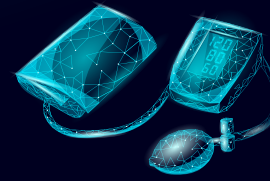


Feeling the Pressure: Complications Associated with Pregnancy

by

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Part I – Something Is Wrong

Penny sat up and wiped her mouth. She had thought that her morning sickness had passed, but maybe not. She flushed the toilet and headed back to her birthing class at the hospital. She slipped into the room and took her seat.

A few minutes later, Penny felt something warm on her face. She wiped it with her hand and realized her nose was bleeding. Penny stood up to get some tissues and suddenly felt the onset of a severe headache; she clutched her head.

“Penny?! Are you okay?!” the birthing instructor asked as she grabbed some tissue and handed it to Penny.

“Yeah, just feeling pretty crappy today with this nosebleed and headache. I also thought the morning sickness was supposed to be totally gone when you were this far into pregnancy.” Penny shrugged and tried to play it cool, her head still aching.

“Perhaps you should go home and rest, but call your partner because you shouldn’t risk driving yourself,” the instructor replied. “You should also go see your obstetrician to make sure there is nothing wrong. Headaches, severe nausea, and nose bleeds in pregnancy can often signal an underlying problem.”

“Oh no, I’m really okay. I think I’m just a little dehydrated. I’ve had a headache and been feeling pretty tired this week. You know how it is being pregnant and all,” Penny replied, feeling embarrassed about the episode.

The instructor insisted on calling Penny’s partner, Jo, who worked as an EMT. About ten minutes later, Jo arrived frantically worried, and insisted Penny be rushed to the doctor. Penny stubbornly refused, but compromised by letting Jo check her vital signs with her equipment at home.

“Penny, your blood pressure is 160/110 mmHg,” Jo exclaimed. “Your feet are swollen four times the normal size. Why haven’t you said anything?!”

Penny looked puzzled. “I’m sorry Jo, I had no idea. I thought that was just because of the pregnancy. I’m 28 weeks along you know. Besides, I’ve never had high blood pressure before. Don’t worry, I have an appointment tomorrow, I’ll have Dr. Vasandani check into it.”

Jo sighed. “Okay dear, just take it easy tonight and please avoid doing anything that could worsen this condition until you have it checked out. Hypertension can be really dangerous, especially during pregnancy.”

Jo was still worried as they lay in bed that night. She was concerned about her wife and unborn child. Penny was thinking about how she had been feeling lately and whether it was typical for pregnancy.

Penny whispered, “Jo, are you still up?”

“Yes,” she replied. “I can’t sleep; I’m worried about you.”

“I’m a bit worried too, Jo. Could you explain blood pressure to me and why having high blood pressure is a problem?”

“Of course,” said Jo.

Questions

1. What signs and symptoms has Penny been experiencing?
2. Define blood pressure. What is the difference between systolic and diastolic pressure measures? You may need to use information from class or you can use a website from a reputable source (e.g., American Heart Association or MedlinePlus).

Blood pressure:

Systolic pressure measure:

Diastolic pressure measure:

3. According to the American Heart Association, what are the normal, healthy ranges for systolic and diastolic blood pressure in a typical adult?
4. According to the American Heart Association or the Mayo Clinic (both have websites), define hypotension and hypertension. Provide the definition and include the systolic and diastolic values associated with these definitions, and then fill out the below chart (make sure you are using a chart that was made in or after 2017).

Hypotension:

Hypertension:

<i>Blood Pressure Category</i>	<i>Systolic mmHg</i>	<i>And/Or</i>	<i>Diastolic mmHg</i>
Hypotension			
Normal			
Elevated			
High blood pressure (hypertension) stage 1			
High blood pressure (hypertension) stage 2			
Hypertensive crisis (consult doctor immediately)			

5. Chronic hypertension is associated with multiple health conditions. Please use information provided by the American Heart Association or the Mayo Clinic to list seven different complications associated with hypertension.

Part II – But What Is Blood Pressure?

“Thanks, Jo” said Penny. “That helped me understand blood pressure and hypertension, but why is blood pressure important? What does it do for the body?”

“Great question,” Jo replied. “But before we get too deep into this, let’s make sure you understand some basic principles of cardiac function and blood pressure measurement.”

Questions

- Why is blood pressure important for physiological function and survival?
- How is blood pressure generated? Make sure to include the source of pressure generation and resistance in your answer.
- Fill in the chart below by matching the term to its definition. Select from the following: pulse pressure; mean arterial pressure (MAP); cardiac output; flow rate; flow velocity; vessel compliance; resistance; vasoconstriction; vasodilation.

<i>Word</i>	<i>Definition</i>
	This is the average blood pressure in a single cardiac cycle. This is useful because atrial pressure is pulsatile (increases with cardiac systole) and this number gives a representative measure of driving pressure through the arteries. Calculated as diastolic pressure + $1/3$ (systolic - diastolic pressure). Example: 120/80 BP = 93 mm Hg. Also written as: diastolic + (pulse pressure/3).
	This is the pumping power or efficiency of the heart; it is measured in ml/min and is the heart rate (beats per min) \times the stroke volume (ml/beat).
	A measure of the blood vessel ability to change diameter. This can be measured as change in volume/change in pressure.
	A decrease in blood vessel diameter, which decreases the volume of blood that can flow through it; can be caused by many different cues, such as vasopressin and angiotensin II.
	The volume of blood that travels past a certain point per time unit. This is constant throughout the vasculature. It is directly proportional to change in pressure and inversely proportional to resistance, or is inversely proportional to $1/\text{resistance}$.
	An increase in blood vessel diameter which allows a greater volume of blood to flow through. Can be caused by many different cues, such as epinephrine, histamine, and nitric oxide.
	The systolic minus diastolic pressure. This is a measure of the pressure wave created with cardiac systole.
	The speed at which blood flows past a certain point. This is not the same in all vessels (in the body, blood flows faster in vessels with lower total diameter (large veins and arteries) and slower in vessels with higher total diameter (capillaries)). Flow rate/cross-sectional area
	The tendency of the cardiovascular system to oppose blood flow and is abbreviated as R. This varies with vessel length, blood viscosity, and vessel diameter.

Jo explained that the heart and the blood vessels make a closed system of fluid (blood)-filled tubes in the body. As a consequence, the volume of blood, diameter of the vessels, and pressure are directly related. If blood volume increases, or vessel diameter decreases, pressure on the walls of the vessels increases. Likewise, if fluid volume decreases, or vessel diameter increases, pressure in the system decreases.

“Think of it like a water balloon,” said Jo. “If I have a balloon and let out water, the balloon is less stretched, there is less pressure; but if I add more water to the balloon, the pressure on the balloon walls increases.”

“Got it,” said Penny. “So if a person were to decrease their blood volume, say if they had a major cut and were bleeding, their blood pressure would drop?”

“Exactly! Additionally, the length of the vessel and the viscosity, or thickness, of the blood matters. Think about drinking out of a straw; which one is easier to use? One that is of typical length or one that is five feet long? The shorter straw is easier to use because there is less resistance. Likewise, what is easier to suck up through a straw, a thick milkshake or orange juice?”

“Orange juice, for sure!” said Penny. “Sometimes you really have to suck to get a thick milkshake to move in the straw.”

“That’s right. The cardiovascular system works much the same way; longer tubes and thicker blood increase resistance, which means the heart has to generate more force to move the blood, which increases blood pressure.”

“Wow, that’s amazing; I hadn’t realized how important blood pressure is for our health. Are there additional issues I should be aware of because I’m pregnant?”

“Unfortunately, yes,” said Jo. “A woman’s body goes through all sorts of physiological changes during pregnancy. In some cases, pregnant women develop high blood pressure and if that happens there can be risks to both the mother and the baby. I don’t know as much about specifics, though. We should consult Google Scholar and the American College of Obstetrics and Gynecologists webpage for information so that you’re prepared for your appointment in the morning. Sound okay?”

“Yes, that sounds great.”

Jo and Penny grabbed the computer and found helpful peer-reviewed publications that discussed the physiology of pregnancy. Jo was currently enrolled in a Master of Science program, so she had experience with credible scientific articles and helped interpret some of the complicated information for Penny. They read about the maternal-placental (uteroplacental) and fetal-placental (fetoplacental) blood circulation. The mother and the fetus each have their own blood supply and that blood does not mix (at least typically). The placenta is the organ of gas, nutrient, and waste transfer. The fetus is connected to the placenta via the umbilical cord (houses the umbilical artery and vein) and the placenta is implanted into the mother’s uterus. As pregnancy progresses, the placenta becomes more developed and the mother’s vascular network within the placenta grows; there are new spiral arteries, intervillous spaces (funnel-shaped areas that aid in exchange with fetal blood), and veins. The remodeling of the utero-placental vasculature is typically complete by weeks 20–22 of pregnancy.

They also found typical cardiovascular changes that occur in the mother during pregnancy include:

- A 40–50% increase in plasma volume.
- A 25% increase in red blood cells (RBC), but a decrease in overall hematocrit and hemoglobin concentration.
- A decrease in vascular resistance driven by fetoplacental developmental changes, a decreased sensitivity of the mother to angiotensin, and increased production of nitric oxide and relaxin.
- An increase in arterial compliance.
- A 30–50% increase in cardiac output, driven by an increase in both stroke volume (about a 30% increase) and heart rate (about a 15% increase).

After their web browsing session, Jo and Penny felt that they had looked up enough information for one night and were finally able to fall asleep.

Questions

9. Based on what Jo and Penny found, make a prediction (increase, decrease or no effect) about how each of the listed physiological changes would impact blood pressure.

<i>Measure</i>	<i>Predicted Impact on Blood Pressure</i>
New arteries and veins develop in utero-placental unit	
Increase in plasma volume	
Decrease in blood viscosity	
Decrease in vascular resistance	
Increase in arterial compliance	
Increase in cardiac output	

10. Based on your table, do you think a pregnant woman typically has blood pressure that is higher or lower compared to her pre-pregnancy reading?

Part III – Medical Tests

The next day Penny went to her doctor's appointment. When she arrived, a nurse took her vital signs and asked Penny to provide a urine sample for further analysis. Penny complied and was escorted to the exam room.

When Dr. Vasandani entered the room, Penny reported her vomiting, headaches, and nosebleed she experienced the day before. She also mentioned the discussion she had had with Jo about blood pressure, and their conclusion that pregnant women should generally have lower rather than higher blood pressure.

Dr. Vasandani was impressed that Penny had done so much background research and reading. However, he was still very concerned about her symptoms. He looked at her chart to find the blood pressure value that the nurse had taken when she arrived; it was 148/90 mmHg.

Throughout his assessment of Penny, he asked a variety of questions regarding her diet, exercise, familial history, and home medications, all of which are factors that can attribute to hypertension. After considering Penny's background information, Dr. Vasandani recognized that none of these risk factors for hypertension were applicable to Penny.

"Penny, based on the new symptoms you told me about and today's blood pressure reading, I'd like to do some more tests to find out what's going on. High blood pressure can be especially dangerous in pregnancy because it can be associated with a diagnosis of preeclampsia."

Penny was now really worried. She didn't understand what preeclampsia was; she couldn't believe that all of this was happening to her. "Dr. Vasandani, I'm very concerned for my baby's health, as well as my own. Could you please explain to me what exactly preeclampsia is?"

"Absolutely." He went over to the white board in his office and explained.

Watch the following video:

- *Preeclampsia and Eclampsia: Causes, Symptoms, Diagnosis, Treatment, Pathology*. Running time: 6:46 min. Produced by Osmosis.org, 2017. <<https://youtu.be/RB5s85xDshA>>

This new information made Penny even more anxious because she had never had high blood pressure before and had always lived a healthy lifestyle. The doctor advised her to stay calm and explained that they were going to run some further tests. First they needed to get at least one more blood pressure reading and a measure of the protein in her urine over a 24-hour period. Penny was instructed to take the provided containers home and, starting the next morning, collect all urine produced in the next 24 hours. She was to note the time of first urination and discard that sample. She was then to collect all urine for 24 hours and keep it cool, either in the refrigerator or on ice in a cooler and then return the samples. The technicians would look for protein in her urine. Protein in the urine can be a sign of multiple physiological conditions. Elevated blood pressure can cause issues with several physiological systems, one of which is the renal system. Prolonged increase in blood pressure can damage the glomeruli of the nephrons, leading to protein leaking into the filtrate and ultimately into the urine.

Dr. Vasandani said he would provide a laboratory analysis of her urine immediately and call her as soon as the results were available. Penny was also instructed to have Jo take her blood pressure that evening before going to bed, and then again in the morning before getting out of bed. Dr. Vasandani's office would take it again when she returned with the urine. Penny nodded in agreement. Dr. Vasandani handed Penny two reference sheets on preeclampsia and a flyer explaining how to properly take one's blood pressure. Even though he knew Jo was an EMT, he emphasized the importance of following the proper protocol for collecting a blood pressure reading. Penny hurried home to read her resources and talk with Jo.

Questions

- List five things that Jo should do when taking Penny’s blood pressure in order to get an accurate reading with the sphygmomanometer. You may use credible sources such as the American Medical Association or the American Heart Association.

As soon as Penny had completed her sample collection she returned to Dr. Vasandani’s office to drop it off and to get her blood pressure taken again. She also brought her blood pressure readings from home. A nurse took Penny’s blood pressure and collected the samples. The nurse assured Penny that Dr. Vasandani would call as soon as the results came in.

- Using the chart you completed in Question 4 of Part I above, provide the blood pressure classification for each of Penny’s readings.

<i>Blood Pressure Results</i>	<i>Penny’s Values</i>	<i>Classification According to AHA Chart</i>
Initial blood pressure at home	160/110 mmHg	
Blood pressure in office (initial reading)	148/90 mmHg	
Blood pressure before bed at home	142/89 mmHg	
Blood pressure upon waking at home	135/89mmHg	
Blood pressure in office (follow-up)	160/95 mmHg	

<i>Urinary results</i>	
24 hr urinary protein (typical < 229 mg)	355 mg

- Why do you think Penny was asked to take her blood pressure several times?

Early the next day, Dr. Vasandani received Penny’s results and called her in to discuss the data. Penny was now 29 weeks pregnant and Dr. Vasandani was concerned. He did some quick calculations to determine Penny’s mean arterial pressure (MAP). Based on medical studies (Cnossen *et al.*, 2008), MAP is a better predictor of preeclampsia risk than solely systolic or diastolic blood pressure readings and thus he wanted to consider those values.

- Calculate Penny’s pulse pressure and MAP for each of her blood pressure readings.

<i>Measure</i>	<i>Penny’s values</i>	<i>Pulse Pressure</i>	<i>MAP</i>
Initial blood pressure at home	160/110 mmHg		
Blood pressure in office (initial reading)	148/90 mmHg		
Blood pressure before bed at home	142/89 mmHg		
Blood pressure upon waking at home	135/89mmHg		
Blood pressure in office (follow-up)	160/95 mmHg		

- Calculate Penny’s average MAP. Then, using Figure 1 from the below paper as a reference, determine if Penny’s average MAP falls within the average range for her stage of pregnancy.
 - Hall, M.E., E.M. George, and J.P. Granger. 2011. The heart during pregnancy. *Revista Española de Cardiología* (English Edition), 64(11), 1045–50. <<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3802121/>>

Part V – Conclusion

Dr. Vasandani continued to monitor Penny and her developing fetus following the *Gestational Hypertension and Preeclampsia Practice Bulletin* published by the American College of Obstetricians and Gynecologists (ACOG). Dr. Vasandani and his team were careful to look for any changes or worsening in Penny's condition, including consistent blood pressure of over 160 mmHg (systolic) or 110 mmHg (diastolic) even with antihypertensives; persistent headaches that cannot be alleviated; epigastric pain; visual disturbances, motor deficit or altered sensorium; stroke; myocardial infarction; HELLP syndrome; renal dysfunction; pulmonary edema; eclampsia; or placental abruption. Penny was borderline for being diagnosed with severe preeclampsia, but Dr. Vasandani prescribed some antihypertensive drugs and Penny's blood pressure lowered. Dr. Vasandani did weekly monitoring of the fetus using ultrasound and routinely checked Penny's blood count, serum creatinine, LDH, AST, ALT, and urinary proteins.

Penny's condition was maintained until week 34 of gestation, but then her symptoms worsened. A baby was vaginally delivered early via induction. The baby was sent to the neonatal intensive care unit but was doing well and progressing as expected. It was possible that the baby would encounter some complications as it grew; long-term health issues, including learning disorders, cerebral palsy, epilepsy, deafness, and blindness, have been noted in babies born to mothers with preeclampsia. Penny was also being monitored and was expected to make a full recovery. Penny was lucky that Dr. Vasandani and his team were up to date on literature and made sure to monitor her condition. Unfortunately, many women in the United States are not as lucky as maternal mortality is currently at an all-time high (see the CDC for more information).