Journal of the American College of Cardiology
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Published by Elsevier Science Inc.

Vol. 38, No. 6, 2001
ISSN 0735-1097/01/$20.00
PII S0735-1097(01)01617-5

Congenital Heart Disease

Coarctation of the Aorta: Outcome of Pregnancy

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OBJECTIVES The study sought to determine the outcome of pregnancy in women with coarctation of the thoracic aorta.

BACKGROUND Patients with coarctation of the thoracic aorta are expected to reach childbearing age, but data on the outcome of pregnancy in this population are limited.

METHODS The Mayo Clinic database was reviewed for women of childbearing age (≥16 years old) with a diagnosis of aortic coarctation evaluated from 1980 to 2000. Spectrum of cardiovascular disease, surgical history, and obstetrical and neonatal outcomes were determined.

RESULTS Fifty women with coarctation had pregnancies: 30 had coarctation repair before pregnancy, 10 had repair after pregnancy, 4 had repair both before and after pregnancy, and 6 had no history of repair. The 50 women had 118 pregnancies resulting in 106 births. There were 11 miscarriages (9%), 4 premature deliveries (3%), and 1 early neonatal death; 38 deliveries (36%) were by cesarean section. Of the 109 offspring, 4 (4%) had congenital heart disease. A patient with Turner syndrome died of a Stanford type A dissection at 36 weeks of pregnancy. Nineteen women (38%) were known to have hemodynamically significant coarctation during pregnancy (gradient ≥20 mm Hg). Fifteen women (30%) had hypertension during their pregnancy, 11 of whom (73%) had hemodynamically significant coarctation during that time (8 with native and 3 with residual/recurrent coarctation).

CONCLUSIONS Major cardiovascular complications were infrequent but continue to be a source of concern for patients with coarctation who become pregnant. Systemic hypertension during pregnancy was common and related to the presence of a significant coarctation gradient. (J Am Coll Cardiol 2001;38:1728–33) © 2001 by the American College of Cardiology

Coarctation of the thoracic aorta occurs in approximately 6% to 8% of patients with congenital heart disease (CHD) (1). Although there may be some anatomical variation, coarctation usually is characterized by a discrete narrowing of the aorta distal to the left subclavian artery. The diagnosis is made during infancy or childhood in 80% of patients, and survival into adulthood is common (2). Females who have aortic coarctation are expected to reach childbearing age with a previous history of surgical repair or, less commonly, with native coarctation (hemodynamically mild or unrecognized). The outcome of pregnancy in women with coarctation of the aorta has been described in previous series and case reports (3–15); however, the number of patients in these reports has been small and the findings have been contradictory. We sought to better define the maternal and fetal outcomes of pregnancy in women with coarctation of the thoracic aorta.

METHODS

The medical and surgical databases of the Mayo Clinic were reviewed for all women with a diagnosis of aortic coarctation who were evaluated from 1980 to 2000 and who would have been 16 years or older at the time of the study (2000). Patients or relatives were contacted by mail or telephone, and their medical records were reviewed. A detailed obstetrical history was obtained from each patient, with emphasis on pregnancy, delivery, and fetal outcome (Table 1). Data relating to the nature of the aortic coarctation, including the type of surgical repair and the need for reoperation, were collected. In addition, the status of the aortic valve, age at surgery, and the presence of associated lesions were also sought.

Hypertension was defined as present if reported by the patient. Status of the coarctation during pregnancy was determined when possible (native, surgically repaired with or without residual/recurrent gradient). Coarctation segments with the presence of collaterals or a gradient of 20 mm Hg or greater (derived by catheterization, echocardiography, or arm-leg blood pressure difference, depending on available data) were considered hemodynamically significant. The diagnosis of coarctation of the aorta was established by one or more of the following: echocardiography, computerized tomography, magnetic resonance imaging, or cardiac catheterization with aortic root angiography or at the time of surgical intervention. Patients with single ventricle physiology, abdominal aortic coarctation, or pseudocoarctation or those who died at an age <16 years were excluded. In all offspring with CHD, the diagnosis was made by a pediatric cardiologist. The protocol was reviewed and approved by the Institutional Review Board of Mayo Foundation.

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Manuscript received April 2, 2001; revised manuscript received July 12, 2001, accepted August 10, 2001.

Abbreviations and Acronyms

CHD = congenital heart disease
CI = confidence interval
NS = not significant
VSD = ventricular septal defect

Statistical methods. The median and range were determined for continuous variables and frequencies for categorical variables. Continuous variables were compared by the Mann-Whitney *U* test. These included age at initial repair for women with or without re-do surgery, age at initial repair for women with or without persistent/late hypertension, age at initial repair for women with or without hypertension during pregnancy, and infant weight in the native coarctation or surgical repair group. Categorical variables were compared by the Fisher exact test. These included: 1) hypertension during pregnancy versus the presence of coarctation, and 2) incidence of miscarriage, cesarean delivery, and hypertension during pregnancy versus the presence or absence of a previous repair. Ninety-five percent confidence intervals (CIs) were derived for obstetrical and neonatal data. A p value <0.05 was considered statistically significant. The SPSS 7.0 statistical software package was used for all calculations.

RESULTS

One hundred thirty-seven potential subjects were identified from the database review. After an initial chart review, 29 were excluded because of presence of single ventricle physiology, abdominal coarctation, pseudocoarctation, or death at an age <16 years. In the remaining 108 subjects, questionnaires were sent and in those with no response phone contact was attempted. Seventy-three subjects (68%) were traced and agreed to respond. Of this group, 23 had not been pregnant. At the time of the questionnaire, one woman was pregnant for the first time and was excluded from the study. One woman who died during pregnancy and whose medical records were available was also included in the data set. Fifty women had a history of pregnancy with an established outcome: 30 became pregnant after surgical repair of the coarctation, 10 were pregnant before surgical repair, 4 had surgical repair both before and after pregnancy, and 6 had no history of surgical repair (Fig. 1). The 50 women had a total of 118 pregnancies: 74 pregnancies (63%) occurred in women who had previously had surgical repair and 44 (37%) occurred in women with no previous history of repair.

Table 1. Data Abstracted From Questionnaire, Telephone Interview and Medical Record Review

Cardiovascular data
Associated lesions
Bicuspid aortic valve
History of hypertension
Status of coarctation during pregnancy
Surgical history
Type of repair
Age at repair
Obstetrical history
Maternal age
Miscarriage
Type of delivery
Premature delivery
Hypertension
Preeclampsia
Neonatal data
Complication at birth
Birth weight
Congenital heart disease

Spectrum of cardiovascular disease. Of the 50 women, 9 (18%) had associated cardiovascular lesions at birth in addition to aortic coarctation: 4 had a history of patent ductus arteriosus, 1 had a history of ventricular septal defect (VSD), 1 had a history of both patent ductus arteriosus and VSD, 2 had congenital aortic stenosis, and 1 had an aberrant left subclavian artery distal to the coarctation segment in the setting of a right-sided arch (Table 2). Except for the latter patient and a patient with a small VSD, all had had surgical repair of these associated anomalies before becoming pregnant. The morphology of the aortic valve was not known for 1 of the 50 women, but of the other 49, a total of 28 (57%) had a bicuspid aortic valve. After having completed their pregnancies, five women eventually required aortic valve replacement for stenosis. The median time from the last pregnancy to the time of aortic valve replacement was 25 years (range, 3 to 40 years). No women had a history of hemodynamically significant aortic valve insufficiency, and none had a mitral valve anomaly. None of the women were known to have an aneurysmal dilation of the ascending aorta during pregnancy. One patient had Turner syndrome, and another had Noonan syndrome.

History of surgical intervention. Forty-four women (88%) had a history of surgical intervention to repair the aortic coarctation (Table 2). None had a history of percutaneous catheter-based intervention. The median age at the time of the initial repair for the entire group was 15 years (range, 1 to 60 years). The median age at the time of the initial repair for the subgroup who had their first pregnancy after repair was 13 years (range, 1 to 36 years). For this subgroup, the median time from initial surgical repair to first pregnancy was 13 years (range, 1 to 36 years). The type of procedure at initial surgical repair varied: an end-to-end anastomosis was performed in 15 women (34%), patch aortoplasty in 13 (30%), interposition graft in 5 (11%), and bypass graft in 1 (2%). No woman had subclavian flap repair. For 10 women (23%), the type of procedure was not known. Nine women (20%) had reoperation for recurrent coarctation. The median age at initial repair for those who had reoperation for residual or recurrent coarctation was 10 years (range, 1 to 19 years), compared with 17 years (range, 1 to 60 years) for those who did not have reoperation (p = NS). Of the 44 women who had surgical repair, 26 (59%) had persistent or late hypertension. For one woman, blood

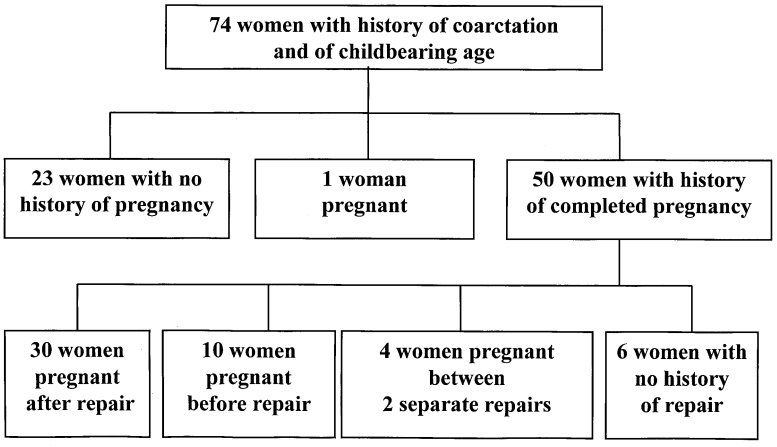

Figure 1. Study group characteristics.

pressure level was not known. The median age at initial repair in women with persistent or late hypertension was 21 years (range, 5 to 60 years), compared with 10 years (range, 1 to 36 years) for those without residual or late hypertension ($p < 0.05$).

Obstetrical and neonatal data. The 50 women had 118 pregnancies resulting in 106 live births. There were two twin pregnancies and one triplet pregnancy. Nine women had 11 miscarriages (9%), all of which occurred in the first trimester of pregnancy. One woman had an ectopic pregnancy that was unsuccessful. No therapeutic abortion was performed. One neonate died 2 h after delivery; no information was available about the cause of death. Thirteen women (26%) had been advised against becoming pregnant because of perceived maternal and fetal risk. The median maternal age at the time of pregnancy was 27 years (range, 17 to 39 years). The median number of pregnancies per woman was two (range, 1 to 6). Of the 106 births, 38 (36%) were cesarean deliveries, 7 of which were performed for obstetrical reasons and the other 31 for perceived maternal cardiovascular risk. Four women (3% of deliveries; 95% CI, 1% to 9%) had premature deliveries, defined as 37 weeks or less of gestation: 3 were at 36 weeks of gestation and 1 twin delivery occurred at 34 weeks. Two women (2% of deliveries; 95% CI, 0% to 6%) had preeclampsia during pregnancy; this occurred during their first pregnancy, and they had no history of hypertension before or after pregnancy. In both women, a significant gradient was present during pregnancy (one with previous surgical repair had a residual gradient of 20 mm Hg, and the other had native coarctation and a gradient of 49 mm Hg). Other pregnancy-related complications included one infant small for gestational age, one pregnancy complicated by oligohydramnios, and two women with gestational diabetes. The median infant weight at delivery was 3.5 kg (range, 1.9 to 4.3 kg) (Table 3).

CHD in offspring. Four of 109 children (4%; 95% CI, 1–9%) were born with CHD. Two children were born with CHD in the setting of a chromosomal abnormality or a

Table 2. Spectrum of Disease in Pregnant Women With History of Aortic Coarctation

Variable	No.	(%)
Associated lesions at birth (n = 50)	9	18
PDA*	4	
VSD	1	
PDA and VSD	1	
Congenital AS	2	
Aberrant LSCA with right arch	1	
Bicuspid aortic valve (n = 49)†	28	57
History of surgical repair (n = 50)	44	88
Initial surgical repair (n = 44)‡		
End-to-end anastomosis	15	34
Patch aortoplasty	13	30
Interposition graft	5	11
Bypass graft	1	2
Subclavian flap	0	0
Unknown	10	23
Reoperation for coarctation (n = 44)	9	20
Percutaneous intervention (n = 44)	0	0
History of residual or late hypertension (n = 44)§	26	59
Hypertension during pregnancy (n = 50)	15	30
Coarctation during pregnancy (n = 50)‖	19	38

*All patients underwent surgical division. †Morphology of the aortic valve was not known for one woman. ‡Age at initial repair: median, 15 years (range, 1 to 60). §History of hypertension was not established for one woman. ‖Presence of hemodynamically significant coarctation (defined as presence of collaterals or gradient >20 mm Hg).

AS = aortic stenosis; LSCA = left subclavian artery; PDA = patent ductus arteriosus; VSD = ventricular septal defect.

Table 3. Obstetrical and Neonatal Data for 118 Pregnancies

Variable	Value	95% CI*
Maternal age at pregnancy, years, median (range)	27 (17–39)	
No. of pregnancies, median (range)	2 (1–6)	
Miscarriage, no. (%)	11 (9)	5–16%
Cesarean delivery, no. (%)	38 (36)	24–42%
Premature delivery, no. (%)	4 (3)	1–9%
Preeclampsia, no. (%)	2 (2)	0–6%
Infant weight, kg, median (range)	3.5 (1.9–4.3)	
Congenital cardiac defect in infant, no. (%)	4 (4)	1–9%

*95% confidence intervals (CI) of percentages for categorical variables.

Table 4. Contingency Table of Relation Between Hypertension During Pregnancy and Presence of Coarctation*†

	Hypertension	No Hypertension
Coarctation present	11	8
Coarctation not present	3	24

*Includes native coarctation or residual/recurrent coarctation (defined as presence of collaterals or gradient >20 mm Hg). †Four women were not included because of insufficient data to determine status of coarctation at time of pregnancy. Of 19 women with coarctation present, 11 (58%) had hypertension during pregnancy, compared with 3 of 27 women (11%) without coarctation (p = 0.001).

recognized systemic syndrome. One mother had a child with Down syndrome with complete atrioventricular canal. A woman with Noonan syndrome bore a child with the same syndrome and associated pulmonic stenosis. Two children without a chromosomal abnormality or a recognized systemic syndrome had cardiac congenital anomalies: one with aortic coarctation requiring surgical repair and one with a small VSD, which closed spontaneously.

Maternal outcome. One woman died of complications of a Stanford type A dissection at 36 weeks of pregnancy (see below). No other pregnancy-related maternal deaths or serious cardiovascular complications occurred. There was no documented case of endocarditis, congestive heart failure, or intracranial hemorrhage. Excluding the 2 women who had isolated preeclampsia during pregnancy, 15 women (30%; 95% CI, 18% to 45%) had systemic hypertension during pregnancy. In many cases, it was difficult to determine whether hypertension had been documented before the pregnancy. Of this group of 15 women, 7 had native coarctation that eventually was repaired, 3 required reoperation shortly after pregnancy, 1 had native coarctation that never was repaired (gradient, 38 mm Hg), and 3 had had surgical repair, with no significant residual coarctation (gradient, <20 mm Hg). Detailed information was not available for the one other woman. Thus, of the 15 women with hypertension during pregnancy, 11 (73%) had hemodynamically significant coarctation. Of the 19 women (38% of the cohort) with hemodynamically significant coarctation (native or residual/recurrent), 11 (58%) had hypertension during pregnancy, compared with only 3 of the 27 women (11%) with no hemodynamically significant coarctation (p = 0.001) (Table 4). For four women, the status of coarctation during pregnancy was not known. The age at coarctation repair did not influence the presence or absence of hypertension during pregnancy (median, 11 years [range, 5 to 23 years] for those with hypertension vs. 13 years [range, 1 to 36 years] for those without hypertension; p = NS).

Patient with fatal aortic dissection during pregnancy. A 30-year-old woman with cytogenetically documented Turner syndrome and a history of juxtaductal coarctation had surgical repair with end-to-end anastomosis at age four years. She also had a bicuspid aortic valve, with no hemodynamically significant stenosis or regurgitation. The patient was receiving hormone replacement therapy with cyclic estrogen and progesterone. In vitro egg fertilization from her sister, followed by transcervical uterine embryo transfer, resulted in a triplet pregnancy. At 12 weeks of pregnancy, she had selective reduction to twin pregnancy. This woman was not evaluated by a cardiologist at our institution. Hypertension was not documented before or during pregnancy. She died suddenly at 36 weeks of pregnancy, and emergency cesarean delivery was performed 25 min after collapse. The twins were alive but ventilated and had seizure activity. Autopsy of the woman demonstrated a Stanford type A dissection with an entry tear in the proximal aorta, with associated hemopericardium and tamponade. The ascending aorta had cystic degeneration of the media. Only mild recoarctation was reported at the previous repair site. The maximal diameter of the ascending aorta was 2.9 cm.

Native coarctation versus repaired coarctation. The differences in obstetrical, neonatal, and maternal outcomes between women who had had surgical repair before pregnancy (the "postrepair group") and those who did not (the "native group") were not statistically significant. The miscarriage rate was 8% for the postrepair group and 11% for the native group (p = NS). The cesarean delivery rate was 40% among the postrepair group and 28% among the native group (p = NS). The median infant weight was 3.3 kg (range, 1.9 to 4.5 kg) for the postrepair group and 3.2 kg (range, 1.8 to 4.3 kg) for the native group (p = NS). Of the 34 women in the postrepair group, 8 (24%) had hypertension during pregnancy, compared with 7 of the 16 women (43%) in the native group (p = NS).

DISCUSSION

Several issues are of concern in the care of a woman with coarctation of the aorta who becomes pregnant. Possible changes in the aortic wall during the gravid state, coarctation-associated aortopathy, and long-standing hypertension combine to increase the risk of aortic rupture or dissection. Theoretically, beta-adrenergic blockade may decrease the risk of these events by decreasing the hemodynamic stress on the aortic wall, although this remains unproved in pregnancy. Poorly controlled hypertension leads to adverse neonatal (growth retardation, abruptio placentae, and premature delivery) and maternal (renal failure, hypertensive crisis) outcomes (16). In addition, hypertensive surges may precipitate the rupture of an intracranial aneurysm, which reportedly has an increased incidence in this population (17). Some commonly used classes of antihypertensive agents, such as angiotensin-converting enzyme inhibitors, have teratogenic effects and must be discontinued before conception. Significant stenosis at the site of coarctation with a pressure drop distally may result in placental hypoperfusion (5). Associated anomalies such as a stenotic bicuspid aortic valve may become hemodynamically significant and symptomatic with the physiologic changes of pregnancy. Endarteritis or endocarditis is a source of concern at the time of delivery. Also, compared with the general population, the child of a mother with aortic coarctation is

at increased risk for CHD (18). The reported maternal (0% to 9% mortality) and neonatal (8% to 19% spontaneous abortion) outcomes vary widely among previously published series (3–15), perhaps because the older reports predated widespread access to surgical repair and modern advances in cardiac diagnosis and obstetric care. Our report represents the largest series of pregnant women with aortic coarctation.

Maternal outcome. The woman with Turner syndrome had a catastrophic cardiovascular complication, dying of aortic dissection at 36 weeks of pregnancy. Several cases have been reported of aortic rupture or dissection during pregnancy in women with aortic coarctation (4,19). An intrinsic aortopathy associated with aortic coarctation has a predisposition for dilation, rupture, and dissection (20–23). Also, because of hormonal and hemodynamic alterations, pregnancy appears to increase the likelihood of dissection. In a report by Williams et al. (24), one-half of aortic dissections in women younger than 40 years occurred during pregnancy. The presence of a bicuspid aortic valve has also been linked with aortopathy (25). Women with Turner syndrome are at increased risk for aortic rupture or dissection, even if they do not have coarctation, bicuspid aortic valve, or hypertension (26,27). Our patient had several risk factors for dissection or rupture of the aorta, that is, Turner syndrome, bicuspid aortic valve, previous coarctation, and pregnancy. Although aortic dilation increases the risk of rupture or dissection (28), the aortic dimension of our patient with Turner syndrome was within normal limits. Oocyte donation and embryo transfer technology have made pregnancy possible in women with Turner syndrome (29). These women will need to be evaluated carefully, counseled about potential risks, and monitored closely for aortopathy and aortic complications.

In our series, 37% of the pregnancies occurred in women with native coarctation and 63% in women whose coarctation had been repaired (median age at initial repair, 13 years). Future series probably will report a higher proportion of women who had surgical repair at an earlier age, reflecting improvement in clinical practice. The role of percutaneous intervention in coarctation is evolving (30); it has been used primarily to repair recurrent coarctation. Angioplasty, with or without stenting, increasingly is being used to repair native coarctation. Theoretically, the localized dissection at the time of inflation could predispose the site to further dissection or rupture, especially during pregnancy. To date, there have been no reports of women with aortic coarctation who had percutaneous intervention before becoming pregnant.

Hypertension during pregnancy. Hypertension in pregnancy may be due to pre-existing systemic hypertension or preeclampsia or it may be transient. The incidence of systemic hypertension during pregnancy is 1% to 5% (16), but in our series, 30% of the women (95% CI, 18% to 45%) had systemic hypertension during pregnancy. The majority of them (73%) had native coarctation with a hemodynamically significant gradient or evidence of residual or recurrent coarctation. Of the women who had hemodynamically significant coarctation (native or residual/recurrent), 58% had hypertension during pregnancy. However, only 11% of the women without hemodynamically significant coarctation had hypertension during pregnancy. Earlier reports have shown that pregnant women with coarctation have a blood pressure response similar to that of normal patients (4). The tendency is for blood pressure to decrease during the middle trimester of pregnancy and then return to pregestational levels at preterm. The presence of hypertension during pregnancy in our group most likely reflected prepregnancy-elevated blood pressure. Our data suggest that the degree of obstruction at the site of coarctation is important independently of the state of repair. Although the age at initial repair predicted the presence of residual or late hypertension for the entire group, no significant relation existed between the age at initial repair and hypertension during pregnancy. This most likely was due to the small number of patients in the study group.

Obstetrical and neonatal outcome. The rate of cesarean delivery for the study group was 36% (95% CI, 24% to 42%), which is higher than the national rate of up to 21.8% (31). This high rate probably was due to a perceived cardiovascular risk for the mother from an increase in blood pressure during delivery. Although vaginal delivery generally is preferred for women with CHD, cesarean delivery may be safer if the woman has significant systemic hypertension, a dilated aorta, or significant residual coarctation.

The miscarriage rate in our series was 9% (95% CI, 5% to 16%), which is equivalent to the expected national rate of 10% (32). Also, 2% of the pregnancies (95% CI, 0% to 6%) were complicated by preeclampsia, which is comparable to the national rate of 3% (33). The incidence of CHD in the offspring was 4% (95% CI, 1% to 9%), which is similar to the previously reported rate in parents with congenital heart disease (18).

General issues regarding pregnant women with aortic coarctation. Pregnant women with aortic coarctation may present in several ways. Most commonly they have a history of previous surgical repair. Occasionally, coarctation is diagnosed initially during pregnancy when a cause for hypertension is sought (7) or when aortic dissection occurs (19). Occasionally, a woman with an established mild native coarctation may become pregnant. Except for our patient with Turner syndrome and aortic dissection, the major morbidity during pregnancy in our series—whether the woman had had native coarctation or surgical repair—was hypertension related to a hemodynamically significant gradient at the site of coarctation.

Study limitations. In addition to the problems inherent with any retrospective study, several limitations should be emphasized. Many of the women identified were referred to the Mayo Clinic specifically for surgical intervention, and not all subjects responded to the questionnaire. These two issues create potential selection bias and this may limit generalization of the results of this study. Only a small

proportion of the women received obstetrical care at the Mayo Clinic, making it difficult to access the details of the pregnancy. The exact status of aortic valve function during pregnancy was available for only a limited number of patients. Data on aortic size during pregnancy were not available and would be important for proper counseling in this population. The majority of offspring data were derived from the questionnaire and were not confirmed by review of outside material. Finally, we were not able to report on the use or type of antihypertensive agents or blood pressure control during pregnancy.

Conclusions. Most women with coarctation of the thoracic aorta reach childbearing age. Although major cardiovascular complications are infrequent in pregnant women with coarctation, they continue to be a source of concern. The obstetrical and neonatal outcomes of the women in our series were similar to those of the general population, except for a modest increase in the rate of cesarean delivery. Systemic hypertension during pregnancy was common and related to a hemodynamically significant coarctation gradient. Women with a history of coarctation of the aorta who contemplate pregnancy should have a formal hemodynamic assessment of the site of coarctation, preferably before conception, and undergo close monitoring of blood pressure during pregnancy.

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