Journal of the Saudi Heart Association

Manuscript 1465

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Abstract

Cardiovascular disease complicates pregnancy and elevates maternal and fetal risks. Local data in Saudi Arabia is scarce. This study examines pregnancy outcomes in women with cardiovascular disease at a tertiary center. A retrospective cohort study of 103 cardio-obstetric patients (2015−2023) at King Khalid University Hospital. Multivariable logistic regression identified risk factors for adverse maternal and neonatal outcomes, with significance at $p < 0.05$. The cohort (mean age = 35.5 ± 5.03 years, mean BMI = 31.33 ± 6.32 kg/m^2) had high rates of hypertension (45.6 %) and preterm delivery (<37 weeks: 37/101, 36.6 %). Maternal hypertension occurred in 14.7 % (15/102). Neonatal outcomes included NICU admission (15.7 %, 16/102) and fetal loss (6.8 %, 7/103). Multivariable analysis revealed that a history of preeclampsia increased the odds of preterm birth (OR = 7.29, 95 % CI [2.16−24.63], p = 0.001), maternal hypertension (OR = 8.38, 95 % CI [1.90−36.97], p < 0.01), and NICU admission (OR = 6.98, 95 % CI [1.78−27.40], p < 0.01). Pre-existing diabetes (Types I/II) was associated with preterm birth (OR = 7.74, 95 % CI [1.70−35.24], p < 0.01). A higher BMI independently increased the odds of maternal hypertension (OR = 1.14 per unit, 95 % CI [1.01−1.28], p < 0.05). Bivariate analysis indicated that autoimmune disease increased the risk of low APGAR scores (0−6: 57.1 % vs. 11.1 %, p = 0.008), and prior cardiac procedures increased the risk of fetal loss (18.8 % vs. 4.6 %, p = 0.039). A history of preeclampsia, diabetes, and elevated BMI is a critical risk factor. Multidisciplinary preconception counseling and stringent antenatal monitoring are essential for this high-risk.

Keywords: Cardiovascular disease, Pregnancy outcome, Maternal health, Saudi Arabia, Preterm birth, Cardio-obstetrics

1. Introduction

Cardiovascular disease (CVD) is a major risk in pregnancy and remains one of the leading non-obstetric causes of maternal death [1−3]. CVD contributes to up to 15 % of pregnancy-related fatalities and complicates 1−4% of all pregnancies [4]. Pregnancy induces profound physiological changes, yet distinguishing normal adaptations from pathological responses is crucial. Hemodynamic adjustments are central to pregnancy physiology but impose strain on the cardiovascular system, and in women with structural or functional lesions, they may precipitate congestive heart failure [3]. Such patients carry a markedly higher risk of adverse maternal and fetal outcomes [5].

In its 2019 Practice Bulletin, the American College of Obstetricians and Gynecologists identified obesity, hypertension, advanced maternal age, and race or ethnicity as the four major determinants of cardiovascular mortality in pregnancy and the postpartum period [6]. Recognizing the scale of this

Received 7 October 2025; revised 23 October 2025; accepted 25 October 2025.
Available online 22 November 2025

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https://doi.org/10.37616/2212-5043.1465

burden, multiple professional societies, including the American College of Cardiology, the American Heart Association, the European Society of Cardiology, and the Canadian Cardiovascular Society, have issued dedicated guidelines for management [7]. Despite these efforts, nearly half of severe cardiac events in pregnancy, including maternal deaths, are considered preventable, with failures in clinical recognition and provider management accounting for most avoidable outcomes [8].

Local evidence remains sparse. At King Khalid University Hospital (KKUH) in Riyadh (1993–1997), review of 33,320 pregnancies found CVD in 0.5 % of women, most often valvular lesions, particularly mitral valve prolapse. Despite the burden of valvular disease, no cases of infective endocarditis, infant mortality, or congenital cardiac abnormalities were reported [9]. More recently, the ROPAC registry (2010–2016) in Madina highlighted congenital heart disease (CHD) as a significant contributor to hypertensive disorders of pregnancy. High birth rates and consanguinity may influence CHD prevalence in Saudi Arabia, yet data on rheumatic heart disease, CHD, cardiomyopathies, and coronary artery disease in pregnancy remain limited [2].

This study aims to examine maternal and fetal outcomes among pregnant women with pre-existing CVD in a tertiary care center in Saudi Arabia, and to identify risk factors associated with adverse events in this population.

List of abbreviations

AFib	Atrial Fibrillation
APS	Antiphospholipid Syndrome
APGAR	Appearance, Pulse, Grimace, Activity, Respiration (newborn scoring system)
AR	Aortic Regurgitation
AS	Aortic Stenosis
ASD	Atrial Septal Defect
AVNRT	Atrioventricular Nodal Reentrant Tachycardia
BMI	Body Mass Index
BNP	B-type Natriuretic Peptide
CABG	Coronary Artery Bypass Grafting
CAD	Coronary Artery Disease
CVD	Cardiovascular Disease
CHD	Congenital Heart Disease
EPS	Electrophysiology Study
GA	Gestational Age
GDM	Gestational Diabetes Mellitus
HFpEF	Heart Failure with Preserved Ejection Fraction
ICU	Intensive Care Unit
IQR	Interquartile Range
KKUH	King Khalid University Hospital
MR	Mitral Regurgitation
MS	Mitral Stenosis
NICU	Neonatal Intensive Care Unit
OR	Odds Ratio
PR	Pulmonary Regurgitation
PS	Pulmonary Stenosis
PVCs	Premature Ventricular Contractions
RA	Rheumatoid Arthritis
RFCA	Radiofrequency Catheter Ablation
ROPAC	Registry Of Pregnancy And Cardiac disease
RVOT	Right Ventricular Outflow Tract
SD	Standard Deviation
SLE	Systemic Lupus Erythematosus
SPSS	Statistical Package for the Social Sciences
SVT	Supraventricular Tachycardia
TR	Tricuspid Regurgitation
TS	Tricuspid Stenosis
VSD	Ventricular Septal Defect
WPW	Wolff-Parkinson-White Syndrome

2. Methods and results

2.1. Study design

This retrospective cohort observational study included women with CVD managed in the cardio-obstetrics services between 2015 and 2023. The study period extended from November 2023 to December 2024. Data were extracted from the medical records at KKUH.

2.2. Study participants

A total of 103 women aged 18 years or older met eligibility criteria. Participants were either pregnant women with pre-existing CVD or those who developed cardiovascular complications during pregnancy and up to six months postpartum. Eligible patients were evaluated in maternal–fetal medicine clinics, admitted for delivery, or followed in the heart function clinic after diagnosis of a peripartum cardiovascular disorder. Women with non-cardiac symptoms not assessed by cardiology, those delivering outside the study period, and those whose pregnancies or deliveries occurred at other institutions were excluded.

2.3. Data collection

Patients' data were collected from medical records between November 2023 and December 2024. Extracted variables included demographics (age, body mass index, gravidity, and parity), cardiovascular risk factors (diabetes type 1, diabetes type 2, or gestational; smoking status, dyslipidemia, prior myocardial infarction, gestational hypertension, and myocarditis), and relevant laboratory results (BNP and troponin). Cardiovascular diagnoses recorded were coronary artery disease, autoimmune disorders (systemic lupus erythematosus, rheumatoid arthritis, vasculitis, antiphospholipid syndrome), preeclampsia, hypertension, CHD, arrhythmias, valvular disease, and cardiomyopathy. Previous cardiac procedures were noted, including coronary artery bypass grafting, valve replacement or repair, congenital defect repair, radiofrequency catheter ablation, electrophysiologic study/ablation, and mitral balloon valvuloplasty.

Pregnancy outcomes included mode of delivery (spontaneous vaginal, assisted vaginal, or caesarean section), gestational age, and neonatal Apgar scores. Maternal outcomes comprised hypertension, arrhythmia, heart failure, cardiac arrest, intensive care admission, and death. Neonatal outcomes included NICU admission, structural cardiac anomaly, non-cardiac congenital defect, and fetal loss.

2.4. Confidentiality and ethics

Data access was granted by the KKUH IT department following confidentiality agreements. All records were anonymized, secured on password-protected systems, and accessible only to the principal investigator and designated team members. Informed consent was not required due to the retrospective nature of the study design. The study received ethical approval from King Saud University- College of Medicine Institutional Review Board (Registration No. E-24-8905).

2.5. Statistical analysis

Descriptive statistics were used to summarize variables. Categorical data were reported as frequencies and percentages, while numerical data were expressed as mean, standard deviation, and range. Associations between selected risk factors and maternal or neonatal outcomes were evaluated using bivariate analysis (chi-square or Fisher's exact test for categorical variables; binary logistic regression where appropriate). Significant factors identified through bivariate analysis were included in multivariable logistic regression models to assess their independent effects. Odds ratios with 95 % confidence intervals were reported. A two-sided p-value of 0.05 was considered statistically significant. Analyses were performed using SPSS Statistics version 30.0.

A total of 103 females were enrolled in this study (Table 1). The mean age was 35.50 years (±5.03 years), and the mean BMI was 31.33 kg/m^2 (±6.32 kg/m^2). The majority of participants (98.0 %) had never smoked. The most common risk factors among the participants were having a history of preeclampsia (22.2 %), followed by gestational diabetes (20.4 %). Type I and type II diabetes were found to be 3.9 % and 8.7 %, respectively.

Table 1. Characteristics of study participants.

Characteristics	Frequency (%) or Mean ± SD [Range]
Demographics	
Age (years)	35.50 ± 5.03 [22–47]
BMI (kg/m^2)	31.33 ± 6.32 [16.63–47.95]
Gravidity	3.98 ± 2.26 [1–12]
Parity	2.60 ± 1.89 [0–9]
Risk factors	
Diabetes mellitus	34 (33.0 %)
• Type I diabetes	4 (3.9 %)
• Type II diabetes	9 (8.7 %)
• Gestational diabetes	21 (20.4 %)
Troponin (n = 21)	4.43 ± 3.94 [0.01–14.00]
BNP (n = 14)	Median = 92.60; IQR 43.65–148.00; Range [5.80–2024]
Hemoglobin (g/L)	115.56 ± 16.34 [77–151]
Smoker status	
Never smoked	101 (98.0 %)
Smoker	1 (1.0 %)
Ex-smoker	1 (1.0 %)
Dyslipidemia	5 (4.9 %)
Previous myocardial infarction	1 (1.0 %)
Autoimmune disease (SLE, RA, vasculitis, antiphospholipid syndrome, others)	7 (6.8 %)
History of preeclampsia	23 (22.3 %)
Gestational hypertension	14 (13.6 %)

Note: SD = standard deviation; IQR = interquartile range, n = 103.

Among the medical characteristics of our participants, as shown in Table 2, the most common heart disease was hypertension (45.6 %). For the congenital heart diseases, the ventricular septal defect was the most frequent (2.9 %). The most common arrhythmia was supraventricular tachycardia (7.8 %), followed by other arrhythmias like RVOT and PVC, atrioventricular nodal re-entry tachycardia, sinus tachycardia, and premature ventricular contractions (6.8 %).

Among the reported cardiac procedures (Table 3), the most common was radiofrequency catheter ablation (5.8 %). Valve surgeries and congenital heart repairs, including ASD and truncus arteriosus, were each reported in 1.9 % of patients, as were cardiac catheterization and mitral balloon valvuloplasty.

Regarding contributing risk factors for maternal and fetal events (Table 4), we identified the following outcomes with a sufficient number of events: APGAR score 0–6 (moderate abnormal or

Table 2. Types of cardiovascular diseases included.

Medical Characteristics	Frequency (%)
Underlying heart disease	
Hypertension	47 (45.6 %)
Congenital heart disease (VSD, ASD, aortic stenosis, truncus arteriosus)	7 (6.8 %)
Arrhythmias	
Atrial fibrillation/atrial flutter	0 (0 %)
Tachyarrhythmias (sinus tachycardia, SVT, WPW, AVNRT, RVOT, PVCs)	16 (15.5 %)
Bradyarrhythmias (sinus bradycardia)	3 (2.9 %)
Valvular heart disease	
Mitral stenosis (MS)	5 (4.9 %)
Mitral regurgitation (MR)	11 (10.7 %)
Aortic stenosis (AS)	2 (1.9 %)
Aortic regurgitation (AR)	2 (1.9 %)
Tricuspid regurgitation (TR)	4 (3.9 %)
Tricuspid stenosis (TS)/Pulmonary regurgitation (PR)/ Pulmonary stenosis (PS)	0 (0 %)
Cardiomyopathies	
Peripartum cardiomyopathy	1 (1.0 %)
Dilated cardiomyopathy	2 (1.9 %)
Hypertrophic cardiomyopathy	0 (0 %)
Restrictive cardiomyopathy	0 (0 %)
Arrhythmogenic right ventricular cardiomyopathy	0 (0 %)
Heart failure with preserved ejection fraction (HFpEF)	1 (1.0 %)
Coronary artery disease	2 (1.9 %)

Afib: Atrial Fibrillation, SVT: Supraventricular Tachycardia, WPW: Wolff-Parkinson-White Syndrome, AVNRT: Atrioventricular Nodal Reentrant Tachycardia, RVOT: Right Ventricular Outflow TractTachycardia, PVCs: Premature Ventricular Contractions, MS: Mitral Stenosis, MR: Mitral Regurgitation, AS: Aortic Stenosis, AR: Aortic Regurgitation, TR: Tricuspid Regurgitation, TS: Tricuspid Stenosis, PR: Pulmonary Regurgitation, PS: Pulmonary Stenosis, n = 103.

critically low) (14.4 %) and Preterm gestational age (less than 37 weeks) (63.4 %). Hypertension was found to be the most common maternal complication (14.7 %). Among neonatal outcomes, NICU admittance and fetal loss were 15.7 % and 6.8 %, respectively.

Table 3. Previous cardiac procedures.

Previous Cardiac Procedures	Frequency (%)
Previous cardiac surgery	
Coronary artery bypass grafting (CABG)	1 (1.0 %)
Valve replacement	2 (1.9 %)
Repair of congenital heart disease (ASD, truncus arteriosus)	2 (1.9 %)
Valve repair (mitral, tricuspid)	2 (1.9 %)
Previous cardiac intervention	
Radiofrequency catheter ablation (RFCA)	6 (5.8 %)
Electrophysiology study/ablation (EPS/ablation)	1 (1.0 %)
Cardiac catheterization	2 (1.9 %)
Mitral balloon valvuloplasty	2 (1.9 %)

CABG: coronary artery bypass grafting, EPS/Ablation: electrophysiological study with ablation, n = 103.

This study found that these variables have sufficient sample size and number of events to be considered potential risk factors (Table 5): Maternal age, BMI, Gravidity, Parity, Diabetes (combined type I and II), Hb, Gestational hypertension, Autoimmune disease, SLE, RA, vasculitis, antiphospholipid syndrome or others, History of preeclampsia, Hypertension, Congenital heart disease, Arrhythmia − Tachyarrhythmia, Valvular heart disease, Cardiomyopathy, and previous cardiac procedures.

Statistically significant risk factors identified through bivariate analysis, along with maternal age (a known biological marker for various medical outcomes), were included in multivariable logistic regression models (Table 6). Only two models have overall statistical significance − preterm gestational age and maternal hypertension. In the preterm gestational age model, there were two significant risk factors − diabetes and a history of preeclampsia. In the maternal hypertension model, the following two factors are significant: BMI and history of preeclampsia.

2.6. Model fit

- APGAR score: χ^2 [8] = 11.21, p = 0.19; Nagelkerke R^2 = 20.6 %
- Preterm GA: χ^2 [8] = 29.50, p = 0.001; Nagelkerke R^2 = 36.1 %
- Maternal hypertension: χ^2 [7] = 25.44, p = 0.001; Nagelkerke R^2 = 40.0 %
- NICU admittance: χ^2 [7] = 12.09, p = 0.10; Nagelkerke R^2 = 20.3 %
- Fetal loss: χ^2 [8] = 10.85, p = 0.21; Nagelkerke R^2 = 26.1 %

Values are adjusted odds ratios with 95 % confidence intervals and exact p-values. "—" indicates a variable excluded due to non-convergence.

3. Discussion

This study evaluated 103 pregnant women with pre-existing CVD or those who developed cardiovascular complications during pregnancy and up to six months postpartum at KKUH. Maternal morbidity, mortality, neonatal outcomes, and congenital malformations were assessed, with particular attention to risk factors that contributed to adverse events. The findings demonstrate a high burden of complications in this population, with

Table 4. Maternal and fetal outcomes in women with cardiovascular disease.

Outcomes	Frequency (%) or Mean ± SD [Range]
Mode of delivery	
Vaginal unassisted	33 (32.0 %)
Vaginal assisted	12 (11.7 %)
Cesarean section − elective	19 (18.4 %)
Cesarean section − emergency	35 (34.0 %)
Pregnancy outcome	
APGAR score	7.70 ± 2.79 [0−10]
APGAR category	
7−10 Healthy (no immediate intervention)	83 (85.6 %)
4−6 Moderate abnormal (may need resuscitation)	3 (3.1 %)
0−3 Critically low (immediate resuscitation required)	11 (11.3 %)
Gestational age (weeks)	35.33 ± 6.91 [6.86−41.00]
Gestational age category	
Extremely preterm (<28 weeks)	8 (7.9 %)
Very preterm (28−<32 weeks)	6 (5.9 %)
Moderate to late preterm (32−<37 weeks)	23 (22.8 %)
Full term (37−<42 weeks)	64 (63.4 %)
Maternal complications	
Hypertension	15 (14.7 %)
Cardiac arrest − shockable	0 (0 %)
Cardiac arrest − non-shockable	0 (0 %)
Arrhythmias	0 (0 %)
Heart failure	0 (0 %)
ICU admission required	2 (2.0 %)
Maternal death	0 (0 %)
Neonatal outcomes	
NICU admittance	16 (15.7 %)
Non-cardiac congenital anomaly	1 (1.0 %)
Structural cardiac anomaly	1 (1.0 %)
Fetal loss	7 (6.8 %)

The most frequent adverse neonatal outcomes were preterm birth (<37 weeks, 63.4 %) and low APGAR score (0−6, 14.4 %). Maternal hypertension was the most common complication (14.7 %). Among neonatal outcomes, NICU admission occurred in 15.7 % and fetal loss in 6.8 % of cases, n = 103.

preterm birth, hypertensive disorders, and gestational diabetes emerging as leading contributors.

Preterm birth occurred in 63.4 % of pregnancies, a strikingly higher rate than reported in prior studies, where prevalence ranged from 11.9 % to 18 % depending on the cardiovascular diagnosis [4,7,10,11]. This discrepancy may reflect more severe baseline disease in our cohort, a greater concentration of comorbidities, or differences in antenatal management. It is also possible that variations in referral patterns to tertiary care centers contributed to the inclusion of higher-risk cases in this study, compared to broader population-based samples.

Hypertensive disorders were frequent. Maternal hypertension, defined as hypertension persisting beyond 12 weeks postpartum (chronic hypertension), was documented in 14.7 % of cases, and gestational hypertension in 13.6 %. According to the American College of Obstetricians and Gynecologists, gestational hypertension is defined as blood pressure ≥140/90 mmHg on two separate occasions, at least 4 h apart, after 20 weeks of gestation in previously normotensive women [12].

In this cohort, gestational hypertension was not only common but also strongly predictive of chronic maternal hypertension, underscoring its role as an early marker of long-term cardiovascular risk. Preeclampsia occurred in 12.1 % of cases, consistent with prior reports showing considerable variability across populations, ranging from 3 % to 27 % [4,6,7]. Its presence markedly increased the risks of preterm delivery and NICU admission, reinforcing earlier evidence that preeclampsia exerts broad effects on maternal and fetal health. Previous literature has firmly linked preeclampsia to fetal growth restriction, preterm birth, and heightened lifetime cardiovascular risk in mothers [7,13]. The elevated incidence of hypertensive disorders in our sample likely reflects the combined influence of pre-existing heart disease, prior hypertension, obesity, and diabetes, all of which are well-established contributors [7].

Neonatal outcomes were mixed. NICU admission occurred in 15.7 % of cases, which is broadly comparable to prior studies reporting rates of 17.4 % and 21.8 % [10,11]. However, fetal loss was 6.8 %, exceeding published figures. For comparison, one study reported a loss rate of 0.8 %, with stillbirths linked to placental abruption and fetal growth restriction [7]. Another reported 3.1 %, attributing losses to structural anomalies, severe growth restriction, and extreme prematurity [10]. Notably, several studies provided incomplete details regarding causes of fetal loss, limiting direct comparison [11,14]. The higher rate in our study suggests a more fragile baseline population, possibly related to underlying maternal cardiovascular pathology or coexisting risk factors.

Gestational diabetes mellitus (GDM) was diagnosed in 20.4 % of women, exceeding the 5−10 % typically reported in the literature [13]. This increased prevalence could be attributed to changes in demographics, such as an increase in obesity. Notably, our data confirmed the already known relationship between maternal BMI and hypertensive complications. Every unit of BMI change was associated with a 12 per cent rise in odds of maternal hypertension, which was consistent with

Table 5. Bivariate analysis of maternal and neonatal risk factors associated with adverse pregnancy outcomes in women with cardiovascular disease.

Risk Factor	APGAR score 0−6	Preterm gestational age (<37 weeks)	Maternal hypertension	NICU admittance	Fetal loss
Maternal age	OR 1.07 (p = 0.27)	OR 0.99 (p = 0.88)	OR 1.02 (p = 0.71)	OR 1.04 (p = 0.44)	OR 1.13 (p = 0.15)
BMI	OR 1.05 (p = 0.28)	OR 1.04 (p = 0.25)	OR 1.12 (p = 0.015)	OR 1.01 (p = 0.78)	OR 1.02 (p = 0.71)
Gravidity	OR 1.10 (p = 0.41)	OR 0.93 (p = 0.46)	OR 1.08 (p = 0.50)	OR 0.95 (p = 0.67)	OR 1.27 (p = 0.12)
Parity	OR 1.04 (p = 0.79)	OR 0.91 (p = 0.41)	OR 1.04 (p = 0.76)	OR 0.88 (p = 0.43)	OR 1.16 (p = 0.43)
Diabetes (type I/II)	15.5 % vs 7.7 % (p = 0.69)	33.0 % vs 61.5 % (p = 0.046)	15.7 % vs 7.7 % (p = 0.69)	12.4 % vs 38.5 % (p = 0.016)	6.7 % vs 7.7 % (p = 1.00)
Gestational diabetes	15.4 % vs 10.5 % (p = 0.73)	38.3 % vs 30.0 % (p = 0.49)	13.6 % vs 19.0 % (p = 0.50)	17.3 % vs 9.5 % (p = 0.34)	8.5 % vs 0 % (p = 0.34)
Haemoglobin	OR 1.01 (p = 0.80)	OR 1.01 (p = 0.44)	OR 1.02 (p = 0.22)	OR 1.02 (p = 0.28)	OR 1.01 (p = 0.63)
Gestational hypertension	14.3 % vs 15.4 % (p = 1.00)	34.5 % vs 50.0 % (p = 0.26)	10.2 % vs 42.9 % (p = 0.006)	14.8 % vs 21.4 % (p = 0.46)	6.7 % vs 7.1 % (p = 1.00)
Autoimmune disease (SLE, RA, vasculitis, APS, other)	11.1 % vs 57.1 % (p = 0.008)	34.0 % vs 71.4 % (p = 0.096)	15.8 % vs 0 % (p = 0.59)	16.8 % vs 0 % (p = 0.59)	6.3 % vs 14.3 % (p = 0.40)
History of preeclampsia	16.0 % vs 9.1 % (p = 0.51)	29.1 % vs 63.6 % (p = 0.003)	7.6 % vs 39.1 % (p = 0.001)	10.1 % vs 34.8 % (p = 0.008)	7.5 % vs 4.3 % (p = 1.00)
Hypertension	14.5 % vs 14.3 % (p = 0.97)	41.8 % vs 30.4 % (p = 0.24)	9.1 % vs 21.3 % (p = 0.08)	20.0 % vs 10.6 % (p = 0.20)	8.9 % vs 4.3 % (p = 0.45)
Congenital heart disease	14.3 % vs 16.7 % (p = 1.00)	37.9 % vs 16.7 % (p = 0.41)	15.6 % vs 0 % (p = 0.59)	15.6 % vs 16.7 % (p = 1.00)	7.2 % vs 0 % (p = 1.00)
Arrhythmia (tachyarrhythmia)	15.2 % vs 11.1 % (p = 1.00)	37.8 % vs 31.6 % (p = 0.61)	16.9 % vs 5.3 % (p = 0.29)	16.9 % vs 10.5 % (p = 0.73)	6.0 % vs 10.5 % (p = 0.61)
Valvular heart disease	13.1 % vs 23.1 % (p = 0.39)	37.5 % vs 30.8 % (p = 0.76)	16.9 % vs 0 % (p = 0.21)	18.0 % vs 0 % (p = 0.21)	5.6 % vs 14.3 % (p = 0.24)
Cardiomyopathy	14.7 % vs 0 % (p = 1.00)	37.4 % vs 0 % (p = 0.53)	15.0 % vs 0 % (p = 1.00)	16.0 % vs 0 % (p = 1.00)	7.0 % vs 0 % (p = 1.00)
Previous cardiac procedure	12.2 % vs 26.7 % (p = 0.22)	35.3 % vs 43.8 % (p = 0.52)	16.3 % vs 6.3 % (p = 0.46)	16.3 % vs 12.5 % (p = 1.00)	4.6 % vs 18.8 % (p = 0.039)

Outcomes included APGAR score 0−6, preterm birth (<37 weeks), maternal hypertension, NICU admission, and fetal loss. Data are expressed as odds ratios (OR) with p-values or as proportions with Fisher's exact or chi-square tests, as appropriate.

Table 6. Multivariable logistic regression analysis of maternal and neonatal risk factors associated with adverse pregnancy outcomes in women with cardiovascular disease.

Risk factor	APGAR score 0–6	Preterm gestational age (<37 weeks)	Maternal hypertension	NICU admittance	Fetal loss
Maternal age	1.08 (0.94–1.24), p = 0.27	0.98 (0.89–1.09), p = 0.88	1.09 (0.93–1.27), p = 0.29	1.07 (0.94–1.22), p = 0.31	1.16 (0.95–1.41), p = 0.15
BMI	1.08 (0.97–1.19), p = 0.19	1.08 (0.99–1.17), p = 0.08	1.14 (1.01–1.28), p = 0.03	1.00 (0.89–1.12), p = 0.95	1.05 (0.91–1.22), p = 0.48
Diabetes (type I/II)	0.55 (0.05–5.54), p = 0.61	7.74 (1.70–35.24), p = 0.008	0.36 (0.03–5.13), p = 0.46	3.35 (0.70–16.09), p = 0.13	1.04 (0.07–16.68), p = 0.97
Gestational hypertension	1.60 (0.26–9.93), p = 0.62	1.11 (0.28–4.37), p = 0.88	4.44 (0.94–20.90), p = 0.06	1.16 (0.24–5.59), p = 0.85	1.31 (0.11–15.63), p = 0.82
Autoimmune disease (SLE, RA, APS, others)	4.34 (0.48–39.31), p = 0.20	2.93 (0.30–28.21), p = 0.35	–	–	0.69 (0.04–12.40), p = 0.80
History of preeclampsia	0.71 (0.12–4.20), p = 0.71	7.29 (2.16–24.63), p = 0.001	8.38 (1.90–36.97), p = 0.004	6.98 (1.78–27.40), p = 0.006	0.91 (0.07–12.49), p = 0.94
Previous cardiac procedures	1.59 (0.29–8.70), p = 0.58	2.51 (0.64–9.91), p = 0.18	0.61 (0.05–7.51), p = 0.69	2.00 (0.33–12.27), p = 0.44	6.85 (0.99–47.66), p = 0.05

Outcomes assessed included low APGAR score (0–6), preterm birth (<37 weeks), maternal hypertension, NICU admission, and fetal loss. Results are presented as odds ratios (OR) with 95 % confidence intervals (CI) and p-values.

the results that indicated that, in addition to predisposing to GDM, obesity also worsens cardiovascular risk in pregnancy [7]. With obesity, diabetes, and hypertension overlapping in this population, pre-pregnancy metabolic optimization is necessary.

Preexisting diabetes also further enhanced poor outcomes. The rates of preterm birth and NICU admission were also much higher in women with diabetes compared to the previous studies that reported the increased risks of prematurity, growth retardation, and complications in infants born to diabetic mothers [11,15]. Another significant cause was autoimmune disease. Autoimmune conditions in our cohort were linked to poor neonatal outcomes, especially involving low APGAR scores, in line with findings of maternal inflammation, placental dysfunction, and exposure to drugs, indicating the assumption that such conditions are related to poor neonatal outcomes [10,16]. These results highlight the need to exercise cautious multidisciplinary care of women with autoimmune and cardiovascular comorbidities. Previous cardiac procedures also emerged as a relevant factor. Women with prior interventions, including valve repair or replacement, congenital defect repair, and ablation procedures, faced higher complication rates. Earlier studies have documented similar risks, including heart failure and valve-related thrombotic events, which may threaten maternal stability and compromise fetal survival [4]. Although advances in surgical and interventional cardiology have improved outcomes, the physiological stresses of pregnancy continue to challenge cardiac reserve in this population.

Taken together, the findings emphasize the need for systematic risk assessment, preconception counseling, and comprehensive antenatal care for women with CAD. A multidisciplinary approach, while bringing together cardiology, maternal–fetal medicine, anesthesia, and neonatology, is essential to anticipate complications and tailor management. Our findings suggest that women who develop hypertensive disorders or diabetes during pregnancy may be at risk of ongoing cardiovascular complications beyond delivery, underscoring the importance of structured postpartum follow-up.

In conclusion, this study identifies preterm birth, hypertensive disorders, gestational diabetes, and prior cardiac disease as key drivers of adverse maternal and fetal outcomes in pregnant women with CVD. These results support the development of individualized management protocols, informed by pre-pregnancy risk stratification and continuous multidisciplinary care, to improve outcomes in this high-risk group.

4. Strengths and limitations

This study adds needed local data on pregnancy outcomes in women with pre-existing CAD and uses a structured retrospective cohort to examine both maternal and neonatal endpoints. The main strengths are the focused cardio-obstetric population and the use of multivariable modelling to identify independent associations.

Key limitations weaken causal interpretation. A large share of participants had chronic hypertension (45.6 %), a strong and independent driver of preeclampsia, preterm birth, and neonatal complications; residual confounding by hypertensive disease is therefore likely and limits attribution of outcomes to underlying CVD alone. The sample size (n = 103) is modest relative to the clinical heterogeneity of cardiovascular conditions, which reduces power for subgroup analyses and increases the risk of unstable effect estimates. The retrospective design and incomplete documentation introduce potential misclassification and information bias, particularly for follow-up and outcome timing. As a single-center study at a tertiary referral hospital, selection bias is likely: women with more severe disease may be overrepresented, and management protocols may differ from those in other centers, limiting external validity. Finally, the study spans 2015—2023, a period during which changes in cardio-obstetric practice and obstetric care could have affected outcomes; however, temporal trends were not explored.

5. Conclusions

In this cohort, a history of preeclampsia, pre-existing diabetes, and higher BMI emerged as the most consistent predictors of adverse maternal and neonatal outcomes. These findings reinforce the need for targeted risk assessment: preconception counselling, tighter glycemic and blood pressure control, and weight management should be priorities for women with CAD who plan pregnancy. Multidisciplinary care and intensified antenatal surveillance are justified for this high-risk group to detect and treat complications early.

However, causality cannot be asserted from these data. The confounding influence of chronic hypertension, small and heterogeneous sample, and retrospective data limitations mean the associations reported should be viewed as hypothesis-generating. Larger, prospective, multicenter studies that standardize exposure definitions, capture disease severity and medication use, and follow maternal and infant outcomes long term are needed to clarify which aspects of CAD drive risk and which interventions reduce it.

Author contributions

Conception and design of Study: NA, SAA, HA. Literature review: NA, SAA, WA, GA, JA, MA, AA, HA. Acquisition of data: WA, GA, JA, MA, AA, HA. Analysis and interpretation of data: NA, SAA. Research investigation and analysis: NA, SAA. Data collection: NA, SAA, WA, GA, JA, MA, AA. Drafting of manuscript: NA, SAA. Revising and editing the manuscript critically for important intellectual contents: NA, SAA. Data preparation and presentation: WA, GA, JA, MA, AA. Supervision of the research: NA. Research coordination and management: NA, SAA. Funding for the research: NA, SAA.

Ethics information

All procedures conducted in this study adhered to the ethical standards of King Saud University Institutional Review Board (KSU-IRB) and in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from the patient in accordance with journal guidelines. Dr. Nouf Alanazi serves as the guarantor of this work and assumes full responsibility for the integrity of the data and the accuracy of the analysis, ensuring that all aspects of the manuscript comply with ethical standards. The datasets generated and analyzed during the study are available from the corresponding author upon reasonable request.

Source of funding

The authors declare that no financial support, grant funding, or external sponsorship was received for the conduct of this study, the preparation of the manuscript, or the decision to submit it for publication.

Declaration of AI

No AI or LLM was used in the drafting of the manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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