

## Communication

# Utility of Ambulatory Non-Invasive Rhythm Monitoring in Pregnant Patients with Palpitations and Structurally Normal Hearts

Diana Kline<sup>1,†</sup>, Merrina Lan<sup>1,†</sup>, Matthew Granger<sup>2</sup>, Lauren Hassen<sup>2</sup> and William H. Marshall V<sup>2,\*</sup>

<sup>1</sup> College of Medicine, The Ohio State University, Columbus, OH 43210, USA; diana.kline@northwestern.edu (D.K.); merrina.lan@osumc.edu (M.L.)

<sup>2</sup> Division of Cardiovascular Medicine, Department of Internal Medicine, The Ohio State University, Columbus, OH 43210, USA; matthew.granger@osumc.edu (M.G.); lauren.hassen@osumc.edu (L.H.)

\* Corresponding author. E-mail: william.marshall@osumc.edu (W.H.M.V.)

† These authors contributed equally to this work.

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**ABSTRACT:** Ambulatory Cardiac Monitoring (ACM) is often used to evaluate pregnant patients with palpitations without structural heart disease; however, the diagnostic yield is not well defined. This single-center retrospective cohort study included pregnant patients without structural heart disease evaluated in a tertiary care cardio-obstetrics clinic between June 2023 and June 2024. The primary outcome was the detection of a clinically significant arrhythmia. Secondary outcomes included symptom–rhythm correlation and adverse maternal cardiac, obstetric, and fetal outcomes. Out of 124 patients identified, 49 (40%) completed ACM. Two patients had symptomatic clinically significant arrhythmias detected on ACM, including non-sustained ventricular tachycardia that did not alter management ( $n = 1$ ), and symptomatic supraventricular tachycardia (SVT) resulting in medical therapy ( $n = 1$ ). Palpitations occurred during monitoring in 35 of the 49 remaining monitored patients; of those, symptoms correlated with non-significant arrhythmias (premature atrial and ventricular contractions) in 11 (31%). No adverse cardiac events occurred in the remaining patients. Obstetric and fetal outcomes did not differ between monitored and unmonitored patients. In this small single center study, ACM in pregnant patients without structural heart disease has a low diagnostic yield. These findings could be used in shared decision-making for pregnant patients being evaluated for palpitations.

**Keywords:** Pregnancy; Palpitations; Arrhythmia; Ambulatory cardiac monitoring; Supraventricular tachycardia; Cardio-obstetrics; Maternal cardiovascular health

## 1. Introduction

Cardiovascular disease is the leading cause of death in pregnant and postpartum patients [1], which has brought increasing attention to maternal cardiovascular health. One common cardiac symptom that leads to cardiology referral during pregnancy is palpitations. While some arrhythmias may occur during normal pregnancy, symptoms raise concern for the well-being of the patient and fetus [2,3]. Supraventricular



tachycardia (SVT) is the most common arrhythmia during pregnancy and may be associated with an increased risk of Cesarean delivery and preterm labor [4], and arrhythmias during pregnancy that lead to hospitalization are associated with maternal mortality and complications [5].

Ambulatory cardiac monitoring (ACM) can be used to evaluate symptomatic patients, and in pregnant patients with structural heart disease, it has high clinical utility in detecting arrhythmias [6,7]. However, many patients with palpitations during pregnancy do not have structural heart disease. To our knowledge, cardiac monitoring in the population has not been studied since 1997 [3]. Furthermore, little is known about the yield of cardiac monitoring in pregnant patients without heart disease and the factors that predict the likelihood of detecting abnormalities from monitoring. Because continuous cardiac monitoring can impose patient burdens and facility costs [8], clinicians may consider monitoring for patients who are more likely to benefit from it.

Given the lack of current data on the efficacy of ACM in pregnant patients without preexisting heart disease, this study aims to evaluate the frequency of clinically significant arrhythmias in pregnant patients without structural heart disease and determine how cardiac monitoring impacts clinical management.

## 2. Methods

### 2.1. Study Design

We performed a single-center, retrospective cohort study of pregnant patients with palpitations seen at the cardio-obstetrics clinic at The Ohio State University Wexner Medical Center from June 2023 to June 2024, with follow-up available through January 2025. The Ohio State University's Biomedical Institutional Review Board (IRB) approved this study.

### 2.2. Patient Identification, Classification, and Data Collection

Patients were included if they were pregnant at the time of evaluation, had no structural heart disease according to chart documentation, and if a transthoracic echocardiogram (TTE, obtained at the treating provider's discretion) revealed a structurally normal heart (defined as normal biventricular size and systolic function with no more than mild valvular disease, including mitral valve prolapse) at the initial evaluation. Thus, patients with more than mild valvular regurgitation or stenosis, congenital heart disease, or pacemakers were excluded.

Baseline characteristics were collected from the medical record and included: maternal age at initial visit, gravidity, parity, race, pre-pregnancy body mass index, pre-pregnancy comorbidities, New York Heart Association (NYHA) functional class during pregnancy, medical therapy during pregnancy, and mode of delivery (cesarean section, vaginal delivery). While a cardiac history was recorded at initial presentation, detailed symptom characterization was not uniformly available due to the retrospective study design and variable documentation. Laboratory data, electrocardiogram, and cardiac monitor findings during pregnancy closest to the initial cardio-obstetric visit were recorded.

TTE data were obtained from the report in the medical record. Left and right ventricular systolic function, ventricular size, and valvular disease were determined based on consensus guidelines [9,10]. TTE and ACM were obtained at the discretion of the treating physician.

During the study time period, our institution utilized Boston Scientific Cardiac Diagnostics, Inc. (Houston, TX, USA), a subsidiary of Boston Scientific Corporation (Marlborough, MA, USA), for ACM. Based on the indication and clinician discretion, ACM included holter monitors, mobile cardiac telemetry, or event monitors, all of which have preset arrhythmia-activated recording as well as patient activated events, with holter monitors and mobile cardiac telemetry also calculating the burden of arrhythmias. Monitoring ranged from 24 h to 30 days, based on the physician's discretion and symptom frequency. All

recordings were reviewed by the prescribing cardiologist. Data were recorded from the monitor results in the chart by the authors, D.K. and M.L.

### 2.3. Outcomes Studied

The primary outcome evaluated was diagnosis of a significant arrhythmia on ACM; consistent with prior reports [6], this included: SVT, atrial fibrillation, atrial flutter, atrial tachycardia, ventricular tachycardia (sustained or non-sustained), symptomatic bradycardia, and second-degree type 2 or third-degree atrioventricular block. Sustained arrhythmias were those that lasted >30 s and/or required treatment.

Secondary outcomes studied included the frequency of symptom correlation with any arrhythmia (including premature atrial complexes [PACs] and premature ventricular complexes [PVCs]) on ACM.

Finally, maternal cardiac, obstetric, and fetal outcomes (detailed below) were compared between the groups with and without ACM. Adverse maternal cardiac outcomes (during pregnancy or 6 months postpartum) included hospitalization for cardiac cause, heart failure (defined as a chart diagnosis of heart failure and/or report of dyspnea and volume overload treated with diuretics), stroke, and death. Obstetric outcomes (defined by the medical record) included gestational hypertension, pre-eclampsia, eclampsia, chorioamnionitis, and postpartum hemorrhage [11]. Fetal outcomes included birth weight, miscarriage (spontaneous pregnancy loss before 20 weeks of gestation) [12], preterm birth (delivery occurring before 37 weeks of gestation) [13], fetal demise (intrauterine fetal death at or beyond 20 weeks of gestation) [14], and neonatal mortality (death of a liveborn infant occurring within the first 28 days of birth) [15].

### 2.4. Statistical Analysis

Categorical data are presented as frequencies and percentages, and compared using chi-square tests. Continuous variables are reported as median (interquartile range [IQR]). The Shapiro-Wilk test of normality was performed, and the Mann-Whitney U tests were used to compare the two groups for non-normally distributed variables. A two-tailed *t*-test of unequal variance was used for normally distributed variables. *p*-values < 0.05 were considered statistically significant. Analyses performed with IBM SPSS statistics version 29.0.2.0 (20).

## 3. Results

### 3.1. Baseline Characteristics

We identified 127 pregnant people with palpitations, 124 of whom met the inclusion criteria (Figure 1). The median age at initial visit was 30 (25–33) years, and the majority (73 (59%)) of patients identified as non-Hispanic white. Chronic hypertension was present in 15 (12%), hyperlipidemia in 6 (5%), and 61 (49%) previously had a cardiac evaluation, most commonly for palpitations, postural orthostatic tachycardia syndrome (POTS), and syncope (Table 1).

Of the 124 patients, 49 (40%) completed ACM, ranging from one to 30 days, for a total of 493 total days of monitoring. There were 75 (60%) patients who did not complete cardiac monitoring, either because the physician did not feel cardiac monitoring was necessary (*n* = 64), the patient had previously had unremarkable monitoring (*n* = 7), or the monitor was ordered but not completed by the patient (*n* = 4) (Table 1).

No significant differences in baseline characteristics were found between the monitored and unmonitored groups (Table 1). Echocardiography results were available for most patients (113 (91%) overall, 45 (92%) of monitored group, 66 (88%) un-monitored group) with a median left ventricular ejection fraction of 65 (60–65)% (Table 2).

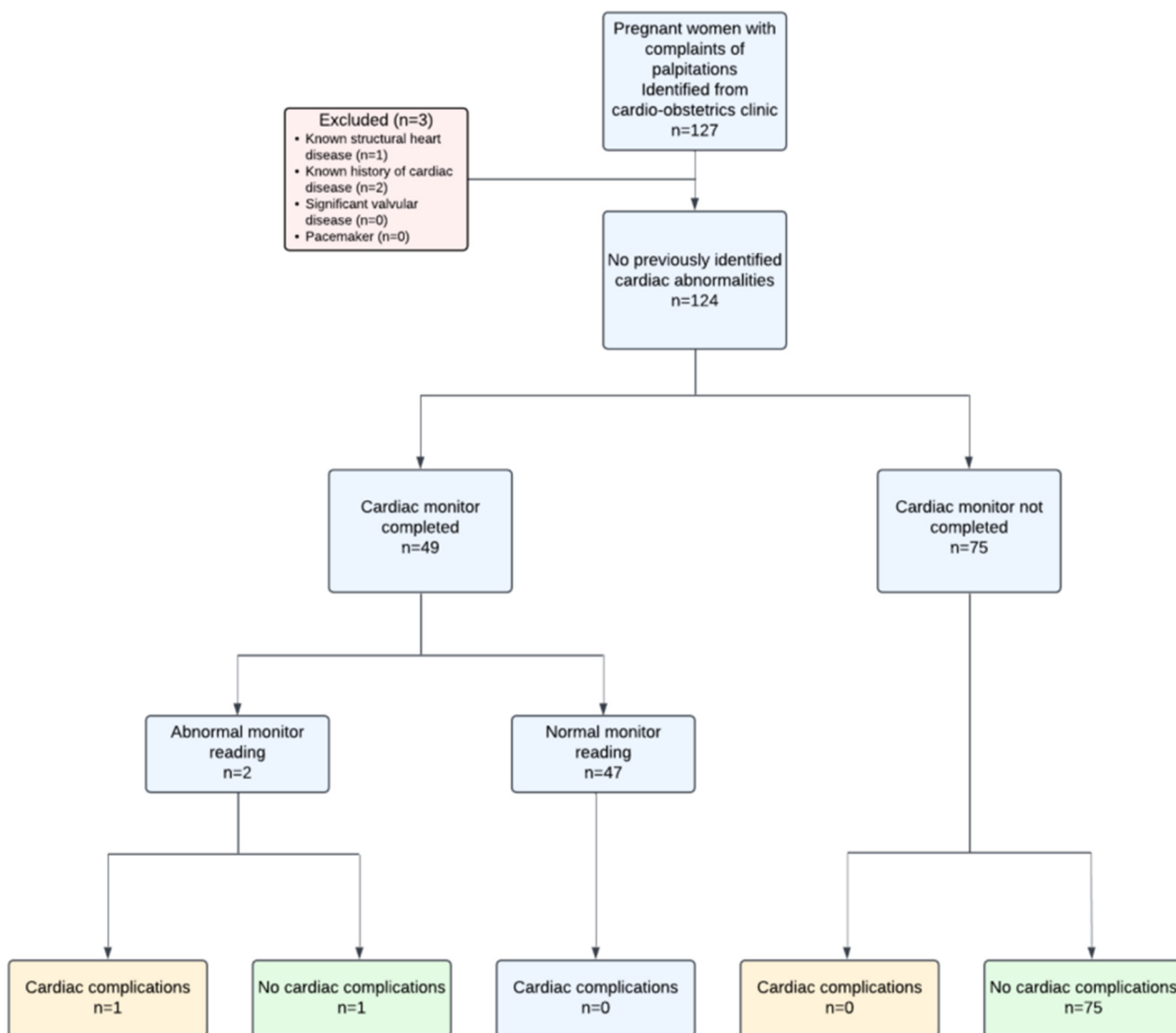


Figure 1. Study design, inclusion, and exclusion criteria.

Table 1. Baseline characteristics, Maternal fetal outcome.

	All Patients (n = 124) <sup>a</sup>	ACM Group (n = 49) <sup>b</sup>	No ACM Group (n = 75) <sup>c</sup>	p-Value (Group 1 vs. Group 2)
Age (years)	30 (25, 33)	30 (25, 34)	30 (25, 33)	0.87
GA at cardiology visit (weeks)	25 (18, 33)	25 (17, 30)	25 (19, 34)	0.44
Maternal race				
Non-Hispanic black	24 (19)	11 (22)	13 (17)	0.48
Non-Hispanic white	73 (59)	27 (55)	46 (61)	1
Hispanic	10 (8)	5 (10)	5 (7)	1
Other	17 (14)	7 (14)	10 (13)	1
Gravida	2 (1, 3)	1 (1, 3)	2 (1, 3)	0.79
Para	1 (0, 2)	1 (0, 2)	0 (0, 1)	0.2
Body mass index (kg/m <sup>2</sup> )	26 (23, 34)	29 (24, 34)	26 (23, 33)	0.12
Chronic hypertension	15 (12)	8 (16)	7 (9)	1
Hyperlipidemia	6 (5)	3 (6)	3 (4)	1
Type 1 DM	1 (1)	0 (0)	1 (1)	1
Type 2 DM	5 (4)	2 (4)	3 (4)	1
Anxiety	50 (40)	23 (47)	27 (36)	1

Depression	43 (35)	14 (29)	29 (39)	1
Hyperthyroidism	2 (2)	2 (4)	0 (0)	1
Hypothyroidism	10 (8)	1 (2)	9 (12)	1
Prior cardiac evaluation or diagnosis	61 (49)	21 (43)	40 (53)	1
Reason for prior cardiac evaluation, <i>n</i> (%)				
SVT	7 (6)	3 (6)	4 (5)	1
Murmur	3 (2)	1 (2)	2 (3)	1
POTS/syncope	21 (17)	4 (8)	17 (22)	1
Palpitations	13 (10)	6 (12)	7 (9)	1
Arrhythmia/irregular rhythm	6 (5)	5 (10)	1 (1)	1
Tachycardia	11 (9)	4 (8)	7 (9)	1
PAC/PVC	6 (5)	3 (6)	3 (4)	1
Cardiac Outcomes, <i>n</i> (%)				
Hospitalization for cardiac cause during pregnancy or 6 months postpartum	1 (1)	1 (2)	0 (0)	1
Heart failure during pregnancy or within 6 months postpartum	1 (1)	1 (2)	0 (0)	1
Stroke	0 (0)	0 (0)	0 (0)	1
Death	0 (0)	0 (0)	0 (0)	1
Obstetric Outcomes, <i>n</i> (%)				
Delivery mode				
Vaginal	79 (64)	33 (67)	46 (61)	1
Cesarean Section	41 (33)	13 (27)	28 (37)	1
Gestational hypertension	24 (19)	9 (19)	15 (20)	1
Pre-eclampsia	16 (13)	8 (16)	8 (11)	1
Postpartum hemorrhage	8 (6)	1 (2)	7 (9)	1
Chorioamnionitis	3 (2)	2 (4)	1 (1)	1
Fetal Outcomes, <i>n</i> (%)				
Miscarriage	2 (2)	1 (2)	1 (1)	1
Stillbirth	0 (0)	0 (0)	0 (0)	1
Preterm delivery	14 (11)	5 (10)	9 (12)	1
Gestational age (weeks)	39 (38, 39)	39 (38, 39)	39 (38, 40)	0.15
Twin gestation	2 (2)	0 (0)	2 (3)	1
Low birth weight	12 (10)	3 (6)	9 (12)	1
Neonatal mortality	0 (0)	0 (0)	0 (0)	1

Continuous variables are presented as median (Interquartile range). Categorical variables are presented as *n* (% of cohort). SVT: Supraventricular Tachycardia; POTS: Postural Orthostatic Tachycardia Syndrome; PAC: Premature Atrial Contraction; PVC: Premature Ventricular Contraction; <sup>a</sup> Unknown baseline characteristics in all patients: gestational age, *n* = 1; race, *n* = 1; BMI, *n* = 15. Unknown maternal fetal outcome in all patients: *n* = 3. <sup>b</sup> Unknown baseline characteristics in all patients with monitor: BMI, *n* = 7. Unknown maternal fetal outcome in all patients with monitor: *n* = 2; induced abortion due to trisomy 18: *n* = 1. <sup>c</sup> Unknown baseline characteristics in all patients without monitor: gestational age, *n* = 1; race, *n* = 1; BMI, *n* = 8. Unknown maternal fetal outcome in all patients without monitor: *n* = 1.

**Table 2.** Echocardiographic data.

<b>All Patients (<i>n</i> = 124) <sup>a</sup> ACM Group (<i>n</i> = 49) <sup>b</sup> No ACM Group (<i>n</i> = 75) <sup>c</sup> <i>p</i>-Value (Group 1 vs. Group 2)</b>				
Echocardiographic data				
Gestational age at echo	24 (18, 29)	24 (18, 28)	24 (18, 30)	0.99
LV size				
LV normal	111 (98)	45 (96)	66 (100)	1.00
LV enlarged	2 (2)	2 (4)	0 (0)	
LVEF (%)	65 (60, 65)	60 (60,65)	65 (60,65)	0.71
RV size				

RV enlarged	8 (7)	3 (6)	5 (8)	1
RV normal	105 (93)	44 (92)	61 (92)	
LA size				
LA normal	104 (92)	43 (91)	61 (92)	1
LA enlarged	9 (8)	4 (8)	5 (8)	
RA size				
RA normal	110 (97)	45 (96)	65 (98)	1
RA enlarged	3 (3)	2 (4)	1 (2)	
TR velocity (m/s)	2.1 (2, 2.3)	2.1 (1.9, 2.3)	2.1 (2.01, 2.3)	0.53
RVSP (mmHg)	20 (19, 24)	21 (19, 24.8)	20 (19, 24)	0.66

LV: left ventricle; LVEF: left ventricle ejection fraction; RV: right ventricle; RA: right atrium; TR: tricuspid regurgitation; RVSP: Right Ventricular Systolic Pressure.<sup>a</sup> Unknown echocardiogram data in all patients:  $n = 11$ . <sup>b</sup> Unknown echocardiogram data in all patients with ACM:  $n = 2$ . <sup>c</sup> Unknown echocardiogram data in all patients without ACM:  $n = 9$ .

### 3.2. Diagnosis of Arrhythmia

Only 2 out of 49 (4%) patients who completed ACM yielded clinically significant arrhythmias. The first patient presented at 17 weeks of gestation with a self-reported history of recurrent SVT, with comorbidities of chronic hypertension, type 2 diabetes, and anxiety disorder. Echocardiogram revealed normal biventricular size and systolic function with no significant valve disease, and 14-day ACM revealed <1% burden PAC, <1% burden PVC, and a single episode of non-sustained ventricular tachycardia (NSVT), lasting 7 beats, at 220 beats per minute. Arrhythmias correlated with symptoms only 29% of the time and did not lead to changes in clinical management. The patient had a preterm delivery at 36 weeks and 5 days due to pre-eclampsia, and the patient did not have any cardiac complications.

The second patient presented to the clinic at 30 weeks' gestation with complaints of dizziness and palpitations that began during pregnancy. Electrocardiogram from a prior hospitalization showed frequent PACs and SVT with right bundle branch aberration. The most recent echocardiogram prior to the visit showed normal biventricular size and systolic function and no significant valve disease, and 7 day ACM showed frequent PACs with a 27% burden, a 2% PVC burden, and frequent paroxysmal SVT. She was subsequently started on metoprolol, which controlled her symptoms. After a Cesarean delivery at 34 weeks in the setting of preterm premature rupture of membranes, she was seen 5 days postpartum in the hospital with sustained SVT resulting in clinical heart failure in the setting of missed metoprolol doses. She was treated with adenosine, and metoprolol was restarted with verapamil added to control the SVT. Heart failure symptoms improved with diuretic therapy, and arrhythmias remained well controlled thereafter.

### 3.3. Correlation of Arrhythmia with Symptoms

Symptoms of palpitations were reported in 35 of the 49 (71%) patients who completed ACM, of which 8 of 35 (23%) correlated with arrhythmias, including PVCs ( $n = 7$ ), PACs ( $n = 2$ ), NSVT ( $n = 1$ ) (one patient had PAC, PVC, and NSVT). Additionally, 7 of 35 (20%) of patient-reported symptoms correlated with sinus tachycardia.

### 3.4. Cardiac, Obstetric, and Fetal Outcomes

Of the 47 (96%) patients with normal cardiac monitor readings and the 75 without ACM, none developed documented cardiac complications. There were no instances of stroke or maternal death during pregnancy or 6 months postpartum. Delivery mode and obstetric outcomes are reported in Table 1, with no significant differences between those with ACM and those without. Complete data on fetal outcomes were available in 94% of the monitored patients and 92% of the unmonitored patients, with no significant differences between the groups (Table 1).

## 4. Discussion

In this contemporary cohort of pregnant patients with structurally normal hearts evaluated for palpitations, we demonstrate that (1) non-invasive ambulatory cardiac monitoring without structural heart disease or prior significant arrhythmia has a low diagnostic yield and (2) only ~30% of patients with symptoms and any arrhythmia correlate on ACM, and most were not clinically significant. However, in patients with a significant history of arrhythmias, ACM may inform treatment.

The prior study evaluating ACM during pregnancy showed an increased incidence of arrhythmia in 110 pregnant patients compared to controls, but identified mostly PVCs and PACs. There was a low association between symptoms and arrhythmias, with only 10% of symptomatic episodes accompanied by an arrhythmia [3]. In our cohort, 29% did not have symptoms while wearing the ACM, and of the patients with symptoms, 23% had some arrhythmia with symptoms, though, as noted, only 2 were significant, and only 1 prompted medical therapy. Furthermore, 1/4 had only sinus tachycardia when reporting symptoms; this may be the result of physiologic hemodynamic changes associated with pregnancy [16].

Consensus guidelines recommend that the initial evaluation of a pregnant patient with palpitations should include a detailed cardiac history and characterization of symptoms, which can indicate who may benefit from further testing [17]. Data from our study support this targeted approach for patient selection for ACM. Based on our patient experience, ACM should be pursued in symptomatic patients with a prior arrhythmia; however, in patients without prior history, it may be possible to defer ACM. Prior studies of patients who experience SVT during pregnancy support this approach, as the majority have a known pre-pregnancy SVT history [4,18]. Clinicians may counsel patients about the low correlation between reported symptoms and clinically significant arrhythmias and reassure them that the vast majority of ACM results have low clinical impact. After a shared decision-making conversation, especially in the presence of financial constraints, inconvenience, or adhesive allergies, our data suggests that monitoring could be safely deferred in most patients. However, this does not render the test without value; many patients may still find reassurance from the absence of documented arrhythmias or from the correlation of symptoms with benign ectopy.

## 5. Limitations

Though not recommended for all patients to evaluate palpitations unless there is concern for underlying structural heart disease, in this real-world cohort, echocardiography was performed in the majority of patients. Though this limits the generalizability of ACM results, it is also a strength of the study, as it assures this cohort did not have significant underlying structural abnormalities. There are several other limitations of this study, including the non-randomized study design. Given this, ACM and TTE data were obtained at the discretion of the treating provider, and we did not have a non-pregnant control group to use for comparison. Data were collected retrospectively from medical records and were subject to inter-reader variability, and some patients had missing data due to unavailable records from outside hospitals. Detailed palpitation history prior to the initial clinic visit was not consistently documented, which limited how symptom history may have influenced ACM utilization and the subsequent diagnostic yield. Due to the retrospective nature of the study, with a limited sample size (only 49 patients completed ACM), the statistical power to detect differences in clinical outcomes is limited. Additionally, since this is a single cardio-obstetrics center with referrals from other hospitals, the patient demographics may not be generalizable to all institutions.

## 6. Conclusions

In this cohort of pregnant patients without structural heart disease, ACM demonstrated a low diagnostic yield for clinically significant arrhythmias. Furthermore, while 23% of patients reported symptoms with correlated rhythm abnormality, only 2 were clinically significant, and ACM likely has higher utility for

patients with prior arrhythmia history. Though they require validation in larger randomized studies, these outcomes support a selective approach to ACM in low-risk patients that is guided by symptom history. These findings suggest that ACM for pregnant patients without preexisting arrhythmia or structural heart disease presenting for palpitations may safely be deferred.

### Author Contributions

The authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and for the interpretation discussed. Concept/design: D.K., M.L., W.H.M.V. and L.H.; Data collection: M.G., D.K. and M.L.; Drafting and writing of article: D.K., M.L. and W.H.M.V.; Data analysis/interpretation: D.K., M.L. and W.H.M.V.

### Ethics Statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board of The Ohio State University (study ID 2023H0313; Approval 12/19/23).

### Informed Consent Statement

The Ohio State University Biomedical Institutional Review Board approved this study with waived consent (study ID 2023H0313; Approval 12/19/23).

### Data Availability Statement

The retrospective data used to support the findings of this study are restricted by the institutional review board in order to protect patient privacy. Data are available from the corresponding author for researchers who meet the criteria for access to confidential data.

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### Declaration of Competing Interest

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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