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Transluminal balloon valvotomy in the surgical treatment of mitral stenosis in pregnant women: a review

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ABSTRACT

Aim. The aim of this study was to investigate current strategies in treatment of pregnant women suffering with mitral stenosis. Mitral stenosis is an obstruction of the pathway of the left ventricle flow at the mitral valve (MV) level as a result of the structural deformation of the MV apparatus, which prevents the necessary opening of the MV during the diastolic filling of the left ventricle. The most frequent lesion of valves in women with rheumatic heart disease (RHD) is MV. It remains the most common acquired valvular lesion in pregnant women and is one of the main causes of maternal death from cardiovascular diseases. According to the literature mitral stenosis (MS) is found in 75–90% of pregnant women with acquired heart defects. In addition, the incidence of fetal morbidity is positively correlated with the severity of MS: it increases from 14% in pregnant women with mild MS to 28% in people with moderate MS and 33% in women with severe mitral stenosis. The course of MS in pregnant women depends on the clinical manifestations, the degree of severity of heart failure, and the degree of rheumatic fever activity.

Conclusion. The advantages of minimally invasive techniques during pregnancy are theoretically undeniable. The choice of the optimal method of delivery, the assessment of the fetal state of the fetus and the methods for its correction are also fundamental.

Review Article

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INTRODUCTION

Mitral stenosis is an obstruction of the pathway of the left ventricle (LV) flow at the mitral valve (MV) level as a result of the structural deformation of the mitral valve (MV) apparatus, which prevents the necessary opening of the MV during the diastolic filling of the left ventricle [1]. The most common cause of mitral stenosis (MS) is rheumatic carditis. Isolated MS is determined in 40% of patients with rheumatic heart disease, and a rheumatic history is present in approximately 60% of patients with pure MS [2-5]. The frequency of isolated MS in women and men is 2: 1 [4, 6].

India has the highest incidence of rheumatic heart disease in the South-East Asia Region, which accounts for about 40% of all cases of the disease in the world [7]. In the Republic of Uzbekistan, the prevalence of rheumatism among women aged 15-35 years living in Tashkent was 29.4%. The highest prevalence rates of rheumatic fever (RF) were found among women aged 15-19 years (39.8%). Primary morbidity was 0.6%, patients with newly diagnosed RF, including those with an already formed heart disease, 1.8% [8]. Cardiovascular diseases worsen the course of pregnancy from 1% to 3% in all pregnant women and is the cause of maternal mortality in 10-15% [9, 10]. Preterm birth in general in women with heart defects is observed in 16% of cases, and perinatal mortality in industrialized countries is 1% [11]. In low-income countries, rheumatic heart disease (RHD) accounts for approximately 90% of all cardiovascular diseases in pregnant women [9]. RHD is a disease of young people, and its effects are observed in women of reproductive age [12, 13]. For some women, the initial diagnosis is made in the antenatal or postpartum period, since women with RHD do not tolerate the effect of physiological changes of pregnancy on damaged heart valves, which leads to clinical decompensation [14, 15].

The most frequent lesion of valves in women with RHD is MV [16]. It remains the most common acquired valvular lesion in pregnant women and is one of the main causes of maternal death from cardiovascular diseases [17, 18]. Mitral stenosis is found in 75–90% of pregnant women with acquired heart defects. In addition,

the incidence of fetal morbidity is positively correlated with the severity of MS: it increases from 14% in pregnant women with mild MS to 28% in people with moderate MS and 33% in women with severe MS [19, 20].

Symptomatic mitral stenosis (MS) is associated with a higher risk of antenatal hospitalization and approximately 50% mortality, which is most common in the postpartum period [14]. During pregnancy, physiological hypervolemia creates an additional load on the heart [20, 21]. The amount of blood that must pass through the constricted mitral orifice increases. In relation to the increased volume of blood flow, the degree of narrowing of the mitral orifice is even more pronounced than before pregnancy [14, 21]. This explains the fact that the slightly pronounced so-called "silent stenosis" begin to appear only with the onset of pregnancy. According to many authors, the average degree of mitral stenosis during pregnancy can cause the same changes in hemodynamics as a high degree of stenosis in non-pregnant women [22]. The decompensation of cardiac activity that develops at the same time threatens not only the life of the mother, but also the fetus [21].

The course of MS in pregnant women depends on the clinical manifestations, the degree of severity of heart failure, and the degree of rheumatic fever activity. Factors determining the severity of MS in pregnant women [11] are: 1) AB area - openings less than 1.5 cm2; 2) pulmonary hypertension (pulmonary artery systolic pressure more than 40 mm Hg); 2) clinical signs of CH III FC (shortness of breath and tachycardia with little exertion, acrocyanosis, etc.); and 3) Atrial fibrillation - the threat of thromboembolic complications.

According to Iris et al. [23]'s work, maternal mortality occurred in 1.9% of pregnant women, ≈ 50% with severe rheumatic mitral stenosis, and 23% with significant mitral regurgitation which was complicated by heart failure during pregnancy. Consultation before pregnancy and consideration of mitral valve surgery in individual patients is important to prevent these complications.

In the absence of surgical treatment of MS before pregnancy, careful observation is recommended from the 3rd month of pregnancy and then on a monthly basis, including clinical and regular EchoCG [11, 24].

Cardiac complications during pregnancy:

• Acute left ventricular failure in the form of cardiac asthma and pulmonary edema (may occur against the background of good health);

• tachysystolic form of atrial fibrillation;

• with the development of atrial fibrillation - thromboembolic complications in a large circle of blood circulation [11].

Pregnancy with rheumatic MS is complicated in most cases with preeclampsia, hypochromic anemia, threatened abortion and fetoplacental insufficiency [15]. Pregnancy can aggravate the severity of the underlying disease, contributing to the development of: thromboembolism (occurs more often with atrial fibrillation), right ventricular HF, the occurrence of pulmonary hypertension, the development of pulmonary edema (most often occurs at 26–34 weeks of pregnancy and during labor), rhythm and conduction disturbances (40–50 % of patients are associated with the formation of a blood clot in the left atrium), a sharp increase in pressure in the left atrium (it can lead to rupture of the bronchial vein and sudden pulmonary hemorrhage). Exacerbation of rheumatic fever is also possible. Critical periods of exacerbation of rheumatic fever correspond to the first 14 weeks, 20–32 weeks of gestation and the postpartum period [25, 26, 27].

Diagnosis of a disease of the cardiovascular system during pregnancy presents certain difficulties associated with limiting diagnostic capabilities [27-29]. The most important diagnostic signs relate to the characteristics of the heart rate, the degree of increase and hypertrophy of the left atrium and both ventricles, the assessment of the severity of I and II heart sounds and the determination of the opening of the mitral valve, the prevalence of noise during systole and diastole, the magnitude and nature of amplification of this noise [30-32]. In addition to electrophysiological, functional and ultrasound methods of research, to clarify the diagnosis and/or establish the extent of damage to the cardiovascular system in pregnant women, one has to resort to a number of examinations and treatments related to the use of X-ray irradiation [11, 33]. Among practicing cardiologists and obstetrician-gynecologists there is a perception of contraindications to the use of these diagnostic methods and treatment because of their negative effects on the fetus. The effects of irradiation depend on the irradiation dose and gestational age of the fetus at the time of irradiation. If possible, these techniques should be used after the period of the main completion of organogenesis (more12 weeks' gestation). There is no evidence of an increase in the risk of fetal malformations, fetal growth retardation syndrome (GRS) or pregnancy loss with radiation doses of less than 50 mGy. The risk of fetal malformations increases with exposure to more than 100 mGy.

Table 1. Evaluation of the effects on the fetus and pregnant radiation doses during various medical procedures

Technique	Radiation			
	Fetus		Mother	
Chest radiograph (straight and lateral)	<0,01 mGr	<0,01 mZv	0,1 mGr	0,1 mZv
Computed tomography (CT) of the chest	0,3 mGr	0, mZv	7 mGr	7 mZv
Coronary angiography	1,5 mGr	1,5mZv	7 mGr	7 mZv
Transluminal balloon angioplasty (TBA) or radiofrequency ablation	3 mGr	3 mGr	15 mGr	15 mZv

During angiography in the absence of abdominal shielding, the radiation dose is 1.5 mGy, but due to the absorbing effect of the surrounding tissues, less than 20% of this dose falls on the fetus. The use of abdominal shielding in examinations and a reduction in exposure time minimize exposure dose [11]. The effect of drug therapy is higher, the greater the proportion of myocardial component in the development of chronic heart insufficiency. In severe valve dysfunction, timely treatment is the only effective treatment [34].

The possibility of therapy aimed at eliminating or weakening the etiological factor should be potentially considered in every patient with mitral disease: even with unconditional indications for surgery, etiotropic treatment will improve the patient's condition by the time of surgery, reduce its risk and achieve greater effect from the operation, than in case of unjustified refusal of such treatment. Some conditions (for example, active myocarditis of rheumatic and other etiologies) may require the transfer of the operation to a later date, prior to the suppression of the activity of the process [35-37]. When determining the indications for surgery for mitral stenosis, one should always be guided by an individual assessment of the patient's condition. The scheme of state diagnosis can only serve as a guide.

Today, surgical correction of mitral stenosis is the only way to effectively treat this disease [38]. However, traditional surgery is traumatic and can be accompanied by serious complications. The development of endovascular surgery has led to the emergence of a number of minimally invasive operations for valvular pathology. One of them is a catheter balloon mitral valvuloplasty (KBMV) [1].

The first operation to eliminate mitral stenosis was surgically performed by Souttar in 1925. The first mitral commissurotomy was performed in the early 1920s by Souttar and Cutler [39]. The introduction of instrumental mitral commissurotomy in clinical practice is associated with the names of Beiley, who in 1948 performed a series of similar interventions with good clinical results [31]. In Russia, the first such operation was performed by Bakulev in 1952 [39]. The first operation under conditions of cardiopulmonary bypass (cardiopulmonary bypass) in a pregnant woman was performed in 1959 [31].

The first in clinical practice successful prosthetics of the mitral valve with a ball prosthesis in 1960 was carried out by Starr-Edwa. Close attention to the possibility of plastic surgery on the mitral valve and their widespread introduction into the practice of most cardiac surgery centers surgeons are obliged to A. Carpentier, whose fundamental work in this direction dates back to the 1970s [31]. Closed mitral commissurotomy is performed extremely rarely and most often for health reasons in pregnant women. Contraindications for closed mitral commissurotomy are left atrioventricular opening area greater than 1.5 cm2, thrombosis of the left atrium, significant mitral regurgitation, bikomissuralnaya or heavy calcification, no commissural adhesions, concomitant severe aortic lesion and / or tricuspid valve concomitant atherosclerosis of the coronary arteries requiring surgical correction [32].

Maternal outcomes with balloon mitral valvuloplasty and open mitral commissurotomy (OMC) are the same, but fetal mortality is high at a ratio of 1: 8. Replacement MV should be carried out in severe cases; with severe cuspid calcifications and mural thrombosis, in which maternal mortality was 1–1.5% and fetal mortality 16–33% [40, 41]. Given all the above, the following indications can be formulated for the operation of mitral commissurotomy during pregnancy, taking into account the data of the clinic and instrumental methods of research [1]:

1. The lack of clinical improvement from drug treatment of heart failure for 10-12 days (increased dyspnea, congestion in the lungs, rhythm disturbance of atrial fibrillation).

2. Reduction of the heart rate and cardiovascular potential by more than 25% compared with the values of healthy pregnant women

3. Reduction in the area of the mitral valve less than 1.5 cm2, reduction or complete disappearance of "" a "" - waves in the movement of the mitral valve, the appearance of a systolic closing of the pulmonary valve cusps (according to echocardiography).

4. High pulmonary hypertension according to echocardiography and reopulmonography.

5. The presence of metabolic acidosis, respiratory alkalosis, reducing the partial tension of oxygen in the blood by 5-6% or more.

6. Violation of the efficiency of pulmonary ventilation, inconsistency of ventilation to blood flow, a sharp violation of the minute respiratory volume and oxygen utilization rate, Increase in MOU by 180-200% and more, and KIO2 by 125% or less. Low tolerance threshold to physical activity (300 kgm / min or less).

The best period for heart surgery is the period from 16 to 22 weeks of gestation, because a significant improvement in regional hemodynamics requires at least 60-70 days, and respiratory function is 80-90. In addition, during the operation during these periods of pregnancy, favorable conditions are created for the development of the fetus. Surgical elimination of stenosis at a later date, despite some improvement in central and organ hemodynamics, the function of external respiration, does not fully restore compensation for blood circulation, does not eliminate fetal hypoxia. Therefore, surgical treatment of stenosis in pregnancy 30 weeks or more should be considered as a necessary measure aimed at saving the patient's life [42].

There are contraindications that need to be remembered when deciding whether to conduct a mitral commissurotomy in pregnant women:

1. The gestation period is less than 15 weeks (high probability of spontaneous abortion).

2. The gestation period is over 30 weeks (lack of time to adapt the cardiovascular system of a pregnant woman to childbirth, high risk of thromboembolic complications).

3. The patient is more than 30 years old, calcification and fibrous changes of heart valves, restenosis.

4. The activity of the rheumatic process.

After undergoing heart surgery during pregnancy, the general principles of pregnancy management in women with heart defects are applied to patients. In addition, if the operation is performed later than 30 weeks of pregnancy, careful monitoring of the hemostatic system is necessary, since during this period of pregnancy, mitral commissurotomy does not eliminate the possibility of severe thromboembolic complications [10, 43, 44].

The choice of mode of delivery is strictly individual, is directly dependent on the results of surgical correction of the defect, the gestational age at which the operation was performed and should be considered in combination with the presence or absence of obstetric pathology. The most appropriate is the method of delivery through the natural birth canal [45]. This is largely due to the peculiarity of the implementation of the MSC, when there is no direct visual control of surgical procedures. Following balloon coronary angioplasty, a method of endovascular treatment of valvular stenosis appeared - balloon valvuloplasty. At first it was used for congenital aortic stenosis and stenosis of the pulmonary valve, but now the indications have expanded significantly: balloon valvuloplasty is also used for acquired heart defects (mitral stenosis and aortic stenosis), not only rheumatic, but also caused by calcification of valves [46-49]. The use of the term "valvuloplasty" in the variant of percutaneous balloon performance is criticized, since this term is more specifically used in foreign surgical literature to describe surgical reconstructive interventions mainly in patients with mitral regurgitation [22, 50, 51]. Indeed, the method of balloon dilatation of the mitral valve more closely matches the term "balloon mitral commissurotomy" or "valvulotomy". The term "balloon valvulotomy" has already become applicable in most clinics, so we use it in this article.

Three potentially possible mechanisms underlie the therapeutic effect of balloon dilatation of the mitral valve: 1) separation of soldered commissures, 2) stretching of commissures, 3) rupture of calcifications. Since the basis of mitral stenosis in young patients is the soldering of the commissures, the gap in the stenotic zones is the main and extremely effective mechanism [44, 52]. The first results of introducing new technology into clinical practice revealed the advantages of the method, which include conducting an operation without thoracotomy, artificial lung ventilation, cardiopulmonary circulation, a short period of hospitalization and rehabilitation, low cost.

The KBMV was proposed by the professor from Japan, Inoue K. in 1984. The original development of K. Inoue was proposed to perform atrial septostomy using a special balloon in the shape of a pillow. Subsequently, this technique was adapted for dilatation of mitral, aortic and pulmonary valves. The first publication reported on 6 patients, 5 of whom had dilatation of the mitral valve, was successful, with a decrease in the average pressure drop by 53% [53]. In 1985, Lock et al. [54] from the Children's Hospital in Boston performed mitral dilatation with a balloon designed for the pulmonary valve. The authors succeeded in increasing the area of the mitral orifice from 0.7 ± 0.3 to 1.3 ± 0.3 cm2 while simultaneously reducing the pressure drop by 54% [54]. Later, Al Zaibag et al. [55] developed a double balloon dilatation technique for the mitral valve. The results were very effective: the area of the mitral increased by more than 100%. In the modern version of the proposal, Palacios et al. [56] perform a BMW with two cylinders introduced through a single septostomy opening in the interatrial

septum, which makes it possible to increase the area of the valve opening by 0.5 cm2 more than when using single-balloon technology. This is due either to a larger dilatation area with two cylinders, or to an elliptical shape that cylinders take, more accurately repeating the natural opening of the mitral valve. The creation of a special balloon surface also led to more efficient dilatation [55]. Large series of studies and long-term results of BMW began to be published only in the last 30 years as a whole, they confirm the first impression that BMW in some patients is practically an alternative to a closed mitral and open mitral commissurotomy [25, 47, 48, 57]. The prognostic evaluation system proposed by Wilkins G.T. and Weyman A. et al. is now widely used for this purpose [58, 59]. Each of the 4 parameters has 4 degrees of severity of the pathological process: the mobility of the valves, subvalvular adhesions, the thickness of the valves and the degree of calcification. In general, with an echo <8, a good BMW result can be assumed, and with> 12 it is unsatisfactory. In the author's version, this evaluation system was confirmed quite convincingly [59, 60], although other researchers do not note such a good correlation [61].

The average time for restenosis after a closed mitral commissurotomy is, according to some authors, about 5 years, after an open commissurotomy - 8 years [40, 62, 63]. If restenoses develop similarly after BMW and surgical intervention, then early restenoses should be characteristic of patients with initially poor indicators [52]. In fact, the term "restenosis" as applied to such patients is erroneous, more often it is simply the absence of the effect of primary dilatation. It is clear that the restenosis process after BMW does not have any specific physiological or anatomical features that distinguish it from coronary restenosis after angioplasty or aortic valvuloplasty [49]. The mechanism of restenosis, of course, includes a return to the outcome of the stretched valve components, fibrosis and calcification of the commissure and cusps zones. BMW can be performed in patients with restenosis after surgical interventions [51].

Immediate and early postoperative results were studied in patients who underwent BMW and closed or open commissurotomy [62, 64]. According to hemodynamic parameters, the numbers of complications by functional class after treatment in 48 of 49 patients, the results were almost identical [65]. These data were obtained in 2 randomized groups of patients in India. The echo forecast was within 7 and the results were quite predictable. Zerzina et al. [66] reported better BMW results compared to closed commissurotomy. However, the authors considered only the short term after the operation, used a thermodilution technique for assessing cardiac output (reassessing results for patients after BMW due to possible shunting of blood from left to right through a septostomy hole) and performed stress tests, which worsened the results in patients with recent thoracotomy.

CONCLUSION

The advantages of minimally invasive techniques during pregnancy are theoretically undeniable. However, the MSCM has not yet received widespread distribution, since opinions on the indications for the MCCM and its effectiveness, the frequency of complications are quite contradictory [49]. The occurrence of complications in KBMV is recorded in 4.7-7.8% of patients [21]. Comparison of the catheter BMV and the closed mitral commissuretomy showed the same effectiveness of these methods [20]. Therefore, due to its high efficiency and greater safety, this X-ray surgery has been widely used in the past decade. Several major centers from Europe, Asia and Latin America published the results of successful use of catheter balloon mitral valvuloplasty in pregnant women with severe mitral stenosis [23, 38, 43, 67]. For a total of seventy-one x-ray surgical operation on the mitral valve in pregnant women described in the literature by 2002, only five fetal deaths associated with this intervention were noted [57]. And although all the authors unanimously agree that the X-ray surgical operation is highly efficient and less traumatic for materi, the remote effect of radiation on the fetus still requires its study [19, 24, 68]. Potentially, X-ray exposure during fluoroscopy may be dangerous for the unborn child. The fetus receives most of the X-ray radiation in scattered rays. During the catheter balloon mitral valvuloplasty, the total radiation dose can be estimated on average as 0.2 Rad. This is regarded as a rather insignificant, non-damaging dose. However, in the event of the need for multiple X-ray studies or the use of therapeutic sessions of radiation therapy, when the total X-ray exposure is reached in 10 rad and more, abortion is shown. Therefore, in all publications on X-ray surgical correction of mitral stenosis in pregnant women, the authors point out the need for this procedure after 20 weeks of gestation, when the development of the fetal organs and systems has been completed, the placenta is fully formed. In this case, everyone points to the need to minimize the time of fluoroscopy and the use of protective screens in the patient's small pelvis area. The authors of the above studies are unanimous in the opinion that for the fetus the risk of catheter balloon mitral

valvuloplasty is much lower than the risk of surgical methods for correcting the defect and therapeutic management of a pregnant woman suffering from mitral stenosis [68].

Some researchers, for example, Gulraze et al. [69] provide long-term follow-up data not exceeding seventeen years for children born to patients who have undergone catheter balloon mitral valvulolotomy during pregnancy. All children had normal physical development and the absence of clinically significant anomalies. Conducting MSCM in these patients is one of the most time-consuming X-ray surgical interventions on the heart for a variety of reasons. Especially the hemodynamics characteristic of pregnancy aggravate cardiac abnormalities caused by impaired blood flow through the stenotic mitral orifice. The risk of developing acute heart failure and pulmonary edema during the preparation and conduct of the operation leaves its mark on the catheter balloon valvuloplasty technique in pregnant women [46, 51, 70-72]. Despite the existence of scientific work by domestic scientists in this field, the KBMV in pregnant women in the modern scheme of surgical treatment of mitral stenosis in cardiac surgery hospitals has not found wide application.

Also, despite certain successes achieved in recent years in the tactics of conducting pregnancy and childbirth in patients with heart defects, this problem still remains relevant. These include: the possibility, indications, timing of mitral commissurotomy during pregnancy, the size of the MO after a BMW, optimal methods for controlling central and intracardiac hemodynamics, fetal survival in such a cohort of pregnant women. The choice of the optimal method of delivery, the assessment of the fetal state of the fetus and the methods for its correction are also fundamental.

DECLARATIONS

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Authors' contributions

Both authors contributed equally to this review.

Competing interests

The authors declare that they have no competing interests.

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