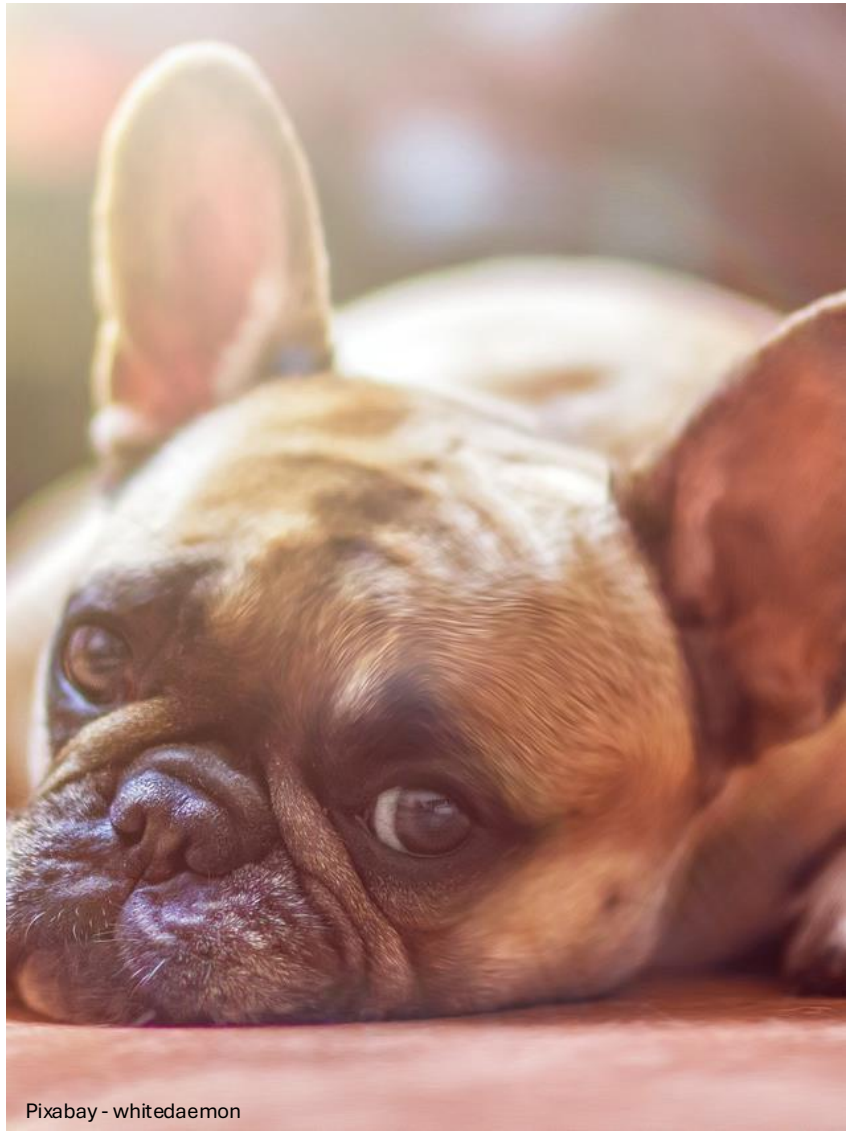

Pixabay - whitedaemon

Anesthesia and Analgesia for the Small Animal Cesarean Section

Kristen Deom, DVM
Third Year Resident in Anesthesia and Analgesia
Iowa State University College of Veterinary Medicine

Pixabay – JACLOU-DL

Dystocia in the Small Animal

- Surgery needed ≥50% canine dystocias[10,12,14]
  - Feline rates similar[13]
- Breed predilection common:
  - Brachycephalics > Toy Breeds[10,14]
  - Purebred cats[13,16]
- ↑Neonatal survival with elective (vs emergent) c-sections[14-16]

Outline

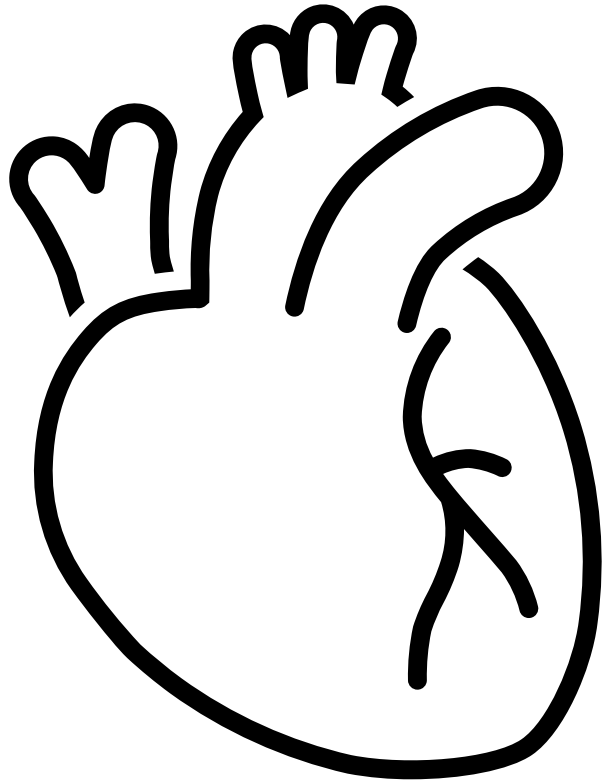
- Considerations for anesthesia of the periparturient patient
- Changes in periparturient maternal physiology
- Devising anesthetic protocol + patient preparation
- Support for the neonate delivered via cesarean section
- Analgesia for the nursing dam
- Summary

Changes in Maternal Physiology

- NOTE: Most data on physiologic Δ from humans and/or ewes
- Most notable Δ's in[1]:
  - Cardiovascular system
  - Pulmonary system
  - Gastrointestinal systems

Changes in Maternal Physiology: Cardiovascular Alterations

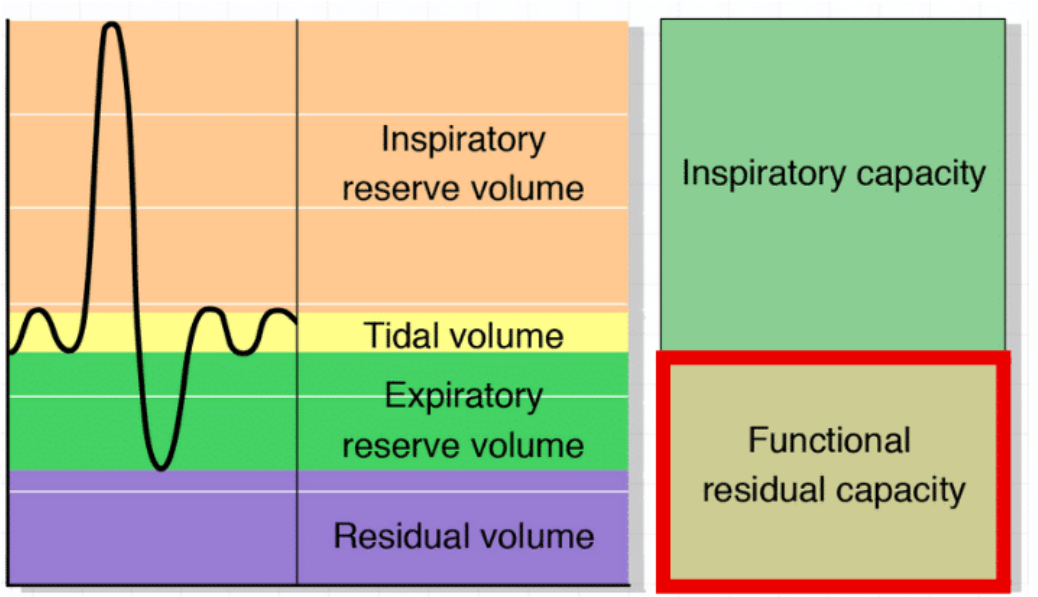
- Maternal blood volume increases by ~40%[1]
  - Plasma volume > RBC = “dilutional” anemia
- ↑HR + ↑SV = ↑CO by ~30-50%[1]
  - ↓”Cardiac Reserve” = may not tolerate further CV depression
- Bottom line: Expect “anemic,” ↑ risk of hypotension



Microsoft 365 stock icons

Changes in Maternal Physiology: Pulmonary Alterations

- ↓ Functional Residual Capacity (FRC)
- ↑O_2 consumption
  - Further increased with labor
- Bottom line: ↑↑↑Hypoxemia risk

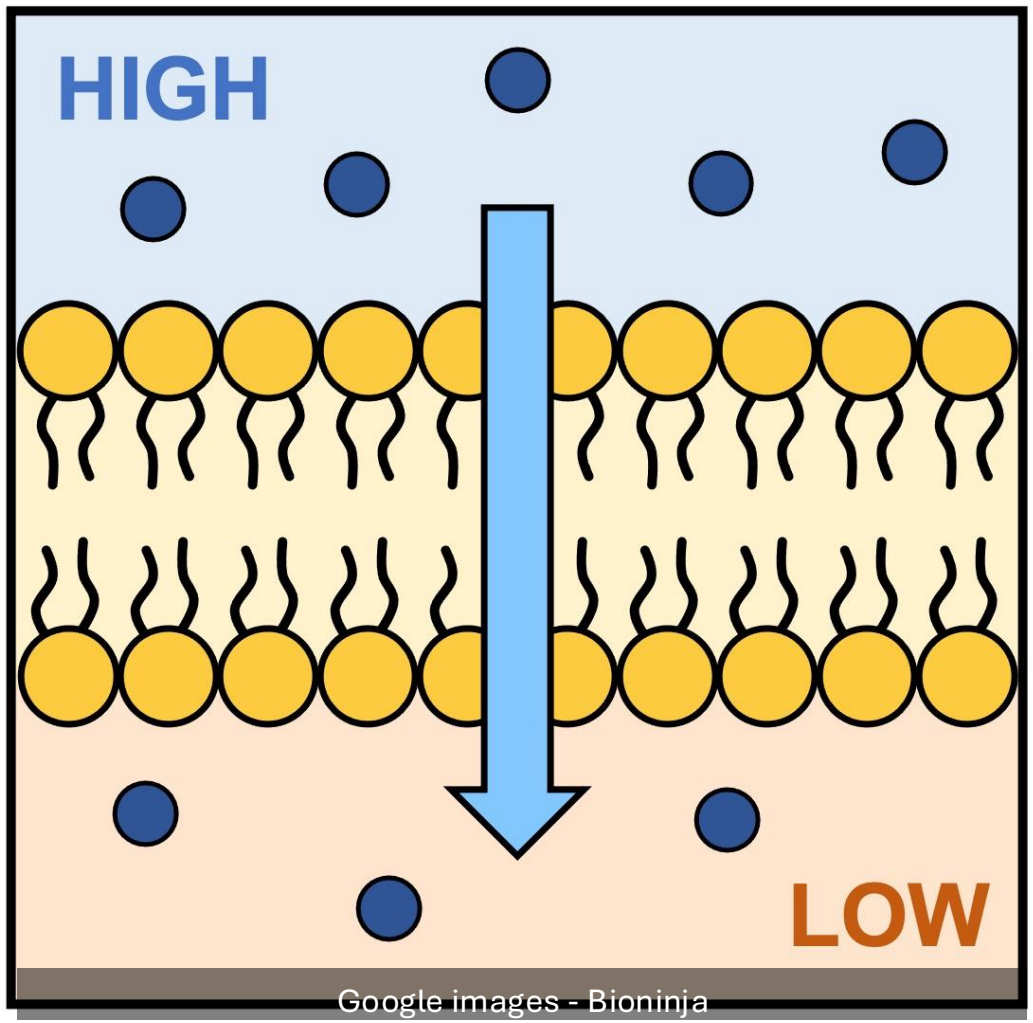


Google images – Respiratory Therapy Zone

Changes in Maternal Physiology: Gastrointestinal Alterations

- ↑Regurgitation Risk[1]
- +/- Fasted patient?
- ↑Regurgitation/aspiration risk brachy anesthesia[2,3]
- Bottom line: ↑↑↑Risk of aspiration

Pneumonia - MarVistaVet



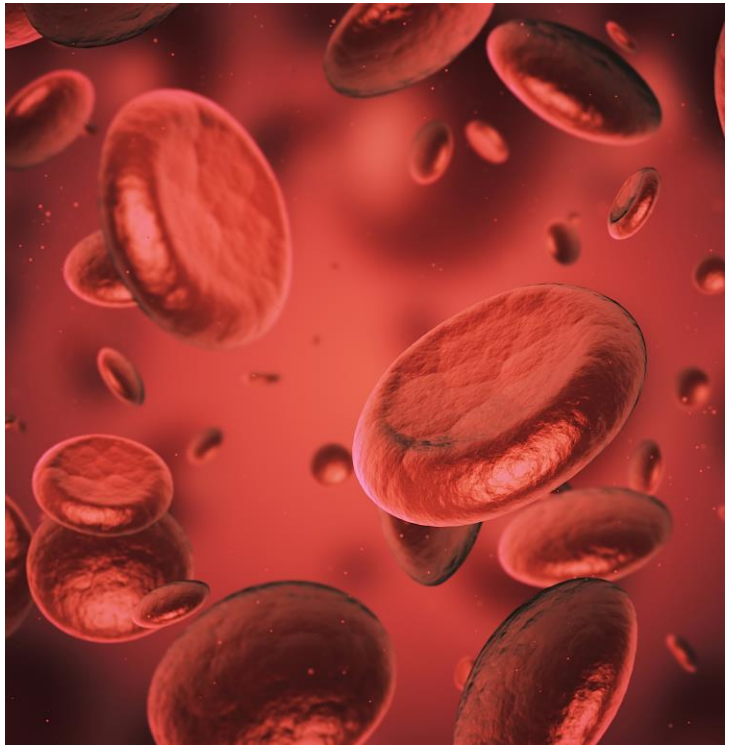
Google images - Bioninja

Placental Permeability

- Placenta HIGHLY permeable to most anesthetic drugs[1]
- FEW drugs have minimal/no transplacental transfer
- Bottom line: “good” anesthetic drug for mom = placental transfer

Uterine Blood Flow (UBF)

- Highly dependent on maternal BP[1]
- Limited autoregulatory capabilities[1]
- Maternal hypotension (+/- ↑ uterine tone) = impaired fetal perfusion
- Bottom line: Maintain maternal BP to maintain fetal perfusion



Microsoft 365 stock images

Considerations for Anesthetic Protocol

- Physiologic changes of periparturient mother ✓
- Effects of selected drugs on mother
- Effects of selected drugs on fetus(es)
- Residual drug effects on neonate(s) once separated from mother

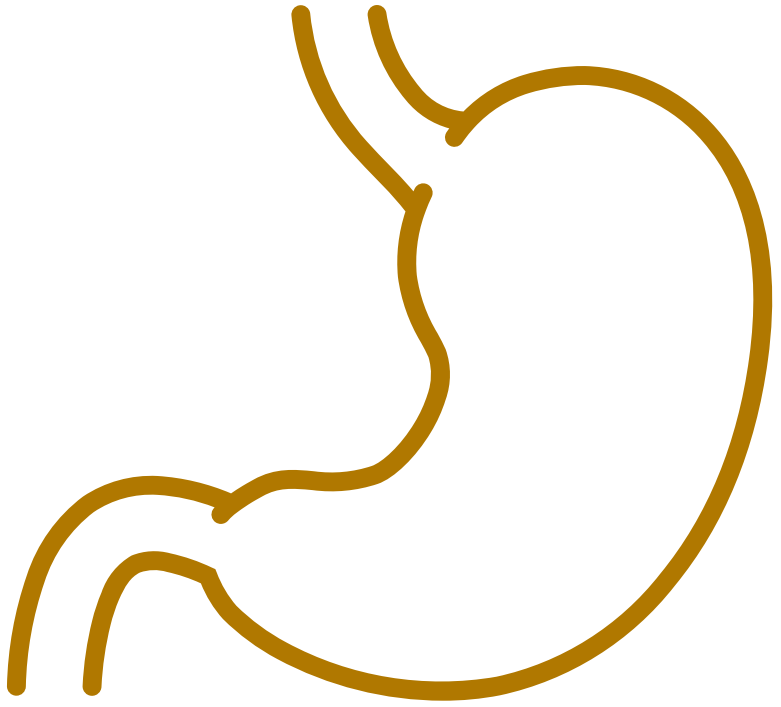
Formulating a Protocol

Microsoft 365 stock icons

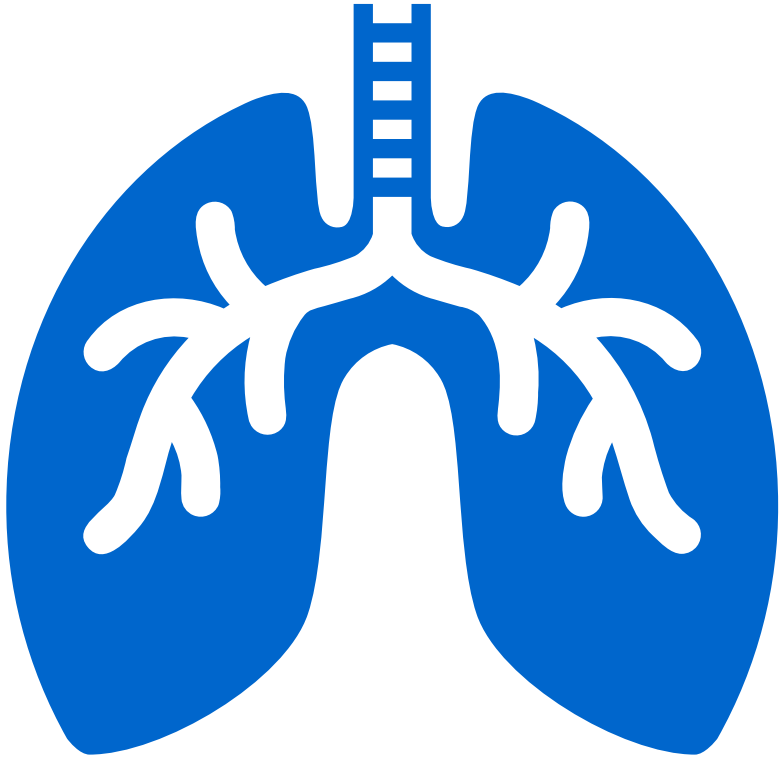
- “Ideal” protocol:
  - Analgesia/muscle relaxation/narcosis for dam alone
- Realistically - ALL protocols will have some undesirable effect(s)
- Choose short-acting and/or “reversible” drugs
- Consider “risks” for dam and ↓ anesthesia time

Peri-anesthetic Management: Gastrointestinal Considerations

- “Treat all patients as if they have full stomach.”
- Maropitant: 1mg/kg IV/SQ
  - SQ ≥ 30 min before opioid[26, 27]
  - IV – transient hypotension[29]
- Metoclopramide: 0.2-1 mg/kg SQ, IV
  - 1 mg/kg IV + 1 mg/kg/hr CRI may be needed[31]
  - IV – SLOW, arrhythmias possible
  - May stimulate milk letdown[32]



Microsoft 365 stock icons



Microsoft 365 stock icons

Peri-anesthetic Management: Pulmonary Considerations

- Pre-oxygenation prior to induction
  - 3 min of O2 significantly prolongs time to desaturation[28]
- Prep as much as tolerated while awake
- Tilt table and/or wedge under head/thorax
- Most patients likely benefit from manual ventilation

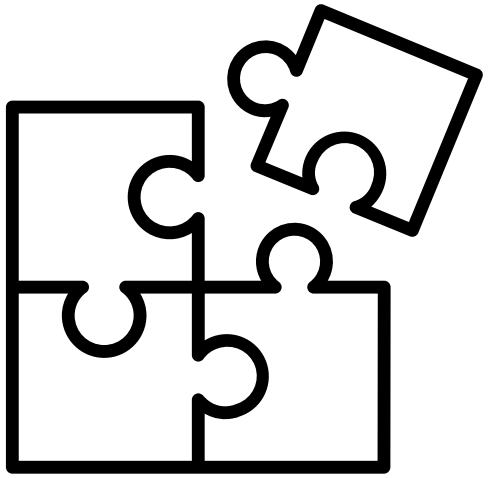
Treatment: Maternal Hypotension

- Ideally – maternal MAP ≥ 70 mmHg
  - Titrate anesthetic agents, (+/-) fluid bolus, (+/-) anticholinergic (*glycopyrrolate) first
- Historically Ephedrine preferred - No longer[4,6]
- Dopamine, Dobutamine – Caution, may ↓ uterine blood flow[7-9]
- Norepinephrine new “drug of choice”
  - NorEpi>Phenylephrine>Ephedrine[4]

Google images – Somerset Pharma

Google images – Penn Care

Selection of Premedications

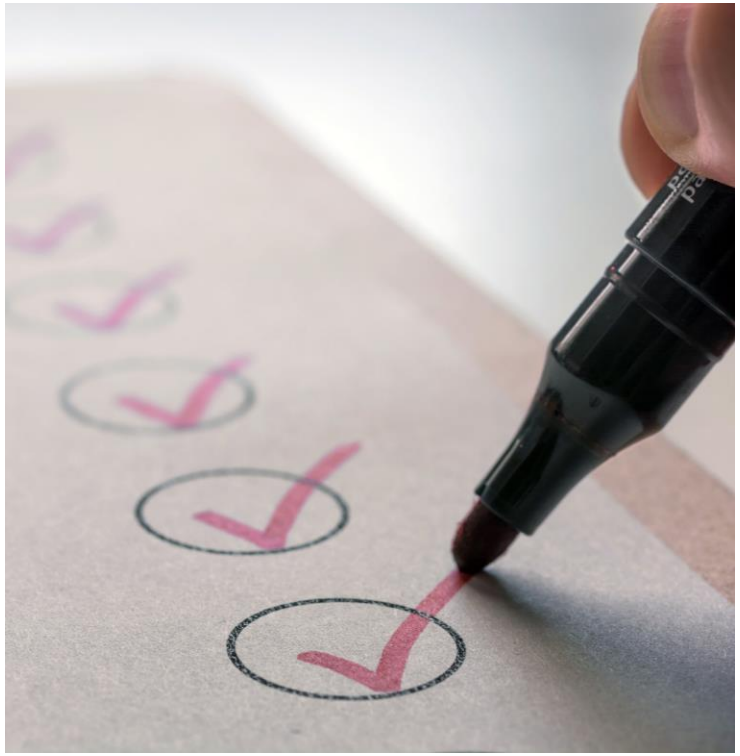


Microsoft 365 stock icons

- Historically “None”:
  - Risk/benefit of ↑induction /MAC requirements vs “less” depression
- Phenothiazines (Acepromazine): **Generally avoid**
- Benzodiazepines (Midazolam, Diazepam): **Generally avoid**
- Opioids:
  - Rapid placental transfer – some neonatal depression
  - Reversible, effects agent/dose dependent
- Alpha-2-Agonists:
  - Xylazine contraindicated in small animals[1]
  - Low-dose dexmedetomidine (0.25-2 mcg/kg IV)

Selecting an Opioid

- Many Full-Mu Agonists used successfully[1,25]
  - Excellent analgesia
  - Placental transfer +/- neonatal depression
- Partial-Mu Agonist: Buprenorphine
  - Good to excellent analgesia
  - Low placental transfer (humans)?[33]
  - **Slower onset** (analgesia 30-45+ min after IV)[34,35]
- Kappa-Agonist/Mu-Antagonist: Butorphanol
  - < Analgesia, Short duration
  - <Respiratory/Cardiac depression, < Vomiting



Microsoft 365 stock images

Timing of Opioid Administration

- Historically “withheld” until delivery: **No longer appropriate**
- Premedication:
  - Lowest “effective” dose of Full-Mu, +/-re-dose once fetus(es) out
  - Short-acting drugs, naloxone available
- Butorphanol use:
  - Consider full-mu or partial-mu once fetus(es) removed
- CRIs – Caution with Fentanyl
  - “short-acting” – but accumulation

Dexmedetomidine

- Sedative, muscle relaxation, analgesia, and MAC ↓
- Newer studies suggest negligible fetal transfer, depression[38]
  - Low doses (2 mcg/kg IV)

ELSEVIER

Contents lists available at ScienceDirect

Theriogenology

journal homepage: www.theriojournal.com

Maternal and neonatal wellbeing during elective C-section induced with a combination of propofol and dexmedetomidine: How effective is the placental barrier in dogs?

Debora Groppetti [a,*], Federica Di Cesare [b], Alessandro Pecile [a], Petra Cagnardi [b], Roberta Merlanti [c], Elisa S. D'Urso [a], Daniela Gioeni [a], Patrizia Boracchi [d], Giuliano Ravasio [a]

Induction Agents

- **Avoid** inhalant induction[1]
- **Avoid** dissociative combinations[1,25, 39]
- **Avoid** etomidate[25,40]
- Alfaxalone vs Propofol
  - Both superior neonatal survival/Apgar[1,25,40]
  - Alfaxalone +/- ↑ Apgar scores after delivery[1,25,40]
  - No difference in neonate survival between agents[1,25]

Google images - zoetis

Google images – Henry Schein

Google images - Keebovet

Maintenance of Anesthesia

- Inhalant agents generally used
- Total IV Anesthesia (TIVA) - alfaxalone or propofol
  - ↑CV stability (dam) but ↓Apgar, prolonged recovery (dam)[1,25]
- Epidural alone
  - Unprotected airway, stressful for dam
  - Comparable survival with balanced inhalant protocol[1,25]

Locoregional Anesthesia

- Line/Incisional Block
  - Lidocaine 1-2 mg/kg during prep
  - Nocita - efficacy/duration questionable[46,47]

Google images – McKesson Medical-Surgical

- Lumbosacral Epidural – Analgesia +/- Motor Blockade
  - Bupivacaine or Lidocaine: Analgesia + motor blockade (<4hrs)[41]
  - PF Morphine: Analgesia only (**slow onset**), *Urinary retention

Neonatal Resuscitation

- Neonatal depression = hypoxemia +/- residual drug effects[45]
- Bradycardia (<180 bpm) = hypoxemia until proven otherwise
  - Anticholinergics CONTRAINDICATED
- Focus on warmth + improving O2 delivery[45]
  - Vigorously rub neonate with warm towel ~60 sec
  - Acupuncture if still apneic
  - THEN Consider reversal(s) if applicable

Courtesy of BHK

Doxapram

- CONTROVERSIAL – no longer used in human medicine
- No clear benefit in this clinical trial

JOURNAL OF Veterinary Pharmacology and Therapeutics

ORIGINAL ARTICLE | Open Access

The effect of doxapram on survival and APGAR score in newborn puppies delivered by elective caesarean: A randomized controlled trial

Timothy H. Hyndman, Shelby Fretwell, Ross S. Bowden, Flaminia Coaicetto, Peter C. Irons, Joshua W. Aleri, Nino Kordzakhia, Stephen W. Page, Gabrielle C. Musk ... See all authors

First published: 21 May 2023 | https://doi.org/10.1111/jvp.13388

Neonatal Acupuncture

- Stimulation of either acupoint resulted in ↑RR, HR, and Apgar

frontiers in Veterinary Science

Front Vet Sci. 2025 Apr 9;12:1579758. doi: 10.3389/fvets.2025.1579758

Efficacy of VG26 and K1 acupuncture points in cardiopulmonary resuscitation of neonatal puppies born by cesarean section

Maria Lucia G Lourenço [1,*], Fabíola C Knupp [1], Keylla Helena N P Pereira [1,2], Kárita M Fuchs [1], Gleice M Xavier [1], Júlia C Mendonça [1], Miriam Harumi Tsunemi [3], Fabiana F Souza [4], Jean G F Joaquim [4]

Analgesia for the Lactating Dam

- NSAIDs – safe in humans, likely safe for short-term use
  - Cattle + Dogs – minimal residue[22-24]
  - *Caution with mastitis?[22]
- Opioids
  - Likely safe for short-term use[1,43]
    - Buprenorphine - nursing humans[44]
  - Monitor neonate behavior + time feedings /doses[43]

Google images - Chewy

Summary

- Periparturients have physiologic Δ's increasing anesthetic risks:
  - ↑Risk of aspiration
  - ↑Risk hypotension
  - ↑Risk hypoxemia
- Choose protocol with analgesia for dam + limited/reversible effects on neonate(s)
  - Opioid +/- dexmedetomidine, propofol or alfaxalone, inhalant in most patients
- Bradycardia in neonate = hypoxemia until proven otherwise
  - Keep warm + oxygen support (reversal agents if needed)
- NSAIDs (+/- opioids) likely safe for short-term analgesia in lactating dams

Questions?

kdeom@iastate.edu

References:

1. Raffe, M.R. and Goudie-DeAngelis, E. (2024). Anesthetic Considerations During Pregnancy and for the Newborn. In Veterinary Anesthesia and Analgesia (eds L. Lamont, K. Grimm, S. Robertson, L. Love and C. Schroeder). https://doi.org/10.1002/9781119830306.ch45

2. Filipas, M. C., Owen, L., & Adami, C. (2024). A retrospective observational cohort study on the postoperative respiratory complications and their risk factors in brachycephalic dogs undergoing BOAS surgery: 199 cases (2019-2021). *Journal of Small Animal Practice*, *65*(5), 329-337.

3. Gruenheid, M., Aarnes, T. K., McLoughlin, M. A., Simpson, E. M., Mathys, D. A., Mollenkopf, D. F., & Wittum, T. E. (2018). Risk of anesthesia-related complications in brachycephalic dogs. *Journal of the American Veterinary Medical Association*, *253*(3), 301-306.

4. Singh, P. M., Singh, N. P., Reschke, M., Ngan Kee, W. D., Palanisamy, A., & Monks, D. T. (2020). Vasopressor drugs for the prevention and treatment of hypotension during neuraxial anaesthesia for Caesarean delivery: a Bayesian network meta-analysis of fetal and maternal outcomes. *British journal of anaesthesia*, *124*(3), e95–e107. https://doi.org/10.1016/j.bja.2019.09.045

5. Cannarozzo, C. J., Araos, J., & Martin-Flores, M. (2023). Phenylephrine and norepinephrine increase blood pressure through opposing physiologic mechanisms in isoflurane-anesthetized dogs receiving acepromazine. *American Journal of Veterinary Research*, *84*(11).

6. Kee, W. N., Khaw, K. S., Tan, P. E., Ng, F. F., & Karmakar, M. K. (2010). Placental transfer and fetal metabolic effects of phenylephrine and ephedrine during spinal anesthesia for cesarean delivery. *Obstetric Anesthesia Digest*, *30*(3), 159-160.

7. Rolbin, S. H., Levinson, G., Shnider, S. M., Biehl, D. R., & Wright, R. G. (1979). Dopamine treatment of spinal hypotension decreases uterine blood flow in the pregnant ewe. *Anesthesiology*, *51*(1), 37-40.

8. Fishburne Jr, J. I., Dormer, K. J., Payne, G. G., Gill, P. S., Ashratzadeh, A. R., & Rossavik, I. K. (1988). Effects of amrinone and dopamine on uterine blood flow and vascular responses in the gravid baboon. *American journal of obstetrics and gynecology*, *158*(4), 829-835.

9. Fishburne, J. I., Meis, P. J., Urban, R. B., Greiss, F. C., Wheeler, A. S., James, F. M., ... & Rhyne, A. L. (1980). Vascular and uterine responses to dobutamine and dopamine in the gravid ewe. *American Journal of Obstetrics and Gynecology*, *137*(8), 944-952.

10. O'Neill, D. G., O'sullivan, A. M., Manson, E. A., Church, D. B., Boag, A. K., McGreevy, P. D., & Brodbelt, D. C. (2017). Canine dystocia in 50 UK first-opinion emergency-care veterinary practices: prevalence and risk factors. *Veterinary Record*, *181*(4), 88-88.

11. O'Neill, D. G., O'Sullivan, A. M., Manson, E. A., Church, D. B., McGreevy, P. D., Boag, A. K., & Brodbelt, D. C. (2019). Canine dystocia in 50 UK first-opinion emergency care veterinary practices: clinical management and outcomes. *Veterinary Record*, *184*(13), 409-409.

12. Hollinshead, F. K., & Hanlon, D. W. (2017). Factors affecting the reproductive performance of bitches: A prospective cohort study involving 1203 inseminations with fresh and frozen semen. *Theriogenology*, *101*, 62-72

13. Holst, B. S., Axnér, E., Öhlund, M., Möller, L., & Egenvall, A. (2017). Dystocia in the cat evaluated using an insurance database. *Journal of feline medicine and surgery*, *19*(1), 42–47. https://doi.org/10.1177/1098612X1560048.

References continued:

14.. Zhu, C., Timothy, C. L., McCobb, E., Rozanski, E. A., & Schoeffler, G. L. (2024). Resource setting impacts neonatal but notmaternal survival in bitches treated for dystocia: 243 cases (2015–2020). *Journal of the American Veterinary Medical Association*, *1*(aop), 1-7.

15. Adams, D. J., Ellerbrock, R. E., Wallace, M. L., Schmiedt, C. W., Sutherland, B. J., & Grimes, J. A. (2022). Risk factors for neonatal mortality prior to hospital discharge in brachycephalic and nonbrachycephalic dogs undergoing cesarean section. *Veterinary Surgery*, *51*(7), 1052-1060.

16. Černá, P., Pugalendhi, S. J., Shaw, D. J., & Gunn-Moore, D. A. (2024). Feline dystocia and kitten mortality up to 12 weeks in pedigree cats. *Journal of Feline Medicine and Surgery*, *26*(12), 1098612X241284766.

17. De Cramer, K. G. M., Joubert, K. E., & Nöthling, J. O. (2016). Hematocrit changes in healthy periparturient bitches that underwent elective cesarean section. *Theriogenology*, *86*(5), 1333-1340.

18. Moxon, R., Dutton Worsfold, R., Davis, J., Adams, W., & England, G. C. (2023). Luteal phase decrease in packed cell volume in healthy non-pregnant and pregnant bitches. *Veterinary Medicine and Science*, *9*(5), 1989-1997.

19. Abitbol, M. M. (1978). Inferior vena cava compression in the pregnant dog. *American Journal of Obstetrics and Gynecology*, *130*(2), 194-198.

20. Chalifoux, N. V., Silverstein, D. C., Page, B., & Fudge, J. M. (2022). Assessment of changes in intra-abdominal pressure and abdominal perfusion pressure in late-term pregnant queens undergoing elective ovariohysterectomy. *American Journal of Veterinary Research*, *83*(8).

21. PROBST, C. W., BROADSTONE, R. V., & EVANS, A. T. (1987). Postural influence on systemic blood pressure in large full-term pregnant bitches during general anesthesia. *Veterinary Surgery*, *16*(6), 471-473.

22. Ferrari, D., Lundgren, S., Holmberg, J., Edner, A., Ekstrand, C., Nyman, G., ... & Hagman, R. (2022). Concentration of carprofen in the milk of lactating bitches after cesarean section and during inflammatory conditions. *Theriogenology*, *181*, 59-68.

23. Mzyk, D. A., Giles, C. B., Baynes, R. E., & Smith, G. W. (2023). Milk residues following multiple doses of meloxicam and gabapentin in lactating dairy cattle. *Journal of the American Veterinary Medical Association*, *261*(12), 1873-1879.

24. Ludwig, B., Jordan, J. C., Rehm, W. F., & Thun, R. (1989). Carprofen in veterinary medicine. I. Plasma disposition, milk excretion and tolerance in milk-producing cows. *Schweizer Archiv fur Tierheilkunde*, *131*(2), 99-106.

25. Navarro-Altuna, V., Purwin, S., & Ranninger, E. (2024). The influence of anaesthesia drugs on puppy vitality after caesarean section: A systematic review. *Veterinary Anaesthesia and Analgesia*.

26. Kraus, B. L. H. (2014). Effect of dosing interval on efficacy of maropitant for prevention of hydromorphone-induced vomiting and signs of nausea in dogs. *Journal of the American Veterinary Medical Association*, *245*(9), 1015-1020.

27. Lorenzutti, A. M., Martín-Flores, M., Litterio, N. J., Himelfarb, M. A., & Zarazaga, M. P. (2016). Evaluation of the antiemetic efficacy of maropitant in dogs medicated with morphine and acepromazine. *Veterinary Anaesthesia and Analgesia*, *43*(2), 195-198.

28. McNally, E. M., Robertson, S. A., & Pablo, L. S. (2009). Comparison of time to desaturation between preoxygenated and nonpreoxygenated dogs following sedation with acepromazine maleate and morphine and induction of anesthesia with propofol. *American Journal of Veterinary Research*, *70*(11), 1333-1338.

29. Chi, T. T., & Hay Kraus, B. L. (2020). The effect of intravenous maropitant on blood pressure in healthy awake and anesthetized dogs. *Plos one*, *15*(2), e0229736.

30. Boscan, P., Monnet, E., Mama, K., Twedt, D. C., Congdon, J., & Steffey, E. P. (2011). Effect of maropitant, a neurokinin 1 receptor antagonist, on anesthetic requirements during noxious visceral stimulation of the ovary in dogs. *American Journal of Veterinary Research*, *72*(12), 1576-1579.

References continued

31. Wilson, D. V., Evans, A. T., & Mauer, W. A. (2006). Influence of metoclopramide on gastroesophageal reflux in anesthetized dogs. *American journal of veterinary research*, *67*(1), 26-31.

32. Keller, S. R., Abonyi-Tóth, Z., Sprenger, N., Austin, S. C., Wichert, B. A., Liesegang, A., ... & Reichler, I. M. (2018). Effectof metoclopramide treatment of bitches during the first week of lactation on serum prolactin concentration, milk composition, and milk yield and on weight gain of their puppies. *American Journal of Veterinary Research*, *79*(2), 233-241.

33. Nanovskaya, T., Deshmukh, S., Brooks, M., & Ahmed, M. S. (2002). Transplacental transfer and metabolism of buprenorphine. *The Journal of pharmacology and experimental therapeutics*, *300*(1), 26-33.

34. Andaluz, A., Moll, X., Abellán, R., Ventura, R., Carbó, M., Fresno, L., & García, F. (2009). Pharmacokinetics of buprenorphine after intravenous administration of clinical doses to dogs. *The Veterinary Journal*, *181*(3), 299-304.

35. Robertson, S. A., Lascelles, B. D. X., Taylor, P. M., & Sear, J. W. (2005). PK-PD modeling of buprenorphine in cats: intravenous and oral transmucosal administration 1. *Journal of Veterinary Pharmacology and Therapeutics*, *28*(5), 453-460.

36. Michelsen, L. G., Salmenperä, M., Hug Jr, C. C., Szlam, F., & VanderMeer, D. (1996). Anesthetic potency of remifentanil in dogs. *Anesthesiology*, *84*(4), 865-872.

37. Van de Velde, M. (2016). The use of remifentanil during general anesthesia for caesarean section.*Current Opinion in Anesthesiology*, *29*(3), 257-260.

38. Groppetti, D., Di Cesare, F., Pecile, A., Cagnardi, P., Merlanti, R., D'Urso, E. S., ... & Ravasio, G. (2019). Maternal and neonatal wellbeing during elective C-section induced with a combination of propofol and dexmedetomidine: How effective is the placental barrier in dogs?. *Theriogenology*, *129*, 90-98.

39. Luna, S. P. L., Cassu, R. N., Castro, G. B., Teixeira Neto, F. J., Silva, J. R., & Lopes, M. D. (2004). Effects of four anaesthetic protocols on the neurological and cardiorespiratory variables of puppies born by caesarean section. *Veterinary Record*, *154*(13), 387-389.

40. Srithunyarat, T., Jitpean, S., Wipoosak, P., Nonthakotr, C., Boonbal, N., Kunkitti, P., & Seesupa, S. (2024). Apgar scores in puppies following the induction of etomidate compared with alfaxalone or propofol for cesarean section. *Veterinary World*, *17*(3), 527.

41. Steagall, P. V., Simon, B. T., Teixeira Neto, F. J., & Luna, S. P. (2017). An update on drugs used for lumbosacral epidural anesthesia and analgesia in dogs. *Frontiers in veterinary science*, *4*, 68.

42. Cain, J., & Davidson, A. (2023). Canine cesarean section: Emergency and elective. *Veterinary Clinics: Small Animal Practice*, *53*(5), 1123-1146.

43. Mathews, K. A. (2005). Analgesia for the pregnant, lactating and neonatal to pediatric cat and dog.*Journal of veterinary emergency and critical care*, *15*(4), 273-284.

44. Drugs and Lactation Database (LactMed®) [Internet]. Bethesda (MD): National Institute of Child Health and Human Development; 2006-. Buprenorphine. [Updated 2024 May 15]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK501202/

45. Traas, A. M. (2008). Resuscitation of canine and feline neonates. *Theriogenology*, *70*(3), 343-348.

46. Hollenbeck, D. L., Knue, J. D., Simon, B. T., Jeffery, N. D., Mankin, K. M. T., & Dickerson, V. M. (2025). Use of peri-incisional liposomal bupivacaine was not different than placebo regarding pain score or rescue analgesia in a randomized clinical trial of 83 dogs. *Journal of the American Veterinary Medical Association*, *1*(aop), 1-7.

47. Hixon, L. P., Wallace, M. L., Appleton-Walth, K., Shetler, S., Aiello, J. S., Durocher, E., ... & Schmiedt, C. W. (2024). Bupivacaine liposomal injectable suspension does not provide improved pain control in dogs undergoing abdominal surgery. *Journal of the American Veterinary Medical Association*, *262*(2), 1-9.