

# Pregnancy in congenital heart disease: Focus on patients with a systemic right ventricle

## Grossesse et cardiopathies congénitales: Le ventricule droit systémique comme exemple

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### Résumé

La grossesse entraîne d'importantes modifications cardio circulatoires qui peuvent être mal tolérées en cas de cardiopathie congénitale préexistante. Le risque des complications dépend du type de malformation cardiaque et du statut clinique de la patiente. D'où la nécessité d'une stratification du risque individualisée pendant chaque étape de la prise en charge. Dans cette revue, les auteurs rappellent les modifications hémodynamiques liées à la grossesse, proposent une stratification du risque cardiaque selon les scores de risque, discutent la surveillance et la prise en charge globale de ces patientes. Un exemple de cardiopathie congénitale a été abordé : Le ventricule droit systémique comme situation à haut risque observée essentiellement dans la double discordance et la transposition complète des gros vaisseaux traitée par switch atrial.

### Mots-clés

Grossesse, cardiopathies congénitales, stratification du risque, complications, ventricule droit systémique

### Summary

Advances in the care of patients with congenital heart disease (CHD) have enabled the majority to survive well into adulthood. Consequently, many women are contemplating pregnancy. Management of pregnancy in CHD remains an ongoing challenge because of maternal and fetal risks. The latter depends on the type of the underlying defect. Thus, a risk stratification must be carefully obtained and based on validated score risks but mainly should be individualized for each case. In this review, the authors describe also commonly encountered obstetrical and neonatal complications and discusses potential cardiovascular maternal concerns with a particular focus on systemic right ventricle as a highly risk situation.

### Keywords

Pregnancy, congenital heart disease, complications, counselling, systemic right ventricle.

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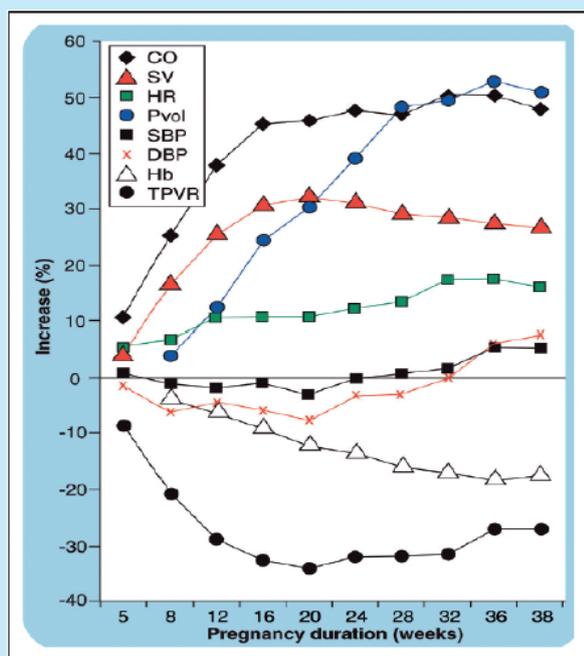
## INTRODUCTION

Advances in pediatric cardiology and cardiac surgery have improved the survival of patients with congenital heart disease (CHD) and currently adults with CHD are estimated at >1 million which is atleast equal to the pediatric population[1].

Thus, most women born with CHD are surviving and embarking on pregnancy. Pregnancy, however, is associated with hemodynamic stresses which can result in cardiac decompensation in these patients. Nevertheless, our knowledge and experience with this subject is still limited making it necessary the development of an effective strategy for the management of this population. In this paper, the authors will discuss risk stratification and management of pregnant patients with CHD with particular focus on systemic right ventricle.

### Pregnancy and congenital heart diseases:

During pregnancy and in order to accommodate the developing foetus there is a 40-50% increase in blood volume and heart rate increases by about 15-20 beats/min. [2]. There is also a decrease in pulmonary and systemic vascular resistance. All these changes result in a 30- 50% increase in cardiac output, with a maximum rise between 5<sup>th</sup> and 8<sup>th</sup> months [3]. (Figure 1).



**Figure 1 :** Hemodynamic changes during pregnancy(from Karamermer et al[3])

CO : cardiac output ;SV :stroke volume ;HR: heart rate; Pvol:plasma volume ;SBP : systolic blood pressure; DBP:diastolic blood pressure;Hb: haemoglobin ; TPVR:total peripheral vascular resistance

The heart can increase its size by up to 30%, which is partially due to dilatation. Systolic function increases first but may decrease in the last trimester. Pregnancy also induces a series of haemostatic changes leading to hypercoagulability and an increased risk of thrombo-embolic events [4-5]. Moreover, uterine contractions, bleeding, pain, anxiety and uterine involution cause significant haemodynamic changes during labour and post-partum. Anaesthesia and analgesia may induce additional cardiovascular stress. All these physiological adaptations to pregnancy can result in cardiac complications in women with pre-existing cardiac disease. And in the database analysis of Optowsky [6], the presence of maternal CHD was associated with a significant increase in heart failure 8%, arrhythmias with 1.6% ventricular arrhythmia and 0.7% supraventricular arrhythmia, embolic events, cerebrovascular events and death (0.15 to 0.5%). CHD was the most common type of heart disease complicating pregnancy in in the European Registry on Pregnancy and Cardiac Disease [ROPAC] registry :66% of cases) [7].

Unfortunately, more than one-half of women with CHD had never been informed that they were at increased risk for maternal cardiac complications during pregnancy[8].

This risk varies indeed with the underlying disease and the clinical condition. Thus a risk assessment should be performed prior to pregnancy and should have for purpose to answer 3 questions: \*Will the patient have cardiac problems during her pregnancy? Will her baby have complications due to her heart disease? and finally will her heart have permanent damage due to the pregnancy?

Several risk scores have been developed of which the CARPREG [8] risk score is most widely used (Table 1). The ZAHARA [9] study proposed some predictors specifically for CHD but not all validated by other studies.

**Table 1 :** Components of the CARPREG score [9]

Criteria	Definition
Prior cardiac event	History of any prior qualifying cardiac event: *congestive heart failure *stroke *transient ischemic attack *arrhythmia
Baseline NYHA functional class	NYHA class >II
Evidence of left heart obstruction	Mitral valve area <2 cm <sup>2</sup>
Abnormal ejection fraction	Aortic valve area <1.5 cm <sup>2</sup> Outflow tract gradient >30 mm Hg Ejection fraction <40%

The Task Force recommends that risk assessment is carried out using the modified World Health Organization (WHO) risk classification which integrates all known maternal cardiovascular risk factors combining the underlying heart disease and any other co-morbidity. Moreover and in order to guide cardiologists, obstetricians who will be managing these women and based on expert consensus opinion, the European Society of Cardiology [10] and the American College of Cardiology and American Heart Association [11] have created guidelines addressing the optimal management of reproductive issues in women with CHD.

### Systemic right ventricle (SRV):

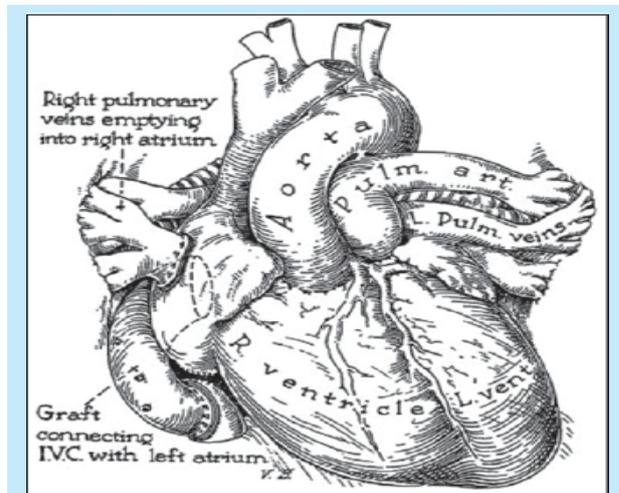
*\*What is SRV ?*

SRV is an anatomical feature characterized by the presence of a functional and morphological systemic right ventricle, as opposed to a systemic left ventricle [12]. The right ventricle in sub-aortic position called "systemic" is found mainly in two types of heart defect: transposition of the great arteries (TGA) treated by atrial switch (Mustard/senning) and congenitally corrected transposition of the great arteries (ccTGA) [13]. SRV is also found in 2 other extremely rare situations: double inlet right ventricle mostly with previous Fontan palliation and hypoplastic left heart syndrome palliated with the Norwood-Fontan protocol [14]. In these 2 late cases, the outcome depends mainly on the Fontan circulation and Norwood operation respectively more than the SRV itself. Thus, our concern in this review will be about SRV in TGA and ccTGA.

TGA has an incidence of about 1 per 5,000 live births accounting for 5-7% of all congenital heart malformations and is characterized by ventriculoarterial discordance [15]; the morphological right atrium is connected to the morphological right ventricle which gives rise entirely to or most of the aorta; the morphological left atrium is connected to the morphological left ventricle from where the pulmonary trunk emerges [16]. Historically, it was treated surgically with the atrial switch procedure. In this procedure; the atrial chambers are opened and channels are created within the chambers to re-direct venous blood [16] (Figure 2). Thus, the blood returning from the body (oxygen-poor) through the superior and inferior vena cava is channeled over to the mitral valve and left ventricle and then in the pulmonary artery. Blood returning from the lungs (oxygen-rich) through the pulmonary veins is channeled over to the tricuspid valve and right ventricle to get pumped to the aorta [17]. This surgery restored a normal pattern of blood flow, but it left the right ventricle as the pumping chamber for the body. The most common repair for TGA until the 1990s was an "atrial switch" procedure (then superseded by the arterial switch) [18-19].

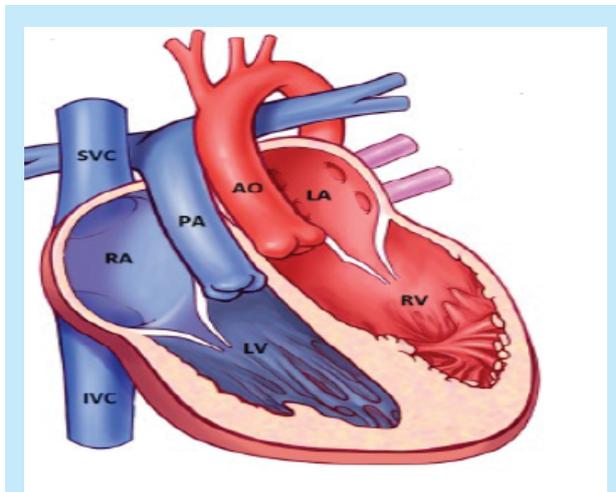
CCTGA is more rare with an incidence of  $\approx 1$  in 33000 live

births (0.5% of all patients with congenital heart defects) and implies both ventriculoarterial discordance and atrioventricular discordance ("double discordance") [20]. It is characterized by an anterior and leftward aorta arising from the right ventricle, with pulmonary artery posterior and rightward from the left ventricle (ventricular inversion, meaning right atrium emptying into the LV through a mitral valve, and left atrium emptying into the RV through a tricuspid valve [20] (Figure 3)



**Figure 2 :** Representation of atrial switch in complete transposition of great arteries: Baffles operation: Right pulmonary veins directed to right atrium. Inferior vena cava baffled to left atrium using a graft. (by Baffes TG [16])

L. Pulm. Veins = Left pulmonary veins, L. vent. = Left ventricle, Pulm. art. = Pulmonary artery, R. ventricle = Right ventricle



**Figure 3 :** Schematic representation of congenitally corrected transposition of the great arteries (ccTGA) in levocardia (by Shelby Kutty et al [20])

Additional cardiac lesions are present in 95% of cases with ccTGA and include ventricular septal defect (70%), Ebstein-like anomaly of the tricuspid valve (90%), pulmonary stenosis (40%), and complete heart block (2% risk per year)[22].

Patients with ccTGA typically remain asymptomatic until the 3rd or 4th decade of life but this depends on associated lesions. In the absence of the above, patients with ccTGA may survive until the 7th or 8th decade of life.

In both situation, the right ventricle is exposed to systemic afterload. It adapts initially by myocardial hypertrophy. But in over half of cases, it progresses to a dilation and irreversible heart failure. The reasons for the dysfunction of the SRV are multifactorial and some are still controversial. They include a distinct fibromuscular architecture comparatively to the left ventricle (predominantly longitudinal fibers that are not enough to support the systemic pressure); coronary artery supply mismatch mainly because of high wall stress, intrinsic abnormalities of the tricuspid valve, collagen degradation and fibrosis[23], intrinsic or acquired conduction abnormalities. For all these reasons, a morphological right ventricle will never be a true left ventricle [24].

**\*Systemic right ventricle and pregnancy:**

Today, there have been about 250 pregnancies in TGA reported in 10 studies and about 125 in ccTGA as described in 3 studies. However, these data come mainly from small retrospective series. [9-25-26]

According to the guidelines, patients with SRV belong to a modified WHO maternal risk class III, which means significantly increased maternal risk and severe morbidity.

**Maternal outcome :** Jain VD [9] et al in their study comparing events in pregnant women with SRV to those with systemic left ventricle demonstrated that Women with a SRV were more likely to develop congestive heart failure and arrhythmia, during pregnancy or postpartum. In the largest study of pregnancies among patients with D-TGA after atrial switch (69 women), described by Drenthen et al [26], arrhythmia occurred in 29% of patients and 2% was the incidence of congestive heart failure. CcTGA patients are mainly at risk of atrioventricular block.

Maternal risk depends on systemic ventricular function, the presence of significant hemodynamic lesions and functional capacity before pregnancy. Also, a mortality rate of up to 4% has been reported.

**Obstetric and offspring outcome:**

Pregnancies complicated by a systemic right ventricle were more likely to deliver before 37 weeks gestation (58.3% vs. 20.3%,  $p=.007$ ) [9]. Miscarriage occurred more frequently than in healthy population in both diseases

.18-25% TGA and 5-27% CCTGA. Studies have reported small prevalence of CHD in the neonates.

**The approach to pregnancy in systemic right ventricle:**

Patients with moderate to severe ventricular dysfunction (NYHA class III or IV) should be advised against becoming pregnant [25-11].

Preconception evaluation should be directed toward ventricular and valvular function and the presence of arrhythmias [10]. Evaluation should be based on clinical examination, echocardiogram or MRI, holter monitoring, and should include cardiopulmonary exercise testing. Invasive hemodynamic assessment depends on associated lesions [10].

During pregnancy, It is recommended that patients with a Mustard or Senning repair have monthly or bimonthly cardiac and echocardiographic surveillance of symptoms, systemic RV function [10], and heart rhythm. CcTGV patients may be seen at the first, second and third trimester.

Vaginal delivery is the preferred mode of delivery: it causes smaller shifts in blood volume and fewer complications [27].

Careful monitoring should occur for at least 24 hours following delivery because of continued fluid shifts and may include telemetry for patients considered at high risk for arrhythmia. Cardiac complications do not end at delivery; They continue into the postpartum period [28]. Patients need to be seen about 4-6 weeks after delivery with clinical examination and imaging [10-11].

## CONCLUSION

Pregnancy is a unique physiological state that can be challenging for women with CHD. Patients with systemic right ventricle are at particularly high risk of complications. However, a good outcome in mothers and neonates is often possible. Thus, risk stratification should be done and patients should be well informed before pregnancy. By the way, there is no "one-size-fits-all" way and individualized assessment in each patient must be performed with a multidisciplinary team of maternal-fetal Medicine specialists and cardiologists.

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