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Pregnancy and delivery management in women with congenital heart defects in the fetus: challenges and contemporary approaches

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ABSTRACT

Congenital heart defects are the most prevalent developmental anomalies in children and remain a leading cause of infant mortality. According to various sources, the prevalence of congenital heart defects in children varies widely, ranging from 4 to 50 cases per 1000 live births. Given the relative rarity of severe congenital heart defects and the historical lack of interdisciplinary collaboration in this area, research on perinatal cardiac care has often been limited to small case series or single-center studies. The aim of this review is to analyze recent literature on advancements in the perinatal and postnatal management of fetuses and newborns with congenital heart defects, including novel approaches to prenatal diagnosis, antenatal, intrapartum, and neonatal care, as well as to provide recommendations for enhancing accessibility of specialized care and outlining future research directions. A systematic search for publications was conducted using the following keywords and their combinations in both Russian and English: *врождённые пороки сердца / congenital heart defects, ВПС/CHD, фетальная кардиология / fetal cardiology, внутриутробная визуализация / intrauterine imaging, фетальная хирургия / fetal surgery.* Rapid advancements in fetal cardiac diagnostics, perinatal maternal–fetal monitoring, and in utero surgical interventions have significantly impacted pregnancy outcomes and neonatal prognosis in mother–newborn dyads affected by congenital heart defects. Early fetal echocardiography and routine obstetric screening have enhanced the early detection of pregnancies complicated by congenital heart defects. Novel approaches to prenatal counseling are being explored, and standardized algorithms are being developed to optimize fetal cardiac care, ensuring multidisciplinary perinatal support for families and labor management.

Keywords: congenital heart defects; fetal cardiology; intrauterine imaging; fetal surgery; multidisciplinary approach.

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Ведение беременности и родов у женщин с врождёнными пороками сердца плода: актуальные вопросы и возможности на современном этапе

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АННОТАЦИЯ

В настоящее время врождённые пороки сердца занимают лидирующие позиции по распространённости в сравнении с другими пороками развития у детей и остаются ведущей причиной их смерти. По разным данным, показатели распространённости врождённых пороков сердца у детей значительно варьируют и составляют от 4 до 50 случаев на 1000 живорождённых. С учётом относительной редкости формирования серьёзных врождённых пороков сердца и отсутствия междисциплинарного сотрудничества по этому вопросу в прошлом исследования в области перинатальной кардиологической помощи часто ограничиваются сериями небольших случаев или исследованиями в одном учреждении. Цель обзора — проанализировать современные литературные данные, посвящённые последним достижениям в области перинатального ведения плода и новорождённых с врождёнными пороками сердца, включая новые подходы к внутриутробной диагностике, ведению дородового периода и периода в родильном зале, а также представить рекомендации по улучшению доступности медицинской помощи с определением направления будущих исследований. Алгоритм поиска публикаций включал использование следующих ключевых слов и их сочетаний на русском и английском языках: «врождённые пороки сердца», «ВПС», «фетальная кардиология», «внутриутробная визуализация», «фетальная хирургия», «congenital heart defects», «CHD», «fetal cardiology», «intrauterine imaging», «fetal surgery». Стремительный прогресс в кардиологической диагностике плода, перинатальном наблюдении за матерью и плодом и внутриутробных хирургических вмешательствах в значительной степени повлиял на течение беременности и послеродовые исходы у пар «мать–новорождённый с врождённым пороком сердца». Ранняя эхокардиография плода и протокольный акушерский скрининг используются для более раннего выявления беременностей, осложнённых врождёнными пороками сердца, опробуются новые подходы к пренатальному консультированию, а для стандартизации кардиологической помощи плоду используются алгоритмы, ориентированные на перинатальную многопрофильную поддержку семьи и ведение родов.

Ключевые слова: врождённые пороки сердца; фетальная кардиология; внутриутробная визуализация; фетальная хирургия; мультидисциплинарный подход.

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胎儿先天性心脏病的孕产管理：当前挑战与现代医学的发展趋势

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摘要

先天性心脏病目前在儿童出生缺陷中占据首位，并仍然是儿童死亡的主要原因。据不同统计数据，儿童先天性心脏病的发病率差异较大，范围为每1000例活产儿中4至50例。由于严重先天性心脏病相对少见，并且过去缺乏跨学科合作，围产期心脏病学的研究往往局限于小规模病例系列或单中心研究。本综述的目的是分析现有文献中关于先天性心脏病胎儿及新生儿围产期管理的最新进展，包括胎儿期诊断的新方法、产前及分娩期管理策略，并提出改善医疗可及性的建议，同时明确未来研究方向。文献检索在电子数据库（PubMed、Google Scholar）中进行，使用的关键词及其组合（俄文和英文）包括："врождённые пороки сердца / congenital heart defects"（先天性心脏病）、"ВПС / CHD"（先心病）、"фетальная кардиология / fetal cardiology"（胎儿心脏病学）、"внутриутробная визуализация / intrauterine imaging"（宫内影像学）、"фетальная хирургия / fetal surgery"（胎儿外科）。胎儿心脏病学诊断技术的快速发展、围产期母胎监测的改进以及宫内手术的进步，对"母亲-先天性心脏病新生儿"群体的妊娠过程及产后结局产生了重要影响。胎儿超声心动图和标准化产科筛查有助于更早发现受先天性心脏病影响的妊娠，并推动产前咨询方式的改进。此外，以围产期多学科家庭支持及分娩管理为核心的胎儿心脏病学护理标准化方案正在逐步推广应用。

关键词：先天性心脏病；胎儿心脏病学；宫内影像学；胎儿外科；多学科协作。

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INTRODUCTION

Congenital heart defects (CHDs) are the most prevalent developmental anomalies in children and remain a leading cause of infant mortality. The prevalence of CHD in children varies widely, ranging from 4 to 50 cases per 1,000 live births [1]. Although most cases of CHD are not life-threatening in utero, fetal death can occur in 20% of cases [2], with an increased risk of adverse pregnancy outcomes including preterm delivery and neurological complications [3, 4]. ЭPotential adverse sequelae have led to increased efforts to detect and monitor CHD during pregnancy to ensure optimal postpartum outcomes. In recent years, rapid advances in intrauterine imaging and fetal surgery allow modifying the course of CHD [5–7]. Currently, fetal cardiac surgery is a multidisciplinary field that contributes to earlier detection of fetal cardiovascular disease that affects neonatal outcomes. However, research on perinatal cardiac care has often been limited to small case series or single-center studies due to the relatively low rates of severe CHD and the historical lack of interdisciplinary collaboration in this area. Therefore, further advances in comprehensive studies and management of fetal CHD will require continued interdisciplinary, multi-center collaboration to optimize outcomes and access to care.

AIM. The aim of this review is to analyze recent publications on advances in the management of fetal and neonatal patients with CHD, including novel approaches to prenatal diagnosis and perinatal care, and to provide recommendations for improved access to specialized care and future research.

METHODS

PubMed, eLibrary, and Google Scholar databases were searched for publications. The following keywords and their combinations were used in both Russian and English: *врождённые пороки сердца / congenital heart defects, ВПС/CHD, фетальная кардиология / fetal cardiology, внутриутробная визуализация / intrauterine imaging, фетальная хирургия / fetal surgery.* The authors independently reviewed the titles and abstracts of the articles and then extracted the full text of the relevant studies. The review included relevant experimental and clinical studies published in Russian and English.

PRISMA guidelines were used to select articles. The review included all relevant articles published up to September 2024. The search yielded 3,157 articles from PubMed and 1,416 articles from eLibrary. Duplicate and incomplete articles were excluded.

The authors independently evaluated the titles and abstracts of all identified articles. The full text of potentially eligible articles was read for final selection. Any disagreement between authors was settled by consensus. Figure 1 shows the search algorithm.

RESULTS AND DISCUSSION

Prenatal Diagnosis of Fetal Heart Condition

Role of Prenatal Diagnosis of CHD in Pregnancy Outcomes

Studies evaluating the effect of prenatal diagnosis of CHD on mortality rates, especially for ductus-dependent CHD, are inconsistent. A population-based study by Oster et al. [8] found higher mortality rates in newborns with prenatal diagnosis of CHD. The authors hypothesized that prenatal diagnosis could identify difficult-to-treat, high-risk patients, but patients with undiagnosed CHD at the time of death were not included. A meta-analysis by Holland et al. [9] revealed increased mortality rates in patients with a postnatal diagnosis of CHD, especially in the preoperative period. Other studies have found no difference in mortality rates between prenatal and postnatal diagnosis of CHD in the preoperative or postoperative period [4, 10]. However, confounding factors introduce significant selection bias, including a higher potential for severe disease in newborns with prenatal diagnosis and for death before tertiary hospitalization in newborns with postnatal diagnosis of CHD.

Although prenatal diagnosis has no significant effect on fetal/neonatal mortality rates, several studies have shown that patients with a postnatal diagnosis of CHD have more severe preoperative clinical manifestations and are more likely to have neurological complications [4, 11]. Studies conducted by Mahle et al. [12] in patients with hypoplastic left heart syndrome (HLHS) and Peyvandi et al. [11] in patients with HLHS and transposition of the great arteries showed lower rates of neurological complications in patients with prenatal diagnosis of CHD, including a lower risk of intraoperative coma and less severe preoperative brain damage

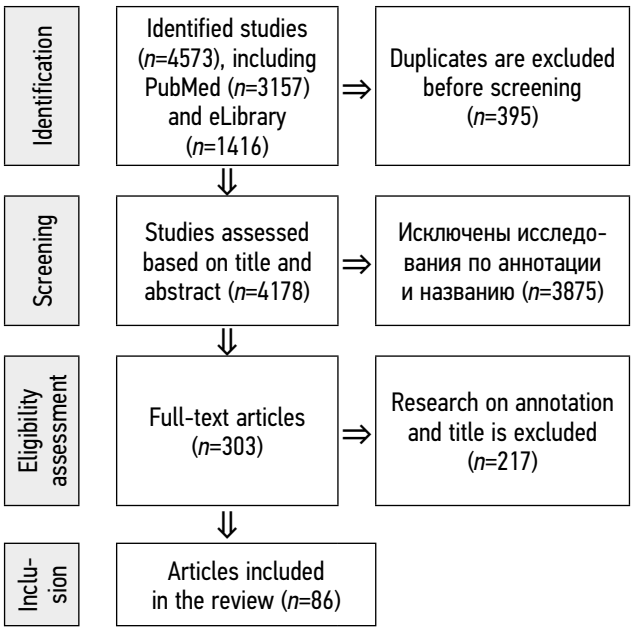

Fig. 1. Study selection algorithm.

on a magnetic resonance imaging scan. Although there is no evidence that patients with postnatal diagnosis of CHD have higher mortality rates, the simultaneous improvement in perioperative emergency care and surgical management may challenge the use of mortality as an independent outcome measure. Further studies are needed to compare long-term morbidity and mortality in patients with prenatal and postnatal diagnosis of CHD.

Recent Advances in Fetal Cardiac Imaging

The development of earlier and more sensitive and accurate prenatal screening for CHD is an important area of research in fetal cardiology and obstetrics. Recent research has focused on improving standardized prenatal screening and using first-trimester cardiac screening. Fetal cardiac screening is indicated in all pregnancies, usually during an obstetric examination at 18 to 22 weeks of gestation [13]. Current guidelines, including multidisciplinary guidelines published in 2018 by the American Institute of Ultrasound in Medicine (AIUM), American College of Radiology (ACR), American College of Obstetricians and Gynecologists (ACOG), Society for Maternal-Fetal Medicine (SMFM) and Society of Radiologist in Ultrasound (SRU), as well as guidelines published in 2022 by the International Society of Ultrasound in Obstetrics & Gynecology (ISUOG) recommend fetal cardiac screening, including assessment of heart rhythm, heart size/position, ventricles, and ventricular outflow tracts [14, 15]. Doppler ultrasound is also recommended in the updated 2023 ISUOG guidelines [16]. Patients with significant or suspected maternal/fetal risk factors for CHD on ultrasound should be referred to a fetal cardiologist for fetal echocardiography. This diagnostic modality included additional evaluation of the interventricular septum, superior and inferior vena cava, ducts, and aortic arches [16, 17]. Primary fetal echocardiography in patients at high risk for CHD is recommended between 18 and 22 weeks of gestation [16, 18, 19]. However, patients with suspected CHD based on obstetric ultrasound should be referred for earlier evaluation.

The majority of pregnancies resulting in fetal CHD occur in low-risk patients, highlighting the need for careful screening [20]. Routine obstetrics screening provides a virtually universal opportunity to detect CHD. The use of standard cardiac screening views has increased significantly. The four-chamber cardiac view alone detects 30%–60% of congenital heart defects [21], whereas additional evaluation of the ventricular outflow tracts increases sensitivity to 60%–90% [22]. Increased physician awareness and additional cardiac screening capabilities have improved the prenatal diagnosis of CHD [18, 23], but the real-world clinical effectiveness of standardized screening protocols remains suboptimal [24, 25]. Further improvement in CHD diagnosis is limited by center-specific fetal CHD volume and experience, local patient care patterns and disparities in access to care [23].

New approaches, including the use of artificial intelligence (AI), are being actively explored to improve prenatal CHD detection and screening [26]. A recent study by Day et al. [27] compared the performance of an AI-based model with a current screening program for HLHS. The study showed that the AI-based model performed worse. Universal fetal echocardiography has been proposed as an alternative, but low cost-effectiveness, resource allocation, and healthcare accessibility are significant barriers [23]. Further research on prenatal CHD diagnosis and new approaches to increase the sensitivity of obstetric screening are needed to improve fetal cardiac diagnosis.

Historically, device resolution and technology have limited fetal echocardiography in early pregnancy. However, recent advances in ultrasound imaging, including color Doppler, high-resolution high-frequency transducers, and 3D/4D echocardiography [28], as well as improved training and experience of sonographers, allow earlier and more comprehensive cardiac screening, timely access to expert fetal cardiac diagnosis, and selection of appropriate pregnancy and delivery management strategies. Several small studies evaluating the feasibility of early fetal echocardiography in high-risk patients have demonstrated a 60%–95% sensitivity for CHD when performed in the late first and early second trimesters [29, 30]. However, these studies were conducted in large tertiary referral centers with sonographers trained in fetal echocardiography. A retrospective study published in 2024 evaluated the feasibility of first-trimester cardiac screening during routine obstetric ultrasound in a large population of fetuses at low risk for CHD in Denmark [31]. A complete cardiac evaluation was performed in 85% of the total population, but only 25% were diagnosed with CHD in the first trimester [31]. Other studies evaluating early obstetric screening in low-risk groups show detection rates of 50%–70% at 11–14 weeks of gestation using different screening protocols [32, 33].

Current clinical imaging guidelines provide varying recommendations for first-trimester cardiac screening, taking into account established technical limitations and expert needs. The ISUOG recommends local, 4-chamber and 3-vessel views in low-risk groups during the first trimester using a high-frequency transabdominal transducer to optimize resolution [16, 34]. The AIUM recommends first-trimester screening between 12 weeks 0 days and 13 weeks 6 days of gestation for high-risk patients or those with suspected fetal anomalies [35]. The American Society of Echocardiography (ASE) recognizes the possibility of fetal echocardiography in the early second trimester. However, the ASE recommends repeat testing at 18–22 weeks due to the difficulty of comprehensive testing in early pregnancy [36].

Therefore, first trimester screening and early fetal echocardiography between 12 and 16 weeks of gestation are most effective in detecting CHD in high-risk groups or when a cardiac anomaly is suspected. However, its use in real-world clinical settings is limited because the detection rate is still lower than in the later stages of pregnancy and its performance is currently dependent on the doctor experience [31].

Perinatal Cardiology

Multidisciplinary fetal cardiac care is needed to address the complex medical and psychosocial needs of families with a prenatal diagnosis of CHD. Although there are limited data on the effectiveness of multidisciplinary management, active collaboration between specialists allows planning of the place and timing of delivery and postpartum surgery [37]. Despite the established collaboration between fetal cardiologists and obstetricians/gynecologists, the involvement of other specialists in fetal cardiac care is not common. A large survey of 41 quaternary intensive care units evaluated differences in clinical practice for patients with CHD [38]. The study found that the nature and type of collaboration varied widely, but only 31% had regular prenatal consultations with neonatologists [38]. In addition, other specialists were involved in counseling: nurse coordinators in 86% of cases, but social care workers in only 69% of cases, psychologists in 34% of cases, and palliative care specialists in 7% of cases [38]. However, the studies show that involvement of these specialists can reduce anxiety and improve communication and shared decision-making [38–40]. Comprehensive diagnosis and specialized perinatal care involve many specialists, including obstetricians/gynecologists, cardiologists, fetal and cardiothoracic surgeons, radiologists, anesthesiologists, palliative care specialists, medical geneticists, psychologists, and social care workers [41, 42].

It is difficult to conduct robust studies to support the development of comprehensive perinatal cardiac care guidelines because of the relatively low rates of CHD, variable treatment options, and barriers to interdisciplinary collaboration [43]. Recently, consortia have emerged to promote collaboration in perinatal care and research (e.g., Fetal Heart Society) [43]. Multidisciplinary guidelines for the diagnosis and optimal management of prenatally diagnosed CHD have been developed by the American Heart Association (AHA), AIUM, and the International Fetal Medicine and Surgical Society / the North American Fetal Therapy Network (IFMSS/NAFT) [19, 44]. The Fetal Cardiology Task Force of the Association for European Pediatric and Congenital Cardiology has developed fetal cardiology guidelines for European countries, emphasizing the need for collaboration between cardiologists and obstetricians/gynecologists to ensure accurate diagnosis, appropriate support, clear communication, timely management and treatment, and continued research [45]. Several recent studies have evaluated various multidisciplinary management protocols for pregnant women with a fetus with CHD. Wautletet et al. [46] used a multidisciplinary management protocol for pregnant women with univentricular fetuses to standardize prenatal visits, screening, management, and specialist consultations. However, the generalizability of this study is limited because it was conducted in a large center with easy access to highly specialized care. Ronai et al. [37] evaluated the effectiveness of a multidisciplinary model including fetal cardiology, neonatology, and genetic counseling. No newborns required unexpected interventions, confirming the ability of the model to accurately predict postnatal physiology and influence perinatal management/outcomes [37]. A retrospective study conducted by the University of California Fetal-Maternal Consortium found that a standardized clinical evaluation and management plan resulted in higher rates of vaginal delivery (61% vs. 50%) and term delivery (48% vs. 34%) [47].

Multidisciplinary pregnancy management models are feasible and can impact critical CHD outcomes. Maternal and neonatal safety is essential, and special attention is given to effective monitoring of a fetus with CHD through the collaborative efforts of cardiologists, neonatologists, obstetricians/gynecologists, and other specialists [48]. Multidisciplinary teams provide high-quality care, comprehensive and timely support, and ongoing psychosocial support [38]. The development of healthcare algorithms and consensus clinical guidelines helps to standardize team-based prenatal care to reduce maternal risk, improve neonatal outcomes, and reduce healthcare costs [47, 48]. Future research should focus on a clear consensus on effective interdisciplinary care and consider ways to improve its accessibility.

Prenatal Counseling

Once CHD is diagnosed, the next important step for fetal cardiologists and obstetricians/gynecologists is to provide timely and accurate support. Counseling is an integral part of pediatric cardiology and requires special knowledge of echocardiography, cardiac physiology, prenatal and postnatal treatment options, and long-term management and outcomes of CHD. The 2014 AHA Scientific Statement on the Diagnosis and Treatment of Fetal Cardiac Disease highlights the role of counseling and psychosocial support following the diagnosis of fetal CHD [49]. In addition, Williams et al. [50] found that prenatal diagnosis improved parental awareness of neonatal CHD even with formal education, highlighting the importance of such counseling to provide a basis for informed parental involvement. Despite the essential role of prenatal counseling, there are few relevant studies on the most effective counseling techniques and several relevant guidelines.

A few small studies evaluated prenatal counseling needs from the parents' perspective, including perceptions of important counseling topics and their impact on actual parental awareness. Kovacevic et al. [51, 52] developed a questionnaire to assess parents' counseling needs and found that only 45% of patients considered counseling successful. The results showed that medical information was difficult to understand during communication, but comprehension could be improved by providing patients with written handouts, increasing the length of the consultation, and providing a private room [51, 52]. In a small Swedish study by Bratt et al. [53], parents were interviewed after prenatal diagnosis of CHD to assess the content and structure of the consultations. Parents were found to appreciate the understanding of

the CHD diagnosis, practical advice about the birth and future daily living of their child, and the opportunity to communicate with others in a similar situation. Timely and understandable face-to-face information, especially visual, was critical [51–54]. Finally, Arya et al. [55] interviewed parents of older children with CHD and compared their prenatal education / counseling expectations with those of cardiologists. In general, parents consistently rated educational issues as more important than cardiologic ones, with the most significant differences in the quality of life, including lifelong surgeries, need for transplantation, exercise limitations, and potential impact on future family history of CHD [55]. Studies are inconclusive about how much information should be given to patients; too much information may increase anxiety, whereas too little information may affect the perception of the diagnosis [55]. However, both parents and cardiologists considered it important to understand heart disease nomenclature, postpartum intervention options, short- and long-term survival, comorbidities, and health care options [55]. Parents always appreciate being informed, especially about future outcomes and quality of life [53–55].

Two recent studies evaluated 3D printing to improve practical understanding compared with standard counseling [56, 57]. Although parents find 3D models useful and helpful in communicating with healthcare professionals, the effectiveness of these models in improving parental awareness of CHD anatomy and surgical options remains controversial [56, 57]. These studies suggest the potential use of new methods to improve prenatal counseling.

A multidisciplinary approach plays a critical role in clinical decision-making. Current practice includes consultation with specialists experienced in prenatal and postnatal diagnosis and management of CHD. However, provision of honest and accurate information about the diagnosis, prognosis, and potential treatment options, as well as timely and ongoing dialogue with parents should be a priority [54, 58]. Visual aids such as diagrams and models can help assess the level of knowledge that parents have about the disease. In addition, a multidisciplinary team ensures a consistent approach and a wide range of support tools that contribute to the achievement of management goals [54, 58]. Therefore, further research and guidelines are needed to improve the effectiveness of intrauterine counseling and training of fetal cardiologists.

Several recent studies have shown that prenatal diagnosis of CHD increases maternal stress during pregnancy and for several months after delivery [59, 60]. Maternal stress can affect fetal health through growth and development, risk of preterm delivery, and postnatal neurodevelopment [59, 61, 62]. However, parent surveys consistently show a preference for prenatal diagnosis over postnatal diagnosis [60, 63]. Maternal stress/anxiety/depression can be prevented by maternal social support from the social environment [61] and consultation with qualified psychologists [64].

Labor Management

Optimal management of the mother and fetus with CHD dyad is the goal of multidisciplinary perinatal cardiac care. Key components of such management include planning the place, timing, and mode of delivery, based on the impact on both mother and fetus. This area of perinatal care requires close interaction between different specialists, although data on the effectiveness of multidisciplinary labor management are limited [37].

The high rates of preterm delivery in pregnancies complicated by CHD, due to intrauterine and maternal causes, persist and affect infant morbidity and mortality [65]. Therefore, induced labor or cesarean section for prenatal diagnosis of CHD is often coordinated by tertiary referral centers and is considered safe after 37 weeks of gestation [66]. However, analysis of full-term newborns with CHD born between 37 and 40 weeks of gestation shows further reductions in hospital length of stay, pulmonary complications, and mortality with each additional week of gestation [49, 66–68]. These data suggest that morbidity and mortality are reduced with later gestation, so delivery should occur closer to 40 weeks of gestation whenever possible. Therefore, most fetal cardiologists recommend watchful waiting until 39 weeks of gestation to plan delivery, minimize morbidity and mortality, and coordinate care. Despite this generalization, delivery recommendations should be specific to CHD. For example, in certain types of CHD, including Ebstein anomaly, tetralogy of Fallot with absent pulmonary valve, or any diagnosis with severe valvular regurgitation, delivery before 39 weeks of gestation should be considered due to the increased risk of intrauterine fetal death [69].

Some studies evaluated delivery methods in pregnancies with CHD, including vaginal delivery, induction of labor, planned cesarean section, and cesarean section after trial of labor, and found no differences in overall Apgar scores, duration of preoperative intubation, metabolic acidosis, length of hospital stay, or mortality [68, 70–74]. In addition, a study of patients with HLHS found no differences in the need for intensive care based on mode of delivery [71]. A trial of labor with careful maternal-fetal monitoring by an experienced obstetric team and prompt access to neonatal intensive care is warranted because a fetus with CHD is often stable in utero [71, 72].

The choice of a place of delivery should balance the ability to safely monitor the mother and fetus with easy access to tertiary care. Studies of newborns with ductus-dependent CHD show that delivery near a cardiac surgery center (<10 min) is associated with lower preoperative mortality [49, 75]. However, another study compared delivery in a tertiary referral center with delivery in other types of centers and showed no difference in mortality rates for newborns with duct-dependent CHD [76]. Therefore, studies provide inconsistent data on neonatal outcomes associated with the place of delivery. The current standard of care is to recommend a place of delivery near, but not necessarily in, a cardiac

surgery center. However, delivery in a cardiac surgery center is recommended for newborns requiring immediate postnatal intervention, such as newborns with total anomalous pulmonary venous drainage or HLHS with patent foramen ovale or intact atrial septum. In some cases, this may require the mother to relocate prior to the estimated date of delivery. Maternal health studies show that pregnancies complicated by fetal CHD are at increased risk for maternal morbidity, including intensive care unit admission, need for blood transfusion, unplanned surgery, and hospital transfer, even after adjustment for known risk factors [77]. This study emphasizes the need for multidisciplinary discussion of safe place of delivery based on the risks associated with differences in maternal and neonatal care between centers. In some countries, multidisciplinary clinics have been established to manage these patients, driven by collaborative protocols between fetal cardiologists and obstetricians/gynecologists and an increasing interest in delivering infants as close as possible to medical centers that can provide timely postpartum care. Further studies to evaluate the performance of these clinics, including maternal and neonatal outcomes, will help inform future guidelines for CHD management.

The choice between early and delayed umbilical cord clamping in newborns with CHD is a special focus of labor management. A risk–benefit ratio of delayed cord clamping has been well studied in healthy preterm infants. However, there are limited data in infants with CHD, who have increased fluid overload and blood viscosity due to increased volume and concentration overload [78]. A small pilot randomized controlled trial of 30 critically ill neonates with CHD, published in 2015 by Backes et al. [79], demonstrated that delayed umbilical cord clamping is safe and feasible. No differences were found in specific safety parameters such as Apgar score, bilirubin, preoperative mortality and polycythemia, and postoperative morbidity [79]. Another retrospective study by Fite et al. [78] reviewed the medical records of 160 critically ill newborns with CHD and found no differences in pre- or postpartum hemoglobin levels with delayed versus early umbilical cord clamping. These studies suggest that delayed umbilical cord clamping should be recommended whenever possible, based on its safety profile and potential benefit in the early postpartum period. However, further studies evaluating long-term outcomes are needed to confirm whether this practice should be recommended.

Fetal Surgery Techniques

Some infants with CHD require prenatal cardiac surgery with timely involvement of fetal cardiologists. Fetal cardiac surgery is a rapidly evolving area of CHD treatment, both to improve prenatal/postnatal survival and to stop disease progression [80]. In Russia, intrauterine treatment of CHD is performed only at the Almazov Federal Center of Heart, Blood, and Endocrinology, St. Petersburg (isolated surgeries), in Irkutsk and Yekaterinburg. It is currently difficult to evaluate the effectiveness and availability of fetal cardiac surgery due to the relatively low rates of treatable fetal CHD and the limited number of medical centers with sufficient capacity and experience to achieve optimal outcomes [7, 81]. In this area, medical care has become regionalized with the emergence of specialized centers for fetal cardiac surgery [44]. These medical centers provide the multidisciplinary care necessary for successful fetal cardiac surgery, but their lack creates problems with access to surgical care [7, 44]. In addition, this limitation justifies the importance of interagency consortia and registries to promote collaboration and transparency in fetal cardiac surgery and scientific research [44].

Role of Socioeconomic Factors

Access to prenatal diagnosis, perinatal management and cardiac care is critical due to a trend toward institutionalization. Socioeconomic factors are one of the elements that influence the availability of healthcare, which can lead to adverse maternal and infant outcomes [82–84]. High social deprivation is associated with later ultrasound screening, longer interval between screening ultrasound and fetal echocardiography, and later diagnosis of CHD, according to studies evaluating the association between socioeconomic factors and access to fetal cardiac care [82, 83]. These findings were confirmed by Krishnan et al. [85], who found that the lower socioeconomic quartile was associated with lower rates of prenatal diagnosis of HLHS and transposition of the great vessels. Delayed fetal diagnosis or failure to recognize a critical stage of CHD may affect safe delivery planning and, consequently, postpartum outcomes. In addition, the potential need to relocate for delivery may create additional challenges for the family in some types of CHD. Early pregnancy screening for social determinants to ensure timely multidisciplinary support and access to care is now recognized as an important healthcare issue. In addition, a recent American Heart Association/American College of Cardiology (AHA/ACC) report recognizes the importance of these factors and provides definitions of cardiac-related social determinants of health (SDOH) and a thorough review of specific data elements useful in researching the impact of SDOH at the intrapersonal, interpersonal, and societal levels [86]. This new document standardizes future research on SDOH and the impact of SDOH on the prenatal CHD management.

CONCLUSION

Rapid advances in fetal cardiac diagnosis, perinatal maternal-fetal monitoring, and fetal surgery have significantly improved the course of pregnancy and maternal-fetal/neonatal outcomes in CHD. Early fetal echocardiography and routine obstetric screening have improved the early identification of pregnancies complicated by CHD. Novel approaches to prenatal counseling are explored and standardized algorithms are developed to optimize fetal cardiac care and ensure multidisciplinary perinatal family support and labor management.

Fetal cardiac surgery is effective in only a small population of patients with CHD, and access to care is still limited to few tertiary referral centers. However, broader access to other fetal cardiac surgery options offers opportunities to improve both prenatal and postnatal CHD outcomes. Future progress will require multidisciplinary and multicenter collaboration to advance research, optimize CHD outcomes, and ensure access to high-quality fetal cardiac care.

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ADDITIONAL INFORMATION

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REFERENCES | СПИСОК ЛИТЕРАТУРЫ

1. Saperova EV, Vahlova IV. Congenital heart diseases in children: incidence, risk factors, mortality. *Current Pediatrics*. 2017;16(2):126–133. doi: 10.15690/vsp.v16i2.1713 EDN: YRGVRT
2. Ziganshin AM, Nizamutdinova RI, Nagimova EM, Khalitova RSh. Risk factors of intrauterine fetal death. *Russian Bulletin of Obstetrician-Gynecologist*. 2023;23(2):4752. doi: 10.17116/rosakush20232302147 EDN: VZXJVN
3. Rudaeva EV, Mozes VG, Kashtalap VV, et al. Congenital heart disease and pregnancy. *Fundamental and Clinical Medicine*. 2019;4(3):102–112. doi: 10.23946/2500-0764-2019-4-3-102-112 EDN: EAKKTS
4. Colaco SM, Karande T, Bobhate PR, et al. Neonates with critical congenital heart defects: Impact of fetal diagnosis on immediate and short-term outcomes. *Ann Pediatr Cardiol*. 2017;10(2):126–130. doi: 10.4103/apc.APC_125_16
5. Aksenov AN, Bocharova II, Troitskaia MV, et al. The effect of surgical correction of congenital heart defects in mothers on the health status of their newborns. *Russian Bulletin of Obstetrician-Gynecologist*. 2020;20(2):5563. doi: 10.17116/rosakush20202002155 EDN: VQNOBL
6. Pervunina TM, Vasichkina ES, Erman MV. Personalized approach in the management of children with cardiorenal syndrome (combined congenital heart and kidney defects). *Russian Journal for Personalized Medicine*. 2023;3(2):77–81. doi: 10.18705/2782-3806-2023-3-2-77-81 EDN: VEMNZA
7. Guseh S, Tworetzky W. Transforming congenital heart disease management: advances in fetal cardiac interventions. *Prenat Diagn*. 2024;44(6-7):733–738. doi: 10.1002/pd.6592
8. Oster ME, Kim CH, Kusano AS, et al. A population-based study of the association of prenatal diagnosis with survival rate for infants with congenital heart defects. *Am J Cardiol*. 2014;113(6):1036–1040. doi: 10.1016/j.amjcard.2013.11.066
9. Holland BJ, Myers JA, Woods CR Jr. Prenatal diagnosis of critical congenital heart disease reduces risk of death from cardiovascular compromise prior to planned neonatal cardiac surgery: a meta-analysis. *Ultrasound Obstet Gynecol*. 2015;45(6):631–638. doi: 10.1002/uog.14882
10. Sullivan ID. Prenatal diagnosis of structural heart disease: does it make a difference to survival? *Arch Dis Child Fetal Neonatal Ed*. 2002;87(1):F19–20. doi: 10.1136/fn.87.1.f19
11. Peyvandi S, De Santiago V, Chakkarapani E, et al. Association of prenatal diagnosis of critical congenital heart disease with postnatal brain development and the risk of brain injury. *JAMA Pediatr*. 2016;170(4):e154450. doi: 10.1001/jamapediatrics.2015.4450
12. Mahle WT, Clancy RR, McGaurn SP, et al. Impact of prenatal diagnosis on survival and early neurologic morbidity in neonates with the hypoplastic left heart syndrome. *Pediatrics*. 2001;107(6):1277–1282. doi: 10.1542/peds.107.6.1277
13. Gorokhova SG, Morozova TE, Arakelyants AA, et al. Algorithm of echocardiography in pregnant women. *Russian Journal of Cardiology*. 2018;23(12):75–83. doi: 10.15829/1560-4071-2018-12-75-83 EDN: YPPAZN
14. AIUM-ACR-ACOG-SMFM-SRU practice parameter for the performance of standard diagnostic obstetric ultrasound examinations. *J Ultrasound Med*. 2018;37(11):13–24. doi: 10.1002/jum.14831
15. Salomon LJ, Alfirevic Z, Berghella V, et al. ISUOG practice guidelines (updated): performance of the routine mid-trimester fetal ultrasound scan. *Ultrasound Obstet Gynecol*. 2022;59(6):840–856. doi: 10.1002/uog.24888
16. Carvalho JS, Axt-Fliedner R, Chaoui R, et al. ISUOG practice guidelines (updated): fetal cardiac screening. *Ultrasound Obstet Gynecol*. 2023;61(6):788–803. doi: 10.1002/uog.26224
17. AIUM practice parameter for the performance of detailed second- and third-trimester diagnostic obstetric ultrasound examinations. *J Ultrasound Med*. 2019;38(12):3093–3100. doi: 10.1002/jum.15163
18. Pomortsev AV, Karakhalis MN, Matulevich SA, et al. Congenital heart diseases: risk factors and ultrasound diagnostic potential at the first screening. *Innovative Medicine of Kuban*. 2023;8(4):51–59. doi: 10.35401/2541-9897-2023-8-4-51-59 EDN: TPLIWH
19. AIUM practice parameter for the performance of fetal echocardiography. *J Ultrasound Med*. 2020;39(1):E5–E16. doi: 10.1002/jum.15188
20. Sood E, Newburger JW, Anixt JS, et al. American heart association council on lifelong congenital heart disease and heart health in the young and the council on cardiovascular and stroke nursing. neurodevelopmental outcomes for individuals with congenital heart disease: updates in neuroprotection, risk-stratification, evaluation, and management: a scientific statement from the American heart association. *Circulation*. 2024;149(13):e997–e1022. doi: 10.1161/CIR.0000000000001211
21. Quartermain MD, Pasquali SK, Hill KD, et al. Variation in prenatal diagnosis of congenital heart disease in infants. *Pediatrics*. 2015;136(2):e378–385. doi: 10.1542/peds.2014-3783
22. Levy DJ, Pretorius DH, Rothman A, et al. Improved prenatal detection of congenital heart disease in an integrated health care system. *Pediatr Cardiol*. 2013;34(3):670–679. doi: 10.1007/s00246-012-0526-y
23. Moon-Grady AJ, Donofrio MT, Gelehrter S, et al. Guidelines and recommendations for performance of the fetal echocardiogram: an update from the American society of echocardiography. *J Am Soc Echocardiogr*. 2023;36(7):679–723. doi: 10.1016/j.echo.2023.04.014
24. Vepa S, Alavi M, Wu W, et al. Prenatal detection rates for congenital heart disease using abnormal obstetrical screening ultrasound alone as indication for fetal echocardiography. *Prenat Diagn*. 2024;44(6-7):706–716. doi: 10.1002/pd.6544
25. McLean KC, Meyer MC, Peters SR, et al. Obstetric imaging practice characteristics associated with prenatal detection of critical congenital heart disease in a rural US region over 20 years. *Prenat Diagn*. 2024;44(6-7):698–705. doi: 10.1002/pd.6551
26. Mamedov MN, Savchuk EA, Karimov AK. Artificial intelligence in cardiology. *International Heart and Vascular Disease Journal*. 2024;12(43):5–11. doi: 10.24412/2311-1623-2024-43-5-11 EDN: VNYVEA
27. Day TG, Budd S, Tan J, et al. Prenatal diagnosis of hypoplastic left heart syndrome on ultrasound using artificial intelligence: how does performance compare to a current screening programme? *Prenat Diagn*. 2024;44(6-7):717–724. doi: 10.1002/pd.6445
28. Hutchinson D, McBrien A, Howley L, et al. First-trimester fetal echocardiography: identification of cardiac structures

for screening from 6 to 13 weeks' gestational age. *J Am Soc Echocardiogr*. 2017;30(8):763–772. doi: 10.1016/j.echo.2017.03.017
29. Pike JI, Krishnan A, Donofrio MT. Early fetal echocardiography: congenital heart disease detection and diagnostic accuracy in the hands of an experienced fetal cardiology program. *Prenat Diagn*. 2014;34(8):790–796. doi: 10.1002/pd.4372
30. Persico N, Moratalla J, Lombardi CM, et al. Fetal echocardiography at 11–13 weeks by transabdominal high-frequency ultrasound. *Ultrasound Obstet Gynecol*. 2011;37(3):296–301. doi: 10.1002/uog.8934
31. Helmbæk ME, Sundberg K, Jørgensen DS, et al. Clinical implementation of first trimester screening for congenital heart defects. *Prenat Diagn*. 2024;44(6-7):688–697. doi: 10.1002/pd.6584
32. Orlandi E, Rossi C, Perino A, et al. Simplified first-trimester fetal cardiac screening (four chamber view and ventricular outflow tracts) in a low-risk population. *Prenat Diagn*. 2014;34(6):558–563. doi: 10.1002/pd.4348
33. Karim JN, Bradburn E, Roberts N, Papageorghiou AT. First-trimester ultrasound detection of fetal heart anomalies: systematic review and meta-analysis. *Ultrasound Obstet Gynecol*. 2022;59(1):11–25. doi: 10.1002/uog.23740
34. International Society of Ultrasound in Obstetrics and Gynecology; Bilardo CM, Chaoui R, et al. ISUOG practice guidelines (updated): performance of 11–14-week ultrasound scan. *Ultrasound Obstet Gynecol*. 2023;61(1):127–143. doi: 10.1002/uog.26106
35. AIUM practice parameter for the performance of detailed diagnostic obstetric ultrasound examinations between 12 weeks 0 days and 13 weeks 6 days. *J Ultrasound Med*. 2021;40(5):E1–E16. doi: 10.1002/jum.15477
36. Hernandez-Andrade E, Valentini B, Gerulewicz D. Practical evaluation of the fetal cardiac function. *Clin Obstet Gynecol*. 2024;67(4):753–764. doi: 10.1097/GRF.0000000000000899
37. Ronai C, Kim A, Dukhovny S, et al. Prenatal congenital heart disease-it takes a multidisciplinary village. *Pediatr Cardiol*. 2023;44(5):1050–1056. doi: 10.1007/s00246-023-03161-6
38. Leon RL, Levy PT, Hu J, et al. Practice variations for fetal and neonatal congenital heart disease within the children's hospitals neonatal consortium. *Pediatr Res*. 2023;93(6):1728–1735. doi: 10.1038/s41390-022-02314-2
39. Lowenstein S, Macauley R, Perko K, Ronai C. Provider perspective on the role of palliative care in hypoplastic left heart syndrome. *Cardiol Young*. 2020;30(3):377–382. doi: 10.1017/S1047951120000128
40. Hancock HS, Pituch K, Uzark K, et al. A randomised trial of early palliative care for maternal stress in infants prenatally diagnosed with single-ventricle heart disease. *Cardiol Young*. 2018;28(4):561–570. doi: 10.1017/S1047951117002761
41. Sethi N, Miller S, Hill KD. Prenatal diagnosis, management, and treatment of fetal cardiac disease. *Neoreviews*. 2023;24(5):e285–e299. doi: 10.1542/neo.24-5-e285
42. Wilkins-Haug LE, Benson CB, Tworetzky W, et al. In-utero intervention for hypoplastic left heart syndrome — a perinatologist's perspective. *Ultrasound Obstet Gynecol*. 2005;26(5):481–486. doi: 10.1002/uog.2595
43. Pinto NM, Morris SA, Moon-Grady AJ, Donofrio MT. Prenatal cardiac care: goals, priorities & gaps in knowledge in fetal cardiovascular disease: perspectives of the Fetal Heart Society. *Prog Pediatr Cardiol*. 2020;59:101312. doi: 10.1016/j.ppedcard.2020.101312
44. Moon-Grady AJ, Baschat A, Cass D, et al. Fetal treatment 2017: The evolution of fetal therapy centers — a joint opinion from the International fetal medicine and surgical society (IFMSS) and the North American fetal therapy network (NAFTNet). *Fetal Diagn Ther*. 2017;42(4):241–248. doi: 10.1159/000475929
45. Allan L, Dangel J, Fesslova V, et al. Recommendations for the practice of fetal cardiology in Europe. *Cardiol Young*. 2004;14(1):109–14. doi: 10.1017/s1047951104001234
46. Wautlet CK, Kops SA, Silveira LJ, et al. Maternal-fetal comorbidities and obstetrical outcomes of fetal single ventricle cardiac defects: 10 years' experience with a multidisciplinary management protocol at a single center. *Prenat Diagn*. 2024;44(6-7):783–795. doi: 10.1002/pd.6591
47. Afshar Y, Hogan WJ, Conturie C, et al. Multi-institutional practice-patterns in fetal congenital heart disease following implementation of a standardized clinical assessment and management plan. *J Am Heart Assoc*. 2021;10(15):e021598. doi: 10.1161/JAHA.121.021598
48. Udine M, Donofrio MT. The role of the neonatologist in fetuses diagnosed with congenital heart disease. *Neoreviews*. 2023;24(9):e553–e568. doi: 10.1542/neo.24-9-e553
49. Donofrio MT, Moon-Grady AJ, Hornberger LK, et al. Diagnosis and treatment of fetal cardiac disease: a scientific statement from the American Heart Association. *Circulation*. 2014;129(21):2183–2242. doi: 10.1161/01.cir.0000437597.44550.5d
50. Williams IA, Shaw R, Kleinman CS, et al. Parental understanding of neonatal congenital heart disease. *Pediatr Cardiol*. 2008;29(6):1059–1065. doi: 10.1007/s00246-008-9254-8
51. Kovacevic A, Simmelbauer A, Starystach S, et al. Assessment of needs for counseling after prenatal diagnosis of congenital heart disease — a multidisciplinary approach. *Klin Padiatr*. 2018;230(5):251–256. doi: 10.1055/a-0633-3331
52. Kovacevic A, Simmelbauer A, Starystach S, et al. Counseling for prenatal congenital heart disease — recommendations based on empirical assessment of counseling success. *Front Pediatr*. 2020;8:26. doi: 10.3389/fped.2020.00026
53. Bratt EL, Järvholm S, Ekman-Joelsson BM, et al. Parent's experiences of counselling and their need for support following a prenatal diagnosis of congenital heart disease — a qualitative study in a Swedish context. *BMC Pregnancy Childbirth*. 2015;15:171. doi: 10.1186/s12884-015-0610-4
54. Kovacevic A, Elsässer M, Fluhr H, et al. Counseling for fetal heart disease-current standards and best practice. *Transl Pediatr*. 2021;10(8):2225–2234. doi: 10.21037/tp-20-181
55. Arya B, Glickstein JS, Levasseur SM, Williams IA. Parents of children with congenital heart disease prefer more information than cardiologists provide. *Congenit Heart Dis*. 2013;8(1):78–85. doi: 10.1111/j.1747-0803.2012.00706.x
56. Galliotto F, Veronese P, Cerutti A, et al. Enhancing parental understanding of congenital heart disease through personalized prenatal counseling with 3D printed hearts. *Prenat Diagn*. 2024;44(6-7):725–732. doi: 10.1002/pd.6583
57. Marella NT, Gil AM, Fan W, et al. 3D-printed cardiac models for fetal counseling: a pilot study and novel approach to improve communication. *Pediatr Cardiol*. 2023;44(8):1800–1807. doi: 10.1007/s00246-023-03177-y

58. Martens AM, Lim CC, Kelly M, et al. Evaluating how physician attitudes may affect practice in fetal cardiac counseling. *Pediatr Cardiol*. 2024;45(7):1550–1558. doi: 10.1007/s00246-023-03210-0

59. Mutti G, Ait Ali L, Marotta M, et al. Psychological impact of a prenatal diagnosis of congenital heart disease on parents: is it time for tailored psychological support? *J Cardiovasc Dev Dis*. 2024;11(1):31. doi: 10.3390/jcdd11010031

60. Sklansky M, Tang A, Levy D, et al. Maternal psychological impact of fetal echocardiography. *J Am Soc Echocardiogr*. 2002;15(2):159–166. doi: 10.1067/mje.2002.116310

61. Erbas GS, Herrmann-Lingen C, Ostermayer E, et al. Anxiety and depression levels in parents after counselling for fetal heart disease. *J Clin Med*. 2023;12(1):394. doi: 10.3390/jcm12010394

62. Dunkel Schetter C, Tanner L. Anxiety, depression and stress in pregnancy: implications for mothers, children, research, and practice. *Curr Opin Psychiatry*. 2012;25(2):141–148. doi: 10.1097/YCO.0b013e3283503680

63. Houlihan TH, Combs J, Smith E, et al. Parental impressions and perspectives of efficacy in prenatal counseling for single ventricle congenital heart disease. *Pediatr Cardiol*. 2024;45(3):605–613. doi: 10.1007/s00246-023-03355-y

64. Harris KW, Hammack-Aviran CM, Brelsford KM, et al. Mapping parents' journey following prenatal diagnosis of CHD: a qualitative study. *Cardiol Young*. 2023;33(8):1387–1395. doi: 10.1017/S1047951122002505

65. Reddy RK, McVadon DH, Zyblewski SC, et al. Prematurity and congenital heart disease: a contemporary review. *Neoreviews*. 2022;23(7):472–485. doi: 10.1542/neo.23-7-e472

66. Costello JM, Pasquali SK, Jacobs JP, et al. Gestational age at birth and outcomes after neonatal cardiac surgery: an analysis of the Society of thoracic surgeons congenital heart surgery database. circulation. 2014;129(24):2511–2517. doi: 10.1161/CIRCULATIONAHA.113.005864

67. Cnota JF, Gupta R, Michelfelder EC, Ittenbach RF. Congenital heart disease infant death rates decrease as gestational age advances from 34 to 40 weeks. *J Pediatr*. 2011;159(5):761–765. doi: 10.1016/j.jpeds.2011.04.020

68. Peyvandi S, Nguyen TA, Almeida-Jones M, et al. Timing and mode of delivery in prenatally diagnosed congenital heart disease — an analysis of practices within the university of California fetal consortium (UCfC). *Pediatr Cardiol*. 2017;38(3):588–595. doi: 10.1007/s00246-016-1552-y

69. Divanovic A, Bowers K, Michelfelder E, et al. Intrauterine fetal demise after prenatal diagnosis of congenital heart disease: assessment of risk. *Prenat Diagn*. 2016;36(2):142–147. doi: 10.1002/pd.4755

70. Trento LU, Pruetz JD, Chang RK, et al. Prenatal diagnosis of congenital heart disease: impact of mode of delivery on neonatal outcome. *Prenat Diagn*. 2012;32(13):1250–1255. doi: 10.1002/pd.3991

71. Peterson AL, Quartermain MD, Ades A, et al. Impact of mode of delivery on markers of perinatal hemodynamics in infants with hypoplastic left heart syndrome. *J Pediatr*. 2011;159(1):64–69. doi: 10.1016/j.jpeds.2011.01.004

72. Adams AD, Aggarwal N, Fries MH, et al. Neonatal and maternal outcomes of pregnancies with a fetal diagnosis of congenital heart disease using a standardized delivery room management protocol. *J Perinatol*. 2020;40(2):316–323. doi: 10.1038/s41372-019-0528-1

73. Sanapo L, Moon-Grady AJ, Donofrio MT. Perinatal and delivery management of infants with congenital heart disease. *Clin Perinatol*. 2016;43(1):55–71. doi: 10.1016/j.clp.2015.11.004

74. Donofrio MT, Levy RJ, Schuette JJ, et al. Specialized delivery room planning for fetuses with critical congenital heart disease. *Am J Cardiol*. 2013;111(5):737–747. doi: 10.1016/j.amjcard.2012.11.029

75. Morris SA, Ethen MK, Penny DJ, et al. Prenatal diagnosis, birth location, surgical center, and neonatal mortality in infants with hypoplastic left heart syndrome. *Circulation*. 2014;129(3):285–292. doi: 10.1161/CIRCULATIONAHA.113.003711

76. Bennett TD, Klein MB, Sorensen MD, et al. Influence of birth hospital on outcomes of ductal-dependent cardiac lesions. *Pediatrics*. 2010;126(6):1156–1164. doi: 10.1542/peds.2009-2829

77. Tseng SY, Anderson S, DeFranco E, et al. Severe maternal morbidity in pregnancies complicated by fetal congenital heart disease. *JACC Adv*. 2022;1(4):100125. doi: 10.1016/j.jacadv.2022.100125

78. Fite EL, Rivera BK, McNabb R, et al. Umbilical cord clamping among infants with a prenatal diagnosis of congenital heart disease. *Semin Perinatol*. 2023;47(4):151747. doi: 10.1016/j.semperi.2023.151747

79. Backes CH, Huang H, Cua CL, et al. Early versus delayed umbilical cord clamping in infants with congenital heart disease: a pilot, randomized, controlled trial. *J Perinatol*. 2015;35(10):826–831. doi: 10.1038/jp.2015.89

80. Skorobogachev RV, Belekhova DA, Belova EA, et al. Indications and methods for intrauterine intervention in the surgical correction of cardiac malformations. *Russian Journal of Operative Surgery and Clinical Anatomy*. 2019;3(2):2533. doi: 10.17116/operhirurg2019302125 EDN: KUOYDV

81. Kang SL, Jaeggi E, Ryan G, Chaturvedi RR. An overview of contemporary outcomes in fetal cardiac intervention: a case for high-volume superspecialization? *Pediatr Cardiol*. 2020;41(3):479–485. doi: 10.1007/s00246-020-02294-2

82. Perez MT, Bucholz E, Asimacopoulos E, et al. Impact of maternal social vulnerability and timing of prenatal care on outcome of prenatally detected congenital heart disease. *Ultrasound Obstet Gynecol*. 2022;60(3):346–358. doi: 10.1002/uog.24863

83. Davey B, Sinha R, Lee JH, et al. Social determinants of health and outcomes for children and adults with congenital heart disease: a systematic review. *Pediatr Res*. 2021;89(2):275–294. doi: 10.1038/s41390-020-01196-6

84. Kaltman JR, Burns KM, Pearson GD, et al. Disparities in congenital heart disease mortality based on proximity to a specialized pediatric cardiac center. *Circulation*. 2020;141(12):1034–1036. doi: 10.1161/CIRCULATIONAHA.119.043392

85. Krishnan A, Jacobs MB, Morris SA, et al. Fetal heart society. impact of socioeconomic status, race and ethnicity, and geography on prenatal detection of hypoplastic left heart syndrome and transposition of the great arteries. *Circulation*. 2021;143(21):2049–2060. doi: 10.1161/CIRCULATIONAHA.120.053062

86. Morris AA, Masoudi FA, Abdullah AR, et al. 2024 ACC/AHA Key data elements and definitions for social determinants of health in cardiology: a report of the American college of cardiology/american heart association joint committee on clinical data standards. *Circ Cardiovasc Qual Outcomes*. 2024;17(10):e000133. doi: 10.1161/HCQ.0000000000000133

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