

Maternal Atrial Remodeling and Diastolic Function in Grand Multiparity: An Echocardiographic Study

Çoklu Gebelik Sayısının Atriyal Yeniden Şekillenme ve Diyastolik Fonksiyonlar Üzerindeki Etkisi: Ekokardiyografik Bir Çalışma

Ömer KÜMET^{1*}, İpek UZALDI², Remzi SARIKAYA¹

¹Health Sciences University Van Training and Research Hospital, Cardiology Department, Van, Türkiye,

omerkumet@hotmail.com

²Medipol University Hospital, Gynecology and Obstetrics Department, İstanbul, Türkiye

*Sorumlu Yazar / Corresponding Author

Received: 10.03.2026
Accepted: 04.08.2026

Abstract

Despite the association between grand multiparity and various maternal health risks, the specific effects on cardiac structure and function during pregnancy are not yet well understood. This study investigates how grand multiparity influences maternal cardiac remodeling, using echocardiographic measurements. In this retrospective study, 288 pregnant women had transthoracic echocardiography. The cohort was split into two groups: low parity (less than 4 pregnancies, n = 193) and grand multiparity (4 or more pregnancies, n = 95). Key echocardiographic parameters, including the left atrial volume index (LAVI), tricuspid annular plane systolic excursion (TAPSE), and left ventricular volumes, were subjected to comparative analysis. The grand multiparity group showed a significantly higher LAVI and end-diastolic volume (EDV). TAPSE was notably lower in grand multiparas, indicating decreased right ventricular systolic function. Parity correlated strongly and positively with LAVI ($p = 0.66$, $p < 0.001$), while negatively with TAPSE ($p = -0.51$, $p < 0.001$). Grand multiparity is associated with changes in maternal cardiac structure and function, such as higher left atrial volume index and reduced right ventricular systolic performance. Echocardiographic assessment helps identify cardiac remodeling in women with multiple pregnancies.

Keywords: Grand multiparity, LAVI, Maternal cardiac remodeling, TAPSE.

Özet

Çoklu gebelik sayısı ile çeşitli anne sağlığı riskleri arasındaki ilişkiye rağmen, gebelik sırasında kalp yapısı ve fonksiyonu üzerindeki kesin etkiler henüz tam olarak anlaşılmamıştır. Bu çalışma ekokardiyografik ölçümler kullanarak çoklu gebeliğin maternal kardiyak yeniden şekillenmesini nasıl etkilediğini araştırmaktadır. Bu retrospektif çalışmada, 288 gebe kadına transtorasik ekokardiyografi uygulandı. Kohort iki gruba ayrıldı: düşük gebelik sayısı (4'ten az gebelik, n = 193) ve çoklu gebelik sayısı (4 veya daha fazla gebelik, n = 95). Sol atriyal hacim indeksi (LAVI), triküspit anüler düzlem sistolik ekskürsiyonu (TAPSE) ve sol ventrikül hacimleri dahil olmak üzere temel ekokardiyografik parametreler karşılaştırmalı analize tabi tutuldu. Çok doğum yapmış grupta, düşük doğum yapmış gruba kıyasla belirgin şekilde daha yüksek LAVI ve diyastol sonu hacmi (EDV) gözlemlendi. TAPSE, çok doğum yapmış kadınlarda belirgin şekilde daha düşüktü. Doğum sayısı, LAVI ile güçlü ve pozitif bir korelasyon gösterirken ($p = 0.66$, $p < 0.001$), TAPSE ile negatif bir korelasyon gösterdi ($p = -0.51$, $p < 0.001$). Yaşa göre düzeltilmiş çok değişkenli lineer regresyon analizlerinde, grand multiparitenin artmış LAVI ve azalmış TAPSE değerleri ile bağımsız olarak ilişkili olduğu gösterildi. Çoklu doğum, daha yüksek sol atriyal hacim indeksi ve azalmış sağ ventriküler sistolik performans gibi maternal kardiyak yapı ve fonksiyon değişiklikleriyle ilişkilidir. Ekokardiyografik değerlendirme, çoklu gebelik geçiren kadınlarda kardiyak yeniden şekillenmeyi ortaya çıkarmaya yardımcı olur.

Anahtar Kelimeler: Çoklu gebelik, LAVI, Maternal kardiyak yeniden şekillenme, TAPSE.

Introduction

Pregnancy causes major changes in the maternal cardiovascular system to support both mother and fetus. Cardiac output typically rises 30–50%, largely from increased stroke volume and heart rate, along with lower systemic vascular resistance. These changes lead to structural and functional adaptations in the heart, known as maternal cardiac remodeling (1,2).

Echocardiography is the key noninvasive method for assessing cardiovascular changes during pregnancy. This method enables comprehensive evaluation of heart chamber size, ventricular function, and atrial changes. Parameters like LAVI, left ventricular volumes, and TAPSE are used to track cardiac adaptation during pregnancy (3). Among these parameters, LAVI reflects chronic diastolic loading conditions and atrial remodeling, whereas TAPSE provides a simple and reproducible assessment of right ventricular systolic performance. Both parameters have emerged as sensitive markers of early cardiac adaptation during pregnancy.

Multiple pregnancies can place increasing hemodynamic demands on the maternal cardiovascular system. Grand multiparity—typically defined as four or more prior pregnancies—is recognized as a risk factor for several maternal health issues, such as hypertensive disorders, anemia, and obstetric complications. Despite these identified risks, the specific effects on cardiac structure and function remain unclear. Notably, some research indicates that repeated exposure to pregnancy-induced cardiovascular load may contribute to ongoing remodeling and elevate long-term cardiovascular disease risk.

Although maternal cardiovascular health is a growing area of interest, data on echocardiographic findings in grand multiparous women during pregnancy remain limited. Previous investigations have generally centered on cardiovascular changes in broader pregnancy populations or in conditions like preeclampsia, rather than specifically addressing the cumulative effects of multiple pregnancies on cardiac anatomy and function. Therefore, further targeted research is necessary to clarify these specific effects.

To our knowledge, few studies have specifically evaluated atrial remodeling and right ventricular systolic function simultaneously in pregnant women with grand multiparity. By focusing on both structural (LAVI and EDV) and functional (TAPSE) echocardiographic

parameters, the present study aims to provide a more comprehensive assessment of maternal cardiac adaptation associated with repeated pregnancies.

Clarifying the effect of parity on maternal cardiac remodeling helps detect possible long-term cardiovascular risks associated with multiple pregnancies (6,7). Echocardiographic markers such as LAVI, left ventricular volumes, and TAPSE are useful for early detection of changes associated with grand multiparity (8).

Accordingly, this study set out to examine how grand multiparity affects maternal cardiac structure and function, with a focus on echocardiographic assessment. Building on the identified gaps, the central hypothesis was that grand multiparity would be linked to changes in diastolic function and atrial remodeling. The research compared essential echocardiographic parameters between women with low and high parity to determine whether repeated pregnancies result in detectable cardiac alterations.

Material and Method

Study Population and Design

This retrospective study was designed at a tertiary hospital that serves as both a cardiology center and a clinic specializing in high-risk pregnancies. Pregnant women who had routine transthoracic echocardiography during pregnancy were screened for eligibility. A total of 288 pregnant women were included. Participants were grouped by parity:

- Low parity group: Women with fewer than four pregnancies (<4 pregnancies, n = 193)
- Grand multiparity group: Women with four or more pregnancies (≥4 pregnancies, n = 95)

Grand multiparity was defined as four or more pregnancies in accordance with previous obstetric and cardiovascular studies evaluating pregnancy-related maternal outcomes (4). Inclusion criteria: confirmed pregnancy, complete clinical and echocardiographic data, and age ≥18 years. Patients were excluded if they had known structural or congenital heart disease, cardiomyopathy, significant valvular disease, or incomplete data. Clinical and lab data—including age, heart rate, blood pressure, gestational week, and biochemistry—were obtained from electronic medical records.

The study adhered to the principles outlined in the Declaration of Helsinki, and approval was

secured from the local ethics committee (Approval: 2022/20-05).

Echocardiographic examination

All participants had standard transthoracic echocardiography by experienced cardiologists using a Philips Epiq 7C system. Measurements were performed in accordance with the guidelines set forth by the American Society of Echocardiography. Left ventricular function, dimensions, volumes, diastolic function, and right heart parameters were recorded. LAVI was measured using the biplane area-length method and subsequently indexed to body surface area.

Statistical analysis

Statistical analyses were performed using Python statistical libraries (pandas, scipy.stats, and statsmodels). Normality of continuous variables was evaluated using the Shapiro–Wilk test. Since the variables were not normally distributed, continuous variables were expressed as median (Q1–Q3). Comparisons between groups were performed using the Mann–Whitney U test. Correlations between parity and

echocardiographic parameters were assessed using Spearman correlation analysis. Separate multivariable linear regression models were constructed for LAVI, TAPSE, and EDV as dependent variables, with grand multiparity and maternal age included as independent variables. Regression assumptions were assessed prior to multivariable analyses. A p-value <0.05 was considered statistically significant.

Results

A total of 288 pregnant women were included in the study. Participants were categorized by parity as low parity (<4 pregnancies, n = 193) or grand multiparity (≥4 pregnancies, n = 95).

Table 1 summarizes the baseline clinical characteristics of the study population. Women in the grand multiparity group were significantly older than those with fewer than four pregnancies (p<0.001). They also had a modestly higher heart rate, whereas systolic blood pressure and gestational age were comparable between the groups.

Table 1. Baseline characteristics and echocardiographic parameters according to parity

Variable	<4 Pregnancies (n=193)	≥4 Pregnancies (n=95)	p-value
Age (year)	27.00 (22.00-34.00)	35.00 (30.50-39.00)	<0.001
Heart Rate (bpm)	83.00 (73.00-93.00)	88.00 (80.50-98.00)	0.001
EF (%)	63.00 (60.00-66.00)	64.00 (60.00-67.00)	0.199
E (cm/sn)	93.00 (80.00-106.00)	89.00 (79.00-104.00)	0.261
A (cm/sn)	54.00 (47.00-61.00)	57.00 (49.00-65.50)	0.021
E' (cm/sn)	12.00 (10.00-14.00)	12.00 (10.00-14.00)	0.200
A' (cm/sn)	7.00 (6.00-8.00)	7.00 (6.00-9.00)	0.596
E/E'	7.57 (6.57-9.38)	7.92 (6.83-9.22)	0.602
EDV (ml)	94.00 (82.00-103.00)	99.00 (88.50-109.00)	0.001
ESV (ml)	46.00 (38.00-53.00)	45.00 (39.00-51.00)	0.403
IVSD (mm)	0.90 (0.80-1.00)	0.98 (0.80-1.00)	0.686
LVEDD (mm)	4.50 (4.20-4.70)	4.50 (4.25-4.80)	0.100
LVESD (mm)	2.80 (2.60-3.10)	2.80 (2.60-3.00)	0.345
FS (%)	36.00 (34.00-40.00)	36.00 (33.00-39.50)	0.344
TAPSE (mm)	22.00 (21.00-24.00)	20.00 (19.00-21.00)	<0.001
LAVI (ml/m ²)	25.00 (23.00-26.00)	29.00 (28.00-31.00)	<0.001

Values are presented as median (Q1–Q3). Comparisons between groups were performed using the Mann–Whitney U test.

EF: Ejection Fraction, EDV: End-diastolic volume, ESV: End-systolic volume, IVSD: Interventricular septum diameter, LVEDD: Left ventricular end-diastolic diameter, LVESD: Left ventricular end-systolic diameter, FS: Fractional shortening, TAPSE: Tricuspid annular plane systolic excursion, LAVI: Left atrial volume index

Grand multiparity was associated with significant changes in cardiac structure and function. Median LAVI values were significantly higher in women with grand multiparity (29.0 [28.0–31.0] vs. 25.0 [23.0–26.0] mL/m², p <0.001), reflecting greater atrial enlargement (Figure 1).

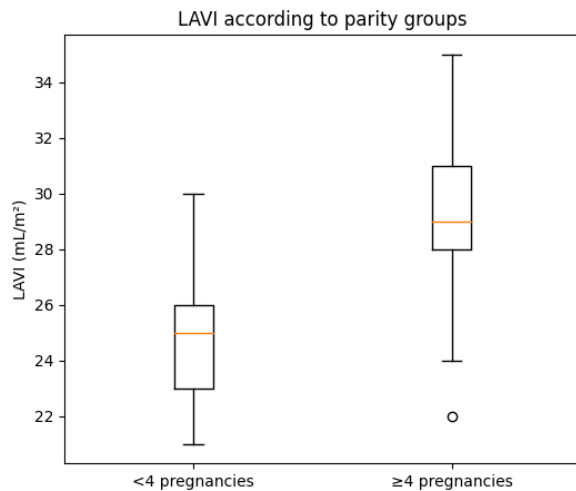


Figure 1. Distribution of left atrial volume index according to parity groups

TAPSE was significantly lower in the grand multiparity group (22.00 [21.00-24.00] mm vs. 20.00 [19.00-21.00] mm, $p < 0.001$), indicating reduced right ventricular systolic function (Figure 2). Left ventricular EDV was also higher in the grand multiparity group (94.00 [82.00-103.00] mL vs. 99.00 [88.50-109.00] mL, $p = 0.001$), further supporting the presence of cardiac remodeling in this group.

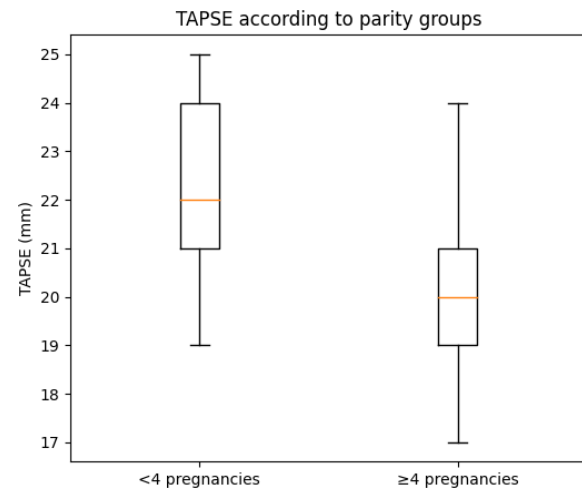


Figure 2. Distribution of TAPSE according to parity groups

Among the diastolic parameters, A wave velocity was higher in the grand multiparity group (54.00 [47.00-61.00] cm/s vs. 57.00 [49.00-65.50] cm/s, $p = 0.02$). No significant differences were seen in left ventricular ejection fraction, E wave velocity, E' velocity, E/E' ratio, LVEDD, LVESD, fractional shortening, IVSD, or ESV. Spearman correlation analysis showed a strong positive correlation between the number of pregnancies and LAVI ($\rho = 0.66$, $p < 0.001$). Conversely, TAPSE showed a moderate negative correlation with the number of pregnancies ($\rho = -0.51$, $p < 0.001$). Weak but statistically significant positive correlations were also observed between the number of pregnancies and EDV ($\rho = 0.22$, $p < 0.001$) and A wave velocity ($\rho = 0.18$, $p = 0.002$).

In age-adjusted multivariable linear regression analyses, grand multiparity remained independently associated with increased LAVI ($\beta = 4.604$, 95% CI: 3.984–5.224, $p < 0.001$), lower TAPSE ($\beta = -1.843$, 95% CI: -2.295 to -1.391, $p < 0.001$), and increased EDV ($\beta = 6.212$, 95% CI: 2.400–10.024, $p = 0.001$) (Table 2).

Table 2. Age-adjusted multivariable linear regression analysis evaluating the association between grand multiparity and echocardiographic parameters

Outcome	Variable	β coefficient (95% CI)	p-value
LAVI	Grand multiparity	4.604 (3.984–5.224)	<0.001
	Maternal age	0.019 (-0.022–0.060)	0.364
TAPSE	Grand multiparity	-1.843 (-2.295 to -1.391)	<0.001
	Maternal age	-0.025 (-0.055 to 0.005)	0.099
EDV	Grand multiparity	6.212 (2.400–10.024)	0.001
	Maternal age	-0.131 (-0.384 to 0.123)	0.311

TAPSE: Tricuspid annular plane systolic excursion, LAVI: Left atrial volume index, EDV: End diastolic volume

Footnote: Separate multivariable linear regression models were constructed for LAVI, TAPSE, and EDV. Maternal age was included in all models as an adjustment variable. β coefficients represent unstandardized regression coefficients.

Discussion

The present study evaluated the impact of grand multiparity on maternal cardiac structure and function using echocardiographic parameters. The main findings of this study were that women with four or more pregnancies exhibited significantly higher left atrial volume index (LAVI), higher left ventricular end-diastolic volume (EDV), increased A wave velocity, and lower tricuspid annular plane systolic excursion (TAPSE) compared with women with fewer pregnancies. The persistence of these associations after age adjustment supports the independent relationship between grand multiparity and maternal cardiac remodeling. These results show that repeated pregnancies may be associated with measurable changes in maternal cardiac remodeling.

Pregnancy produces notable functional adaptations in the maternal cardiovascular system. These adaptations include increased blood volume, increased cardiac output, and reduced systemic vascular resistance, which together result in structural and functional remodeling of the heart (1,9). Echocardiographic studies have demonstrated that pregnancy is associated with increases in left ventricular dimensions and atrial size, indicating a volume-overload state during gestation (2).

The principal finding of the current study was the significant increase in LAVI in women with grand multiparity. Left atrial enlargement is recognized as a significant indicator of chronic volume overload and diastolic dysfunction. Previous studies have shown that LAVI may progressively increase during pregnancy due to elevated preload and changes in ventricular filling dynamics (10,11). The strong correlation observed between the number of pregnancies and LAVI in our study further supports the hypothesis that repeated pregnancies may lead to long-term atrial remodeling.

Another notable finding of our study was the reduction in TAPSE in women with grand multiparity. TAPSE is widely used as a simple and reliable indicator of right ventricular systolic function. Although most physiological pregnancies are not associated with overt right ventricular dysfunction, subtle changes in right ventricular mechanics have been reported in previous echocardiographic studies of pregnancy (12). The lower TAPSE values observed in the grand multiparity group in our study may reflect mild alterations in right ventricular adaptation resulting from repeated hemodynamic stress.

In addition, we observed significantly higher left ventricular EDV in women with grand multiparity. Increased ventricular volumes during pregnancy are generally considered part of normal cardiovascular adaptation and reflect the volume-loaded state of gestation (9). However, repeated exposure to such physiological volume overload across multiple pregnancies may lead to progressively more pronounced ventricular remodeling over time.

Interestingly, most other echocardiographic parameters, including left ventricular ejection fraction, LV dimensions, and E/E' ratio, were similar between the two groups. This suggests that although repeated pregnancies may lead to subtle structural and functional changes, overall systolic function remains largely preserved in most women.

Therefore, the observed alterations may primarily represent adaptive physiological remodeling rather than established pathological cardiac dysfunction. Longitudinal studies are required to determine whether these changes persist after pregnancy or are associated with future cardiovascular events.

The results of this study may possess significant clinical implications. Increasing evidence suggests that reproductive history, including parity, may be associated with long-term cardiovascular risk in women (13). Observing early echocardiographic markers of cardiac remodeling, such as increased LAVI or altered right ventricular function, may therefore help improve cardiovascular risk assessment in women with a history of multiple pregnancies. Despite the focus on diastolic function, conventional Doppler indices, such as E/E', did not show significant differences between groups, suggesting that atrial remodeling may precede overt diastolic dysfunction.

Although our findings do not support routine echocardiographic screening solely based on parity, they suggest that grand multiparity may be considered during cardiovascular risk assessment, particularly in women with additional cardiovascular risk factors or pregnancy-related complications. These findings should be interpreted within the context of physiological cardiovascular adaptation during pregnancy and should not be considered evidence of clinically significant cardiac disease in otherwise healthy women.

Study limitations

Several limitations of this study may be recognized. Firstly, this was a retrospective, single-center study, which may constrain the generalizability of the findings. Second, echocardiographic measurements were obtained at a single time point during pregnancy, and longitudinal follow-up data were not available. The observational nature of the study precludes causal inference. Third, other potential confounding variables, such as heart rate and gestational age, were not included in the multivariable models. Future prospective studies with larger sample sizes and longitudinal follow-up are essential to further elucidate the relationship between parity and maternal cardiac remodeling.

Conclusion

In conclusion, grand multiparity was associated with increased left atrial volume index, larger left ventricular EDV, and lower TAPSE during pregnancy. These findings suggest subtle maternal cardiac remodeling rather than overt cardiac dysfunction. Incorporating reproductive history into cardiovascular risk assessment may improve identification of women who could benefit from closer clinical follow-up. Further prospective multicenter longitudinal studies are warranted to confirm these findings.

Acknowledgements

The authors have no acknowledgements.

Conflict of interest statement

There is no conflict of interest among the authors.

Ethics Committee Approval

The study received local ethics committee approval. Approval was obtained from the Health Sciences University Van Training and Research Hospital Clinical Research Ethics Committee with document number 2022/20-05 dated 21.09.2022.

Funding

No funding was used for this study.

References

1. Lan L, Zhang C, Geng J, et al. Echocardiographic assessment of the maternal heart: Structural and

functional changes during pregnancy. *Echocardiography*. 2025;42(6).

2. Ferreira AF, Araújo J, Azevedo M, et al. Cardiovascular remodelling and reverse remodelling during pregnancy and postpartum: Looking at the right side. *Pregnancy Hypertens*. 2024; 38: 101171.

3. Giorgione V, Kitt J, Leeson P, et al. Cardiac dysfunction during adverse maternal outcomes in hypertensive disorders of pregnancy. *Acta Obstet Gynecol Scand*. 2026;105(2):280-7.

4. Aggarwal SR. Parity and cardiovascular disease [master's thesis]. Winston-Salem (NC): Wake Forest University; 2015. p. 1-10.

5. Sonaglioni A, Napoli F, Dell'Anna R, et al. Comprehensive assessment of biventricular and biatrial myocardial strain parameters at six years postpartum in a cohort of women with previous hypertensive disorders of pregnancy. *J Clin Med*. 2025;14(13):4767.

6. Melchiorre K, Sharma R, Thilaganathan B. Cardiovascular implications in preeclampsia: An overview. *Circulation*. 2014;130(8):703-14.

7. Sanghavi M, Rutherford JD. Cardiovascular physiology of pregnancy. *Circulation*. 2014;130(12):1003-8.

8. Regitz-Zagrosek V, Roos-Hesselink JW, Bauersachs J, et al. 2018 ESC guidelines for the management of cardiovascular diseases during pregnancy: The task force for the management of cardiovascular diseases during pregnancy of the European Society of Cardiology (ESC). *Eur Heart J*. 2018;39(34):3165-241.

9. Savu O, Jurcuț R, Giuscă S, et al. Morphological and functional adaptation of the maternal heart during pregnancy. *Circ Cardiovasc Imaging*. 2012;5(3):289-97.

10. Xiang Q, Wei Y, Li Z, et al. Longitudinal assessment of maternal echocardiographic changes in singleton versus twin pregnancies and their association with preeclampsia risk. *Hypertens Res*. 2025;48(10):2701-13.

11. Sonaglioni A, Sutti I, Ferrara G, et al. Cardiac and vascular adaptation during pregnancy in Asian and Caucasian women: Insights from a prospective cohort study. *J Clin Med*. 2026;15(2):756.

12. Kampman MA, Valente MA, van Melle JP, et al. Cardiac adaptation during pregnancy in women with congenital heart disease and healthy women. *Heart*. 2016;102(16):1302-8.

13. Beale AL, Cosentino C, Segan L, et al. The effect of parity on exercise physiology in women with heart failure with preserved ejection fraction. *ESC Heart Fail*. 2020;7(1):214-23.

14. Buddeberg BS, Sharma R, O'Driscoll JM, et al. Impact of gestational diabetes mellitus on maternal cardiac adaptation to pregnancy. *Ultrasound Obstet Gynecol*. 2020;56:240-6.