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Contraception and Cardiovascular Effects: What Should the Cardiologist Know?

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Abstract

Purpose of Review Cardiovascular disease (CVD) is the leading cause of death in women. This review highlights contraceptive options and their effects on the cardiovascular system (CVS). It provides guidance to cardiologists to make informed decisions regarding the safety of contraceptive use and cardiovascular risk stratification in the care of women of childbearing age.

Recent Findings Approximately 44% of American women live with some type of CVD. Many women use hormonal contraception during their lifetime. It is imperative that cardiologists have a robust understanding of the forms of contraception in current use and their cardiovascular effects.

Summary This contemporary review provides a comprehensive summary of available contraceptive methods to practicing cardiologists and aims to be used as a resource to guide cardiovascular specialists on contraception in the context of cardiovascular disease.

Keywords Coronary heart disease · Adults with congenital heart disease (ACHD) · Cardiovascular disease (CVD) · Oral contraceptives · Pregnancy

Introduction

Heart disease is a leading cause of death in the USA among males and females. Women ages 40–54 are 3 to 4 times more likely to have diabetes and hypertension compared to women ages 20–29, and maternal mortality in women ages 35 and older is higher, with 32.3 deaths per 100,000 live births, as compared to women under 35, with 7.1–12.1 deaths per 100,000 live births [1]. Conception and contraception in this cohort of women with increased cardiovascular risk

Ankit Vyas and Anhthu Trinh share equal contributions to the manuscript as the first authors.

Disclaimer For the purpose of the article, "women" refers to any person with female reproductive organs and the potential to become pregnant. Contraceptive needs in transgender men and gender nonbinary persons should also be considered.

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are an increasingly relevant concern for the cardiovascular clinician in the modern era. Since the year 2000, mortality rates among women have increased in ages 35–44 due to increased rates of obesity, smoking, and a decline in physical activity. Furthermore, 44% of women are living with some type of CVD [2], and many of them are on some form of contraception. From 2017 to 2019, 65% of women in the USA used some method of contraception, with 14% using oral contraceptive methods [2]. Additionally, there was an increase in oral contraceptive (OC) use in women aged 35–44 from 4 to 17%.

Contraceptives used by premenopausal and perimenopausal women are commonly prescribed by gynecologists and primary care practitioners. Many cardiologists lack detailed knowledge of the subject. A survey conducted at a medical institution in West Virginia to assess contraception use showed that 80% of participating medical students aged 20–30 years used some contraceptive method. A majority preferred contraceptives with an oral estrogen component (62.2%), which was chosen from peer experience. The next preferred method was the etonogestrel implant (Nexplanon) at 17.0% and the levonorgestrel intrauterine device (IUD) at 15.1%.

The majority of the participants took Tier 2 contraceptives which were associated with higher CV risk. Sixty-four percent of those participants who took Tier 2 contraceptives had either a family or personal history of hypertension. For women with a history of adequately controlled hypertension, the medical eligibility criteria (MEC) category for combined oral contraceptives (COCs), a Tier 2 contraceptive, is not recommended (MEC 3—risks outweigh benefits). Tier 1 contraceptives including copper IUDs, levonorgestrel-releasing IUDs, and progestin are MEC Category 1 (no restriction on use) and are the preferred method of contraception.

According to this survey, many women in medicine were unaware of the cardiovascular effects of their contraceptive choice. The goal of this review is to increase awareness of the contraceptive methods available and provide a summary to increase knowledge about the cardiovascular effects of current contraceptive options and the current recommendations in pre and perimenopausal women.

Biological Effects of Endogenous Estrogen and Progesterone on the Cardiovascular System

It is important to discuss and understand the effects endogenous sex hormones have on the cardiovascular system. Evidence indicates that the female sex hormone estradiol, the form of estrogen in premenopausal women, plays a critical cardioprotective role.

Estradiol levels regulate the presence of estrogen receptors (ER) in vascular tissue and evidence shows that the arteries of premenopausal women with atherosclerosis have fewer ER than normal arteries. Estradiol also inhibits vascular smooth muscle cell (VSMC) growth and proliferation. The growth and proliferation of VSMCs promote plaque formation which is one of the initial steps in atherosclerosis [3]. In addition, many studies have shown that estradiol stimulates the release of nitric oxide (NO) by VSMCs which can attenuate atherogenic processes by causing vasodilation in coronary vasculature [3]. Estradiol can also promote neovascularization through angiogenesis as seen by the high amount of vascular endothelial growth factor in tissues with high estradiol [3].

The impact of progesterone on the cardiovascular system remains uncertain [4]. Progesterone interferes with estradiol-mediated vascular relaxation and inhibits estradiol's reduction of plaque size and cellular proliferation in animal models. [3] It has been associated with increased coagulation factors and platelet aggregation while decreasing nitric oxide [3]; however, it has not been shown to significantly increase the risk of thrombosis at contraceptive doses [4, 5]. It has a limited effect on the lipid profile [6].

Endogenous estrogen and progesterone have many protective benefits as outlined above. However, we must consider the potential adverse physiologic effects of exogenous estrogen and progesterone on the CV system when given as a contraceptive.

Biological Effects of Exogenous Estrogen and Progesterone on the Cardiovascular System (Table 1)

Ethinyl estradiol (EE), a synthetic form of estrogen, is commonly used in COCs with varying doses of 20 to 50 µg. Studies have shown an association between cardiovascular disease and exogenous hormone therapy. The presence of ER and progesterone receptors (PR) throughout the layers of the blood vessels increases the risk for venous and arterial thrombosis and systemic hypertension, diseases that have become more common among young women [7•].

Estrogen can promote thromboembolism due to increased production of coagulation factors [8]. EE leads to increased production of thrombin and coagulation factors like fibrinogen, factors VII, VIII, IX, X, XII, and XIII while decreasing coagulation inhibitors such as protein S and antithrombin, which leads to a mild increase in coagulation [7•]. The risk of venous thrombosis is associated with higher doses of EE, > / = 50 µg with a two times higher associated risk. Exogenous progesterone alone has not been associated with increased thrombotic risk. Progestogen-only contraceptives are not associated with significant coagulation or

Table 1 Observed cardiovascular effects of hormonal contraceptives [7•, 9, 12–14]

CARDIOVASCULAR EFFECTS	ESTROGEN	PROGESTERONE
Thrombotic Risks: • Risk of Myocardial Infarction: 1.6-fold higher risk • Risk of Venous Thrombosis: 2-4 times higher risk • Risk of Stroke: Risk higher with use of estrogen. Progesterone on the stroke risk lacks evidence	↑↑ Coagulation Factors ↑↑ Platelet Aggregation	↑↑ Coagulation Factors ↑↑ Platelet Aggregation May ↓ Nitric Oxide
Effects on CAD risk factors: • Blood pressure • Lipids • Glucose tolerance	↑↑ Coagulation Factors (↑ Inflammatory state) ↓LDL, ↑ HDL , ↑ Triglycerides Increase in systolic BP up to 7-8 mmHg No change in fasting blood glucose; but can increase insulin resistance	No increased risk in thrombosis ↑ LDL, ↓ HDL No change in BP
Electrophysiological effects: • Introduction of arrhythmias: Easier at certain times of menstrual cycle • Increased risk of QT prolongation in post-menopausal women and in those with DMPA use • No specific increased event rate with CHC use	↑ QT interval ↓ Platelet aggregation	↓ or ↑ QT Interval
Anticoagulation and Contraception • Use of warfarin	Both estrogen and progesterone interfere with warfarin metabolism, unknown mechanism. Heavy menstrual bleeding is expected (Agents that reduce bleeding or induce amenorrhea can be beneficial).	

LDL low-density lipoprotein, HDL high-density lipoprotein, DMPA depot medroxyprogesterone acetate

fibrinolysis changes. However, third-generation progestogens, gestodene, and desogestrel, when combined with EE, were also associated with a two times higher risk of thrombosis compared to second-generation progestogens like levonorgestrel [7•]. Levonorgestrel is more androgenic than the other progestogens and associated with lower protein C resistance.

Although arterial thrombosis is uncommon among young women, those with other cardiovascular risk factors such as smoking, obesity, sedentary lifestyle, and other medical comorbidities such as diabetes mellitus, high cholesterol, and high blood pressure have a higher risk. The risk is also linked to the estrogen dose but even a low dose (< 50 µg) EE can lead to a two times higher risk of arterial thrombosis. Regarding lipids, estrogen was shown to increase HDL and triglycerides while lowering LDL [9]. This is thought to be mediated through estrogen receptor alterations affecting the upregulation of hepatic apolipoprotein and a decrease in hepatic lipase activity, leading to increased HDL [10].

EE compared to endogenous estradiol is of higher potency and causes an excessive production of hepatic angiotensinogen which leads to increased activation of the renin–angiotensin–aldosterone system (RAAS) to raise blood pressure [11]. Progestogen in association with EE has a similar effect. Of the available progestogens, only drospirenone maintains the antimineralocorticoid effect of natural progesterone. Progesterone-only contraceptives are not known to have an adverse association between use and blood pressure, although there are limited studies available.

The cardiovascular effects of hormonal contraception are summarized in further detail in Table 1.

In addition to the biochemical effects, the use of COC can have electrophysiological effects increasing the propensity for arrhythmias [14]. One study showed sotalol-induced QT interval prolongation was amplified in women taking oral contraceptives with anti-androgenic properties especially in drospirenone compared to levonorgestrel [15].

Types of Contraception

Pre-menopause encompasses the years from puberty to perimenopause. The average age of onset for perimenopause is 47.5 years [16]. Many women in the pre-menopause and

perimenopause groups are sexually active and can become pregnant. Pregnancy can be associated with cardiovascular risks such as hypertensive disorders, thromboembolism, and cardiomyopathy [17, 18]. Pregnant women are fourfold to fivefold more likely to have a venous thromboembolism (VTE) than non-pregnant women, contributing to 9.3% of maternal deaths [19]. It is essential for women to have reliable, safe contraception if they do not desire pregnancy and even more so when there is a high risk of CV complication with pregnancy. The cardiovascular risk profiles of various kinds of contraceptives are important to understand in the context of a patient's risk profile. There is limited data on contraceptives and the risk of cardiovascular disease [18].

A tier-based simplified classification is often used to determine the 1-year failure rates for current contraceptive options (Fig. 1).

Copper IUD

A copper IUD is a small flexible plastic device with copper sleeves or copper wires that is inserted into the uterus. These can be placed immediately after childbirth. Cu-IUD are advantageous in many patients with cardiovascular diseases, including ischemic heart disease, thromboembolism, cardiomyopathy, and those at high risk of other CVDs. Due to their long-acting properties and the fact that they can be used by women with contraindications to hormones, copper IUDs have significantly higher satisfaction and continuation rates than hormonal methods [20]. They can be used for up to 10 years with a typical use failure rate of 0.8% after 1 year. However, Cu IUD can increase menstrual bleeding and pain.

Levonorgestrel (LNg) IUD

A LNg IUD is similar to a copper IUD but without the copper sleeves/wires. It can be used between 3 and 8 years and releases small amounts of progesterone over a long period of time. The typical use failure rate of LNg IUD is 0.1–0.4% [20]. In comparison to other intrauterine devices, LNG-IUS (levonorgestrel-releasing intrauterine system) has one of the lowest failure rates (0.1%) and is considered safe for women in perimenopause, but it is associated with an increased risk of depression [21]. Risk of MI, VTE, and stroke was not associated with progestin use alone. LNg IUDs can also help with heavy menstrual bleeding. Like copper IUDs, these IUDs require a trained health care provider to insert and remove them.

Etonogestrel Implant

These subdermal implants are single, thin rods that are inserted under the skin of the upper arm and contain progestin which is released over 3 years. They have a perfect use failure rate of 0.05% [22]. These can be used in nursing mothers 6 weeks after childbirth.

Combined Oral Contraceptives (COC)

COC remain the most widely used contraceptive option (12.6%) aside from female sterilization (18.6%) [23]. They generally contain estrogen and progesterone. They must be taken at the same time every day. Their typical use failure rate is 6–8% in the first year of use [20]. It is also shown that the MI risk is increased 1.6×, and the VTE risk is 2–4×higher in patients taking COC. COC also increases

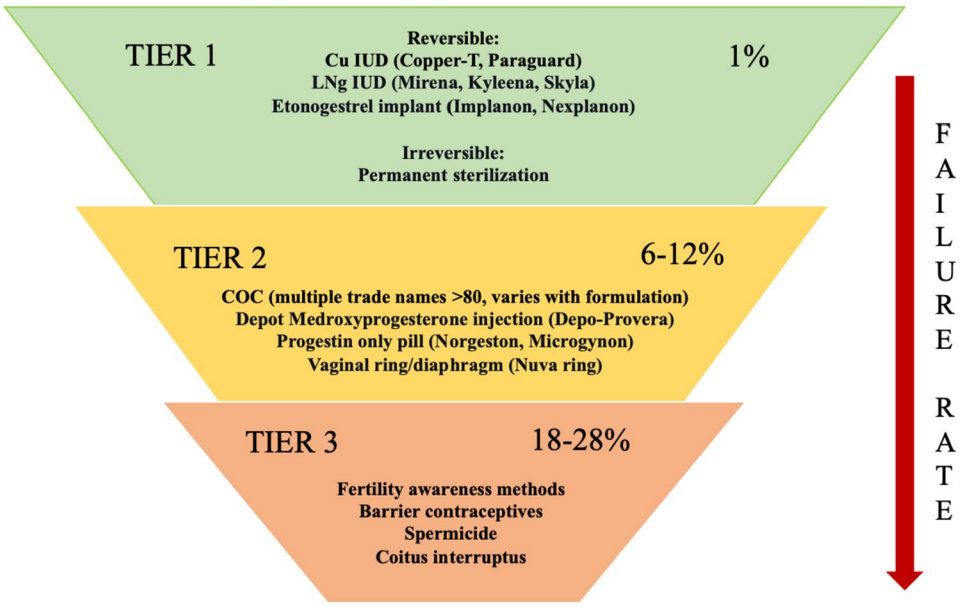

Fig. 1 Tier classification based on 1 year contraception failure rates. Abbreviations: Cu IUD, copper containing intrauterine device; LNg IUD, levonorgestrel (LNg) intrauterine device; COC, combined oral contraceptives (modified from: J Am Coll Cardiol. 2021 Apr 13;77(14):1823–34, Elsevier [2021], with permission from Elsevier) [18]

stroke risk with a higher risk being associated with increased estrogen dose [20].

COC are popular among perimenopausal women for their satisfactory menstrual control, migraine reduction, bone preservation, and protection from various cancers [24–26]. The relative risk of stroke and MI is 2.0 for 30–50 μg ethinyl estradiol (EE) and 1.6 for 20 μg EE. The incidence of venous thromboembolism (VTE) is 2.4 times higher in women on COCs ages 45–49 than compared to ages 30–34 [27, 28]. COCs containing levonorgestrel (LNG) have a 50% lower risk of PE compared with third-generation progestins [29]. Smoking, hypertension, diabetes, obesity, and hyperlipidemia also increase stroke and MI risks, as age and EE dose increase.

For women over 40 years of age using COC, the modern oral contraceptive pills, estradiol valerate (E2V) + dienogest (DNG), and micronized estradiol (E2) + nomegestrol acetate (NOMAc) are reported to be a safe alternative to traditional oral contraceptives. There is a lower cardiovascular risk associated with E2V + DNG compared to COCs that contain LNG or other progestins [30]. According to a large study using two COCs, one of which was EE-LNG-based and the other in which the COC used E2-NOMAc, the risk of VTE and PE in the NOMAc-E2 was similar to or even lower in the LNG-based COC [31].

Depo-medroxyprogesterone Acetate (DMPA) Injection

DMPA contains only progestin and is administered every 3 months with a typical use failure rate of 4% [22]. Common side effects include amenorrhea and weight gain.

Progestin-Only Oral Contraceptives

OCPs containing only progestin (i.e., minipill) are less effective at preventing pregnancy than COC if not taken as directed, with perfect use being 99% effective and typical use being 91% effective [20]. They contain 1/2 to 1/10th the amount of progestin found in COC. They are the preferred oral contraceptive for breastfeeding women because they do not reduce milk production [32]. There is no increased risk of estrogen-related complications such as MI, stroke, or VTE.

There are many options for contraception, but shared decision-making with the patient is critical to ensure consistent use for efficacy as well as patient safety. According to the CDC, there are different medical eligibility criteria (MEC) risk categories that are associated with the various available contraceptives and underlying conditions.

To assist and guide health care providers, the Centers for Disease, Control, and Prevention (CDC) published updated recommendations for the use of specific and most safe contraception in women with various risk factors and medical conditions. Recommendations specific to cardiovascular diseases are collated in Table 2.

Contraception in Perimenopause

As per The North American Menopause Society (NAMS), menopause is defined as 12 months of amenorrhea in women aged 40 and older; it is common for women in the perimenopausal period to continue ovulating even though estrogen levels are declining; contraception remains a necessity to avoid an unplanned pregnancy. Seventy-five percent of pregnancies in women after age 40 are unplanned [34]. The likelihood of pregnancy in sexually active women without any type of contraception is estimated to be 30% per year in women aged 40–44 and 10% per year for those aged 45–49 [16]. Risks of miscarriages, chromosomal abnormalities, ectopic pregnancies, preeclampsia, and postpartum hemorrhages increase in pregnancy after the age of 40 [35]. Most women begin perimenopause or menopausal transition between ages 45 and 55, with the transition lasting as long as 14 years for some to reach menopause. Therefore, contraception should be considered until the mid-50 s.

To provide safe, effective contraception and reduce the risk of cardiovascular events for perimenopausal women, it is necessary to understand the effects of various contraceptive methods on the cardiovascular system. It is also important to consider contraceptive options for patients using hormone replacement therapy (HRT). HRT does not provide the same amount of hormones as OCPs and should not be substituted for contraception. Women who are on HRT may still ovulate and must be counseled about birth control until 1 year after their final menstrual period.

Women between the ages of 40 and 45 are inclined to use long-acting reversible contraceptives (LARCs) and permanent sterilization and should be considered along with vasectomy for the male partner since there is no increased risk of cardiovascular disease or stroke [27]. As a result of fewer menstrual cycles, less spotting, and a lower side effect profile, the vaginal ring is regarded as the second most popular contraceptive agent. However, there is little information available about its cardiovascular risk [36]. Current longitudinal safety data is insufficient to make recommendations for the use of new-generation COCs in women over 40 [37]. Progestin-only pills should only be used if a patient has contraindications to COC's, such as tobacco use, obesity, migraines with aura, hypertension, or prior VTE. Depot medroxyprogesterone acetate (DMPA) is not recommended during perimenopause because it reduces bone density [38].

Table 2 Available contraceptives in the USA—CDC safety profile in cardiovascular diseases

	DVT	Ischemic Heart Disease	Stroke	Vascular Disease	HTN (140-159/90-99)	Hx of HTN during pregnancy	Superficial venous thrombosis	Peripartum cardiomyopathy	Smoking
Nexplanon (etonogestrel implant)	2	2 if beginning 3 if continuing	2 if beginning 3 if continuing	1	1	1	1	1	1
Depo-Provera (medroxyprogesterone acetate injectable)	2	3	3	1	2	1	1	1	1
Ortho Tri-Cyclen (oral norgestimate ethinyl estradiol)	4	4	4	2/4**	3	2	3	4	2-4*
Mirena (levonorgestrel IUD)	2	2 if beginning 3 if continuing	2	1	1	1	1	2	1
Camila (oral norethindrone)	2	2 if beginning 3 if continuing	2 if beginning 3 if continuing	1	1	1	1	1	1
Nuvaring, Annovera (etonogestrel/ethinyl estradiol vaginal ring)	4	4	4	2/4**	3	2	3	4	2-4*
Junel, Loestrin (oral norethindrone/ethinyl estradiol)	4	4	4	2/4**	3	2	3	4	2-4*
Aviane, Lessina, Levora (oral levonorgestrel/ethinyl estradiol)	4	4	4	2/4**	3	2	3	4	2-4*
Gianvi, Lorynza, Ocella (oral drospirenone/ethinyl estradiol)	4	4	4	2/4**	3	2	3	4	2-4*
Micronor (oral norethisterone)	2	2 if beginning 3 if continuing	2 if beginning 3 if continuing	1	1	1	1	1	1
Xulane (norelgestromin/ethinyl estradiol transdermal patch)	4	4	4	2/4**	3	2	3	4	2-4*
Paragard (copper IUD)	2	1	1	1	1	1	1	2	1

(modified from a CDC table in the public domain) [33••]. Medical eligibility criteria: 1: No restriction on use. Use the method in any circumstance. 2: Benefits outweigh risks. Generally used. 3: Risks outweigh benefits. Use is not usually recommended unless other appropriate methods are not available. 4: Unacceptable level of risk. Method not to be used

*2 for age < 35, 3 for age > 35 and < 15 cigarettes/day, 4 for age > 35 and > 15 cigarettes/day; **2 for uncomplicated valvular heart disease and 4 for complicated valvular heart disease. DVT, deep venous thrombosis; HTN, hypertension; IUD, intrauterine device

Contraception and Pregnancy Considerations in Adults with Congenital Heart Disease (ACHD)

With major advances in surgical repair of congenital heart diseases, more ACHD patients are living to childbearing age [15]. Pregnancy in women with CHD is considered high risk and requires specialized care from a team with expertise in ACHD and obstetrics. Knowledge of pregnancy and contraception risks linked to ACHD is necessary for optimal care. The risks associated with pregnancy and ACHD vary based on the type and severity of a patient's heart defect and its hemodynamic properties. Risk stratification varies based on diagnosis, severity of condition, and prior surgical intervention [39, 40].

The WHO pregnancy risk classification for various CHDs allows us to better ensure adequate pre-conception and contraceptive counseling (Fig. 2) [39]. Classification ranges from very low risk (WHO class I) to extremely high risk (WHO class IV). For example, pulmonary hypertension is considered a WHO class IV classification—pregnancy is a contraindication as it confers the highest risk of morbidity and mortality [41]. Patients with pulmonary hypertension have a maternal mortality close to 50% [42]. Therefore, in those with Eisenmenger's syndrome, pregnancy is usually contraindicated due to baseline pulmonary

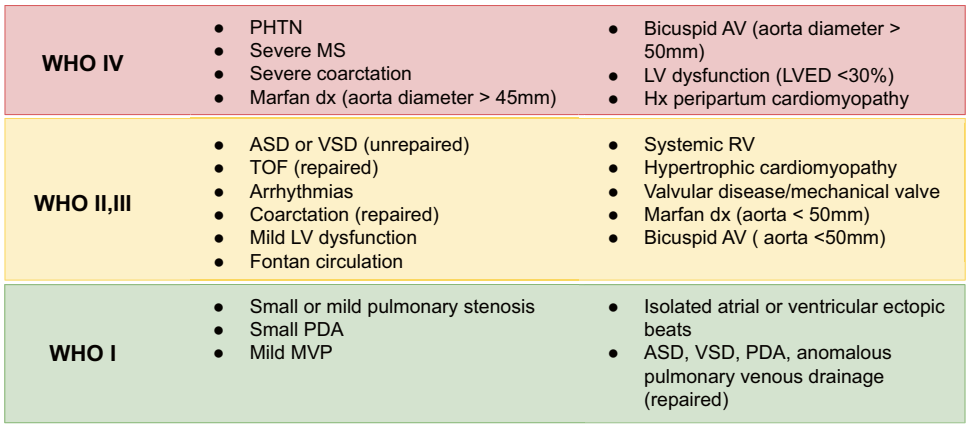

Fig. 2 WHO pregnancy risk classification and categorization of CHD. **This classification uses maternal cardiovascular risk factors to classify patients as very low risk (class I), low to moderate risk (class II), high risk (class III), and extremely high risk (class IV), in which pregnancy is contraindicated. Abbreviations: PHTN, pulmonary hypertension; MS, mitral stenosis; AS, aortic stenosis; RV, right ventricle; LV, left ventricular; LVEF, left ventricular ejection fraction; AV, aortic valve; ASD, atrial septal defect; VSD, ventricular septal defect; TOF, tetralogy of Fallot; MVP, mitral valve prolapse; PDA, patent ductus arteriosus (modified from: Heart Br Card Soc. 2006 Oct;92(10):1520–5, with permission from BMJ Publishing Group Ltd.) [39]

hypertension. Other conditions, including mitral and aortic valve stenosis, may require surgical treatment before a patient can conceive safely and are generally considered WHO class II or III.

There are many considerations for contraceptive methods in ACHD. Combined contraceptive methods containing estrogen are used with caution in those with WHO class III classification and contraindicated in those with WHO class IV disease. Progesterone-only methods, with no increased risk of VTE, are safe in the majority of patients with ACHD. Depo provera has no cardiac contraindications and is a highly effective method. However, the use in patients on warfarin may lead to hematomas at the site of intramuscular injection, and injections must be maintained at regular 12-week intervals to maintain efficacy. Oral progesterone methods have no contraindications; however, due to the Mini Pill's lack of efficacy without perfect use, it is not recommended for patients with WHO 3 or 4 classifications, in which pregnancy is contraindicated. For these patients, it is most important to counsel about high-efficacy methods, including LARCs and sterilization.

The IUD can be a preferred method for many patients due to its high efficacy; however, it is not recommended for those with high endocarditis risk, pulmonary hypertension, or other conditions where a vasovagal reaction could precipitate a serious cardiac event. Vasovagal reactions are seen in up to 5% of women with cervical manipulation during IUD placement [39]. This can lead to potential cardiovascular collapse and fatality in patients with pulmonary vascular disease or Fontan circulation. Therefore, the subdermal implant is the most preferred LARC for all patients with CHD due to the reliability and safety of insertion. The emergency contraception pill, containing progestogen only, is considered safe for patients with CHD.

Contraceptive Use Recommendations in Cardiovascular Disease

Myocardial Infarction

The copper (Cu) intrauterine device (IUD) is the preferred method of contraception post-myocardial infarction (MI). In the case of hormonal contraceptives, progesterone-only pills, LNg IUD, and the etonogestrel implant are considered cardio-safe. While these agents can be continued post-myocardial infarction (MEC 2), they are not advisable to initiate following a cardiac event.

Valvular Disease

All of the previously mentioned contraceptives besides COC have no restrictions for use in both complicated and uncomplicated valvular disease. For uncomplicated valvular disease, COC can be used (MEC 2). However, for complicated valvular disease, COC are contraindicated and should not be used (MEC 4).

Hypertension (HTN)

For adequately controlled HTN, COC is generally not recommended for use (MEC 3) and DMPA can have some risks (MEC 2). All other contraceptive options are recommended for use. For uncontrolled HTN with systolic

140–159 or diastolic 90–99, the same recommendations apply. However, for higher blood pressures such as systolic > 160 and diastolic > 100, COC are contraindicated (MEC 4), and DMPA are not recommended for use (MEC 3). The contraceptive method of choice for this condition is the copper IUD, while other contraceptive options are generally used but can have some risks (MEC 2).

Cardiomyopathy

For patients with dilated cardiomyopathy, pregnancy can be associated with significant maternal morbidity and mortality. A review of dilated cardiomyopathy and pregnancy physiology found that ventricular arrhythmias, heart failure, stroke, and death occurred in 39 to 60% of patients with significant disease, including those with LVEF of less than 30% [43]. Therefore, these patients should be counseled to use the high-efficacy methods of contraception. However, patients with mild LV dysfunction usually tolerate the cardiac effects of pregnancy and are considered WHO II or III risk (Fig. 2).

Peripartum cardiomyopathy (PPCM), which develops most commonly in the month prior to or following delivery, carries risks for future pregnancies. For patients whose EF normalized, the recurrence rate is estimated between 14 and 44%, with one review reporting that approximately 20% of patients with recovered EF may have a relapse in subsequent pregnancies [44]. For those whose EF did not normalize, the risk of LV dysfunction in subsequent pregnancies can be as high as 50% [44]. Overall, pregnancies after PPCM carry a mortality rate as high as 48% with worse LV dysfunction associated with worse maternal and fetal outcomes [44–46].

Patients with hypertrophic cardiomyopathy (HCM) are considered WHO II or III (Fig. 2), depending on cardiac function [39]. Therefore, specific contraceptive recommendations will depend on the individual's risks associated with pregnancy and the need for effective contraception.

Post-cardiac Transplantation

For those who have undergone heart transplants, pregnancy is usually avoided for at least a year following transplantation. Most literature does not give specific guidelines for post-cardiac transplant patients. After uncomplicated solid organ transplants, any type of contraception is generally used in these patients (MEC 2). However, for women after complicated solid organ transplantation, COC is contraindicated (MEC 4). Initiation of any IUD is generally not recommended (MEC 3), but all other contraceptive methods are generally used (MEC 2).

Summary/Conclusion

It is important for all clinicians who care for people with the capacity to become pregnant to have reliable information regarding contraceptive efficacy and safety. Cardiologists manage patients with complex cardiovascular conditions, making knowledge about contraceptive safety profiles necessary. Certain contraceptive methods are associated with cardiovascular risk, and, therefore, it is important to understand how various contraceptive methods affect an individual's chances for a cardiovascular event. It is important to consider the changes in risk for cardiovascular events given age, menopause status, and health history, paying special attention to recommendations for patients with ACHD and CV risk factors. With the fall of Roe and changes to abortion access across the country, it is necessary for physicians who care for patients with CV contraindications to pregnancy to maintain an understanding of contraceptive options for these individuals. For patients in whom pregnancy is contraindicated due to cardiovascular risks, it is important to counsel patients about high efficacy and permanent methods of contraception that align with their lifestyle and preferences.

Data Availability No datasets were generated or analysed during the current study.

Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Human and Animal Rights and Informed Consent The present study did not involve human or animal subjects.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. Long ME, Faubion SS, MacLaughlin KL, Pruthi S, Casey PM. Contraception and hormonal management in the perimenopause. J Womens Health 2002. 2015;24(1):3–10.
2. Daniels K, Abma JC. Current contraceptive status among women aged 15–49: United States, 2017–2019. NCHS Data Brief. 2020;388:1–8.
3. Skafar DF, Xu R, Morales J, Ram J, Sowers JR. Female sex hormones and cardiovascular disease in women. J Clin Endocrinol Metab. 1997;82(12):3913–8.
4. Heinemann LA, Assmann A, DoMinh T, Garbe E. Oral progestogen-only contraceptives and cardiovascular risk: results from the transnational study on oral contraceptives and the health of young women. Eur J Contracept Reprod Health Care Off J Eur Soc Contracept. 1999;4(2):67–73.

5. Cardiovascular disease and use of oral and injectable progestogen-only contraceptives and combined injectable contraceptives. Results of an international, multicenter, case-control study. World Health Organization Collaborative Study of Cardiovascular Disease and Steroid Hormone Contraception. Contraception. 1998;57(5):315–24.
6. Barkfeldt J, Virkkunen A, Dieben T. The effects of two progestogen-only pills containing either desogestrel (75 microg/day) or levonorgestrel (30 microg/day) on lipid metabolism. Contraception. 2001;64(5):295–9.
7.• Brito M, Nobre F, Vieira C. Hormonal contraception and cardiovascular system. Arq Bras Cardiol. 2011;1(96):e81–9. **This article highlights the physiological effects of endogenous and exogenous hormones on the cardiovascular system.**
8. Abou-Ismail MY, Sridhar DC, Nayak L. Estrogen and thrombosis: a bench to bedside review. Thromb Res. 2020;192:40–51.
9. Zhu X, Bonet B, Gillenwater H, Knopp RH. Opposing effects of estrogen and progestins on LDL oxidation and vascular wall cytotoxicity: implications for atherogenesis. Proc Soc Exp Biol Med Soc Exp Biol Med N Y N. 1999;222(3):214–21.
10. Jones DR, Schmidt RJ, Pickard RT, Foxworthy PS, Eacho PI. Estrogen receptor-mediated repression of human hepatic lipase gene transcription. J Lipid Res. 2002;43(3):383–91.
11. Oelkers WK. Effects of estrogens and progestogens on the renin-aldosterone system and blood pressure. Steroids. 1996;61(4):166–71.
12. Howard BV, Rossouw JE. Estrogens and cardiovascular disease risk revisited: the Women's Health Initiative. Curr Opin Lipidol. 2013;24(6):493–9.
13. Manson JE, Hsia J, Johnson KC, Rossouw JE, Assaf AR, Lasser NL, et al. Estrogen plus progestin and the risk of coronary heart disease. N Engl J Med. 2003;349(6):523–34.
14. Salem JE, Dureau P, Bachelot A, Germain M, Voiriot P, Lebourgeois B, et al. Association of Oral contraceptives with drug-induced QT interval prolongation in healthy nonmenopausal women. JAMA Cardiol. 2018;3(9):877–82.
15. Shekhar S, Agrawal A, Pampori A, Lak H, Windsor J, Ramakrishna H. Mortality in adult congenital heart disease: analysis of outcomes and risk stratification. J Cardiothorac Vasc Anesth. 2022;36(8 Pt B):3379–88.
16. Baldwin MK, Jensen JT. Contraception during the perimenopause. Maturitas. 2013;76(3):235–42.
17. Creanga AA, Syverson C, Seed K, Callaghan WM. Pregnancy-related mortality in the United States, 2011–2013. Obstet Gynecol. 2017;130(2):366–73.
18. Lindley KJ, BaireyMerz CN, Davis MB, Madden T, Park K, Bello NA, et al. Contraception and reproductive planning for women with cardiovascular disease: JACC focus seminar 5/5. J Am Coll Cardiol. 2021;77(14):1823–34.
19. American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics. ACOG practice bulletin No. 196: thromboembolism in pregnancy. Obstet Gynecol. 2018;132(1):e1–17.
20. Managing Contraception [Internet]. [cited 2023 Apr 6]. Contraceptive technology 21st edition. Available from:https://managingcontraception.com/contraceptive-technology-21st-edition/.
21. Skovlund CW, Mørch LS, Kessing LV, Lidegaard Ø. Association of hormonal contraception with depression. JAMA Psychiat. 2016;73(11):1154–62.
22. Trussell J. Contraceptive failure in the United States. Contraception. 2011;83(5):397–404.
23. Tsao CW, Aday AW, Almarzooq ZI, Anderson CAM, Arora P, Avery CL, et al. Heart disease and stroke statistics-2023 update: a report from the American Heart Association. Circulation. 2023;147(8):e93-621.
24. Cole JA, Norman H, Doherty M, Walker AM. Venous thromboembolism, myocardial infarction, and stroke among transdermal contraceptive system users. Obstet Gynecol. 2007;109(2 Pt 1):339–46.
25. Tepper NK, Whiteman MK, Marchbanks PA, James AH, Curtis KM. Progestin-only contraception and thromboembolism: a systematic review. Contraception. 2016;94(6):678–700.
26. Chiara Del Savio M, De Fata R, Facchinetti F, Grandi G. Drospirenone 4 mg-only pill (DOP) in 24+4 regimen: a new option for oral contraception. Expert Rev Clin Pharmacol. 2020;13(7):685–94.
27. Allen RH, Cwiak CA, Kaunitz AM. Contraception in women over 40 years of age. CMAJ Can Med Assoc J. 2013;185(7):565–73.
28. Lidegaard Ø, Nielsen LH, Skovlund CW, Skjeldestad FE, Løkkegaard E. Risk of venous thromboembolism from use of oral contraceptives containing different progestogens and oestrogen doses: Danish cohort study, 2001–9. BMJ. 2011;25(343): d6423.
29. Sugiura K, Kobayashi T, Ojima T. Risks of thromboembolism associated with hormonal contraceptives related to body mass index and aging in Japanese women. Thromb Res. 2016;137:11–6.
30. Reed S, Koro C, DiBello J, Becker K, Bauerfeind A, Franke C, et al. Prospective controlled cohort study on the safety of a monophasic oral contraceptive containing nomegestrol acetate (2.5mg) and 17β-oestradiol (1.5mg) (PRO-E2 study): risk of venous and arterial thromboembolism. Eur J Contracept Reprod Health Care Off J Eur Soc Contracept. 2021;26(6):439–46.
31. von Stockum S, Becker K, Bauerfeind A, Franke C, Fruzzetti F, Calaf J, et al. NOMAC-E2 compares to LNG combined oral contraceptives in women over forty: real-world PRO-E2 study. Gynecol Endocrinol Off J Int Soc Gynecol Endocrinol. 2023;39(1):2166032.
32. Contraception During Breastfeeding [Internet]. [cited 2023 May 25]. Available from:https://my.clevelandclinic.org/health/drugs/15280-contraception-during-breastfeeding.
33.•• Curtis KM. U.S. Medical Eligibility Criteria for Contraceptive Use, 2016. MMWR Recomm Rep [Internet]. 2016 [cited 2023 Feb 28];65. Available from:https://www.cdc.gov/mmwr/volumes/65/rr/rr6503a1.htm. **This reference gives guidelines for various conditions, including cardiovascular conditions, and their recommendations for contraception which was one of the main purposes of this article. The table in this article was updated in 2020.**
34. Johnson-Mallard V, Kostas-Polston EA, Woods NF, Simmonds KE, Alexander IM, Taylor D. Unintended pregnancy: a framework for prevention and options for midlife women in the US. Womens Midlife Health. 2017;3:8.
35. Antinori S, Gholami GH, Versaci C, Cerusico F, Dani L, Antinori M, et al. Obstetric and prenatal outcome in menopausal women: a 12-year clinical study. Reprod Biomed Online. 2003;6(2):257–61.
36. Dinger J, Möhner S, Heinemann K. Cardiovascular risk associated with the use of an etonogestrel-containing vaginal ring. Obstet Gynecol. 2013;122(4):800–8.
37. Grandi G, Barra F, Ferrero S, Facchinetti F. Estradiol in non-oral hormonal contraception: a "long and winding road." Expert Rev Endocrinol Metab. 2019;14(3):153–5.
38. Petitti DB, Piaggio G, Mehta S, Cravioto MC, Meirik O. Steroid hormone contraception and bone mineral density: a cross-sectional study in an international population. The WHO Study of Hormonal Contraception and Bone Health. Obstet Gynecol. 2000;95(5):736–44.
39. Thorne S, MacGregor A, Nelson-Piercy C. Risks of contraception and pregnancy in heart disease. Heart Br Card Soc. 2006;92(10):1520–5.
40. Swan L. Congenital heart disease in pregnancy. Best Pract Res Clin Obstet Gynaecol. 2014;28(4):495–506.

41. Greutmann M, Pieper PG. Pregnancy in women with congenital heart disease. Eur Heart J. 2015;36(37):2491–9.
42. Weiss BM, Zemp L, Seifert B, Hess OM. Outcome of pulmonary vascular disease in pregnancy: a systematic overview from 1978 through 1996. J Am Coll Cardiol. 1998;31(7):1650–7.
43. Schaufelberger M. Cardiomyopathy and pregnancy. Heart. 2019;105(20):1543–51.
44. Elkayam U. Risk of subsequent pregnancy in women with a history of peripartum cardiomyopathy. J Am Coll Cardiol. 2014;64(15):1629–36.
45. Hilfiker-Kleiner D, Haghikia A, Masuko D, Nonhoff J, Held D, Libhaber E, et al. Outcome of subsequent pregnancies in patients with a history of peripartum cardiomyopathy. Eur J Heart Fail. 2017;19(12):1723–8.
46. Yaméogo NV, Samadoulougou AK, Kagambèga LJ, Kologo KJ, Millogo GRC, Thiam A, et al. Maternal and fetal prognosis of subsequent pregnancy in black African women with peripartum cardiomyopathy. BMC Cardiovasc Disord. 2018;18(18):119.