Anesthesia for Elective and Emergency C-Section

Sarah Shane, DVM, MS

Residency Trained in Anesthesia & Analgesia

MEDVET

Leading Specialty Healthcare for Pets

Neonate Information

- Mortality rate
  - 15-25% (Concannon, 2002)
- Predisposing factors for mortality (Munnich, 2008)
  - Dystocia
  - Type and timing of intervention at birth
  - In-breeding
  - Malformations
  - Genetic defects
  - Diseases
  - Infectious disease


https://thehappypuppysite.com/

Factors Associated with Improved Survival (Moon, 2000)

- Elective vs. emergent surgery
- Non-brachycephalic breeds
- <4 puppies in the litter
- Spontaneous breathing of the neonate within 1 minute
- Avoidance of xylazine and/or ketamine in the anesthetic protocol
- Propofol/alfaxalone with isoflurane anesthesia

https://www.buyatestkit.com/

Overview of Maternal Physiology

- Patients are at a greater anesthetic risk than healthy non-parturient patients
- Cardiac reserve diminishes
- Pulmonary
  - Hypoventilation, hypoxemia, and hypercapnia
- Anesthetic requirement
  - Decreased
  - Increased risk of overdose and excessive depression
- Regurgitation

Maternal Physiology – Cardiovascular

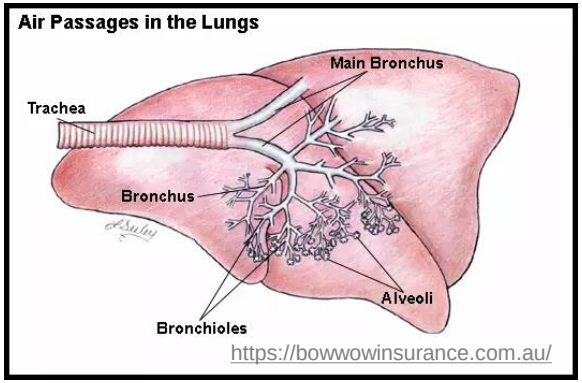
- Blood volume increases by ~40%
  - Plasma volume increases more than red cell mass
- Cardiac output increases by 30-50%
  - Females have an increase in HR and SV
- Decreased cardiac reserve during pregnancy and parturition
- Patient positioning
  - Posterior vena cava and aorta can be compressed by an enlarged uterus

Maternal Physiology - Cardiovascular

Variable	Effect
Heart Rate	↑
Cardiac Output	↑
Blood Volume	↑
Plasma Volume	↑
PCV, Hemoglobin, Plasma Protein	↓
Arterial Blood Pressure	-

Maternal Physiology - Pulmonary

- Decreased PaCO2
  - Respiratory alkalosis
- Hyperventilation
- Decreased functional residual capacity
  - Craniodorsal displacement of the diaphragm
- Hypoxemia
  - Due to the decreased FRC

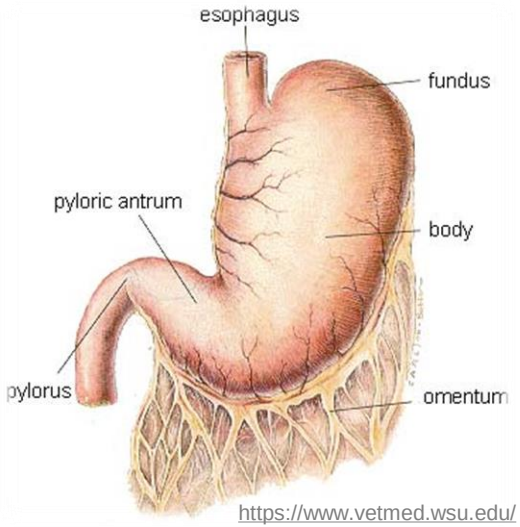


Maternal Physiology – Pulmonary

Variable	Effect
Minute Volume	↑
Oxygen Consumption	↑
pHa & PaO2	-
PaCO2	↓
Total Lung & Vital Capacity	-
Functional Residual Capacity	↓

Maternal Physiology - Gastrointestinal

- Delayed gastric emptying
  - Displacement of the stomach
  - Decreased gastric motility
  - Increased serum progesterone
- Regurgitation and aspiration
  - Metoclopramide
  - H2 receptor antagonists
  - Plan for rapid airway management



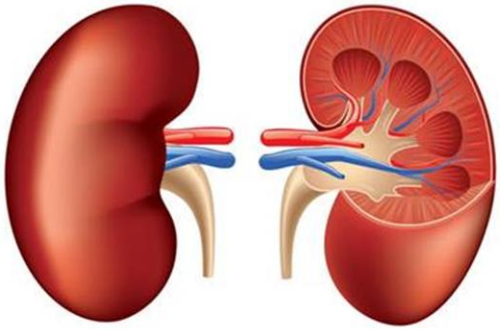
https://www.vetmed.wsu.edu/

Maternal Physiology – Gastrointestinal

Variable	Effect
Gastric Emptying Time & Intragastric Pressure	↑
Gastric Motility & pH of Gastric Secretions	↓
Gastric Chloride Ion Concentration	↑

Maternal Physiology – Liver & Kidney

- Liver
  - Pregnancy induces minor changes
  - Decreased plasma cholinesterase concentration
- Kidney
  - Renal plasma flow and GFR are increased by ~60%
  - Decreased BUN and creatinine



https://www.allaboutdogfood.co.uk/

Maternal Physiology – Liver & Kidney

Variable	Effect
Plasma Cholinesterase	↓
Renal Plasma Flow & GFR	↑
BUN & Creatinine	↓
Sodium Ion & Water Balance	-

Maternal Physiology – Uterine Blood flow

- Blood flow is directionally proportional to systemic perfusion pressure
  - Inversely proportional to vascular resistance
  - **Not** auto-regulated
- Anesthesia can decrease uterine blood flow → reduced fetal viability
- Placental hypotension
  - Hypovolemia
  - Anesthetic-induced cardiovascular depression
  - Sympathetic blockade

https://simplyfordogs.com/

Pharmacologic Alterations

- Pregnancy affects uptake, distribution, and disposition of anesthetic agents
- Minimal alveolar concentration (MAC)
  - Reduced compared to non-pregnant females
- Placental diffusion
  - Low molecular weight (<500 Da)
  - Low degree of protein binding
  - High lipid solubility
  - Non-ionized at maternal blood pH

Pharmacologic Alterations

- Ion trapping
  - Fetal pH usually 0.1 units less than maternal
  - Lower fetal pH will increase the ionized drug concentration
  - Non-ionized (basic) drugs will cross the placenta
  - Once in the placenta the ionized form of the drug will be trapped in the acidic environment
- Redistribution
  - 85% of umbilical venous blood
  - Fetal circulation buffer drug concentration
- Metabolism
  - Longer drug half-life

Pharmacologic Alterations

- Protein Binding
- ↑ circulating progesterone levels
  - Progesterone has an effect on the $GABA_A$ receptors (agonist)
  - Decreased anesthetic requirement by 25-40%
  - Effect:
    - Sedation
    - Anxiolysis
    - Muscle relaxation

Pre-Anesthetic Considerations

- Hypocalcemia
  - Calcium involved in cardiac smooth muscle and skeletal muscle contraction
  - <1 mmol/L
  - 0.5-1.5 ml/kg over 15-20 minutes
- Regurgitation
  - Maropitant
  - Cuffed endotracheal tube
- Decreased FRC
  - Pre-oxygenate

Anticholinergics

- Atropine and glycopyrrolate
- Increases the gastric pH
  - Decreased severity of aspiration pneumonia
- Glycopyrrolate does not readily cross the placenta
- Neonates have an incomplete cardiac autonomic development
  - Anticholinergics unlikely to affect the fetus

Phenothiazine & Benzodiazepine

- Acepromazine
  - Can induce fetal and maternal depression
  - Requires hepatic metabolism (Pascoe, 2001)
  - Not associated with increased maternal or fetal mortality (Moon, 1998)
- Benzodiazepines
  - Can induce neonatal depression
  - Decreased elimination
  - Clinical signs: decreased vocalization, lethargy, hypotonus, apnea, hypothermia

https://pipevet.com/

MEDVET

α-2 Adrenergic Agonist

- Xylazine
  - Rapidly crosses the placenta
  - Maternal and fetal respiratory and circulatory depression
  - Associated with higher mortality rates
- Dexmedetomidine
  - No current canine or feline studies on pregnancy or parturition

https://www.zoetisus.com/

Opioids

- Rapidly cross the placenta
  - Can cause respiratory and neurobehavioral depression
- Reversal agents
  - Advantage of using a full mu opioid
  - Will cross the placenta
    - Can be given to the mother prior to delivery
    - Deprives the mother of analgesia
  - Naloxone
    - Very effective
    - Duration of action is shorter than most full mu opioids

Induction Agents

- Propofol
  - Produces rapid induction for intubation
  - Crosses the placenta but rapidly cleared from neonatal circulation
- Alfaxalone
  - Minimal cardiorespiratory effects (Muir, 2008)
  - Associated with increased APGAR scores (Doebeli, 2013)
- Etomidate
  - Rapid anesthesia
  - Minimal cardiovascular effects
  - Maintenance of fetal tissue perfusion
  - Repeated dosing can cause acute hemolysis

https://en.wikipedia.org/

MEDVET

Dissociatives

- Rapid onset of action and short duration
  - Highly lipophilic
- Ketamine will cross the placenta
  - Enters fetal circulation
- Leads to respiratory depression, apnea, decreased vocalization and increased mortality at birth (Moon-Massat, 2002)(Luna, 2004)

Induction Agents

- Readily cross the placenta
  - Rapid fetal and maternal equilibration
- Ventilation is the primary route of elimination (Eger, 2005)
- Deep levels of anesthesia:
  - Maternal hypotension
  - Decreased uterine blood flow
  - Fetal acidosis

http://vetlandmedical.com/

Local Anesthetics

- Amide derivates (ie. lidocaine and bupivacaine)
  - Metabolized by hepatic microsomal enzymes
  - Can have increased concentrations within the fetus
- Epidural anesthesia
  - Local anesthetic accumulation rarely occurs
  - Sympathetic blockade
    - Maternal hypotension
    - Decreased uteroplacental perfusion
  - 1/3 to ½ of the original dose (Pascoe, 2001)

General Anesthetics

- Disadvantages of GA:
  - Greater neonatal depression
  - Inadequate anesthetic plane
- Advantages of GA:
  - Speed and ease of induction
    - Control of the maternal airway
  - Reliability
    - Immobile patients
  - Reproducibility
  - Control
    - Oxygenation
    - Cardiopulmonary function

General Anesthesia

- GA Goals (Raffe, 2015):
  - Induction must be smooth and rapid
  - Intubation should be quick followed by ventilator support
  - Drugs and technique selected to maintain fetal viability
- Perfusion
  - Maintain MAP ≥ 70 mmHg
- Ventilation
  - Hyperventilation
    - Decreased uterine artery blood flow → fetal hypoxia, hypercapnia and acidosis

Hypotension

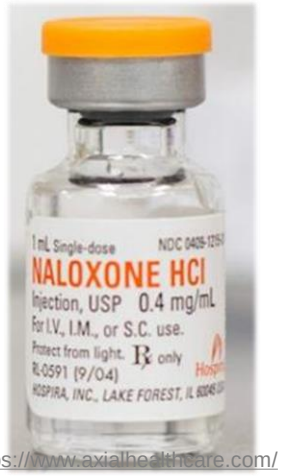
- Primary Action:
  - Decrease inhalant percentage
  - Fluid bolus
    - Colloids are more effective than crystalloids (Cyna, 2006)
- Ephedrine or phenylephrine
  - Equally effective in human trials (Chooi, 2017)
  - Human APGAR scores remained >8
  - Possible tachycardia and hypertension with higher doses of ephedrine

Neonatal Resuscitation

- Delivery
  - Milk the umbilical vessels towards the fetus
  - Clamp umbilical vessels and sever from the placenta
- Management
  - Remove the amniotic fluid from the nose and mouth
  - Begin rubbing the new born within a towel → support the head and neck
  - Oxygen delivery ?
  - Heat
- GV 26 ?
  - Acupuncture site
  - Stimulates the sympathetic nervous system

Neonatal Resuscitation

- Doxapram
  - Respiratory stimulant
  - Not currently used in human neonates
- Naloxone
  - Commonly used opioid antagonist
  - Reverse the opioids administered during surgery
- Atropine
  - Ineffective <14 days old
- Dextrose
  - 0.1-0.5 ml sublingual administration



https://www.axialhealthcare.com/

MEDVET

APGAR Scoring System

Indicator		0 Points	1 Point	2 Points
A	Activity (muscle tone)	Absent	Flexed limbs	Active
P	Pulse	Absent	< 100 BPM	> 100 BPM
G	Grimace (reflex irritability)	Floppy	Minimal response to stimulation	Prompt response to stimulation
A	Appearance (skin color)	Blue Pale	Pink body Blue extremeties	Pink
R	Respiration	Absent	Slow and irregular	Vigorous cry

Maternal Pain Management

- Opioids
  - Do not cause maternal depression
  - Butorphanol
  - Methadone
  - Hydromorphone
- NSAIDs
  - Do not cause maternal depression
  - Carprofen
- Inadequate pain management can decrease milk production
- 1-2% of the maternal dose (opioids, NSAIDs, and alpha-2 agonists) will transfer to the milk

Questions

https://www.europuppy.com/