SHUNT FRACTION

HEPATOPULMONARY SYNDROME: A CASE STUDY

Greenslopes Lung Function

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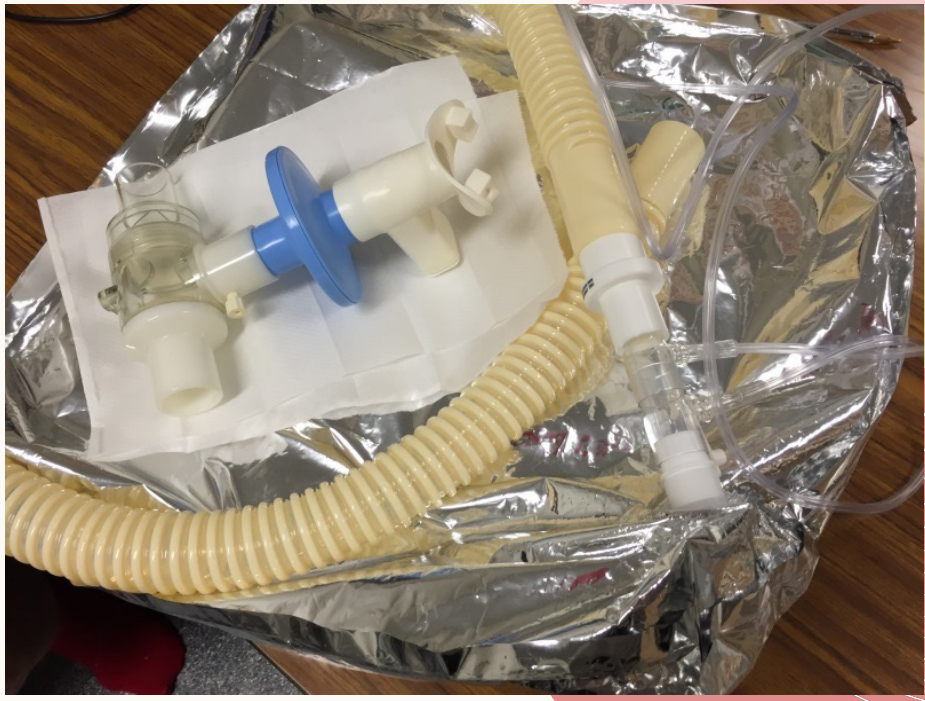
100% OXYGEN SHUNT STUDY

What is it?

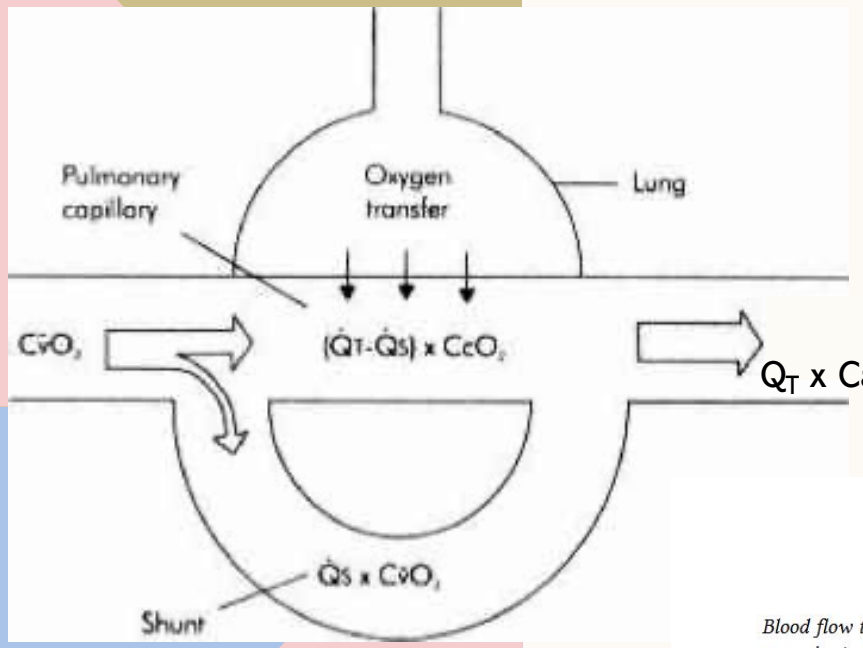
How is it Performed?



PROBLEMS WITH THE TECHNIQUE

- Prolonged 100% oxygen may lead to N2 washout and alveolar collapse
- Arterial blood gas collection is both difficult and painful
- Analysis of arterial blood is time dependent

SHUNT FRACTION



$Q_T \times CaO2$

$$Q_T \times CaO2 = Q_S \times CvO2 + (Q_T - Q_S) \times CcO2$$

Pulmonary end-capillary O_2 content- Generally held to be the same as the alveolar O_2 content

Blood flow though the shunt, per minute

Arterial O_2 content

$$\frac{Q_s}{Q_t} = \frac{(Cc_{O2} - Ca_{O2})}{(Cc_{O2} - Cv_{O2})}$$

Total cardiac output, per minute

Mixed venous O_2 content

SHUNT FRACTION CALCULATION

C_{CO2} or P_AO2

$$P_AO2 = P_IO2\,[Pb - P_AH_2O] - (P_aCO2/0.8)$$

P_AO2 = Alveolar oxygen tension
Pb = Barometric pressure
P_AH_2O = Water vapour pressure with the alveoli at body temp. (constant value of 47mmHg)
RER = respiratory exchange ratio (constant value of 0.8)

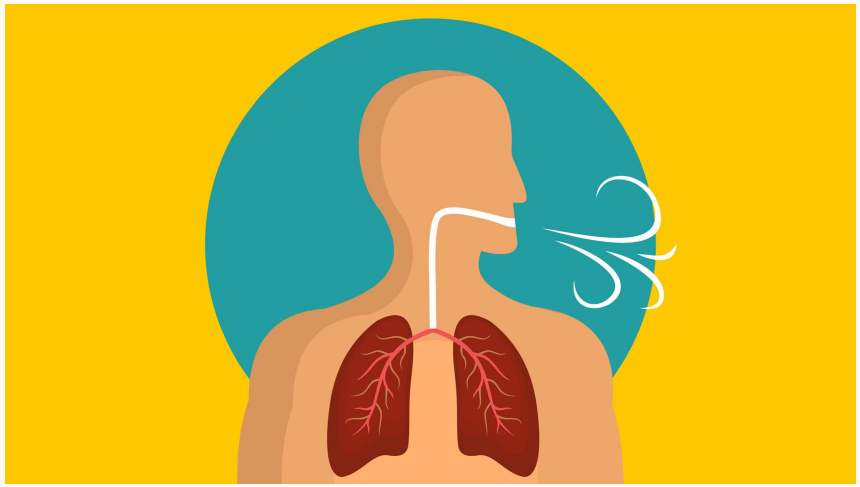
$$\frac{Q_S}{Q_T} = \frac{(P_AO2 - P_aO2) \times 0.0031}{(C(a\text{-}v)O2 + [(P_AO2 - P_aO2) \times 0.0031]}$$

$\frac{Q_s}{Q_t} = \frac{(Cc_{O2} - Ca_{O2})}{(Cc_{O2} - Cv_{O2})}$

Q_S =Blood flow through shunt
Q_T =Total blood flow
0.0031 =Solubility coefficient for oxygen in whole blood
PaCO2 =Partial pressure of CO2 in arterial blood
C(a-v)O2 =4.5 (arterial-mixed venous oxygen content) assumed to equal 4.5mL/dL
P_AO2 = Alveolar oxygen tension

INDICATIONS FOR A SHUNT STUDY

- Hypoxia
- Liver transplant workup



WHAT DOES THE RESULTS MEAN?

Normal Shunt <5%
Abnormal Shunt >10%

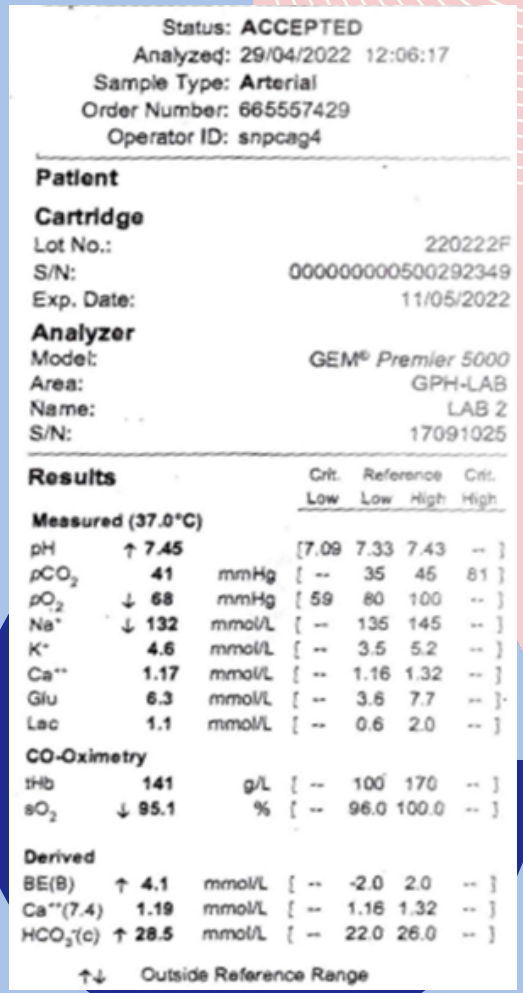
Physiological Shunt

- Poorly ventilated lung units
  - Lung collapse
  - Consolidation of the lung

Anatomical Shunt

- **Intrapulmonary Shunting**
  - Arteriovenous malformation
    - Hepatopulmonary syndrome
      - Portal hypertension – arteriovenous malformation
- **Intracardiac shunting**
  - Occurs when defect in the atrial or ventricular septa allowing mixed venous blood to pass from the right to left side of the heart without traversing the pulmonary capillaries

SHUNT FRACTION CALCULATION



Status: ACCEPTED
Analyzed: 29/04/2022 12:06:17
Sample Type: Arterial
Order Number: 665557429
Operator ID: snpcag4

Patient

Cartridge
Lot No.: 220222F
S/N: 00000000500292349
Exp. Date: 11/05/2022

Analyzer
Model: GEM® Premier 5000
Area: GPH-LAB
Name: LAB 2
S/N: 17091025

Results			Crit. Low	Reference Low	Reference High	Crit. High
Measured (37.0°C)						
pH	↑ 7.45		[7.09	7.33	7.43	--]
pCO_2	41	mmHg	[--	35	45	81]
pO_2	↓ 68	mmHg	[59	80	100	--]
Na^+	↓ 132	mmol/L	[--	135	145	--]
K^+	4.6	mmol/L	[--	3.5	5.2	--]
Ca^{++}	1.17	mmol/L	[--	1.16	1.32	--]
Glu	6.3	mmol/L	[--	3.6	7.7	--]
Lac	1.1	mmol/L	[--	0.6	2.0	--]
CO-Oximetry						
tHb	141	g/L	[--	100	170	--]
sO_2	↓ 95.1	%	[--	96.0	100.0	--]
Derived						
BE(B)	↑ 4.1	mmol/L	[--	-2.0	2.0	--]
Ca^{++}(7.4)	1.19	mmol/L	[--	1.16	1.32	--]
HCO_3^-(c)	↑ 28.5	mmol/L	[--	22.0	26.0	--]

↑↓ Outside Reference Range

PAO2 = 664.75 mmHg
PaO2 = 68mmHg

Qs	=Blood flow through shunt
Qt	=Total blood flow
0.0031	=Solubility coefficient for oxygen in whole blood
PaCO2	=Partial pressure of CO2 in arterial blood
C(a-v)O2	=4.5 (capillary arterial-mixed venous oxygen content)

$$\frac{Qs}{Qt} = \frac{(PAO2-PaO2) \times 0.0031}{(C(a\text{-}v)O2 + [(PAO2-PaO2) \times 0.0031]}$$

= (665 Hg- 68mmHg) x 0.0031 / 4.5+ [665-488mmHg x0.0031]
= 597 mmHg x 0.0031 / [4.5 + (597x 0.0031)]
= 1.8507 / (4.5 + 1.8507)
= 1.8507/6.3507
= 0.29
=0.29 x 100

$\frac{Qs}{Qt}$ **= 29%**

HEPATOPULMONARY SYNDROME

A CASE STUDY

PRESENTATION

- Chronic liver disease (unknown origin, not alcohol related)
- 6 months of increasing breathlessness
- Cough
- Jaundice
- Finger clubbing
- Cyanosis
- Wheeze

Resting hypoxia + chronic liver disease was highly suggestive for Hepatopulmonary Syndrome

LUNG FUNCTION TEST RESULTS

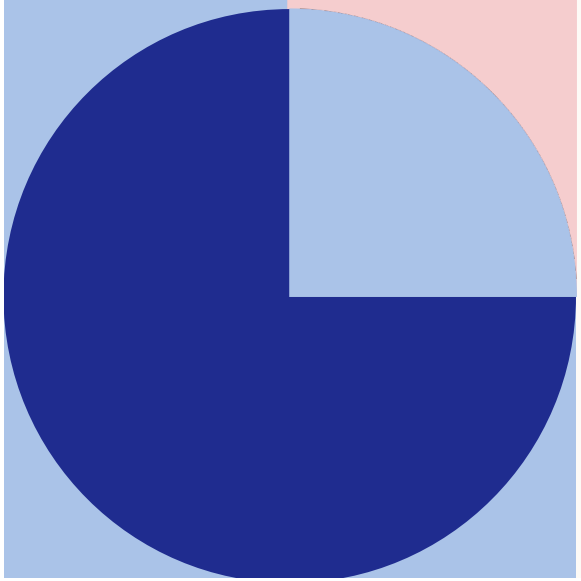
DLCO, lung volumes and spirometry

- DLCO – 10.04 mL/min/mmHg 33% of predicted KCO 54% of predicted
- TLC – 5.50L 74% of predicted
- FVC – 2.86L 57% of predicted and FEV1 2.38L 61% of predicted – Ratio 83%

Arterial Blood Gas

- PaO2 52mmHg (normal 80-100)
- PCO2 38mmHg (normal 35-45)

LUNG FUNCTION TEST RESULTS



Shunt Study – 29% shunt fraction

Echocardiography- Significant shunting visualised, consistent with transpulmonary shunting, not a PFO

Six minute walk test – unable to perform due to hypoxia

Pulse oximetry

- SpO2 on room air at rest when seated was 80%
- SpO2 on 4L/min at rest when seated was 83%
- SpO2 on room air when supine was 88%
- SpO2 on 2L/min when supine was 93%

ORTHODEOXIA

Arterial deoxygenation (>5% loss in PaO2) in upright vs supine position

PLATYPNOEA

Shortness of breath when sitting up, improved by lying supine

PLATYPNOEA + ORTHODEOXIA
+ CHRONIC LIVER DISEASE

Highly suggestive of Hepatopulmonary Syndrome

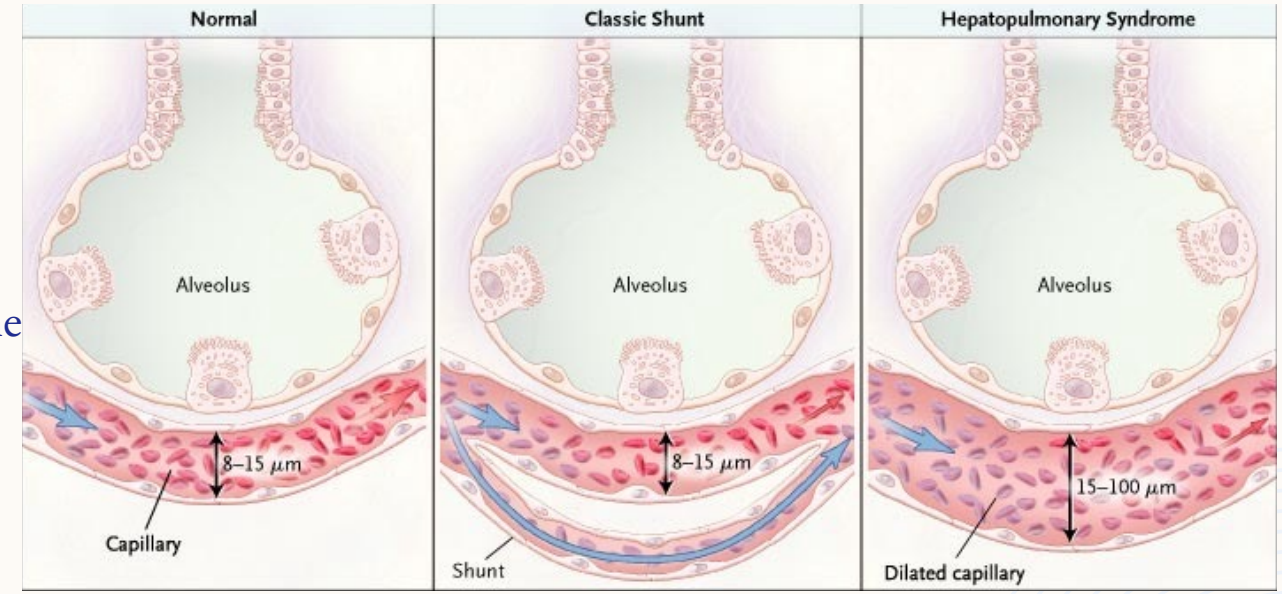
WHAT IS HEPATOPULMONARY SYNDROME?

Hepatic Disease + Arterial Oxygen Defect + Intrapulmonary Vascular Dilations

- Imbalance of vasodilators and vasoconstrictors
- Increased pulmonary artery pressure and arteriovenous malformations
- Low vascular resistance and altered pulmonary vascular tone

Decreased blood transit time + Reduced Gas exchange

V/Q Mismatch + Shunt



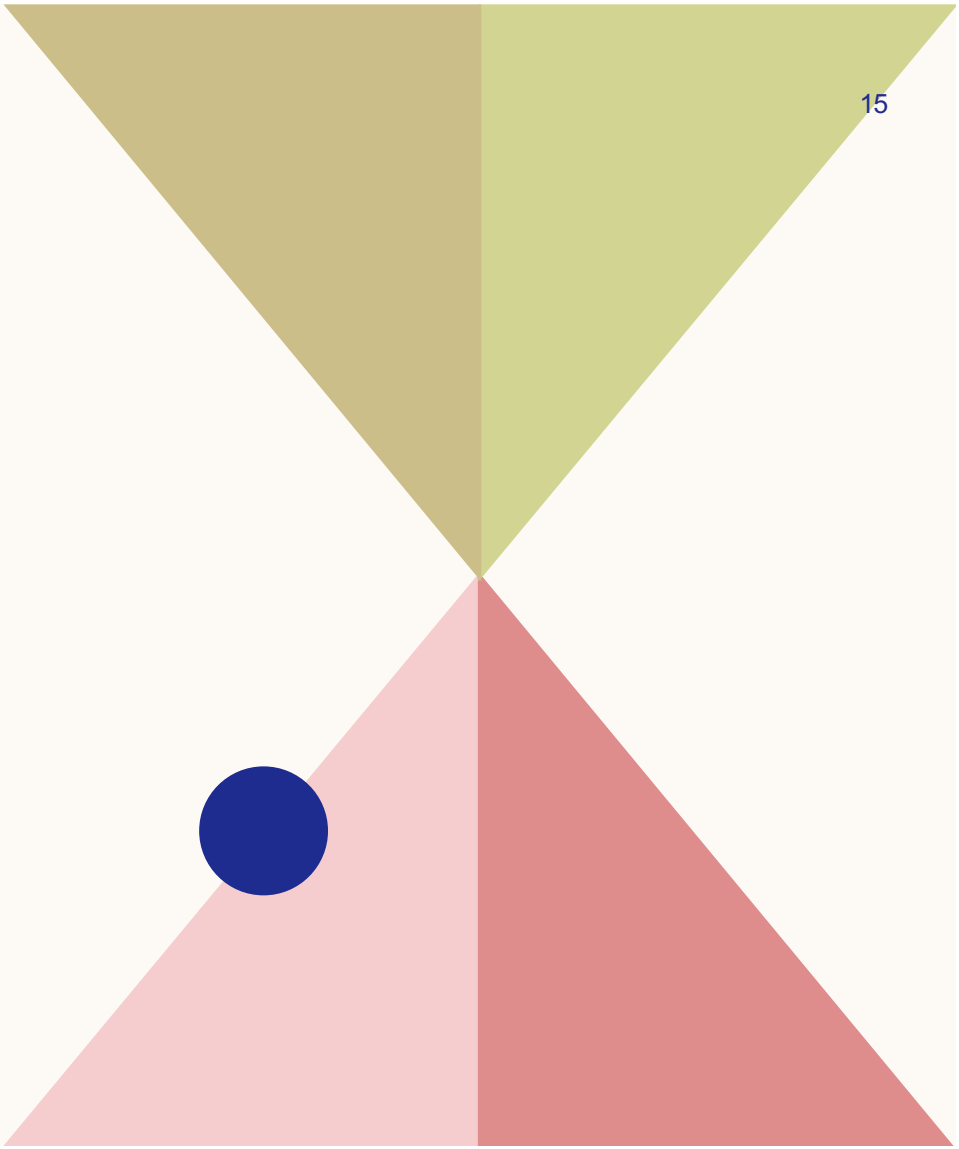
TREATMENT

Liver transplant only successful treatment for HPS

- Improves all abnormalities leading to shunt and improved hypoxaemia in 6-12 months

If not suitable for transplant

- No medical therapies available for HPS
- Oxygen therapy
- Palliative care



THANK YOU

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