



Original Research Paper

Cardiac Functional Changes on Echocardiography in Third-Trimester Pregnancies Complicated by Iron Deficiency Anemia: A Case–Control Study

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Abstract

Introduction:

Iron deficiency anemia (IDA) is highly prevalent during pregnancy, particularly in the third trimester, and is associated with significant hemodynamic changes. These alterations may impact maternal cardiac function, which can be effectively assessed using echocardiography. This study aimed to evaluate cardiac functional changes in third-trimester pregnancies complicated by IDA.

Methodology:

A hospital-based case–control study was conducted among 100 third-trimester pregnant women, including 50 cases with IDA and 50 age- and gestational age-matched healthy controls. IDA was diagnosed based on hemoglobin <11 g/dL with low serum ferritin. All participants underwent detailed clinical evaluation and transthoracic echocardiography. Parameters assessed included left ventricular ejection fraction (LVEF), fractional shortening (FS), stroke volume, cardiac output, diastolic indices (E/A ratio, deceleration time, IVRT), and ventricular dimensions. Statistical analysis was performed using appropriate tests, with $p < 0.05$ considered significant.

Results:

Hemoglobin levels were significantly lower in cases (8.6 ± 1.2 g/dL) compared to controls (11.8 ± 0.9 g/dL; $p < 0.001$). Cases showed reduced LVEF ($58.2 \pm 4.6\%$ vs $61.5 \pm 3.8\%$) and FS ($30.1 \pm 3.5\%$ vs $33.4 \pm 2.9\%$), but increased stroke volume (76.8 ± 9.4 mL vs 69.5 ± 8.1 mL) and cardiac output (6.8 ± 1.1 L/min vs 5.9 ± 0.9 L/min) ($p < 0.001$). Diastolic dysfunction was evident with lower E/A ratio and prolonged relaxation parameters. Left ventricular dimensions were also significantly increased in cases.

Conclusion:

IDA in third-trimester pregnancy is associated with significant subclinical cardiac dysfunction, emphasizing the importance of early detection and management to improve maternal cardiovascular outcomes.

Keywords

Iron deficiency anemia; Pregnancy; Third trimester; Echocardiography; Cardiac function; Left ventricular function; Diastolic dysfunction; Cardiac output; Maternal hemodynamics

Introduction

Iron deficiency anemia (IDA) remains the most common nutritional deficiency worldwide and is highly prevalent during pregnancy, particularly in developing countries. It is estimated that nearly 40–50% of pregnant women globally are affected by anemia, with iron deficiency accounting for the majority of cases [1]. During pregnancy, physiological changes such as plasma volume expansion, increased iron requirements for fetal growth, and inadequate dietary intake predispose women to anemia [2]. The third trimester, in particular, represents a critical period when iron

demand peaks, often unmasking or exacerbating underlying iron deficiency [3].

Anemia during pregnancy has been associated with several adverse maternal and fetal outcomes, including preterm delivery, low birth weight, and increased perinatal mortality [4]. In addition to these well-recognized complications, IDA exerts significant effects on the cardiovascular system. To compensate for reduced oxygen-carrying capacity, the maternal body undergoes adaptive hemodynamic changes, including increased cardiac output, reduced systemic vascular resistance, and alterations in ventricular function [5]. While these changes are initially compensatory, persistent anemia may lead to cardiac strain and functional impairment, especially during late pregnancy when circulatory demands are highest [6].

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Echocardiography is a non-invasive, widely available, and reliable imaging modality for assessing cardiac structure and function. It provides valuable insights into parameters such as left ventricular systolic and diastolic function, chamber dimensions, and cardiac output [7]. In recent years, echocardiographic evaluation has gained importance in detecting subclinical cardiac dysfunction in pregnant women, allowing early identification of those at risk of adverse outcomes [8]. Several studies have suggested that anemia may be associated with subtle alterations in cardiac function, even in the absence of overt heart disease [9].

In the third trimester, physiological cardiovascular changes of pregnancy, such as increased blood volume and heart rate, are already at their peak. The coexistence of IDA during this stage may further exacerbate cardiac workload, potentially leading to measurable functional changes on echocardiography [10]. However, the extent and clinical significance of these changes remain inadequately explored, particularly in resource-limited settings where anemia prevalence is high [11].

A case-control study design offers an effective approach to compare echocardiographic findings between anemic and non-anemic pregnant women, thereby elucidating the specific impact of iron deficiency on cardiac function [12]. Understanding these changes is crucial for early diagnosis, timely intervention, and prevention of long-term cardiovascular complications in affected women.

Therefore, the present study aims to evaluate cardiac functional changes using echocardiography in third-trimester pregnancies complicated by iron deficiency anemia and to compare these findings with healthy pregnant controls.

Methodology

A hospital-based case-control study was conducted in the Department of Obstetrics and Gynecology in collaboration with the Department of Cardiology at a tertiary care center over a period of 12 months. The study aimed to evaluate cardiac functional changes on echocardiography in third-trimester pregnant women with iron deficiency anemia (IDA) and compare them with healthy pregnant controls. Ethical approval for the study was obtained from the Institutional Ethics Committee prior to commencement. Confidentiality of participant information was maintained throughout the study.

A total of 100 pregnant women in their third trimester (gestational age ≥ 28 weeks) were enrolled and divided into two groups: 50 cases and 50 controls. Cases included pregnant women diagnosed with iron deficiency anemia, defined as hemoglobin (Hb) levels < 11 g/dL along with laboratory evidence of iron deficiency (low serum ferritin < 15 μ g/L and/or low transferrin saturation). Controls were age- and gestational age-matched healthy pregnant

women with normal hemoglobin levels (Hb ≥ 11 g/dL) and no evidence of anemia.

Participants were recruited using a purposive sampling technique after obtaining informed written consent. Women with pre-existing cardiovascular disease, hypertension, diabetes mellitus, renal disorders, multiple pregnancies, thyroid disorders, or any other systemic illness that could independently affect cardiac function were excluded. Women with other causes of anemia, such as hemoglobinopathies or vitamin B12/folate deficiency, were also excluded.

A detailed clinical history was obtained, including demographic details, obstetric history, dietary habits, and symptoms suggestive of anemia or cardiac dysfunction. A thorough physical examination was performed, including measurement of pulse rate, blood pressure, and body mass index (BMI). Laboratory investigations included complete blood count, peripheral smear, serum ferritin, and other relevant parameters to confirm iron deficiency anemia.

All participants underwent transthoracic echocardiography using a standardized protocol, performed by an experienced cardiologist who was blinded to the study groups. Echocardiographic parameters assessed included left ventricular (LV) end-diastolic and end-systolic dimensions, ejection fraction (EF), fractional shortening (FS), stroke volume, cardiac output, and diastolic function parameters such as E/A ratio and deceleration time. Measurements were obtained in accordance with the guidelines of the American Society of Echocardiography.

Data were entered into a Microsoft Excel spreadsheet and analyzed using appropriate statistical software. Continuous variables were expressed as mean $\pm$ standard deviation (SD), and categorical variables as percentages. The independent t-test was used to compare means between the two groups, while the chi-square test was applied for categorical variables. A p-value of < 0.05 was considered statistically significant.

Results

A total of 100 third-trimester pregnant women were included in the study, comprising 50 cases (iron deficiency anemia) and 50 controls (non-anemic). The mean age of women in the case group (26.8 ± 3.9 years) was comparable to that of the control group (27.2 ± 4.1 years), with no statistically significant difference ($p = 0.621$). Similarly, gestational age was nearly identical between the two groups (33.9 ± 2.8 weeks vs 34.2 ± 2.6 weeks; $p = 0.548$). Other variables such as BMI, gravidity, and parity also did not differ significantly ($p > 0.05$ for all). These findings indicate that both groups were well matched, and any observed differences in cardiac parameters are unlikely to be confounded by demographic or obstetric factors. (Table 1)

Table 1: Demographic and Obstetric Characteristics of Study Participants

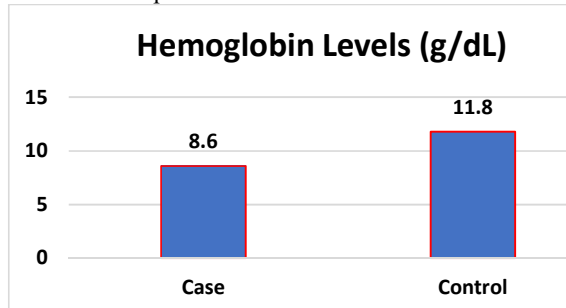
Variable	Cases (n=50) Mean $\pm$ SD	Controls (n=50) Mean $\pm$ SD	p-value
Age (years)	26.8 $\pm$ 3.9	27.2 $\pm$ 4.1	0.621
Gestational age (weeks)	33.9 $\pm$ 2.8	34.2 $\pm$ 2.6	0.548
BMI (kg/m ²)	24.6 $\pm$ 3.2	24.1 $\pm$ 3.0	0.432
Gravidity	2.1 $\pm$ 1.0	2.0 $\pm$ 0.9	0.703
Parity	1.2 $\pm$ 0.8	1.1 $\pm$ 0.7	0.655

The mean hemoglobin level in cases (8.6 ± 1.2 g/dL) was markedly lower than in controls (11.8 ± 0.9 g/dL), confirming the presence of anemia ($p < 0.001$). Serum ferritin levels were also significantly reduced in cases (11.3 ± 4.5 μ g/L) compared to controls (36.7 ± 8.2 μ g/L), indicating depleted iron stores. Red cell indices, including MCV and MCH, were significantly lower in the case group ($p < 0.001$), consistent with microcytic hypochromic anemia. (Table 2, Figure 1)

Table 2: Hematological Parameters

Parameter	Cases (n=50) Mean $\pm$ SD	Controls (n=50) Mean $\pm$ SD	p-value
Serum Ferritin (μ g/L)	11.3 $\pm$ 4.5	36.7 $\pm$ 8.2	<0.001*
MCV (fL)	72.4 $\pm$ 6.8	86.2 $\pm$ 5.7	<0.001*
MCH (pg)	23.6 $\pm$ 2.9	29.4 $\pm$ 2.5	<0.001*

Figure 1: Comparison of Hemoglobin Levels Between Groups



The mean left ventricular ejection fraction was lower in cases ($58.2 \pm 4.6\%$) compared to controls ($61.5 \pm 3.8\%$), and this difference was statistically significant ($p < 0.001$). Fractional shortening was also reduced in the case group ($30.1 \pm 3.5\%$) as compared to controls ($33.4 \pm 2.9\%$), showing a significant difference ($p < 0.001$). In contrast, stroke volume was higher among cases (76.8 ± 9.4 mL) than controls (69.5 ± 8.1 mL), which was statistically significant ($p < 0.001$). Similarly, cardiac output was significantly increased in the case group (6.8 ± 1.1 L/min) compared to the control

group (5.9 ± 0.9 L/min) with a p-value of <0.001 . (Table 3)

Table 3: Comparison of Systolic Cardiac Function

Parameter	Cases (n=50) Mean $\pm$ SD	Controls (n=50) Mean $\pm$ SD	p-value
LV Ejection Fraction (%)	58.2 $\pm$ 4.6	61.5 $\pm$ 3.8	<0.001*
Fractional Shortening (%)	30.1 $\pm$ 3.5	33.4 $\pm$ 2.9	<0.001*
Stroke Volume (mL)	76.8 $\pm$ 9.4	69.5 $\pm$ 8.1	<0.001*
Cardiac Output (L/min)	6.8 $\pm$ 1.1	5.9 $\pm$ 0.9	<0.001*

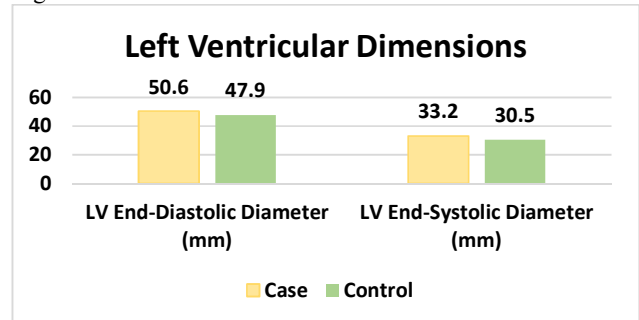
The E/A ratio was significantly lower in cases (0.92 ± 0.18) compared to controls (1.18 ± 0.22), indicating impaired diastolic function ($p < 0.001$). The deceleration time was prolonged in the case group (228 ± 24 ms) compared to controls (204 ± 20 ms), and this difference was statistically significant ($p < 0.001$). Additionally, the isovolumetric relaxation time was higher in cases (98 ± 12 ms) compared to controls (84 ± 10 ms), also showing a significant difference ($p < 0.001$). (Table 4)

Table 4: Comparison of Diastolic Function Parameters

Parameter	Cases (n=50) Mean $\pm$ SD	Controls (n=50) Mean $\pm$ SD	p-value
E/A Ratio	0.92 $\pm$ 0.18	1.18 $\pm$ 0.22	<0.001*
Deceleration Time (ms)	228 $\pm$ 24	204 $\pm$ 20	<0.001*
Isovolumetric Relaxation Time (ms)	98 $\pm$ 12	84 $\pm$ 10	<0.001*

The mean left ventricular end-diastolic diameter was significantly higher in cases (50.6 ± 3.8 mm) compared to controls (47.9 ± 3.2 mm), with a p-value of <0.001 . Similarly, the left ventricular end-systolic diameter was increased in the case group (33.2 ± 3.1 mm) compared to the control group (30.5 ± 2.7 mm), and this difference was also statistically significant ($p < 0.001$). (Figure 2)

Figure 2: Left Ventricular Dimensions



Discussion

The present study evaluated echocardiographic cardiac functional changes in third-trimester

pregnancies complicated by iron deficiency anemia (IDA) and demonstrated significant alterations in systolic function, diastolic function, and cardiac structure compared to healthy controls. These findings are in concordance with previously published literature and highlight the cardiovascular impact of anemia during pregnancy.

With respect to baseline characteristics, our study showed no statistically significant differences between cases and controls in age (26.8 ± 3.9 vs 27.2 ± 4.1 years), gestational age (33.9 ± 2.8 vs 34.2 ± 2.6 weeks), or BMI (24.6 ± 3.2 vs 24.1 ± 3.0 kg/m²) ($p > 0.05$). Similar findings were reported by Bencaiova et al. [4], who observed comparable maternal characteristics between anemic and non-anemic pregnant women. Likewise, Mann et al. [12] emphasized the importance of proper matching in case-control studies to eliminate confounding variables. Additionally, studies on maternal cardiovascular adaptation such as Sanghavi et al. [6] also evaluated comparable populations, reinforcing that observed differences are attributable to physiological or pathological conditions rather than demographic variation.

Regarding hematological parameters, our study demonstrated significantly lower hemoglobin (8.6 ± 1.2 g/dL) and serum ferritin levels (11.3 ± 4.5 µg/L) in cases compared to controls (11.8 ± 0.9 g/dL and 36.7 ± 8.2 µg/L, respectively; $p < 0.001$). These findings are consistent with Milman et al. [3], who reported hemoglobin levels typically between 8–9 g/dL in iron-deficient pregnant women, especially in the third trimester. Similarly, Bothwell et al. [2] described depleted iron stores due to increased maternal and fetal demand during pregnancy. Furthermore, global data from Stevens et al. [11] highlight the high prevalence of anemia in pregnancy and its physiological implications, supporting our observations.

In terms of systolic cardiac function, our study found a statistically significant reduction in left ventricular ejection fraction ($58.2 \pm 4.6\%$ vs $61.5 \pm 3.8\%$) and fractional shortening ($30.1 \pm 3.5\%$ vs $33.4 \pm 2.9\%$) in anemic women ($p < 0.001$). These findings are in agreement with Sanghavi et al. [6], who reported that while ejection fraction generally remains within normal limits during pregnancy, mild reductions may occur due to increased hemodynamic stress. Similarly, Soma-Pillay et al. [5] noted that chronic volume overload during pregnancy can affect myocardial contractility, even if clinically overt dysfunction is absent. Additionally, Hunter et al. [10] described adaptive cardiac changes during pregnancy that may lead to subtle alterations in systolic performance.

Despite reduced systolic indices, our study demonstrated a significant increase in stroke volume (76.8 ± 9.4 mL) and cardiac output (6.8 ± 1.1 L/min) compared to controls (69.5 ± 8.1 mL and 5.9 ± 0.9 L/min; $p < 0.001$). These findings reflect a

compensatory hyperdynamic circulation and are consistent with Soma-Pillay et al. [5], who reported cardiac output values of approximately 6–7 L/min in late pregnancy. Similarly, Sanghavi et al. [6] and Hunter et al. [10] described increased stroke volume and cardiac output as key physiological adaptations to meet increased metabolic demands. These compensatory mechanisms are further exaggerated in anemia due to reduced oxygen-carrying capacity. With regard to diastolic function, our study revealed significant impairment, as evidenced by a reduced E/A ratio (0.92 ± 0.18 vs 1.18 ± 0.22), prolonged deceleration time (228 ± 24 ms vs 204 ± 20 ms), and increased isovolumetric relaxation time (98 ± 12 ms vs 84 ± 10 ms) ($p < 0.001$). These findings suggest impaired ventricular relaxation. Similar results were reported by Melchiorre et al. [8], who observed subclinical diastolic dysfunction in pregnant women due to chronic volume overload. Additionally, Eghbali et al. [9] demonstrated that pregnancy-induced cardiac remodeling alters myocardial relaxation and compliance. Furthermore, Soma-Pillay et al. [5] also noted that diastolic function may be affected in conditions of increased cardiac workload, such as anemia.

Regarding cardiac structural changes, our study showed significantly increased left ventricular end-diastolic diameter (50.6 ± 3.8 mm vs 47.9 ± 3.2 mm) and end-systolic diameter (33.2 ± 3.1 mm vs 30.5 ± 2.7 mm) in anemic women ($p < 0.001$). These findings are consistent with Hunter et al. [10], who reported LV end-diastolic diameters ranging from 48–52 mm in late pregnancy. Similarly, Sanghavi et al. [6] described cardiac remodeling and chamber dilatation as physiological adaptations during pregnancy. Additionally, Eghbali et al. [9] highlighted structural myocardial changes associated with pregnancy-induced hypertrophy, which may be exaggerated in pathological conditions such as anemia.

Therefore, the findings of the present study are in agreement with existing literature and demonstrate that iron deficiency anemia in third-trimester pregnancy is associated with a hyperdynamic circulatory state characterized by increased cardiac output (6.8 L/min), mild reduction in systolic function (LVEF ~58%), significant diastolic dysfunction (E/A ratio <1), and ventricular dilatation (LVEDD ~50.6 mm). These changes represent compensatory mechanisms that may progress to subclinical cardiac dysfunction if anemia persists.

The present study has certain limitations. The sample size was relatively small and conducted at a single center, which may limit generalizability. Being a case-control design, causal relationships cannot be definitively established. Echocardiographic assessment was performed at a single time point without longitudinal follow-up. Additionally, advanced modalities such as strain

imaging were not used, which could have detected more subtle myocardial dysfunction. Potential confounding factors such as nutritional status and physical activity were not extensively evaluated.

Conclusion

The present study demonstrates that iron deficiency anemia in third-trimester pregnancy is associated with significant alterations in cardiac function as assessed by echocardiography. Anemic pregnant women exhibited a hyperdynamic circulatory state characterized by increased stroke volume and cardiac output, along with subtle but significant reductions in systolic function parameters such as ejection fraction and fractional shortening. In addition, evidence of diastolic dysfunction and left ventricular dilatation was observed, indicating early subclinical cardiac involvement.

These findings highlight that iron deficiency anemia is not merely a hematological disorder but also has important cardiovascular implications during pregnancy. Early identification and timely management of anemia are essential to prevent potential cardiac complications. Incorporating echocardiographic evaluation in moderate to severe cases may aid in early detection of functional changes, thereby improving maternal outcomes and guiding appropriate clinical interventions.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

References

1. The global prevalence of anaemia in 2011. <https://www.who.int/publications/i/item/9789241564960> (accessed 2026-04-30).
2. Bothwell, T. H. Iron Requirements in Pregnancy and Strategies to Meet Them. *Am J Clin Nutr* 2000, 72 (1 Suppl), 257S-264S. <https://doi.org/10.1093/ajcn/72.1.257S>.
3. Milman, N. Iron and Pregnancy--a Delicate Balance. *Ann Hematol* 2006, 85 (9), 559-565. <https://doi.org/10.1007/s00277-006-0108-2>.
4. Bencaiova, G.; Burkhardt, T.; Breymann, C. Anemia--Prevalence and Risk Factors in Pregnancy. *Eur J Intern Med* 2012, 23 (6), 529-533. <https://doi.org/10.1016/j.ejim.2012.04.008>.
5. Soma-Pillay, P.; Nelson-Piercy, C.; Tolppanen, H.; Mebazaa, A. Physiological Changes in Pregnancy. *Cardiovasc J Afr* 2016, 27 (2), 89-94. <https://doi.org/10.5830/CVJA-2016-021>.
6. Sanghavi, M.; Rutherford, J. D. Cardiovascular Physiology of Pregnancy. *Circulation* 2014, 130 (12), 1003-1008. <https://doi.org/10.1161/CIRCULATIONAHA.114.009029>.
7. Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging - Journal of the American Society of Echocardiography. [https://www.onlinejase.com/article/S0894-7317\(14\)00745-7/fulltext](https://www.onlinejase.com/article/S0894-7317(14)00745-7/fulltext) (accessed 2026-04-30).
8. Melchiorre, K.; Sharma, R.; Khalil, A.; Thilaganathan, B. Maternal Cardiovascular Function in Normal Pregnancy: Evidence of Maladaptation to Chronic Volume Overload. *Hypertension* 2016, 67 (4), 754-762. <https://doi.org/10.1161/HYPERTENSIONA.115.06667>.
9. Eghbali, M.; Deva, R.; Alioua, A.; Minosyan, T. Y.; Ruan, H.; Wang, Y.; Toro, L.; Stefani, E. Molecular and Functional Signature of Heart Hypertrophy during Pregnancy. *Circ Res* 2005, 96 (11), 1208-1216. <https://doi.org/10.1161/01.RES.0000170652.71414.16>.
10. Hunter, S.; Robson, S. C. Adaptation of the Maternal Heart in Pregnancy. *Br Heart J* 1992, 68 (6), 540-543. <https://doi.org/10.1136/hrt.68.12.540>.
11. Stevens, G. A.; Finucane, M. M.; De-Regil, L. M.; Paciorek, C. J.; Flaxman, S. R.; Branca, F.; Peña-Rosas, J. P.; Bhutta, Z. A.; Ezzati, M.; Nutrition Impact Model Study Group (Anaemia). Global, Regional, and National Trends in Haemoglobin Concentration and Prevalence of Total and Severe Anaemia in Children and Pregnant and Non-Pregnant Women for 1995-2011: A Systematic Analysis of Population-Representative Data. *Lancet Glob Health* 2013, 1 (1), e16-25. [https://doi.org/10.1016/S2214-109X\(13\)70001-9](https://doi.org/10.1016/S2214-109X(13)70001-9).
12. Mann, C. J. Observational Research Methods. Research Design II: Cohort, Cross Sectional, and Case-Control Studies. *Emerg Med J* 2003, 20 (1), 54-60. <https://doi.org/10.1136/emj.20.1.54>.