



VetAgro Sup

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de Lyon

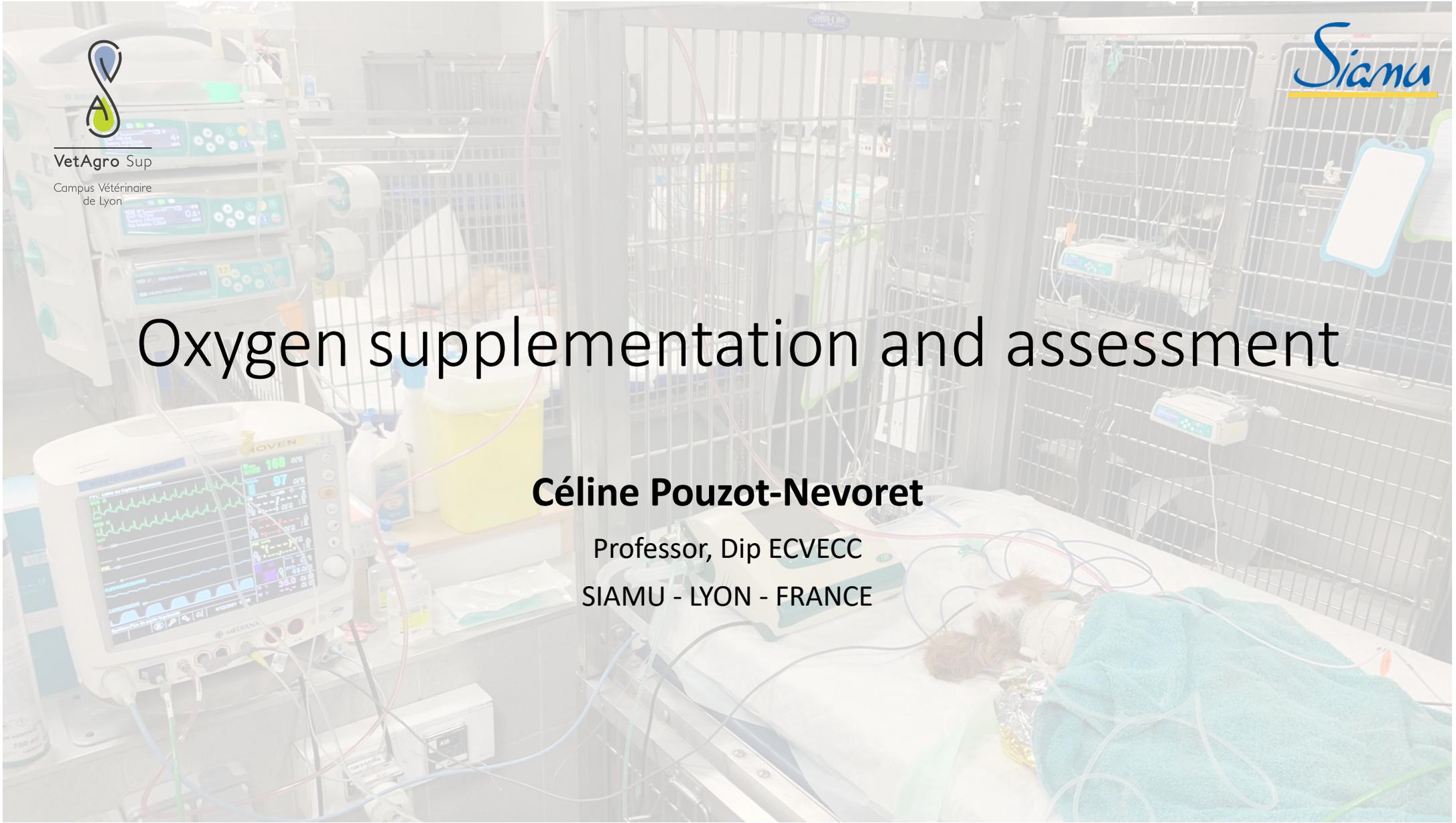
Siamu

Oxygen supplementation and assessment

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Professor, Dip ECVECC

SIAMU - LYON - FRANCE



Oxygen therapy



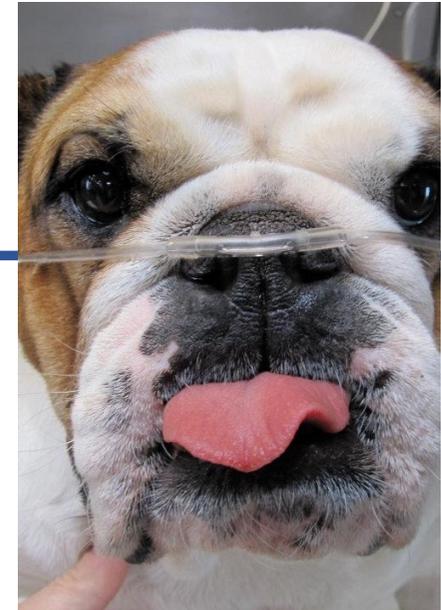
- First line treatment for patient in respiratory distress
- **Objectives**
 - Improve oxygenation (increase FiO_2)
 - Decrease respiratory efforts (increase respiratory support)

Oxygen therapy - Different methods



Choice

- Based on
 - Origin of dyspnea
 - Expected duration of oxygen therapy
 - Stress and behaviour of the patient
 - Availability/training



Outline



- Overview and indications of different oxygen therapy techniques
- Diagnose hypoxemia
- Interpret the results of oxygen assessment techniques

Eymie



- 6-year-old FN Dachshund presented for respiratory distress
- Lethargy and vomiting for 2 days
- Cough for 1 day
- Worsening respiratory distress



Admission



- Weakness
- Signs of hypovolemia
- T: 39.5°C





Flow By



- Easy to use
- Fast to implement
- FiO_2 25-40%, Flow rate: 2-3L/min
- **1st line oxygen therapy technique**

- Oxygen waste
- Mild FiO_2 increase
- **Short term administration**



Eymie initial stabilisation



- Oxygen Flow-by
- Butorphanol (0.3 mg/kg SC)
- Fluids
- Maropitant
- Ampicillin-Sulbactam

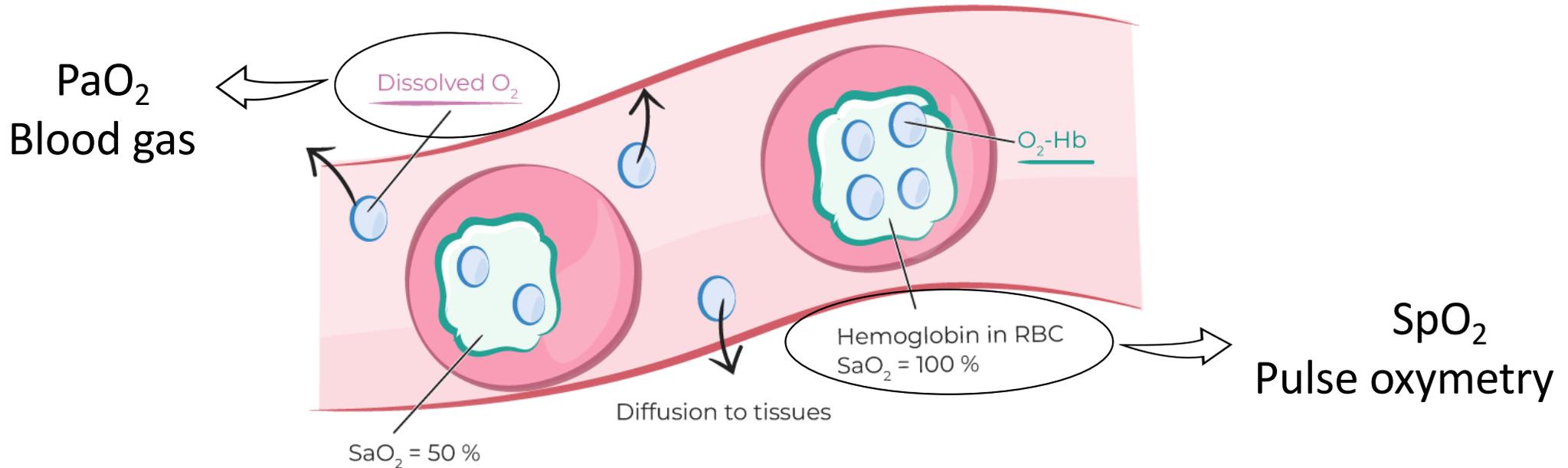
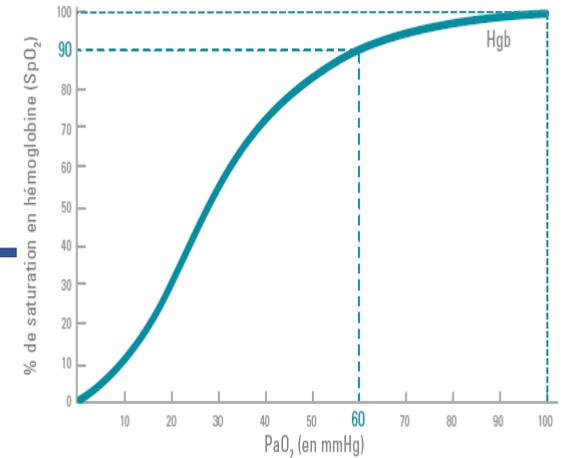
Treatment efficacy?

Aspiration pneumonia



Oxygenation assessment

$$\underline{O_2 \text{ Delivery} = CO * O_2 \text{ Content}}$$



Pulse oxymetry



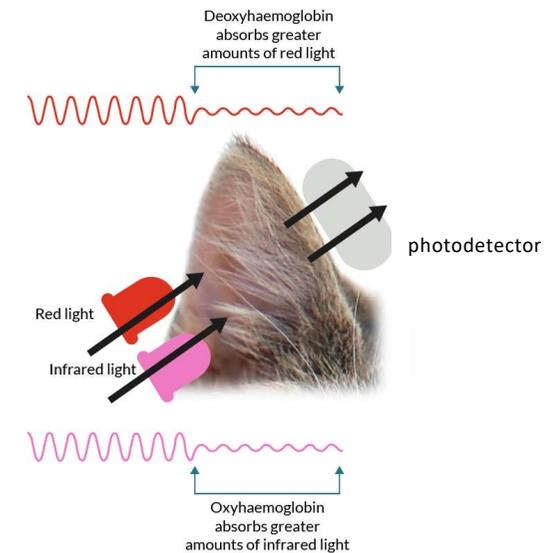
- Non invasive oxygenation assessment technique
- Provide continuous oxygen monitoring
- Easy to use
- Non invasive surrogate of PaO_2

Pulse oxymetry



- Uses two wavelengths of light to differentiate oxyhemoglobin from deoxygenated hemoglobin (deoxyhemoglobin)

Plethysmograph
Graphic waveform







Uses and values



- **Uses**

- Triage/admission
- Anaesthesia
- During hospitalisation

- Normal: $\text{SpO}_2 = 95\text{-}100\%$
- Hypoxemia: $\text{SpO}_2 < 95\%$
- Severe hypoxemia: $\text{SpO}_2 < 90\%$

Limits



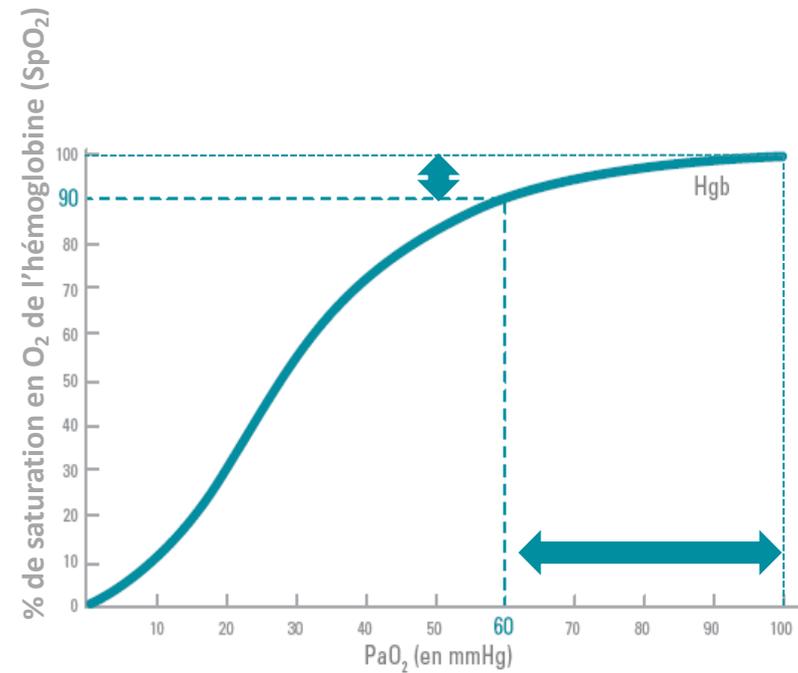
- Normal: $\text{SpO}_2 = 95\text{-}100\%$
- Hypoxemia: $\text{SpO}_2 < 95\%$
- Severe hypoxemia: $\text{SpO}_2 < 90\%$

Only few saturation percentage points

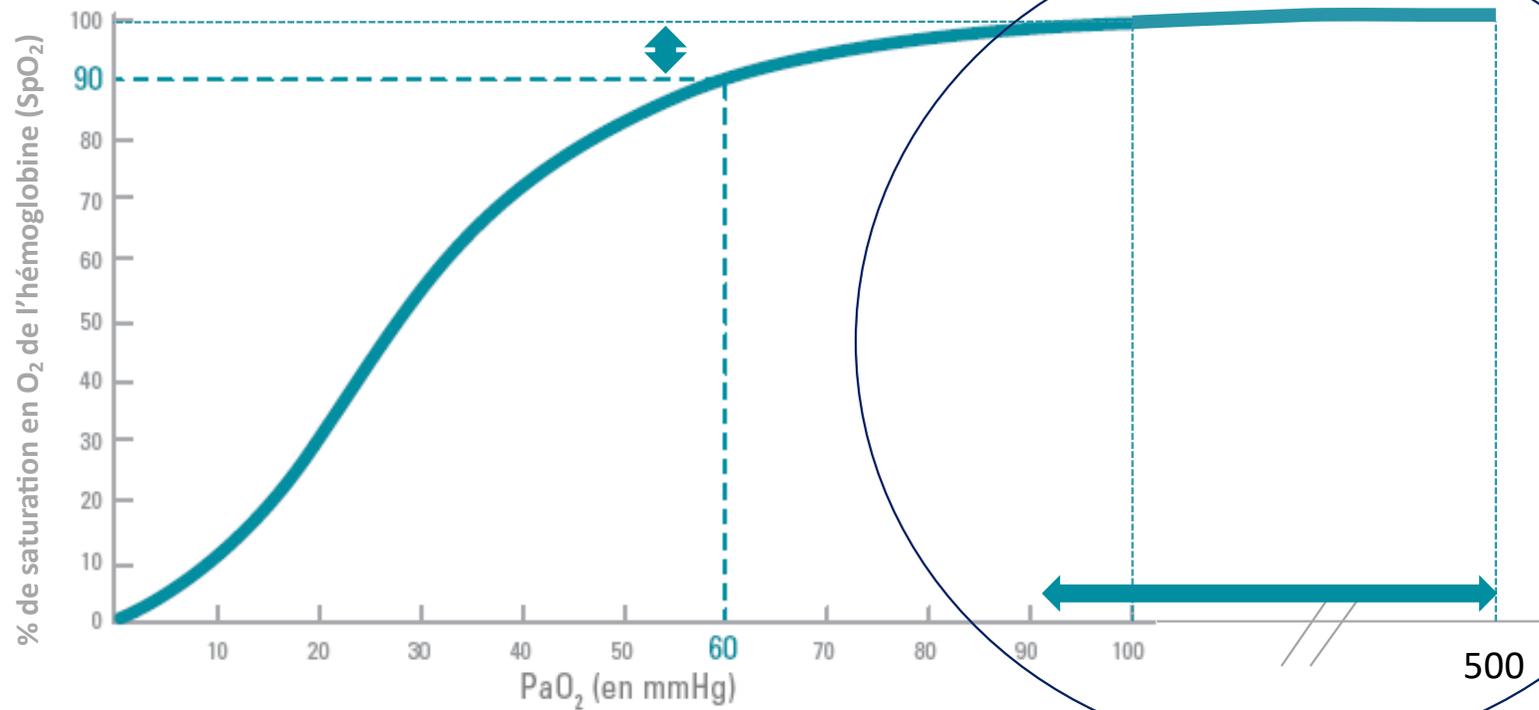
Limits



- Normal: $SpO_2 = 95-100\%$
- Hypoxemia: $SpO_2 < 95\%$
- Severe hypoxemia: $SpO_2 < 90\%$



Limits



Technical issues



- Skin pigment
 - Movement artifacts
 - Dyshemoglobinemias
 - Hypoperfusion
 - Hypothermia
 - Severe anemia
-
- ... But still a nice tool for noninvasive oxygen assessment

Eymie initial stabilisation



- Oxygen Flow-by
- Butorphanol
- Fluids
- Maropitant
- Ampicillin-Sulbactam

$SpO_2 = 90-98\%$

Treatment efficacy?

Nasal oxygen



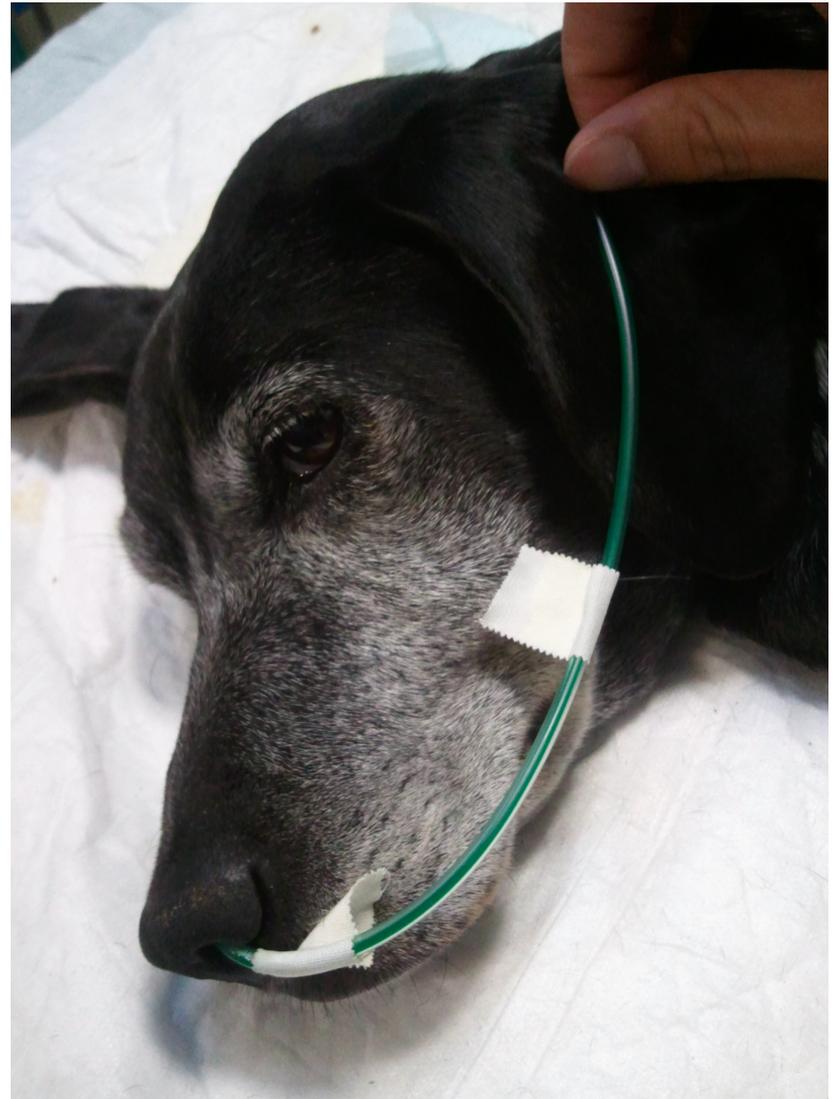
- Easy to use, well tolerated
- FiO_2 30-60%
- **Access to the patient**
- **Titration, No O_2 waste**
- **Can be used for long term O_2**

- **Facial or head trauma**
- **Epistaxis**
- **Intolerance**

Technique

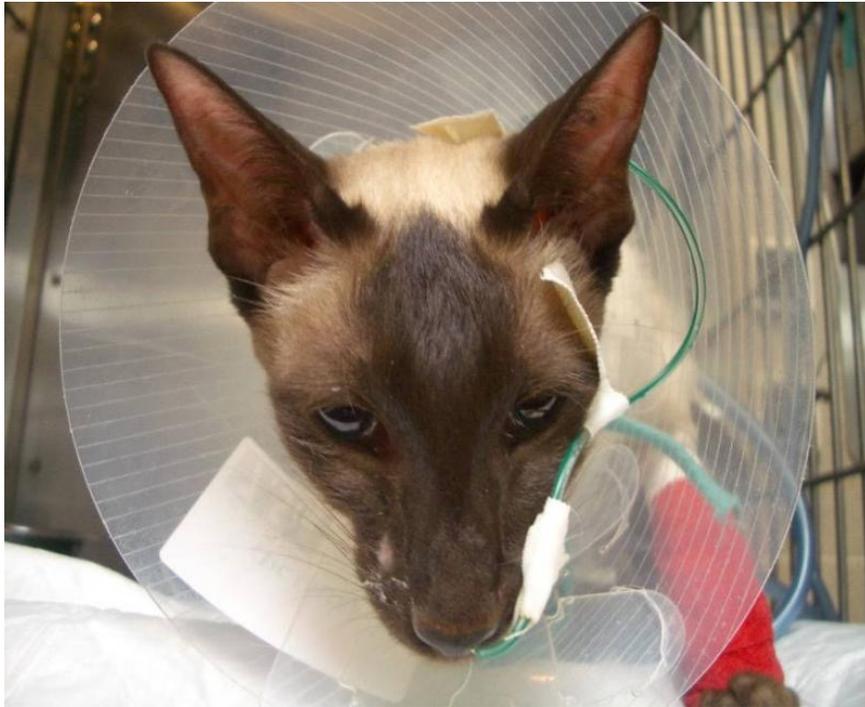








Titration of oxygen



Flow rate
100-150 ml/kg/min





Oxygen cage

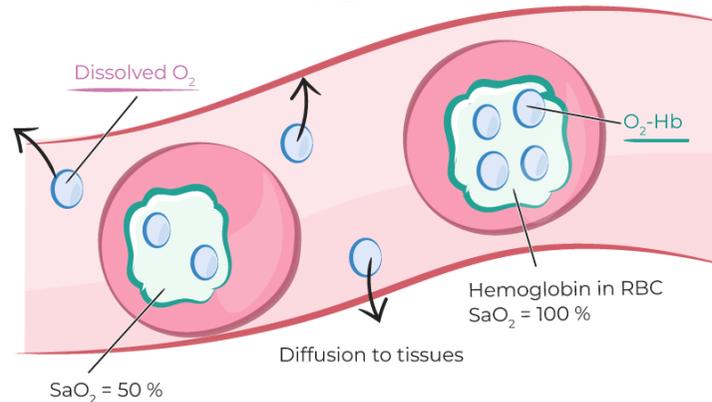


- Easy to use, well tolerated
- Can be used for long term O₂
- Variable FiO₂
- **No access to the patient**
- Oxygen waste
- Corneal ulceration
- *Risk of CO₂ rebreathing*
- *Risk of hyperthermia*

Eymie



- Initially stable on nasal oxygen
- SpO₂: 95%
- How can we go further on her oxygenation assessment?



Blood gas analysis



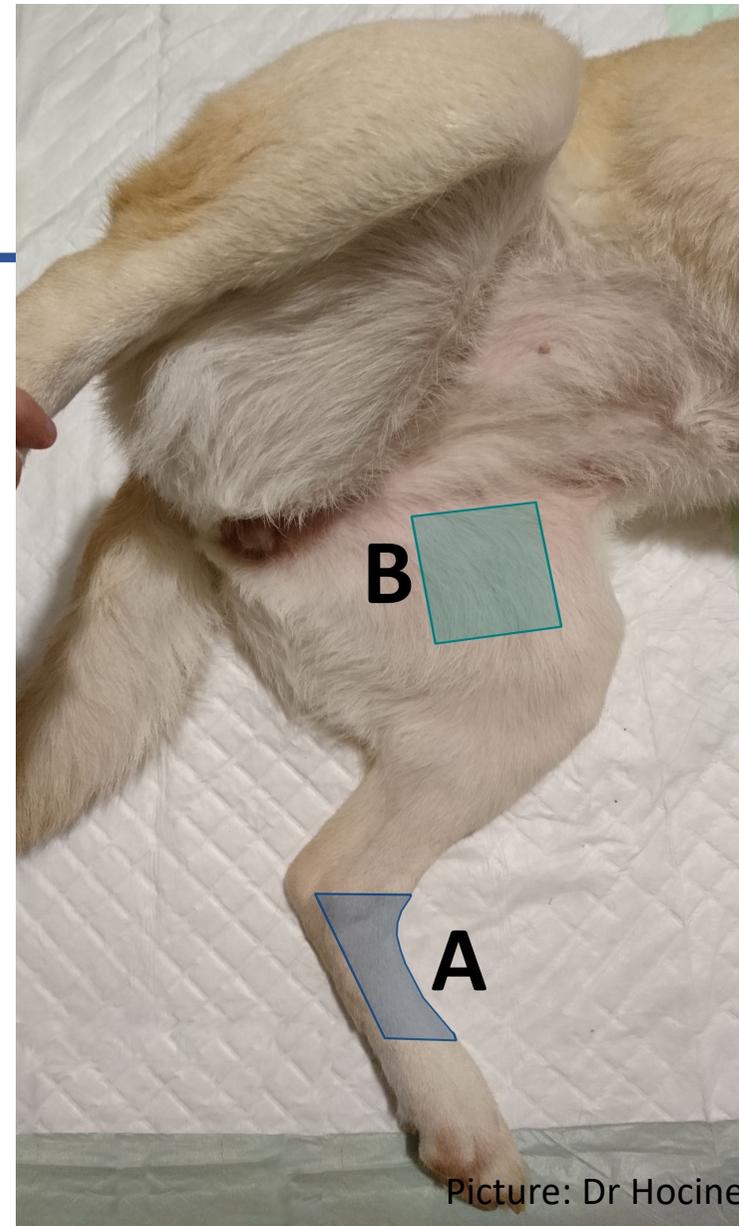
Arterial and Venous Blood Gas Values for Normal Dogs (temperature corrected for dog)

	Arterial	Venous
pH	7.361 – 7.444	7.345 – 7.433
PCO ₂ (mm Hg)	27 - 39	40 - 46
Base deficit (mmol/L)	-7 to -1.6	-6 to 0.4
Bicarbonate (mmol/L)	17 - 23	19 - 26
Total CO ₂ (mmol/L)	18 - 24	20 - 27
PO ₂ (mm Hg) (sea level)	83 - 120	32 - 64

Arterial and Venous Blood Gas Values for Normal Cats (at 37°C)^a

	Arterial	Venous
pH	7.46 (7.44-7.47)	7.39 (7.38-7.4)
PCO ₂ (mm Hg)	30 (28-32)	37.5 (36-39)
Bicarbonate (mmol/L)	21 (20 – 22)	22 (21-24)
PO ₂ (mm Hg) (sea level)	97 (94-100)	35 (33-37)

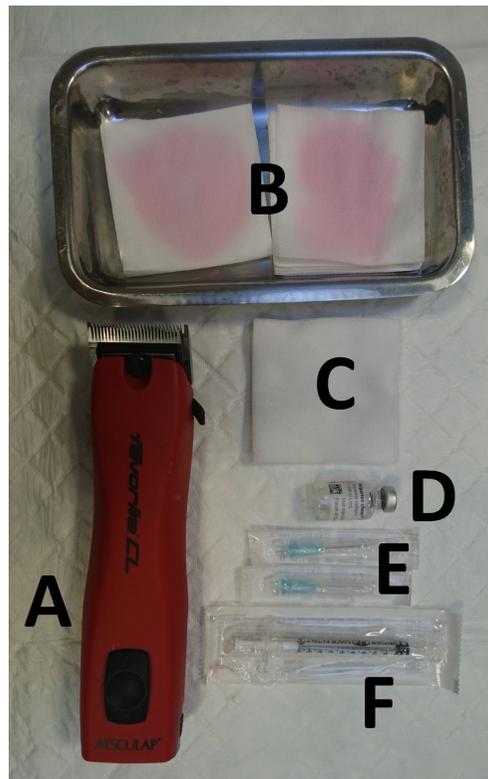
Puncture sites (arterial)



Blood gas - What do you need



- Clipper
- Scrub
- 1 ml syringe / Needle
- Heparin



Partial pressure of oxygen



- Hypoxemia : $\text{PaO}_2 < 80$ mmHg
- Severe hypoxemia : $\text{PaO}_2 < 60$ mm Hg

$$\text{PaO}_2 = 5 \times \text{FiO}_2$$

Expected PaO₂

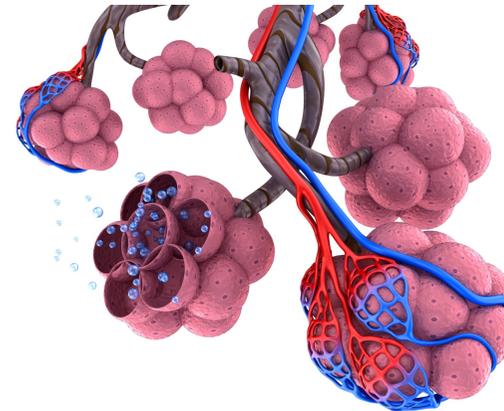


FiO₂	Expected PaO₂
21%	100 mm Hg
30%	150 mm Hg
100%	500 mm Hg

Evaluation of gas exchanges

A-a gradient

P/F ratio



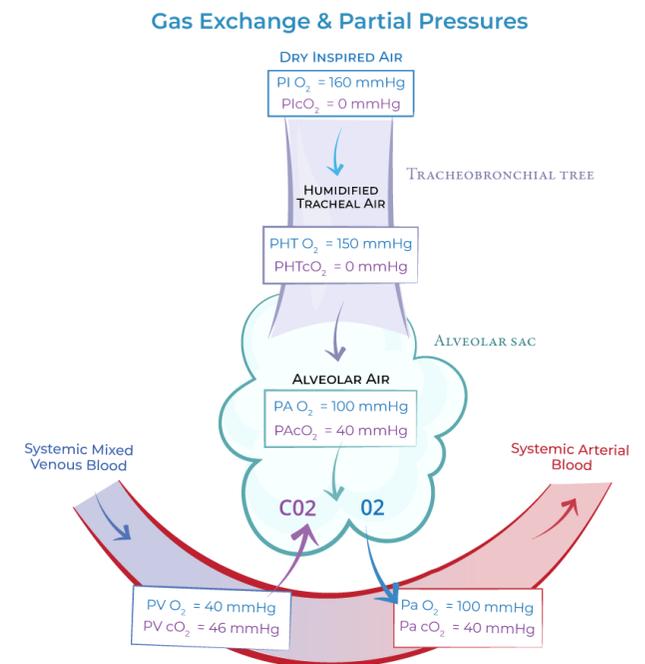
A-a gradient



- Difference between
 - Alveolar partial pressure of oxygen (PAO_2)
 - Arterial partial pressure of oxygen (PaO_2)

- A-a gradient = $PAO_2 - PaO_2$

- PaO_2 = On arterial blood gas
- PAO_2 = Calculated



Alveolar gas equation

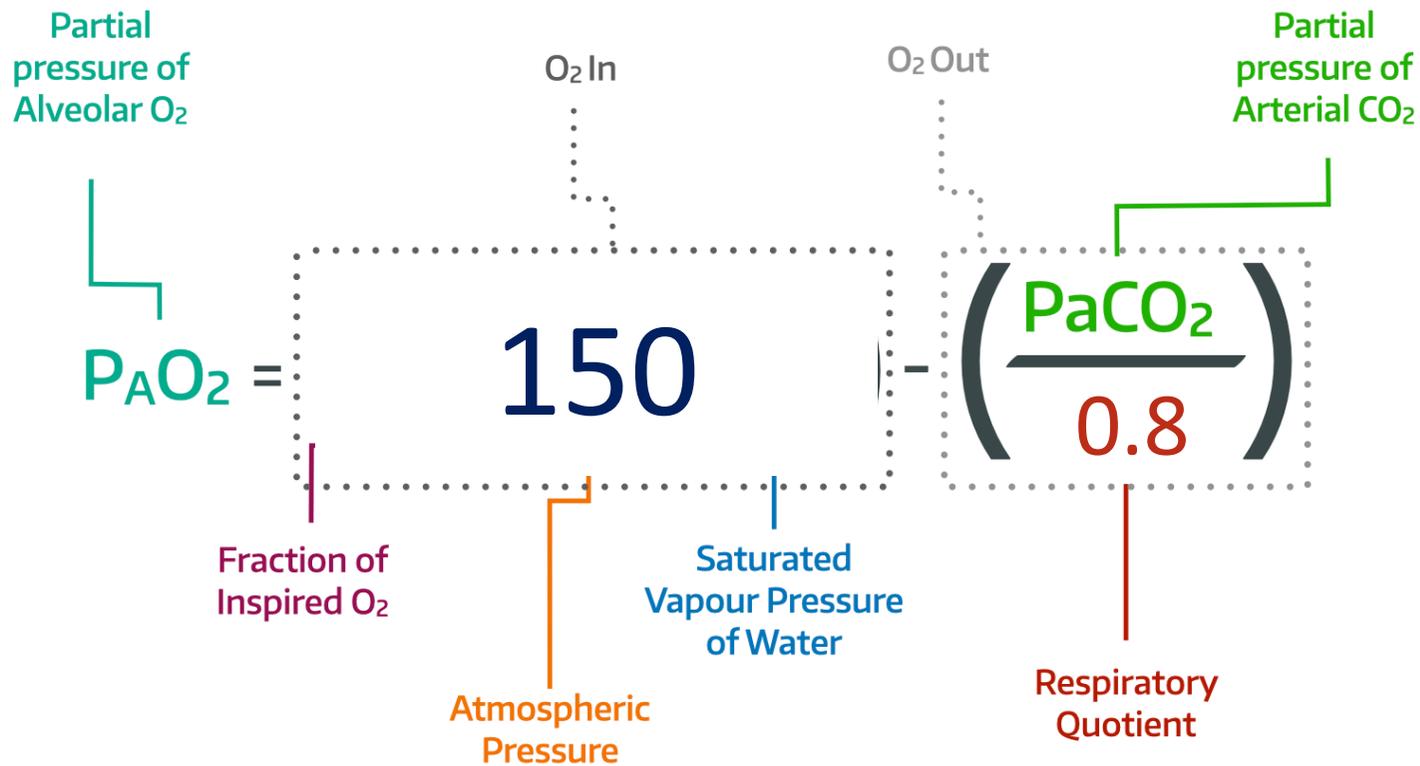


Partial pressure of Alveolar O₂ O₂In O₂Out Partial pressure of Arterial CO₂

$$P_{A}O_2 = F_{i}O_2 \left(P_{ATM} - P_{H_2O} \right) - \left(\frac{P_{a}CO_2}{RQ} \right)$$

Fraction of Inspired O₂ Atmospheric Pressure Saturated Vapour Pressure of Water Respiratory Quotient

Alveolar gas equation at room air and sea level



A-a gradient



- Assess oxygenation ability of the lungs while removing the impact of PCO_2
- At room air
 - Normal A-a gradient < 10 mm Hg
 - Venous admixture \Rightarrow A-a gradient > 20 mm Hg
- Non reliable on oxygen therapy

Interpretation



- **$P_aO_2 = 68$ mmHg, $P_aCO_2 = 60$ mmHg**

- $P_AO_2 = 150 - 60/0.8 = 75$ mm Hg
- A-a gradient = $75 - 68 = 7$ (Normal)
- **Hypoxemia due to hypoventilation**

- **$P_aO_2 = 100$ mmHg, $P_aCO_2 = 19$ mm Hg**

- $P_AO_2 = 150 - 19/0.8 = 126$ mm Hg
- A-a gradient = $126 - 100 = 26$ (Increased)
- **Normoxemia, but presence venous admixture compensated by hyperventilation**

- **$PaO_2 = 50$ mm Hg, $PaCO_2 = 50$ mm Hg**

- $P_AO_2 = 150 - 50/0.8 = 87.5$ mm Hg
- A-a gradient = $87.5 - 50 = 37.5$ mm Hg
- **Hypoxemia due to hypoventilation AND venous admixture**

At room air

P/F ratio



$$\text{PaO}_2 = 5 \times \text{FiO}_2$$



$$\text{PaO}_2/\text{FiO}_2 = 5$$

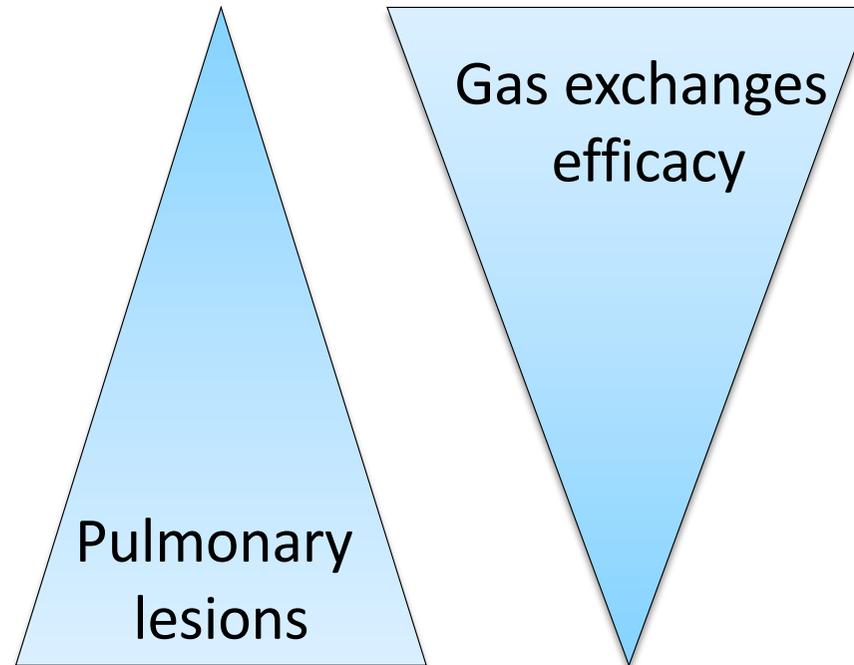
- PaO₂ in mm Hg
- FiO₂ in decimal


$$\text{PaO}_2/\text{FiO}_2 = 500$$

P/F ratio



Normal P/F ratio ≈ 500



When to use P/F ratio



- In a dyspneic patient under oxygen therapy
- To evaluate treatment efficacy
- Prognostic

A New Global Definition of Acute Respiratory Distress Syndrome

Criteria That Apply to Specific ARDS Categories			
	Nonintubated ARDS [†]	Intubated ARDS	Modified Definition for Resource-Limited Settings [‡]
Oxygenation [§]	$Pa_{O_2}:Fi_{O_2} \leq 300$ mm Hg or $Sp_{O_2}:Fi_{O_2} \leq 315$ (if $Sp_{O_2} \leq 97\%$) on HFNO with flow of ≥ 30 L/min or NIV/CPAP with at least 5 cm H ₂ O end-expiratory pressure	Mild [¶] : $200 < Pa_{O_2}:Fi_{O_2} \leq 300$ mm Hg or $235 < Sp_{O_2}:Fi_{O_2} \leq 315$ (if $Sp_{O_2} \leq 97\%$) Moderate: $100 < Pa_{O_2}:Fi_{O_2} \leq 200$ mm Hg or $148 < Sp_{O_2}:Fi_{O_2} \leq 235$ (if $Sp_{O_2} \leq 97\%$) Severe: $Pa_{O_2}:Fi_{O_2} \leq 100$ mm Hg or $Sp_{O_2}:Fi_{O_2} \leq 148$ (if $Sp_{O_2} \leq 97\%$)	$Sp_{O_2}:Fi_{O_2} \leq 315$ (if $Sp_{O_2} \leq 97\%$) [†] . Neither positive end-expiratory pressure nor a minimum flow rate of oxygen is required for diagnosis in resource-limited settings.

Oxygen assessment on ABG



- PaO₂ alone is not enough for gas exchange evaluation
- **A-a gradient**
 - At room air
 - Impact of hypoventilation on hypoxemia
- **P/F ratio**
 - Under oxygen therapy
 - Good evaluation and prognostic tool

Eymie's blood gas H+3



pH 7,42 7,36 - 7,44

PCO2(art) 24

36,0 - 44,0 mmHg

PO2(art) 70

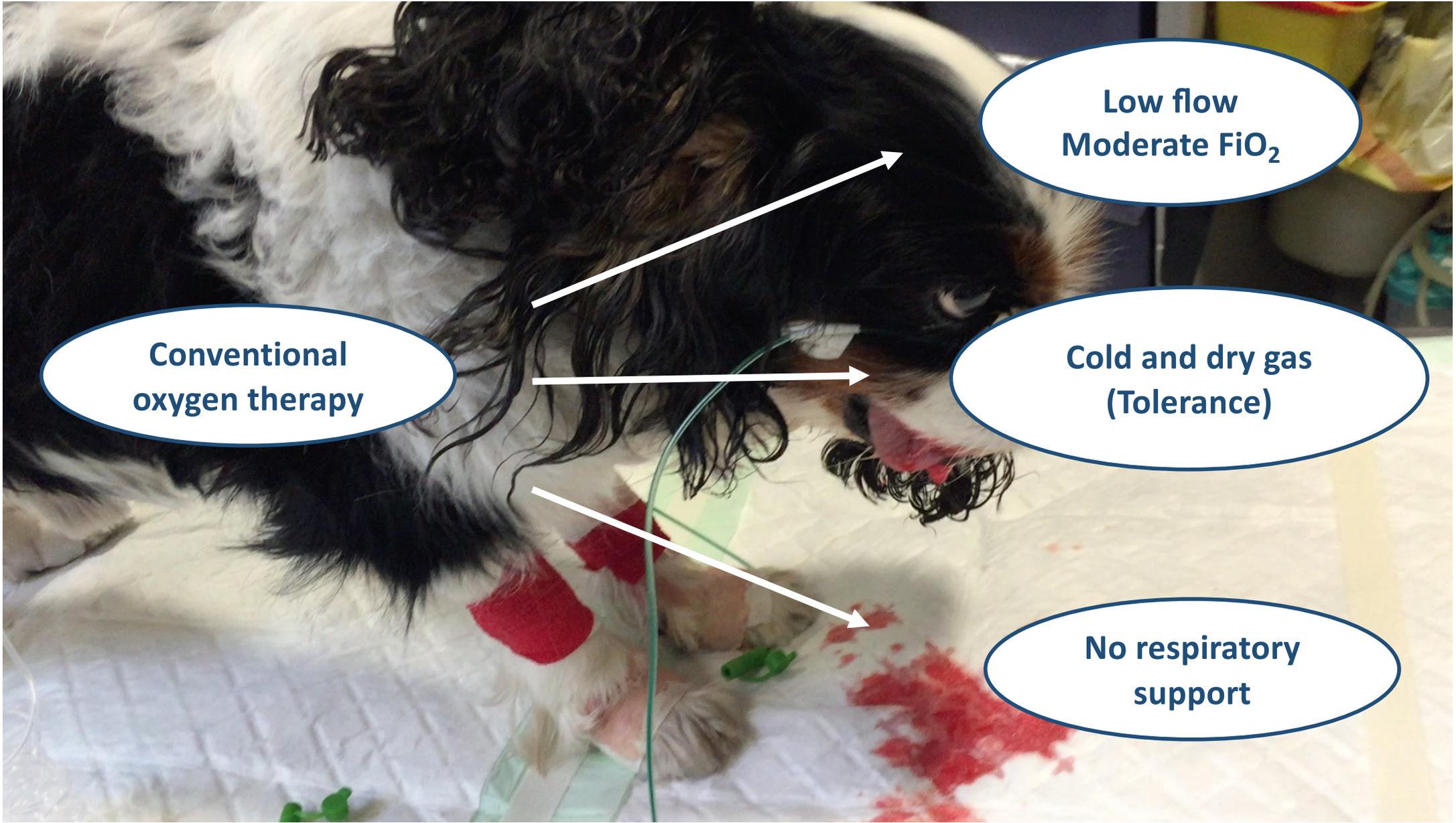
90,0 - 100,0 mmHg

Oxygen escalation?



P/F = 230

Increased respiratory efforts



**Low flow
Moderate FiO₂**

**Conventional
oxygen therapy**

**Cold and dry gas
(Tolerance)**

**No respiratory
support**

Mechanical ventilation



- Invasive respiratory support => intubation and general anesthesia

- The ventilator will
 - Provide a positive pressure that will increase the airway pressure and move gas into the lung
 - Perform part or all of the work of breathing

Indications of mechanical ventilation



Severe hypoxemia despite oxygen therapy
(PaO₂ < 60 mm Hg)

Severe hypoventilation
PaCO₂ > 60 mm Hg

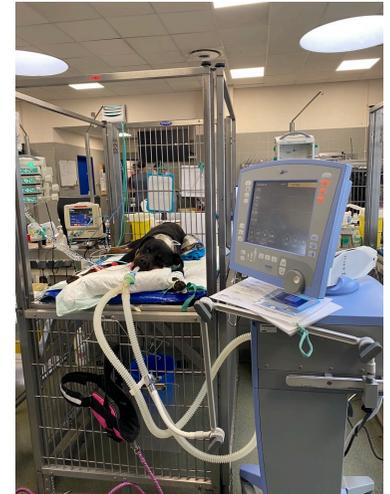
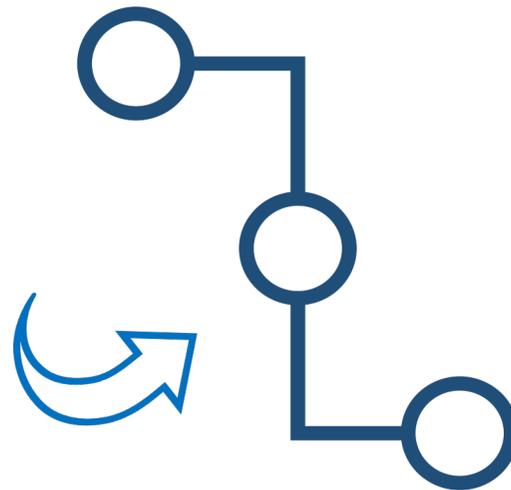
Severe respiratory efforts

Oxygen escalation



**Conventional
oxygen therapy**

High flow oxygen therapy



**Mechanical
ventilation**

High flow oxygen therapy



- Hot topic in respiratory ECC!
- Providing non- invasively heated and humidified air-oxygen mixture
 - At high flow rate (up to 60 L/min)
 - With FiO_2 ranging from 21 to 100%
- Simple set-up and user-friendly interface

Devices



Optiflow®



Airvo® 2

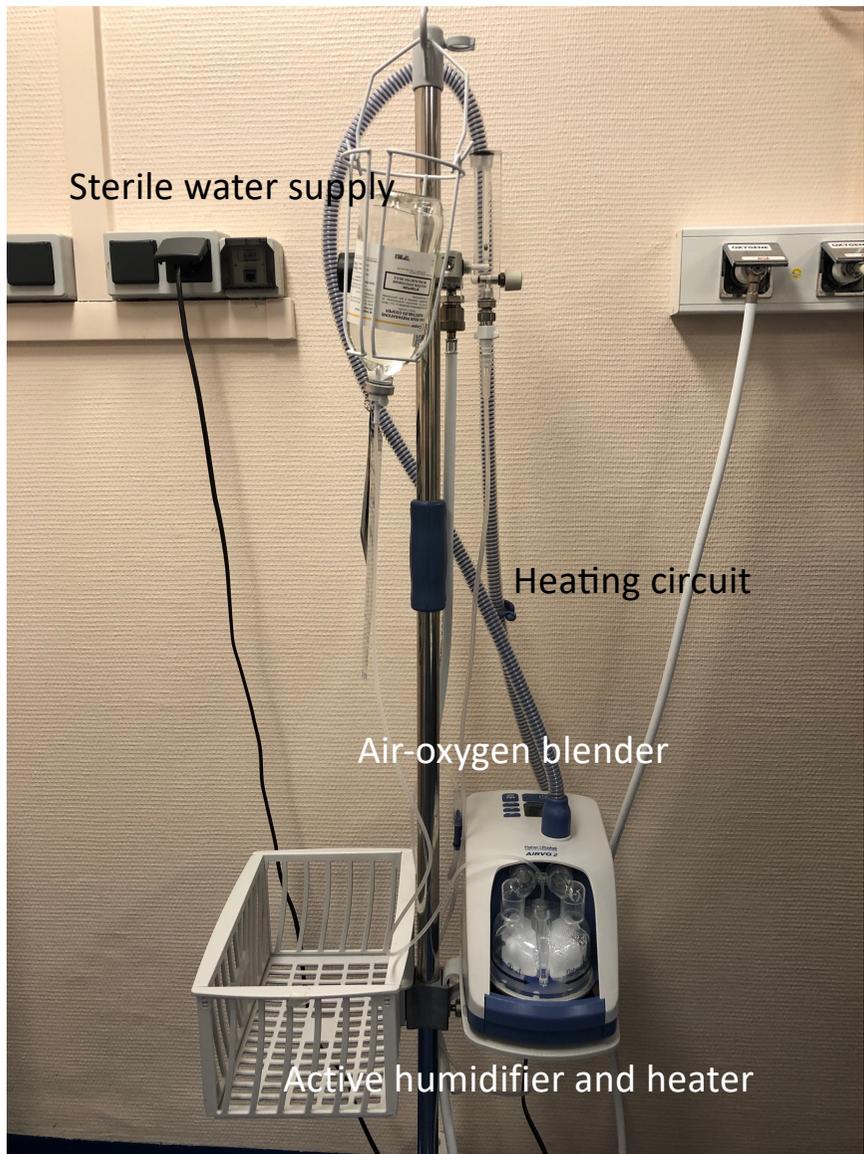


Precision flow®



Volumax®

Set up



Set up



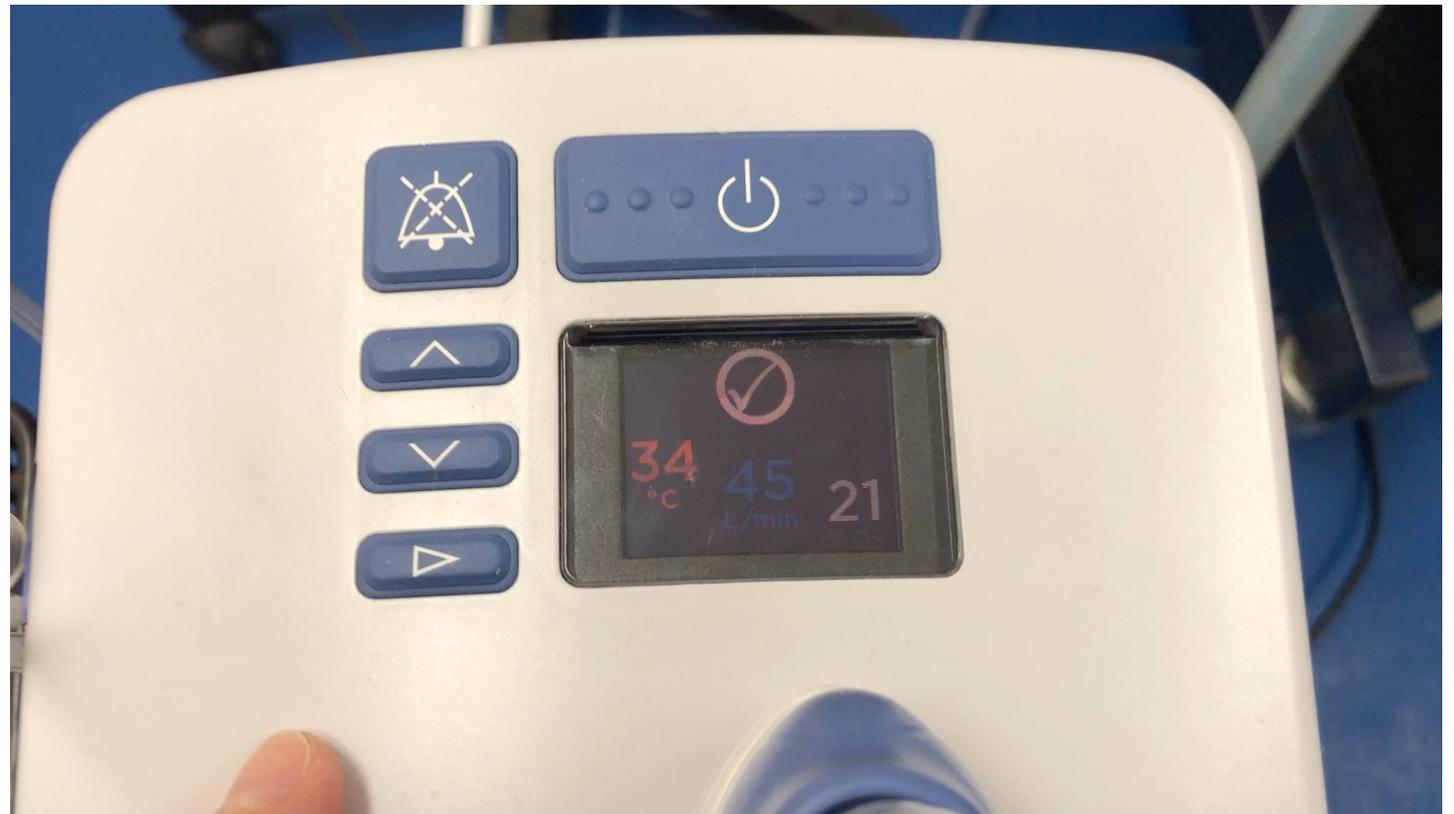
Temperature

Impact of flow and temperature on non-dyspnoeic dogs' tolerance undergoing high-flow oxygen therapy

C. HARDUIN¹, B. ALLAOUCHICHE^{1,2}, J. NÈGRE^{1,2}, I. GOY-THOLLOT^{1,2}, A. BARTHÉLEMY^{1,2}, A. FOUGERAY¹, F. BAUDIN^{1,2}, J. M. BONNETT-GARIN¹ AND C. POUZOT-NEVORET^{1,2,*} JSAP 2020



Adapt to body temperature

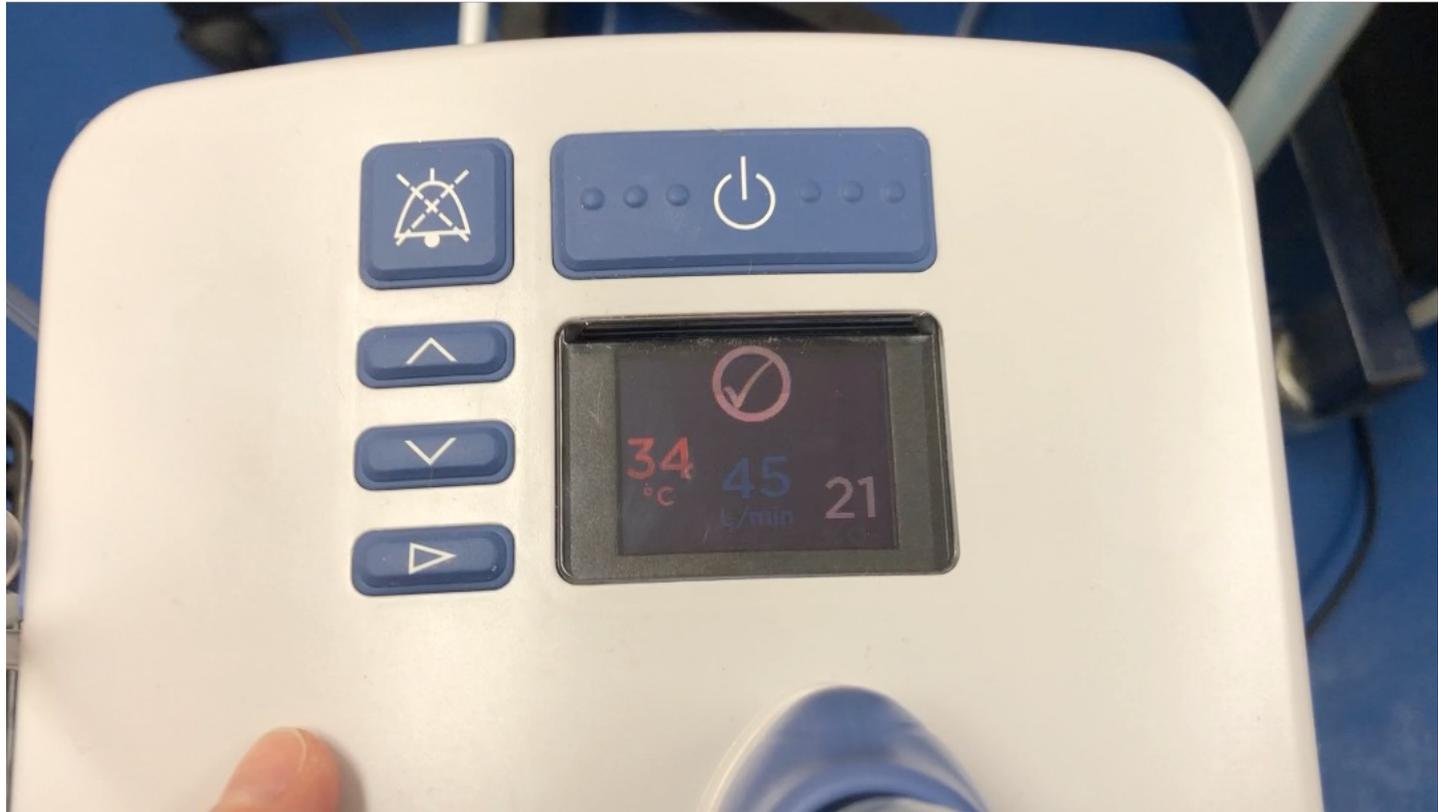


Set up



Temperature

Flow rate



ORIGINAL STUDY

WILEY 

Comparison of high flow nasal cannula oxygen administration to traditional nasal cannula oxygen therapy in healthy dogs 2019

Tiffany A. Jagodich DVM, DVSc, DACVECC | Alexa M.E. Bersenas DVM, MSc, DACVECC | Shane W. Bateman DVM, DVSc, DACVECC | Carolyn L. Kerr DVM, DVSc, PhD, DACVAA

 1-2 L/kg/min

Flow rate



Nasal oxygen

- 150 mL/kg/min
- 1.5 L/min



10 kg

High flow oxygen therapy

- 1 L/kg/min
- 10 L/min

10 L/min \neq 10 L/min of oxygen

Set up



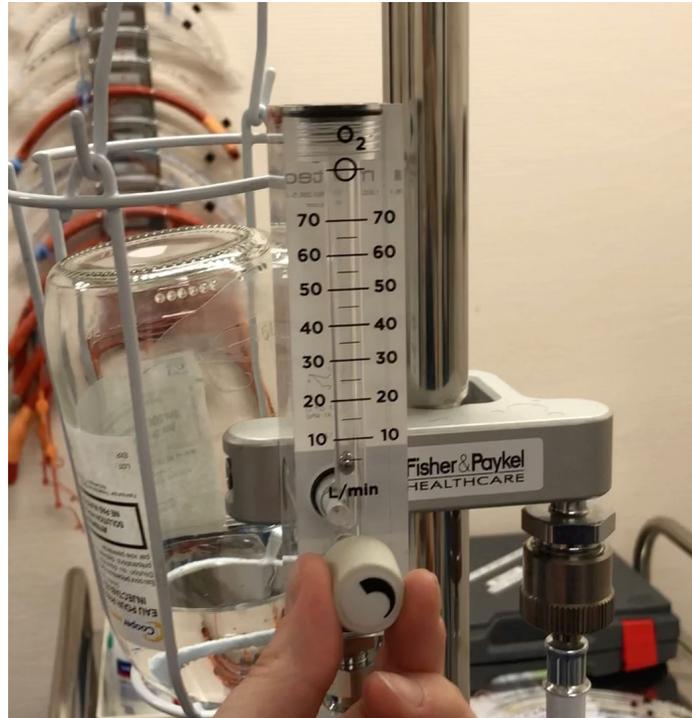
Temperature

Flow rate

FiO₂



Titration



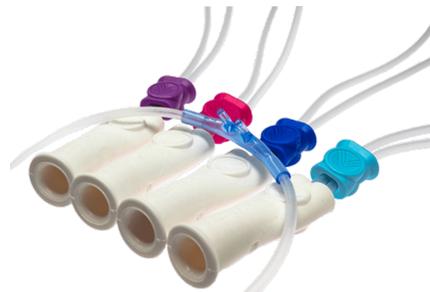
Set up





Nasal cannula

50% of patient's nares



F&P OPTIFLOW JUNIOR													
OPTIFLOW JUNIOR NASAL CANNULA	ITEM CODE	APPROX WEIGHT (KG)											
		2	4	6	8	10	12	14	16	18	20	22	
Premature Size	OPT312	Max. flow 8 L/min											
Neonatal Size	OPT314	Max. flow 8 L/min											
Infant Size	OPT316	Max. flow 20 L/min											
Pediatric Size	OPT318	Max. flow 25 L/min											



Dr Briganti



Dr Briganti



Courtesy Dr Nectoux

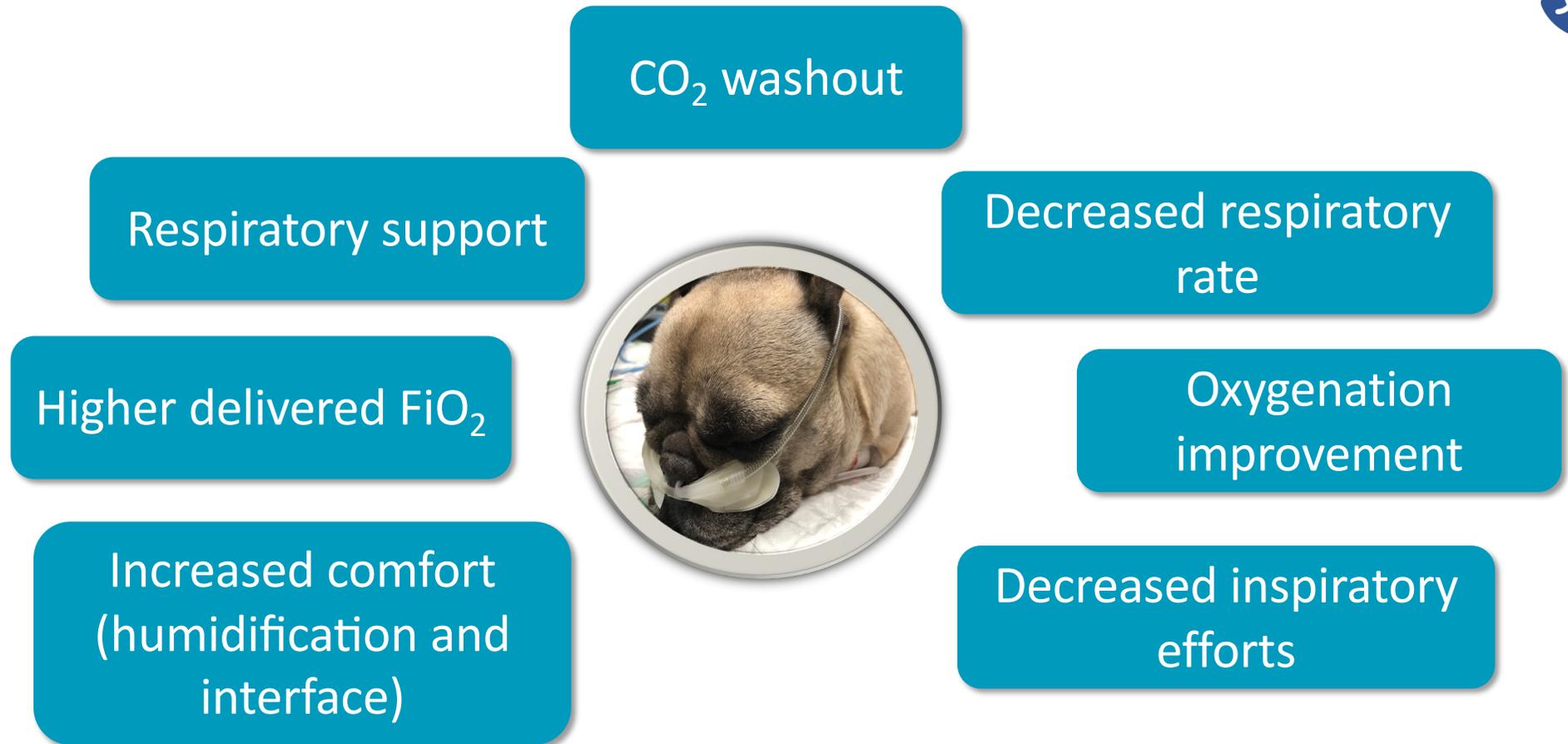


Picture Dr her

When to use HFOT?



Physiological effects of high flow oxygen



HFOT indications



- Significant increase in PaO₂ compared to conventional oxygen therapy
 - In healthy and dyspneic dogs and cats
 - Main indication: Hypoxemia
- No clear effect on PCO₂
 - Hypoventilation is not a HFOT indication
- Other uses
 - Post extubation
 - Bronchoscopy
 - ...

(Keir 2016, Daly 2017, Pouzot-Nevoret 2019, Jagodich 2020, Her 2024)

Conclusion



- Assessment of oxygenation will guide your oxygen therapy
- Do not hesitate to switch between oxygen therapy techniques
- One option does not fit all patient



Thank you for your attention

