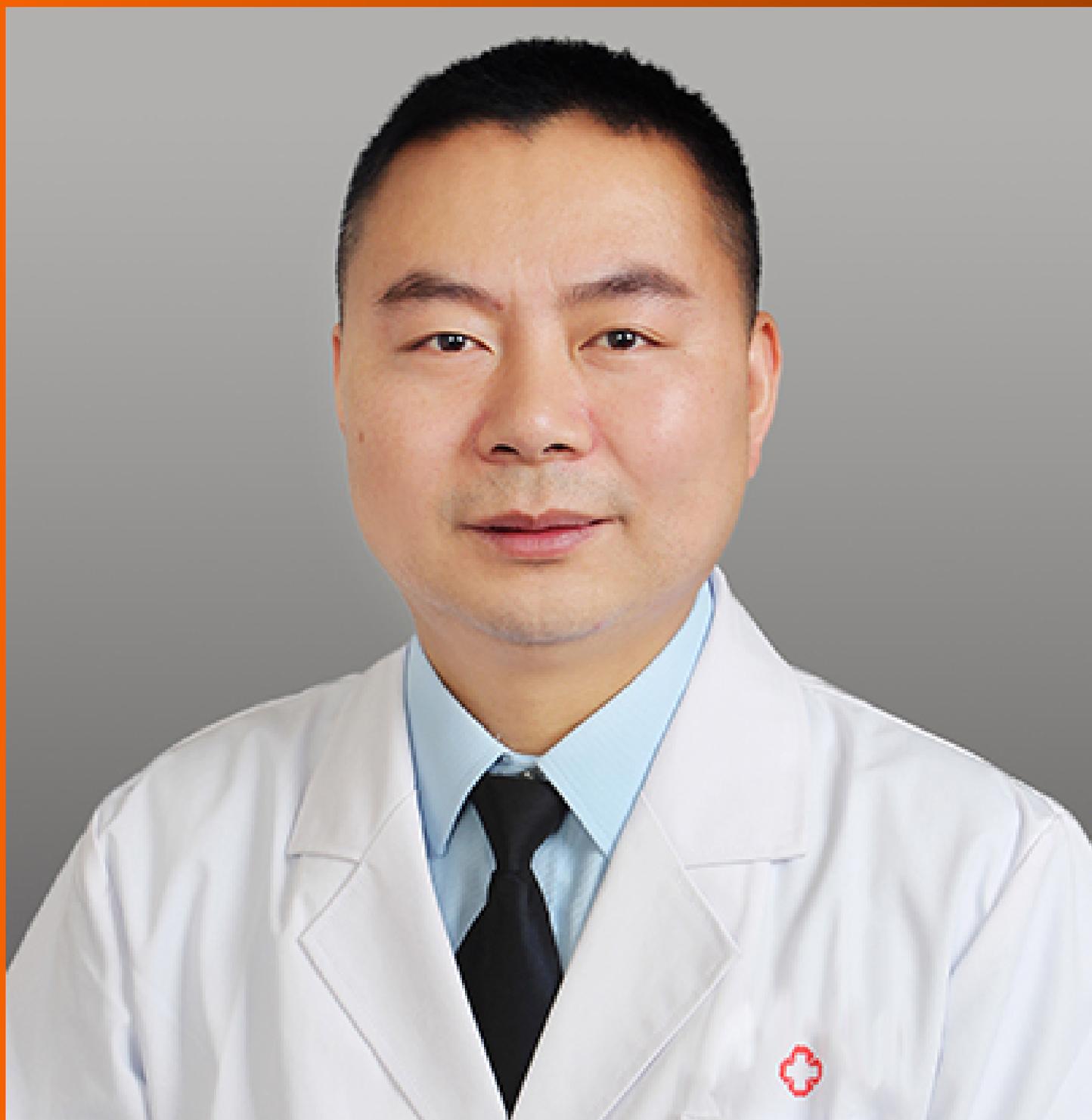


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The primary aim of *World Journal of Cardiology (WJC, World J Cardiol)* is to provide scholars and readers from various fields of cardiology with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJC mainly publishes articles reporting research results and findings obtained in the field of cardiology and covering a wide range of topics including acute coronary syndromes, aneurysm, angina, arrhythmias, atherosclerosis, atrial fibrillation, cardiomyopathy, congenital heart disease, coronary artery disease, heart failure, hypertension, imaging, infection, myocardial infarction, pathology, peripheral vessels, public health, Raynaud's syndrome, stroke, thrombosis, and valvular disease.

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Cardiovascular complications following medical termination of pregnancy: An updated review

Tejveer Singh, Ajay K Mishra, Nikhil Vojjala, Kevin John John, Anu A George, Anil Jha, Michelle Hadley

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Abstract

BACKGROUND

Around 1 million cases of medical termination of pregnancy (MTP) take place yearly in the United States of America with around 2 percent of this population developing complications. The cardiovascular (CVD) complications occurring post MTP or after stillbirth is not very well described.

AIM

To help the reader better understand, prepare, and manage these complications by reviewing various cardiac comorbidities seen after MTP.

METHODS

We performed a literature search in PubMed, Medline, RCA, and google scholar, using the search terms "abortions" or "medical/legal termination of pregnancy" and "cardiac complications" or "cardiovascular complications".

RESULTS

The most common complications described in the literature following MTP were infective endocarditis (IE) ($n = 16$), takotsubo cardiomyopathy (TTC) ($n = 7$), arrhythmias ($n = 5$), and sudden coronary artery dissection (SCAD) ($n = 4$). The most common valve involved in IE was the tricuspid valve in 69% ($n = 10$). The most observed causative organism was group B Streptococcus in 81% ($n = 12$). The most common type of TTC was apical type in 57% ($n = 4$). Out of five patients de-

veloping arrhythmia, bradycardia was the most common and was seen in 60% (3/5) of the patients. All four cases of SCAD-P type presented as acute coronary syndrome 10-14 d post termination of pregnancy with predominant involvement of the right coronary artery. Mortality was only reported following IE in 6.25%. Clinical recovery was reported consistently after optimal medical management following all these complications.

CONCLUSION

In conclusion, the occurrence of CVD complications following pregnancy termination is infrequently documented in the existing literature. In this review, the most common CVD complication following MTP was noted to be IE and TTC.

Key Words: Cardiovascular complications; Termination of pregnancy; Infective Endocarditis; Stress cardiomyopathy; Outcome

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Core Tip: The most common cardiovascular complications following the medical termination of pregnancy (MTP) are infective endocarditis (IE) and takotsubo cardiomyopathy (TTC). The most common organism identified in IE is group B Streptococcus and the tricuspid valve is the most common valve involved. TTC occurs most commonly in the first trimester after MTP. Spontaneous coronary artery dissection mostly presents with chest pain and the right coronary artery is the most common vessel to be involved. Bradyarrhythmia is the most common arrhythmia noted. These patients improve with appropriate medical management and mortality tends to be low.

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INTRODUCTION

The legality of abortion and the various restrictions imposed on the procedure vary significantly among various states of the United States and are ever-changing. The initial law, *Roe vs Wade*, which was made in 1973, streamlined the decision-making process. Over the last 50 years, there has been a paradigm change in the perspective of patients regarding the termination of pregnancy in the United States. Centers for Disease Control (CDC) reports an abortion rate of 11.4 for the year 2020 with around 1 million abortions taking place annually in the United States. Around 2% of this population have been reported to develop complications[1].

Due to the recent identification of female-specific factors associated with a greater cardiovascular (CVD) risk, it provides the potential to implement effective and targeted preventative measures to decrease disease burden at an individual and population level[2]. Therefore, having an understanding of the female specific risk stratification and prevention is important. Recent CVD risk guidelines have included miscarriage and stillbirth as risk factors for women[3]. Because of the changing times and laws, we must highlight various CVD complications which are associated with the termination of pregnancy[4]. In this article, we review the various cardiac comorbidities reported after the medical termination of pregnancy (MTP). We also describe their clinical profile, management, and outcomes observed in these patients. Various systemic reviews discuss the complications associated with the termination of pregnancy. However, none describes cardiac complications following the same. Therefore, this article can contribute towards a better understanding, and facilitate preparedness and management of the cardiac complications following termination of pregnancy.

MATERIALS AND METHODS

In this review, we aimed to describe the demographic details, clinical presentation, diagnosis, and management of the various CVD complications following MTP. We used the meta-analysis guidelines for the material and methodology of our study.

Search strategy

We performed a systemic search in various bibliographic databases including PubMed, Medline, RCA, and google scholar databases, using the search terms “abortions” or “medical/legal termination of pregnancy” and “cardiac complications” or “cardiovascular complications”. The reference citation analysis tool was also used to find more articles. We screened references of the initial articles for identifying other relevant articles. Search strategies were tailored to each database for identifying relevant articles. All search outputs were exported to Microsoft Excel version 2022. For those articles where the main text was missing, we reached out to the authors. We acknowledge their support in sharing their work with us.

Study selection

All articles reported in English including adult patients (age > 18 years) published before August 2022, were eligible to be included in this review. Articles lacking clinical details, including comments, opinions, and letters, were excluded. The inclusion and exclusion criteria for the patients were established in advance before the initiation of the study. To be included in this review, articles had to provide clinical details of the pregnancy and the reported cardiac complication. For those articles where the main text was missing, we directly contacted the authors. We acknowledge their support in sharing their work with us. We added complete information on the studies included in this study. Two reviewers independently screened the abstracts. Cardiac complications had to fulfill the diagnostic definitions as described below.

Definitions

Infective endocarditis: Cases of infectious endocarditis (IE) had to fulfill the Modified Duke's criteria, which include the presence of either a blood culture of the organism consistent with IE or an echocardiogram showing positive evidence of IE, abscess, new partial dehiscence of a prosthetic valve, or new regurgitation (major criteria). Minor criteria include a previous heart condition or history of intravenous drug use, fever, presence of microorganisms not typically seen with IE, immunological phenomena such as glomerulonephritis, Roth spots, or vascular phenomena such as major arterial emboli or Janeway lesions. The presence of two major criteria, one major and three minors, or five minor criteria is diagnostic for definitive IE[5].

Takotsubo cardiomyopathy: Cases of takotsubo cardiomyopathy (TTC) had to fulfill the Mayo Clinic diagnostic criteria, which include: (1) Transient left ventricular systolic dysfunction with regional wall motion abnormalities extending beyond a single epicardial coronary distribution; (2) Absence of obstructive coronary disease or any angiographic evidence of acute plaque rupture; (3) Presence of new electrocardiogram (EKG) changes as either sinus tachycardia (ST)-segment elevation and/or T wave inversion or elevation in cardiac troponin levels; and (4) Documentation of absence of pheochromocytoma or myocarditis[1].

Spontaneous coronary artery dissection: Cases of spontaneous coronary artery dissection (SCAD) had to provide details of coronary angiography, which used an iodinated contrast agent to fill the lumen of coronary arteries and X-rays to image the lumen. Alternatively, if an alternate imaging modality such as optical coherence tomography or intravascular ultrasound was used to delineate the cause of narrowing and showed a tear or blood accumulation in the arterial wall, it would also be eligible for inclusion[6].

Cardiac arrhythmia: To be included in this review, reported arrhythmias had to have details of an investigation showing the pattern of the arrhythmia[7].

Risk and bias assessment: Two reviewers (Singh T and Vojjala N) independently screened for risk of error and bias in the articles. Disagreements were resolved through final verification and consensus of the third reviewer (Mishra AK)[8].

Data extraction: Extracted data include information on the publication year, authors, study type, and methodology. We also extracted data on study participants, including recent age, gender, clinical presentation, CVD, imaging, and laboratory parameters and management. Finally, we studied the outcomes, including CVD complications and mortality[9,10].

Data synthesis and analysis: Continuous variables are expressed as the mean or percentages. Given the small sample size under each subgroup, we were not able to identify any odds or associations.

RESULTS

The initial screening identified 300 cases that were published between 1990 and 2022, of which 34 fulfilled the inclusion criteria, as shown in the PRISMA diagram (Figure 1). These included 16 cases of IE, seven cases of TTC, six cases of arrhythmia, and five cases of SCAD. The clinical profile, management, and outcomes of these events are described in Tables 1-4[11-41].

Of the 16 cases of IE following abortion, 15 occurred following elective surgical abortion and one was a case of clandestine induced abortion. Only two patients had an underlying risk factor for IE, including a history of aortic valve replacement (AVR)/mitral valve replacement (MVR) for IE and rheumatic heart disease. The median age of these patients was 24 years[15-37]. Following termination of pregnancy, the initial clinical presentation occurred as early as one week after the abortion to as late as several weeks, with the most delayed presentation seen 60 d after the abortion. Data on prior antibiotic prophylaxis was available for 11 patients, four of whom received prophylaxis, including doxycycline in two cases, ampicillin and gentamicin in one, and a combination of ciprofloxacin and doxycycline in one. The tricuspid valve was the most commonly involved, as seen in 11 patients (69%), with multivalvular involvement in two patients and rare pulmonary valve involvement in one patient (6%). Group B Streptococcus (GBS) was the most common organism detected in these patients ($n = 13$, 81%), with culture being negative in one patient. *Escherichia coli* and methicillin sensitive *Staphylococcus aureus* were positive in one patient each. Most patients had IE related complications at the time of presentation, with the most common complication being septic emboli as seen in 69% ($n = 11$) followed by heart failure in 19% ($n = 3$). All patients were treated with intravenous antibiotics and 56% ($n = 9$) required surgical intervention, including MVR in two patients, tricuspid valve replacement in four, AVR in two, and pulmonary valve replacement in one. An embolectomy was performed on one patient, along with medical management. The prognosis for this subset of patients was good, with a mortality rate of 6% ($n = 1$) in Table 1[10-25].

Table 1 Patients with infective endocarditis following medical termination of pregnancy

No.	Age/details	Time interval	Antibiotic prophylaxis	Microbiological diagnosis	Valves involved	Other complications	Management	Final outcome	Ref.
1	17 yr/ clandestine abortion	28 d	No	Neg	TV	None	Mx	Survived	[10]
2	30 yr/post ciprofloxacin and doxycycline	10 d	No	GBS	MV	S Ar, R Ar	Mx, MVR	Survived	[11]
3	31 yr/post-surgical abortion	48 d	No	GBS	TV	STE	Mx, TVR	Survived	[12]
4	37 yr/post-surgical abortion, past history of AVR/MVR for IE	60 d	Yes (ampicillin and gentamycin)	GBS	AV	SE	Mx	Survived	[13]
5	18 yr/elective abortion	Several weeks	No	GBS	TV	SE	Mx	Survived	[14]
6	30 yr/elective abortion	28 d	No	GBS	TV	SE, 1 st HB	Mx, TVR	Survived	[15]
7	33 yr/elective abortion	28 d	No	GBS	TV	SE, VRA	Mx, TVR	Survived	[16]
8	24 yr/elective abortion	28 d	No	GBS	TV	SE, RHF	Mx	Survived	[17]
9	15 yr/elective abortion	7 d	Doxycycline	GBS	PV	SE, PAA	Mx, PVR	Survived	[18]
10	15 yr/elective abortion	11 d	Ciprofloxacin + doxycycline	GBS	AV	HF, AR	Mx, AVR	Survived	[19]
11	18 yr/elective abortion	14 d	Doxycycline	GBS	TV	SE	Mx, Emb	Survived	[20]
12	22 yr/elective abortion	7 d	-	GBS	TV	SE, PAA, TR	Mx	Lost to follow-up	[21]
13	Young female	-	-	-	Mu	-	Mx, AVR, TVR	Death	[22]
14	37 yr	11 d	-	GBS	TV	SE, SI	Mx	Survived	[23]
15	25 yr/rheumatic heart disease	14 d	-	MSSA	Mu	SE	Mx	Survived	[24]
16	21 yr	21 d	-	E coli	MV	HF	Mx, MVR	Survived	[25]

GBS: Group B streptococcus; MSSA: Methicillin sensitive staphylococcus aureus; MV: Mitral valve; TV: Tricuspid valve; AV: Aortic valve; PV: Pulmonary valve; Mu: Multiple valves involved; S Ar: Septic arthritis; R Ar: Reactive arthritis; STE: Septic thromboembolism; SE: Septic embolism; 1st HB: First degree heart block; VRA: Valve ring abscess; RHF: Right heart failure; PAA: Pulmonary artery aneurysm; HF: Heart failure; TR: Tricuspid regurgitation; AR: Aortic regurgitation; SI: Sacroiliitis; Mx: Medical management; MVR: Mitral valve replacement; PVR: Pulmonary valve replacement; AVR: Aortic valve replacement; Emb: Embolectomy; TVR: Tricuspid valve replacement.

TTC was reported in seven cases in the literature as a post-abortion CVD complication. The mean age at presentation was 34.4 years, with a range of 22 to 43 years. Of the four patients (57%) for whom gestational age was available, all had undergone an abortion or miscarriage in the first trimester (within less than 12 wk). Three (43%) patients had experienced miscarriages, two (29%) had undergone surgical termination of pregnancy, and one had undergone an elective abortion. One patient had a history of myoma removal surgery during the 14th wk of pregnancy, which resulted in fetal death four weeks later and led to five recurrent episodes of TTC that improved with follow-up care. The most common presentation in the emergency department was chest pain, which was reported by three (43%) patients, with one patient experiencing right-sided pain radiating to the neck and the other two experiencing severe left-sided, non-radiating acute pain. Other common presentations included hypotension ($n = 1$), abdominal pain, and vaginal bleeding ($n = 1$). Abnormal EKG finding was reported in three (43%) patients only. EKG findings in most patients were normal sinus rhythm ($n = 2$) or T wave inversion ($n = 2$) in the inferior and anteroseptal walls. Other EKG findings included up-sloping ST depression ($n = 1$) and sinus tachycardia ($n = 1$). Troponin levels were available and elevated in six (86%) patients. Coronary angiography was performed on six (86%) patients who did not show any evidence of obstructive coronary artery disease. Echocardiograms in all seven (100%) patients reported a reduced ejection fraction (EF) of less than 40%, with the most common wall involvement being the apex in 57% ($n = 4$) and basal wall in 29% ($n = 2$). Only 43% were started on guideline-directed medical therapy ($n = 3$). Treatment for these patients commonly included beta-blockers (BB) and angiotensin-converting-enzyme inhibitors (ACEi) in 43% ($n = 3$), and diuretics in 29% ($n = 2$). Other pharmacological agents used for treatments

Table 2 Patients with takotsubo cardiomyopathy following medical termination of pregnancy

No.	Age, gestation	Clinical feature	TTC criteria: EKG and Trop; echo; coronary angiography negative; pheochromocytoma	Possible pathophysiology	Treatment given	Outcome: Mortality and EF repeat	Ref.
1	36 yr, 12 wk gestation	Misc; hypovolemia	EKG: ST and Trop T elevated; eCHO: TTE (35%) EF, hypok LV apex; coronary angiography: Negative	Catecholamine surge: (1) Direct toxicity; (2) Coronary vasoconstriction; and (3) Microvascular spasm	IV furosemide	5 th d repeat echo: LV to EF: 60%. F/u: 11 mo, no relapse	[26]
2	22 yr, gestation: NA	Post Sx TOP with evacuation of retained POC; hypovolemia	EKG: Normal and Trop T elevated; 2D echo: DCM; coronary angiography: Negative	Catecholamine release post procedure	Diuretics. Bisoprolol and lisinopril	Echo: Repeat day 2 had EF 56%. Follow-up, full recovery	[27]
3	37 yr, Misc	Chest pain, radiating to the neck	EKG: ST depression, Trop T elevated; 2D echo: EF < 40%; coronary angiography: Negative	NA	NA	F/u echo EF normal. F/u Trop T normal	[28]
4	43 yr, gestation: NA	Chest pain	EKG: Normal and Trop T elevated; echo: LV hypokinesia, apical, diaphragmal, posterio-basal segments; coronary angiography: Negative	Stress factors: (1) H/o fetal death at 18 wk gestation; and (2) Domestic stress	Beta-blockers, ACE inhibitors, aspirin	5 d later, 2D echo EF 72%, normal wall movements. F/u: Developed 4 episodes of TTC, 6 mo, 9 mo, 10 mo, and 19 mo later. With eventual normalization of EF	[29]
5	43 yr, 9 wk gestation	Post Sx TOP. Shock, hypoxia, cardiac arrest requiring CPR	EKG: T wave inv, Trop T elevated; echo: LV EF 33%, LV apex hypo/akinesia; angiography: NA	h/o autoimmune diseases; post-op stress; cervical infiltration of epinephrine	Infusion of levosimendan	Echo: 3 mo later showed return of the LV function to normal	[30]
6	28 yr, 12 wk gestation	Chest pain	EKG: T wave inv, Trop T elevated; echo: EF (30%-35%); hypokinesia mid ventricular and hyperkinesia apical and basal wall; coronary angiography: Negative	Post abortion depression; suicidal ideation	Carvedilol. Lisinopril spironolactone	F/u echo: NA. Hemodynamically stable on follow-up	[31]
7	32 yr, 10 + 1 wk gestation; Misc	Abdominal pain, vaginal bleeding. Later underwent POC evacuation	EKG: Intermittent VT and QRS broadening. Trop T: NA; TTE: EF: 32%, global LV hypokinesia and akinesia of inferior and inferio-septal wall; coronary angiography: Negative	Septic miscarriage with blood C/S: Group C Streptococcus; amphetamine usage	IV antibiotics	Full recovery in 6 wk. 2D echo: Normal on repeat	[32]

Misc: Miscarriage; POC: Product of conception; Sx TOP: Surgical termination of pregnancy; CPR: Cardiopulmonary resuscitation; ST: Sinus tachycardia; DCM: Dilated cardiomyopathy; VT: Ventricular tachycardia; Post-op: Post-operation; EF: Ejection fraction; LV: Left ventricle; TTC: Takotsubo cardiomyopathy; TTE: Transthoracic echocardiography; NA: Not available; EKG: Electrocardiogram; C/S: Culture and susceptibility; F/u: Follow-up.

included aspirin, antibiotics, spironolactone, and levosimendan (*n* = 1 each). Six (87%) patients with available follow-up information had echocardiograms showing restoration of EF. Following the initial episode, one patient had five distinct episodes of TTC recurrence following an altercation with her partner. No recurrences were reported for the remaining patients, and there were no reported mortalities[26-32].

In four reported cases of SCAD following abortion or stillbirth, individual patient data was available for three patients. The median age of these patients was 36 years, with a range of 33 to 41 years. All three patients presented within 14 d of undergoing abortion or stillbirth. The most common clinical presentation was chest pain, which was reported by two patients (50%). EKG changes in these patients included ST elevation, with the most common leads involved being the inferior leads (50% of patients), mimicking acute myocardial infarction. Cardiac biomarkers were normal in all cases. Echocardiography was performed on two patients, with one showing normal findings and the other showing decreased left ventricle contractility with an EF of 30%. Coronary angiography showed dissection in the right coronary artery in two patients (one with proximal involvement and one with distal involvement) and the left anterior descending artery in one. Management included percutaneous coronary intervention besides medical management for two of the three patients. All three patients survived the event. One patient had no similar episode after eight months of follow-up, while the other patient had a remnant anoxic brain injury[33-36].

Out of five patients developing arrhythmia, the most common type reported was bradycardia which was seen in 60% (*n* = 3) of patients. Other two patients developed an arrhythmia post administration of prostaglandin F2 alpha drugs. The two patients who developed bradycardia did so after the passage of the product of conception (POC) and the application of pressure to their cervix. The mechanism which was speculated to cause this was the triggering of the vagus nerve during this process, resulting in the development of bradycardia. In all these patients, bradycardia improved after forceps assisted removal of the POC. There was also a patient who developed supraventricular tachycardia (SVT) after the administration of the misoprostol injection[37-41].

Table 3 Patients with spontaneous coronary artery dissection following medical termination of pregnancy

No.	Age	C/F and EKG	Labs and imaging	Angiography	Management and prognosis	Ref.
1	36 yr	Chest pain 2 wk post abortion. ECG: STE in V2-V4, STD in inferior leads	Cardiac biomarkers: Normal. Echo: Normal	Angiography: Type C dissection in LAD	Management: PCI with stenting to LAD. Survived, no similar episodes at follow-up after 8 mo	[33]
2	41 yr	2 wk post still birth, became unresponsive, cardiac arrest post CPR, ROSC. ECG: STE in leads 2, 3, avF	Cardiac biomarkers: Normal. Echo: Decreased LV contractility, EF: 30%	Angiography: Type 2 SCAD involving distal RCA	Management: Medical management. Survived post cardiac arrest, anoxic brain injury	[34]
3	33 yr	Chest pain 10 d post abortion. EKG: STE in inferior leads	Cardiac biomarkers: Increased	Angiography: Dissection involving RCA	Management: PCI. Survived	[35]
4	N/A	2 cases had SCAD a/w stillbirth and miscarriage	N/A	N/A	N/A	[36]

C/F: Clinical features; EKG: Electrocardiogram; N/A: Not applicable; STE: Sinus tachycardia elevation; STD: Sinus tachycardia depression; CPR: Cardiopulmonary resuscitation; ROSC: Return of spontaneous circulation; SCAD: Spontaneous coronary artery dissection; LV: Left ventricle; EF: Ejection fraction; LAD: Left anterior descending artery; RCA: Right coronary artery; PCI: Percutaneous coronary intervention.

Table 4 Patients with arrhythmia following medical termination of pregnancy

No.	Age	Clinical details	Arrhythmia observed	Possible mechanism for arrhythmia	Treatment given	Outcome	Ref.
1	NA, 2 nd trimester	Induced by PGF2a	Bradycardia	Drug induced hypokalemia	NA	NA	[37]
2	32 yr, 20 th wk gestation	Induced by PGF2a	Bradycardia and hypotension	PG acting on ventricular receptor	IV RL, 0.5 mg atropine no response	F/u 1 mo EKG and echo normal	[38]
3	37 yr, 10 wk gestation	In miscarriage	Bradyarrhythmia	POC through cervix trigger vagal stimulation	POC removed	EKG normal on F/u	[39]
4	42 yr, 12 wk gestation	Miscarriage, with lower abdominal pain	Bradyarrhythmia with hypotension. USG TVS: POC in UC	POC through cervix, triggering vagus	POC removed	BP and HR improved	[40]
5	Age: NA, 2 nd trimester	Induced by PGF2a and IV oxytocin	Bradycardia, hypothermia and hypotension	Rupture of the cervix	NA	NA	[41]

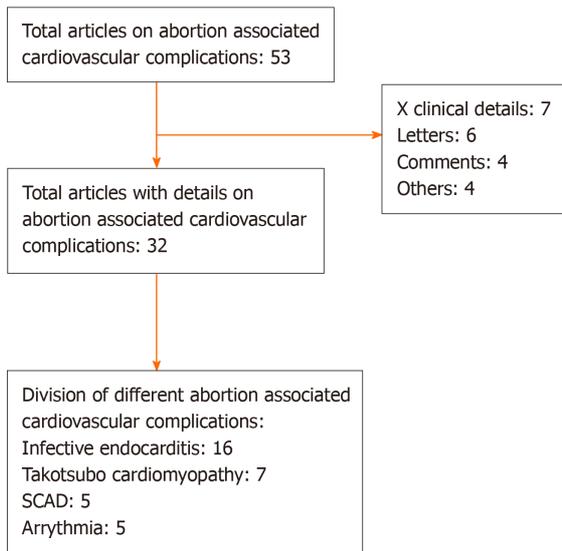
PGF2a: Prostaglandin F2 alpha; NA: Not available; USG: Ultrasound; TVS: Transvaginal ultrasound; POC: Product of conception; UC: Uterine cavity; RL: Ringer lactate; F/u: Follow-up; EKG: Electrocardiogram; BP: Blood pressure; HR: Heart rate.

DISCUSSION

In the year 2020, the CDC reported rate of abortion was 11.2 abortions per 1000 women of age 15-44 years in the United States[1]. The type of abortion can also be classified as either being safe (performed in a safe, clean environment with experienced providers and no legal restrictions) or unsafe (performed with hazardous materials and techniques, by a person without the needed skills, or in an environment where minimal medical standards are not met)[42]. Abortion related complications and deaths occur predominantly in unsafe abortions and in settings where it is illegal[43]. Complications following an abortion can be diverse. The maternal mortality rate following safe, legal induced abortion for 2013-2019 was reported to be 0.43 deaths per 100000 reported legal abortions[1]. Pregnancy is a state of altered neuro-humoral balance and continuous inflammation with significant effects on the physiology of the CVD system[44-47]. It is probable that even abortion or stillbirth can also result in altered neuro-humoral balance and chronic inflammatory changes affecting the functioning of the CVD system[4,42]. In this descriptive review, we highlight the various CVD complications following MTP reported in the medical literature. We identified four distinct CVD complications following MTP, which have been defined as above (Figure 2).

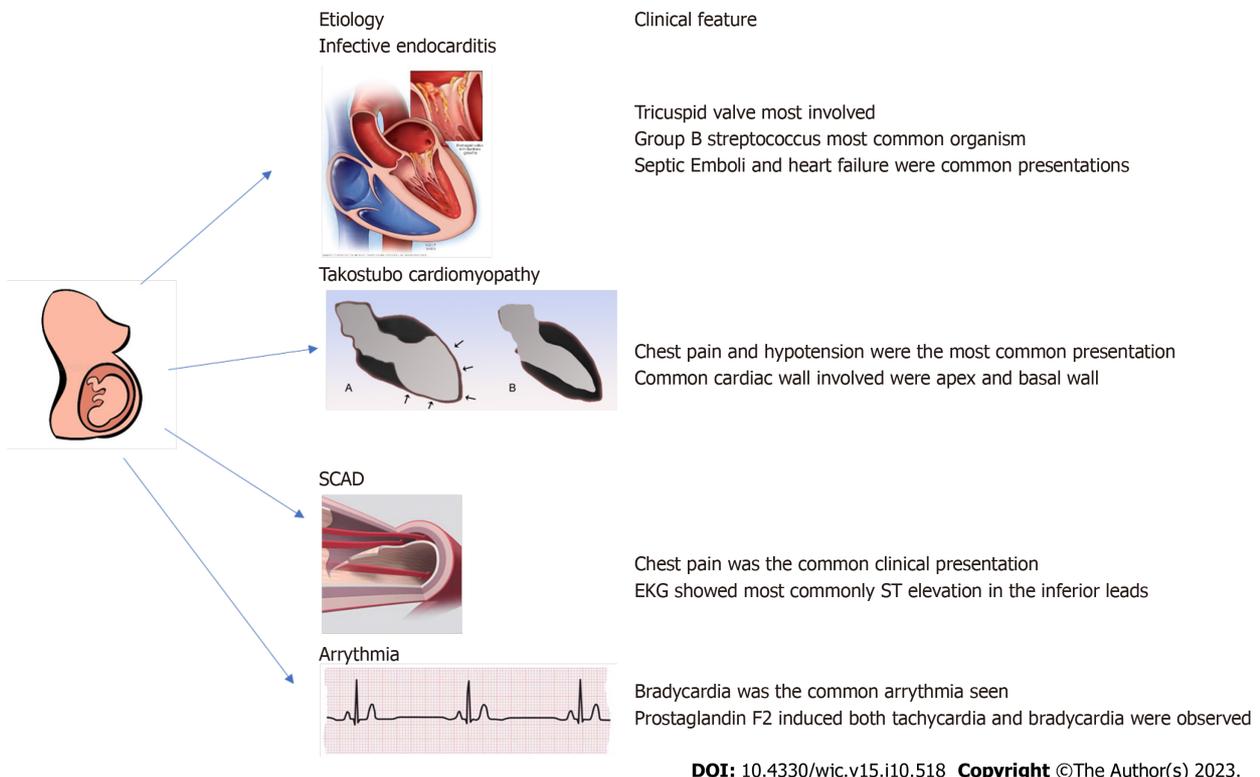
IE

In this review, IE was the most common CVD complication observed following MTP. While multiple organisms are reported to cause IE, in these patients the most common organism causing IE was GBS, which is a common colonizer of the genital tract and lower gastrointestinal tract[48,49]. The reported risk factors that predispose to GBS IE are diabetes mellitus, malignant disease, advanced liver disease, human immunodeficiency virus, alcohol use disorders, and injection drug use[50]. Surgical abortion has been reported to be an independent risk factor for IE in patients with GBS, irrespective



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Figure 1 Flow diagram of study participant inclusion. SCAD: Sudden coronary artery dissection.



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Figure 2 Cardiovascular complications following medical terminations of pregnancy. SCAD: Sudden coronary artery dissection; EKG: Electrocardiographic.

of the presence or absence of underlying structural heart disease or antibiotic prophylaxis before the procedure[12,13]. The Society of Obstetricians and Gynaecologists of Canada recommends antimicrobial prophylaxis for patients who are undergoing surgical abortion to reduce the incidence of post-abortion infections[51]. This recommendation is based on a meta-analysis of 12 randomized controlled trials conducted in pregnant women at less than 16 wk gestation. Patients who received antibiotics during the abortion procedure had a 0.58 (0.47-0.71) relative risk of developing upper genital tract infection, compared to those who did not receive the antibiotics[52]. A single appropriate antibiotic regimen was not recommended in the study. Though antibiotic therapy has been shown to prevent genitourinary infections, antibiotics were not uniformly administered in the above subsets of patients. Clinicians providing MTP should be aware of this rare complication in patients with risk factors as mentioned above. So far there are no studies to guide antibiotic prophylaxis in patients undergoing MTP, however, patients with risk factors for developing GBS IE might benefit from pre-procedure

prophylaxis. In a study done in Sweden on women undergoing an induced abortion, the administration of antibiotics reduced the post-abortion complications in patients with positive bacterial screening to the level with those having negative bacterial screening[53]. Despite the above study, given the rarity of this complication, prolonged prophylactic anti-biotic courses are not feasible or evidence-based.

The most common valve involved was the tricuspid valve, but multivalvular involvement was also seen[15,17,21,54]. Pelvic infections occurring after a septic abortion can provide a portal of entry for bacteria through pelvic veins into the venous system. This can subsequently spread to the right-sided circulation, eventually causing tricuspid endocarditis. Most of these patients presented with constitutional symptoms like chills, anorexia, and weight loss. Complications including septic pulmonary emboli are common among patients with right-sided IE, occurring in up to 75% of patients with tricuspid involvement. Clinical manifestations of such emboli include cough, pleuritic chest pain, hemoptysis, and dyspnoea[42,55,56]. In our study, the common complications seen were septic emboli and heart failure. All patients were treated with appropriate antibiotics based on culture and sensitivity results[57-61]. Patients with septic emboli, para-valvular abscess, conduction blocks, and the presence of large vegetations required surgical management as shown in Table 1. Overall, the prognosis was good with a mortality of 6.25%.

TTC

TTC, also called transient apical ballooning syndrome, was initially described in Japan in 1990[62,63]. Improved access to coronary angiography has led to increased recognition of TTC in patients presenting with symptoms of acute coronary syndrome, with studies reporting a 20-fold increase in incidence from 2006 to 2012[64-66]. Mayo Clinic Criteria and International Takotsubo Diagnostic Criteria (InterTAK Diagnostic Criteria) are two of the most commonly used tools to establish the diagnosis[64,67]. In our study, Mayo Clinic Criteria was used. TTC has been reported to be precipitated in 70% of patients by several acute triggers including emotional, natural disaster, illness, envenomation, infection, *etc.*[68-70]. In this paper we discuss TTC precipitated following MTP. Patients who developed TTC post MTP presented with symptoms and signs of ACS including chest pain, ST-T wave changes in EKG, and elevated troponin as seen in patients with other precipitators of TTC[71]. In this review apical wall involvement was the most common echocardiographic abnormality, as reported by Templin *et al*[64] in 81.7% of their patient population ($n = 1750$)[72]. Multiple mechanisms have been proposed to precipitate TTC[72]. The various mechanisms postulated to precipitate TTC in this review were catecholamine surge following physical and emotional distress (depression, posttraumatic stress disorder, and suicidal ideation) and exogenous epinephrine[26,31,32]. It has been hypothesized that direct myocardial damage from catecholamines may cause TTC and the regional wall motion abnormalities occur due to the regional distribution of adrenergic receptors. At presentation all these patients had low left ventricular EF, however, less than half of the patients were treated with guideline directed medical therapy with ACEi and BB. Interestingly, no mortality was reported and at follow-up all these patients were found to have normal left ventricular ejection fraction.

SCAD

SCAD is a rare condition, with an estimated prevalence of 0.2% to 1.1%[49,73]. The prevalence of SCAD post pregnancy, stillbirth, and abortion remains unknown. There are several proposed mechanisms for the development of SCAD in these situations, including structural changes to the vascular system due to excess progesterone during pregnancy leading to the loss of normal corrugation of elastic fibers, increasing the fragmentation of reticular fibres, and decreasing the amounts of mucopolysaccharides reducing the strength of vessel wall, increased mechanical stress on the coronary artery during labor, prolonged coronary artery spasm, and the use of uterotonic drugs[36,74-77]. Maternal risk factors, such as multiple pregnancies, advanced age, and anxiety, may also increase the risk of SCAD due to repeated exposure to high levels of progesterone and altered neuro-hormonal balance[74,75,77]. In this review, SCAD was reported within 2 wk of MTP presenting as an ACS. Although the risk of SCAD post pregnancy and stillbirth may differ, early intervention with high clinical suspicion can result in good outcomes, as reported in various studies[44,73,78].

Arrhythmia

Bradycardia was the most common arrhythmia observed in our review[35-37,47]. The common cause of bradycardia is vagal stimulation during the passage of the fetus or POC through the cervix, a phenomenon known as cervical vasovagal shock[39,40]. This is typically observed with retained POC, and management often involves dilatation and curettage to remove the POC. In a study conducted in Cambridge, Kyejo *et al*[40] suggest that for patients with symptomatic bradycardia secondary to cervical shock, it is important to stop cervical manipulation and remove all instruments, keep the patient in the supine position with legs elevated to improve venous return, and, if necessary, administer 500-600 microgram of IV atropine followed by a saline flush. In this review, removal of the POC with forceps improved shock and bradycardia. Other causes of arrhythmia observed in our patients include prostaglandin F2 and E (misoprostol), which have been linked to tachycardia and SVT. A study in mice suggests that these medications may cause tachyarrhythmias due to their direct effect of inflammatory mediators on the heart[79]. Stopping the medications resulted in the improvement of arrhythmias in these patients.

This review has several limitations. It included all the patients with MTP and reported CVD complications from various case reports over the years, which had varied uniformity in reporting. These patients were young and lacked baseline echocardiography or electrocardiography. All the reports of SCAD and TTC consistently did not report cardiac catheterization results[80]. Reports did not mention functional status at discharge, recurrence, and long-term follow-up details[81-84]. However, the strengths of this study are: (1) Having a strict inclusion criterion for each clinical entity; and (2) Evidence-based detailing on the clinical profile and the outcome of each described complication. As per the authors' knowledge, there are previous studies done including Kyriacou *et al*[3] who have reported that women with previous

pregnancy loss, following a miscarriage, stillbirth, and induced abortion, are at higher risk of coronary heart disease and stroke. However, this is the first review detailing the clinical profile, imaging details, complications, and outcomes of the various CVD complications following MTP.

CONCLUSION

In conclusion, CVD complications are uncommon following MTP. The most frequently reported complications are IE and TTC. IE can occur in these subgroups of patients without risk factors for IE. Perioperative antibiotics prophylaxis was not uniformly administered. IE can occur within 1 wk of MTP, and the most common organism identified is GBS. The most commonly involved valve reported is the tricuspid valve, and the most common complication reported is septic emboli. More than half of the IE patients required surgical intervention owing to worsening heart failure, valvular regurgitation, para valvular abscess, conduction block, and embolic phenomenon. TTC most commonly occurred after MTP in the first trimester. Most patients presented with acute chest pain, troponin elevation, and nonspecific ST-T changes. The most common pattern of TTC as identified by echocardiography was apical. All these patients had low EF at presentation and at follow-up most had normal EF even though only half of them were treated with ACEi and BB. SCAD occurred within 2 wk of MTP. Most patients presented with chest pain and EKG abnormalities. The most common vessel involved in dissection was the right coronary artery. Bradycardia was the most common pattern of arrhythmia noted and occurred during the time of MTP and was self-limiting. All patients with the above complications improved with appropriate medical management. Overall, mortality was low in this population.

ARTICLE HIGHLIGHTS

Research background

Millions of medical terminations of pregnancy (MTP) take place yearly in the United States of America with a smaller percentage of this population developing complications. There is a lack of structured reporting of the cardiovascular (CVD) complications in this subset of patients.

Research motivation

The CVD complications occurring post MTP or after stillbirth are not very well described. The literature on the various CVD comorbidity following MTP is scanty.

Research objectives

In this review we aimed to study the various cardiac comorbidities seen after MTP, which will help the reader better understand, prepare, and manage these complications.

Research methods

A literature search in multiple databases including PubMed, Medline, RCA and google scholar, using the search terms “abortions” or “medical/Legal termination of pregnancy” and “cardiac complications” or “cardiovascular complications” were conducted. All research studies, clinical studies, case series, and case reports with relevant clinical details were included.

Research results

The most common complications described in the literature following MTP were infective endocarditis (IE), takotsubo cardiomyopathy (TTC), arrhythmia, and sudden coronary artery dissection (SCAD). The most common valve involved in IE was the tricuspid valve. The most observed causative organism of endocarditis was group B Streptococcus. The most common type of TTC was apical. Bradycardia was the most common arrhythmia. All four cases of SCAD-P type presented as acute coronary syndrome with predominant involvement of the right coronary artery. Mortality was only reported following IE in 6.25%. Clinical recovery occurred after optimal medical management following all these complications.

Research conclusions

The most common CVD complications following the MTP are IE, TTC, bradycardia, and SCAD. Most of these complications are adequately treated with appropriate medical management.

Research perspectives

As per the authors' knowledge, this is the first review detailing on the clinical profile, imaging details, complications, and outcomes of the various CVD complications following MTP.

FOOTNOTES

Author contributions: Mishra AK and Hadley M planned and formulated the study; Singh T and Vojjala N collected and analysed the data; Singh T, Mishra AK, John KJ, George AA, and Jha A completed the manuscript; Singh T and Mishra AK revised the manuscript; Mishra AK and Hadley M reviewed the manuscript; and Hadley M approved the manuscript.

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