# 4b. Physiological changes and Diagnosis of Pregnancy

## (b) Physiological Changes in Pregnancy and Diagnosis of Pregnancy

### Learning goals

- System-wise maternal adaptations with **key numbers** and **clinical implications**.
- **Diagnosis of pregnancy**: presumptive–probable–positive signs, timelines of **β-hCG** and **ultrasound**.
- **Uterine size by weeks**, eponymous clinical signs, and **early-pregnancy differentials**.
- Exam-ready tables, pitfalls, and case-sheet phrasing.

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- 1st Trimester 3D model
- 2nd Trimester 3D model
- 3rd Trimester 3D model

## 1) Overview: why physiology matters for ANC (antenatal care)

Normal pregnancy requires coordinated changes in **blood volume, cardiac output, ventilation, renal filtration, coagulation, metabolism, and the genital tract**. Understanding these prevents over-investigation of normal variants (e.g., physiologic anaemia, soft systolic murmurs) and ensures timely recognition of pathology (e.g., preeclampsia, VTE, GDM).

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## 2) System-wise physiological changes

### 2.1 Genital tract and breasts

- **Uterus**: hypertrophy and hyperplasia; weight **~70 g → 900–1000 g**; capacity **~10 mL → ≥5 L**.
  - **Braxton–Hicks**: irregular, painless tightenings from 2nd trimester; **no cervical change**.
- **Uterine size landmarks**: 12 w—just above symphysis; **20 w—umbilicus**; 36 w—near xiphisternum; **lightening** at term.
- **Cervix**: softening (Goodell), increased vascularity and bluish hue (Chadwick); mucus plug.
- **Vagina/vulva**: increased blood flow and secretions; acidic pH.
- **Ovaries**: **corpus luteum** sustains early progesterone till placental takeover (~10–12 w).
- **Breasts**: enlargement, nodularity, areolar darkening, **Montgomery tubercles**; **colostrum** late pregnancy.

**Applied:** Distinguish Braxton–Hicks from labour (irregular, settle with rest, no show/ROM/progressive pain).

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### 2.2 Cardiovascular

- **Plasma volume** ↑ **~40–50%** (peak 32–34 w).
- **RBC mass** ↑ **~15–20%** → **physiologic (dilutional) anaemia**; Hb nadir ~**11 g/dL**.
- **Cardiac output** ↑ **~30–50%** (↑ stroke volume early; **HR** +10–15 bpm).
- **BP**: mid-pregnancy fall **~5–10 mmHg**, returns to baseline near term.
- **Peripheral**: ejection systolic murmur common; dependent oedema/varicosities.

**Applied:**

- **Supine hypotension** (IVC compression) → advise **left lateral** rest.
- Judge anaemia with pregnancy norms; treat iron deficiency, not the physiologic drop alone.

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## 2.3 Respiratory

- **Tidal volume** ↑ **~30–40%**; **minute ventilation** ↑ **~30–50%** (progesterone-driven).
- Mild **respiratory alkalosis**: $PaCO_2$ **~30–32 mmHg**, with renal $HCO_3^-$ loss.
- **FRC** ↓ (diaphragm elevation ~4 cm); **RR** ~unchanged.

**Applied:** Dyspnoea of pregnancy is common; beware disproportionate breathlessness, hypoxia, chest pain (PE, cardiac disease).

## 2.4 Renal/urinary

- **RPF & GFR** ↑ **~40–50%** → **serum creatinine** and **urea** fall.
- **Physiologic hydronephrosis** (R>L) from progesterone + compression.
- **Frequency** ↑; **glycosuria** can occur (lower renal threshold).

**Applied:** Screen and treat **asymptomatic bacteriuria** (reduces pyelonephritis/preterm birth). Interpret creatinine using pregnancy ranges.

## 2.5 Haematology/coagulation

- **Leukocytosis** (up to 12–16×$10^9$/L).
- **Hypercoagulable**: ↑ fibrinogen, factors **VII, VIII, X**; ↓ protein S; decreased fibrinolysis.

**Applied:** VTE risk ↑; give prophylaxis when indicated (prior VTE, thrombophilia, immobility, obesity).

## 2.6 Endocrine/metabolic

- **hCG** peaks ~**9–10 w**; maintains corpus luteum.
- **Placental progesterone & estrogens** rise steadily → uterine quiescence, breast prep, fluid retention.
- **hPL** induces **insulin resistance** → maternal glucose availability to fetus.
- **Thyroid**: ↑ TBG; higher total $T_4$/$T_3$; **free fractions ~normal**; slight TSH suppression early (hCG cross-reactivity).
- **Adrenal/RAAS**: ↑ cortisol; sodium and water retention.
- **Weight gain (singleton)**: ~**11–16 kg** (BMI-dependent).

**Applied:** Screen for **GDM**; interpret thyroid tests with trimester-specific reference ranges.

## 2.7 Gastrointestinal/hepatobiliary

- **Progesterone-mediated hypomotility** → reflux, constipation, bloating.
- **GB hypomotility** → sludge/stones.
- **ALP** ↑ (placental); other LFTs near normal. **Hyperemesis** early.

**Applied:** Dietary measures, antacids safe in pregnancy; evaluate pruritus + ↑ bile acids for intrahepatic cholestasis.

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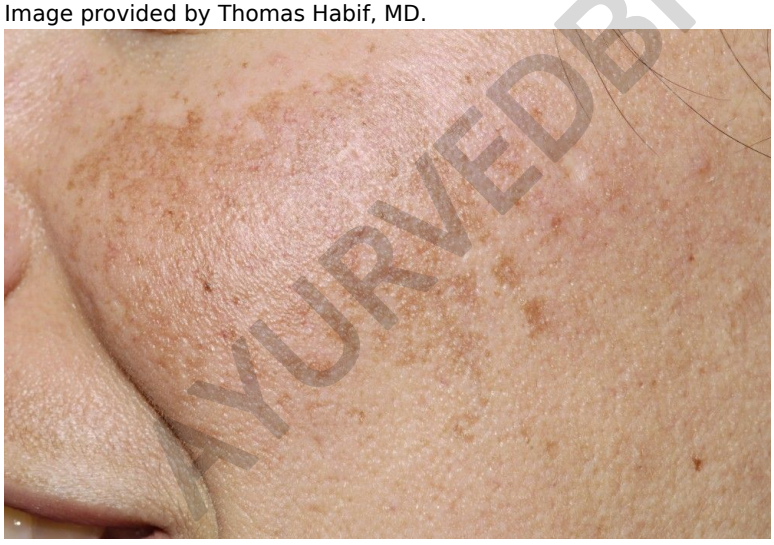
## 2.8 Musculoskeletal/skin/neurologic

- **Relaxin + estrogen** → ligament laxity, **lordosis**, pelvic girdle pain.
- **Skin**: **chloasma**, **linea nigra**, **striae gravidarum**, spider naevi.
- **Neurologic**: carpal tunnel symptoms; **IOP** falls; contact-lens intolerance.

**Applied:** Posture training, physiotherapy, supportive belts; reassure on benign pigmentary changes.

**Spider Angioma**
Spider angiomas (nevus araneus) are small, bright red spots that are surrounded by tiny capillaries, which resemble spider legs. After releasing pressure sufficient to blanch them, they refill from the central area. They are normal in many healthy patients. They commonly develop in pregnant patients, in patients who use oral contraceptives, and in patients who have cirrhosis.
Image provided by Thomas Habif, MD.



**Melasma**
This photo shows brown patches on the cheek of a patient with melasma.
DR P. MARAZZI/SCIENCE PHOTO LIBRARY

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**Linea Nigra**
A linea nigra is a dark line that appears down the midabdomen during pregnancy.
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# 3) Diagnosis of pregnancy

## 3.1 Classification of signs

- **Presumptive (subjective)**: amenorrhoea, morning sickness, breast tenderness, fatigue, urinary frequency, **quickening** (16–20 w; earlier in multiparas), skin changes.
- **Probable (exam/test)**: uterine enlargement, **Hegar** (isthmic softening ~6–8 w), **Goodell** (soft cervix ~6–8 w), **Chadwick** (bluish cervix/vagina), **Palmer** (early rhythmic uterine contractions), **ballottement** (16–20 w), positive urine hCG.
- **Positive (confirmatory)**: **USG visualization of embryo with cardiac activity**, auscultable **FHR**, fetal movements seen/felt by examiner.

## 3.2 β-hCG

- Detectable in serum **~8–11 days post-conception**; rises exponentially (doubling every **~48–72 h** early).
- **Urine test** positive around missed period; false negatives early/dilute urine; false positives (trophoblastic disease, some tumours).
- **Quantitative trends** help differentiate viable IUP vs failing/ectopic when scan is non-diagnostic.

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### 3.3 Ultrasound (TVUS early)

- **Intrauterine gestational sac**: **~4.5–5 w**.
- **Yolk sac**: **~5 w** (earliest confirmatory sign of IUGS).
- **Embryo + cardiac activity**: **~5.5–6 w** (CRL 2–4 mm).
- **CRL**: most accurate first-trimester dating (±3–5 days).
- **Discriminatory zone** (institution-specific; often TVUS **~1500–2000 mIU/mL**): above this β-hCG, an IUGS should be seen—absence suggests ectopic or failing gestation (interpret with clinical caution).

### 3.4 Fetal heart and clinical dating

- **Doppler FHR**: **~10–12 w** (110–160 bpm). Fetoscope: **~18–20 w**.
- **Fundal height** after 20 w ≈ **gestational age (cm) ±2 cm** (singleton; vertex; no fibroids/poly/oligo).

#### Applied pitfalls

- Do **not** label “missed abortion” on a single borderline early scan—**re-scan in 7–10 days** if criteria not met.
- In **pregnancy of unknown location** (positive hCG, empty uterus), always **exclude ectopic** (serial hCG + repeat TVUS).
- Use **CRL** over LMP for dating when cycles are irregular.

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## 4) Early-pregnancy differentials (when test positive/amenorrhoea)

- **Viable intrauterine pregnancy** (normal early).
- **Early pregnancy loss** (declining/plateau hCG, absent cardiac activity by criteria).
- **Ectopic** (pain, spotting, empty uterus above discriminatory zone, adnexal mass, free fluid).
- **Gestational trophoblastic disease** (very high hCG, “snow-storm” USG, theca-lutein cysts).
- **Non-pregnancy amenorrhoea**: lactation, PCOS, thyroid disease, hyperprolactinaemia, premature ovarian insufficiency.

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## 5) Case-sheet phrasing (how to write in exams)

> **G2P1L1**, LMP **10+4 w** ago, amenorrhoea, NVP, breast fullness; vitals stable. Abdomen: uterus ~**10–12 w**, soft, non-tender. PV: **Goodell +**, **Hegar +**. Urine hCG **positive**. **TVUS**: single live IUP, **CRL 38 mm (10+5 w)**, **FHR 162/min**. **Dx:** 10+5 w IUP (dated by CRL). **Plan:** routine ANC, IFA, dating card, danger-sign counselling.

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## 6) High-yield tables

### 6.1 System changes at a glance

| System | Change | Numbers to quote | Clinical significance |
|---|---|---|---|
| **CVS** | CO ↑; plasma > RBC | CO **+30–50%**; plasma **+40–50%**; RBC **+15–20%** | Physiologic anaemia; soft murmurs; avoid supine |
| **Resp** | Hyperventilation | $PaCO_2$ **30–32 mmHg**; MV **+30–50%** | Mild dyspnoea normal; alkalosis |
| **Renal** | GFR ↑ | **+40–50%**; creatinine falls | Treat bacteriuria; dose adjust renally cleared drugs |

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| System | Change | Numbers to quote | Clinical significance |
|---|---|---|---|
| **Heme** | Hypercoagulable | ↑ fibrinogen; ↓ protein S | VTE risk ↑; consider prophylaxis if high-risk |
| **Endocrine** | Insulin resistance | hPL effect; weight **+11–16 kg** | Screen **GDM**; diet/activity |
| **GI** | Motility ↓ | Reflux/constipation | Antacids, fibre, posture |
| **Breast/uterus** | Growth | Colostrum late; size landmarks | Distinguish Braxton–Hicks vs labour |

### 6.2 Signs of pregnancy

| Class | Examples |
|---|---|
| **Presumptive** | Amenorrhoea, NVP, breast changes, fatigue, frequency, quickening |
| **Probable** | Uterine enlargement; **Hegar**, **Goodell**, **Chadwick**, **Palmer**; urine hCG; ballottement |
| **Positive** | **USG embryo with cardiac activity**, FHR by Doppler, fetal movements seen/felt |

### 6.3 Early ultrasound landmarks

| Finding (TVUS) | Typical timing |
|---|---|
| Intrauterine sac | **4.5–5 w** |
| Yolk sac | **~5 w** |
| Embryo + cardiac activity | **5.5–6 w** |
| Accurate dating | **CRL (1st trimester)** |

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## 7) Viva pearls & common pitfalls

- Fundal height rule (20–36 w): **cm ≈ GA** (±2 cm); exceptions in poly/oligo, fibroids, obesity.
- **Physiologic anaemia** is haemodilution; treat iron deficiency (low MCV/serum ferritin), not numbers alone.
- Innocent systolic murmurs are common; red flags: syncope, cyanosis, resting dyspnoea, abnormal $SpO_2$.
- **Discriminatory zone** is not absolute; correlate with clinical picture and serial hCG.
- **Hyperemesis** beyond 1st trimester—rule out twins, GTD, thyroid dysfunction.
- Document **danger signs** at booking: bleeding, leaking, severe headache/visual symptoms, epigastric pain, decreased movements, fever.

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## Assessment

### A) Short Answer Questions (SAQ — 5 marks each)

1. Enumerate **five cardiovascular and respiratory changes** in pregnancy and their clinical implications.
2. Classify the **signs of pregnancy** and give **two examples** under each.
3. Describe the **timeline of early sonographic findings** and the role of **CRL** in dating.
4. Explain **Hegar, Goodell, Chadwick, Palmer** signs and approximate weeks of appearance.
5. Why does **physiologic anaemia** occur in pregnancy? Distinguish it from **iron-deficiency anaemia**.

### B) Long Answer Questions (LAQ — 10 marks)

1. Discuss **system-wise physiological adaptations** in pregnancy, giving key numerical changes and their relevance to antenatal care.
2. Describe the **diagnosis of pregnancy** under the headings: presumptive/probable/positive signs, **β-hCG** interpretation, **TVUS** criteria and discriminatory zone, uterine size by weeks, and differentials for **positive test with empty uterus**.

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## C) MCQs (Single best answer)

1. The **earliest reliable sonographic sign** confirming an **intrauterine** pregnancy is:
   A) Fetal pole  B) **Yolk sac**  C) Cardiac flicker  D) Crown–rump length
   **Ans:** B
2. Cardiac output in normal pregnancy increases by approximately:
   A) 5–10%  B) **30–50%**  C) 60–80%  D) No change
   **Ans:** B
3. **Hegar sign** denotes:
   A) Cervical softening  B) **Isthmic softening**  C) Bluish vagina  D) Uterine contractions
   **Ans:** B
4. The typical **$PaCO_2$** in late first/second trimester is around:
   A) 40–45 mmHg  B) **30–32 mmHg**  C) 25 mmHg  D) Unchanged
   **Ans:** B
5. After 20 weeks, **fundal height (cm)** in a singleton, vertex pregnancy usually corresponds to:
   A) GA + 4  B) GA − 4  C) **Gestational age (±2 cm)**  D) Not related
   **Ans:** C

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## Quick recap (30 seconds)

- CO **+30–50%**, plasma **+40–50%**, GFR **+40–50%**, MV **+30–50%**, $PaCO_2$ **~30–32 mmHg**, hypercoagulable; GI motility ↓; uterus & breasts enlarge; Braxton–Hicks ≠ labour.
- **Diagnosis**: organise as **presumptive → probable → positive**; use **β-hCG + TVUS** timeline; **CRL** for dating; Doppler FHR **~10–12 w**.
- Document clearly; avoid over-calling early loss; always consider **ectopic** in PUL.

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