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# A Decade of Retrospective Study on the Pregnancy Outcomes of Fetal Congenital Heart Disease

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## Abstract

# Objective

To analyze the incidence features and postnatal outcomes of fetal congenital heart disease (CHD) for clinical reference.

# Methods

Clinical data of fetal CHD diagnosed via fetal echocardiography from 2014 to 2023 were retrospectively analyzed. OR and 95%CI were adopted for statistical analysis.

# Results

A total of 5112 fetal CHD cases were identified between 2014 and 2023, showing an increasing detection trend. Complete follow-up was achieved for 4959 pregnancies, including 2691 simple and 2268 complex CHD cases, with a gradual decline in the overall pregnancy termination rate over the decade. Complex CHD presented a markedly higher rate of adverse pregnancy outcomes than simple CHD (87.21% vs. 37.83%). Statistical analysis demonstrated that complex CHD and extracardiac anomalies significantly elevated the risks of pregnancy termination and neonatal death (all $P < 0.001$). Specifically, complex CHD conferred substantially higher risks of pregnancy termination and neonatal mortality, and CHD combined with extracardiac malformations also independently increased the risks of adverse perinatal outcomes.

# Conclusion

The detected fetal CHD cases increased while pregnancy termination rate decreased. Complex CHD and combined extracardiac malformations are major risk factors for adverse pregnancy outcomes.

## What's already known about this topic?

Congenital heart disease (CHD) is a major leading cause of perinatal and infant mortality. Complex fetal CHD and extracardiac malformations are generally associated with poor pregnancy and neonatal outcomes.

### What does this study add?

Based on a large 10-year cohort of over 5000 fetal CHD cases, this study identifies increased CHD detection and decreased pregnancy termination rates over time. It quantitatively confirms that complex

CHD and extracardiac anomalies significantly increase adverse perinatal risks with robust statistical data.

## Introduction

Congenital heart disease (CHD) is caused by defects in the heart's structure and function due to abnormal development during fetal growth. CHD is the leading cause of mortality during the perinatal and infant stages[1, 2]. According to the 2017 Global, Regional, and National Burden of CHD Study, the global prevalence of CHD is nearly 1.8 per 1,000, varying by region[3].

In China, the prevalence of CHD is 8.98 per 1,000 live births, significantly higher than the global average, leading to a greater burden for the family[4, 5]. In recent decades, the integration of prenatal and postnatal care, along with rapid advancements in prenatal diagnostic technology, pediatric surgery, and intensive care, have played a crucial role in improving the survival rates of newborns with CHD[6, 7]. However, fetuses with CHD continue to experience a high rate of labor induction. This may be due to insufficient awareness among clinicians and patients about the diagnosis and treatment of CHD, as well as a lack of interdisciplinary collaboration between prenatal and postnatal care[5, 8, 9]. In this study, we summarize our 10-year experience in managing CHD, focusing on the incidence characteristics and postnatal outcomes of infants with CHD.

## Methods

# Participants

This retrospective study was conducted at Women’s Hospital, Zhejiang University School of Medicine from January 2014 to December 2023. A total of 29,220 pregnant women were identified based on prenatal ultrasound examinations indicating fetal structural abnormalities. The enrollment criteria were cases diagnosed or showed suspicious signs of CHD through fetal cardiac ultrasound according to the standards of the National Birth Defects Prevention and Control Report. Cases with missing clinical data or lost to follow-up were excluded.

## Classification of CHD and Group

Based on the " Expert consensus on prognosis grading and perinatal risk assessment of fetal heart disease", the cases in this study were categorized into four levels[10].

Level I: No structural abnormalities or congenital anomalies were detected, indicating normal variation

Level II: Simple congenital heart diseases may self-resolve after birth or have a high treatment success rate, with good mid- to long-term prognosis, life quality and expectancy comparable to the general population.

Level III: Complex congenital heart diseases have a high treatment success rate after birth and good mid- to long-term prognosis, with life quality and expectancy similar to those in the general population.

Level IV: Complex congenital heart diseases may lead to poor treatment outcomes and long-term prognosis after birth, with significant differences in life quality and expectancy compared to the general population.

We classify levels I and II as the simple CHD group, which include ventricular septal defect, coronary fistula, pulmonary stenosis, and aortic stenosis, etc.; and levels III and IV as the complex CHD group, which include tetralogy of Fallot, atrioventricular septal defect, anomalous pulmonary venous connection, transposition of the great arteries, persistent truncus arteriosus, double outlet right ventricle, hypoplastic left heart syndrome, hypoplastic right heart syndrome, and situs inversus syndrome, etc..

The simple CHD group without extracardiac anomalies is designated as Group A, and with extracardiac anomalies as Group B, the complex CHD group without extracardiac anomalies as Group C, and with extracardiac anomalies as Group D.

## Data collection

We review the demographic information, obstetric history, imaging evaluations, genetic test results, and other relevant data of all pregnant women participating in the study. Furthermore, we monitor pregnancy outcomes and postnatal interventions by scrutinizing medical records and conducting telephone follow-ups. The follow-up period spans from six months after the prenatal examination to eighteen months postpartum; for those who decide to terminate their pregnancies, the follow-up continues until the termination is complete. The follow-up includes the final pregnancy outcomes and delivery outcomes of the participants, along with the survival and treatment status of those who continue their pregnancies.

# Statistical analysis

The Statistical Package for Social Science, version 27 for Windows (SPSS27.0) is used for statistical analyses. Categorical variables are expressed as frequencies or percentages. An unconditional logistic regression model is used to calculate the odds ratio (OR) and 95% confidence interval (95% CI) to analyze factors influencing adverse pregnancy outcomes. A p-value less than 0.05 is considered statistically significant.

## Result

# Characteristics of CHD in fetuses

From January 2014 to December 2023, a total of 29,220 cases of fetal malformations were diagnosed through prenatal ultrasound examinations in our center, among which 5,112 cases (17.49%) were diagnosed with CHD. The proportion of CHD among fetal malformations ranged from 13.52% to 21.43%

over the past decade. The number of CHD diagnosed in fetuses shows a fluctuating upward trend, reaching the highest number in 2023, which is 1.92 times than that of 2014 (Table 1).

Table 1
Fetal Malformations and CHD Detection from 2014 to 2023.

| Year | Number of fetal malformations | Number of fetal CHD | Percentage(%) |
|---|---|---|---|
| 2014 | 2255 | 358 | 15.88% |
| 2015 | 2711 | 478 | 17.63% |
| 2016 | 3174 | 429 | 13.52% |
| 2017 | 3436 | 642 | 18.68% |
| 2018 | 3318 | 557 | 16.79% |
| 2019 | 2423 | 450 | 18.57% |
| 2020 | 2409 | 385 | 15.98% |
| 2021 | 2594 | 556 | 21.43% |
| 2022 | 2881 | 570 | 19.78% |
| 2023 | 4019 | 687 | 17.09% |
| Total | 29220 | 5112 | 17.49% |
| Percentage: Number of fetal CHD/ Number of fetal malformations*100% | | | |

In this study, a total of 4,959 pregnancies completed follow-up, with 153 lost to follow-up, resulting in a loss rate of 2.99%. From 2014 to 2023, the termination rate of pregnancies due to fetal CHD decreased and remained relatively stable between 2021 and 2023. The survival rate of fetal CHD increased. The changes in the termination rate and survival rate of fetal CHD followed a symmetrical pattern (Figure.1).

## Pregnancy outcomes of CHD in fetuses

Among the 4959 cases, 2,691 pregnancies were classified as simple CHD and 2,268 as complex CHD. In the simple CHD group, 969 pregnancies were terminated, including miscarriage, medically induced termination, and fetal reduction. Among the pregnancies that continued, 10 experienced intrauterine fetal demise, 39 resulted in postnatal death (include neonatal death and postoperative death), and 1,673 survived. The overall incidence of adverse pregnancy outcomes is approximately 37.83%. Within the simple CHD group, Group A included 1,641 pregnancies. Of these, 298 pregnancies were terminated. Among the pregnancies that continued, 4 experienced intrauterine fetal demise, 15 resulted in postnatal death, and 1,324 survived. Group B comprised 1,050 pregnancies, with 671 terminated. Among the continuing pregnancies, 6 experienced intrauterine fetal demise, 24 resulted in postnatal death, and 349 survived.

In the complex CHD group, 1,881 pregnancies were terminated. Among the pregnancies that continued, 8 experienced intrauterine fetal demise, 89 resulted in postnatal death, and 290 survived. The overall incidence of adverse pregnancy outcomes is approximately 87.21%. Within the complex CHD group, Group C included 1,829 pregnancies. Of these, 1,487 pregnancies were terminated. Among the pregnancies that continued, 5 experienced intrauterine fetal demise, 66 resulted in postnatal death, and 271 survived. Group D comprised 439 pregnancies, with 394 terminated. Among the continuing pregnancies, 3 experienced intrauterine fetal demise, 23 resulted in postnatal death, and 19 survived (Table 2).

Table.2 Pregnancy Outcomes of CHD in Fetuses

| | Total | Termination | Intrauterine fetal death | Neonatal death | Survive |
|---|---|---|---|---|---|
| Group A | 1641 | 298 / 18.16% | 4 / 0.24% | 15 / 0.91% | 1324 / 80.68% |
| Group B | 1050 | 671 / 63.90% | 6 / 0.57% | 24 / 2.29% | 349 / 33.24% |
| Group C | 1829 | 1487 / 81.30% | 5 / 0.27% | 66 / 3.61% | 271 / 14.82% |
| Group D | 439 | 394 / 89.75% | 3 / 0.68% | 23 / 5.24% | 19 / 4.33% |

Termination: including miscarriage, medically induced termination, and fetal reduction.

## The risk factors for adverse pregnancy outcomes of CHD

The risk factors for adverse pregnancy outcomes in CHD include complex CHD and CHD with extracardiac anomalies. Complex CHD and CHD with extracardiac anomalies may overlap, but they represent distinct risk categories. For different types of CHD, the risk of medically indicated pregnancy termination is 15.981-fold higher (95% CI 13.633–18.733, $P < 0.001$), the risk of intrauterine fetal demise is 4.709-fold higher (95% CI 1.799–12.325, $P < 0.005$), and the risk of postnatal death is 20.768-fold higher (95% CI 13.167–32.758, $P < 0.001$) for complex CHD compared to simple CHD (Table 3). In addition, the risk of pregnancy termination is 6.328-fold higher (95% CI 5.368–7.460, $P < 0.001$), the risk of intrauterine fetal demise is 5.115-fold higher (95% CI 1.968–13.296, $P < 0.005$), and the risk of postnatal death is 5.804-fold higher (95% CI 3.621–19.302, $P < 0.001$) for CHD with extracardiac anomalies compared to those without (Table 4).

Table 3
The Impact of Different Types of CHD on Adverse Pregnancy Outcomes

| | Termination | | Intrauterine fetal death | | Neonatal death | |
|---|---|---|---|---|---|---|
| | **No** | **Yes** | **No** | **Yes** | **No** | **Yes** |
| Simple CHD | 1722 | 969 | 1712 | 10 | 1673 | 39 |
| Complex CHD | 387 | 1881 | 379 | 8 | 290 | 89 |
| *χ2* | 1108.883 | | 8.251 | | 242.793 | |
| *P* | < 0.001 | | < 0.005 | | < 0.001 | |
| *OR (95%CI)* | 1.000 | | 1.000 | | 1.000 | |
| | 15.981 (13.633, 18.733) | | 4.709 (1.799, 12.325) | | 20.768 (13.167, 32.758) | |
| Termination: including miscarriage, medically induced termination, and fetal reduction. | | | | | | |

Table 4
The Impact of CHD Combined with Extracardiac Anomalies on Adverse Pregnancy Outcomes.

| | Termination | | Intrauterine fetal death | | Neonatal death | |
|---|---|---|---|---|---|---|
| | **No** | **Yes** | **No** | **Yes** | **No** | **Yes** |
| Not Combined | 1685 | 1785 | 1676 | 9 | 1595 | 81 |
| Combined | 424 | 1065 | 415 | 9 | 368 | 47 |
| *χ2* | 171.941 | | 10.102 | | 24.398 | |
| *P* | < 0.001 | | < 0.005 | | < 0.001 | |
| *OR (95%CI)* | 1.000 | | 1.000 | | 1.000 | |
| | 6.328 (5.368, 7.460) | | 5.115 (1.968, 13.296) | | 5.804 (3.621, 9.302) | |
| Termination: including miscarriage, medically induced termination, and fetal reduction. | | | | | | |

# Discussion

**The study describes the characteristics of CHD in fetuses.**

From 2014 to 2023, the number of congenital heart disease (CHD) cases detected in fetuses at this center showed a fluctuating growth trend. The first peak occurred in 2017, which may be related to China's ‘two-child’ policy; this policy led to an increase in the number of newborns from 2015 to 2017[11]. After the first peak in CHD cases in 2017, the number began to decline but rose again after 2020. This increase was likely due to the gradual improvement of prenatal diagnostic technology, resulting in an apparent increase in the detection of birth defects and fetal CHD. This finding is consistent with the

results reported by Tomek and Davtyan, et al[12, 13]. With the popularization of prenatal testing and the maturation of prenatal diagnostic technology, the prenatal detection rate of congenital heart disease in our country has significantly improved. Data from the national birth defect monitoring platform showed that the reported incidence of perinatal congenital heart disease in our country increased to 5.3 times that of 2010 by 2020, with a more significant rise in the incidence of simple congenital heart disease[14]. In the past decade, the termination rate for fetuses with CHD has declined. This is primarily due to the maturation of prenatal diagnosis, pediatric cardiothoracic surgical techniques. Additionally, increased national and societal attention and financial support for CHD have enabled more children and their families affected by the condition to receive assistance.

# Analysis of the influencing factors on pregnancy outcomes in fetuses with CHD

Research shows that the pregnancy outcomes of fetuses with CHD are associated with the type and prognosis of congenital heart disease; the presence of extracardiac anomalies; genetic testing results; gestational age at disease diagnosis; travel distance for medical care; and the extent of medical insurance coverage[15–18].

This study analyzes the prognosis of fetuses with CHD classified by different perinatal risk levels and finds that the risk of adverse pregnancy outcomes (including pregnancy termination, intrauterine fetal demise, and neonatal death) in the complex congenital heart disease group is significantly higher than that in the simple congenital heart disease group. Studies by Baardman and Cloete [19, 20] also confirm that the termination rate of pregnancies with severe fetal cardiac anomalies has significantly increased, which is consistent with the results of this study. Over the past decade, the overall termination rate of pregnancies with fetal CHD has shown a downward trend. This may be associated with advancements in prenatal diagnostic techniques and pediatric cardiothoracic surgical methods, as well as increased national awareness and financial support for CHD[21, 22]. In addition, the integrated management mode of prenatal diagnosis-postnatal treatment for CHD, based on multidisciplinary collaboration in medical imaging, genetics, obstetrics and pediatric cardiac surgery, greatly reduces the mortality rate of CHD and improves the survival rate[23–25].

This study investigates whether the combination of CHD with extracardiac structural abnormalities is an important influencing factor for adverse pregnancy outcomes. Termination of pregnancy rates in the fetal CHD with extracardiac abnormalities group showed a downward trend over ten years. However, families expecting fetuses with CHD and extracardiac abnormalities opted for termination more frequently than those with CHD alone[26, 27]. Additionally, the risks of intrauterine death and neonatal death after birth during continued pregnancy were higher in this group. These results are consistent with those of Li et al[28, 29]. Among the types of fetal CHD with extracardiac abnormalities, the most common are multiple-system malformations. Among single-system abnormalities, central nervous system malformations are the most common; these findings align with the results of Dovajak[30]. Therefore, during the follow-up of pregnancies involving fetuses with CHD, it is necessary to enhance the

assessment of associated extracardiac malformations. If necessary, additional fetal cranial magnetic resonance imaging should be considered to exclude the possibility of associated neurodevelopmental abnormalities[31–33]. This approach aims to provide more comprehensive clinical counseling to families and improve pregnancy outcomes.

## Conclusions

The number of CHD cases detected in fetuses has increased, while the termination rate for fetuses with CHD has declined over the past decade. Fetuses with simple CHD generally have a good prognosis, and it is recommended to continue the pregnancy. However, those with complex CHD require individualized analysis to carefully decide on the continuation of pregnancy. CHD combined with extracardiac malformations increases the risk of adverse pregnancy outcomes compared to CHD alone, and it is recommended to strengthen the assessment of malformations in other organ systems in the CHD fetuses.

## Declarations

# Conflict of Interest Statement

The authors report no conflict of interest.

**Ethics approval and Consent to Participate**

The study was granted approval by the Ethics Committee of the Women's Hospital, School of Medicine, Zhejiang University at 2024.12.24 (IRB-20240399-R), in accordance with relevant guidelines and regulations, including the Declaration of Helsinki. As this is a retrospective study, written informed consent was waived according to the regulations of our hospital’s Institutional Review Board (IRB). All data were handled with strict confidentiality to ensure the anonymity of the participants.

# Consent for publication

Not applicable.

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# Author Contribution

Xiaomin Wang and Zhiyan Zhou drafted the manuscript, carried out data collection. Xiaohan Guo and Xiaofeng Weng assisted with data collection and manuscript revision. Songjia Yi were responsible for data analysis and synthesis. Wensheng Hu contributed to the study's design, data interpretation, and manuscript revision. All authors reviewed and approved the final manuscript.

# Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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# Figures

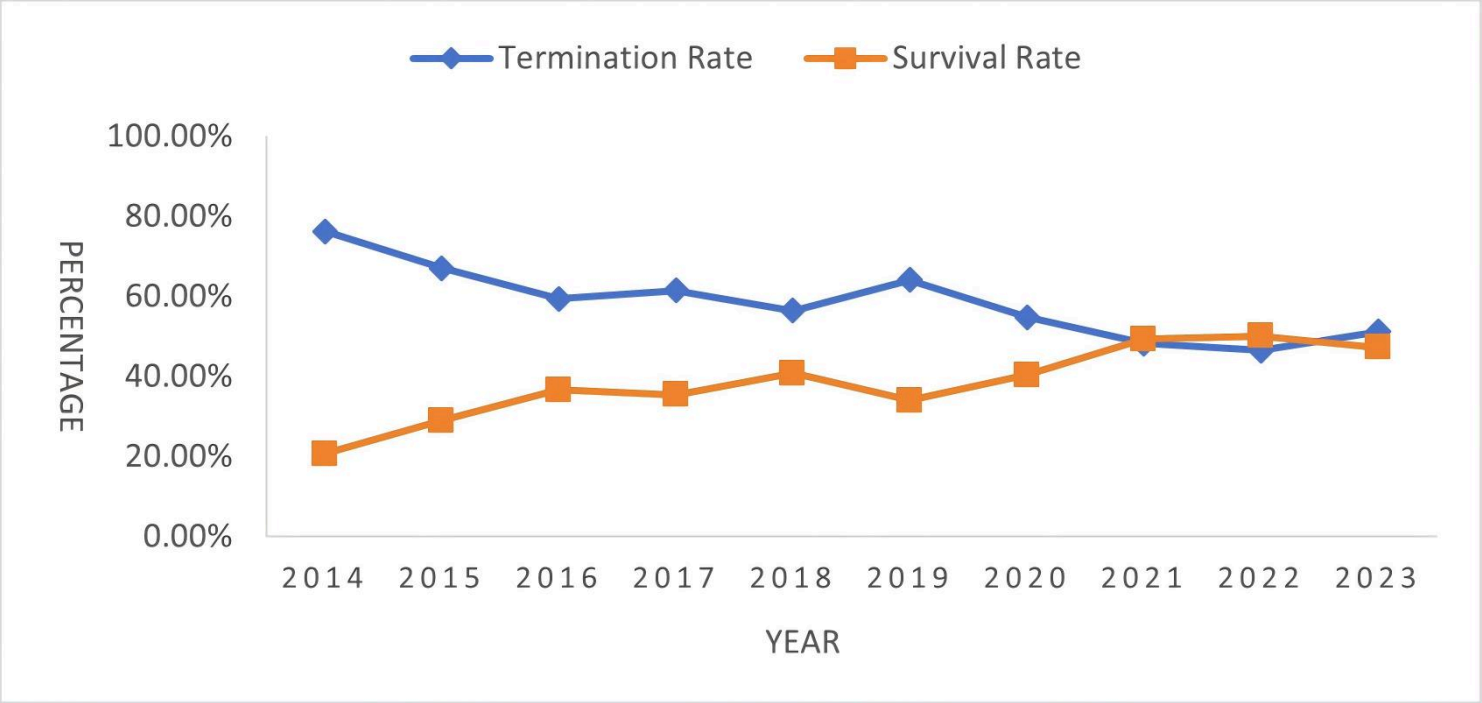



**Figure 1**

The Ten-Year Trend of Pregnancy Outcomes for Fetal CHD.