Cardiac operation under cardiopulmonary bypass during pregnancy

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Abstract

Background: Certain pregnant women suffer from cardiac pathology, and a few of them need cardiac operations under cardiopulmonary bypass during pregnancy. Feto-neonatal and maternal outcomes have not been sufficiently described.

Methods: We conducted a retrospective review of 22 cases of women undergoing cardiac operations under cardiopulmonary bypass during pregnancy in our hospital from Jan. 2014 to Mar. 2019.

Results: All 22 patients were alive after treatment. The types of cardiac disorders included congenital heart defects, rheumatic heart disease, infective endocarditis, aortic dissection, obstruction and/or thrombosis of a prosthetic valve. Only one case was a twin pregnancy, and the other 21 cases were singletons. Four fetuses died in the utero after surgery. Three patients chose termination of the pregnancy after the cardiac operations: one fetus was detected abnormality of the brain and the other two patients abandoned pregnancy. Fourteen fetuses were alive and born without any abnormality. Two fetuses suffered from neonatal intracranial hemorrhage and died after birth.

Conclusions: Cardiac operation under cardiopulmonary bypass during pregnancy is a challenge for physicians in multidisciplinary teams. Strictly evaluating the indication is vital. On the other hand, some patients can benefit from this management.

Keywords: Cardiac operation, Cardiopulmonary bypass, Pregnancy, Outcome

Background

Heart disease complicates more than 1% of pregnancies and is now the leading cause of indirect maternal deaths [1]. Pregnancy creates a great burden on the cardiovascular system and can result in decompensation in women with underlying cardiac disease. To minimize the maternal and fetal risks, the first choice of treatment should be medical. In cases that are refractory to medical treatment, however, corrective cardiac operations should be undertaken [2]. As the Guangdong provincial obstetrical cardiology intensive care center in China, our hospital has accumulated a significant amount of clinical data of pregnant women with heart disease receiving cardiac operations under cardiopulmonary bypass during pregnancy. To investigate feto-neonatal and maternal outcomes, we conducted this study.

Materials and methods

Subject

We searched in our medical record database from Jan. 2014 to Mar. 2019. The search terms included “pregnancy”, “cardiopulmonary bypass” and “cardiac
operation”. We obtained 22 copies of the patients’ medical materials containing the entire pregnancy course and fetal outcomes with their consent.

NYHA classes
The NYHA classification was developed in 1928 to describe an overall cardiac appraisal of the status of a patient with heart disease. It was divided into four classes [3]: Class I: Patients with cardiac disease but without resulting limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, dyspnea, or anginal pain. Class II: Patients with cardiac disease resulting in a slight limitation of physical activity. They are comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnea, or anginal pain. Class III: Patients with cardiac disease resulting in marked limitation of physical activity. They are comfortable at rest. Less than ordinary activity causes fatigue, palpitation, dyspnea, or anginal pain. Class IV: Patients with cardiac disease resulting in inability to carry on any physical activity without discomfort. Symptoms of heart failure or anginal syndrome may be present even at rest. If any physical activity is undertaken, discomfort increases.

Cardioplegia technique
Adequate myocardial protection is essential for achieving successful outcomes of any surgical procedure necessitating cardiac arrest. The Del Nido solution (blood and crystalloid mixed formula) was used in all the cardiac operations of our study. The route of administration was antegrade or combined antegrade & retrograde.

Cardiac surgical procedures
Corrective cardiac operations consisted of mitral or/and tricuspid valve repair, aortic valve replacement (AVR), mitral valve replacement (MVR), ruptured sinus of Valsalva repair, atrial septal defect closure, ventricular septal defect closure, right ventricle outlet obstruction repair, prosthetic mitral/aortic valve thrombectomy and Betall procedure.

Maternal, fetal and neonatal complications after operation
The most common maternal complication was arrhythmia after operation. Fetal and neonatal complications included stillbirth, preterm delivery (<37 weeks of gestation), neonatal intracranial hemorrhage and death.

Statistical analysis
A retrospective analysis was performed. Measurement data and enumeration data were expressed as mean ± standard deviation (SD) or frequencies.

Results
Patient general information
The average age of the patients was 29.5 ± 5.4 years, with an age range of 21 to 42 years. Half the patients were nulliparous (n = 12, 54.5%). There was one twin pregnancy(n = 1, 4.5%) and the other patients were singletons(n = 21, 95.5%). The patient’s characteristics are listed in Table 1.

Cardiac surgical procedure, intraoperative parameters and fetal outcomes
There were 22 patients with different types of heart diseases who received cardiac operations under cardiopulmonary bypass during pregnancy. The composition and proportion distribution of these patients by the type of heart disease, weeks of gestation during operation, NYHA functional classification, cardiac surgical procedure, intraoperative parameters and fetal outcomes are presented in Table 1, Table 2 and Table 3.

Feto-neonatal and maternal outcomes
All 22 patients were alive after treatment. Three cases were complicated by arrhythmia after operations, especially atrial fibrillation, which needed medications. Four fetuses died in the utero after operations. Three patients chose termination of the pregnancy; one fetus was detected a brain abnormality and the other two patients abandoned pregnancy. Fourteen fetuses were alive and born without any abnormality. Two fetuses had complicated neonatal intracranial hemorrhage and died after birth. Feto-neonatal outcomes and mode of delivery are presented in Table 4.

Discussion
Heart disease is the primary cause of maternal and fetal death in 1–4% of pregnancies. Pregnancy creates an increased burden on the maternal cardiovascular system and can result in decompensation in women with underlying cardiac disease. To minimize the maternal and fetal risks, the first choice of treatment should be medical. However, in some cases, medical therapy is not always sufficient, and open heart operation might be necessary [4]. In 1958, Leyse and colleagues [5] first used cardiopulmonary bypass (CPB) in a heart operation during pregnancy. After the initial trials, pregnant women have been recognized to tolerate CPB as well as non-pregnant women, but the effects of CPB on the fetus have varied [6]. Several review articles, reported the maternal mortality rate ranged from 1.5 to 5%, and the fetal mortality rate has ranged from 16 to 33% [4, 6]. Currently, reported maternal mortality for cardiac operations is similar to the mortality rate for non-pregnant female patients [7]. Therefore, CPB during pregnancy has a greater effect on the fetus than mother. In our report,
the maternal mortality rate was 0%, and fetal mortality rate was 18.2%, as same as the above mentioned reviews.

The present study demonstrated that mitral and/or aortic valve disorders were the most common surgical indications for CPB during pregnancy, although it has been recognized that coronary arterial disease is increasingly prevalent in gynecological patients [8]. The latter, however, could be managed interventionally in most patients, avoiding the risk associated with CPB for feto-neonatal outcomes. In our report, the indications for surgical procedure under CPB during pregnancy consisted of congenital heart defect (ASD, DCRV, VSD), rheumatic heart disease (mitral or aortic valve disorders), infective endocarditis, aortic dissection, obstruction and thrombosis of the prosthetic valve. Seven patients (all with a congenital heart defect) accompanied moderate to severe PAH, which could result in sudden death and greatly increase the maternal and fetal risk. Consequently, we performed cardiac operations during pregnancy to maintain the pregnancy and to decrease the risk of adverse feto-neonatal outcomes. Other indications were life-threatening diseases, such as severe MS/AR, infective endocarditis, aortic dissection (Stanford type A), obstruction and thrombosis of the prosthetic valve. All patients were alive, and 3 cases had complicated arrhythmia after operations, especially atrial fibrillation. There were no other complications. The results indicate that cardiac operations can be performed during pregnancy with remarkable safety for mothers.

Pregnant women who have cardiac operations requiring CPB must face a nonphysiologic hemodynamic status where the tolerance is not clearly known, which can adversely affect the fetus [4]. CPB can compromise utero-placental perfusion and fetal development by potential adverse effects such as coagulation and blood component alterations, the release of vasoactive substances from leukocytes, complement activation, particulate and air embolism, nonpulsatile flow, hypothermia.

### Table 1: Patient's characteristics

| Patient No. | Age (y) | Gravidity | Parity | Singleton/Twin (S/T) | Weight during operation (kg) | Type of heart disease | NYHA functional classification | Weeks of gestation during operation (w) |
|-------------|---------|-----------|--------|---------------------|------------------------------|-----------------------|------------------------------|----------------------------------------|
| 1           | 32      | 1         | 0      | S                   | 43                           | ASD (PAH accompanied)  | II                           | 22±4                                   |
| 2           | 36      | 4         | 1      | S                   | 60                           | MR (PAH accompanied)    | II                           | 20±4                                   |
| 3           | 33      | 3         | 0      | T                   | 63                           | DCRV                   | II                           | 26±5                                   |
| 4           | 35      | 5         | 2      | S                   | 60                           | MS (PAH accompanied)    | III                          | 18±6                                   |
| 5           | 25      | 1         | 0      | S                   | 49                           | Prosthetic AV stuck     | III                          | 20±6                                   |
| 6           | 42      | 3         | 1      | S                   | 72                           | MS (PAH accompanied)    | IV                           | 27±3                                   |
| 7           | 30      | 2         | 1      | S                   | 66                           | MS + ASD (PAH accompanied) | II                         | 23±4                                   |
| 8           | 23      | 1         | 0      | S                   | 48                           | AR                      | II                           | 18±1                                   |
| 9           | 29      | 4         | 2      | S                   | 49                           | IE + MR                 | IV                           | 25±5                                   |
| 10          | 24      | 2         | 0      | S                   | 41                           | ASD (PAH accompanied)   | II                           | 20±4                                   |
| 11          | 26      | 1         | 0      | S                   | 49                           | Prosthetic AV stuck     | IV                           | 19±5                                   |
| 12          | 28      | 3         | 1      | S                   | 51                           | VSD (PAH accompanied)   | II                           | 24±2                                   |
| 13          | 25      | 4         | 1      | S                   | 55                           | ASD (PAH accompanied)   | II                           | 22±3                                   |
| 14          | 28      | 5         | 0      | S                   | 57                           | Prosthetic AS           | II                           | 30±5                                   |
| 15          | 37      | 2         | 1      | S                   | 74                           | VSD + AR                | II                           | 20±3                                   |
| 16          | 28      | 3         | 0      | S                   | 47                           | ASD (PAH accompanied)   | II                           | 25±3                                   |
| 17          | 36      | 3         | 1      | S                   | 50                           | AD (Stanford type A)    | III                          | 23±6                                   |
| 18          | 26      | 2         | 1      | S                   | 68                           | IE                      | III                          | 26                                     |
| 19          | 30      | 1         | 0      | S                   | 49                           | MS (PAH accompanied)    | III                          | 28                                     |
| 20          | 24      | 1         | 0      | S                   | 45                           | ASD + VSD (PAH accompanied) | III                         | 25±6                                   |
| 21          | 21      | 1         | 0      | S                   | 48                           | Ruptured sinus of Valsalva of the right coronary cusp + IE | IV                         | 21                                     |
| 22          | 25      | 1         | 0      | S                   | 48                           | Prosthetic AS           | III                          | 26±4                                   |

* Year, kg Kilogram, w Week, S Singleton, T Twin, ASD Atrial septal defect, VSD Ventricular septal defect, MR Mitral valve regurgitation, DCRV Double cavity of right ventricle, MS Mitral valve stenosis, AR Aortic valve regurgitation, IE Infective endocarditis, MR Mitral valve regurgitation, PAH Pulmonary artery hypertension, AD Aortic dissection, AS Aortic valve stenosis*
and hypotension [2]. Three main pathophysiological changes can occur in pregnant patients under CPB: uterine contraction, placental hypo-perfusion and fetal hypoxia. Utero-placental hypo-perfusion and fetal hypoxia subjected to sustained uterine contractions during CPB are considered risk factors for fetal death [9]. Despite the limited experimental data regarding the effect of CPB on uterine/placental blood flow and its effect on the fetus, it has been postulated that pulsatile, high-flow, high-pressure, normothermic bypass poses the least risk to the fetus [10, 11].

According to the above theories we

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**Table 2** Cardiac surgical procedure, intraoperative parameters and fetal outcomes

| Patient No. | Cardiac surgical procedure                          | Size of the cardiac valves/defects (mm) | Aortic cross-clamp time (minutes) | CPB time (minutes) | CPB maximum flow (L) | CPB minimum temperature (°C) | Fetal outcomes |
|-------------|-----------------------------------------------------|----------------------------------------|----------------------------------|--------------------|-----------------------|-------------------------------|---------------|
| 1           | atrial septal defect closure                         | 45                                     | 10                               | 40                 | 3.7                   | 35.8                          | term birth, alive |
| 2           | mitral and tricuspid valve repair                    | /                                      | 60                               | 96                 | 5.8                   | 35.3                          | term birth, alive |
| 3           | right ventricle outlet obstruction repair            | /                                      | 20                               | 47                 | 4.7                   | 35.4                          | preterm birth, alive |
| 4           | MVR                                                 | 27                                     | 47                               | 75                 | 4.5                   | 36                            | termination of pregnancy |
| 5           | MVR                                                 | 25                                     | 66                               | 102                | 5.5                   | 35.5                          | term birth, alive |
| 6           | MVR                                                 | 25                                     | 31                               | 52                 | 5                     | 36.5                          | preterm birth, alive |
| 7           | MVR+ atrial septal defect closure                    | 27/13                                  | 35                               | 62                 | 4.5                   | 35.7                          | preterm birth, alive |
| 8           | AVR                                                 | 24                                     | 75                               | 112                | 4.6                   | 34.4                          | term birth, alive |
| 9           | prosthetic mitral valve thrombectomy + mitral valve repair | /                                      | 101                              | 133                | 4.9                   | 34.8                          | abnormality of the brain, termination of pregnancy |
| 10          | atrial septal defect closure                         | 35                                     | 18                               | 35                 | 3.5                   | 34.9                          | term birth, alive |
| 11          | MVR                                                 | 23                                     | 120                              | 170                | 4.8                   | 30                            | term birth, alive |
| 12          | ventricular septal defect closure                   | 13.8                                   | 30                               | 72                 | 4.5                   | 35.1                          | term birth, alive |
| 13          | atrial septal defect closure                         | 21.7                                   | 21                               | 40                 | 4.2                   | 35.8                          | term birth, alive |
| 14          | AVR                                                 | 19                                     | 95                               | 122                | 5                     | 34.7                          | preterm birth, death |
| 15          | ventricular septal defect closure + AVR             | 16.3/23                                | 78                               | 97                 | 5.2                   | 36.6                          | term birth, alive |
| 16          | atrial septal defect closure                         | 30                                     | 13                               | 25                 | 4.5                   | 36.2                          | term birth, alive |
| 17          | Bi-leaflet procedure                                | /                                      | 172                              | 241                | 4.5                   | 30                            | death in utero |
| 18          | MVR                                                 | 29                                     | 32                               | 57                 | 4.4                   | 36.3                          | death in utero |
| 19          | MVR                                                 | 25                                     | 31                               | 52                 | 4.98                  | 36                            | preterm birth, death |
| 20          | atrial septal defect closure + ventricular septal defect closure | 12/25                                  | 35                               | 74                 | 4.3                   | 34.1                          | death in utero |
| 21          | ruptured sinus of Valsalva repair + valves thrombectomy | /                                      | 163                              | 211                | 4.1                   | 33.1                          | termination of pregnancy |
| 22          | prosthetic aortic valve thrombectomy                | /                                      | 65                               | 174                | 4.0                   | 17.7                          | death in utero |

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**Table 3** Summary of indications for cardiac operation

| Indication                                         | n (% ) |
|----------------------------------------------------|--------|
| Congenital heart defect                            | 8 (36.4%) |
| Rheumatic heart disease                            | 7 (31.8%) |
| Infective endocarditis                              | 2 (9.1%) |
| Aortic dissection                                   | 1 (4.5%) |
| Obstruction and thrombosis of prosthetic valve      | 4 (18.2%) |
applied high-flow, high-pressure, normothermic bypass to the patients and shortened the operation time to greatly decrease the influence on the fetus. Finally, the fetuses gained good outcomes, and the mortality rate was 18.2%, lower than that reported in recent literature. Fourteen fetuses were alive and born without any abnormality. Unfortunately, two fetuses suffered neonatal intracranial hemorrhage and died after birth. However, we do not think it was associated with the operation or the CPB during pregnancy. The inappropriate use of Warfarin after operations was the main cause. The results indicate that cardiac operations can be performed during pregnancy with a degree of safety for fetus.

**Conclusion**

In conclusion, the decision to subject a pregnant woman to operation must be made by a team composed of an obstetrician, a cardiologist, an anesthesiologist and a neonatologist. Cardiac operation under CPB during pregnancy is a challenge for physicians in multidisciplinary teams. Strictly evaluating the indication is vital. On the other hand, some patients can benefit from this form of case management.

**Abbreviations**

y: Year; kg: Kilogram; w: Week; S: Singleton; T: Twin; mm: Millimetre; L: Litre; ASD: Atrial septal defect; VSD: Ventricular septal defect; MR: Mitral valve regurgitation; DCRV: Double cavity of right ventricle; MS: Mitral valve stenosis; AR: Aortic valve regurgitation; IE: Infective endocarditis; MR: Mitral valve regurgitation; PAH: Pulmonary artery hypertension; AD: Aortic dissection; AS: Aortic valve stenosis; AVR: Aortic valve replacement; MVR: Mitral valve replacement; SD: Standard deviation; CPB: Cardiopulmonary bypass

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**Authors’ contributions**

Yanli Liu: design the study, collect and analyze the data and write the paper. Fengzhen Han: design the study and explain the data. Jian Zhuang: financial and professional support. Xiaojing Liu: professional support. Jimei Chen: financial and professional support. Huanlei Huang: professional support. Xiaoqing Liu: professional support. Jimei Chen: design the study, collect and analyze the data and write the paper. Yanli Liu: intrauterine death after operation.

**Competing interests**

The authors have no conflicts of interest.

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