NORMAL MATERNAL RESPIRATORY CHANGES in PREGNANCY

FLAME LECTURE: 25

BURNS 5.14.19

LEARNING OBJECTIVES

- Discuss the maternal physiologic and anatomic changes associated with pregnancy
- Prerequisites: NONE
- See also:
  - FLAME 24 – Normal cardiovascular changes in pregnancy
  - FLAME 89 – Asthma in pregnancy

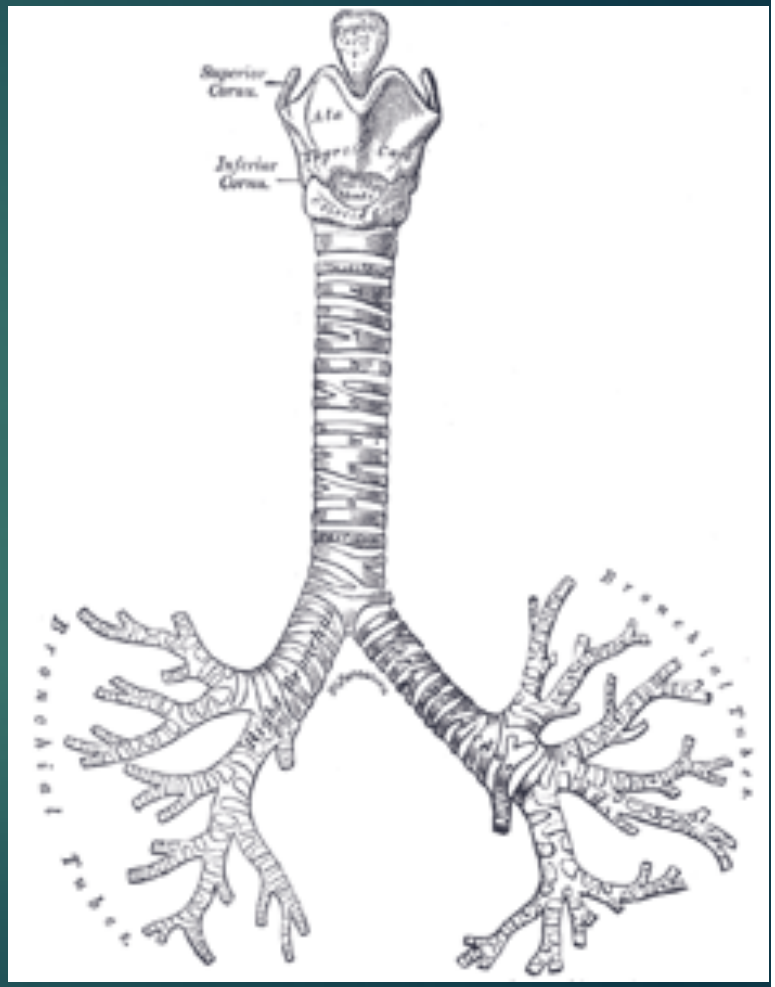
NORMAL RESPIRATORY PHYSIOLOGY

CELL TYPES

- Capillary endothelium
- Alveolar Type I pneumocytes: makes up 90-95% of alveolar surface, blood-gas exchange, highly susceptible to damage
- Alveolar Type II pneumocytes: produce surfactant, can transform into type I if type I's are damaged
- Alveolar macrophages: innate immune response to pathogens that evaded the lung's primary mechanical defenses
- PMN's: not usually seen, only in smokers/inflammation
- Mast/Clara/Club cells: secretagogue sentinel immune and exocrine cells

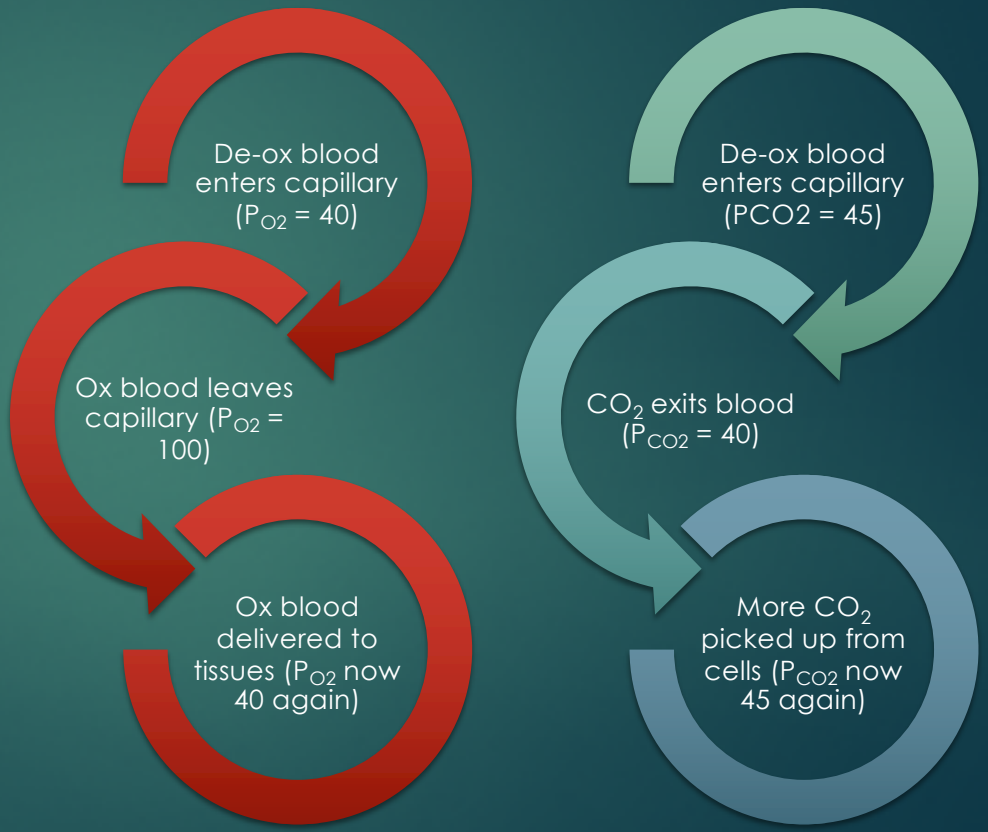
NORMAL GAS EXCHANGE

- Conducting zone: anatomic dead space (no gas exchange)
  - Trachea ➔ terminal bronchioles
- Respiratory zone: where gas exchange occurs
  - Respiratory bronchioles ➔ alveolar sacs



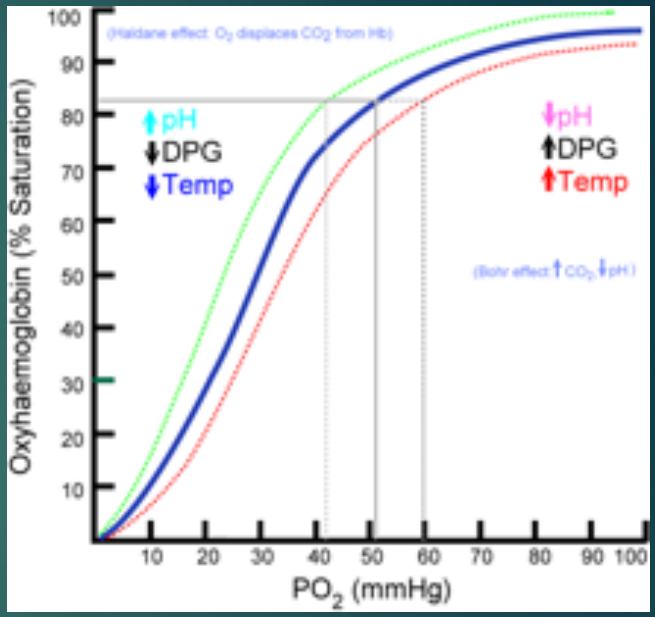
NORMAL GAS EXCHANGE

- Gas exchange (via diffusion) is driven by partial pressure differences of O_2 & CO_2 in alveoli vs. blood



NORMAL GAS TRANSPORT IN BLOOD

- 98.5% of O_2 is bound to Hgb / 1.5% is dissolved in plasma
  - Recall hemoglobin binding curve. Hgb binds O_2 in a sigmoidal distribution so that the more O_2 molecules bound, the more favorable it is to bind another O_2 molecule
    - However, Hgb has the capacity to release more oxygen if the tissue's (OR FETUS') needs are greater **(right shift)**
    - Conversely, Hgb can withhold more O_2 if tissue needs are decreased **(left shift)**
- Carbon Dioxide transport:
  - Bicarbonate (HCO_3) – 60%, Carbaminohemoglobin (bound to Hgb) – 30%, Dissolved in plasma – 10%



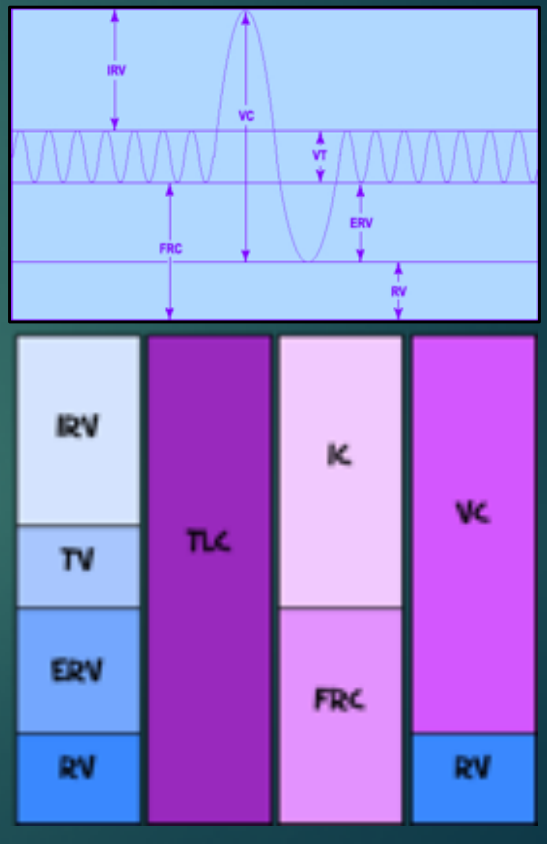
Factors that shift the curve right (more O2 released):

- < pH
- > DPG
- < body temp

NORMAL LUNG VOLUMES

THIS IS JUST A REVIEW, DON'T GET BOGGED DOWN IN THE DETAILS

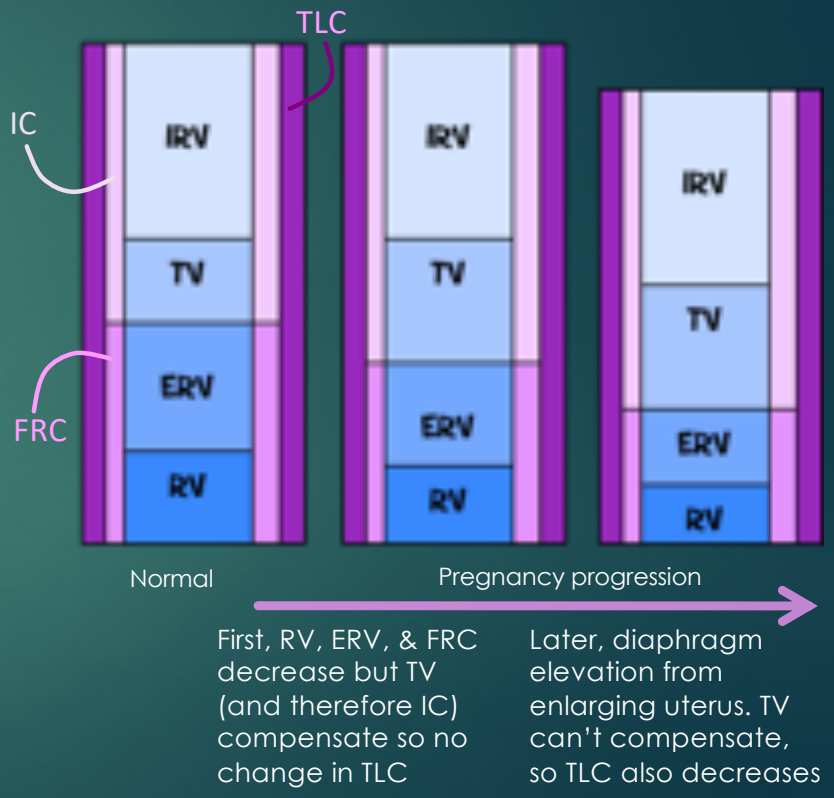
- The lung has 4 different volumes:
  - **IRV** (inspiratory reserve volume) - maximal volume that can be inhaled from the end-inspiratory level
  - **TV** (tidal volume) - volume of air moved into or out of the lungs during quiet breathing
  - **ERV** (expiratory reserve volume) - maximal volume of air that can be exhaled from the end-expiratory position
  - **RV** (residual volume) - volume of air remaining in the lungs after a maximal exhalation
- 2 or more volumes together = a capacity:
  - **TLC**: total lung capacity = IRV + TV + ERV + RV
  - **VC**: vital capacity = IRV + TV + ERV
  - **IC**: inspiratory capacity = IRV + TV
  - **FRC**: functional reserve capacity = ERV+ RV
- **FEV_1**: volume of air expired in 1st second of forceful expiration
- **Minute ventilation: volume of air inspired/expired per minute**
  - **Can increase with *deeper* breaths or *more frequent* breaths**



LUNG VOLUMES IN PREGNANCY

THE CHANGES BELOW ARENT OVERWHLEMINGLY IMPORTANT CLINICALLY!

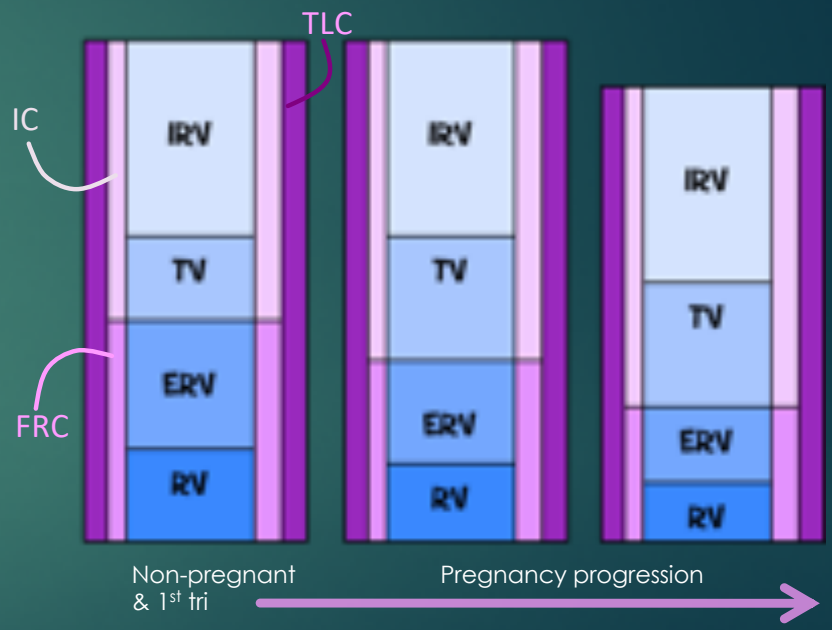
- **RV**, **ERV** (and thus **FRC**) all decrease due to uterus compressing + elevating diaphragm
- **VC** and **TLC** maintained until late pregnancy
  - **IC** initially increases slightly to offset FRC decrease and maintain TLC (2nd diagram)
- **FVC*** and **FEV_1** are UNCHANGED during pregnancy
  - ***VC** can be measured as slow **vital capacity** (**VC**) or **forced vital capacity** (**FVC**); **VC** decreases because diaphragm elevation effects **ERV** passively, but **FVC** doesn't change because diaphragm excursion doesn't change with a forced exhalation
  - Thus, changes in **FVC** and **FEV_1** suggest underlying pulmonary pathology (asthma, bronchitis, COPD)
    - ↓ FVC/FEV_1 = obstructive pulmonary dz
    - ↑ FVC/FEV_1 = restrictive pulmonary dz



LUNG VOLUMES IN PREGNANCY

NOTE: TIDAL VOLUME & MINUTE VENT ARE MORE IMPORTANT!

- **TV** increases in pregnancy, resulting in increased minute ventilation
  - Progesterone stimulates respiratory drive by lowering the respiratory drive center threshold to CO_2, allowing for an increase in ventilation
    - Thus, minute ventilation is increased through **more volume in/out with each breath** and *not by* increased respiratory rate (RR largely remains unchanged in pregnancy)
  - Also, the chest wall broadens to facilitate increased TV
    - This occurs both from the expanding abdomen and via the same protein *relaxin* that allows for relaxation of pelvic ligaments to expand pelvis



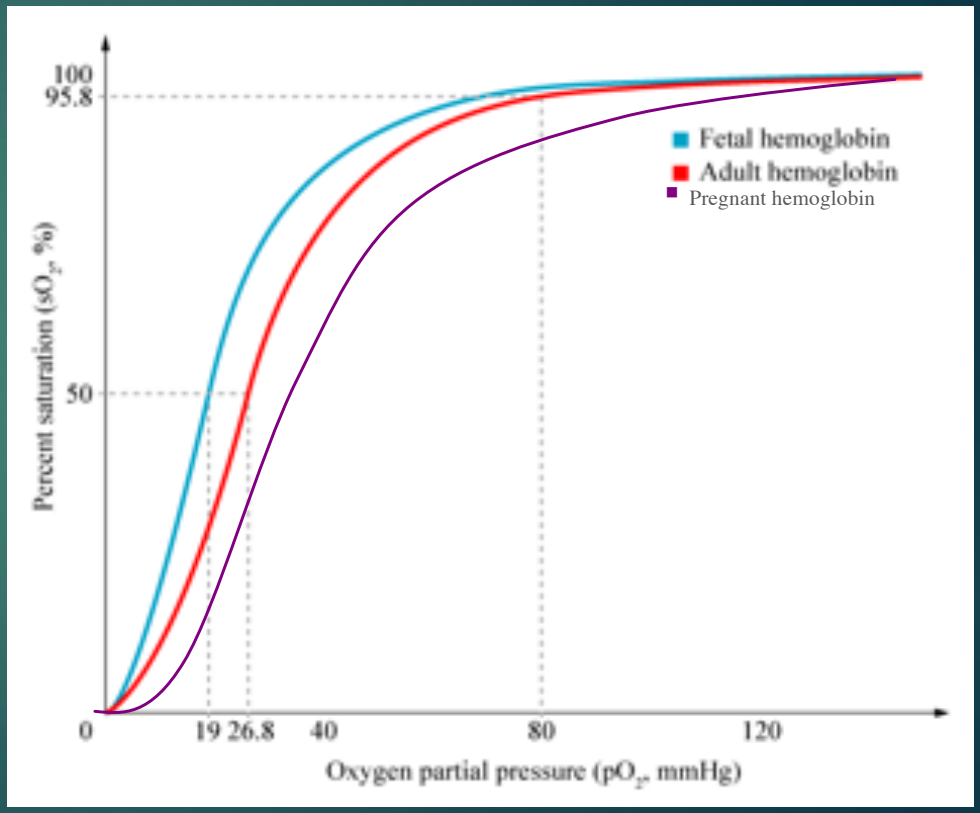
CHANGES IN BLOOD GASSES

- The increase in minute ventilation allows for more CO_2 to be blown off causing a mild **respiratory alkalosis**
- **AND WHY IS PROGESTERONE MEDDLING IN RESPIRATORY PHYSIO?**
  - Because the fetus not only depends upon the maternal respiratory system for obtaining O_2, but also for CO_2 excretion; decreased maternal P_{CO2} creates a gradient that allows the fetus to offload CO_2
  - This is partially compensated with increased maternal renal loss of HCO_3, but blood gasses are still shifted during pregnancy

ABG	NON-PREGNANT	PREGNANT
pH	7.38-7.42	7.39-7.45
pCO_2	38-42	25-33
pO_2	90-100	92-107
BICARB	22-26	16-22

RESPIRATORY ALKALOSIS

- Consider again the hemoglobin binding curve!
- Maternal respiratory alkalosis causes a right shift so that Hgb binds less tightly to O_2
  - At the same time, fetal hemoglobin has a higher binding affinity for O_2
  - Thus, fetal blood can draw more O_2 from maternal blood as maternal Hgb releases more O_2



TAKE HOME POINTS

1. The progesterone-mediated increase in minute ventilation allows mom to blow off more CO_2 thus becoming more alkalotic at baseline. This alkalosis is what drives efficient O_2 and CO_2 exchange between mom and baby.
2. With exception of the above, most pregnancy-related anatomic and physiologic changes are not of great clinical importance to mom, UNLESS she gets sick!

PREVIEW TO PATHOLOGIC LECTURES:

1. When pulmonary pathology arises in mom (asthma, CAP, etc), gas exchange will be impaired, and she will start to retain CO_2. Thus, her pH will first normalize to that of a non-pregnant patient before becoming more acidotic
2. Thus, it is of critical importance to understand that:
    1. A pH in the normal range of a non-pregnant patient is NOT normal for mom. Do not miss her early decline in respiratory status, or she can spiral downwards
    2. If mom is increasingly retaining CO_2, baby is also becoming acidemic! Because now the gradient is not allowing for baby to offload CO_2 either

REFERENCES

1. UpToDate
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4. Soma-Pilay P, et al. Physiological changes in pregnancy. Cardiovasc J Afr. 2016; 27(2):89-94.
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