New Techniques for Stabilizing Dyspneic Dogs and Cats

Amanda A Cavanagh, DVM, DACVECC

Auburn Annual Conference 2024

1

2

Road Map

- How Dyspnea Occurs
- Phone Triage
- Treating Dyspnea
- Overcoming Airway Obstruction
  - Tricky intubation
  - Cricothyroidotomy

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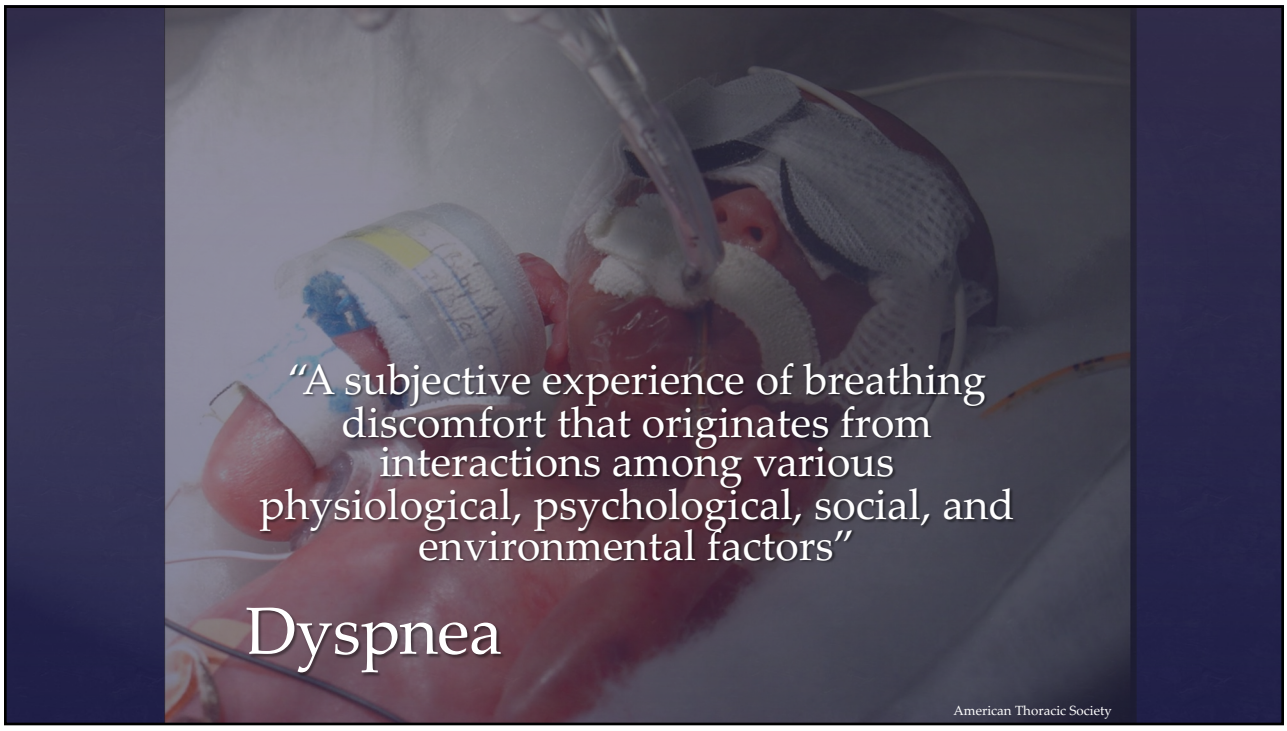

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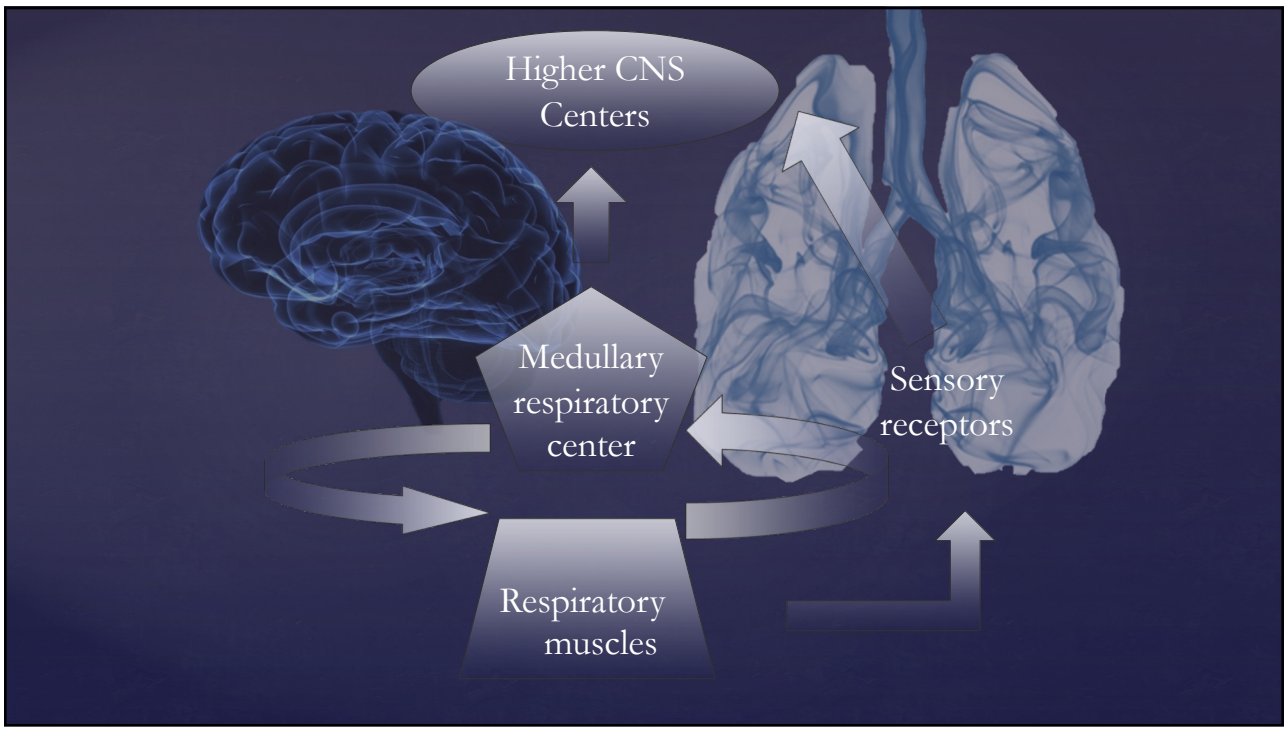
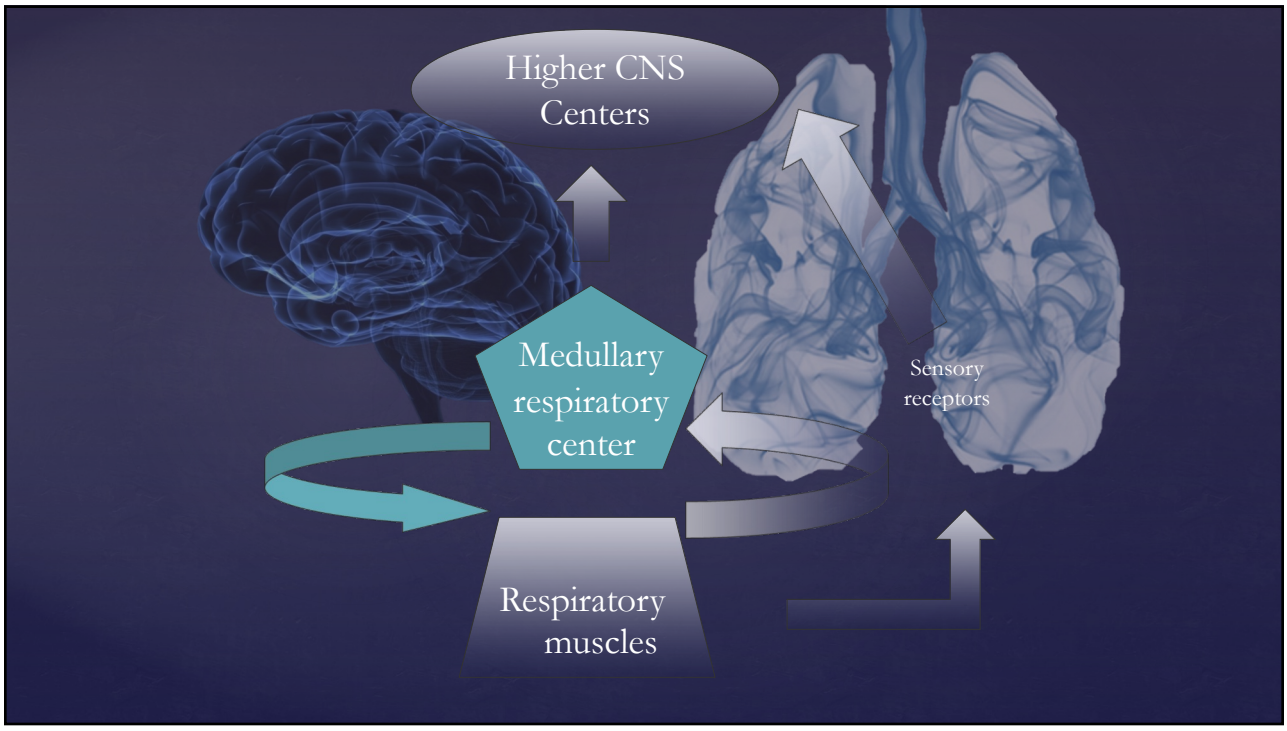

Higher CNS Centers
Medullary respiratory center
Sensory receptors
Respiratory muscles

5


Higher CNS Centers
Medullary respiratory center
Sensory receptors
Respiratory muscles

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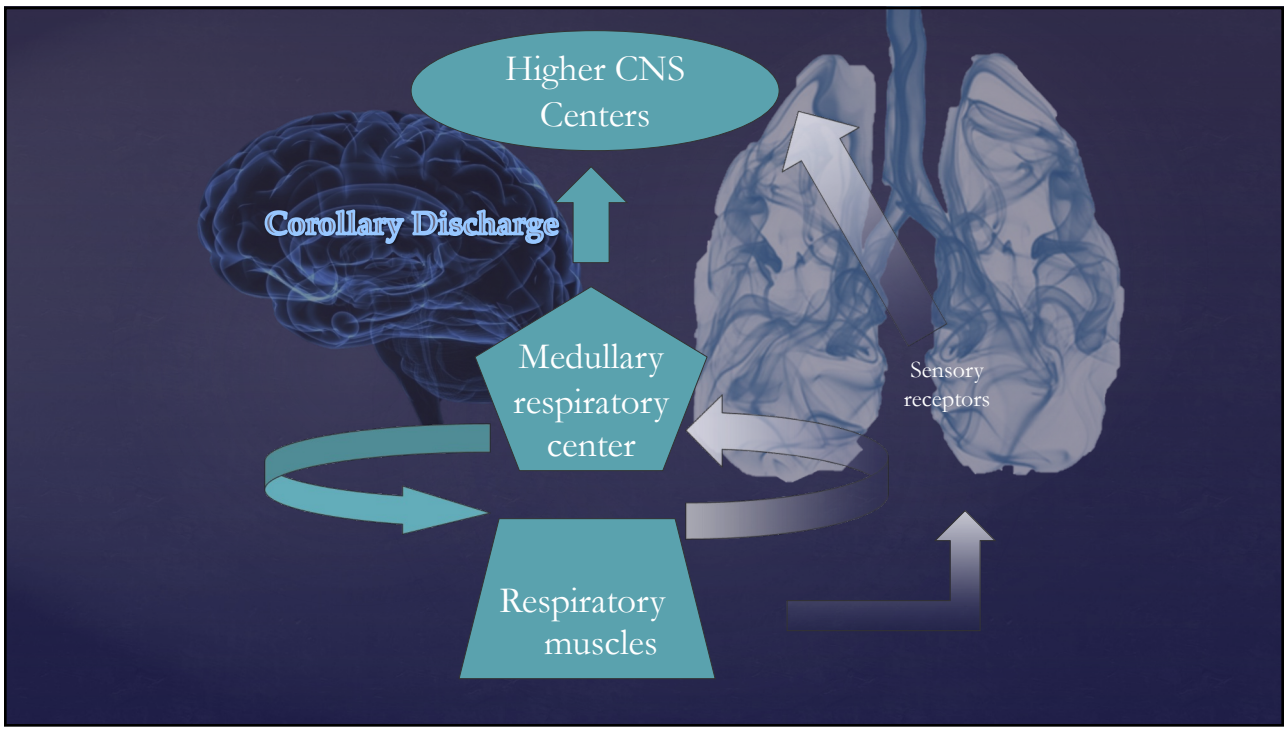
Higher CNS Centers
Corollary Discharge
Medullary respiratory center
Sensory receptors
Respiratory muscles

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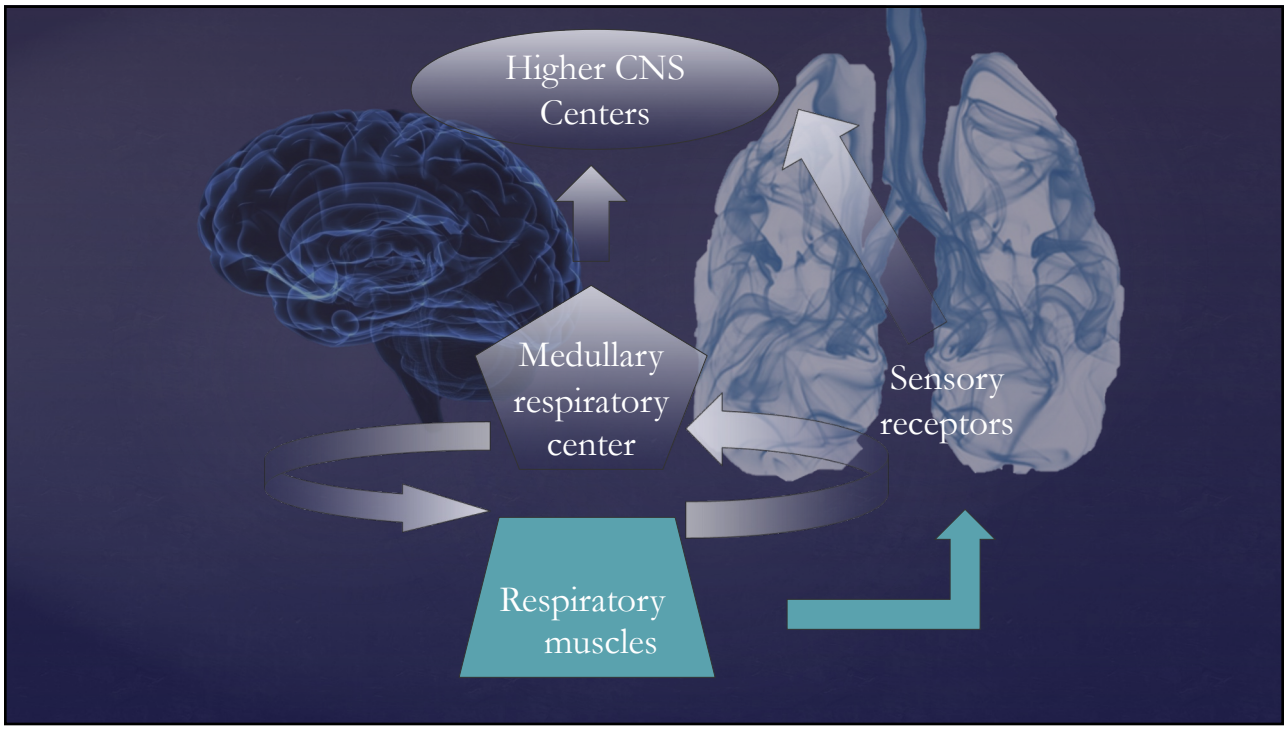
Higher CNS Centers
Medullary respiratory center
Sensory receptors
Respiratory muscles

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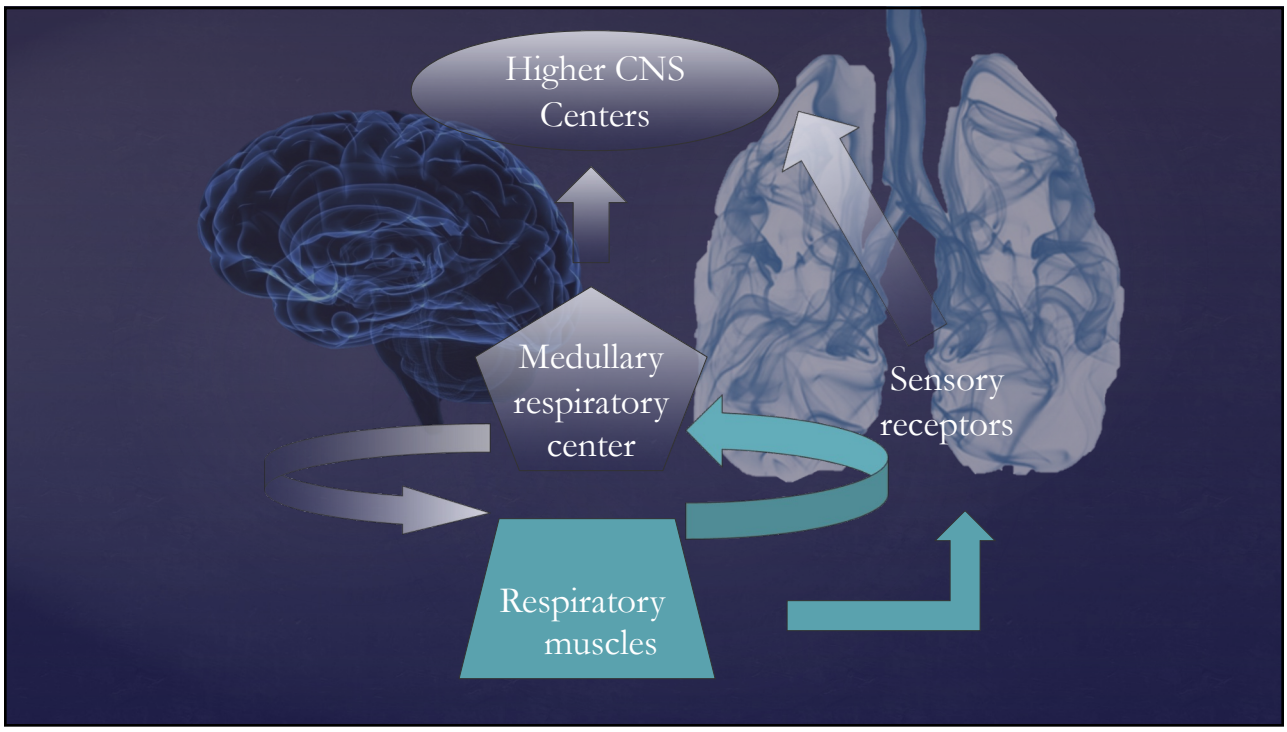
Higher CNS Centers
Medullary respiratory center
Sensory receptors
Respiratory muscles

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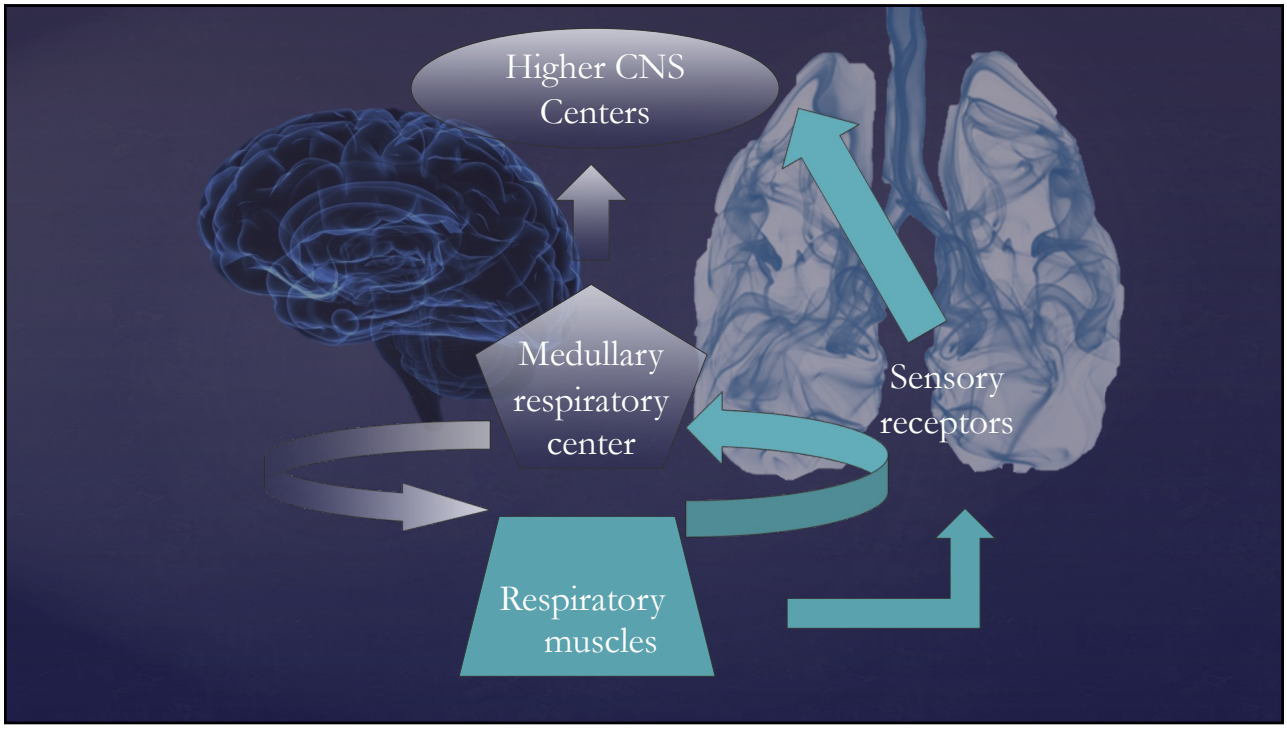
Higher CNS Centers
Medullary respiratory center
Sensory receptors
Respiratory muscles

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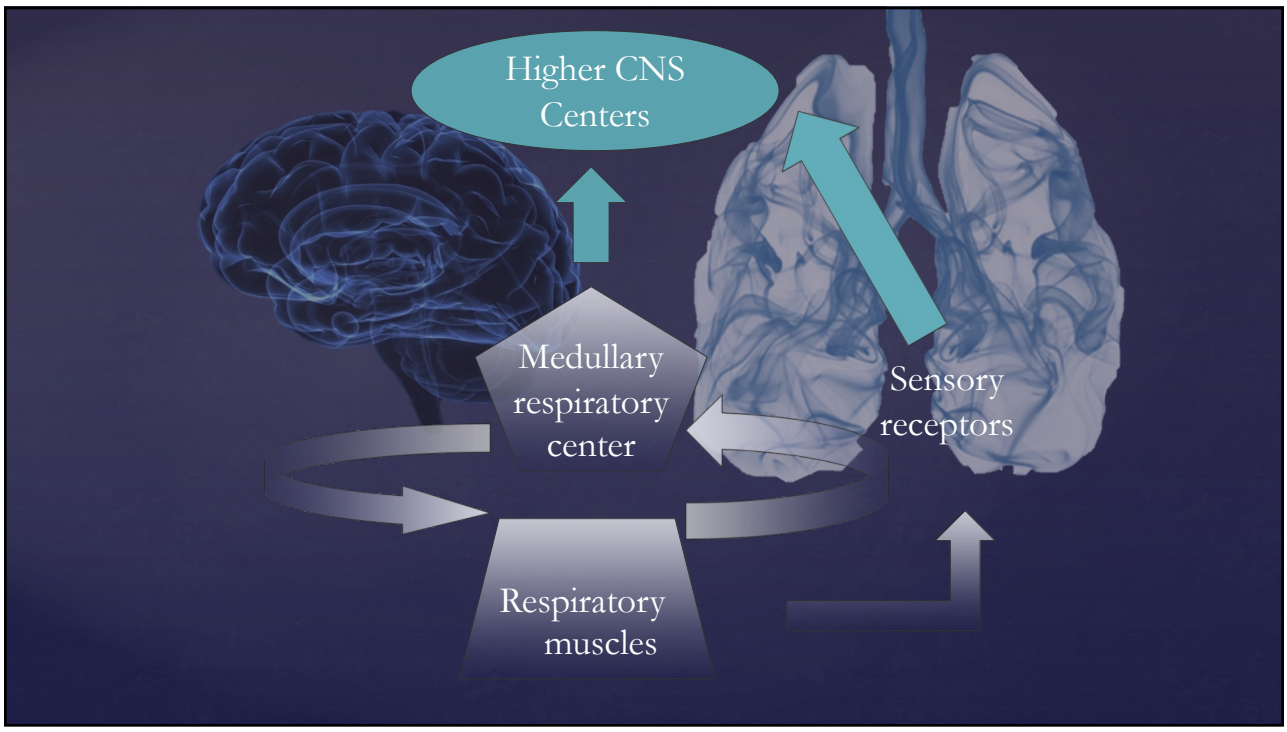
Higher CNS Centers
Medullary respiratory center
Sensory receptors
Respiratory muscles

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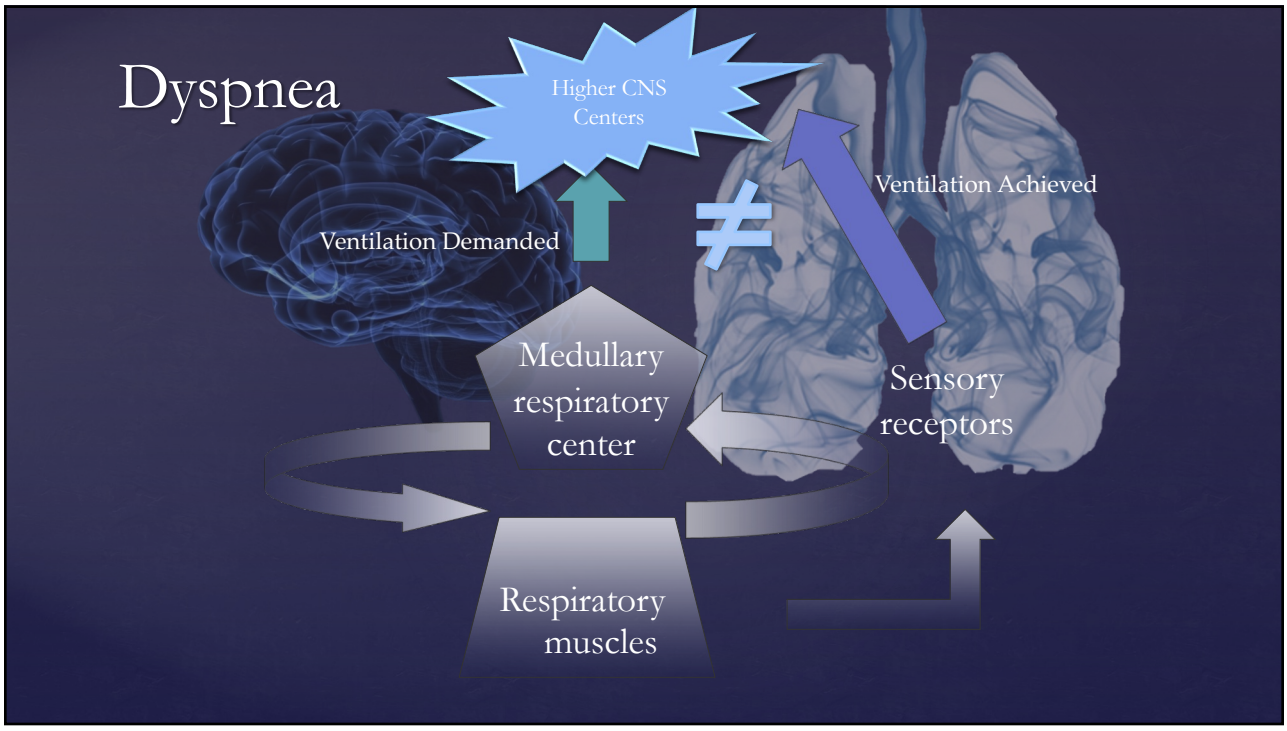

Dyspnea
Higher CNS Centers
Ventilation Demanded
≠
Ventilation Achieved
Medullary respiratory center
Sensory receptors
Respiratory muscles

12

Air hunger: Uncomfortable, unsatisfied urge to breathe

Increased work/effort: Imbalance between the work required and the capacity of muscles

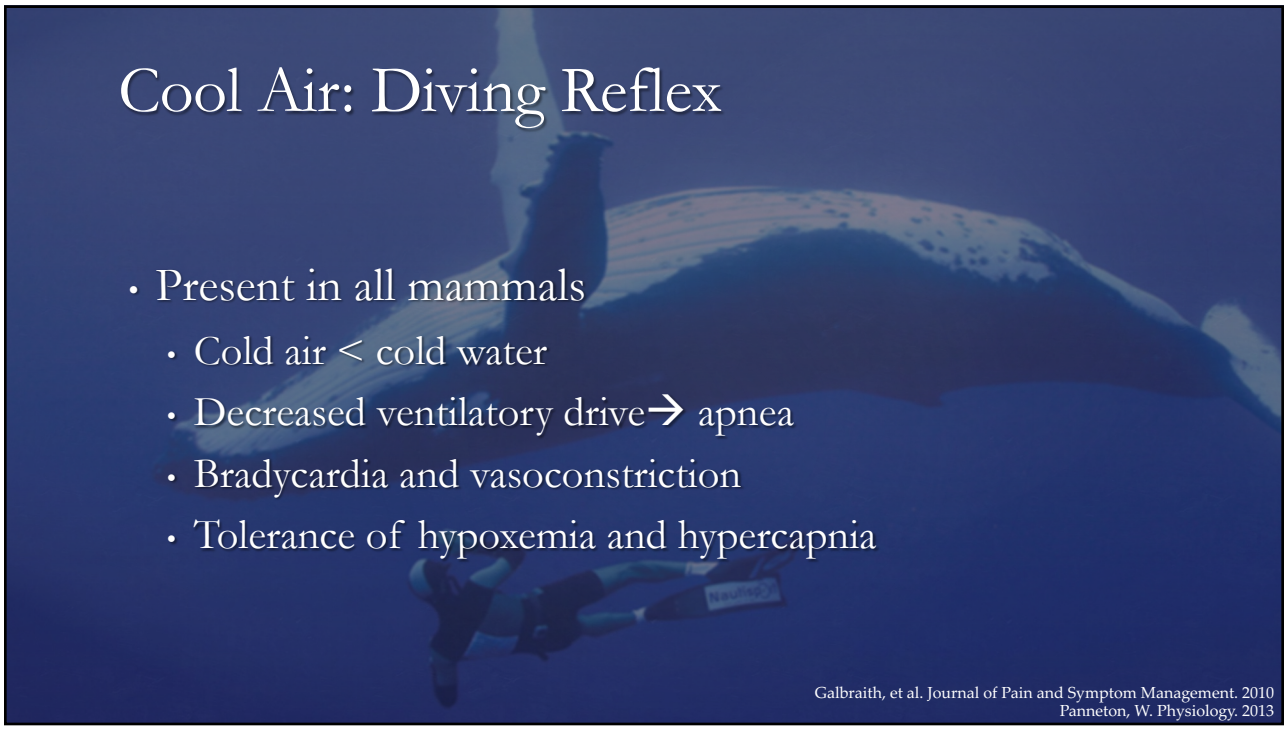
Chest tightness: Bronchoconstriction

13

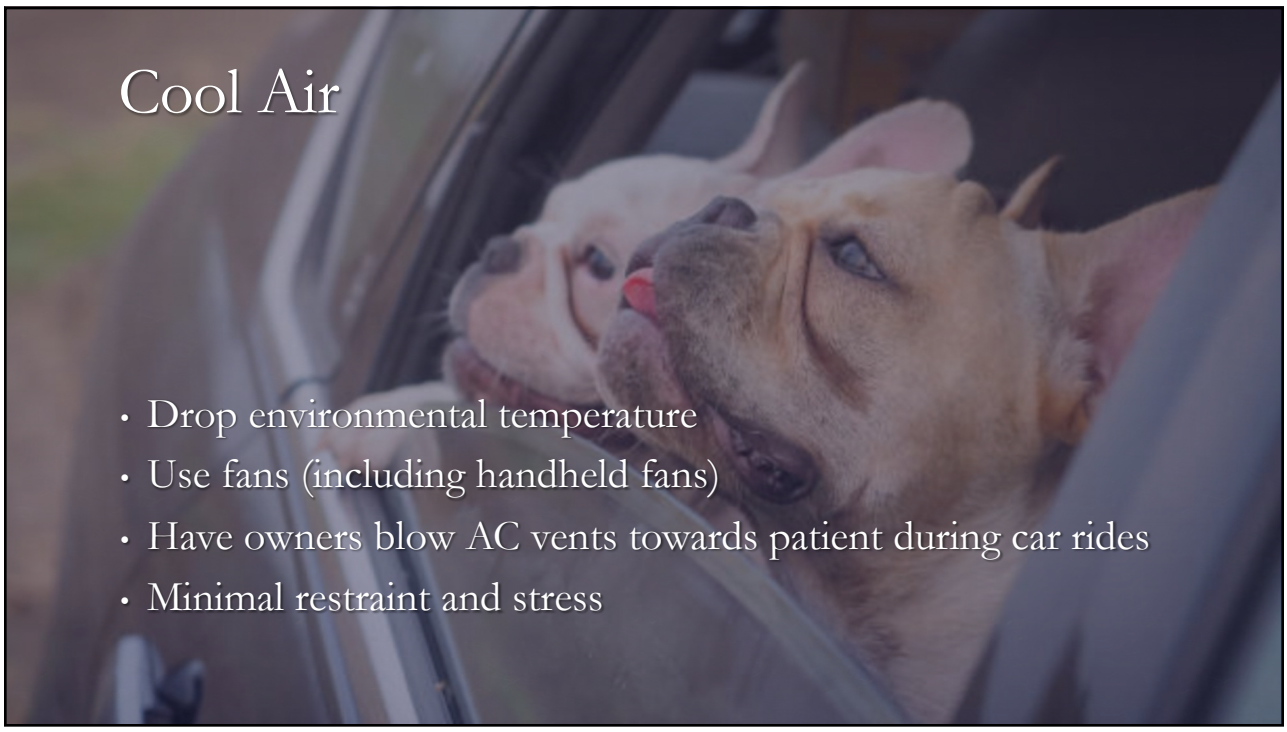
14


Cool Air
• Cool air directed at the face decreases breathlessness
• Trigeminal nerve
• Stimulation of cold receptors in upper airway
Galbraith, et al. Journal of Pain and Symptom Management. 2010
Panneton, W. Physiology. 2013

15


Cool Air: Diving Reflex
• Present in all mammals
• Cold air < cold water
• Decreased ventilatory drive→ apnea
• Bradycardia and vasoconstriction
• Tolerance of hypoxemia and hypercapnia
Galbraith, et al. Journal of Pain and Symptom Management. 2010
Panneton, W. Physiology. 2013

16


Cool Air
• Drop environmental temperature
• Use fans (including handheld fans)
• Have owners blow AC vents towards patient during car rides
• Minimal restraint and stress

17


Obstructive Pattern:
slow and deep
stertor
stridor
https://www.youtube.com/watch?v=kqx0ZyEcOwg

18

19

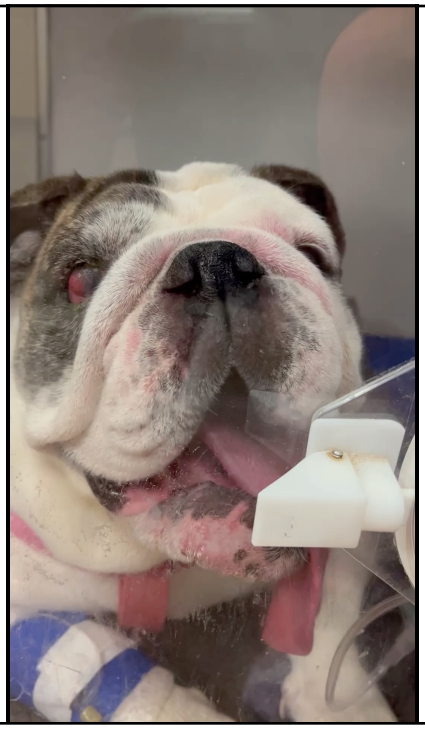
20

21

22

Approach to Airway Obstruction

- Triage: cool fans
- O2 + Cool
- Sedation
- Endotracheal intubation (challenging)
- Cricothyroidotomy
  - Emergency procedure
- Tracheostomy
  - Controlled surgical procedure



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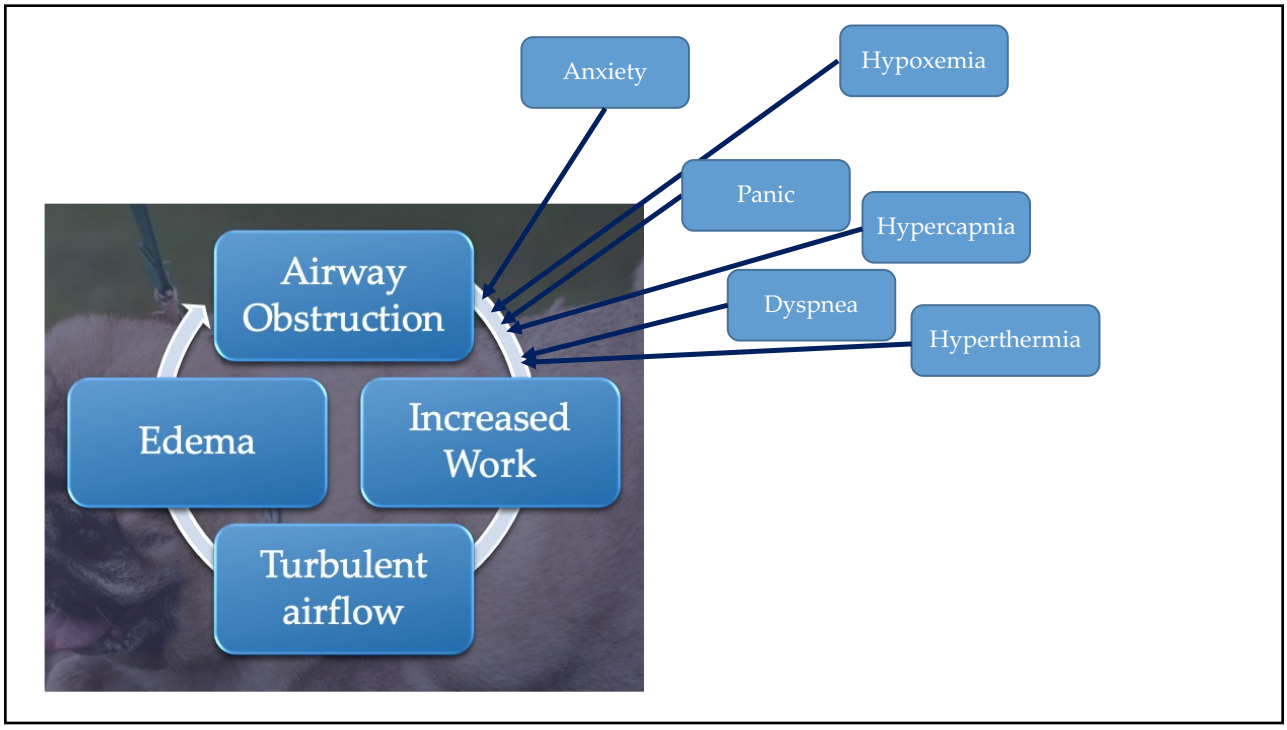

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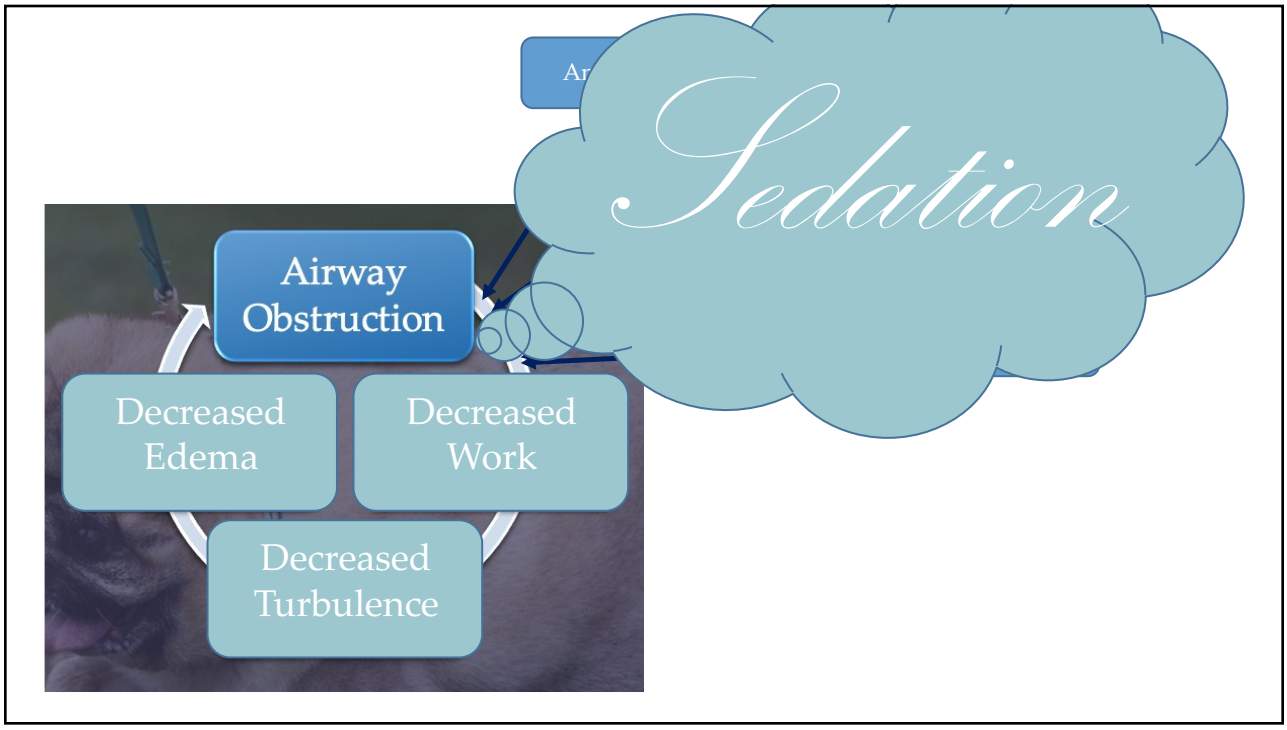


26

Sedation

Kappa agonist
Mu antagonist

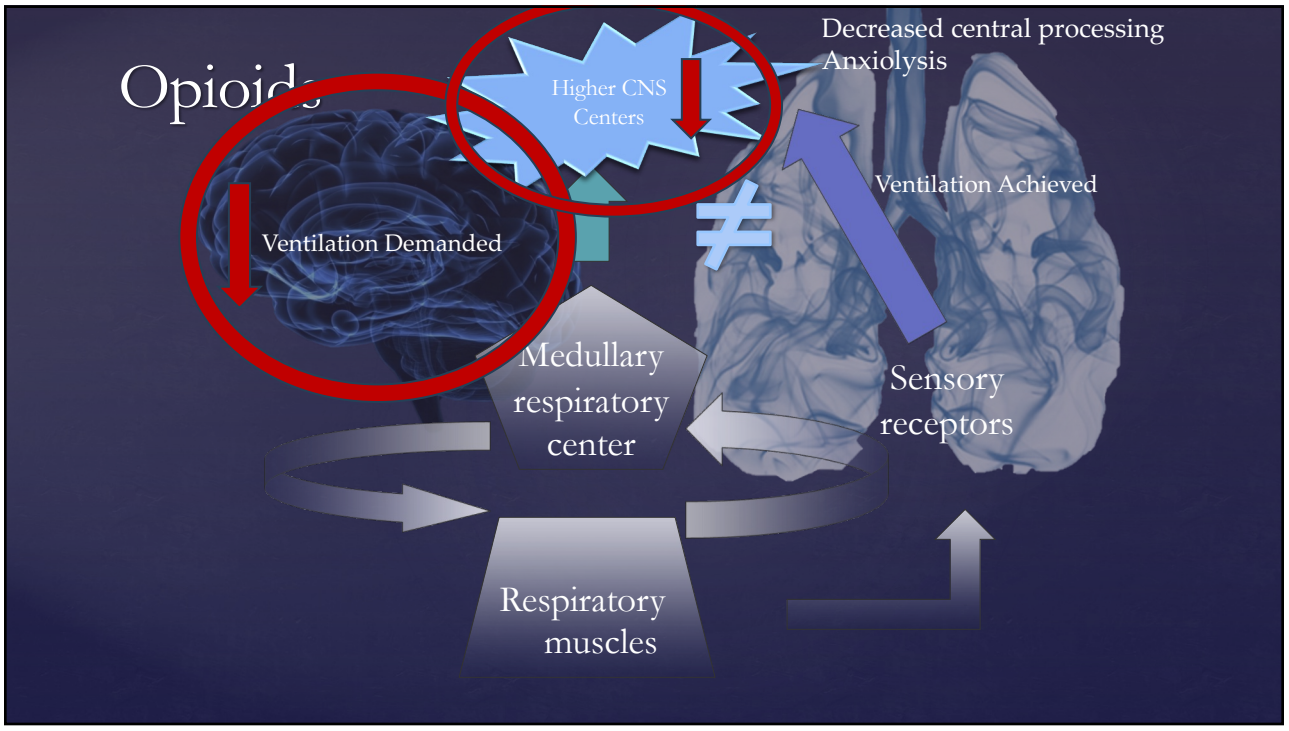
Cough Suppressant
Respiratory Depressant

27

Opioids

- Respiratory depressant
- Decreased sensitivity to hypercapnia
- Decreased central processing of dyspnea
- Mild anxiolytic

28

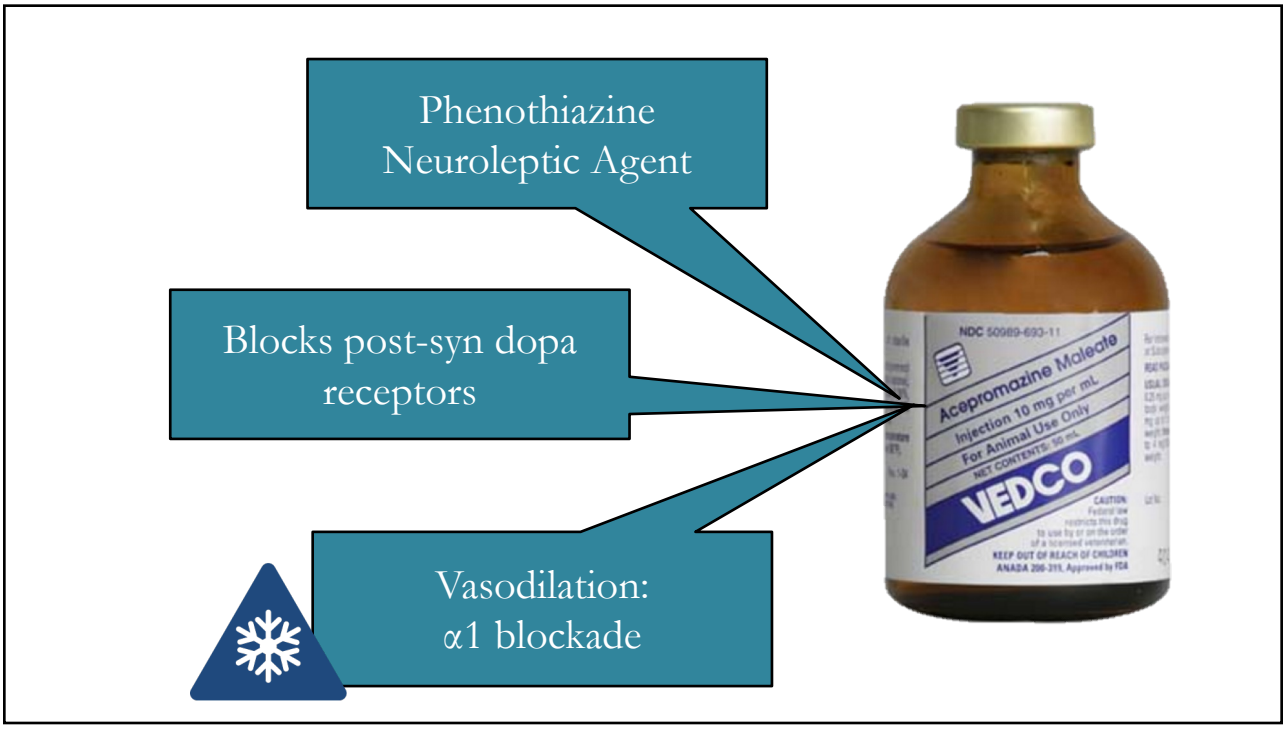


29

Opioids + Anxiolytics

- Anxiolytics do not directly treat dyspnea
  - Multifactorial
- Treat anxiety elicited by dyspnea
  - Benzodiazepine, acepromazine
- Dyspnea resolution variable

30



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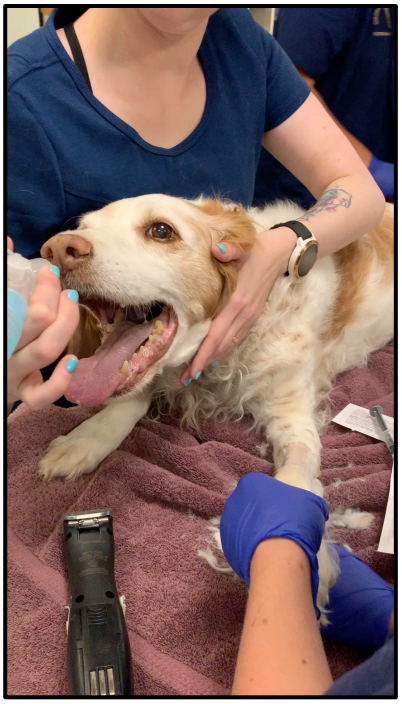
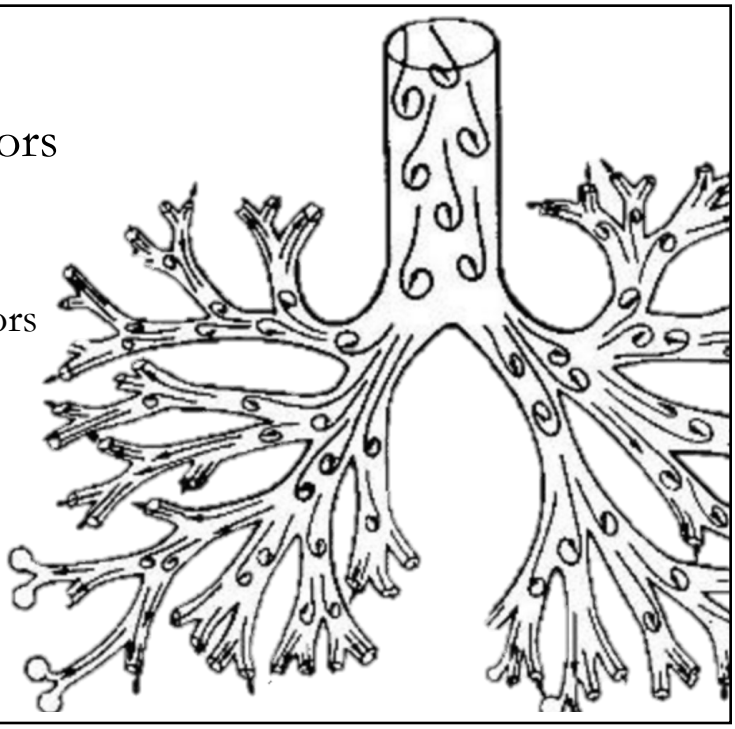


32

Lower Airway Receptors

- Slow Adapting Receptors
- Rapidly Adapting Receptors
- C-fibers
- Neuroepithelial Bodies
- Aδ Nociceptors



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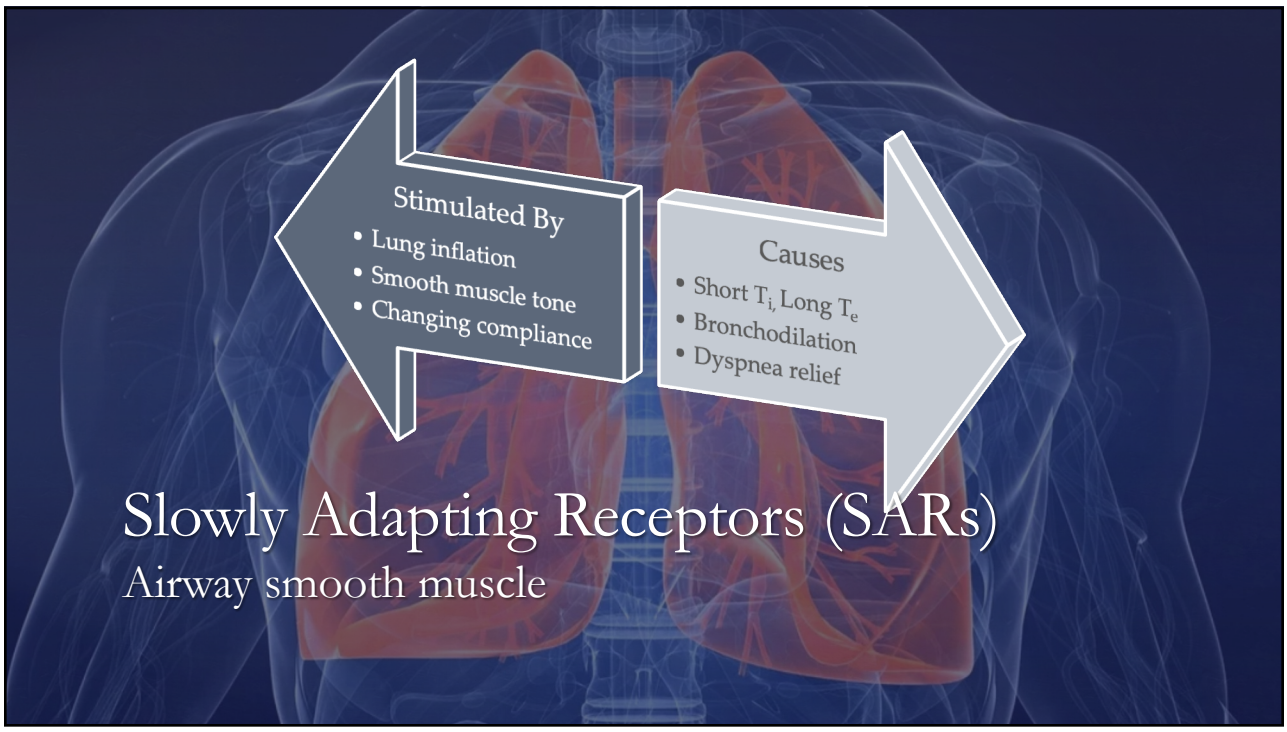


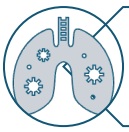
34

Rapidly Adapting Receptors: epithelium, submucosa

- Mechanical Stimuli
- Chemical Stimuli
- Airway or Lung Pathology

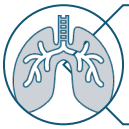
35

Rapidly Adapting Receptors: epithelium, submucosa



Mechanical Stimuli

Chemical Stimuli



Airway or Lung Pathology

Increased Dyspnea

Prolonged Ti, Short Te

Bronchoconstriction

36

SAR Sensitizers: Nebulized Furosemide

Uncomfortable urge to breathe. Alleviated by increased chest wall expansion.

Relieves feelings of *air hunger* and *increased work/effort*

Imbalance of work required and CAPACITY of muscles to perform work. Alleviated by muscle stimulation

Nishino, et al., Am J of Resp and Critical Care Med. 2000
Moosavi, et al. Resp Physio and Neurobiology. 2007

37

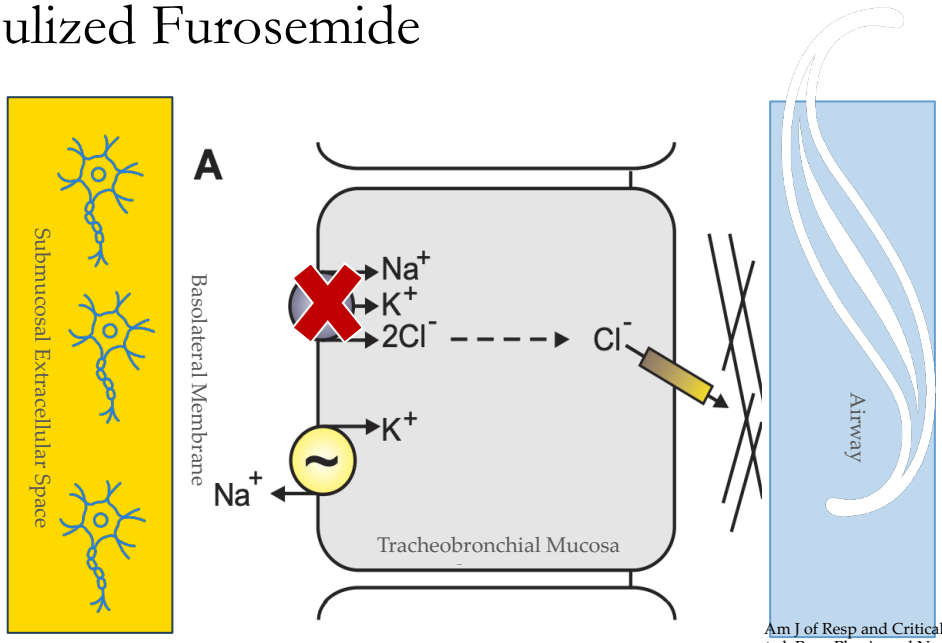
Nebulized Furosemide

- Stimulates SARs
- Desensitizes RARs
- Inhibits Cough
- Dec Bronchoconstriction

Sudo et al., Am J of Resp and Critical Care Med. 2000
Nishino, et al., Am J of Resp and Critical Care Med. 2000
Moosavi, et al. Resp Physio and Neurobiology. 2007

38

Nebulized Furosemide



Am J of Resp and Critical Care Med. 2000
Moosavi, et al. Resp Physio and Neurobiology. 2007

39

Anesthesiology 2001; 95:1234–7

Inhaled Furosemide Inhibits Behavioral Response to Airway Occlusion in Anesthetized Cats

Shino Nehashi, M.D., Takashi Nishino, M.D.,† Tohru Ide, M.D.‡*

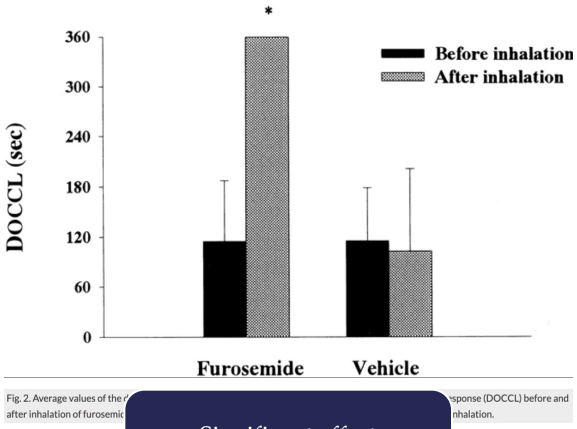


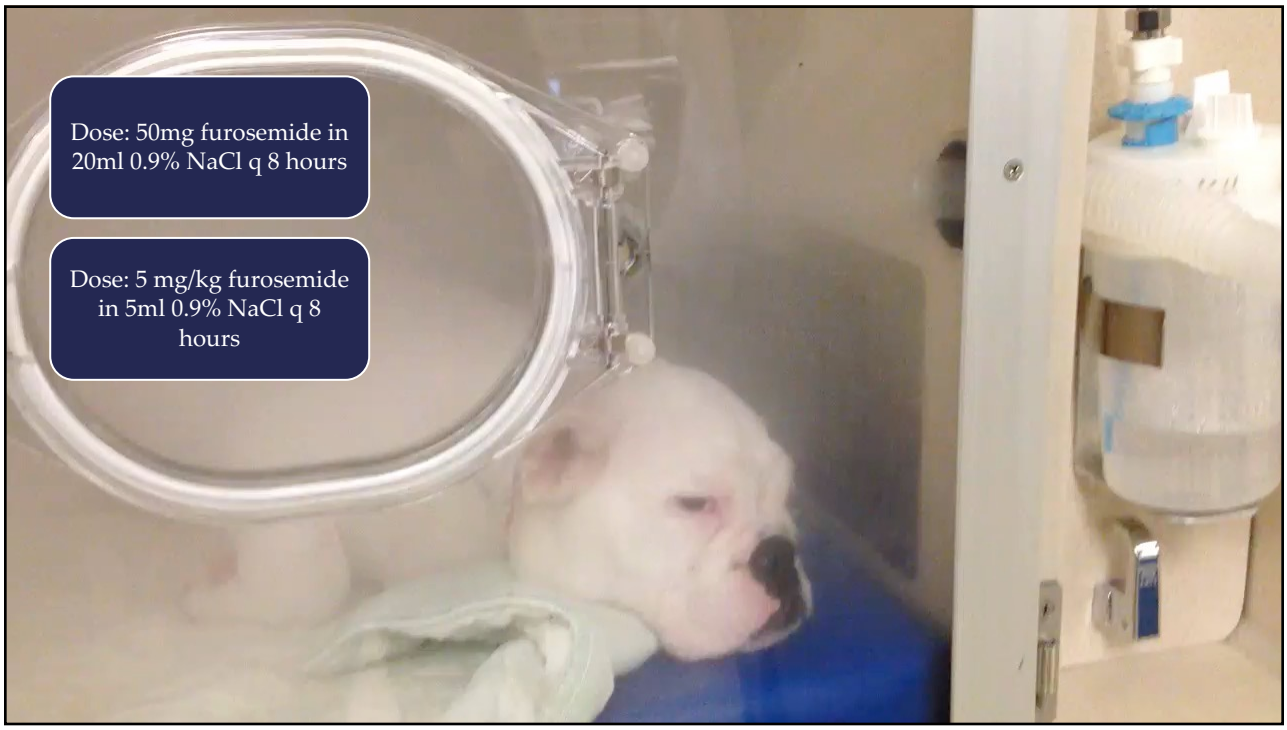
Fig. 2. Average values of the ( ) response (DOCCL) before and after inhalation of furosemic inhalation.

Ultrasonic Nebulizer: 60 mg furosemide in 6ml 6ml saline

Time from airway occlusion to escape response

Significant effect Lasts 3 hours

40



Dose: 50mg furosemide in 20ml 0.9% NaCl q 8 hours

Dose: 5 mg/kg furosemide in 5ml 0.9% NaCl q 8 hours

42

Nebulizers

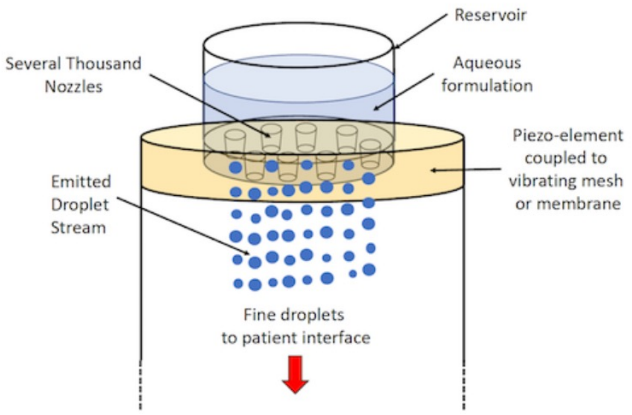


Figure 4: Schematic showing the atomization process in a vibrating mesh nebulizer

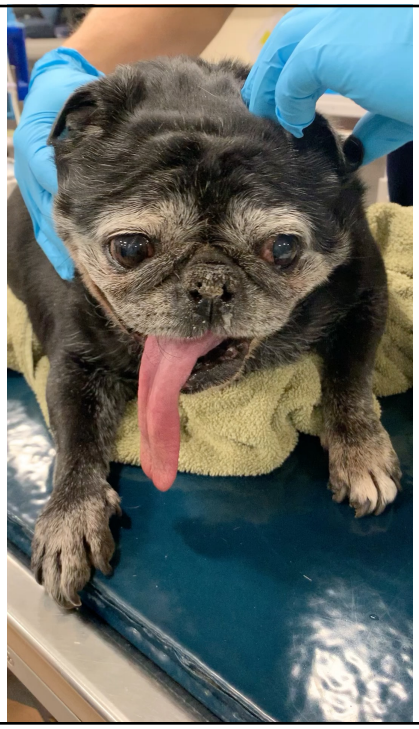
43

Nebulizers

44

Nebulized Epinephrine

- Mitigate airway obstruction
- Vasoconstrict upper airway mucosa
  - Alpha receptors
  - Decreased edema
  - Avoid tracheostomy and crics



45

Nebulized Epinephrine

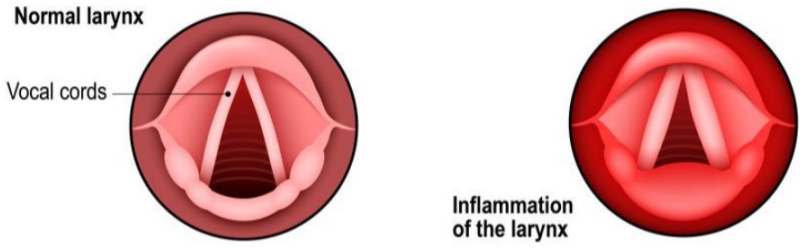
Cochrane Database of Systematic Reviews | Review - Intervention

Nebulized epinephrine for croup in children

Candice Bjornson, Kelly Russell, Ben Vandermeer, Terry P Klassen, David W Johnson

Version published: 10 October 2013 Version history

https://doi.org/10.1002/14651858.CD006619.pub3



46

Crit Care Med. Author manuscript; available in PMC 2013 Dec 2.
Published in final edited form as:
Crit Care Med. 2011 Apr; 39(4): 10.1097/CCM.0b013e318207ec52.
doi: 10.1097/CCM.0b013e318207ec52
PMCID: PMC3845036
NIHMSID: NIHMS527613
PMID: 21263320

Preclinical evaluation of epinephrine nebulization to reduce airway hyperemia and improve oxygenation after smoke inhalation injury

Matthias Lange, MD, Atsumori Hamahata, MD, Daniel L. Traber, PhD, Robert A. Cox, PhD, Gabriela A. Kulp, PhD, Yoshimitsu Nakano, MD, Lillian D. Traber, RN, David N. Herndon, MD, and Perenlei Enkhbaatar, MD, PhD

ELSEVIER
Journal of Critical Care
Volume 19, Issue 2, June 2004, Pages 99-102

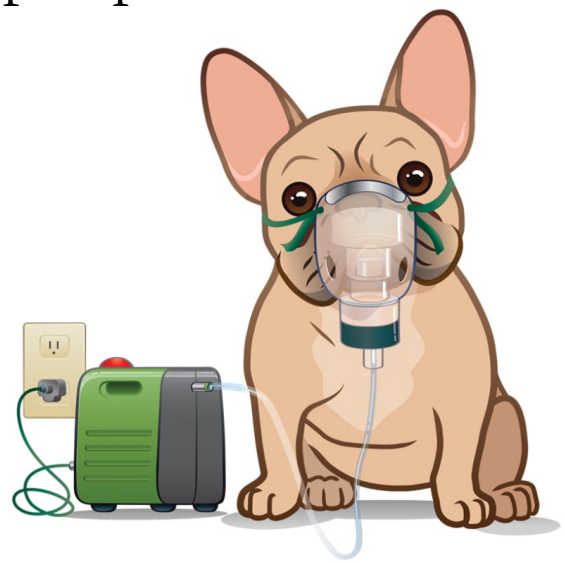
Comparison of nebulized epinephrine and terbutaline in patients with acute severe asthma: a controlled trial [1]

Michèle Adoun [a], Jean-Pierre Frat [a], Pierre Doré [b], Jean Rouffineau [c], Cendrine Godet [a], René Robert [a]

47

Nebulized Epinephrine

- Timing
  - Acute airway obstruction
  - Post extubation recovery
- Epi 0.05 mg/kg
- Dilute in 5ml 0.9% NaCl
- Deliver for 10 minutes



48

Nebulization of epinephrine to reduce the severity of brachycephalic obstructive airway syndrome in dogs

Phil H. Franklin MA, VetMB, MRCVS | Nai-Chieh Liu DVM, MPhil, PhD | Jane F. Ladlow MA, VetMB, CertSAS, CertVR, DECVS, MRCVS

- BOAS Index via whole body plethysmography
  - 0% = normal airway
  - 100% = severe BOAS
- Pre-op: highest effect on BOAS index >70% and pugs
- Post-op: 14.3% decrease in BOAS index

49

Nebulized Epinephrine

- Adverse Effects
  - Grey mucous membrane (ugly)
  - Tremors
  - Excitement
  - Nausea
  - Tachycardia
  - Arrhythmias

50

- Cool Temps
- O2
- Sedation
- Nebulized Epinephrine

51

Well that didn't work…

- Sedate → Intubate
- Cricothyroidotomy
  - no time for sedation
  - complete obstruction

52

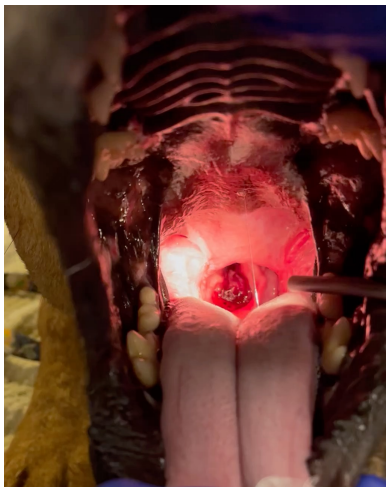
Difficult Intubation

Sedation IV or IM

- Vigorous: Opioid + Propofol 5mg/kg IV to effect
- Mildly Ill: Fentanyl 5-10 mcg/kg, Ketamine 5mg/kg, Midazolam 0.5mg/kg IV
- Moderately Ill: Fentanyl 5 - 10mcg/kg and Midazolam 0.5 mg/kg IV
- Moribund: Fentanyl 5 – 10 mcg/kg IV

54

Difficult Intubation

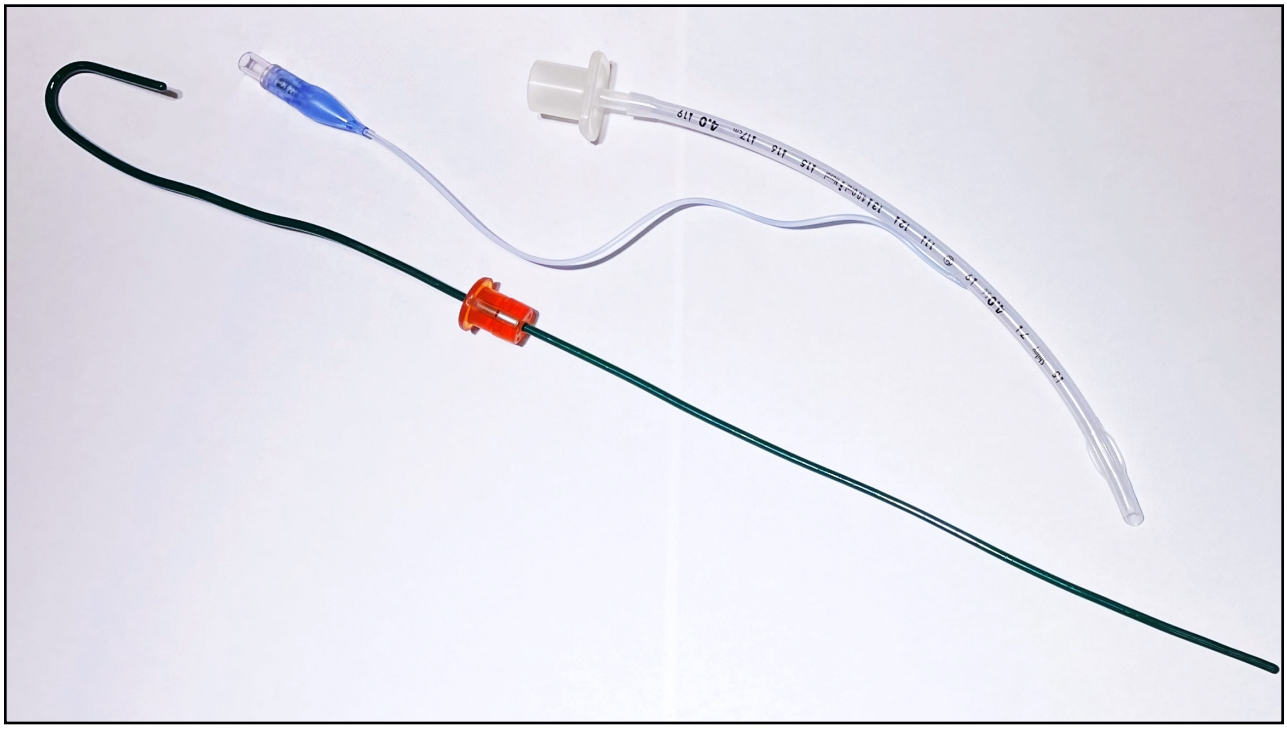


55

Difficult Intubation

- Suction
- Swab
- Styletted ET Tube
- Temporary catheter
- Cricothyroidotomy
- Tracheostomy

56



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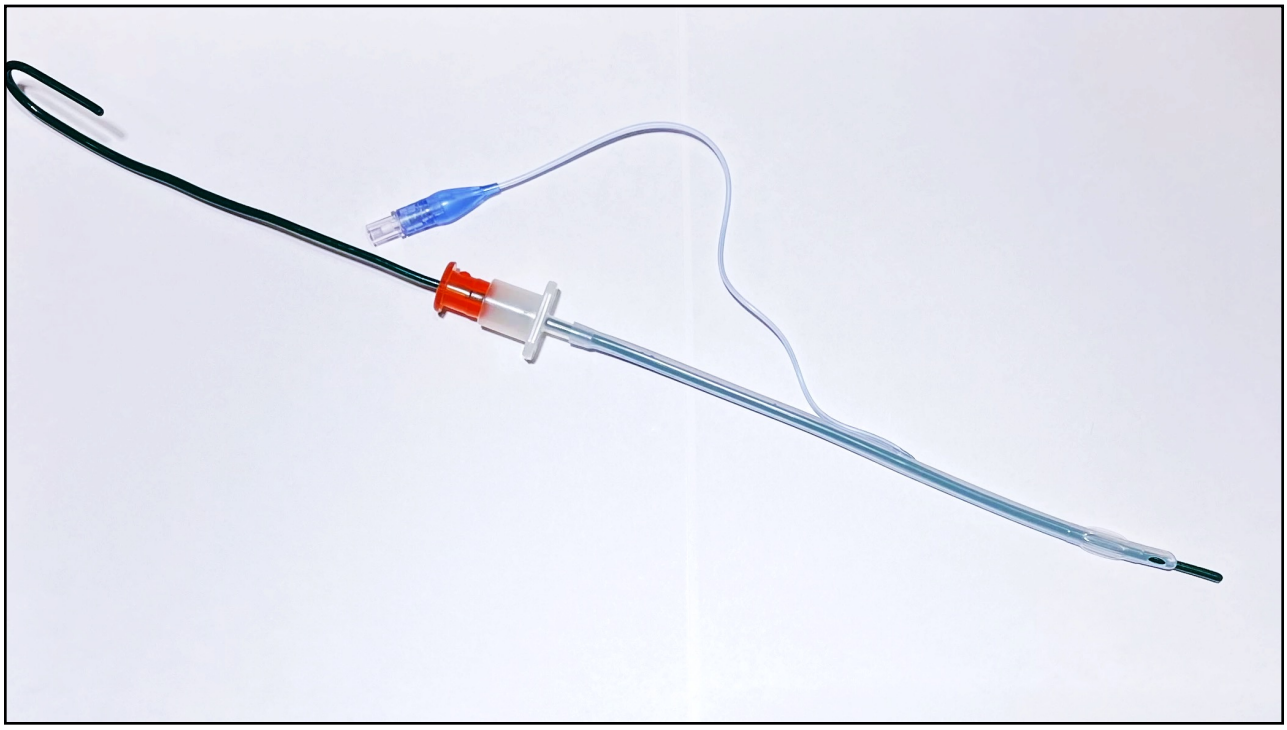

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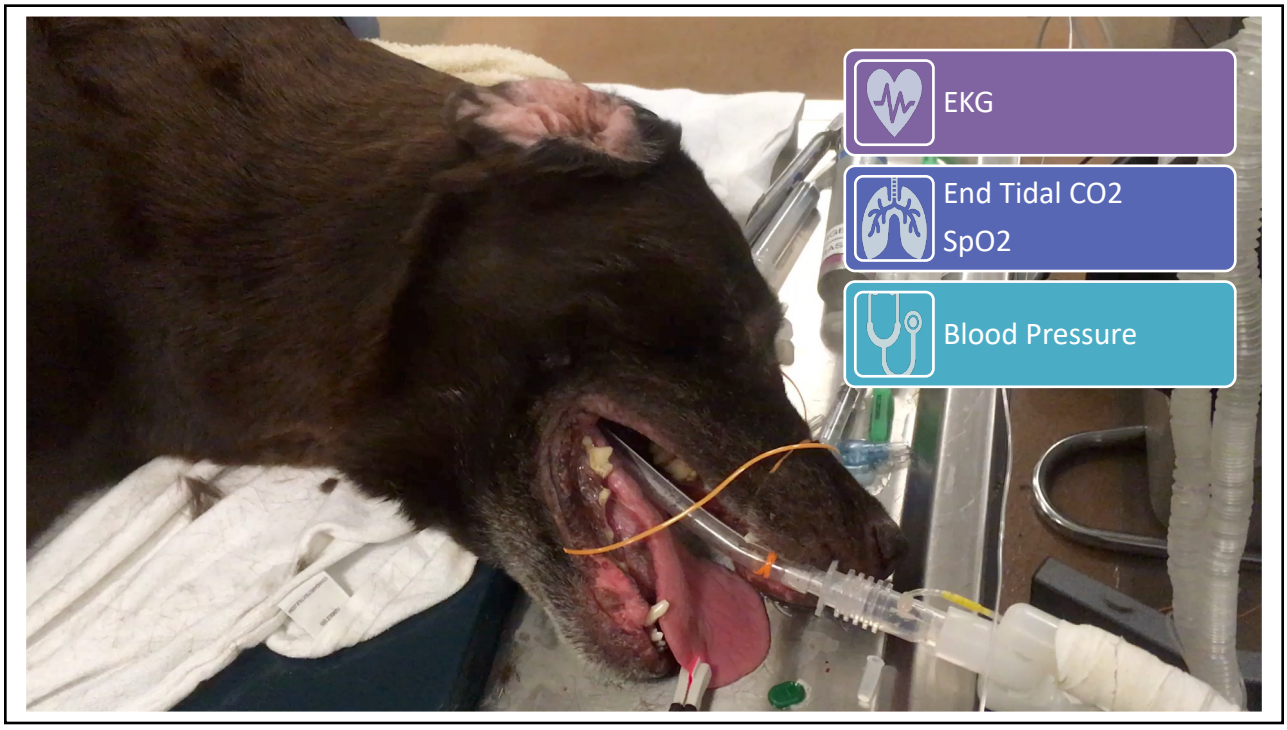


59


Monitoring Devices
CRI of Drugs
Managing Consequences

60

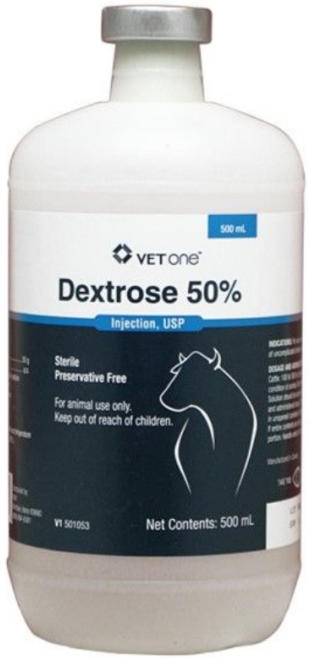

Propofol
Injectable Emulsion, USP
200 mg per 20 mL
(10 mg per mL)
Zoetis
NexGen
KETAMINE HCl
200 mg/mL
Fentanyl
5 mcg/kg IV bolus followed by
5 mcg/kg/hr CRI
Midazolam
0.5 mg/kg IV bolus followed by
0.5 mg/kg/hr CRI

61

Exit Strategy

- Decrease Edema
  - Cool patient
  - Consider systemic steroids
  - Dextrose compress

62



63

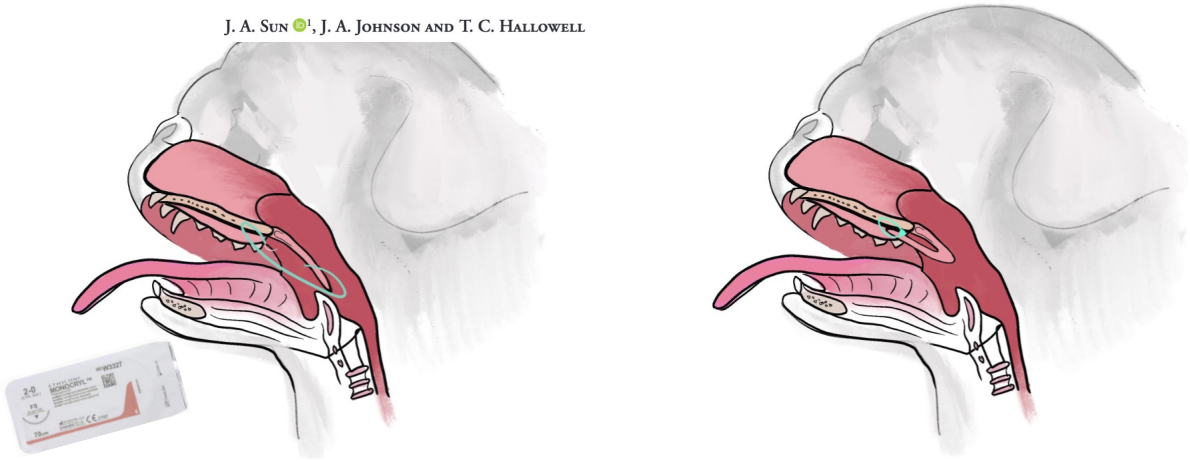
Exit Strategy

- Decrease Edema
  - Cool patient
  - Consider systemic steroids
  - Dextrose compress
- Palatopexy

64

Evaluation of temporary palatopexy to manage brachycephalic obstructive airway syndrome in dogs in respiratory distress

J. A. Sun [1], J. A. Johnson and T. C. Hallowell



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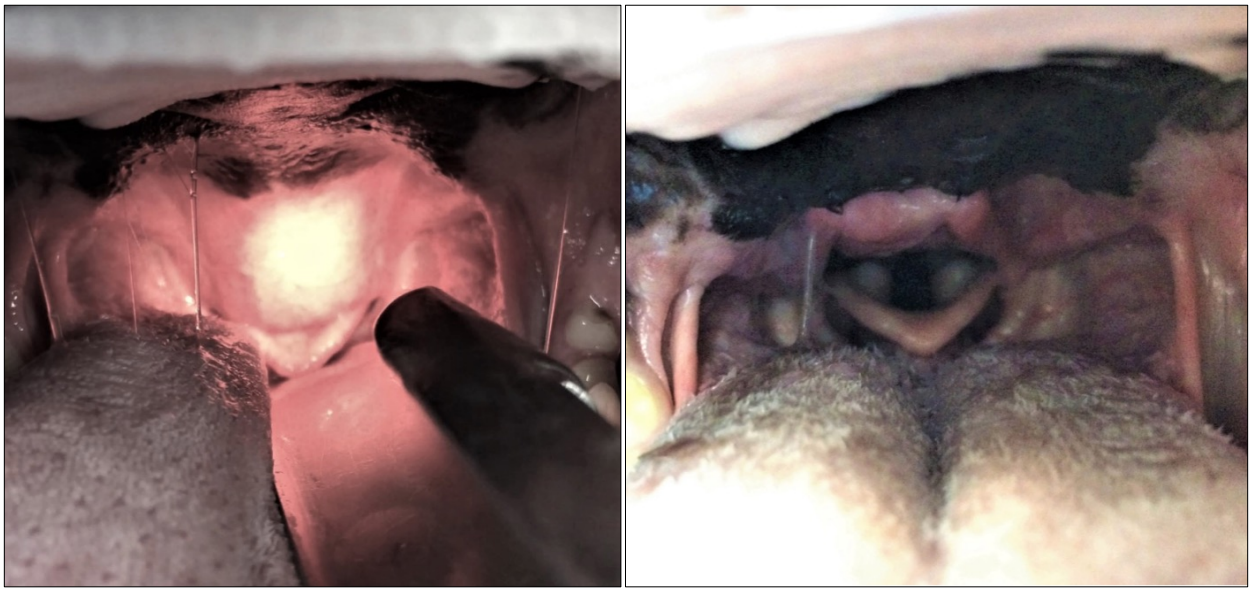


Sun et al., 2022

66

Exit Strategy

- Decrease Edema
  - Cool patient
  - Consider systemic steroids
  - Dextrose compress
- Palatopexy
- Nasogastric Tube to empty stomach and esophagus
- Sedation during recovery

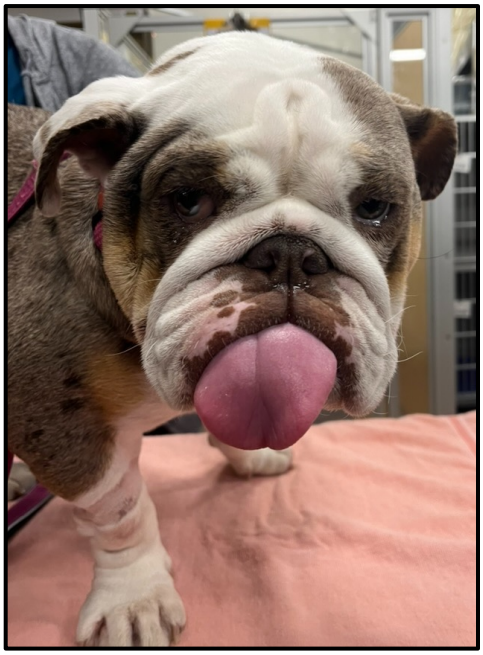
67

Owner-assisted recovery and early discharge after surgical treatment in dogs with brachycephalic obstructive airway syndrome

J. J. Camarasa*,†, I. Gordo†, F. G. Bird*, R. Vallefuoco *, M. Longley* and H. N. Brissot‡

Camarasa et al., 2023

68



Full Airway Obstruction

- No time for IV catheter
- No time for IV or IM sedation
- Peri-arrest
- Cannot oro-tracheally intubate
  - masses, FB, edema

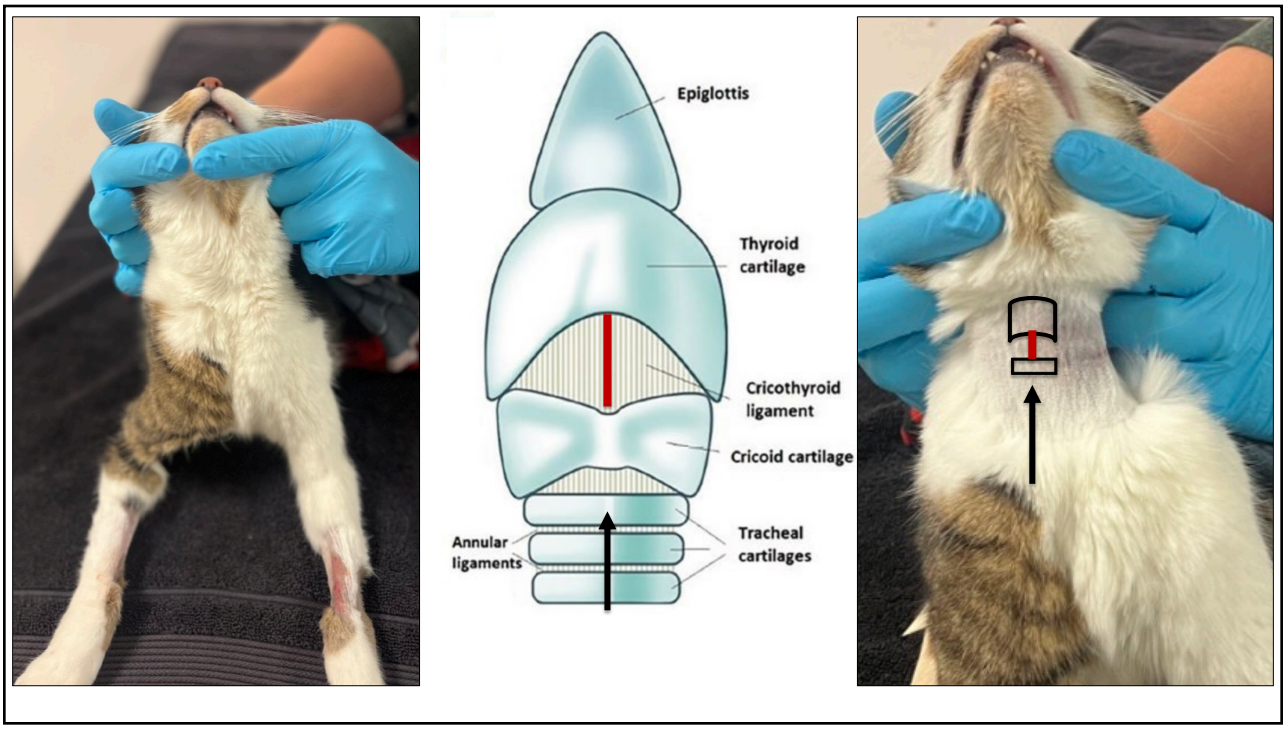
69

70

Cricothyroidotomy

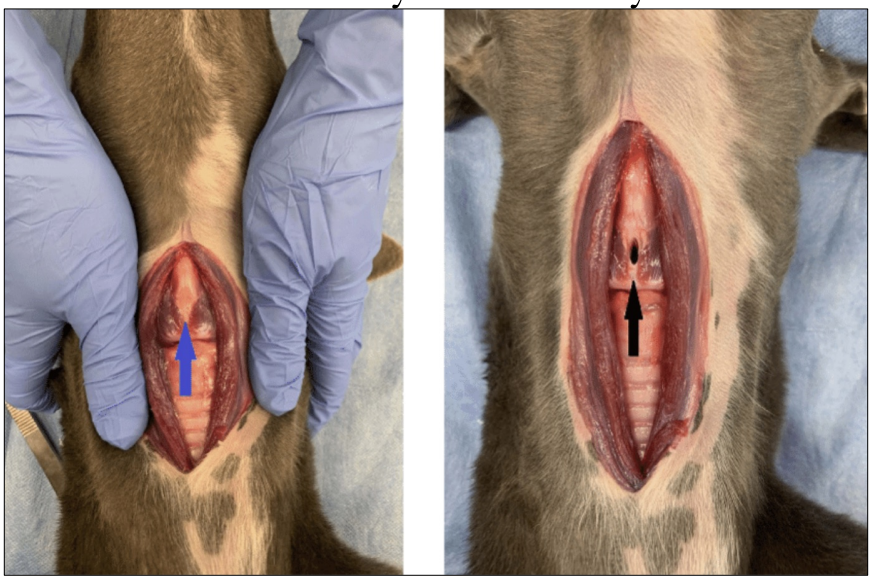
- Pros
  - Patient stays in sternal
  - No sedation required
  - 30 second procedure
  - Simple technique
  - Easy landmarks
  - Dogs or cats
- Cons
  - Working dogs

71



72

Cricothyroidotomy



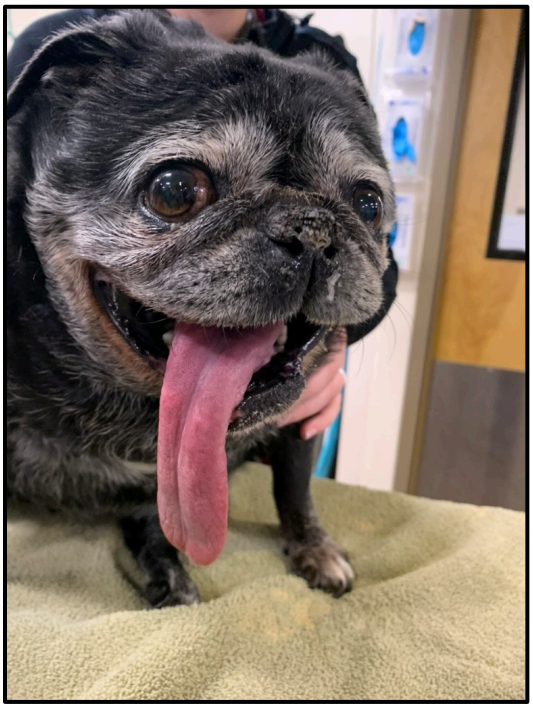
Hardjo S. Veterinary Medicine: Research and Reports. 2019. 10:111-121.

73

74

Summary

- Cold air directed at the face
- Opioids
- Nebulized drugs
  - Epinephrine
  - Furosemide
- Intubation
- Cricothyroidotomy



75

76

77

78

Initial Trauma Triage

1 → 2 → 3 → 4 → 5 → 6

X A B (Breathing) C D E

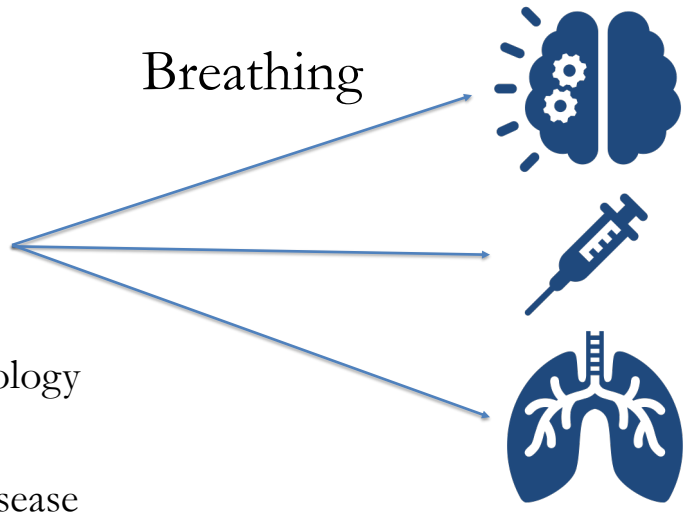
80

Breathing

- Hypoventilation
- Pulmonary Pathology
- Pleural Space Disease

81

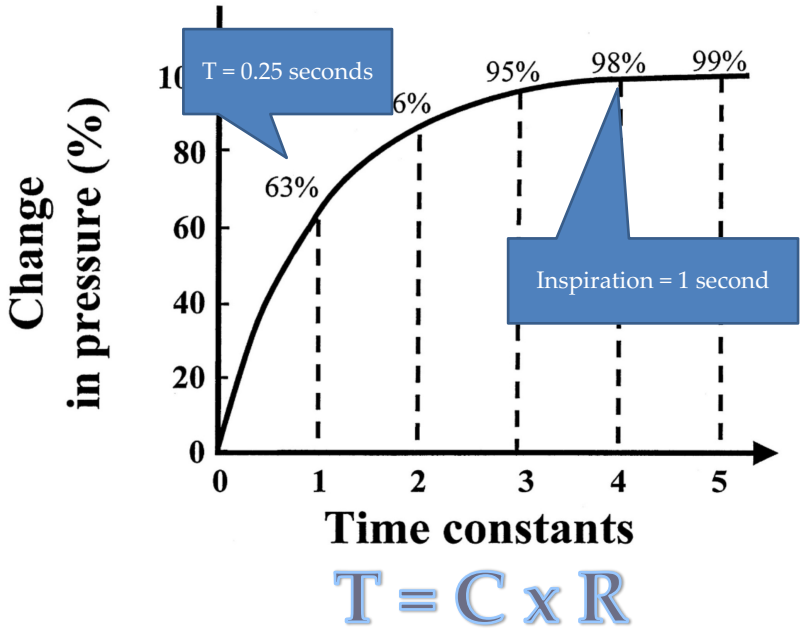
Breathing



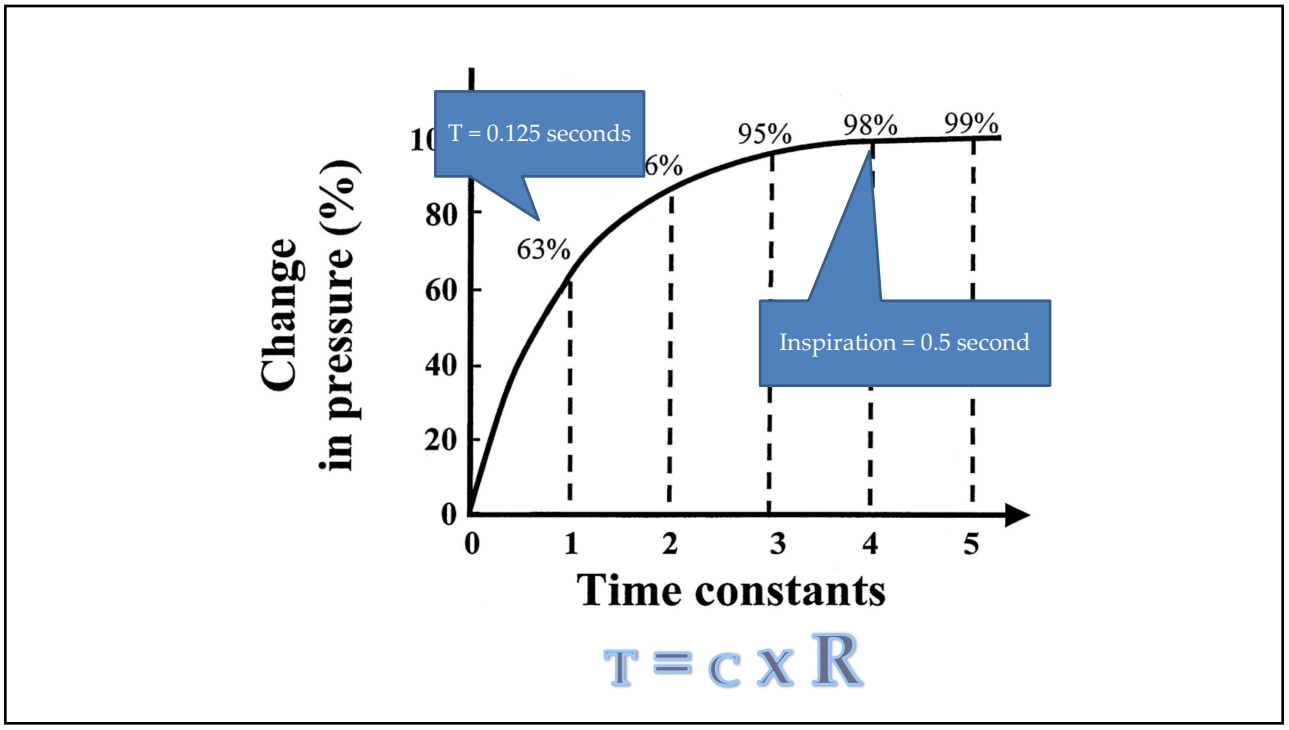
- Hypoventilation
- Pulmonary Pathology
- Pleural Space Disease

82

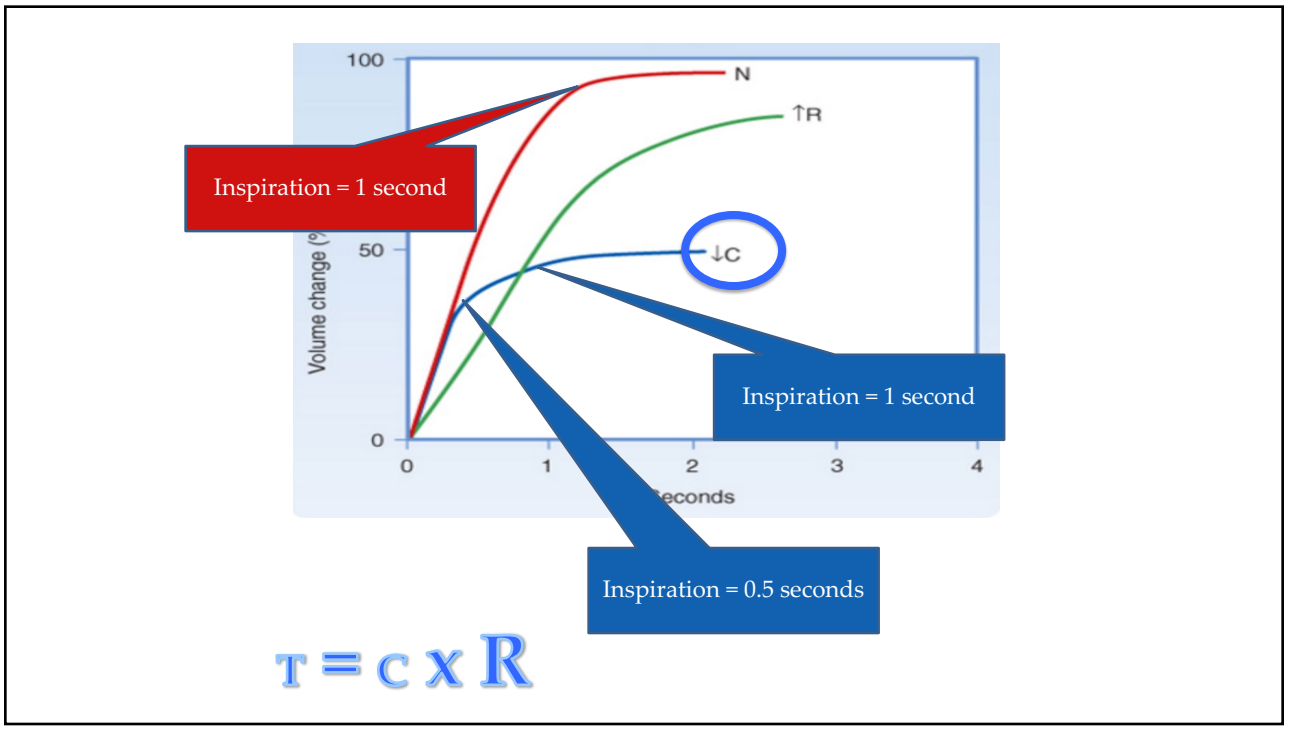
83


T = 0.25 seconds
63%
95%
98%
99%
Inspiration = 1 second
Change in pressure (%)
0
20
40
60
80
0
1
2
3
4
5
Time constants
T = C x R

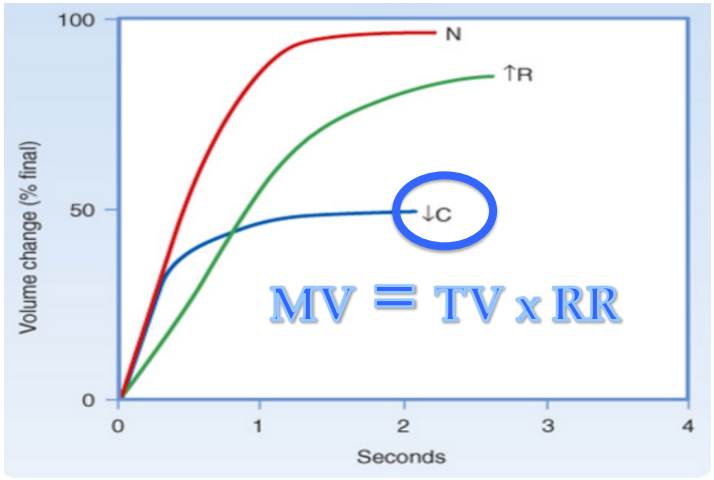
84


T = 0.125 seconds
Inspiration = 0.5 second
Change in pressure (%)
100
80
60
40
20
0
63%
95%
98%
99%
0
1
2
3
4
5
Time constants
T = c x R

85


Inspiration = 1 second
Inspiration = 1 second
Inspiration = 0.5 seconds
100
50
0
N
↑R
↓C
Volume change (%
0
1
2
3
4
T = c x R

86



MV = TV x RR

T = C x R

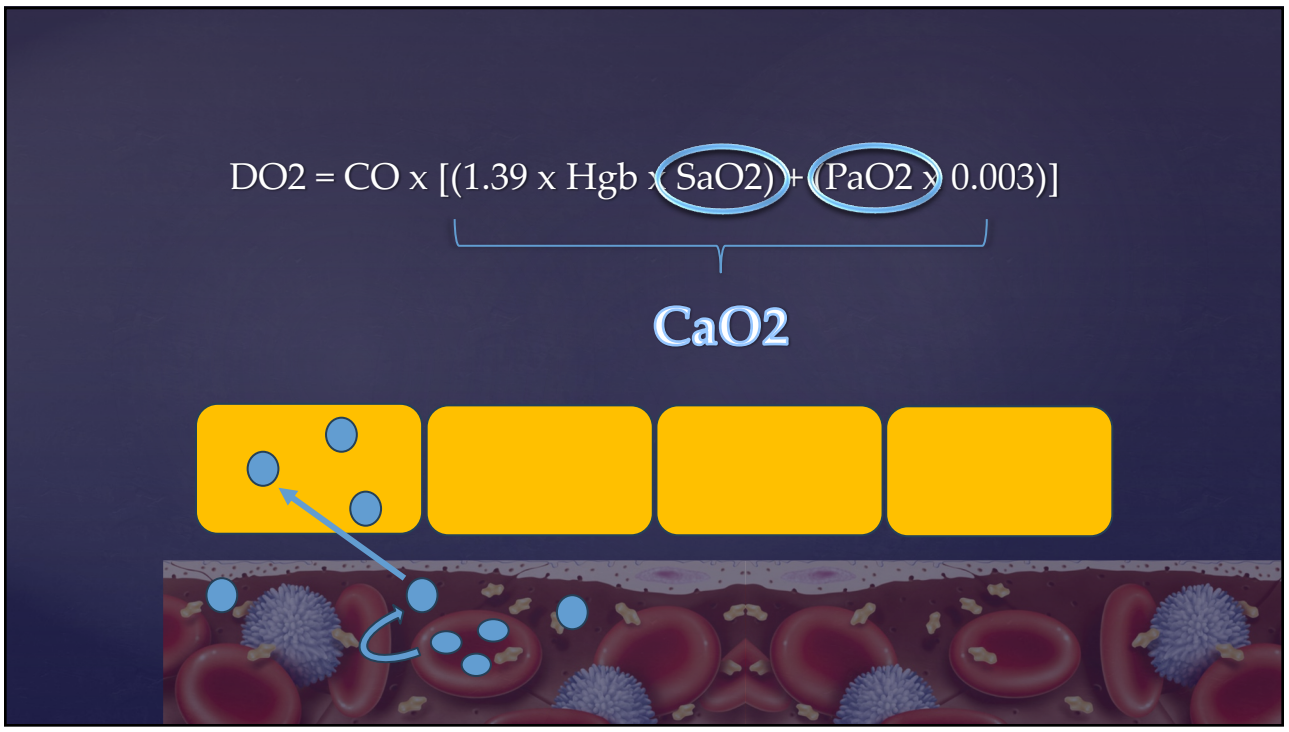
87

88

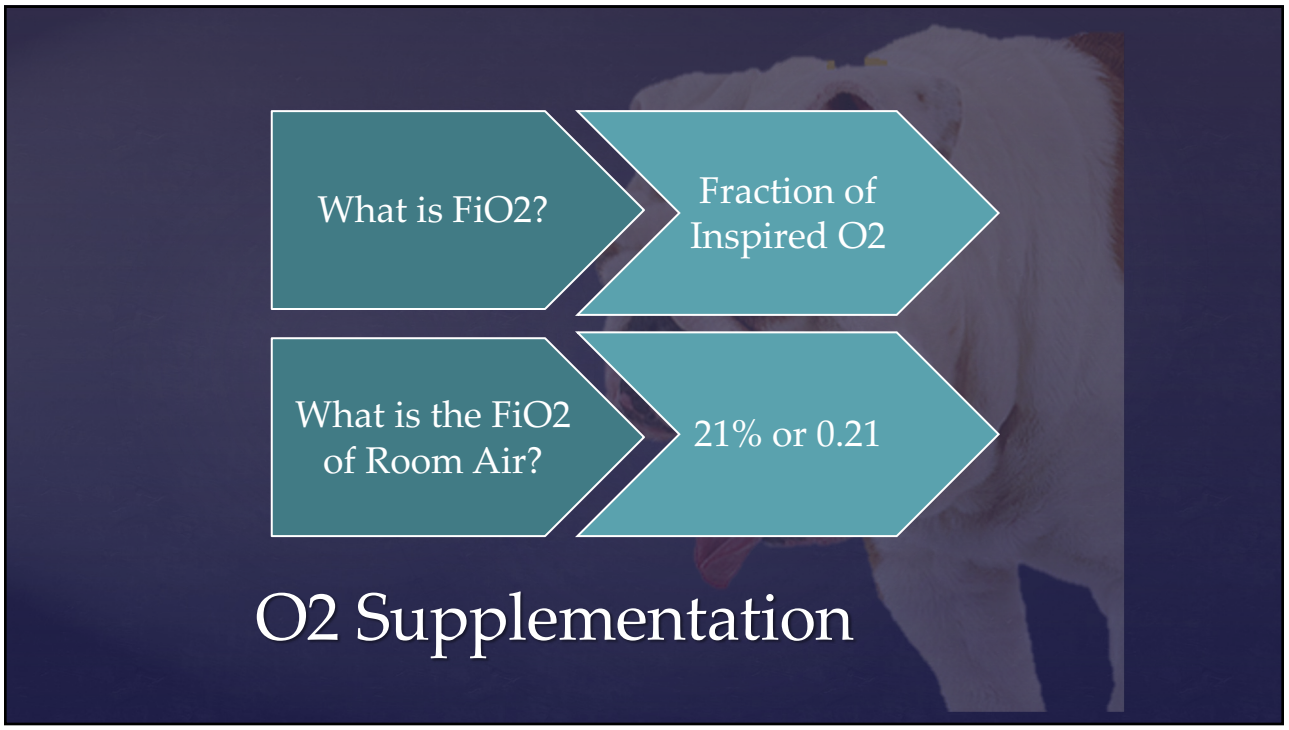
Dyssynchronous

89

90


DO2 = CO x [(1.39 x Hgb x SaO2) + (PaO2 x 0.003)]
CaO2

91


What is FiO2?
Fraction of Inspired O2
What is the FiO2 of Room Air?
21% or 0.21
O2 Supplementation

92

93

TABLE 1 Modes of oxygen supplementation in veterinary patients.

	FiO_2 (%)	Flow rate	Advantages	Limitations	Indications
Low flow					
Flow by	25–45	6–8 L/min	• Utilizes readily available equipment	• Not appropriate for prolonged therapy • Wasteful	• Triage and procedures • Initial stabilization
Oxygen cage	21–60		• Well tolerated • Allows eating and drinking	• Reduced access to patients • FiO_2 rapidly decreases when doors opened • Larger patients	• Patients that will not tolerate nasal oxygen or in which nasal oxygen is contraindicated
Face mask	35–55	1–6 L/min	• Utilizes readily available equipment • Rebreathing at low rates	• Not appropriate for prolonged therapy • FiO_2 depends on fit of mask	• Triage and procedures • Initial stabilization • Risk of rebreathing
Nasal prongs		50–150 ml/kg/min	• Easy to place • Well tolerated	• Poor patient tolerance at high flow rates • Not suitable for some facial conformations	• Ongoing oxygen support in hospital
Nasal catheter	30–60	50–150 ml/kg/min	• Well tolerated	• Poor patient tolerance at high flow rates • Harder to place	• Ongoing oxygen support in hospital
High flow					
CPAP	21–100		• Reliable FiO_2 • Delivers PEEP • Humidifies inhaled gases	• Often requires heavy sedation • Specific equipment	• Hypoxaemia despite oxygen support • Upper airway obstruction
HFNOT	21–100	10–60 L/min	• Reliable FiO_2 • Delivers PEEP • Humidifies inhaled gases	• Specific equipment	• Hypoxaemia despite conventional oxygen therapy • Increased work of breathing
Mechanical ventilation	21–100		• Reliable FiO_2 • Delivers PEEP • Humidifies inhaled gases	• Specific equipment • High complication rate • High cost	• Hypoventilation • Hypoxaemia despite oxygen support • Increased work of breathing (fatigue)

Whitney and Kier. Frontiers. 2023

94

96

Reverse All Drugs

Opioids	Alpha 2 Agonists	Benzos

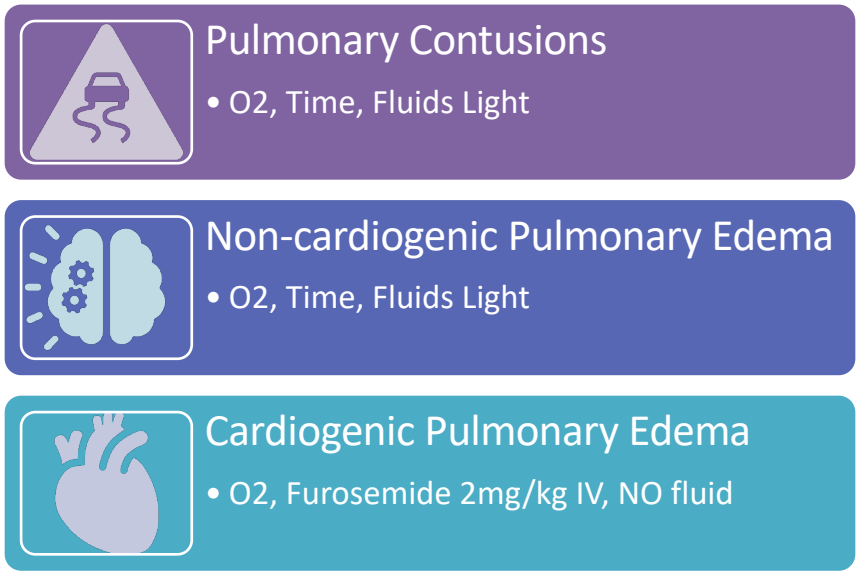
97

Breathing

- Hypoventilation
- Pulmonary Pathology
- Pleural Space Disease

98

99



100

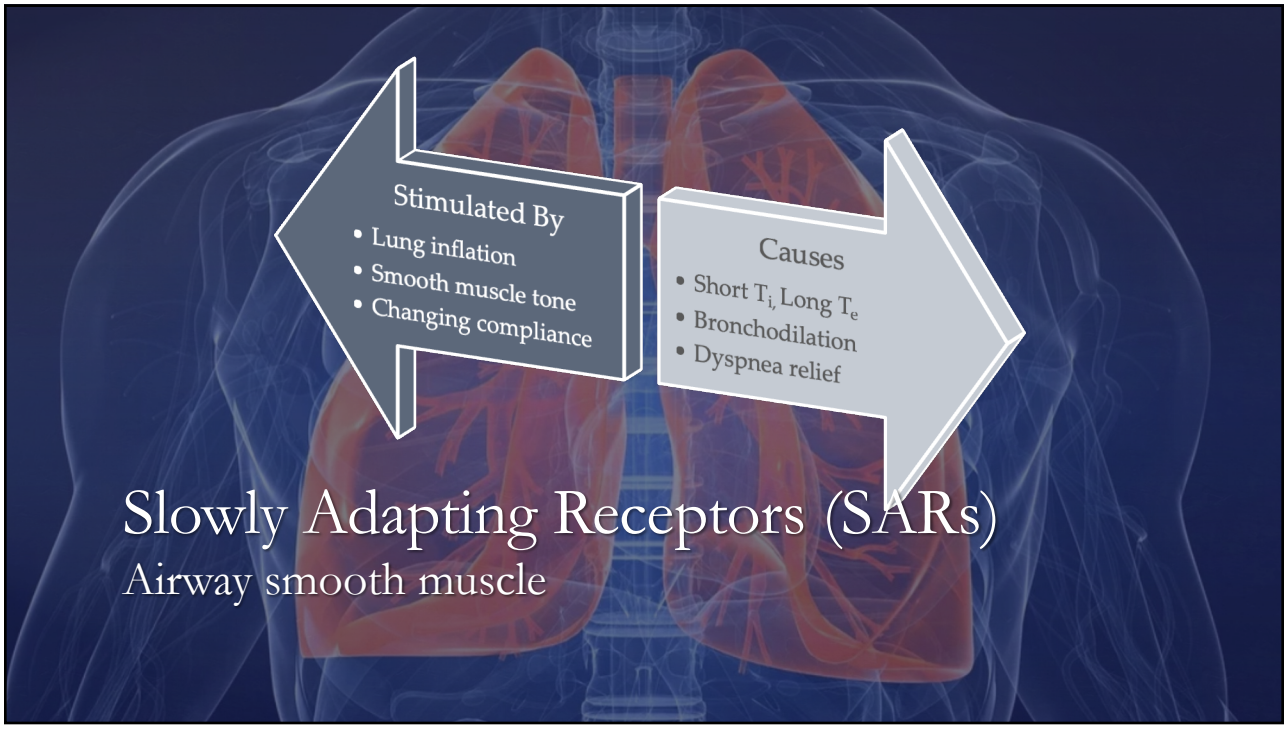
Nebulized Furosemide

101

101


SAR Sensitizers: Nebulized Furosemide
Uncomfortable urge to breathe. Alleviated by increased chest wall expansion.
Relieves feelings of air hunger and increased work/effort
Imbalance of work required and CAPACITY of muscles to perform work. Alleviated by muscle stimulation
Nishino, et al., Am J of Resp and Critical Care Med. 2000
Moosavi, et al. Resp Physio and Neurobiology. 2007

102


Stimulated By
• Lung inflation
• Smooth muscle tone
• Changing compliance
Causes
• Short T_i, Long T_e
• Bronchodilation
• Dyspnea relief
Slowly Adapting Receptors (SARs)
Airway smooth muscle

103

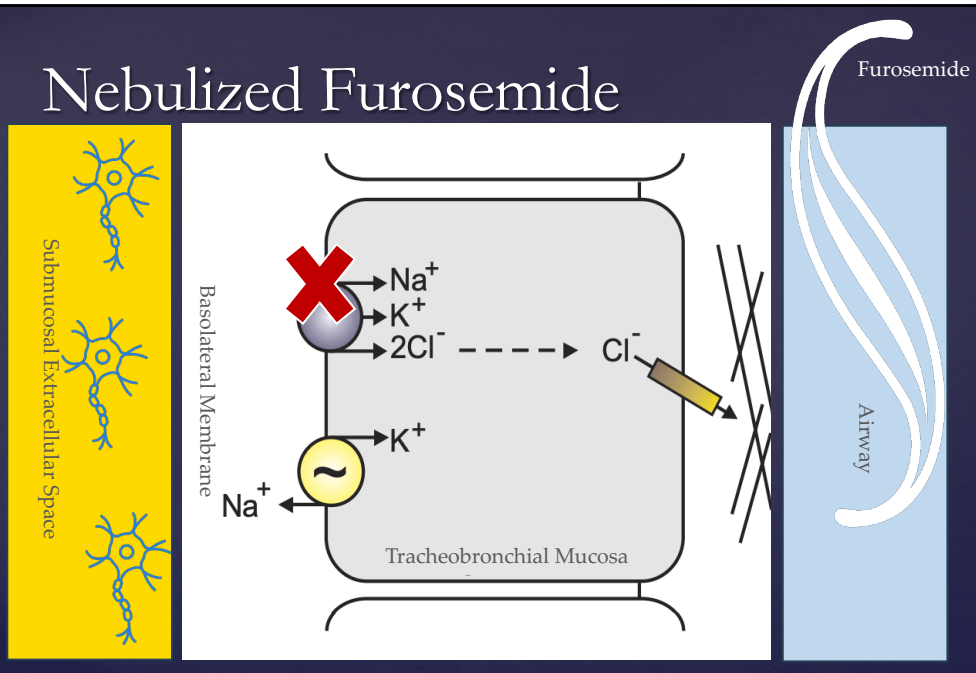
Nebulized Furosemide

- Stimulates SARS
  - Trick the brain into perceiving pulmonary stretch via vagal nerve
  - Pulmonary stretch alleviates breathlessness
- Desensitizes RARs
  - Fewer pulmonary irritant receptor messages to brain
- Inhibits cough
- Decreases bronchoconstriction

Sudo et al., Am J of Resp and Critical Care Med. 2000
Nishino, et al., Am J of Resp and Critical Care Med. 2000
Moosavi, et al. Resp Physio and Neurobiology. 2007

104

Nebulized Furosemide



Nishino, et al., Am J of Resp and Critical Care Med. 2000
Moosavi, et al. Resp Physio and Neurobiology. 2007

105

Nebulized Furosemide

- Results of studies vary
- Investigated and successful in:
  - Healthy animal models
  - Healthy adults with induced breathlessness
  - COPD (stable with induced dyspnea and unstable in ER)
  - Pulmonary neoplasia
  - Asthma

106

Anesthesiology 2001; 95:1234–7

Inhaled Furosemide Inhibits Behavioral Response to Airway Occlusion in Anesthetized Cats

Shino Nehashi, M.D., Takashi Nishino, M.D.,† Tohru Ide, M.D.‡*

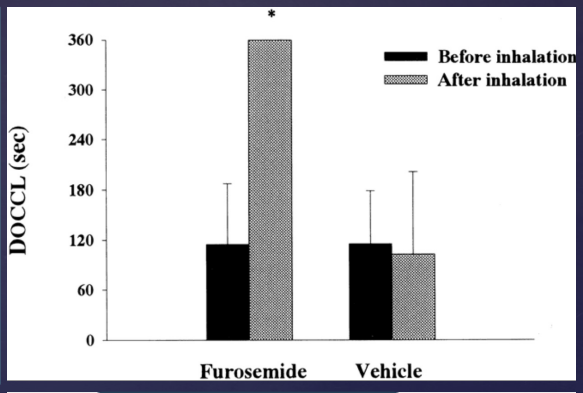


Fig. 2. Average valu… e motor response (DOCCL) before and after inhalation o… ue before inhalation.

Ultrasonic Nebulizer:
60 mg furosemide in 6ml
6ml saline

Time from airway occlusion to escape response

Significant effect
Lasts 3 hours

107

COPD in the ER

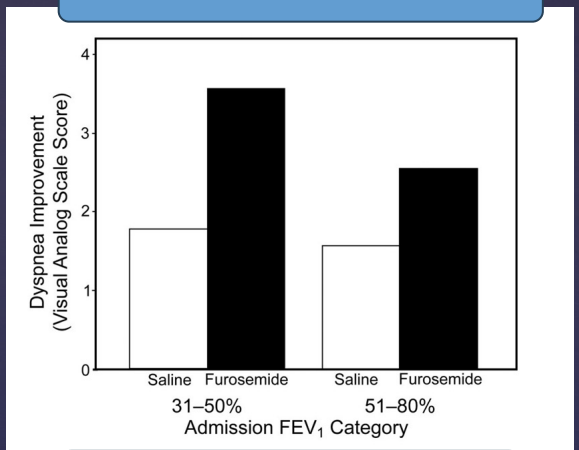


Fig
for
ceb

FEV$_1$ is the amount of air exhaled in 1 second (severe vs. moderate COPD)

Table 2. Changes in Clinical and Laboratory Variables After Treatment

	Intervention Group $n = 50$	Placebo Group $n = 50$	P
Breathing frequency, breaths/min	–7.0 ± 3.2	–3.3 ± 2.1	< .001
Mean arterial blood pressure, mm Hg	–8.9 ± 10.4	0.6 ± 7.3	< .001
Heart rate, beats/min	–4.9 ± 11.9	0.4 ± 6.8	.007
pH	0.07 ± 0.03	0.04 ± 0.02	< .001
P_{aCO_2}, mm Hg	–1.3 ± 6.5	–5.4 ± 4.5	< .001
P_{aO_2}, mm Hg	12.6 ± 5.2	8.2 ± 4.9	< .001
HCO_3^-, mEq/L	1.9 ± 3.8	–2.2 ± 1.6	< .001
S_{aO_2}, %	7.4 ± 7.4	6.7 ± 2.7	.54
FEV_1, % of predicted	11.5 ± 3.6	4.9 ± 3.1	< .001
Dyspnea score	–2.7 ± 1.0	–1.6 ± 0.8	< .001

Values are mean ± SD.
S_{aO_2} = oxygen saturation measured via arterial blood sample

Sheikh Motahar Vahedi et al., Respiratory Care. 2013

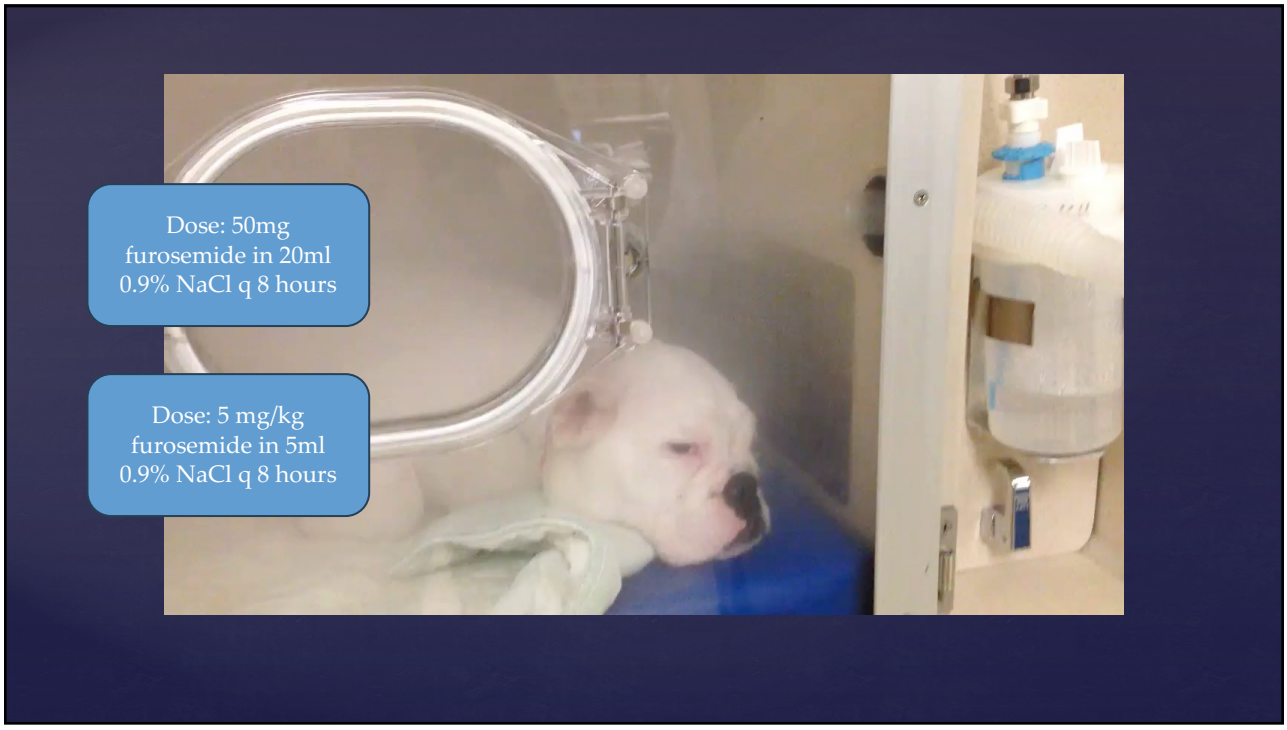
108

Nebulized Furosemide

- Airway Mechanics
  - Increased compliance
  - Increased tidal volume
  - Decrease pulmonary resistance
  - Bronchodilation
  - Unchanged airway resistance
- Duration
  - 15-120 minutes for relief of dyspnea
  - 1-4 hours for respiratory effects
- No diuretic, electrolyte effects
- Dyspnea relief not seen with IV route

Bini, et al. Euro Resp Journal. 2015
Masoumi, et al. Emergency Med International. 2014
Ohki, et al. Acta Paediatr. 1997
Prabhu, et al. Archives of Disease in Childhood. 1997
Rastogi, et al J. Pediatr. 1994

109



110

Nebulizers

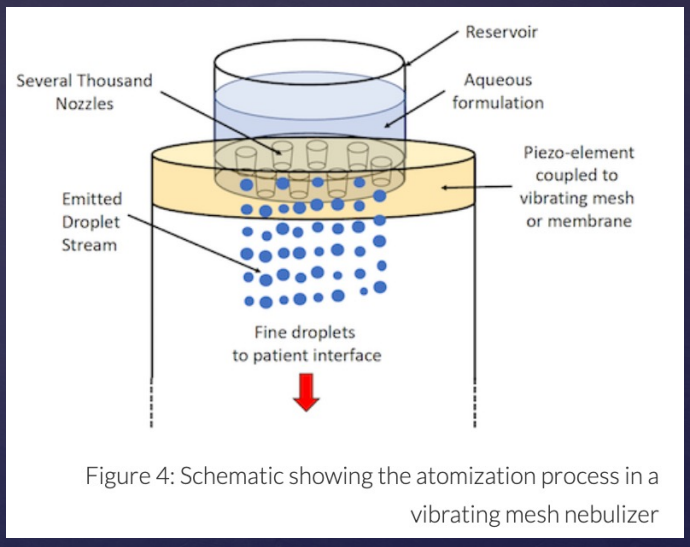


Figure 4: Schematic showing the atomization process in a vibrating mesh nebulizer

111

Nebulizers

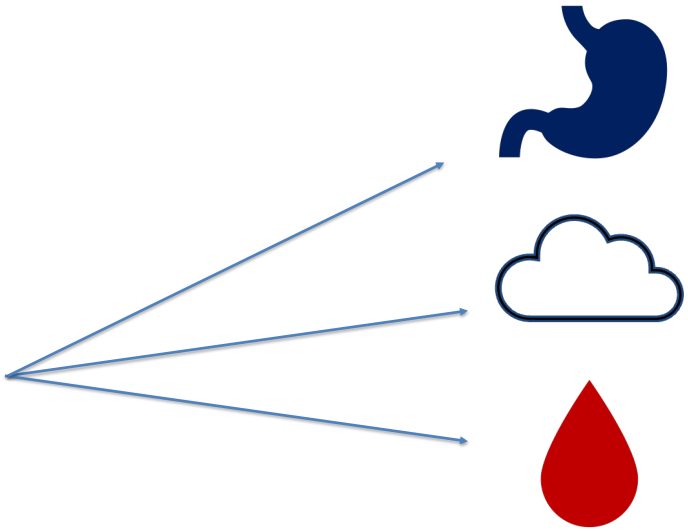
112

Nebulizers

113

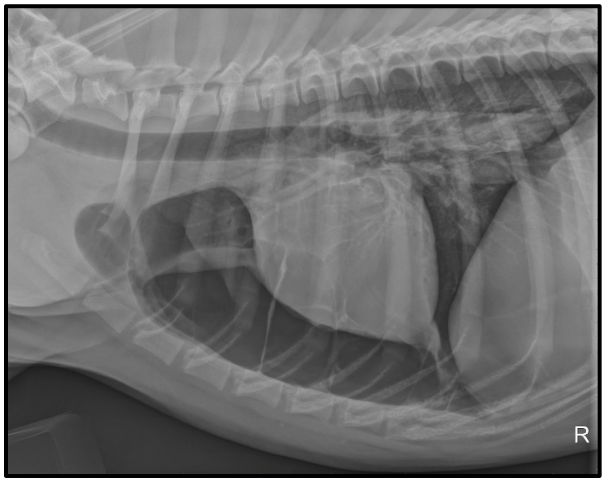
Breathing

- Hypoventilation
- Pulmonary Pathology
- Pleural Space Disease



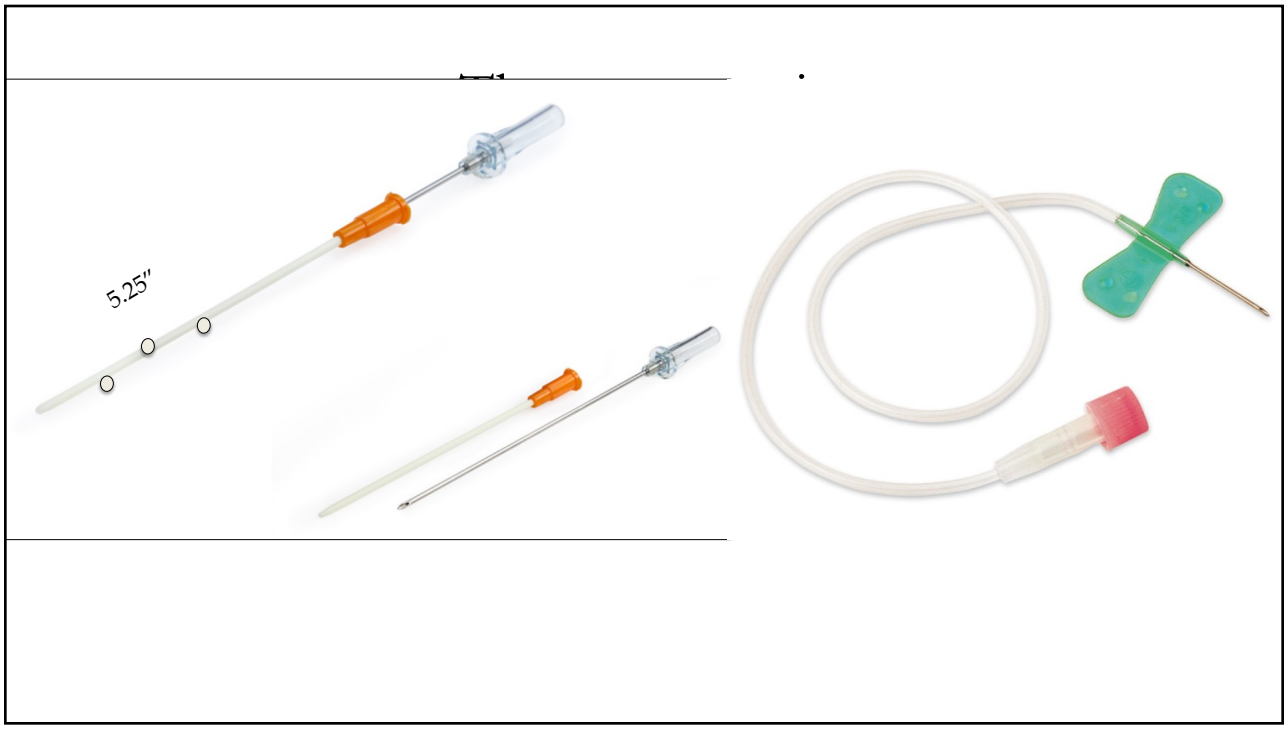
115

Pneumothorax



Pleural Effusion

116



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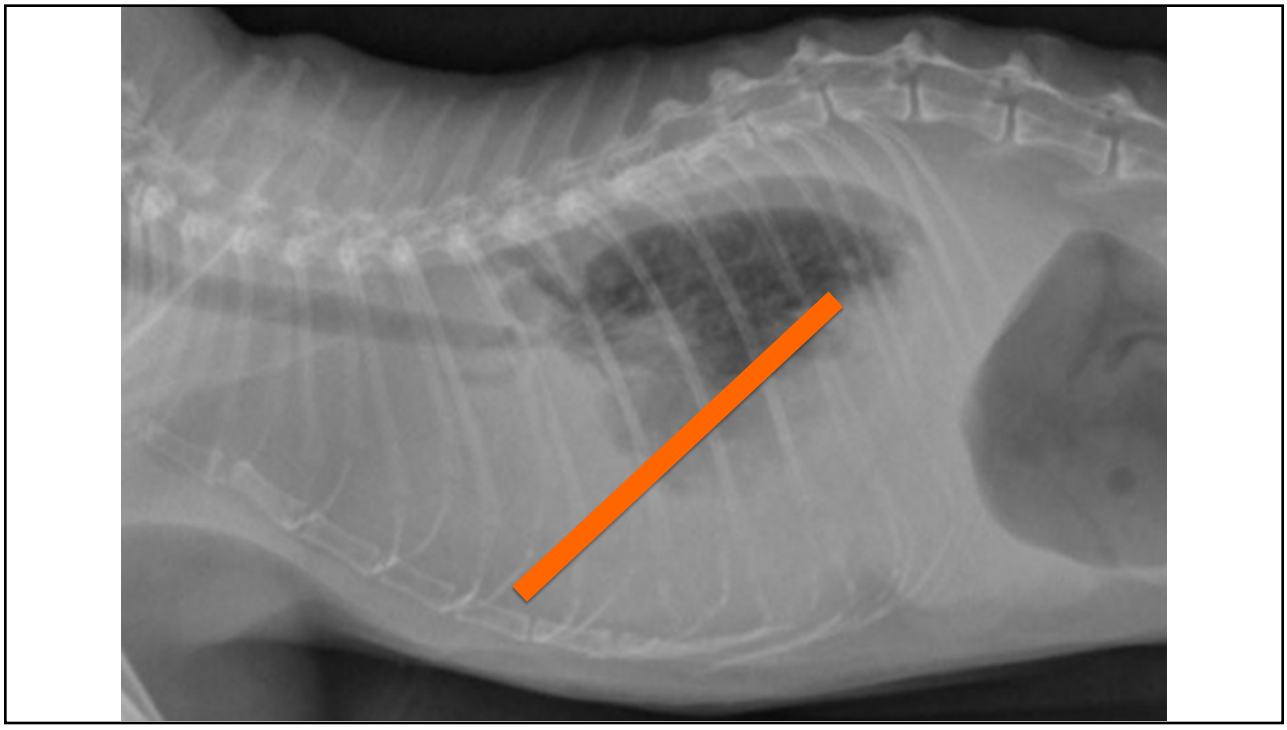

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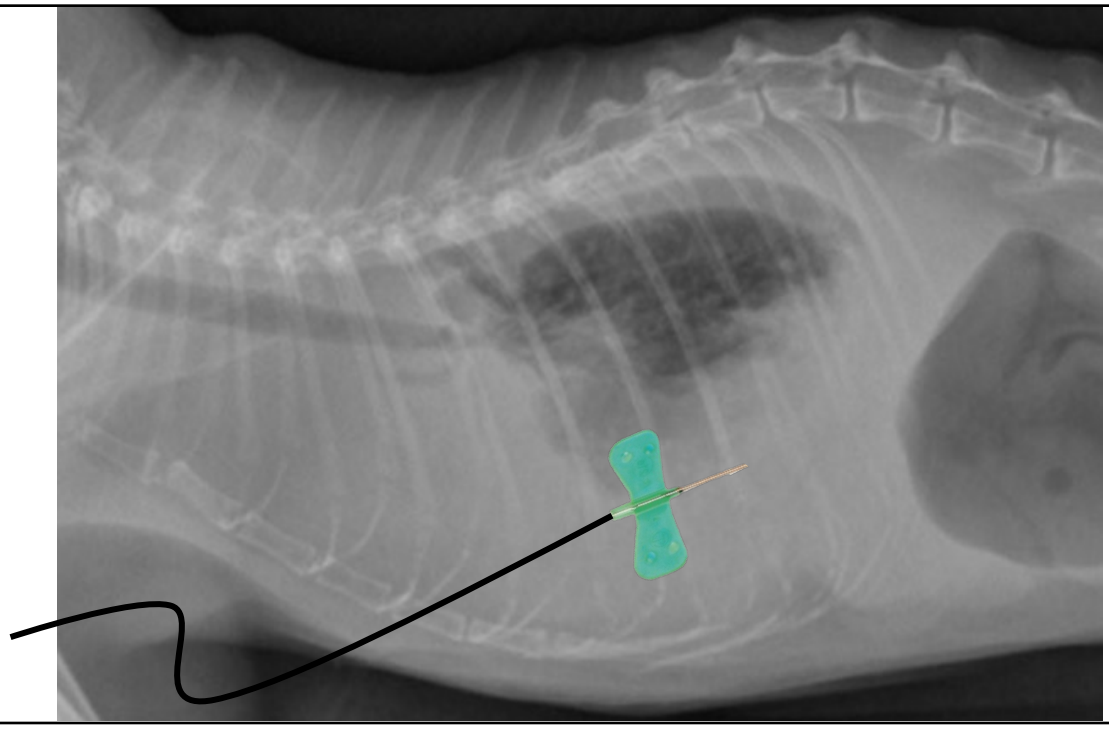
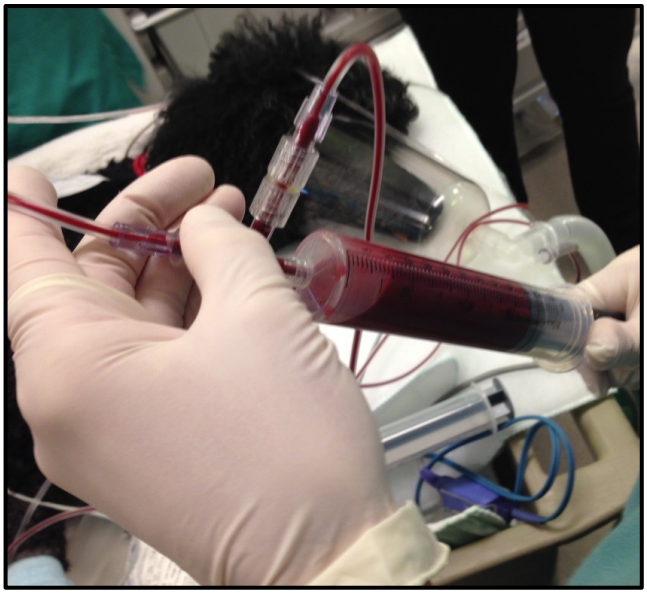


120

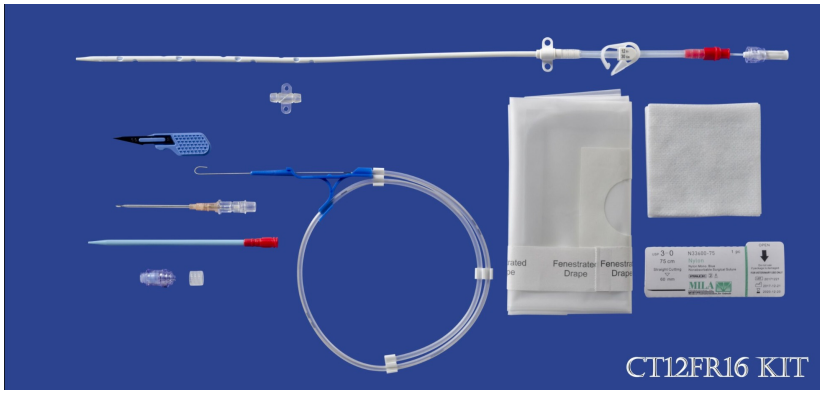
Thoracocentesis



121

MILA Chest Tube Video

- https://www.youtube.com/watch?v=MqnB_Eq6clo



122

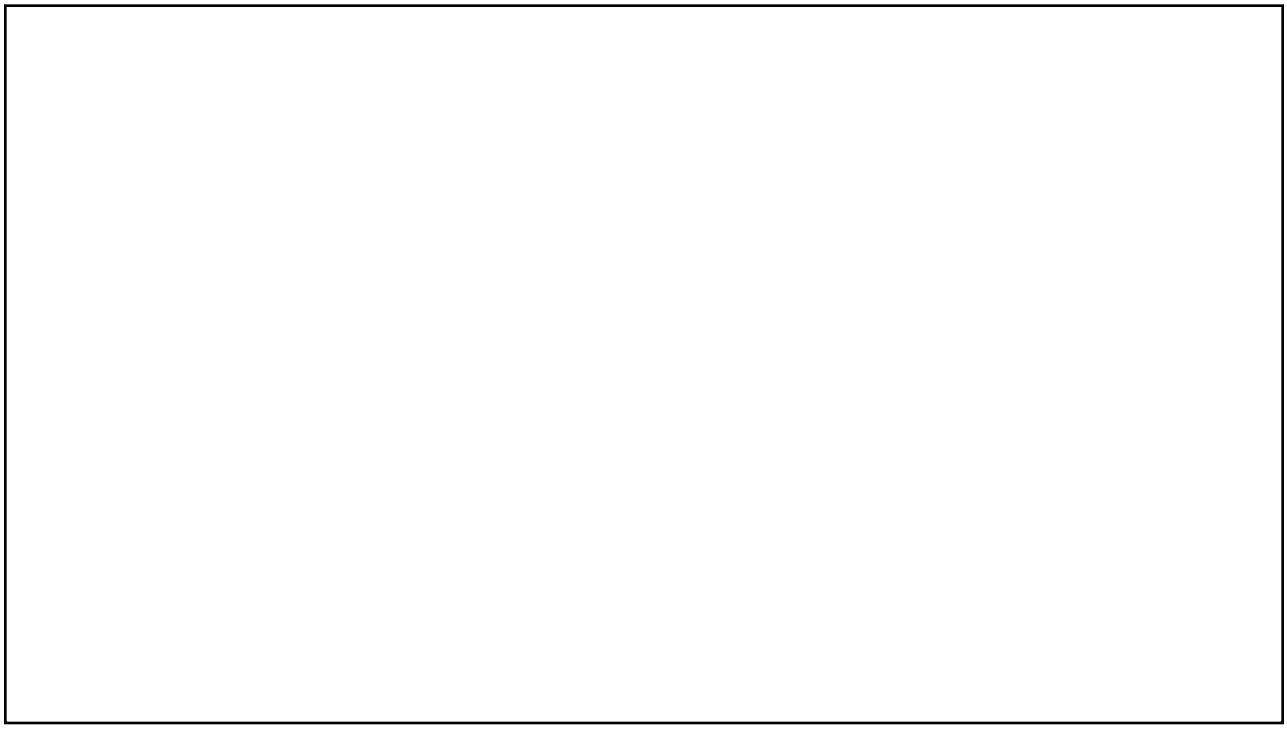
Chest Tube

- Intermittent suction
  - Serial POCUS
  - Clinical decline
- One Way Valve
- Continuous grenade suction
- Pleur-evac continuous suction

123

124

125



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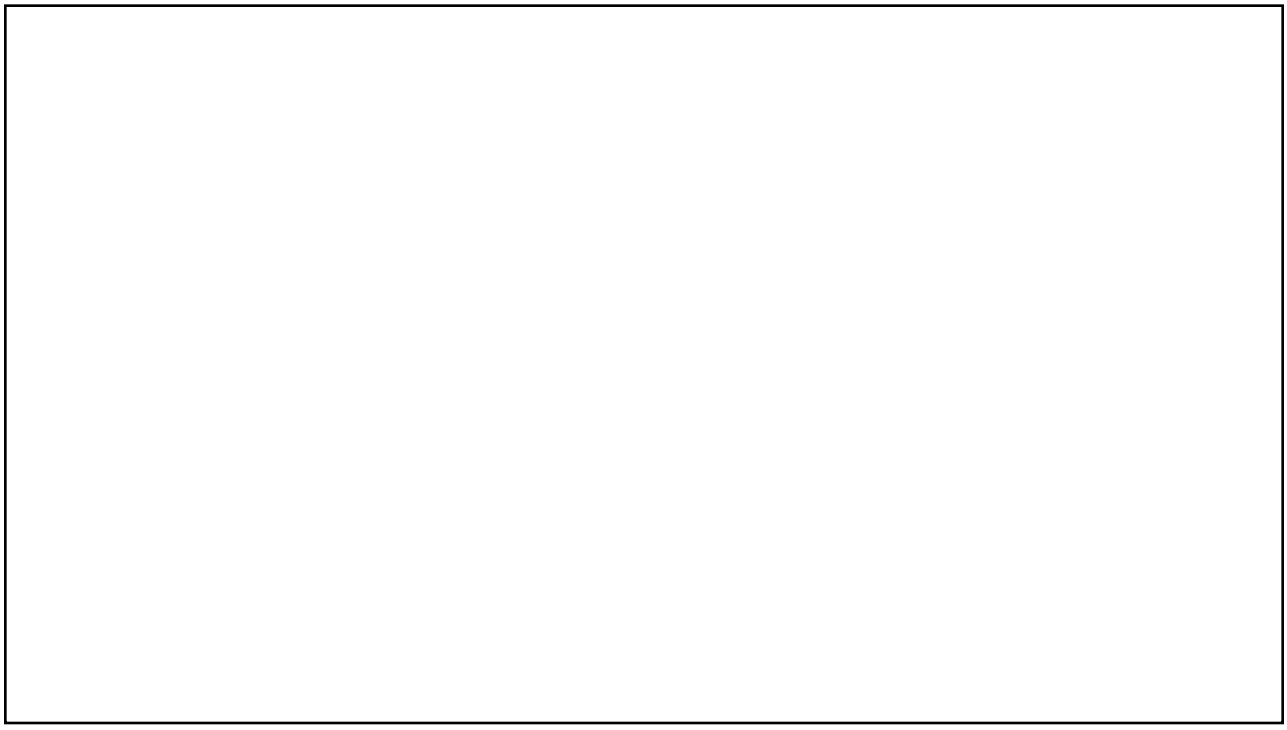

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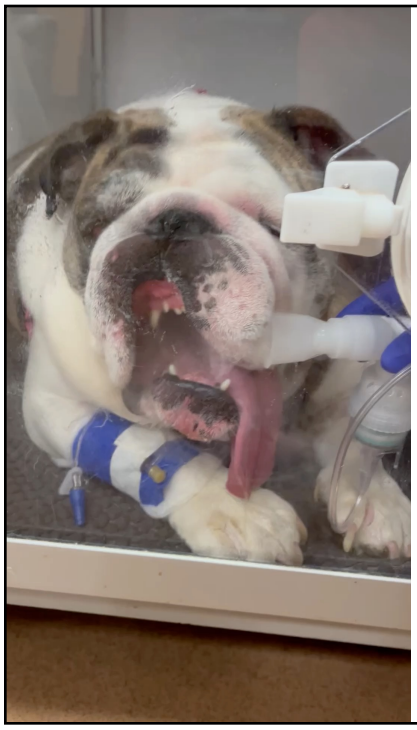

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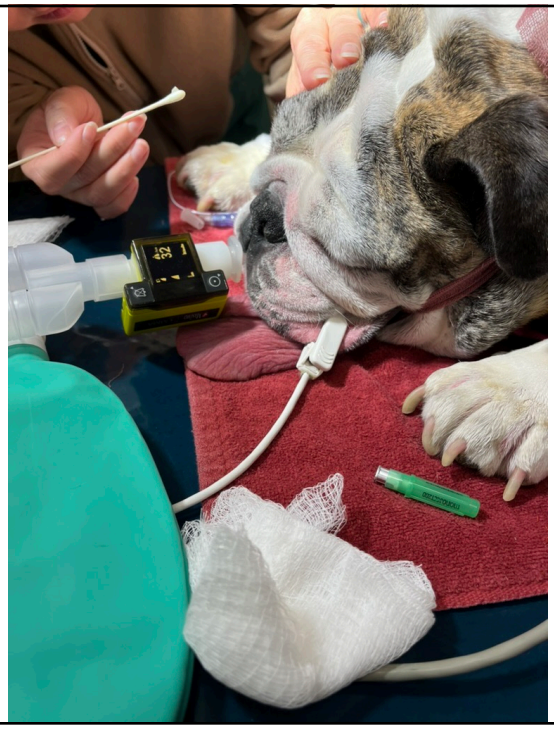

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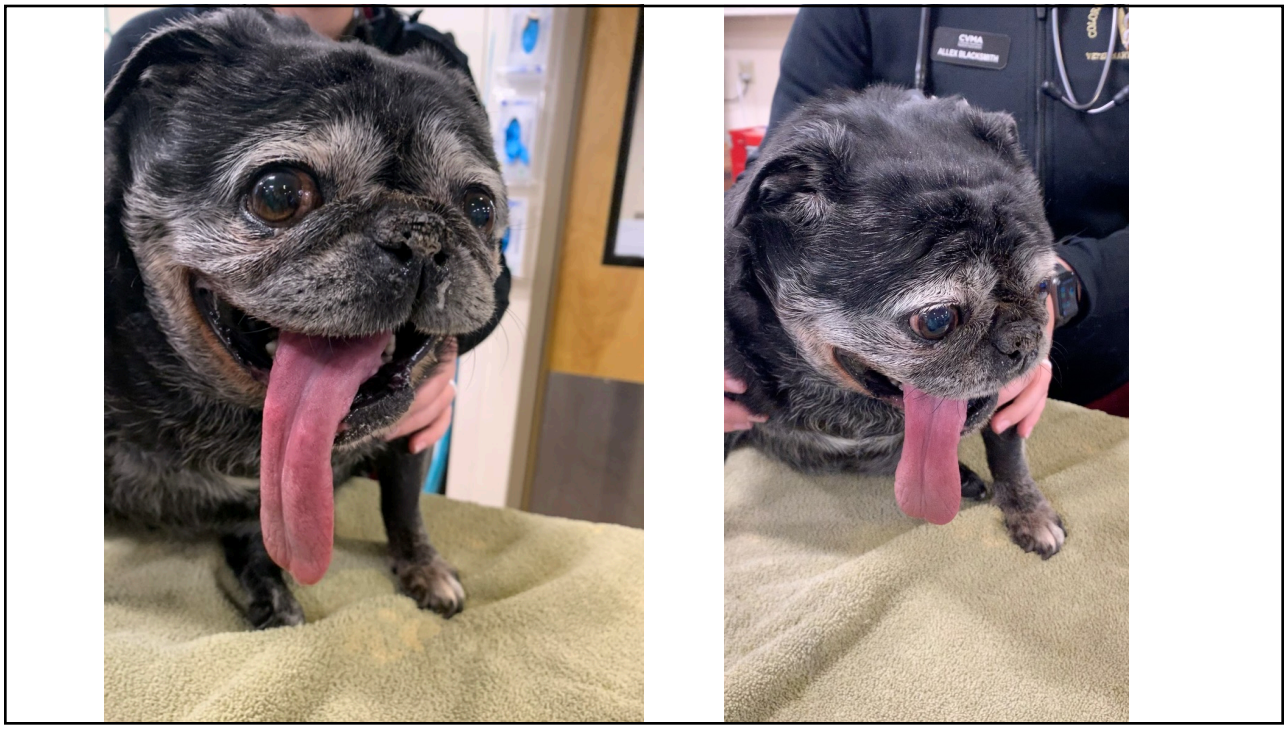

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