Changes in maternal anatomy and physiology during pregnancy

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IMPORTANT!!!!

• Normal pregnancy is a physiologic state!
  – Not a special disease!!!!
  – Special recommendations! (praec onc.)

• 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.

- **Weight gain (9-14 kg/20-30lb)**
  - Average total weight gain during pregnancy is approx. 10-12 kg.
  - Low weight gain – small-for-gestational-age infants (in non-obese pregnant)
  - Overweight women often deliver large-for-gestational-age infants (regardless of their weight gain during pregnancy) (Insulin!)
  - Be careful with oedema! Extra weight!
Anatomical changes II.

• Fat deposits in special places:
  – Abdomen
  – Breasts
  – Bottom
  – Hip
Anatomical changes III.

• **Bones:**
  - Volume of Calcium in the bones is decreasing (extra Ca into diet;) (dental care, visit dentist!)
  - Acromegaloïd 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—relaxin.
  - All joints are more vulnerable (!SYMPHYSEOLYSIS!)
Anatomical changes IV.

- **Bones and joints changes (soften the pubic symphysis)** are believed to be almost entirely caused by the action of hormone *relaxin*.
  - **Source:**
    - 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 body-shape, special curves in the spinal column! (Special type of walking!)
  - Abdominal lordosis (growing weight in the abdomen) (Frequent lumbal 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 disappear
  
  - *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* (sebaceous glands)
  - *Colostrum* (lactation is inhibited by the high estrogen-progesterone 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 → 1000 gramm)
  - *Capacity*: 1000-fold increase (4 → 4000 ml)
  - *Blood flow*: 10-fold increase (50 → 500 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)*
      - Mucus secretion is increased *(thick mucus)*
    - Causing complaints for the pregnant *(fluor??)*
      - Making culture in case of other complaints!!
  - Cervical ectropion or eversion
Anatomical changes in generative organs III.

• **Fallopian tubes and round ligaments:**
  
  – *Round ligaments:*
    • Hypertrophied
    • Elongated
  
  – *Fallopian tubes:*
    • Elongated
    • 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 hormone
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 ↑ (40% above normal)
  - Interstitial fluid volume ↑ (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: ↑ by 46%
- Fibrinogen: ↑ from 300 to 500-600 mg/dl
- Urea and creatinine: ↓
- AFP: peak at 13th weeks’
  - Amniotic fluid : fetal serum level = 1:150
  - Maternal serum level : fetal se.level = 1:10,000
  - Normal 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 ↓
  - Carbon dioxide level of maternal circulation ↓ (pain in the legs during the night!!!)
  - CO2 level of fetal circulation ↓
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 ↑ 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. **Careful at cesarean!**
• Pressure of the uterus on the bladder, traction at the vesicle neck and hyperemia of the trigone cause **frequency of urination**
• 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 300-400 ml)
- Overdistension of the bladder
Physiological changes
Urinary system VII.

- **Renin-angiotensin-aldosterone system:**
  - 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 (hyperptyyalism)
- *Gums* tend to bleed easily (hormonal effect) (gingivitis tends to disappear 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 (131I) uptake is contraindicated during pregnancy, since fetal thyroid follicles are differentiated by the fourth lunar month and may be damaged by 131I*
Physiological changes
Endocrine system III.

- **Parathyroid glands:**
  - Hypertrophy (as fetal demands for calcium ↑) (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)
  - Birth weights is associated to UN/TN ratios
Physiological changes
Metabolism III.

- **Carbohydrates:**
  - Renal threshold for glucose may be reduced from nonpregnant levels (150-200 mg/dl to 100-150 mg/dl)
  - Secretion of insulin is increased
  - Resistance 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, triglycerid)
  – 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: *30-60 mg/day of iron*
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 occurrence 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