Changes in maternal anatomy and physiology during pregnancy

Ákos CSABA, MD

• Normal pregnancy is a physiologic state!

- Not a special disease!!!!

- Special recommendations! (praeconc.)

• But a "special" or "unusual" state!

Certain characteristics!
 – Must know them!!!

First signs of pregnancy -Easy questions-

• Nausea (morning) • Vomiting (till 12th weeks) • Breast tenderness and enlargement Frequent urination Weakness and fatigue Changes in eating habit Special changes in sensation (coffee and smoke)



Important to ask

about these at

first visit!

Complaints in later phase

- Difficulty in sleeping
 - Faint when lying on the back (vena cava syndrome)
- Frequent urination
- Fetal movement (sometimes painful)
- Constipation (sometimes requires laxatives)
- Tachypnoe
 - Galactorrhea

Anatomical changes I.

• <u>Weight gain (9-14 kg/20-30lb)</u>

- Average total weight gain during pregnancy is approx. 10-12 kg.
- Low weight gain <u>small-for-gestational-age</u> infants (in non-obese pregnants)
- Overweight women often deliver <u>large-forgestational-age infants</u> (regardless of their weight gain during pregnancy) (Insulin!)
 Be carefull with oedema! Extra weight!

Anatomical changes II.

• Fat deposits in special places:









Anatomical changes III.

• Bones:

- Volume of Calcium in the bones is decreasing (extra Ca into diet;) (dental care, visit dentist!)
- Acromegaloid changes in the second half (increasing level of IGH and STH) (fingers, hands)

Joints:

- The sacroiliac synchondroses and symphysis pubis are widened and rendered movable (begining about the 10th and 12th week of gestation—hormone--<u>relaxin</u>.
- All joints are more vulnerable (!SYMPHYSEOLYSIS!)

Anatomical changes IV.

Bones and joints changes (soften the pubic symphisis) are believed to be almost entirely caused by the action of hormone *relaxin*.

- <u>Source</u>:

- corpus luteum, ovary, breast
- placenta,
- chorion, decidua pareietale.



- Blood concentration: huge increasing ⁺
 - 0.2 U/ml at 7-10th week
 - 2.0 U/ml at 38-42th week (maximum concentration)

Anatomical changes V

• Extra weight and hormones (relaxin, E2) resulting in a special bodyshape, special curves in the spinal column! (Special type of walking!) Abdominal lordosis (growing weight in the abdomen) (Frequent humbal pain!) – Thoracal kyphosis (compensating)

Anatomical changes VI

• Skin-changes:



- Pigmentation of the skin in different areas (etc.: linea nigra)
- Chloasma (,,mask of pregnancy") may persist for many months after delivery /on the face/
- Palmar erythema (Estrogen)
- Spider nevi (Estrogen)
 - Telangiectasia (Estrogen)

Anatomical changes VII.

- Abdominal wall: {Oils for prevention??? Genetic determination???}
 - Striae gravidarum:
 - Tension and stretching (mechanic)
 - Estrogen, relaxin, cortisol (endocrin)
 - Changes in the collagen and elastic fibers /lose their crisscross appearance/
 - Reddish, irregular lines
 - Discoloration gradually fades, but the scarred lines do not dissappear

Diastasis recti (wide separation of the muscles)

• After delivery complaints about the shape of the abdomen



Anatomical changes VIII.

• **Breasts:** (everybody happy?) Enlarged (Good news for men!) - Sensitive Primary areola deepens in color Secondary areola develops—lighter - Montgomery's tubercules (sebaceus glands) Colostrum (lactation is inhibited by the high estrogenprogesterone levels)

Anatomical changes IX.

• Breasts:

Estrogen stimulates proliferation of the ducts
 Progesterone – proliferation of lobule-alveolar tissue

Engorged veins beneath the surface of the skin
 Prolactin: after delivery stimulates synthesis and secretion of milk

Anatomical changes in generative organs I.

• Uterus

- Size: 5-6 times increases (from 7 by 5 by 3 cm to 35 by 25 by 22 cm)
- Weight:20-fold increase $(50 \rightarrow 1000 \text{ gramm})$ Capacity:1000-fold increase $(4 \rightarrow 4000 \text{ ml})$ Blood flow:10-fold increase $(50 \rightarrow 500 \text{ ml/min})$ Hyperthrophy of the muscle cells!!!



hormonal stimulus (initial)size of the conceptus

Anatomical changes in generative organs II.

- Cervix: (cervical cancer screening important)

 Softening
 Congestation (increased vascularity)
 - Be careful with Pap smear (bleeding) \rightarrow Mucus secretion is increased (thick mu
 - Causing complaints for the pregnants (fluor?) (making culture in case of other complaints!!)
 - Cervical ectropion or eversion



Anatomical changes in generative organs III. • Fallopian tubes and round ligaments: • Hypertrophied • Elongated

*Fallopian tubes:*Elongated

There are an and the second se

• Muscular coats are not hypertrophied!

Anatomical changes in generative organs IV.

Ovaries: INCREASED VASCULARITY
Enlarged
Elongated
Ovulation is suspended during pregnancy because of pituitary inhibition
Decidualike reaction of the stroma
Hyperplasia of the surface epithelium

Anatomical changes in generative organs V.

Vagina: (colposcopy is important!!!)
Chadwick's sign (deeply congested and cyanotic)
Mucosa thickens
Connective tissue becomes less dense
Muscular coat hypertrophies
Highly acid secretion (ph 3.5-5.5)

Physiological changes Circulatory system I.

1. Increased metabolic demands

2. Expansion of vascular channels

3. Increase in steroid hormon

Physiological changes Circulatory system II.

• Blood:

Total blood volume ↑ (30-40%)
Red blood cell volume ↑
Total hemoglobin ↑
Renal erythropoietic factor (REF) ↑ **Dilution anemia (Hgb and Htc ↓)**(True anemia: Hgb<12g/dl; Htc<32%)

Physiological changes Circulatory system III.

• Blood: - Plasma volume \uparrow (40% above normal) Interstitial fluid volume \uparrow (40% above normal) Bone marrow is hyperplastic - Leukocytosis is normal (10000 to 12000) - Se.protein concentrations are lower (5.5-6.0 g/dl) - Colloid osmotic pressure is decreased (by 20%) Albumin/globulin ratio is reduced from 1.5 to 0.8

Physiological changes Circulatory system IV. • Serum lipids: 1 by 46% • Fibrinogen: 1 from 300 to 500-600 mg/dl • Urea and creatinine: \downarrow • AFP: peak at 13th weeks' - Amniotic fluid : fetal serum level = 1:150Maternal serum level : fetal se.level = 1:10,000Normal values in multiples of the median (MoM) - Normal-range is 0.9 MoM and 2.5 MoM - Screening at 16th week for NTD

Physiological changes Circulatory system V.

- Heart:
 - Rotated anteriorly, displaced upward/left
 - Appears enlarged on X-ray
 - ?Cardiac muscle hypertrophy?
 - Soft systolic murmur (at the base-50%)
 - Pulse-rate ↑
 - Extrasystoles are common

Physiological changes Circulatory system VI.

• Blood pressure (BP):

- Arterial BP does not increase in normal pregnancy!
- Venous pressure remains normal
- Vena cava syndrome (late in pregnancy)!
- Capillary permeability remains unchanged

Physiological changes Circulatory system VII.

• Cardiac output (CO): Increase by 30-35%

- Primarily increase in stroke volume

– Heart-rate ↑

Overall increase in oxygen consumption (10-20%)

Physiological changes Respiratory system

- Vital capacity remains unchanged
- Hyperventilation:
 - Respiratory rate ↑
 - Tidal volume ↑
 - Carbon dioxide level of alveolar air \downarrow
 - Carbon dioxide level of maternal circulation \$\u03c4\$ (pain in the legs during the night!!!)
 - CO2 level of fetal circulation \downarrow

Physiological changes Urinary system I.

• Dilatation of the

- Ureter
- Renal pelvis
 - Hydronephrosis
 - All more pronounced on the right
 - The capacity of a dilated kidney pelvis and ureter increases from an original 10-15 ml to 60 ml

Physiological changes Urinary system II.

- **Renal function:**
 - Effective renal plasma flow increases 25% (600ml/min)
 - Glomerular filtration \uparrow by about 50%
 - Filtration fraction is elevated throughout pregnancy (40% above control levels)

Physiological changes Urinary system III.

 Hormones capable of increasing renal function: - ACTH – ADH - Aldosterone Cortisone Growth hormone Thyroid hormone

Physiological changes Urinary system IV.

Glycosuria (increase in glomerular filtration)
Amino acids in larger amount (histidine)
Urea, uric acid and creatinine are lowered in the blood
Iodid clearance is increased (plasma inorganic iodine level is reduced)

Physiological changes Urinary system V.

- The *bladder* is pulled up into the abdomen as the uterus enlarges. <u>Careful at cesarean!</u>
- Pressure of the uterus on the bladder, traction at the vesicle neck and hyperemia of the trigone cause <u>frequency of urination</u>
- Vascularity of the bladder increases
- Varicosity and hemorrhage from these areas

Physiological changes Urinary system VI.

• Decrease in bladder tone

• Progressive increase in capacity up to 1300 to 1500 ml during pregnancy (from 300-400ml)

• Overdistension of the bladder

Physiological changes Urinary system VII.

- <u>Renin-angiotensin-aldosterone system</u>:
 Activity of renin is increased (produced by the kidney)
 - Angiotensinogen----angiotensin formation in two steps by renin
 - Relative resistance to angiotensin (in
 - preeclampsia it is lost)
 - Aldosterone is for salt and water retention

Physiological changes Gastrointestinal tract I.

- Alteration in the normal alkaline pH of the saliva toward acid side!
- Quantity of saliva increases (hyperptyalism)
- *Gums* tend to bleed easily (hormonal effect) (gingivitis tends to dissapear after delivery)
- Gastric acidity is usually reduced
- Gastric motility is reduced
- Nausea and vomiting in early pregnancy

Physiological changes Gastrointestinal tract II. • Peristaltic activity is reduced Tone is decreased - Progesterone: induce atony in the smooth muscle cells of uterus, arteries, veins Resulting: CONSTIPATION—Special **DIET** recommended! • Hiatal hernia: pushed and hormonal Cecum and appendix are displaced upward

Physiological changes Gastrointestinal tract III.

• Gallbladder: **Emptying time is increased** Se cholinesterase activity is reduced by 25% **Biliary calculi** (relative biliary stasis and increased level of cholesterol) Ratio of women to men with calculous disease is approximately 4 : 1

Physiological changes Gastrointestinal tract IV.

Liver:
Liver function remain in the normal range
No morphological changes (by biopsy)
Patients with existing liver disease, high levels of estrogens and overall added work of the liver during pregnancy may adversely affect hepatic function.

Physiological changes Endocrine system I.

• Thyroid glands:

- In 50% the gland is enlarged (diffuse hyperplasia, new follicle formation and increased vascularity)

- Basal metabolic rate is increased (by 10-30%) (the growing fetal and maternal tissues logically increase the oxygen demand)

 Estrogen increase the response of pituitary thyroid-stimulating hormone (TSH) to TRH and also cause increase in TBG level

Physiological changes Endocrine system II.

Evaluation of thyroid activity by radioactive iodine (1311) uptake is contraindicated during pregnancy, since fetal thyroid follicles are differentiated by the fourth lunar month and may be damaged by 1311

Physiological changes Endocrine system III.

• Parathyroid glands: Hypertrophy (as fetal demands for calcium \uparrow) (Dentist visit recommended!) Relative deficiency - Chvostek's sign is frequently positive in the latter part of gestation - Increasing Ca intake corrects relative deficiencies

- One quart of milk daily is protective

Physiological changes Endocrine system IV.

- Pituitary gland:
 - Anterior lobe increases by 20-40% in size
 - Single cell type increase-"pregnancy cell" which is a prolactin-containing cell
 - SeProlactin rise (from 10 to 200 ng/ml)
 - Placental steroids inhibit the secretory activity of the breast by blocking the peripheral action of Prolactin on the breast
 - Posterior lobe remains unchanged (oxytocin and ADH secretion is increased)

Physiological changes Endocrine system V.

• Adrenal glands: Hyperplasia of the cortex (enlargement) Significant increase in corticosteroid secretion Transcortin level is increased (estrogen effect) (biologically less active because of the binding) Aldosterone levels is increased Adrenal medullary activity is slightly increased (epinephrine, norepinephrine)

Physiological changes Metabolism I.

• Proteins:

- Positive nitrogen balance increases progressively through the third trimester when fetal requirements are greatest.
- Nitrogen accumulates during pregnancy.
- A negative balance continues in the puerperium with blood loss, lactation and involutional changes in the uterus and other maternal tissues.
- Maternal protein intake should be at least 65 g/day.
- Diet very important in case of hypoproteinaemia!

Physiological changes Metabolism II.

- Protein:
 - Good maternal protein nutrition plays a key role in providing for normal fetal growth and development
 - Urinary urea nitrogen/total nitrogen index for maternal protein nutrition (UN/TN)
 Disthere is preserved to UNI/TN setion
 - Birth weights is associated to UN/TN ratios

Physiological changes Metabolism III.

Carbohydrates:

- Renal treshold for glucose may be reduced from nonpregnant levels (150-200 mg/dl to 100-150 mg/dl)
- Secretion of insulin is increased
- Resistence to insulin and destruction of insulin also increased
- Increases in corticosteroid and T4 levels in normal pregnancies may have some effects on carbohydrate metabolism, but protein binding of these substances is increased

Physiological changes Metabolism IV.

• Fats: Increase in maternal use of fat stores Increase in insulin resistance Placentar lactogen for mobilizing FFA (free fatty acid) (higher serum level: cholesterol, triglicerid) Elevated level of FFA exerts an antiinsulin effect Oxidation of fats-alternate maternal source of energy and glucose sparing

Physiological changes Metabolism V.

- Fats:
 - Estrogen-increase production of the alpha globulins (lipoproteins)
 - Lipoproteins increased during pregnancy
 - Neutral fats are doubled
 - Ketonuria occurs more readily in pregnant

Physiological changes Metabolism VI.

• Minerals:

 Demands for inorganic substances necessary for growth rise sharply at about the fourth lunar month, when the fetus begins to increase rapidly in weight.

 Materials used for blood and skeletal formation continue to increase progressively to term.

Physiological changes Metabolism VII.

- Ca and P.:
 - Requirements are doubled during pregnancy
 Satisfied by the daily intake of 1.5 g of calcium and 2 g of phosphorus.
 - Total serum calcium levels fall in the last half of pregnancy as a result of the decrease in serum albumin to which calcium is bound.
 Parathyreoid regulation

Physiological changes Metabolism VIII.

• Iron:

- Demand for iron is increased (especially in the last trimester)
- Hemoglobin mass continues to increase until term
- Iron supplements are necessary, because of small storage (1 g of available iron) to prevent anemia
- Appropriate dose: <u>30-60 mg/day of iron</u>

Physiological changes Metabolism IX.

• Folic acid:

- Folates play an important role in the metabolism of several amino acid and in the synthesis of nucleic acids.

- Reduces the occurance of neural tube defects
- Increased demand (rapid tissue growth)
- Deficiency megaloblastic anemia
- Daily requirement: 300-500 ug
- Green vegetables, fruits, liver, kidney are the principal sources

Physiological changes Metabolism X.

- Acid-base balance:
 - Maternal plasma bicarbonate and total base are normally reduced during pregnancy
 - Total base average 146 mEq/L in pregnant and 154 mEq/L in nonpregnant
 - Because the blood pH is unchanged, the alkali deficit is well compensated
 - Probably, the normally increased ventilation effects the change

Summary

• Special changes in every part of the body

• Complex changes

• Almost physiological, but.....

All for the purpose of a healthy infant