Obstetrical Anesthesia

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Outline

- Physiologic Changes of Pregnancy
- Placental Drug Transfer
- Labor Analgesia
- Anesthesia for Cesarean Delivery
- Anesthetic Implications

1.
Physiologic Changes of Pregnancy

Physiologic Changes of Pregnancy

- Hematologic function
- Cardiovascular function
- Respiratory function
- Gastrointestinal function
- Metabolic function
- Altered Drug Responses

Hematologic Function

- Increase **plasma volume** and **total blood volume**
  - Increased mineralocorticoid activity
    - Sodium retention -> increased body water content
- **Physiologic anemia of pregnancy**
  - Reduction in Hb concentration (11 g/dL) and hematocrit (35%)
    - Relatively smaller increase in RBC volume to plasma volume

Hematologic Function

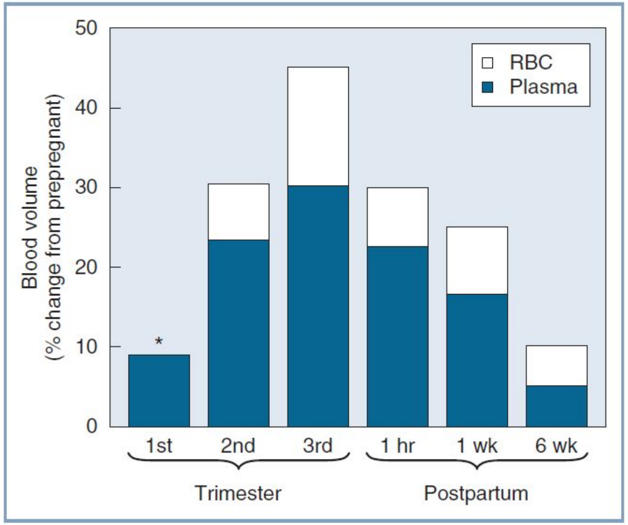


Fig. 2.7 Blood Volume during Pregnancy and the Puerperium. Values during pregnancy measured at the end of the first, second, and third trimesters. Postpartum values measured after a vaginal delivery. The values for red blood cell volume *(RBC)* and plasma volume *(Plasma)* do not represent the actual percentage of change in these parameters but rather reflect the relative contribution of each to the change in blood volume. The asterisk indicates that RBC volume is below the prepregnancy volume at the end of the first trimester.

TABLE 2.6 Hematologic Parameters at Term Gestation

Parameter	Change[a] or Actual Measurement
Blood volume	+45%[a]
Plasma volume	+55%[a]
Red blood cell volume	+30%[a]
Hemoglobin concentration (g/dL)	11.6
Hematocrit	35.5%

[a]Relative to nonpregnant state.

Modified from Conklin KA. Maternal physiological adaptations during gestation, labor, and puerperium. *Semin Anesth.* 1991;10:221–234.

Hematologic Function

- Increase **leukocyte** count to 10,000/mm^3
  but impaired PMN leukocyte function
  - Depressed neutrophil chemotaxis and adherence
  - Greater incidence of infection and autoimmune diseases' symptoms

Hematologic Function

- Decrease platelet count
  - 6% to 15% of pregnant women at term; <150×10^9/L
  - Further 1% of women at term; <100×10^9/L
- *Compensated disseminated intravascular coagulation*
  - Increased clotting and probable secondary fibrinolysis
    - Decrease anticoagulant activity
      - Decreased protein S concentrations
      - Activated protein C resistance
      - Impaired fibrinolysis

Hematologic Function

BOX 2.2 Changes in Coagulation and Fibrinolytic Parameters at Term Gestation[a]

Increased Factor Concentrations

- Factor I (fibrinogen)
- Factor VII (proconvertin)
- Factor VIII (antihemophilic factor)
- Factor IX (Christmas factor)
- Factor X (Stuart-Prower factor)
- Factor XII (Hageman factor)

Unchanged Factor Concentrations

- Factor II (prothrombin)
- Factor V (proaccelerin)

Decreased Factor Concentrations

- Factor XI (thromboplastin antecedent)
- Factor XIII (fibrin-stabilizing factor)

Other Parameters

- Prothrombin time: shortened 20%
- Partial thromboplastin time: shortened 20%
- Thromboelastography: hypercoagulable
- Fibrinopeptide A: increased
- Antithrombin III: decreased
- Platelet count: no change or decreased
- Fibrin degradation products: increased
- Plasminogen: increased
- Plasminogen activator inhibitor-II: increased

[a]Relative to nonpregnant state.

Hematologic Function

- Declines **serum cholinesterase** activity (~20-25%)
  - Moderate succinylcholine doses lead to prolonged apnea is doubtful

Cardiovascular Changes

- O_2 consumption increases
  - Adapt cardiovascular system for metabolic demanding to growing fetus
- Decline in SVR
  - Vessels lose their responsiveness to angiotensin and other pressors
  - Vasodilatory hormone

Cardiovascular Changes

Chronotropic Agents and Vasopressors

- Reduces in chronotropic response to isoproterenol and epinephrine
  - Down-regulation of beta-adrenergic receptors
- Require higher doses of vasopressors (e.g. phenylephrine) for treatment of hypotension
  - Down-regulation of adrenergic receptors

Cardiovascular Changes

- Increase in CO by 30% to 50%
  - Additional increases in CO occur during labor and also in immediate postpartum period
    - Added blood volume from the contracted uterus
      - Exaggerated in multiple gestation pregnancies
- Increase in SV by 20% to 50%
- Mild Increase in HR
- Slightly decrease in BP
  - Decrease in SVR exceeds increase in CO

Cardiovascular Changes

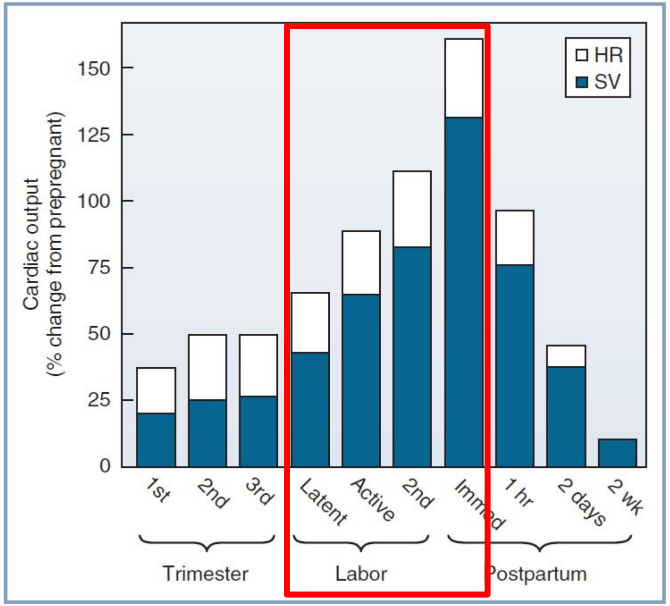


Fig. 2.2 **Cardiac Output during Pregnancy, Labor, and the Puerperium.** Values during pregnancy are measured at the end of the first, second, and third trimesters. Values during labor are measured between contractions. For each measurement, the relative contributions of heart rate *(HR)* and stroke volume *(SV)* to the change in cardiac output are illustrated.

Cardiovascular Changes

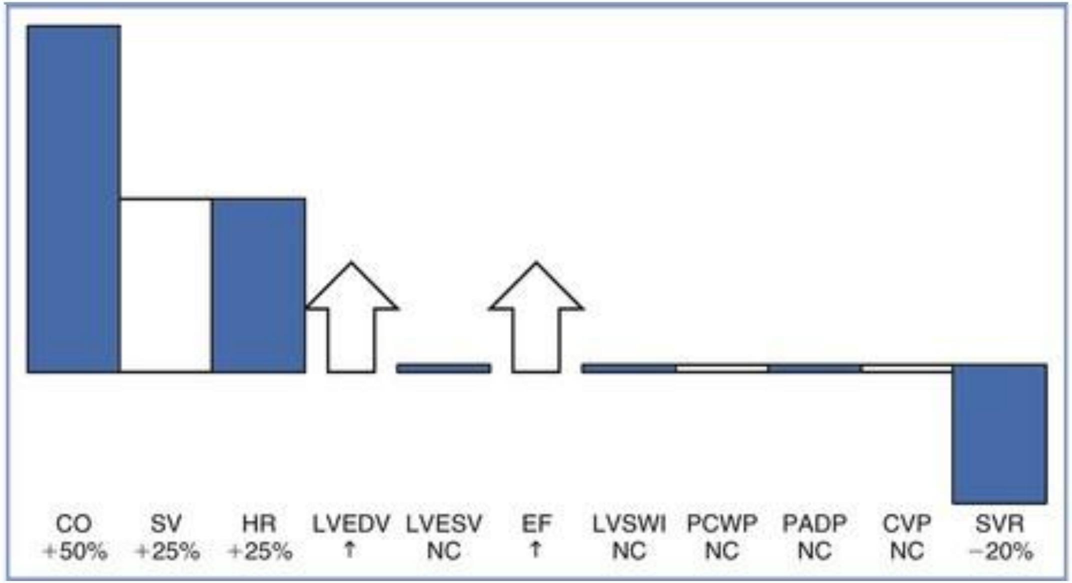


Fig. 2.1 Central Hemodynamic Changes at Term Gestation. Changes are relative to the nonpregnant state. *CO*, cardiac output; *SV*, stroke volume; *HR*, heart rate; *LVEDV*, left ventricular end-diastolic volume; *LVESV*, left ventricular end-systolic volume; *EF*, ejection fraction; *LVSWI*, left ventricular stroke work index; *PCWP*, pulmonary capillary wedge pressure; *PADP*, pulmonary artery diastolic pressure; *CVP*, central venous pressure; *SVR*, systemic vascular resistance; *NC*, no change. (Data from Conklin KA. Maternal physiological adaptations during gestation, labor, and puerperium. *Semin Anesth*. 1991;10: 221–234.)

Cardiovascular Changes

BOX 2.1 Changes in the Cardiac Examination in the Pregnant Patient

- Accentuation of first heart sound (S1) and exaggerated splitting of the mitral and tricuspid components
- Typical systolic ejection murmur
- Possible presence of third heart sound (S3) and fourth heart sound (S4); no clinical significance
- Leftward displacement of point of maximal cardiac impulse

Cardiovascular Changes

Supine hypotensive syndrome

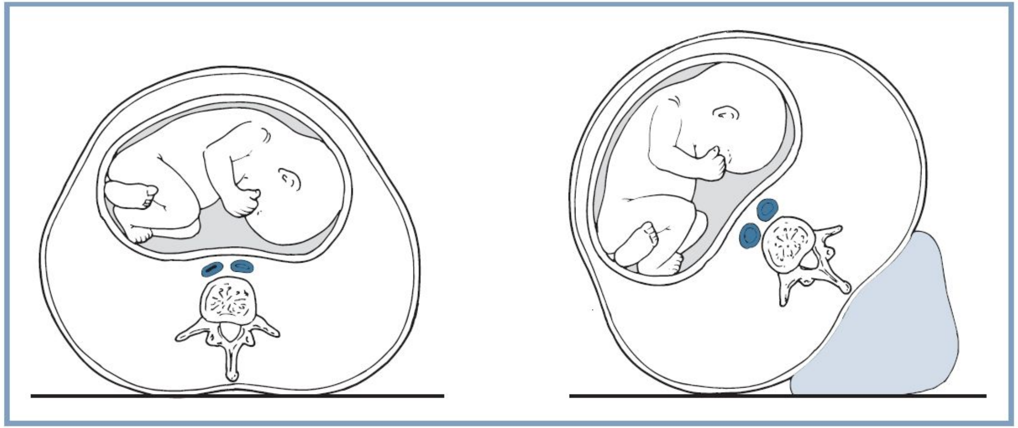


Fig. 2.12 Compression of the aorta and inferior vena cava in the supine *(left)* and lateral tilt *(right)* positions. (Redrawn from Camann WR, Ostheimer GW. Physiologic adaptations during pregnancy. *Int Anesthesiol Clin.* 1990;28:2–10.)

Cardiovascular Changes

Supine hypotensive syndrome

- 10% of 2nd trimester pregnant women in supine position
    - Aortocaval compression by enlarged uterus
        - Decreased preload
            - Decrease CO and BP
            - Increase HR
- Decrease uteroplacental perfusion -> *fetal asphyxia*

Cardiovascular Changes

Supine hypotensive syndrome (cont.)

- Symptoms: mental status changes, nausea, presyncope
- Supine position should be avoided after GA 20 wks
- Prevention by Left uterine displacement (LUD)
  - Placing a wedge under the right hip
  - Providing 15° left lateral pelvic tilt
    - Should be applied routinely during 2nd and 3rd trimesters
    - of pregnancy

Cardiovascular Changes

- ECG changing may also occur
  - Increases HR
  - Left axis deviation
    - Upward displacement of heart by gravid uterus
  - Premature atrial contractions
  - Paroxysmal supraventricular tachycardia
  - Ventricular dysrhythmias

Respiratory Changes

- Respiratory adaptation
  - Increasing metabolic demands
  - Mechanical effects of enlarging uterus
  - Cardiovascular changes of pregnancy

Respiratory Changes

- Edema of upper airway
  - Increased extracellular fluid
  - Hormonal change
  - Vascular engorgement
    - Friable mucous membranes -> Severe bleeding
      - Insertion of nasopharyngeal airways or nasogastric tubes or endotracheal tubes
  - Symptoms
    - Complain of difficulty with nasal breathing

Respiratory Changes

- Edema of upper airway
  - More severe in...
    - Preeclampsia
    - Prolongation of Trendelenburg position
    - Use of tocolytic agents

Respiratory Changes

- Cephalad diaphragm as increases uterus size
  - Accompanied by increase in the anteroposterior and transverse diameters of the thoracic cage
    - Total lung capacity decreases only slightly

Respiratory Changes

- Decrease in functional residual capacity (FRC) by 20% to 30%
  - Leading to hypoxemia
    - pre-existing alterations in closing volume
      - Smoking
      - Obesity
      - Scoliosis
    - Trendelenburg and supine positions
- Increase in expiratory reserve volume (ERV) by 15% to 20%
- Increase in residual volume (RV) by 20% to 25%
- Increase in inspiratory reserve volume

Respiratory Changes

- Increases in minute ventilation due to progesterone
  - Increase in tidal volume by 30% to 50%
  - Small increase in respiratory rate
- Increase in alveolar dead space
- Dead space to tidal volume ratio remains unchanged
- Ventilation returns to normal within 1 to 3 wks
  - Blood progesterone levels decline after delivery

Respiratory Changes

- Airway resistance usually remains unchanged
  - Progesterone-induced bronchiolar smooth muscle relaxation

    VS

    factors increasing airway resistance (e.g. upper airway edema)

Respiratory Changes

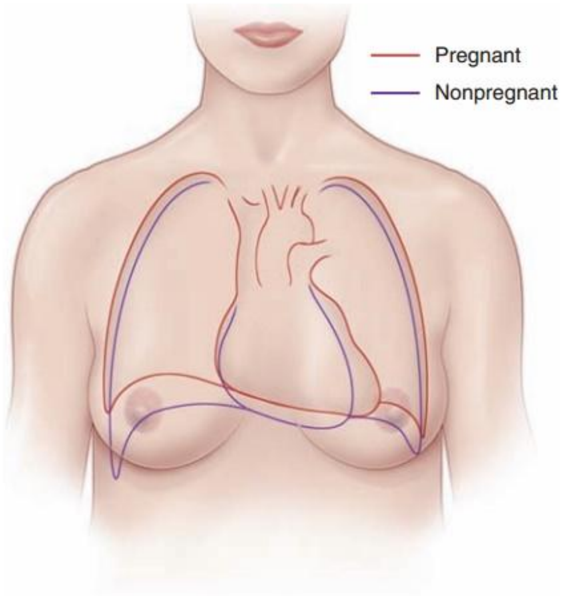
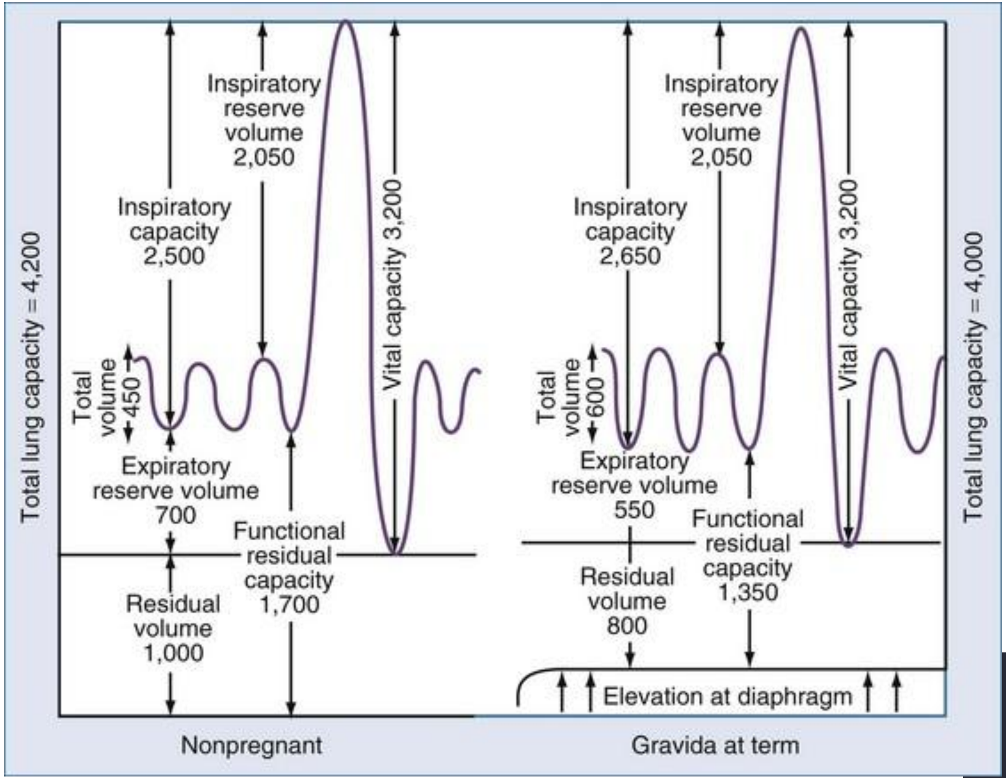


FIGURE 5.1. Changes in the outline of the heart, lungs, and thoracic cage. Adapted from Bonica JJ, McDonald JS, eds. *Principles and Practice of Obstetric Analgesia and Anesthesia*. 2nd ed, Baltimore, MD: Williams & Wilkins; 1995:47,Fig 2.



Respiratory Changes

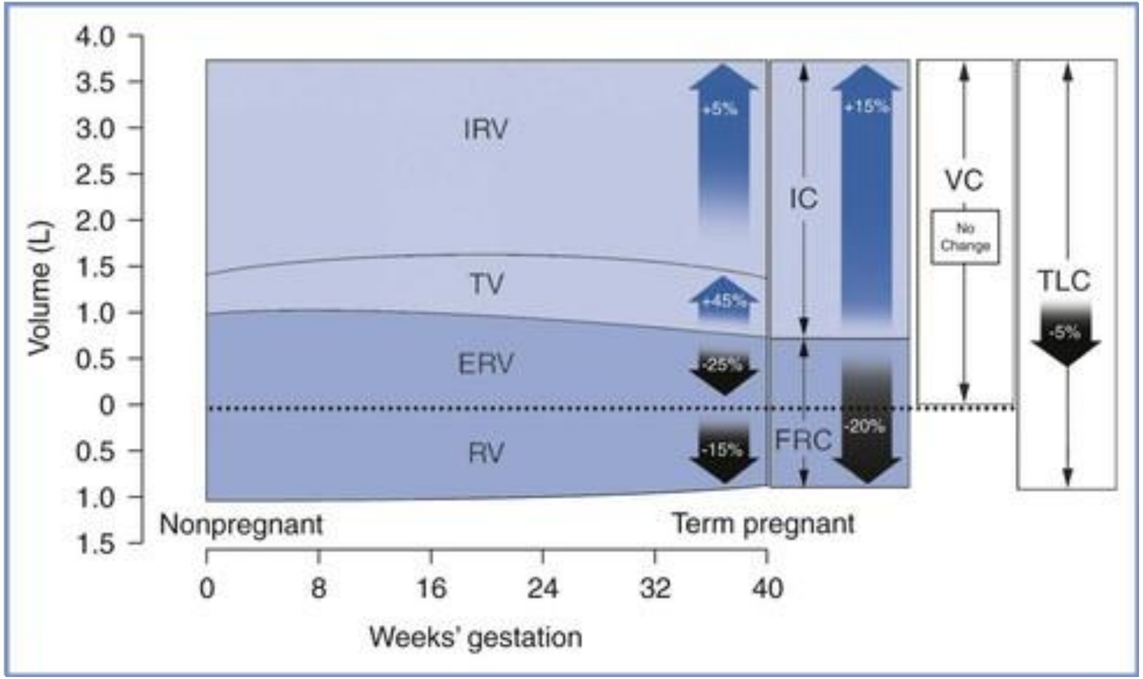
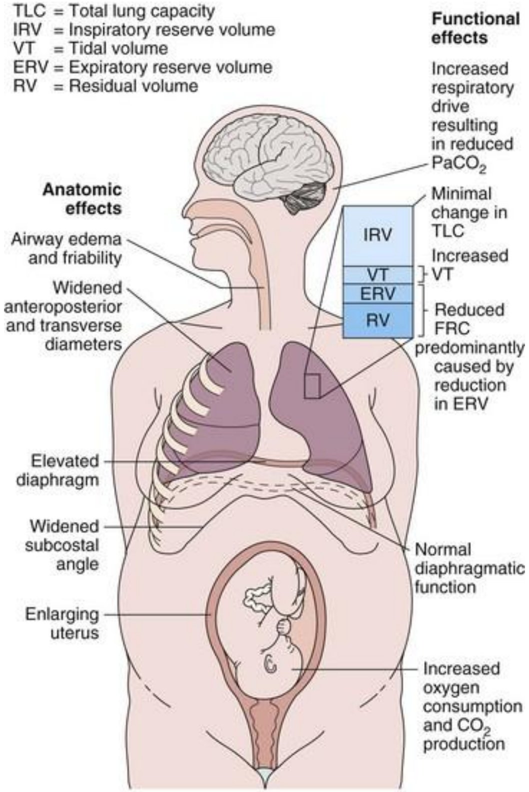


Fig. 2.6 Lung volumes and capacities during pregnancy. *ERV*, expiratory reserve volume; *FRC*, functional residual capacity; *IC*, inspiratory capacity; *IRV*, inspiratory reserve volume; *RV*, residual volume; *TLC*, total lung capacity; *TV*, tidal volume; *VC*, vital capacity.

Respiratory Changes



Respiratory Changes

TABLE 2.2 Effects of Pregnancy on Respiratory Mechanics

Parameter	Change[a]
Diaphragm excursion	Increased
Chest wall excursion	Decreased
Pulmonary resistance	Decreased 50%
FEV_1	No change
FEV_1/FVC	No change
Flow-volume loop	No change
Closing capacity	No change

FEV_1, Forced expiratory volume in 1 second; *FVC*, forced vital capacity.
[a]Relative to nonpregnant state.
Modified from Conklin KA. Maternal physiological adaptations during gestation, labor, and the puerperium. *Semin Anesth.* 1991;10:221–234.

TABLE 2.3 Changes in Respiratory Physiology at Term Gestation

Parameter	Change[a]
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%
Vital capacity	No change
Total lung capacity	–5%
Ventilation	
Minute ventilation	+45%
Alveolar ventilation	+45%

[a]Relative to nonpregnant state.
From Conklin KA. Maternal physiological adaptations during gestation, labor and the puerperium. *Semin Anesth.* 1991;10:221–234.

Metabolism Changes

- Increase in Basal O_2 consumption
  overall increase of 20% by term
  - CO_2 production increases
- Increased alveolar ventilation to...
  - Reduce in partial pressure of CO_2 in arterial blood ($PaCO_2$) to 32 mmHg
  - Increase in the partial pressure of O_2 in arterial blood (PaO_2) to 106 mm Hg

Metabolism Changes

TABLE 2.4 Blood Gas Parameters during Pregnancy

Parameter	Nonpregnant	TRIMESTER		
		First	Second	Third
Pa_{CO_2} in mm Hg (kPa)	40 (5.3)	30 (4.0)	30 (4.0)	30 (4.0)
Pa_{O_2} in mm Hg (kPa)	100 (13.3)	107 (14.3)	105 (14.0)	103 (13.7)
pH	7.40	7.44	7.44	7.44
Bicarbonate (mEq/L)	24	21	20	20

Metabolism Changes

- Enhance in uptake and elimination of inhalational anesthetics
    - Increased alveolar ventilation
    - Decreased FRC

Metabolism Changes

- Hyperglycemia and ketosis
  - Relatively insulin resistant because of Human placental lactogen and Cortisol
  - Transplacental passage of glucose may stimulate fetal secretion of insulin
    - Neonatal hypoglycemia in immediate postpartum period
  - Resolve within 24 hours of delivery

Gastrointestinal Changes

- Increased risk for aspiration of gastric contents
  - from 20 wks of gestation
  - Earlier in symptoms of reflux
- More acidic gastric secretions
- Gastric emptying time is not prolonged

  but overall gastrointestinal time is prolonged

Gastrointestinal Changes

TABLE 2.5 Changes in Gastrointestinal Physiology during Pregnancy[a]

	TRIMESTER				
Parameter	**First**	**Second**	**Third**	**Labor**	**Postpartum (18 h)**
Barrier pressure[b]	Decreased	Decreased	Decreased	Decreased	?
Gastric emptying	No change	No change	No change	Delayed	No change
Gastric acid secretion	No change	No change	No change	?	?
Proportion of women with gastric volume > 25 mL	No change	No change	No change	Increased	No change
Proportion of women with gastric pH < 2.5	No change	No change	No change	No change	No change

[a]Relative to nonpregnant state.
[b]Difference between intragastric pressure and tone of the lower esophageal high-pressure zone.

Gastrointestinal Changes

- Obstetric anesthesia practice guidelines by the American Society of Anesthesiologists
  - Allow for oral intake of modest amounts of clear liquids
    - Uncomplicated laboring patients
    - Scheduled for uncomplicated cesarean delivery up to 2 hrs prior to induction of anesthesia

Gastrointestinal Changes

- Obstetric anesthesia practice guidelines by the American Society of Anesthesiologists (cont.)
  - Restrictions of oral intake
    - Additional risk factors for aspiration (e.g., morbid obesity, diabetes, difficult airway)
    - increased risk for operative delivery (e.g., nonreassuring fetal heart rate [FHR] pattern)

Gastrointestinal Changes

- Risk of regurgitation
  - LES pressure VS Intragastric pressure
  - Lower esophageal sphincter (LES)
    - Distorted and incompetent
    - Decrease tone due to progesterone

Gastrointestinal Changes

- Aspiration prophylactic
  - Agent
    - Nonparticulate antacids
    - Histamine (H_2) receptor antagonists (e.g. ranitidine)
    - Metoclopramide
  - Rapid-sequence induction *with* cricoid pressure *with* intubation with a cuffed endotracheal tube
  - Uncertainty as to when the risk for aspiration of gastric contents returns to normal

Altered Drug Responses

- in General anesthesia
  - Decrease in minimum alveolar concentration (MAC) for inhalation agents
    - GA 8 - 12 wks
    - Related to increase in progesterone levels

Altered Drug Responses

- in Neuraxial anesthesia
  - Cephalad block level
    - 2^{nd} and 3^{rd} trimesters
  - Epidural venous engorgement
    - Increase in local anesthetic spreading
  - Increased in sensitivity of local anesthesia
    - may be due to progesterone
      or other hormonal mediators

Altered Drug Responses

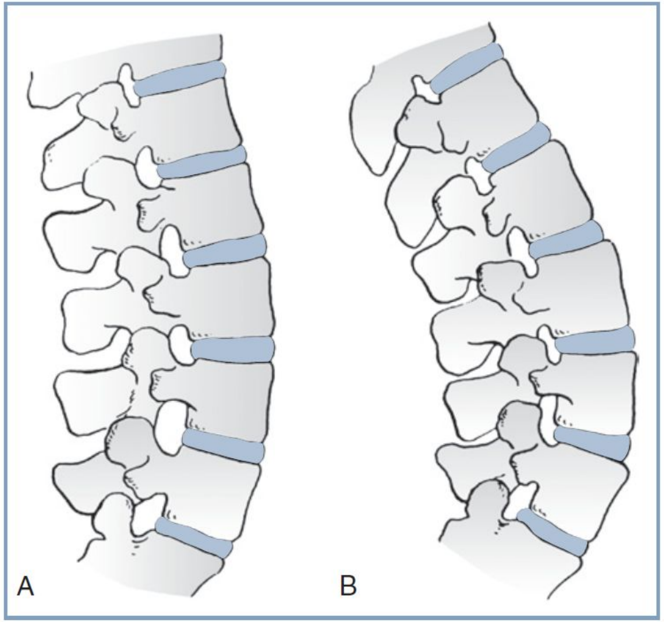


Fig. 2.13 Effects of Pregnancy on the Lumbar Spine. **A,** Nonpregnant. **B,** Pregnant. There is a marked increase in lumbar lordosis and a narrowing of the interspinous spaces during pregnancy. (Modified from Bonica JJ. *Principles and Practice of Obstetric Analgesia and Anesthesia*, Volume 1. Philadelphia, PA: FA Davis; 1967:35.)

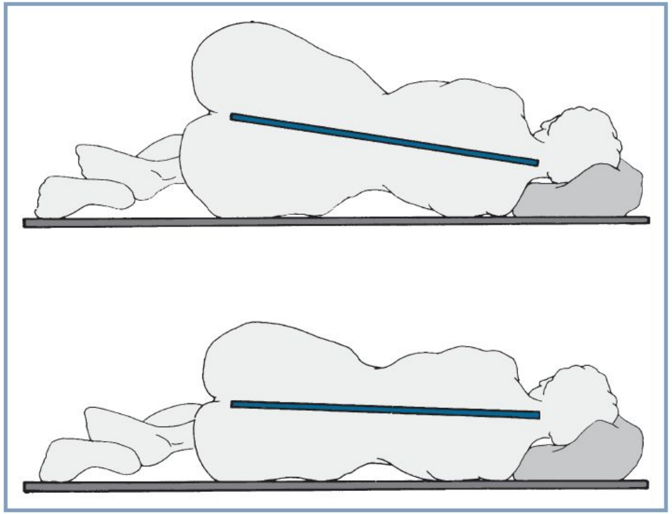


Fig. 2.14 Pelvic widening and resultant head-down tilt in the lateral position during pregnancy. *Upper panel*, pregnant; *lower panel*, nonpregnant. (Modified from Camann WR, Ostheimer GW. Physiological adaptations during pregnancy. *Int Anesthesiol Clin*. 1990;28:2–10.)

Physiologic Changes of Pregnancy

TABLE 40-1. SUMMARY OF PHYSIOLOGIC CHANGES OF PREGNANCY AT TERM

Variable	Change	Amount
Plasma volume	↑	40–50%
Total blood volume	↑	25–40%
Hemoglobin	↓	11–12 g/dL
Fibrinogen	↑	100%
Serum cholinesterase activity	↓	20–30%
Systemic vascular resistance	↓	50%
Cardiac output	↑	30–50%
Systemic blood pressure	↓	Slight
Functional residual capacity	↓	20–30%
Minute ventilation	↑	50%
Alveolar ventilation	↑	70%
Functional residual capacity	↓	20%
Oxygen consumption	↑	20%
Carbon dioxide production	↑	35%
Arterial carbon dioxide tension	↓	10 mm Hg
Arterial oxygen tension	↑	10 mm Hg
Minimum alveolar concentration	↓	32–40%

↑, increase; ↓, decrease.

Systems	Changes in pregnancy	Implications
Nervous system	↓MAC of inhalational anaesthetic	Modify dose of anaesthetics
	↓Local anaesthetic requirement	Pharmacological sympathectomy is detrimental
	Dependence on the sympathetic system for maintaining haemodynamic stability	
Cardiovascular system	↑HR, SV, CO	Difficulty in estimating blood loss
	↓SVR	Left uterine displacement
	Aortocaval compression	
Haematological system	Disproportionate increase in plasma volume	Physiological anaemia
	Hypercoagulability	Transfusion trigger and blood volume replacement
		Thromboembolic events
Airway and respiratory system	Increased mucosal vascularity and oedema	Difficult intubation
	↑Alveolar ventilation and oxygen consumption	Raised ICT during intubation
	Respiratory alkalosis	Epistaxis
	↓FRC	↑Oxygen requirement
		Rapid desaturation
		Hyperventilation not tolerated
		Decreased reserve for gas exchange
Gastrointestinal and hepatobiliary	↑Intragastric pressure and ↓tone of LOS	RSI
	↑Placental ALP	Aspiration prophylaxis
	↑Gall bladder volume and ↓contractility	Mimics obstructive pathology
		↑Chances of gall stone disease

2.
Placental Drug Transfer

Placental Drug Transfer

- Drugs cross biologic biological membranes by simple diffusion
- Rate of which is determined by the Fick principle

$$Q/t = KA(C_m - C_f)/D$$

Q/t = rate of diffusion
K = diffusion constant
A = surface area available for exchange
C_m = concentration of free drug in maternal blood
C_f = concentration of free drug in fetal blood
D = thickness of diffusion barrier

Placental Drug Transfer

Fick principle

$$Q/t = KA(C_m - C_f)/D$$

- Diffusion constant (K) *depends on* physicochemical characteristics
  - Molecular size
    - < 500 Da are unimpeded in crossing placenta
  - Lipid solubility
    - Lipid soluble cross biologic membranes more readily
  - Degree of ionization
    - Nonionized moiety of a drug is more lipophilic

Placental Drug Transfer

TABLE 4.1 Factors Affecting Placental Transfer of Drug (Maternal to Fetal)

	Increased Transfer	Decreased Transfer
Size: molecular weight (Da)	< 1000	> 1000
Charge of molecule	Uncharged	Charged
Lipid solubility	Lipophilic	Hydrophilic
pH versus drug pK_a[a]	Higher proportion of un-ionized drug in maternal plasma	Higher proportion of ionized drug in maternal plasma
Placental efflux transporter[b] proteins (e.g., P-glycoprotein)	Absent	Present
Binding protein type	Albumin (lower binding affinity)[c]	α_1-Acid glycoprotein (AAG) (higher binding affinity)
Free (unbound) drug fraction	High	Low

Da, dalton.

[a]The pH relative to the pK_a determines the amount of drug that is ionized and un-ionized in both maternal and fetal plasma. Fetal acidemia enhances the maternal-to-fetal transfer (i.e., "ion trapping") of basic drugs such as local anesthetics and opioids.

[b]The efflux transporter pumps substances in a fetal-to-maternal direction.

[c]*Note:* albumin concentration is higher in the fetus, and AAG concentration is higher in the maternal circulation.

Placental Drug Transfer

BOX 4.1 Transplacental Transfer of Anesthetic Drugs

Drugs That Readily Cross the Placenta

Anticholinergic Agents
- Atropine
- Scopolamine

Antihypertensive Agents
- Beta-adrenergic receptor antagonists
- Nitroprusside
- Nitroglycerin

Benzodiazepines
- Diazepam
- Midazolam

Induction Agents
- Propofol
- Ketamine
- Etomidate
- Thiopental
- Dexmedetomidine

Inhalation Anesthetic Agents
- Halothane
- Isoflurane
- Sevoflurane
- Desflurane[a]
- Nitrous oxide

Local Anesthetics

Opioids

Vasopressor
- Ephedrine

Drugs That Do Not Readily Cross the Placenta

Anticholinergic Agent
- Glycopyrrolate

Anticoagulant
- Heparin

Muscle Relaxants
- Succinylcholine
- Nondepolarizing agents

Nondepolarizing Agent Binder
- Sugammadex

Vasopressor
- Phenylephrine

[a]Experimental data for desflurane are lacking, but, based on physical characteristics similar to other halogenated anesthetics, placental transfer is assumed.

Placental Drug Transfer

Fick principle

$$Q/t = KA(C_m - C_f)/D$$

- Concentration gradient of free drug between maternal and fetal blood
  - Dose administered
  - Mode and site of administration
  - Use of vasoconstrictors (in local anesthesia)

Placental Drug Transfer

Henderson–Hasselbalch equation

- Relative concentrations of drug existing in the nonionized and ionized forms

$$pH = pKa + \log(\text{base})/(\text{cation})$$

Placental Drug Transfer

Uteroplacental Blood Flow

$$\text{Uteroplacental Blood Flow} = \frac{\text{Uterine Perfusion Pressure}}{\text{Uterine Vascular Resistance}}$$

Placental Drug Transfer

BOX 3.1 Causes of Decreased Uterine Blood Flow

Decreased Perfusion Pressure

Decreased uterine arterial pressure:
- Supine position (aortocaval compression)
- Hemorrhage/hypovolemia
- Drug-induced hypotension
- Hypotension during sympathetic blockade

Increased uterine venous pressure:
- Vena caval compression
- Uterine contractions
- Drug-induced uterine tachysystole (oxytocin, local anesthetics)
- Skeletal muscle hypertonus (seizures, Valsalva maneuver)

Increased Uterine Vascular Resistance

Endogenous vasoconstrictors:
- Catecholamines (stress)
- Vasopressin (in response to hypovolemia)

Exogenous vasoconstrictors:
- Epinephrine
- Vasopressors (phenylephrine > ephedrine)
- Local anesthetics (in high concentrations)

3.
Labor Analgesia

Labor Analgesia

- Nonpharmacologic techniques
- Pharmacologic techniques

Nonpharmacologic Labor Pain Management

- Acupuncture
  - Effective in treating postoperative pain after C/S
- *Massage*
  - Reduction in pain and anxiety during the 1^{st} stage of labor
- Hypnosis
  - for Relaxation but no effective in pain relief

Nonpharmacologic Labor Pain Management

- Breathing techniques described by Lamaze
- LeBoyer technique
- Bradley method
- Transcutaneous nerve stimulation
- *Hydrotherapy*
- Support person
- Intradermal water injections
- Biofeedback

Pharmacologic Labor Pain Management

Considerations

- Labor analgesia options prior to excruciating pain
- Comorbid conditions
  - Healthy women -> laboratory testing is not required
- Obstetric procedures
- Anesthesia

Pharmacologic Labor Pain Management

Considerations

- Adequate nutrition and hydration
  - Moderate amounts of clear liquids (300 mL) be allowed during neuraxial analgesia and throughout labor
  - Not required solid foods abstention before neuraxial analgesia
  - Avoid ingestion of solid foods in laboring patients

Pharmacologic Labor Pain Management

Opioids

- can be Used for labor analgesia, inexpensive, widely available
- Route: IM, IV
- All cross the placenta -> fetal effects (dose-related)
  - Respiratory depression
  - Decreased FHR variability

Pharmacologic Labor Pain Management

Opioids

- **Meperidine** (most commonly used)
  - Long-acting opioid
  - Dose
    - IV: up to 50 mg
    - IM: 50 - 100 mg

Pharmacologic Labor Pain Management

Opioids

- **Meperidine** (cont.)
  - Side Effect
    - Maternal ;-> Neurotoxic
      - CNS stimulant: e.g. anxiety, tremors, seizures
      - Normeperidine can accumulate with repeated doses
    - Fetal ;-> Lower Apgar scores

      and Prolong depress neonatal respiration
      - Increase dosing and shorter intervals between doses and delivery

Pharmacologic Labor Pain Management

Opioids

- **Morphine** (rarely used)
  - Active metabolite (morphine-6-glucuronide)
    - Longer S/E in neonates than in adults
  - Most commonly use in latent labor
    - IM for analgesia, sedation, and rest
    - Onset of analgesia: 10 - 20 mins

Pharmacologic Labor Pain Management

Opioids

- **Morphine** (cont.)
  - Side effect
    - Respiratory depression
    - Histamine release -> pruritus and rash

Pharmacologic Labor Pain Management

Opioids

- **Fentanyl**
  - Dose
    - IV: 50 - 100 μg/h
    - PCA (commonly used during labor)
      - Bolus dose of 10 - 25 μg
        with a lockout interval of 5 - 12 mins
  - S/E: Neonatal depression
    - High doses in immediately prior to birth

Pharmacologic Labor Pain Management

Opioids

- **Remifentanil**
  - Superior pain relief
    but Inferior to epidural labor analgesia
  - Lesser fetal effects than other IV opioids
  - S/E
    - Maternal respiratory depression
      - Require maternal oxygenation and ventilation monitoring

Pharmacologic Labor Pain Management

Inhaled Analgesia

- no longer used
- N_2O (commonly used)
  - Blended with O_2 -> $N_2O : O_2$ ratio is 50 : 50
  - Before and during contractions
  - Less likely in pain control
    but Likely to express satisfaction

Pharmacologic Labor Pain Management

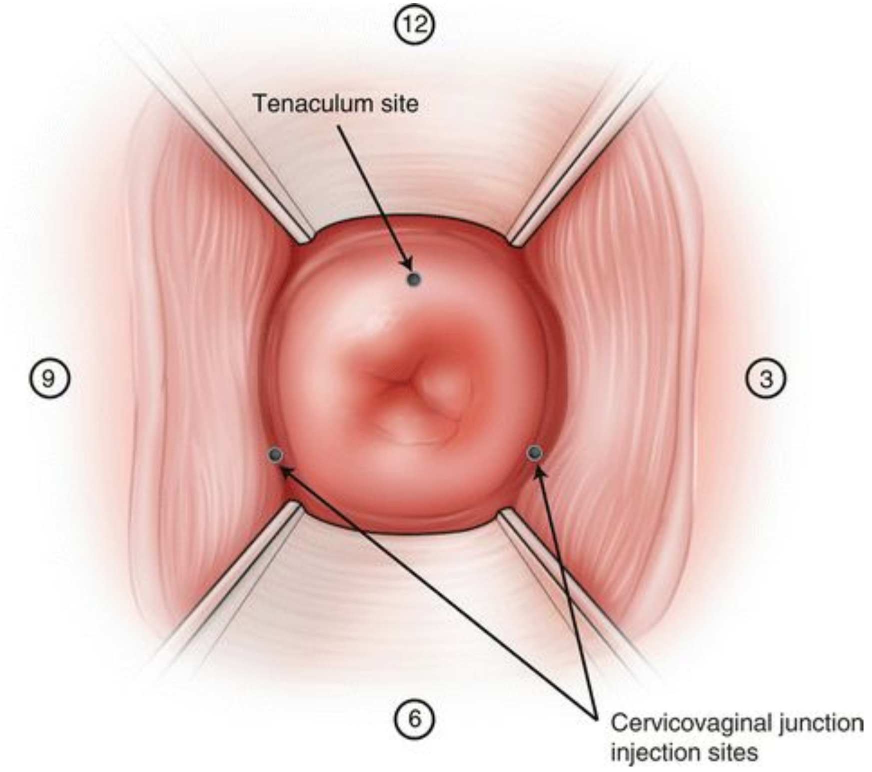
Neuraxial Analgesia

- Superior in analgesia
- Methods
  - Epidural
  - Spinal
  - Combined spinal-epidural (CSE)
  - Dural puncture epidural (DPE)
- Timing
  - Maternal request for labor pain relief

Pharmacologic Labor Pain Management

Regional Nerve Block

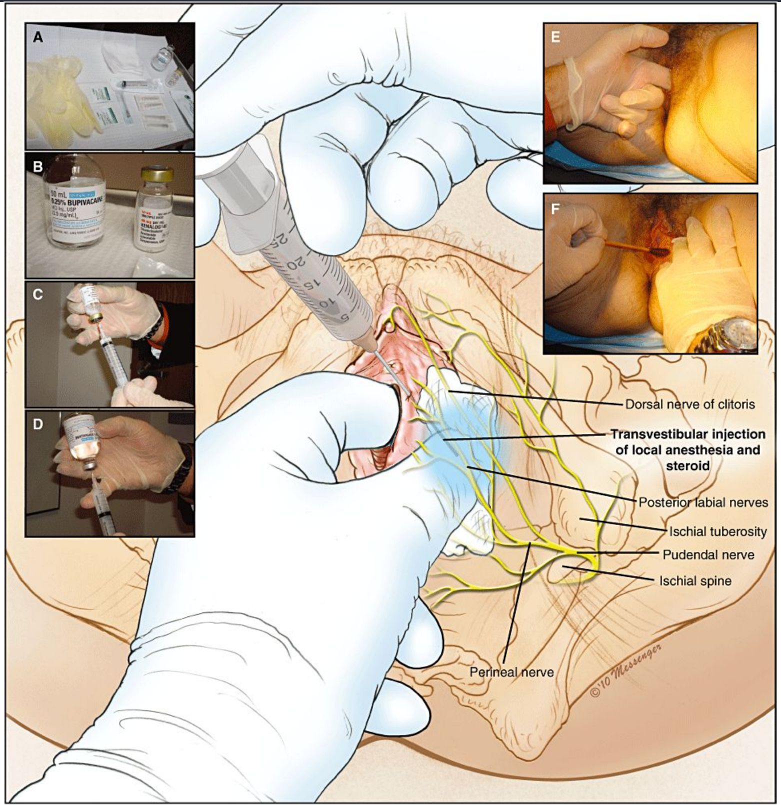
- Paracervical block



Pharmacologic Labor Pain Management

Regional Nerve Block

- Pudendal nerve block



4.
Anesthesia for Cesarean Delivery

Anesthesia for Cesarean Delivery

Indications

- Fetal malpresentation
- Nonreassuring fetal status
- Labor dystocia
- Prior cesarean delivery

TABLE 26.3 Selection of Anesthetic Technique for Cesarean Delivery

Indication(s)	Comments/Examples
For Neuraxial Anesthesia[a]	
Maternal desire to witness birth and/or avoid general anesthesia	Most common maternal preference
Risk factors for difficult airway or aspiration	Physical examination predicts possible difficult airway
	History of difficult tracheal intubation
	High body mass index (obesity)
	History of gastroesophageal reflux (common in pregnancy)
Presence of comorbid conditions	Malignant hyperthermia history
	Pulmonary disease
General anesthesia intolerance or failure	History of significant side effects with general anesthesia
	Attempted general anesthesia with failed intubation; patient awakened
Other benefits	Plan for neuraxial analgesia after surgery
	Less fetal drug exposure
	Less blood loss
	Allows presence of husband or support person
For General Anesthesia[a]	
Maternal refusal or failure to cooperate with neuraxial technique	Strong maternal preference, in the absence of factors that predict a difficult airway
	Severe psychiatric disorder
	Severe developmental delay
	Severe emotional immaturity or lability
Presence of comorbid conditions that contraindicate a neuraxial technique	Coagulopathy
	Local infection at neuraxial insertion site
	Sepsis
	Severe uncorrected hypovolemia (e.g., hemorrhage from placenta previa or uterine rupture)
	Intracranial mass with increased intracranial pressure
	Known allergy to local anesthetic (rare)
Insufficient time to induce neuraxial anesthesia for urgent delivery	Umbilical cord prolapse with persistent fetal bradycardia
Failure of neuraxial technique	Multiple needle placement failures
	Missed spinal segments
	Persistent intraoperative pain that is not treated successfully
Fetal issues	Planned *ex utero* intrapartum treatment (EXIT) procedure

[a]Many indications for or contraindications to specific anesthesia techniques are relative, and the choice of anesthetic must be tailored to individual circumstances.

TABLE 26.5 Advantages and Disadvantages of Neuraxial Anesthetic Techniques for Cesarean Delivery

Neuraxial Technique	Advantages	Disadvantages
Epidural	No dural puncture required Can use *in situ* catheter placed for earlier administration of labor analgesia Ability to titrate extent of sensory blockade Continuous intraoperative anesthesia Continuous postoperative analgesia	Slow onset of anesthesia Larger drug doses required than for spinal techniques: • Greater risk for maternal local anesthetic systemic toxicity • Greater fetal drug exposure
Combined spinal-epidural	May be technically easier than spinal anesthesia in obese patients Low doses of local anesthetic and opioid Rapid onset of dense lumbosacral and thoracic anesthesia Ability to titrate extent of sensory blockade Continuous intraoperative anesthesia Continuous postoperative analgesia	Delayed verification of functioning epidural catheter
Continuous spinal	Low doses of local anesthetic and opioid Rapid onset of dense anesthesia Ability to titrate extent of sensory blockade Continuous intraoperative anesthesia	Large dural puncture increases risk for post–dural puncture headache Possibility of overdose and total spinal anesthesia if the spinal catheter is mistaken for an epidural catheter
Single-shot spinal	Technically simple Low doses of local anesthetic and opioid Rapid onset of dense lumbosacral and thoracic anesthesia	Limited duration of anesthesia Limited ability to titrate extent of sensory blockade

BOX 26.7 Steps for Initiating General Anesthesia for Cesarean Delivery[a]

1. Discuss the operative plan with the multidisciplinary team.
2. Perform preanesthetic assessment, and obtain informed consent.
3. Prepare necessary medications and equipment.
4. Place patient supine with left uterine displacement.
5. Secure 16- or 18-gauge intravenous access. Send blood specimen for baseline laboratory measurements; consider type and screen (or cross-match) if risk factors for peripartum hemorrhage are present.
6. Give metoclopramide 10 mg and/or ranitidine 50 mg intravenously more than 30 minutes before induction, if possible.
7. Give a nonparticulate antacid orally less than 30 minutes before induction.[b]
8. Administer antibiotic prophylaxis (with 60 minutes before incision).[c]
9. Initiate monitoring.
10. Perform a team "time-out" to verify patient identity, position, and operative site; procedure to be performed; and availability of special equipment, if needed.
11. Provide 100% oxygen with a tight-fitting face mask for 3 minutes or longer, when possible, for denitrogenation/preoxygenation. Otherwise, instruct the patient to take four to eight vital-capacity breaths immediately before induction of anesthesia.
12. After the abdomen has been prepared and operative drapes are in place, verify that the surgeon and assistant are ready to begin surgery.
13. Initiate rapid-sequence induction:
    a. Cricoid pressure 10 N while awake; increase to 30 N after loss of consciousness.
    b. Thiopental 4 to 6 mg/kg or propofol 2 to 2.8 mg/kg and succinylcholine 1 to 1.5 mg/kg; wait 30 to 40 seconds.[d]
14. Perform tracheal intubation. Confirm correct placement of endotracheal tube.
15. Provide maintenance of anesthesia:
    a. Use isoflurane, sevoflurane, or desflurane (approximately 1 MAC) in 100% oxygen or oxygen/nitrous oxide (up to 50%).
    b. Treat hypotension (e.g., phenylephrine, ephedrine).
    c. If additional muscle relaxant (e.g., rocuronium, vecuronium) is necessary, titrate dose according to response to peripheral nerve stimulator.
16. Observe delivery of infant.
17. Administer a bolus and/or a continuous infusion of oxytocin; consider other uterotonic agents (e.g., methylergonovine, 15-methyl prostaglandin $F_{2\alpha}$) if uterine tone is inadequate. Monitor blood loss, and respond as necessary.
18. Adjust maintenance technique after delivery of the infant:
    a. Administer a reduced concentration of a volatile halogenated agent (0.5 to 0.75 MAC).
    b. Supplement anesthesia with nitrous oxide and an intravenous opioid.
    c. Give attention to risk for awareness and recall. Consider administration of a benzodiazepine (e.g., midazolam).
19. Perform tracheal extubation when neuromuscular blockade is fully reversed and the patient is awake and responds to commands.
20. Evaluate postoperative issues (e.g., pain, nausea).

IV, Intravenously; *MAC*, minimum alveolar concentration.

[a]The events and sequence of events may need to be modified and tailored to individual circumstances. In an emergency, some tasks may have to be performed simultaneously.

[b]Some anesthesiologists suggest that sodium citrate should be administered within 20 minutes of induction of general anesthesia (see Chapter 28).

[c]Evidence suggests that administration of prophylactic antibiotics *before* incision (rather than after umbilical cord clamping) reduces the incidence of postcesarean endometritis and total maternal infectious morbidity.[52]

[d]Drugs and doses may have to be modified for individual patients and circumstances.

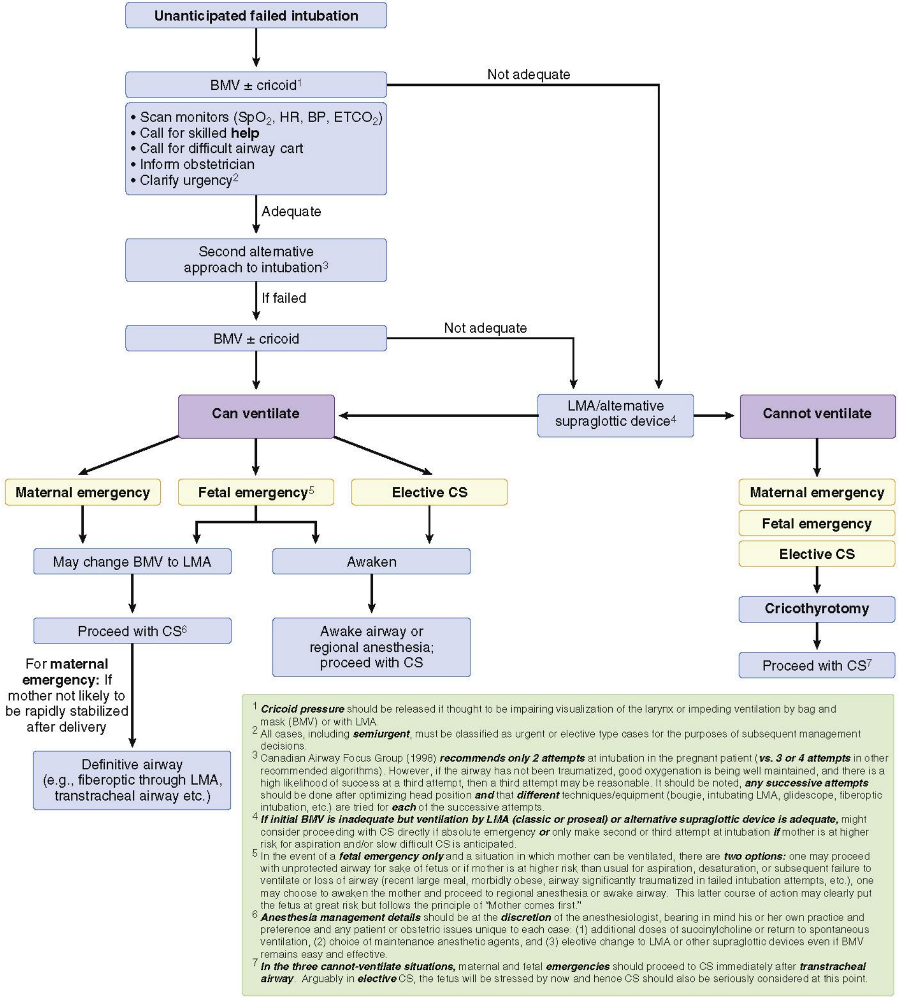


Fig. 62.4 Algorithm for management of unanticipated difficult airway in obstetric patients. *BMV,* Bag-mask ventilation; *BP,* blood pressure; *CS,* cesarean section; *$ETCO_2$,* end-tidal carbon dioxide; *HR,* heart rate; *LMA,* laryngeal mask airway; *SpO_2,* oxygen saturation. (Redrawn from Balki M, Cooke M, Dunington S, et al. Unanticipated difficult airway in obstetric patients: development of a new algorithm for formative assessment in high-fidelity simulation. *Anesthesiology.* 2012;117:883–897, with permission.)

5.
Anesthetic Implications

Anesthetic Implications

Objective

- Maternal safety
- Safe care of fetus
- Prevention of premature labor related to the surgical procedure
- Drugs administered during anesthesia

Anesthetic Implications

- More rapid in induction and emergence from anesthesia
  - Increase in minute ventilation
  - Decreased in FRC
  - Decreased in MAC of volatile agents
- Supine hypotensive syndrome (2^{nd} trimester)

Anesthetic Implications

- Gastric emptying
  - Normal in 1^{st} to 2^{nd} trimester
  - Prolonged in 3^{rd} trimester
- Decrease in gastroesophageal sphincter tone (after GA 20 wks)
- Local anesthetic administered should be reduced by 25% to 30%

Anesthetic Implications

- Teratogenicity
  - Organogenesis occurs in 1^{st} trimester (days 13 to 60)
  - Diazepam
    - high-dose injection in the first trimester -> *cleft palate*
    - Safe: needed to treat perioperative anxiety
  - Nitrous oxide
    - Effect on DNA synthesis
      - Administered for prolonged periods (1 to 2 days)
      - Contraindicated in 1^{st} to 2^{nd} trimesters ???

Anesthetic Implications

- Teratogenicity

Drugs	Inference
Methohexitone, propofol, enflurane	Category B agent
Thiopentone, ketamine, etomidate, mannitol	Category C agent
Nitrous oxide	Probably teratogenic in animal studies
	Inhibition of methionine synthetase
	No teratogenic effect in a clinical concentration in human studies
	Neonatal depression on delivery with 70% N_2O
Benzodiazepines	Earlier studies showed increased risk for cleft lip and palate
	Subsequent studies failed to prove a causal relationship
	Long term administration to the mother can cause fetal dependence and withdrawal
Desflurane, sevoflurane, halothane, isoflurane, opioids, hypertonic saline	Category B and C
Local anesthetic	Category B and C except cocaine

Anesthetic Implications

- Avoid intrauterine fetal asphyxia
  - Maintaining maternal PaO_2, $PaCO_2$, and uterine blood flow
    - Alkalosis
      - Direct vasoconstriction
      - Release of less oxygen to fetus at placenta (Shifts oxyhemoglobin dissociation curve)
  - Reduction in uterine blood flow
    - Maternal hypotension
    - Uterine hypertension
      - Increased uterine irritability

Anesthetic Implications

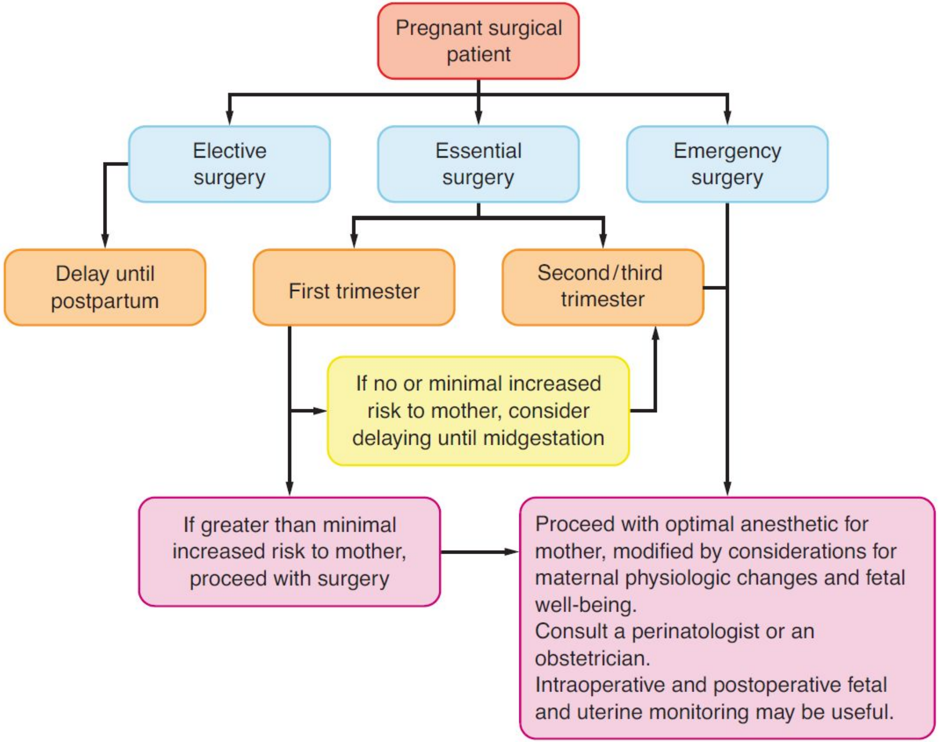
- Anesthesia and surgery may also result in *preterm labor* during intra- and postoperative periods
  - Greater risk in 3rd trimester
  - Abdominal and pelvic procedures

Anesthetic Implications

- Emergency surgery
  - No data to suggest any well-conducted anesthetic
  - Maintain oxygenation and blood pressure
  - Avoid hyperventilation
  - Regional anesthesia should be considered
  - Left uterine displacement
  - Aspiration prophylaxis (suggest in after GA 20 wks)
  - Assess Pre- and postoperative FHR and uterine activity

Anesthetic Implications

FIGURE 40-11. Recommendations for management of parturients and surgical procedures. (From: Rosen MA. Management of anesthesia for the pregnant surgical patient. *Anesthesiology.* 1999;91:1159. © 1999, Lippincott Williams & Wilkins, with permission.)



Anesthetic Implications

BOX 2.3 Considerations for General Anesthesia during Pregnancy

Drugs

- Propofol
  - Induction dose decreased
  - Elimination half-life unaltered
- Thiopental
  - Induction dose decreased
  - Elimination half-life prolonged
- Volatile anesthetic agents
  - Minimum alveolar concentration (MAC) decreased, but unclear whether hypnotic dose requirement differs from that in nonpregnant women
  - Speed of induction increased
- Succinylcholine
  - Duration of blockade unaltered
- Rocuronium
  - Increased sensitivity
- Chronotropic agents and vasopressors
  - Decreased sensitivity

Tracheal Intubation

- Increased rate of decline of PaO_2 during apnea
- Smaller endotracheal tube required (6.5 or 7.0 mm)
- Increased risk for difficult or failed mask ventilation
- Increased risk for failed intubation with traditional laryngoscopy
- Increased risk for bleeding with nasal instrumentation

BOX 2.4 Neuraxial Anesthesia: Anesthetic Implications of Maternal Physiologic Changes

Technical Considerations

- Lumbar lordosis increased[a]
- Apex of thoracic kyphosis at higher level[a]
- Head-down tilt when in lateral position

Treatment of Hypotension

- Decreased sensitivity to vasopressors[a]

Local Anesthetic Dose Requirements[b]

- Subarachnoid dose reduced 25%[a]
- Epidural dose unaltered or slightly reduced[a]

[a]Compared with nonpregnant women.
[b]Change in the segmental dose requirement.
Modified from Conklin KA. Maternal physiologic adaptations during gestation, labor, and the puerperium. *Semin Anesth*. 1991;10:221–234.

Take Home Message

Thank You