Maternal adaptation to pregnancy: Cardiovascular change

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The major pregnancy-related hemodynamic changes:

* increased cardiac output
* expanded blood volume
* reduced systemic vascular resistance and blood pressure

These changes contribute to:

* optimal growth and development of the fetus
* protect the mother from the risks of delivery, such as hemorrhage.
Timeline of cardiovascular changes:

These changes begin early in pregnancy, reach their peak during the second and early third trimester, and then remain relatively constant until delivery.
**Timeline of cardiovascular changes**

Maternal cardiovascular changes during pregnancy by trimester

<table>
<thead>
<tr>
<th>First trimester</th>
<th>Second trimester</th>
<th>Third trimester</th>
<th>Early postpartum</th>
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<tbody>
<tr>
<td><strong>Decrease:</strong></td>
<td><strong>Decrease:</strong></td>
<td><strong>Decrease:</strong></td>
<td><strong>Decrease:</strong></td>
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<tr>
<td>- SVR</td>
<td>- SVR (with a late rise)</td>
<td>- LV longitudinal strain</td>
<td>- Heart rate</td>
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<tr>
<td><strong>Increase:</strong></td>
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<tr>
<td>- Heart rate</td>
<td>- Heart rate</td>
<td>- Heart rate</td>
<td>- SVR</td>
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<tr>
<td>- LVEDD</td>
<td>- LVEDD</td>
<td>- LVEDD</td>
<td>- LV longitudinal strain</td>
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<tr>
<td>- LV mass</td>
<td>- LV mass</td>
<td>- LV mass (with a late drop)</td>
<td>- LV mass</td>
</tr>
<tr>
<td>- Cardiac output</td>
<td>- Cardiac output</td>
<td>- Cardiac output (with a late drop)</td>
<td>- Cardiac output</td>
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<td><strong>No change:</strong></td>
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<td>- LV longitudinal strain</td>
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<td>- LV longitudinal strain</td>
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</table>

**SVR:** Systemic vascular resistance; **LV:** left ventricular; **LVEDD:** left ventricular end diastolic diameter.
Timeline of cardiovascular changes

1\textsuperscript{st} trimester:
* Maternal systemic vasodilation begins at approximately 5 weeks of gestation.

2\textsuperscript{nd} trimester:
* SVR progressively drops by approximately 35 to 40 percent and nadirs in the mid-second trimester.

3\textsuperscript{rd} trimester:
* Cardiac output peaks in the early third trimester.
* Heart rate, which rises throughout gestation, peaks in the late third trimester at an average of 16 beats per minute (bpm; 24 percent).
**Timeline of cardiovascular changes**

3rd trimester:

* **Supine** positioning reduces CO and SV and increases HR.
* Placing the woman in the **left lateral decubitus** position shifts the uterus off the aorta and vena cava, which in turn increases blood flow to the heart and results in increased CO and SV.
* BP returns to prepregnancy levels during the third trimester.
Timeline of cardiovascular changes:

Intrapartum:

- Cardiac output increases by 15 percent above prelabor levels in early labor and 25 percent during the active phase.
- During pushing in the second stage, cardiac output rises by 50 percent.
- With epidural anesthesia, the baseline increase in cardiac output is attenuated; however, the increases associated with uterine contractions persist.
Timeline of cardiovascular changes:

**Intrapartum:**

- The increases in arterial pressure associated with each uterine contraction are mirrored by a rise in pressure in the:
  1. amniotic fluid
  2. intrathoracic venous
  3. cerebrospinal fluid
  4. extradural compartments
Timeline of cardiovascular changes:

Postpartum hemodynamic resolution:

- Fluctuations in CO, SV, and HR occur after delivery.
  1. Within the first 10 min following a term vaginal delivery, the CO and SV increase by 59 and 71%, respectively.
  2. At one hour postpartum, both the CO and SV remain increased (by 49 and 67 %, respectively) while the HR decreases by 15%; BP remained unchanged.
Timeline of blood volume changes

- Expansion of the plasma volume and an increase in red blood cell mass begin as early as the 4th week
- Peak at 28 - 34 weeks
- Then plateau until parturition
- Modest reduction in hematocrit (peak hemodilution) occurring at 24 - 26 weeks.

Physiologic anemia
30 to 34 week
The absence of physiologic anemia appears to be harmful!

* Increased risk of stillbirth
Gestation-Specific Vital Sign Reference Ranges in Pregnancy

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Gestation-Specific V/S Reference Ranges
Gestation-Specific V/S Reference Ranges
• The EF is unchanged (reliable indicator of LV function during pregnancy).
• CVP remains in the normal nonpregnant range.

Stroke Volume: 8% increase (6 mL) in the first trimester
Heart Rate: major factor in late pregnancy
Cardiac Output: rises 30 to 50% (1.8 L/min)
Regardless of the mechanism, the stress induced by the increase in CO can cause women with underlying and, in some cases, asymptomatic heart disease to decompensate during the latter half of pregnancy.

**Increased LV mass** (with the greatest change, an increase of an average of 40 g or 34 percent above baseline in the early third trimester) → **contractility of the myocardium is stable to improved**
Arrhythmias and palpitations

* The exact mechanism of increased arrhythmia burden during pregnancy is unclear, but has been attributed to *hemodynamic, hormonal, and autonomic changes* related to pregnancy.

* **Palpitations** occur frequently during pregnancy and are a common *indication for cardiac evaluation during pregnancy*. 

* The differential diagnosis of palpitations is extensive and the diagnostic evaluation does not differ from nonpregnant women.
Breathlessness (innocent hyperpnea)

easy fatiguing (decreased exercise tolerance)

basal rales (disappear with cough or deep breathing)

peripheral edema

small water hammer pulse

apical impulse is shifted cephalad
Auscultatory changes

- higher basal heart rate
- louder heart sounds
- wide splitting of S1
- splitting of S2 in the third trimester
- S3 is present in most pregnant women

- systolic ejection murmur (up to grade 2/6) over the pulmonary and tricuspid areas
- The venous hum
- mammary soufflé (systolic or continuous) is heard over the breasts in late gestation
**Echocardiogram**
- Physiologic multivalvular regurgitation
- chamber enlargement
- valvular annular dilatation
- small asymptomatic pericardial effusion

**Electrocardiogram**
- 15- to 20-degree left axis deviation
- supraventricular tachycardia and ventricular extrasystoles (common finding)

**Electrocardiogram**
- transient ST segment and T-wave changes
- presence of a Q wave and inverted T waves in lead III
- attenuated Q wave in lead AVF
- inverted T waves in leads V1, V2 and, occasionally, V3
The left, anterior, superior rotation of the heart and hypervolemia give the illusion of ventricular hypertrophy and cardiomegaly.

- Increased pulmonary vascular markings
- Rotation of the heart may also cause an indentation of the esophagus by the left atrium and straightening of the left heart border
- Changes are temporary and return to normal by 8 weeks postpartum.
Expansion of the plasma volume and an increase in red blood cell mass begin as early as the 4th week of pregnancy, peak at 28 to 34 weeks of gestation, and then plateau. Plasma volume expansion exceeds the increase in red cell volume, leading to "physiologic anemia."

The major hemodynamic changes induced by pregnancy include an increase in CO and reductions in SVR and systemic BP. CO peaks a few minutes after delivery, before gradually returning to prepregnancy levels.

Labor is associated with significant hemodynamic changes due to anxiety, exertion, pain, uterine contractions, uterine involution, and bleeding. Infection, hemorrhage, and the administration of anesthesia or analgesia also play a role.

The physiologic and anatomic adaptations to pregnancy influence the interpretation and evaluation of the pregnant woman's cardiac evaluation.