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Original

Maternal and fetal outcomes in pregnant women with moderate-to-severe pulmonary hypertension: A retrospective cohort study from a tertiary cardio-obstetric center in Iran

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Abstract

Background: Pulmonary hypertension (PH) during pregnancy is associated with high maternal and fetal morbidity and mortality. Despite guideline-based recommendations discouraging pregnancy in women with PH, real-world data remain limited. This study aimed to evaluate maternal and fetal outcomes among pregnant women with moderate-to-severe PH managed at a tertiary referral center in Iran.

Methods: This retrospective cohort study included 37 pregnant women with an estimated systolic pulmonary artery pressure (sPAP) ≥40 mmHg managed between January 2019 and December 2023. As right heart catheterization was not routinely feasible during pregnancy, PH diagnosis and classification were based on comprehensive clinical assessment, transthoracic echocardiography, and other non-invasive investigations. Maternal characteristics, PH etiology, pregnancy management, and maternal and perinatal outcomes were retrospectively analyzed.

Results: The mean maternal age was 27.8 ± 2.1 years. Most women were classified as World Health Organization functional class II (56.8%) or III (32.4%). Group 1 pulmonary arterial hypertension (40.5%) and Group 2 PH due to left heart disease (37.8%) were the predominant clinical classifications. Therapeutic pregnancy termination and maternal mortality each occurred in four patients (10.8%). Twenty-nine pregnancies (78.4%) resulted in live births, while preterm birth occurred in 13 pregnancies (35.1%). Cesarean delivery accounted for 60.0% of completed deliveries. Women with higher estimated sPAP appeared to experience a greater burden of adverse maternal outcomes.

Conclusion: Pregnancy complicated by moderate-to-severe PH remains associated with considerable maternal and fetal risk despite specialized multidisciplinary care. Early diagnosis, preconception counseling, individualized risk assessment, and management in experienced cardio-obstetric centers are essential to optimize maternal and fetal outcomes. Given the retrospective single-center design, reliance on echocardiographic diagnosis, and limited sample size, these findings should be interpreted cautiously and confirmed in larger prospective multicenter studies.

Keywords: Hypertension, Premature Birth; Pulmonary Arterial, Risk Assessment

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Introduction

Pulmonary hypertension (PH) is a progressive and potentially life-threatening cardiovascular disorder characterized by elevated pulmonary arterial pressure and pulmonary vascular resistance, eventually leading to right ventricular dysfunction and heart failure. According to the 2022 European Society of Cardiology/European Respiratory Society (ESC/ERS) guidelines, PH is hemodynamically defined as a mean pulmonary artery pressure (mPAP) >20 mmHg at rest confirmed by right heart catheterization (RHC) (1-4). During pregnancy, however, transthoracic echocardiography remains the principal non-invasive screening modality because invasive hemodynamic assessment is reserved for selected clinical situations (5-7).

Pregnancy induces substantial physiological changes, including increases in blood volume, cardiac output, and heart rate, which may overwhelm the limited cardiopulmonary reserve of women with PH. Consequently, these patients are at increased risk of right ventricular failure, arrhythmias, thromboembolic events, and maternal death, making PH one of the highest-risk cardiovascular conditions encountered during pregnancy (2, 8, 9).

Despite advances in diagnostic strategies and multidisciplinary management, pregnancy in women with PH continues to be associated with considerable maternal and fetal morbidity and mortality. Current ESC guidelines strongly discourage pregnancy, particularly in women with pulmonary arterial hypertension (PAH), because of the persistently high maternal risk (1, 10). Nevertheless, pregnancies continue to occur, especially in low- and middle-income countries, where delayed diagnosis, limited access to specialized cardio-obstetric services, and sociocultural factors may influence reproductive decisions.

Most available evidence on pregnancy outcomes in PH has been derived from registries and observational studies conducted in high-income countries and specialized referral centers. Data from developing countries, particularly the Middle East, remain scarce despite regional differences in PH etiology, healthcare infrastructure, and access to multidisciplinary care. Furthermore, rheumatic valvular heart disease and congenital heart disease continue to contribute substantially to pregnancy-associated PH in these settings, highlighting the need for region-specific evidence.

To address this knowledge gap, we conducted a retrospective cohort study of pregnant women with moderate-to-severe PH managed at a tertiary cardio-obstetric center in Iran. The study aimed to describe patient characteristics, underlying etiologies, pregnancy management, and maternal and fetal outcomes in this high-risk population, while providing contemporary real-world evidence from a developing country to inform clinical practice and future research.

Materials and Methods

Study Design and Setting

This retrospective cohort study was conducted at the tertiary cardio-obstetric clinic of Alzahra Hospital, Isfahan University of Medical Sciences, Isfahan, Iran. Medical records of pregnant women with clinically significant pulmonary hypertension managed between January 2019 and December 2023 were retrospectively reviewed to evaluate maternal and fetal outcomes. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for observational research where applicable.

Study Population

Pregnant women with moderate-to-severe pulmonary hypertension, defined by an estimated systolic pulmonary artery pressure (sPAP) ≥40 mmHg on transthoracic echocardiography, were eligible for inclusion (5-9). Women with either a pre-existing diagnosis of PH before conception or a new diagnosis during pregnancy were included. Patients were required to have complete demographic, clinical, echocardiographic, obstetric, and outcome data available through delivery, pregnancy termination, or maternal death. Patients with incomplete medical records or unavailable pregnancy outcomes were excluded.

Diagnostic Evaluation and PH Classification

Because right heart catheterization (RHC) was not routinely feasible during pregnancy, invasive hemodynamic confirmation was not performed in most patients. Consequently, PH diagnosis and clinical classification were established using comprehensive clinical evaluation, transthoracic echocardiography, laboratory investigations, and additional non-invasive diagnostic modalities when clinically indicated (10-12).

All patients underwent electrocardiography and comprehensive transthoracic echocardiography with Doppler assessment. Additional investigations, including arterial blood gas analysis, autoimmune serology, natriuretic peptide measurement, lower-extremity Doppler ultrasonography, chest radiography, computed tomography pulmonary angiography, or ventilation-perfusion scanning, were performed according to the patient's clinical presentation and maternal-fetal safety considerations.

Patients were assigned to the World Health Organization clinical classification of PH using all available clinical, imaging, and laboratory information. Because routine RHC was not performed, these classifications were considered clinical rather than hemodynamically confirmed. Serial echocardiographic examinations were performed according to disease severity and clinical status throughout pregnancy (10-13).

Data Collection

Demographic, clinical, echocardiographic, obstetric, and neonatal data were retrospectively extracted from electronic medical records using a standardized data collection form. Baseline variables included maternal age, gravidity, parity, gestational age at diagnosis, presenting symptoms, WHO functional class, estimated sPAP, right ventricular function, left ventricular ejection fraction, structural cardiac abnormalities, PH-specific therapies, pregnancy management, delivery characteristics, and maternal and neonatal outcomes.

Study Outcomes

The primary outcome was maternal mortality. Secondary maternal outcomes included therapeutic abortion, mode of delivery, maternal complications, and WHO functional status. Fetal and neonatal outcomes included gestational age at delivery, preterm birth (<37 weeks), intrauterine fetal death, and live birth.

Statistical Analysis

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality using the Shapiro-Wilk test and are presented as mean ± standard deviation (SD) or median (interquartile range [IQR]) where appropriate. Categorical variables are reported as frequencies and percentages.

Ethical Considerations

The study protocol was approved by the Ethics Committee of Isfahan University of Medical Sciences (Approval No. IR.ARI.MUI.REC.1402.267). Written informed consent had been obtained from all participants before inclusion in the institutional registry, and all patient data were anonymized before analysis. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

Baseline Characteristics

Of the 37 pregnant women with moderate-to-severe PH, most were diagnosed before 20 weeks of gestation and had preserved left ventricular systolic function. Pulmonary arterial hypertension (Group 1) and PH secondary to left heart disease (Group 2) together accounted for nearly 80% of cases, and the majority of patients were in WHO functional class II or III at presentation (Table 1).

Table 1. Baseline demographic and clinical characteristics of the study population (N = 37)

Characteristic	Value
Maternal age (years), mean ± SD	27.8 ± 2.1
Body mass index (kg/m²), mean ± SD	23.4 ± 2.6
Gestational age at PH diagnosis, n (%)	
<20 weeks	20 (54.1)
≥20 weeks	17 (45.9)
Gravidity, n (%)	
Primigravida	16 (43.2)
Gravida 2	9 (24.3)
Gravida ≥3	12 (32.4)
Cardiac characteristics	
Left ventricular ejection fraction (%), mean ± SD	52.6 ± 6.5
Estimated sPAP (mmHg), mean ± SD	44.6 ± 3.9
sPAP 40–50 mmHg	24 (64.9)
sPAP >50 mmHg	13 (35.1)
Known high-risk cardiac disease before pregnancy	11 (29.7)
WHO functional class, n (%)	
Class I	2 (5.4)
Class II	21 (56.8)
Class III	12 (32.4)
Class IV	2 (5.4)
Clinical classification of PH, n (%)	
Group 1: Pulmonary arterial hypertension	15 (40.5)
Group 2: PH due to left heart disease	14 (37.8)
Group 3: PH due to lung disease/hypoxia	1 (2.7)
Group 4: Chronic thromboembolic PH	6 (16.2)
Group 5: Multifactorial PH	1 (2.7)

Abbreviations: BMI, body mass index; LVEF, left ventricular ejection fraction; PH, pulmonary hypertension; sPAP, systolic pulmonary artery pressure; WHO, World Health Organization.

Underlying Etiologies of Pulmonary Hypertension

The etiologies of PH were heterogeneous. Valvular heart disease was the most common underlying condition, with severe mitral stenosis accounting for 29.7% of all patients. Congenital heart disease was also frequently observed, particularly atrial septal defect

(21.6%). Pulmonary embolism was identified in 16.2% of patients, while connective tissue disease, primary pulmonary arterial hypertension, and isolated asthma were less common. Most patients had an sPAP of 40–50 mmHg, although Group 1 pulmonary arterial hypertension was more frequently observed among women with sPAP >50 mmHg. The distribution of underlying etiologies according to sPAP severity is summarized in Table 2.

Table 2. Underlying etiologies of pulmonary hypertension according to estimated sPAP category

Etiology	sPAP 40–50 mmHg (n = 24)	sPAP >50 mmHg (n = 13)	Total, n (%)
Valvular Heart Disease			
Severe Mitral Stenosis (MS)	8 (21.6)	3 (8.1)	11 (29.7)
Severe Mitral Regurgitation (MR)	2 (5.4)	0 (0.0)	2 (5.4)
Severe Aortic Insufficiency (AI)	1 (2.7)	0 (0.0)	1 (2.7)
Congenital Heart Disease			
Large Atrial Septal Defect (ASD)	6 (16.2)	2 (5.4)	8 (21.6)
Congenital Tricuspid Stenosis	1 (2.7)	0 (0.0)	1 (2.7)
PDA + VSD	0 (0.0)	1 (2.7)	1 (2.7)
Truncus Arteriosus + Eisenmenger	0 (0.0)	1 (2.7)	1 (2.7)
Pulmonary Vascular & Other Diseases			
Pulmonary Embolism (PE)	4 (10.8)	2 (5.4)	6 (16.2)
Connective Tissue Disease	2 (5.4)	0 (0.0)	2 (5.4)
Group 1 PAH	0 (0.0)	3 (8.1)	3 (8.1)
Asthma (no structural lesion)	1 (2.7)	0 (0.0)	1 (2.7)
Total	24 (64.9)	13 (35.1)	37 (100)

Data are presented as n (percentage of the total population, n = 37). Percentages may not sum to exactly 100% due to rounding.
Abbreviations: ASD: Atrial Septal Defect; MS: Mitral Stenosis; MR: Mitral Regurgitation; AI: Aortic Insufficiency; PAH: Pulmonary Arterial Hypertension; PDA: Patent Ductus Arteriosus; PE: Pulmonary Embolism; sPAP: Systolic Pulmonary Artery Pressure; VSD: Ventricular Septal Defect.

Maternal and Perinatal Outcomes

Among the 37 pregnancies, four (10.8%) were terminated before 20 weeks because of maternal cardiovascular risk, and maternal mortality occurred in four women (10.8%). One pregnancy (2.7%) resulted in intrauterine fetal death, while preterm birth occurred in 13 pregnancies (35.1%).

Thirty women continued pregnancy to delivery. The range gestational age at delivery was 30–38 weeks. Cesarean section was the predominant mode of delivery, accounting for 60.0% of births, whereas 40.0% of women delivered vaginally. Maternal complications included gestational diabetes mellitus and preeclampsia/eclampsia, each occurring in two patients (5.4%). Maternal and perinatal outcomes are presented in Table 3.

Table 3. Maternal and perinatal outcomes

Outcome	Value
Gestational age at delivery (weeks)	
Mean ± SD	33.8 ± 2.2
Range	30–38
Mode of delivery (n=30), n (%)	
Vaginal delivery	12 (40.0)
Cesarean delivery	18 (60.0)
Pregnancy outcomes (N=37), n (%)	
Therapeutic abortion	4 (10.8)
Live birth	29 (78.4)
Intrauterine fetal death	1 (2.7)
Maternal mortality	4 (10.8)
Preterm birth (<37 weeks)	13 (35.1)
Maternal complications (N=37), n (%)	
Gestational diabetes mellitus	2 (5.4)
Preeclampsia/eclampsia	2 (5.4)

IUFD, intrauterine fetal death; SD, standard deviation.

Discussion

PH during pregnancy remains one of the most challenging conditions in cardio-obstetric practice and is associated with substantial maternal and fetal morbidity and mortality. Although pregnancy is considered contraindicated in major international guidelines, many women, particularly in low- and middle-income countries, continue their pregnancies because of cultural, social, or economic factors. Our study provides real-world evidence from a tertiary cardio-obstetric referral center in Iran, describing maternal and perinatal outcomes among 37 women with moderate-to-severe PH. The findings demonstrate a considerable burden of adverse outcomes and provide additional evidence regarding the influence of disease

severity and the timing of diagnosis on pregnancy outcomes.

In our cohort, the maternal mortality rate was 10.8%, which remains substantially higher than that of the general obstetric population and is comparable with the upper range reported in previous registries, including the Registry of Pregnancy and Cardiac Disease (ROPAC), and contemporary systematic reviews (14, 15). Notably, three of the four maternal deaths occurred in women with an estimated systolic pulmonary artery pressure (sPAP) >60 mmHg, suggesting that markedly elevated pulmonary arterial pressure is associated with poorer maternal outcomes. This observation is consistent with previous studies reporting an increased risk of right ventricular failure and maternal mortality among women with severe pulmonary hypertension (14). Similarly, recent evidence has demonstrated a progressive increase in maternal risk with increasing pulmonary arterial pressure, particularly in patients with pre-capillary PH and impaired right ventricular reserve (14).

Preterm birth occurred in 35.1% of pregnancies, a frequency comparable with that reported in previous studies, where preterm delivery rates range from 30% to 50% among women with PH (15). Although adverse fetal outcomes appeared to be more frequent among women with advanced functional impairment (NYHA class III–IV), the relatively small sample size precluded formal evaluation of these associations. Nevertheless, these findings are consistent with the well-recognized relationship between worsening maternal cardiovascular status and adverse obstetric outcomes reported in the literature (15).

An important strength of this study is the detailed characterization of the underlying etiologies of PH using a structured, pregnancy-adapted, non-invasive diagnostic approach. Among the 37 patients, most were classified as Group 1 pulmonary arterial hypertension (PAH) or Group 2 PH secondary to left-sided heart disease, with severe mitral stenosis representing the most common individual etiology. This distribution reflects the regional epidemiology of cardiovascular disease, where rheumatic valvular heart disease continues to contribute substantially to PH among women of reproductive age (16) . Severe mitral stenosis accounted for nearly 30% of all PH cases, and most of these women fulfilled current guideline criteria for very high-risk pregnancy because of severe valvular obstruction and impaired functional status (17). Despite these recommendations, none elected therapeutic pregnancy termination.

Among our patients with severe mitral stenosis (mitral valve area <1.5 cm²), seven were diagnosed before 20 weeks of gestation. Notably, five of these women had been informed before pregnancy about their underlying cardiac disease and the potential maternal and fetal risks associated with continuing pregnancy without prior correction of the valvular lesion. Nevertheless, they chose to continue their pregnancies. During follow-up, two patients required percutaneous transvenous mitral commissurotomy (PTMC) because of progressive symptom deterioration.

Interestingly, all patients with a mitral valve area between 1.3 and 1.5 cm², pulmonary artery systolic pressure (PASP) between 40 and 50 mmHg, and WHO functional class I–II remained clinically stable throughout pregnancy, reached at least 36 weeks of gestation, and delivered live neonates without major maternal or fetal complications. Although these findings appear to differ from current guideline recommendations, they should be interpreted cautiously because they are based on a very small subgroup managed in a specialized multidisciplinary center. Both the European Society of Cardiology (ESC) and the American Heart Association (AHA) consider severe mitral stenosis, particularly in the presence of pulmonary hypertension or significant symptoms, a contraindication to pregnancy (Class III recommendation) (1, 2). Nevertheless, our observations suggest that selected women with borderline hemodynamic impairment and preserved functional capacity may experience favorable pregnancy outcomes under intensive multidisciplinary care (13, 18). These findings should not be interpreted as evidence supporting pregnancy in women with severe mitral stenosis but rather as hypothesis-generating observations requiring confirmation in larger prospective studies.

According to the 2022 ESC/ERS guidelines, pulmonary arterial hypertension (PAH; Group 1 PH) is hemodynamically defined by a mean pulmonary artery pressure (mPAP) ≥20 mmHg, pulmonary vascular resistance (PVR) ≥2 Wood units, and pulmonary capillary wedge pressure (PCWP) ≤15 mmHg (1). The updated diagnostic threshold has improved the

sensitivity of early disease recognition and has important implications for the identification of patients at increased cardiovascular risk. The 2018 ESC Guidelines on the management of cardiovascular diseases during pregnancy classify pregnancy in women with PAH as WHO maternal risk class IV and generally recommend avoiding pregnancy regardless of disease severity (2). However, clinical decision-making is often more nuanced in women with congenital heart disease associated with mild pulmonary hypertension. For example, patients with small atrial septal defects (ASD), ventricular septal defects (VSD), or patent ductus arteriosus (PDA) and preserved hemodynamic status may have a substantially different clinical course from women with idiopathic PAH or Eisenmenger syndrome (2). Therefore, comprehensive clinical assessment should complement guideline recommendations when evaluating pregnancy risk in selected patients.

This distinction is particularly relevant because a hemodynamic diagnosis of PAH does not necessarily reflect the same level of clinical risk across all patient populations. Women with stable congenital heart disease and mild pulmonary hypertension may not experience outcomes comparable with those observed in idiopathic PAH or advanced pulmonary vascular disease. Nevertheless, these observations should not be interpreted as conflicting with current guideline recommendations. Rather, they emphasize the importance of individualized multidisciplinary risk assessment and careful interpretation of hemodynamic findings within the broader clinical context when counseling women with PH regarding pregnancy (1, 2).

The timing of diagnosis appeared to have important clinical implications in our cohort. Women diagnosed before 20 weeks of gestation had the opportunity to undergo therapeutic pregnancy termination, whereas those diagnosed later required close multidisciplinary surveillance and frequently delivered preterm. Notably, 11 women (29.7%) had been aware of their high-risk cardiovascular conditions before conception but nevertheless presented with ongoing pregnancies. This subgroup included patients with severe valvular heart disease, pulmonary arterial hypertension, and complex congenital heart disease, several of whom fulfilled guideline criteria for very high maternal risk according to the ESC and AHA recommendations (1, 2). These observations suggest potential gaps in preconception counseling, continuity of cardiovascular care, and access to effective reproductive planning.

Our findings underscore the importance of structured long-term follow-up for women of reproductive age with high-risk cardiovascular disease. Comprehensive contraceptive counseling, including access to long-acting reversible contraception (LARC), should be incorporated into routine cardiovascular care. Furthermore, multidisciplinary cardio-obstetric programs should actively support preconception assessment, individualized risk stratification, and pregnancy planning to reduce preventable maternal morbidity and mortality in this high-risk population.

An additional noteworthy observation was that all four women who underwent therapeutic pregnancy termination were classified as having Group 1 pulmonary arterial hypertension (PAH). Despite early medical intervention, one maternal death still occurred in this group, suggesting that the risk associated with PAH may persist even after pregnancy termination. In contrast, no maternal or fetal deaths were observed among women with Group 2 PH secondary to severe mitral stenosis, despite severe valvular obstruction and, in some cases, the need for percutaneous transvenous mitral commissurotomy. Although these findings should be interpreted cautiously because of the limited sample size, they are consistent with previous reports indicating that pregnancy outcomes are generally poorer in women with Group 1 PAH than in those with PH secondary to left-sided heart disease. These observations further emphasize the importance of early diagnosis, preconception counseling, and individualized risk assessment in women with PAH.

Another noteworthy finding was the occurrence of intermediate-high-risk pulmonary embolism (PE) during pregnancy. One patient was successfully treated with low-dose thrombolysis (50 mg alteplase) and survived, whereas another died despite receiving therapeutic anticoagulation. Although based on only two cases, these observations are consistent with emerging evidence supporting the selective use of thrombolytic therapy in carefully chosen pregnant women with high-risk or intermediate-high-risk PE complicated by right ventricular dysfunction and hemodynamic deterioration, particularly when managed by experienced multidisciplinary teams (19-21).

The timing of diagnosis appeared to have important clinical implications in our cohort. Women diagnosed before 20 weeks of gestation had the opportunity to undergo therapeutic pregnancy termination, whereas those diagnosed later required close multidisciplinary surveillance and frequently delivered preterm. Notably, 11 patients (29.7%) were aware of their high-risk cardiovascular conditions before conception but nevertheless continued their pregnancies. This subgroup included women with severe valvular heart disease, PAH, and complex congenital heart disease, several of whom fulfilled guideline criteria for very high maternal risk according to the ESC and AHA recommendations (1, 2). These findings suggest potential gaps in continuity of cardiovascular care, preconception counseling, and reproductive planning for women with high-risk cardiac conditions.

Our findings reinforce the importance of structured long-term follow-up for women of reproductive age with WHO class III–IV cardiovascular disease. Comprehensive contraceptive counseling, including access to long-acting reversible contraception (LARC), should be integrated into routine cardiovascular care. In addition, multidisciplinary cardio-obstetric teams should actively support preconception assessment, individualized risk stratification, and pregnancy planning to reduce preventable maternal morbidity and mortality in this high-risk population.

An important observation in our cohort was that all four patients who underwent therapeutic pregnancy termination were classified as having Group 1 PAH. Despite early pregnancy termination, one maternal death still occurred in this group, suggesting that the adverse prognosis associated with PAH may persist even after early intervention. In contrast, no maternal or fetal deaths were observed among women with Group 2 PH secondary to severe mitral stenosis, despite severe valvular disease and, in selected cases, the need for percutaneous transvenous mitral commissurotomy. Although these findings should be interpreted cautiously because of the limited sample size, they are consistent with previous reports indicating poorer pregnancy outcomes in women with Group 1 PAH than in those with PH secondary to left-sided heart disease. Collectively, these observations further emphasize the importance of early diagnosis, comprehensive preconception counseling, and individualized multidisciplinary risk assessment in women with PAH.

Another noteworthy finding was the occurrence of intermediate-high-risk pulmonary embolism (PE) during pregnancy. One patient was successfully treated with low-dose thrombolysis (50 mg alteplase) and survived, whereas another died despite receiving therapeutic anticoagulation. Although these observations are based on only two cases, they are consistent with emerging evidence supporting the selective use of thrombolytic therapy in carefully selected pregnant women with intermediate-high-risk or high-risk PE complicated by right ventricular dysfunction or hemodynamic compromise, particularly when managed in experienced multidisciplinary centers (20, 21).

From a clinical perspective, our findings reinforce the importance of early referral to specialized cardio-obstetric centers, comprehensive preconception counseling, and individualized multidisciplinary management for women with PH. Serial echocardiographic assessment, close maternal surveillance, and coordinated decision-making among cardiologists, maternal-fetal medicine specialists, anesthesiologists, and other relevant disciplines remain fundamental to optimizing maternal and perinatal outcomes. Our experience also highlights the importance of timely recognition of disease progression and individualized treatment strategies throughout pregnancy (21).

The present study has several strengths. It provides contemporary real-world data from a tertiary referral cardio-obstetric center in a middle-income country, where the etiological spectrum of PH differs from that reported in many high-income settings. In addition, the detailed characterization of PH etiology, functional status, pregnancy management, and maternal and perinatal outcomes offers clinically relevant information from a population that remains underrepresented in the current literature.

Several limitations should also be acknowledged. First, the retrospective single-center design limits the generalizability of the findings and may have introduced selection bias. Second, the relatively small sample size restricted statistical power and precluded multivariable analyses to identify independent predictors of adverse outcomes. Third, because right heart catheterization was not routinely performed

during pregnancy, PH diagnosis and classification were based primarily on transthoracic echocardiography and comprehensive clinical assessment, which may have resulted in some degree of disease misclassification. Finally, the observational nature of the study does not permit causal inference, and the findings should therefore be interpreted cautiously.

Overall, pregnancy complicated by moderate-to-severe PH continues to be associated with substantial maternal and perinatal risk despite advances in multidisciplinary care. Nevertheless, our findings suggest that outcomes may vary according to the underlying etiology, disease severity, functional status, and timing of diagnosis. These observations support current guideline recommendations emphasizing preconception counseling, individualized risk assessment, and management within experienced multidisciplinary cardio-obstetric centers. Larger prospective multicenter studies are warranted to validate these findings and further refine risk stratification and management strategies for this high-risk population.

Conclusion

Pregnancy complicated by moderate-to-severe PH remains associated with substantial maternal and perinatal risk despite advances in multidisciplinary cardio-obstetric care. In this cohort, adverse outcomes were observed across different PH etiologies, with poorer outcomes appearing more frequent among women with severe pulmonary hypertension and group 1 pulmonary arterial hypertension. Conversely, favorable outcomes were observed in a small subgroup of clinically stable women with severe mitral stenosis managed in a specialized multidisciplinary center, although these findings should be interpreted cautiously because of the limited sample size.

Our findings emphasize the importance of early diagnosis, comprehensive preconception counseling, individualized risk assessment, and management within experienced multidisciplinary cardio-obstetric teams. Given the retrospective single-center design, reliance on echocardiographic diagnosis, and limited sample size, larger prospective multicenter studies are needed to validate these findings, improve risk stratification, and optimize management strategies for pregnant women with pulmonary hypertension.

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Conflicts of 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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