and percentages.

Longitudinal data analysis was performed using a generalized linear mixed model with unstructured covariance for random effects, implemented in R© software (version 4.3) with the lmerTest© and emmeans© packages. Sex was included as a fixed factor, time as a continuous covariate, and the interaction between time and sex was tested. A p-value <0.05 was considered statistically significant.

The study complied with the ethical principles outlined in the Declaration of Helsinki and applicable bioethical regulations. The protocol was assessed and approved by the hospital's ethics committee (registration number 2021-892-1), and all patients provided written informed consent.

3. Results

3.1. Study population

Seventy-four patients with FC were followed at the Adult Congenital Heart Disease Unit. During follow-up, two patients died, two underwent heart transplantation, and one was classified as clinically unstable. Among the 69 patients meeting the criteria for clinical stability, 66 were ultimately included in the study, due to the availability of serial measurements of both CA125 and NT-proBNP obtained at intervals of at least 2 months. (Fig. 1).

The mean age at the time of the last follow-up was 27.8 ± 8 years, and 54.5% were female. The most common underlying congenital heart diseases were tricuspid atresia (31.8%), double-inlet left ventricle (12.1%), and pulmonary atresia with intact septum (10.6%).

An extracardiac conduit was the most common type of Fontan surgery (72.7%), and the mean time since surgery of 21.6 ± 8 years. Most patients were asymptomatic (77.3% NYHA functional class I), with a mean oxygen saturation of 95.65 ± 2.3 Baseline clinical characteristics are summarized in Table 1.

Features of advanced Fontan Associated Liver Disease (FALD) were observed in a subset of patients, including liver stiffness values > 30 kPa in 12 (18.2%) and ascites in 3 (4.5%). No cases of hepatocellular carcinoma were identified.

3.2. Study variables

A total of 766 biomarker measurements were analyzed (377 for CA125 and 389 for NT-proBNP) with a median of five determinations per patient in both cases. The interval between measurements ranged

from 66 to 2591 days for CA125 and from 66 to 4440 days for NT-proBNP.

3.3. Longitudinal evolution of biomarkers and sex-related differences

3.3.1. CA125 levels

Mean baseline CA125 levels were 22.73 ± 46.26 U/mL and showed a small but statistically significant upward trend over time ($p = 0.008$), corresponding to an estimated increase of 1.63 U/mL/year over the follow-up (Fig. 2A). At baseline, CA-125 levels did not differ significantly between males and females (15.7 ± 9.8 vs. 27.5 ± 61.5 U/mL, respectively; $p = 0.257$). However, the longitudinal evolution of CA125 differed significantly according to sex. In male patients, CA125 levels remained stable over time, with no significant change observed ($p = 0.418$) and an estimated annual increase of 0.63 U/mL. In contrast, female patients exhibited a significant increase in CA-125 levels during follow-up ($p < 0.001$), with an absolute increase of 22 U/mL and an estimated annual increment of 2.75 U/mL per year (Fig. 3A).

3.3.2. NT-proBNP levels

Mean baseline NT-proBNP levels were 165.13 ± 161.62 pg/mL and remained largely stable throughout follow-up, showing a non-significant ($p = 0.163$) increase of 3.5 pg/mL/year (Fig. 2B). At baseline, no significant difference was noted in NT-proBNP levels between males and females (159.1 ± 163.7 vs. 176.4 ± 212.4 pg/mL, respectively; $p = 0.437$). In contrast to the pattern seen in CA125; NT-proBNP levels exhibited no gender-related variations in its temporal trend. The annual increase was not found to be statistically significant for either men (3.9 pg/ml/year, $p = 0.295$) or women (3.2 pg/ml/year, $p = 0.360$). (Fig. 3B).

4. Discussion

This study provides the first comprehensive longitudinal analysis of two relevant HF biomarkers, CA125 and NT-proBNP, in a cohort of clinically stable adult patients with Fontan Circulation. The main findings can be summarized as follows: (1) CA125, an emerging HF biomarker in the non-congenital heart disease population, shows a slight but significant upward trend over time and may have clinical utility in Fontan patients, whereas NT-proBNP remains stable without significant changes. (2) CA125 levels evolved differently depending on sex. While a significant increase in the biomarker was observed in women, an upward trend was detected in men without reaching statistical significance. Recognition of these temporal and sex-specific patterns may enhance the interpretation and application of these biomarkers during outpatient follow-up of patients with Fontan Circulation.

Fontan circulation is a palliative procedure for univentricular congenital heart disease that redirects systemic venous return to the pulmonary circulation without a subpulmonary ventricle, resulting in

Table 1
Clinical characteristics for patients. NYHA, New York Heart Association functional class. ACE/ARB, angiotensin converting enzyme inhibitors and angiotensin receptor blockers. PPM/ICD, Permanent Pacemaker/Implantable Cardioverter Desfibrillator. Values are expressed as No. (%) or mean ± standard deviation.

	N = 66
Age, y	27.8 ± 8
Women, %	36 (54.5%)
Anatomic Diagnosis	
Tricuspid atresia	21 (31.8%)
Double-inlet left ventricle	8 (12.1%)
Pulmonary atresia and intact ventricular septum	7 (10.6%)
Unbalanced atrioventricular canal	5 (7.6%)
Other	25 (37,9%)
Syistemic Ventricle	
Right	19 (28,8%)
Left	39 (59,1%)
Indeterminate	8 (12,1%)
Age at Fontan procedure, y	6.2 ± 4.4
Time since Fontan procedure, y	21.6 ± 8
Fontan type	
Atriopulmonary	3 (4.5%)
Lateral tunnel	15 (22.8%)
Extracardiac	48 (72.7%)
NYHA	
I	51 (77.3%)
II	15 (22.7%)
SatO2, %	95.6 ± 2.3
Arrhythmias	
Supraventricular Tachycardia	9 (13,7%)
Ventricular Tachycardia	0 (0%)
Brady-arrhythmias	1 (1,5%)
None	56 (84,8%)
Medical treatment	
Antiplatelet therapy	50 (75.8%)
Anticoagulant therapy	15 (22.7%)
Diuretics	10 (15.2%)
Pulmonary vasodilator	10 (15,2%)
Beta blockers	10 (15.2%)
Aldactone antagonist	10 (15,2%)
ACE/ARB	10/15,2%)
PPM/ICD	2 (3%)
Mean Baseline levels	
CA125, U/mL	22.73 ± 46.26
NTproBNP, pg/mL	165.13 ± 161.62
MELD XI Score	46,66 ± 6,2

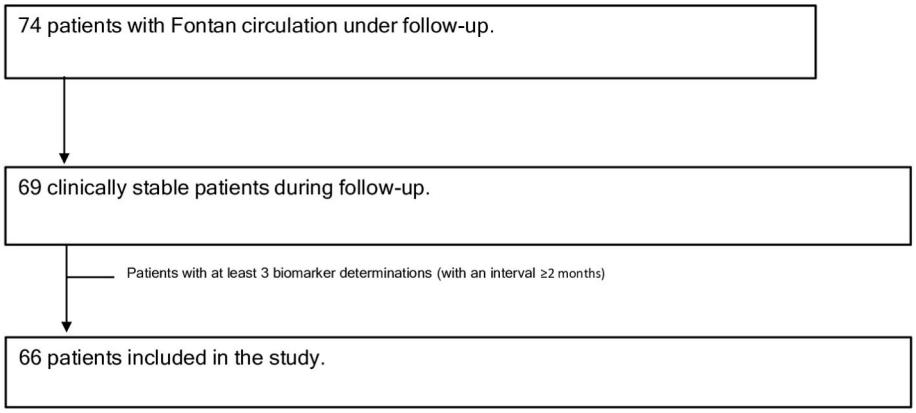


Fig. 1. Flow diagram of patient inclusion.

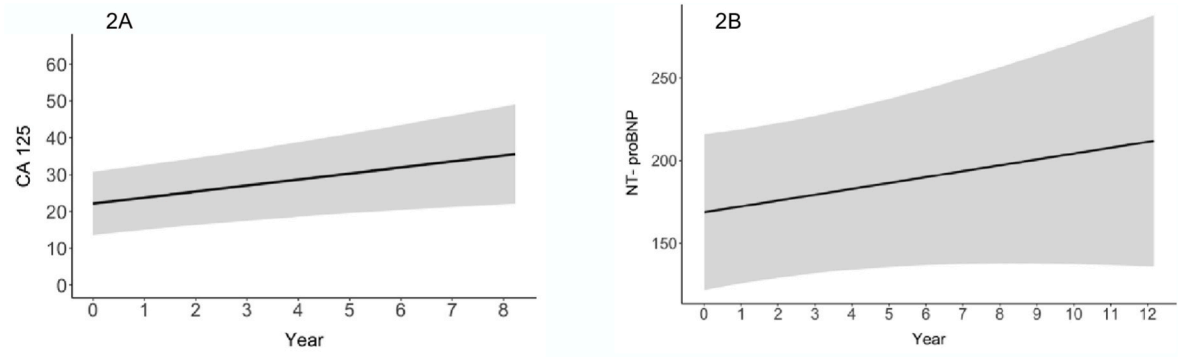


Fig. 2. Temporal evolution of biomarkers. (2A) Temporal evolution of CA125. (2B) Temporal evolution of NT-proBNP.

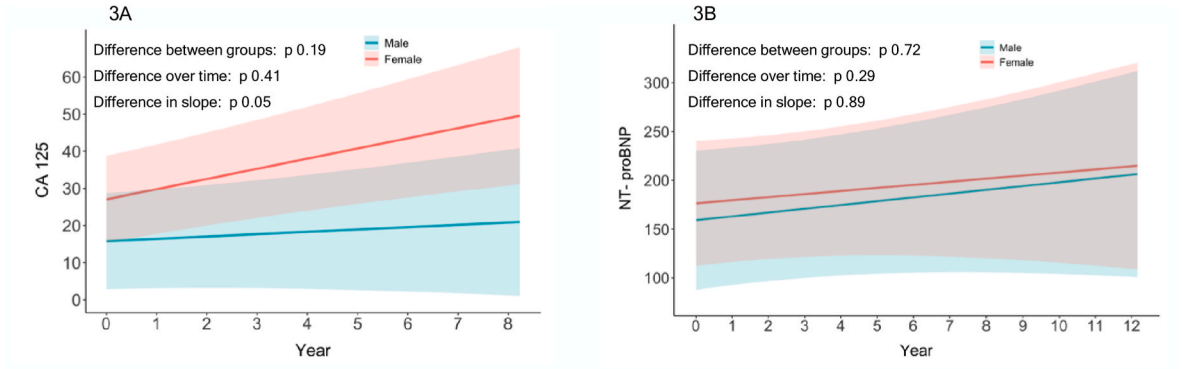


Fig. 3. Temporal evolution of biomarkers according to sex. (3A) CA125 levels were similar between men (green) and women (red) at baseline. While CA125 levels remained stable in men, a significant increase in this biomarker was detected in women during 8-year follow-up. (3B) Baseline and temporal pattern of NT-porBNP levels were simiilar between men (green) and women (red).

chronically elevated venous pressures and reduced cardiac output [6,7,11]. Consequently, long-term complications are common, although the identification and monitoring of HF remain challenging due to the unique Fontan physiology and the lack of standardized progression criteria. In this context, biomarkers emerge as a valuable complementary tool that can potentially enable the early detection of hemodynamic decompensation before overt clinical signs appear [7,11].

4.1. NT-proBNP in patients with Fontan circulation

NT-proBNP is a well-established biomarker of ventricular stress and HF in acquired cardiomyopathy. In Fontan circulation, however, its prognostic role remains less clear, as studies evaluating its association with adverse outcomes have yielded inconsistent results [11].

This variability may be partly explained by differences in NT-proBNP expression according to the type of Fontan surgical connection [4–7].

In patients with classic atriopulmonary connection, NT-proBNP levels are usually higher than in those who underwent extracardiac conduit surgery [6]. This difference is attributed to the greater mass of atrial tissue exposed to chronic pressure overload, which induces increased NT-proBNP secretion, without necessarily being associated with the presence or progression of clinical complications. Conversely, patients with cavopulmonary connections (extracardiac conduit) generally exhibit lower plasma NT-proBNP levels. In this group, however, a marked increase in NT-proBNP is more likely to indicate the onset of HF [4,6,11]. Thus, the anatomical and surgical context plays a critical role in the accurate clinical interpretation of NT-proBNP levels within the Fontan population.

In our cohort, the majority of patients had undergone extracardiac conduit surgery, with only 4.5% having atriopulmonary connections. Consistent with expectations [12], NT-proBNP levels were higher than expected for age- and sex-matched reference values, reflecting chronic ventricular stress inherent to the Fontan physiology. Nevertheless, NT-proBNP remained relatively stable over time in this predominantly extracardiac cohort, likely due to both the surgical type and the clinical stability of our patients. These findings emphasize that baseline NT-proBNP levels and their temporal changes must be interpreted in the context of surgical anatomy to distinguish physiological elevations from early signs of heart failure in adult Fontan patients [12].

4.2. CA125 in patients with Fontan circulation

CA125, initially described as an ovarian tumor marker, has emerged as a biomarker of congestion and inflammation in heart failure [8,13,14], with elevated levels associated with adverse outcomes [15]. Given that both congestion and inflammation are intrinsic to Fontan circulation, CA125 may be particularly relevant in this population [4,5,7]. However, evidence in Fontan patients remains scarce and is currently limited to a small retrospective study reporting association between higher CA125 levels, worse clinical status, and increased complications [7].

An important and novel finding of our study is the sex-related difference in the longitudinal evolution of CA125 levels. While CA125 increased significantly over time in women, only a non-significant upward trend was observed in men. It is well established that CA125 levels may be higher in women due to hormonal and physiological factors [16,17]. In fact, CA125 levels can fluctuate physiologically in relation to the menstrual cycle [16–18], ovulation, or gynecological disorders such as endometriosis, uterine fibroids, or pelvic inflammatory disease [19,20]. In the present study, all female participants were of reproductive age, and the phase of the menstrual cycle during which CA125 was measured was not recorded. Physiologically, CA125 levels can reach 50-60 U/ml

during menstruation and remain below 20 U/ml in the proliferative phase of the cycle [16–18].

Interpretation of CA125 in women with Fontan circulation, particularly those of childbearing age, requires caution, as moderately elevated levels may not necessarily indicate congestion. Sex-specific thresholds and menstrual cycle timing should therefore be considered when assessing CA125 values.

4.3. Temporal dynamics of NT-proBNP and CA125 in clinically stable Fontan patients

To our knowledge, no study has focused on the temporal evolution of biomarkers in adult patients with FC. Understanding both baseline levels and temporal trends of these biomarkers in clinically stable patients is essential if they are to be used for monitoring and risk stratification [7,13,14].

In our cohort, NT-proBNP showed a slight upward trend, reflecting chronic myocardial stress in hemodynamically stable patients; this trend, while not statistically significant, may become relevant in larger populations or with extended follow-up. In contrast, CA125, a marker of serous congestion and inflammation, increased significantly over time, even in clinically stable patients, mainly in women.

These findings suggest that NT-proBNP and CA125 may provide complementary information in adult Fontan patients. NT-proBNP generally reflects myocardial stress, influenced by surgical type and chronic hemodynamic load, whereas CA125 may be sensitive to subtle changes in serous congestion and inflammation, even in clinically stable individuals.

The 2025 ACC/AHA guidelines for management of adults with congenital heart disease support annual assessment of natriuretic peptides and cystatin C in patients with Fontan circulation [21]. In line with these recommendations, and considering the findings of the present study, routine CA125 annual assessment could potentially be considered in this population. Furthermore, CA125 assessment is simple and widely available in routine clinical laboratories, with a very low associated cost.

Cut-off values for NT-proBNP and CA125 have not yet been clearly established in patients with FC. Based on our findings and the limited data available from previous reports NT-proBNP values below approximately 200–250 pg/mL and CA125 values below 20–35 U/mL could be considered within the expected range in clinically stable patients [6,7]. Nevertheless, given the heterogeneity of the Fontan population and the scarcity of available evidence, longitudinal changes in biomarker levels within each individual patient may be more clinically informative than a single universal cut-off value.

4.4. Clinical implications

Serial measurements of NT-proBNP and CA125 may represent useful non-invasive tools for longitudinal assessment in patients with Fontan circulation, potentially helping to monitor clinical stability, detect subtle hemodynamic or inflammatory changes, and support therapeutic decision-making, particularly during subclinical stages. In the present study, although CA125 levels showed a slight but statistically significant increase during follow-up, the magnitude of this change was small and unlikely to be clinically meaningful. Given the clinically stable nature of the cohort, these findings should not be interpreted as evidence of disease progression or worse prognosis. Rather, the overall low and relatively stable biomarker profile observed in this ambulatory Fontan population suggests that serial biomarker assessment may help support longitudinal evaluation of clinical stability. Nevertheless, their prognostic role and ability to predict clinical deterioration in more advanced stages of Fontan circulation remain uncertain and warrant validation in larger, prospective, and more heterogeneous cohorts.

4.5. Limitations

The main limitation of this study is its single-centre and retrospective design. This type of study may involve additional biases, but these could be considered acceptable when the study's objective is primarily descriptive. In this sense, results should be viewed as exploratory and require confirmation in future studies with predefined time points for biomarker assessment.

On the other hand, the single-center nature allows for a more detailed, comprehensive and uniform analysis of each case, as well as the use of the same analytical determination method for all patients.

Given the pathology studied (adult patients with Fontan Circulation), the number of patients included is modest.

In this cohort of patients of childbearing age, the difference in CA125 levels between men and women may have a hormonal basis. However, further studies involving a larger number of patients and taking gynaecological factors into account are needed to definitively interpret the greater increase in CA125 levels observed in women during follow-up.

5. Conclusions

In clinically stable adult patients with Fontan circulation, CA125 levels increased significantly over the follow-up period, particularly in women, whereas NT-proBNP levels remained largely stable in both sexes. These findings provide novel insight into the longitudinal behaviour of NT-proBNP and CA125 in Fontan circulation and suggest that serial assessment of these biomarkers may offer complementary information for the long-term monitoring of clinically stable outpatients. Consideration of sex-specific differences and temporal trends may further improve their clinical interpretation and utility.

CRediT authorship contribution statement

Marta Gil Molina: Writing – original draft, Data curation, Conceptualization. **Francisco Buendía Fuentes:** Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **María Calvo Asensio:** Writing – review & editing. **Miguel Ángel Arnau Vives:** Formal analysis. **María Rodríguez Serrano:** Writing – review & editing. **Jaume Aguero:** Writing – review & editing. **Ana Osa Sáez:** Writing – review & editing. **Luis Martínez Dolz:** Writing – review & editing. **Joaquín Rueda Soriano:** Writing – original draft, Methodology, Data curation, Conceptualization.

Statement on the use of artificial intelligence

The authors used an artificial intelligence–based language tool to assist in improving the clarity and language of the manuscript. The authors take full responsibility for the content of the publication.

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Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] Fontan F, Baudet E. Surgical repair of tricuspid atresia. Thorax 1971 May 1;26(3):240–8.

[2] Gebhdpcljp Kreutzer G. An operation for the correction of tricuspid atresia. J Thorac Cardiovasc Surg 1973;66:613–21.

[3] Rychik J, Atz AM, Celermajer DS, Deal BJ, Gatzoulis MA, Gewillig MH, et al. Evaluation and management of the child and adult with fontan circulation: a scientific statement from the American heart association. Circulation 2019;140:E234–84. Lippincott Williams and Wilkins.

[4] Inai K. Biomarkers for heart failure and prognostic prediction in patients with fontan circulation. Pediatr Int 2022;64. John Wiley and Sons Inc.

[5] Inai K, Nakanishi T, Nakazawa M. Clinical correlation and prognostic predictive value of neurohumoral factors in patients late after the fontan operation. Am Heart J 2005 Sep;150(3):588–94.

[6] Heck PB, Müller J, Weber R, Hager A. Value of N-terminal pro brain natriuretic peptide levels in different types of fontan circulation. Eur J Heart Fail 2013 Jun;15(6):644–9.

[7] Buendía Fuentes F, Jover Pastor P, Arnau Vives MÁ, Lozano Edo S, Rodríguez Serrano M, Aguero J, et al. CA125: a new biomarker in patients with fontan circulation. Rev Esp Cardiol 2023 Feb;76(2):112–20.

[8] Llàcer P, Bayés-Genís A, Núñez J. Carbohydrate antigen 125 in heart failure. New era in the monitoring and control of treatment 2019;152:266–73. Medicina Clinica. Ediciones Doyma, S.L.

[9] Núñez J, de la Espriella R, Miñana G, Santas E, Llácer P, Núñez E, et al. Antigen carbohydrate 125 as a biomarker in heart failure: a narrative review. Eur J Heart Fail 2021;23:1445–57. John Wiley and Sons Ltd.

[10] Núñez J, Llàcer P, García-Blas S, Bonanad C, Ventura S, Núñez JM, et al. CA125-Guided diuretic treatment versus usual care in patients with acute heart failure and renal dysfunction. Am J Med 2020 Mar 1;133(3):370–380.e4.

[11] Burchill LJ, Redington AN, Silversides CK, Ross HJ, Jimenez-Juan L, Mital S, et al. Renin-angiotensin-aldosterone system genotype and serum BNP in a contemporary cohort of adults late after fontan palliation. Int J Cardiol 2015 Aug 5;197:209–15.

[12] Welsh P, Campbell RT, Mooney L, Kimenai DM, Hayward C, Campbell A, et al. Reference ranges for NT-proBNP (N-Terminal Pro-B-Type natriuretic peptide) and risk factors for higher NT-proBNP concentrations in a large general population cohort. Circ Heart Fail 2022 Oct 1;15(10):E009427.

[13] Huang F, Chen J, Liu Y, Zhang K, Wang J, Huang H. New mechanism of elevated CA125 in heart failure: the mechanical stress and inflammatory stimuli initiate CA125 synthesis. Med Hypotheses 2012 Sep;79(3):381–3.

[14] Núñez J, Miñana G, Núñez E, Chorro FJ, Bodí V, Sanchis J. Clinical utility of antigen carbohydrate 125 in heart failure. Heart Fail Rev 2014;19:575–84. Kluwer Academic Publishers.

[15] Núñez J, Bayés-Genís A, Revuelta-López E, ter Maaten JM, Miñana G, Barallat J, et al. Clinical role of CA125 in worsening heart failure: a BIOSTAT-CHF study subanalysis. JACC Heart Fail 2020 May 1;8(5):386–97.

[16] Kan Y, Yeh S, Ng H, Lou C. Effect of menstruation on serum CA125 levels. Asia-Oceania J Obstet Gynaecol 1992 Dec 24;18(4):339–43.

[17] Lehtovirta P, Apter D, Stenman U-H. Serum CA 125 levels during the menstrual cycle. BJOG 1990 Oct 19;97(10):930–3.

[18] Grover S, Koh H, Weideman P, Quinn MA. The effect of the menstrual cycle on serum CA 125 levels: a population study. Am J Obstet Gynecol 1992 Nov;167(5):1379–81.

[19] Bischof P, Galfetti MA, Seydoux J, von Hospenthal JU, Campana A. Peripheral CA 125 levels in patients with uterine fibroids. Hum Reprod 1992 Jan;7(1):35–8.

[20] Hirsch M, Duffy J, Davis CJ, Nieves Plana M, Khan KS. International collaboration to harmonise outcomes and measures for endometriosis. Diagnostic accuracy of cancer antigen 125 for endometriosis: a systematic review and meta-analysis. BJOG 2016 Oct;123(11):1761–8.

[21] Gurvitz M, Krieger EV, Fuller S, Davis LL, Kittleson MM, Aboulhosn JA, et al. ACC/AHA/HRS/ISACHD/SCAI guideline for the management of adults with congenital heart disease: a report of the American college of cardiology/american heart association joint committee on clinical practice guidelines. J Am Coll Cardiol 2025;87(7):822–976. 2026 Feb 24.