

***NEET SS ANAESTHESIA
OBSTETRIC
ANAESTHESIA***

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PHYSIOLOGICAL CHANGES OF PREGNANCY : ANAESTHESIA IMPLICATIONS

Overview

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Physiological changes of pregnancy :

maternal adaptations to meet demands of pregnancy.

- Support to the fetus : maternal body supplies **nutrients, oxygen** to the fetus and eliminate **waste products** from the fetus.
- Preparation of uterus for labor.
- Protection of mother at delivery : Protection from the **blood loss**.

Systems undergoing changes in pregnancy :

- Cardiovascular system.
- Respiratory system.
- Hematological system.
- Gastrointestinal system.
- Renal system.
- Central nervous system.

Cardiovascular system

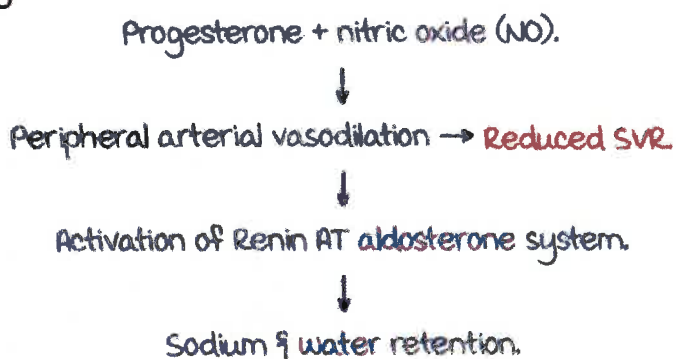
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Changes in physical examination :

- Leftward displacement of cardiac impulse : Shifts the apical impulse at **4th** intercostal space.
- Accentuation of S1 : Due to increased size and blood flow in the heart.
- Typical ejection systolic murmur at left sternal border : It is a benign flow murmur due to tricuspid regurgitation.
- ECG : Increase in HR, short PR & QT interval, left shift of axis is considered normal in pregnancy.
- ECHO : LVH (50% at term), valvular regurgitation (TR, PR, MR).

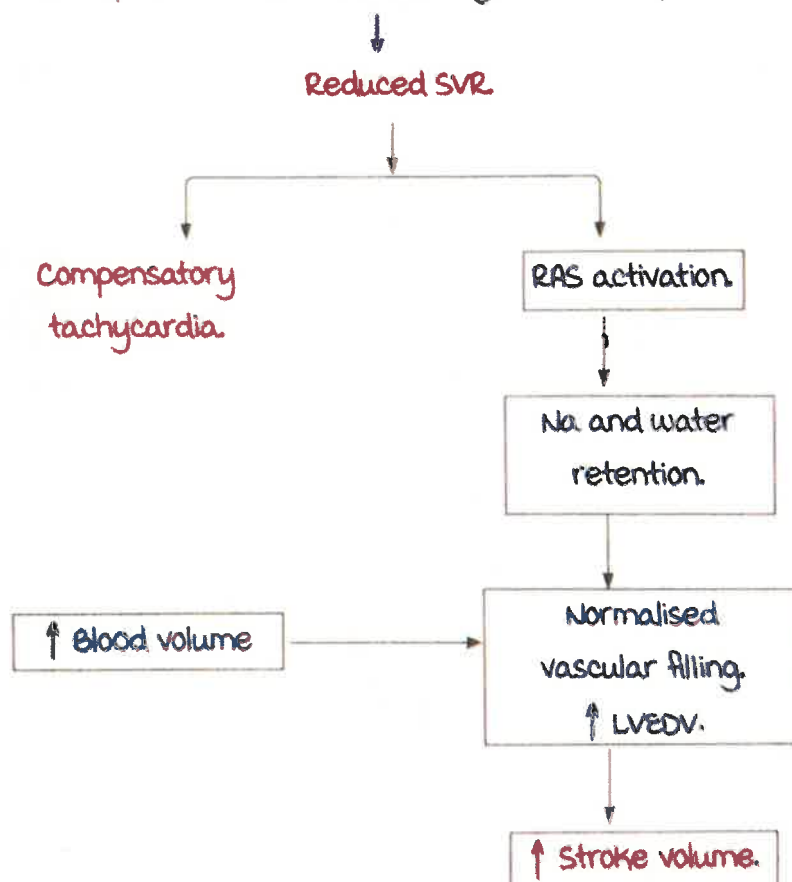
Pathophysiology of these changes :

Early pregnancy :



Late pregnancy :

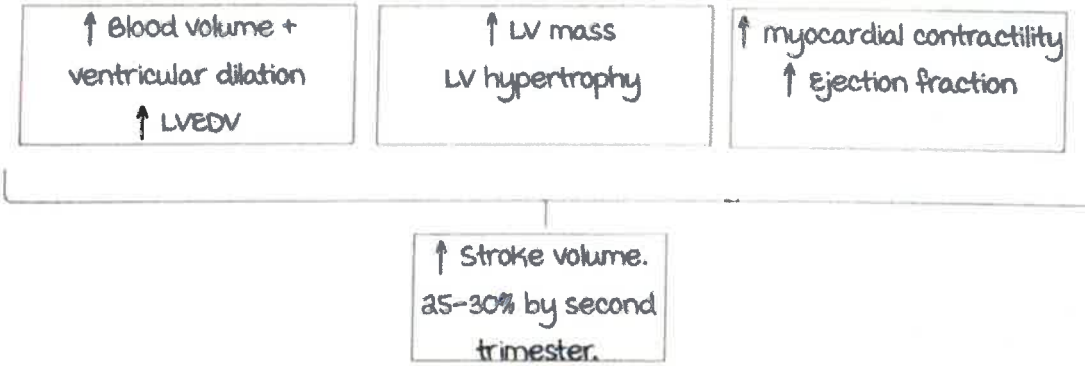
Progressive development of low resistance high flow uteroplacental circulation.



Increased heart rate :

- Increases early (4-5 weeks).
- 15-25% increase by end of first trimester.
- No change in further trimesters.
- Decreases to pre-pregnancy level by 2 weeks post partum.

Stroke volume :



Cardiac output :

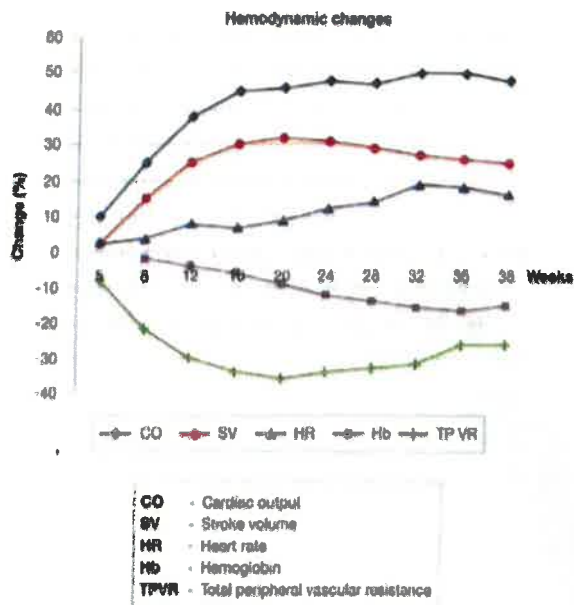
Parameter	begins	First trimester	Second trimester	Third trimester
↑ Heart rate	4-5 weeks	15-25%	No change	No change
↑ Stroke volume		20%	25-30%	
↑ Cardiac output	5 weeks	35-40%	50%	No change

Cardiac output during pregnancy :

	Labor 1st stage	Labor 2nd stage	Immediate postpartum
CO (Pre-labor)	25%	40%	115%
CO (Pre-pregnancy)	75%	90%	150%

- It takes 24 hours for CO to drop to pre-labor values.
- It takes 12 to 24 weeks for CO to drop to pre-pregnancy values.

major hemodynamic changes :



Critical phases in pregnancy (Peak increase in CO) :

- 14-16 weeks.
- 28-32 weeks.
- Labor.
- 72 Hours postpartum (150% increase).
- Return to non pregnant state by 3-6 months postpartum.

These patients with signs of heart failure needs to be evaluated for underlying disease.

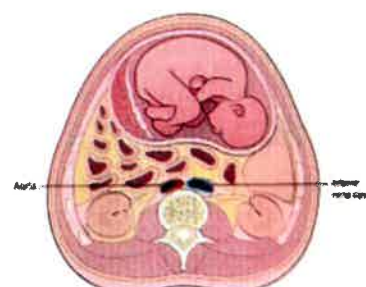
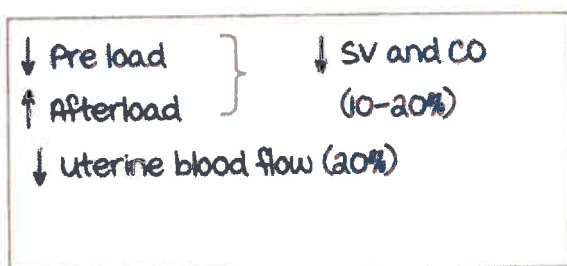
Blood pressure :

- ↓ SVR
- Systemic maternal vasodilation.
- Resultant ↑ CO.
- ↓ SBP, DBP, MAP (First trimester to mid-pregnancy).
- ↓ DBP > ↓ SBP.
- Return to baseline at term.

Aortocaval compression :

Supine position at term gestation leads to :

- Near complete IVC obstruction.
- Partial compression of aorta.



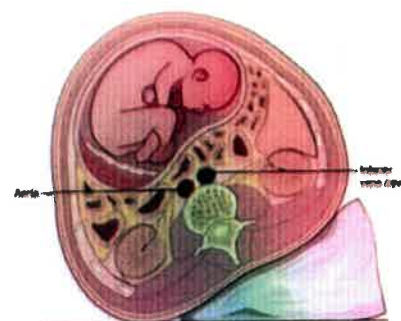
Supine position.

Left lateral position at term gestation :

- Partial IVC compression.
- Venous return maintained by collaterals.

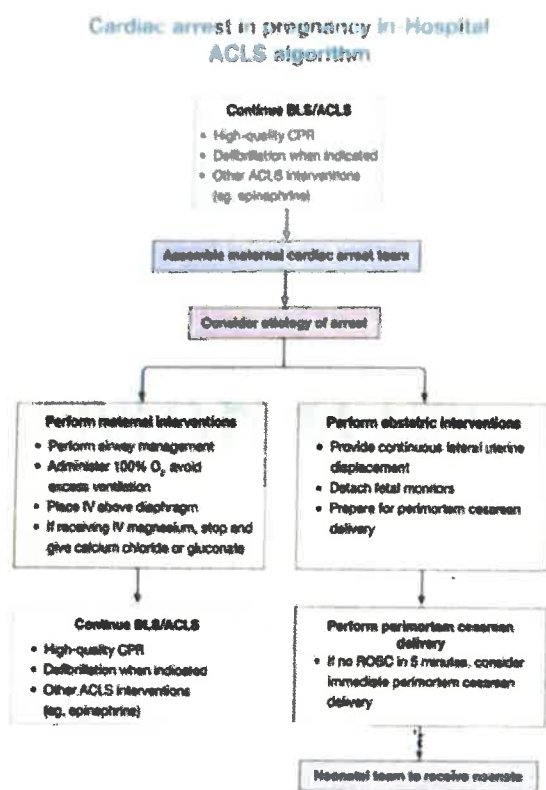
Hence it is advised to maintain :

- **Left uterine displacement** 18-20 weeks onwards.



Left lateral position.

2020 AHA update on maternal resuscitation :



Regional blood flow :

- uterine blood flow
(50 ml/min → 700-900 ml/min).
- Renal plasma flow.
- Skin blood flow.
- Pulmonary blood flow.

All increased.

Blood volume in a pregnant lady would be 6300ml, and might lose upto 4500ml in 5 minutes. Hence do not underestimate blood loss.

Summary :

- Heart rate → Increased 15-25%
- Stroke volume → Increased 25-30%
- Cardiac output → Increased upto 50%
- LV-EDV → Increased.
- Ejection fraction → Increased.
- CVP/PCWP → No change.
- SVR → Reduced 20%.
- BP → Decreased.

Respiratory system

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Anatomical changes :

- ↑ estrogen, ↑ level blood volume and hypervascularity → mucosal edema of nose, oropharynx and larynx

Symptoms :

- Nasal congestion : Perceived as shortness of breath.
- Rhinitis.
- Epistaxis .

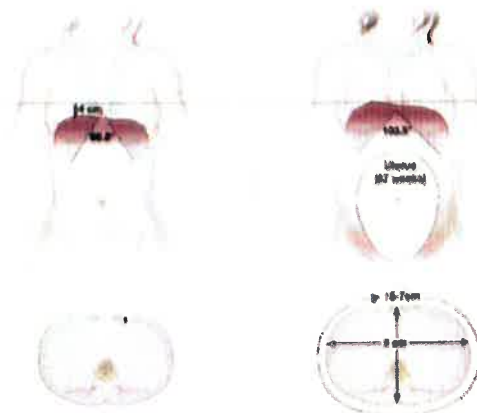
Anaesthesia implications :

- Careful airway handling, laryngoscopy, suctioning due to risk of bleeding.
- Nasal airway placement may lead to epistaxis.
- Early upper airway obstruction.
- Advanced Mallampatti Grade (Can reach MPC 3-4).
- Small handle endotracheal tube needs to be ready.
- Breast engorgement.

Changes in mechanics of respiration :

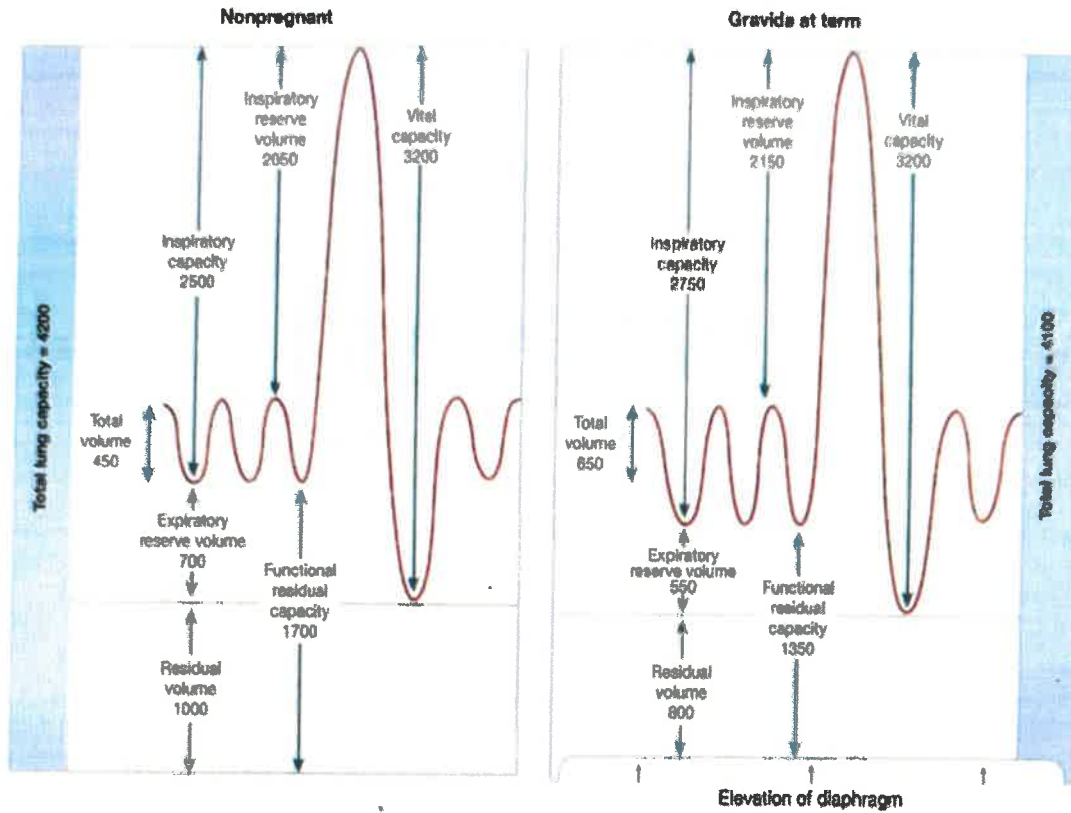
- Diaphragm excursion → Increased
- Chest wall excursion → Decreased
- Respiratory muscle strength → No change.
- FEV1 → No change.
- FEV1/FVC → No change.
- Closing capacity → No change.

Respiration completely changes to **totally diaphragmatic inspiration**.



mechanical changes in respiration.

Lung volumes and capacities :



Lung volumes and capacities.

When patient is supine, the following changes take place :

- upward diaphragmatic displacement.
- Closing capacity > FRC.
- Airway collapse during tidal breathing.
- Risk of atelectasis & hypoxemia.

All of which lead to faster desaturation.

Parameter	Change
Lung volumes	
Inspiratory reserve volume	+ 5%
Tidal volume	+ 45%
Expiratory reserve volume	- 25%
Residual volume	- 15%
Lung capacities	
Inspiratory capacity	+ 15%
Functional residual capacity	- 20% at term - 30% in supine
Vital capacity	No change
Total lung capacity	- 5%

Changes in ventilation :

- Progesterone which is a respiratory stimulant, leads to :
 - \uparrow metabolism and \uparrow CO₂ production \rightarrow \uparrow in minute ventilation \rightarrow Raise in TV upto 40% and RR upto 15%.
- This leads to further increase in oxygen consumption and work of breathing.

Parameter	Term	1st stage of labor	and stage of labor
minute ventilation	+50%	+70-140%	+120-200%
Oxygen Consumption	+20%	+40%	+75%

These changes result in :

- Dyspnea.
- Respiratory alkalosis in pregnancy.
- Hypocarbia & alkalosis during labor.
- Increased O₂ requirement & lactate concentration during labor.

This further results in **left shift** in the dissociation curve.

Hence epidural anaesthesia is given to reduce these changes by reduction in pain and minute ventilation.

Clinical significance :

- Difficult airway, reduced FRC, increased O₂ requirement all leading to \rightarrow Early desaturation.
- This can be managed by pre oxygenation bringing $F_{\text{ET}O_2} > 80\%$

Changes in blood gases :

	Non pregnant	Pregnant
pH	7.35-7.45	7.40-7.45
PaCO ₂	35-45	27-34
PaO ₂	80-100	101-104
HCO ₃	22-26	18-22

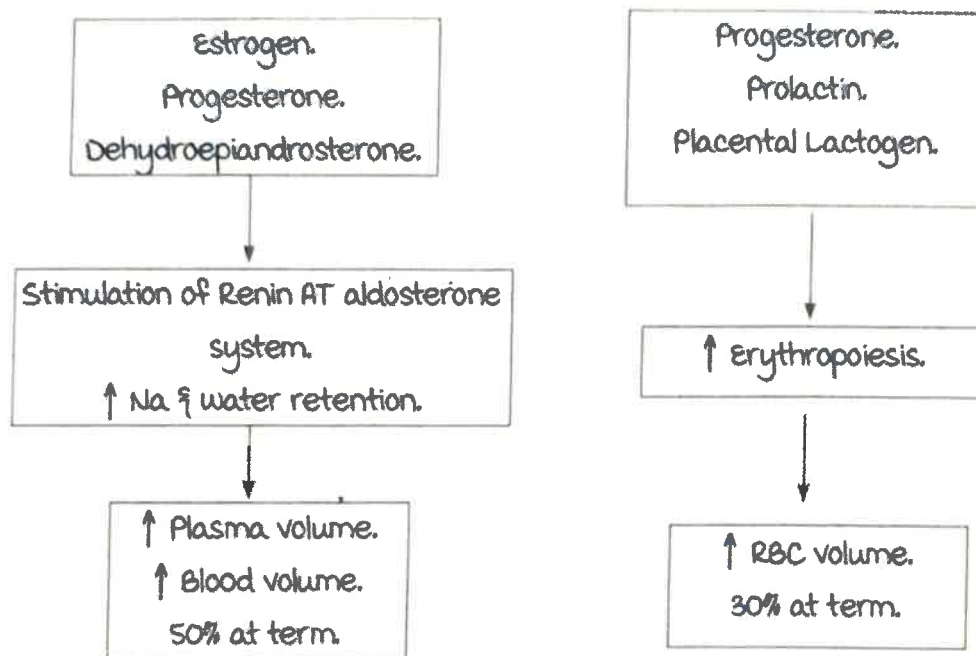
- The net physiologic result of respiratory changes is a lowering of maternal PaCO₂ to less than that of the fetus, thus facilitating effective exchange of CO₂ from fetus to mother.
- maternal CO₂ should always be less than fetal value for normal flow of CO₂.

- Respiratory alkalosis → Normal.
- PaCO₂ >35mmHg → Impending respiratory failure.
- PaCO₂ >40mmHg → Frank respiratory failure.

Hematology

00:35:06

Blood volume :



- Plasma volume > RBC volume, which leads to physiological anemia.

Advantages of maternal hemodilution :

- Decreased blood viscosity, improved uteroplacental perfusion.
- Prevents blood stasis and placental thrombosis.
- Protective mechanism against excessive blood loss at delivery.
- Plasma volume expansion maintains blood pressure in the presence of decreased vascular tone.

Plasma proteins :

- Total proteins : Decreased.
- Albumin concentration : Decreased.

Colloid Osmotic Pressure :

- Non pregnant : 26-28 mmHg.
- Pregnancy : Reduced to 22 mmHg.
- Postpartum : Reduced to 15 mmHg.

When this low colloidal osmotic pressure blood flows through the body, it can lead to **pulmonary edema** and hence precaution needs to be taken before giving fluids.

- PCWP : 6-12 mmHg.
- COP - PCWP gradient : 12-15 mmHg.

Coagulation :

- Pregnancy is a **hypercoagulable state** in order to minimize blood loss at delivery.
- There is :
 - ↑ Clotting factors leading to risk of thrombosis.
 - ↓ Platelets due to increased consumption and destruction of platelets leading to risk of **gestational thrombocytopenia** (Platelet count >1 lakh and <1.5 lakh).
 - ↑ Fibrinolysis.

Coagulation parameters at term gestation :

- Increased factor concentrations :
 - Factor i
 - Factor vii
 - Factor viii
 - Factor ix
 - Factor x
 - Factor xii
- Unchanged factor concentrations :
 - Factor ii
 - Factor v
- Decreased factor concentrations :
 - Factor xi
 - Factor xiii
- Increased clotting factors goes further high in 1st week postpartum, but takes 2 weeks to return back to the pre pregnancy state.
- PT, APTT : Shortened.
TEG : Hypercoagulable.

mother is prepared for the hemorrhage of childbirth, but there is increased risk of thromboembolism not only during pregnancy but also during puerperium.

Reducing the risk of venous thromboembolism during pregnancy and the puerperium :

Risk factors for venous thromboembolism in pregnancy and the puerperium

Pre-existing	Previous VTE	
	Thrombophilia	<p><i>Inherited</i></p> <ul style="list-style-type: none"> Factor V Leiden Prothrombin gene mutation Antithrombin deficiency Protein C deficiency Protein S deficiency <p><i>Acquired</i></p> <ul style="list-style-type: none"> Antiphospholipid antibodies Persistent lupus anticoagulant and/or persistent moderate/high titre anticardiolipin antibodies and/or β_2-glycoprotein I antibodies
		Medical comorbidities e.g. cancer, heart failure; active SLE, inflammatory polyarthropathy or IBD; nephrotic syndrome; type I diabetes mellitus with nephropathy; sickle cell disease; current intravenous drug user
		Age > 35 years
		Obesity (BMI ≥ 30 kg/m ²) either pre-pregnancy or in early pregnancy
		Parity ≥ 3 (a woman becomes para 3 after her third delivery)
		Smoking
Obstetric risk factors		Gross varicose veins (symptomatic or above knees or with associated phlebitis, oedema/skin changes)
		Paraplegia
		Multiple pregnancy Current pre-eclampsia
New onset/transient These risk factors are potentially reversible and may develop at later stages in gestation than the initial risk assessment or may resolve and therefore what is important is an ongoing individual risk assessment		Caesarean section Prolonged labour (> 24 hours) Mid-cavity or rotational operative delivery Stillbirth Preterm birth Postpartum haemorrhage (> 1 litre/requiring transfusion)
		Any surgical procedure in pregnancy or puerperium except immediate repair of the perineum, e.g. appendicectomy, postpartum sterilisation Bone fracture
		Hyperemesis, dehydration
		Ovarian hyperstimulation syndrome (first trimester only)
		Admission or immobility (≥ 3 days bed rest)
	Current systemic infection (requiring intravenous antibiotics or admission to hospital)	Assisted reproductive technology (ART), in vitro fertilisation (IVF) e.g. pelvic/abdominal pain restricting mobility e.g. pneumonia, pyelonephritis, postpartum wound infection
	Long distance travel (≥ 4 hours)	

Pregnant patient with the following risk factors must be given thromboprophylaxis :

- Age ≥ 35 years.
- BMI ≥ 35 .
- Bleeding > 1 litre.
- Severe pre eclampsia.

Renal system

00:43:40

Alteration in system and associated clinical relevance :

Alteration	Clinical relevance
Dilation of collecting system (R > L).	Hydronephrosis. Asymptomatic bacteruria. Risk of pyelonephritis.
Renal vasodilation.	Increase in RBF (75%). Increase in GFR (50%).
Altered tubular function.	Glycosuria. Proteinuria.

Normal lab parameters during pregnancy :

Variable	Normal value
Blood urea nitrogen.	8-9 mg/dl.
Serum creatinine.	0.5-0.6 mg/dl.
Bicarbonate.	18-21 mEq/L.
Urinary proteins.	MAX loss : 300 mg/24 hr.
Plasma osmolarity.	280 mOsm/L (↓ 10 mOsm/L).

Summary :

- Creatinine & nitrogenous waste : Excreted.
- Sodium and water : Filtered but reabsorbed.
- Protein : Excreted.
- Sugars : Excreted.

Gastrointestinal system

00:47:54

Overview :

- Reduced lower esophageal sphincter tone :
 - The gravid uterus pushes the diaphragm up and alters the relation of the diaphragm and the lower esophageal sphincter.
 - Since progesterone is a smooth muscle relaxant, increased levels of progesterone cause change in the lower esophageal sphincter tone.
- Gastric acid secretion : Remains same.
- Delayed gastric emptying in labor.

All the above mentioned reasons cause an increased risk of aspiration.
It also causes a difficult airway.

management :

Antacid prophylaxis :

- Non particulate (0.3 molar sodium citrate 30 ml) rapidly neutralises pH.
- H₂ receptor antagonist like : Ranitidine/famotidine. PO : 1 to 2 hrs prior; IV : 30 mins prior.
- PPI.
- metoclorpromide : Increases gastric emptying and increases LES tone.
 - Given atleast 30 mins before surgery.

Gastric ultrasound :



The "empty" antrum appeared collapsed and "flat", as the anterior and posterior walls were too close to each other.



The antrum appeared to expand in a circle when it was filled with a transparent liquid.



The antrum with mixed echo contents appeared to expand when filled with solid contents, giving the film a "frosted glass" appearance.

Central nervous system

00:54:58

Increased sensitivity to :

- volatile anesthetic agents : MAC reduced by 40%. The clinical doses remain the same.
- Sedatives.
- muscle relaxant :
 - Pseudocholinesterase is reduced by 25% but increased volume of distribution.
 - Clinically there is no prolongation of the duration of single dose succinylcholine.
 - Sensitivity to vecuronium and rocuronium is increased.
- Local anesthetics (Neuraxial anaesthesia) :
 - Progesterone increases **neural sensitivity** towards the local anaesthetics.
 - Engorged epidural veins help in reducing the required dose of local anaesthetic by 25% for spinal anaesthesia.
 - There is no change in drug requirement for epidural anaesthesia.



Pelvic widening and resultant head down tilt in the lateral position during pregnancy (upper panel, pregnant, lower panel, nonpregnant)

Technical aspect of neuraxial anaesthesia :

- Increased lumbar lordosis.
- Widening of pelvis causes head down tilt :
 Difficult to inject → Need for less LA →
 Rapid onset → Tends to spread higher
 due to widening of pelvis.

PLACENTAL DRUG TRANSFER

Introduction

00:01:13

The human placenta is a complex organ that acts as the **interface** between the mother and fetus.

Its functions are :

1. **Gas exchange** and the transfer of **nutrients and waste products** between maternal and fetal plasma.
2. Transfer of **immunity** by transfer of immunoglobulins from the mother to the fetus.
3. Secretion of **hormones** which are important for fetal growth and development.

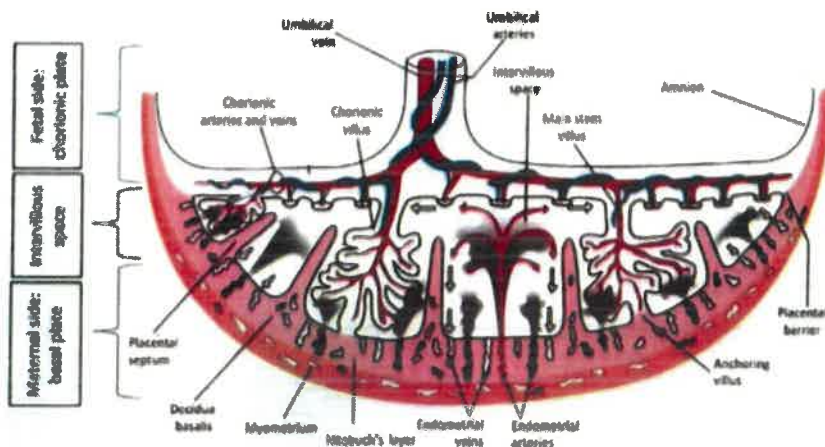
Vascular architecture :

maternal :

Bloody supply to uterus → uterine artery and ovarian artery → Arcuate arteries → Small branches supply myometrium; large branches (Radial artery) supply endometrium → Spiral arteries supply placenta → Trophoblastic invasion during early gestation → Loss of smooth muscular layer → Vasodilation → ↑ Blood flow to placenta → Blood enters into intervillous space (Pool of maternal blood) → Drain into collecting veins → uterine and ovarian veins.

Fetal :

2 Umbilical arteries carry deoxygenated blood → Chorionic arteries → Capillaries → Enter villi → Drains into chorionic veins → Drains into umbilical veins which carry oxygenated blood to fetus.



uteroplacental blood flow :

Causes of decreased uterine blood flow	
Decreased perfusion pressure	Increased uterine vascular resistance
<p>↓ uterine arterial pressure :</p> <ul style="list-style-type: none"> • Aortocaval compression • Hypovolemia • Hypotension <p>↑ uterine venous pressure :</p> <ul style="list-style-type: none"> • vena caval compression • uterine contractions • Drug induced uterine tachysystole (Oxytocin, LA) • Valsalva maneuver, seizures 	<p>Endogenous vasoconstrictors :</p> <ul style="list-style-type: none"> • Catecholamines (Stress) • Vasopressin (In response to hypovolemia) <p>Exogenous vasoconstrictors :</p> <ul style="list-style-type: none"> • Epinephrine • Vasopressors (Phenylephrine > Ephedrine) • Local anaesthetics in high concentrations

Factors affecting placental transfer of drug :

Placental factors	Pharmacologic factors
<ul style="list-style-type: none"> • Placental surface area • Placental thickness • pH of maternal and fetal blood • Placental metabolism • uteroplacental blood flow • Presence of placental drug transporters 	<ul style="list-style-type: none"> • molecular weight of drug • Lipid solubility • pKa • Protein binding • Concentration gradient across placenta

Mechanism

00:12:05

Transport mechanisms :

1. Passive transport.
2. Facilitated transport.
3. Active transport.
4. Pinocytosis.