TOTAL ARTERIAL OXYGEN CONTENT IN PATIENTS ADMITTED TO INTENSIVE CARE WITH HYPOXAEMIC RESPIRATORY FAILURE DUE TO COVID-19

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Introduction

In December 2019, SARS-CoV-2 spread worldwide leading to a pandemic.[1] Presenting as a flu-like illness, COVID-19 can cause severe hypoxaemic respiratory failure, similar to acute respiratory distress syndrome (ARDS). Mechanical ventilation carries a high mortality.[2]

Oxygen is carried in two forms: 98% bound to the intra-erythrocyte protein haemoglobin and 2% dissolved directly in plasma.[3] Measurements of blood oxygen are usually given as the percentage of haemoglobin saturated with oxygen (SpO2), or as the partial pressure of oxygen in arterial blood (PaO2). Total arterial oxygen content (CaO2) is the sum of the two, but there has been limited work to explore it's potential as a measure of oxygenation.[4]

CaO2 = (1.34 x [Hb] x SaO2) + (0.023 x PaO2)

As a novel cause of respiratory failure, COVID-19 offers a unique opportunity to study a cohort of patients with a similar underlying pathology.

Methods

We performed a retrospective observational study in a single university hospital in the UK between 01/03/2020 and 31/07/2020 inclusive. We included all patients admitted to ICU, aged 18 or over, tested positive for COVID-19, required supplemental oxygen and had one or more arterial blood gas (ABG) samples performed.

Suitable patients were identified using admission records. We studied clinical records and electronic patient data. We collected anonymised baseline patient characteristics which were supplemented by ICNARC unit summary data. We collected ABG data and oxygenation parameters from admission through to discharge from intensive care.

Aim

Establish the trend in CaO2 over the first 30 days of intensive care admission for patients with hypoxaemic respiratory failure due to COVID-19

Results

Patient Characteristics and Outcomes

Age (years)		**Severe comorbidities, n (%)**	
Median (IQR)	57 (47,65)	Cradiovascular	0 (0)
Sex, n (%)		Respiratory	0 (0)
Female	36 (38.7)	Renal	1 (1.1)
Male	57 (61.3)	Liver	0 (0)
Ethnicity, n (%)		Metastatic	1 (1.1)
White	51 (60)	Haematological	2 (2.2)
Mixed	10 (11.8)	Immunocomprimise	5 (5.4)
Asian	18 (21.2)	**APACHE II score**	
Black	1 (1.2)	Median (IQR)	15 (13,18)
Other	5 (5.9)	**Organ support at any point, n (%)**	
Body mass index, n (%)		Basic respiratory	76 (81.7)
18.5	0 (0)	Advanced respiratory	55 (59.1)
18.5-<25	27 (29)	Basic cardiovascular	90 (96.8)
25-<30	26 (28)	Advanced cardiovascular	32 (34.4)
30-<40	36 (38.7)	Renal	18 (19.4)
>=40	4 (4.3)	Liver	0 (0)
Index of multiple deprivation (IMD) quintile, n (%)		Neurological	19 (20.4)
1 (least deprived)	8 (9.5)	**Duration of critical care days, median (IQR)**	
2	22 (26.2)	Survivors	9 (3,27)
3	13 (15.5)	Non-survivors	6 (3,16)
4	30 (35.7)	**Outcome at end of critical care, n (%)**	
5 (most deprived)	11 (13.1)	Survived	78 (83.9)
Dependency prior to admission, n (%)		Died	15 (16.1)
No assistance	81 (88)		
Some assistance	11 (12)		
Total assistance	0 (0)		

Figure 1:
Baseline patient characteristics (n=93). Definitions as defined by ICNARC[2]

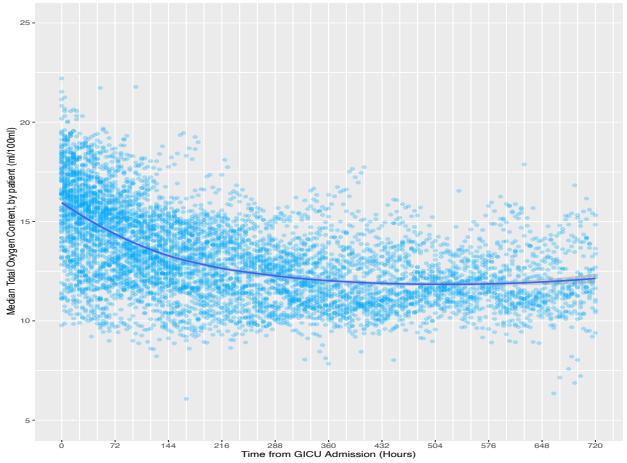

Figure 2:
Trend in 4-hour median CaO2 (ml O_2 / 100ml blood), calculated from 10564 ABGs over the first 30 days of ICU admission (n=93)

Discussion

In patients with hypoxaemic respiratory failure due to COVID-19, CaO2 trends down before reaching a plateau in the first 30 days of admission to ICU.

Hypoxaemia and anaemia affect nearly all critically unwell patients[6]. CaO2 is clearly influenced to a greater extent by the concentration of Hb as opposed to PaO2. Some work has explored the implications of Hb targets in patients with septic shock[7], and historically a restrictive transfusion regime has been adopted for patients with ARDS.[8] However, Hb targets in patients with COVID-19 are usually set by individual clinicians based on the contemporary clinical picture.

Limitations of this work include a retrospective observational design in a single centre, using a small data set from a single COVID-19 wave. Nonetheless, this is the first study to explore CaO2 as an alternative measure of oxygenation in patients with COVID-19, and further work to explore it's potential with larger studies may be warranted.

Conclusion

- COVID-19 offers a unique opportunity to study a homogenous cohort of critically unwell patients
- In adult intensive care patients with COVID-19, CaO2 trends down and then plateaus within the first 30 days
- CaO2 is easily calculated and further work may demonstrate it's usefulness as an alternative measure of oxygenation

References

1. Chauhan S. Comprehensive review of coronavirus disease 2019 (COVID-19). *Biomed J* [Internet] 2020 [cited 2020 Sep 16]; Available from: http://www.sciencedirect.com/science/article/pii/S2319417020300871
2. ICNARC. ICNARC report on COVID-19 in critical care [Internet]. Intensive care national audit & research centre; 2020 Sep p. 27 Available from: https://www.icnarc.org/DataServices/Attachments/Download/499fd2a6-a7f1-ea11-912a-00505601089b
3. David Chambers, Christopher Huang, Gareth Matthews. Section 2, Chapter 7. Oxygen transport. *Basic Physiol Anaesth* 1st ed. Cambridge University Press; 2015. p. 28
4. Harvey. Oxygen exposure as quantified by time-weighted area under curve for arterial oxygen content Is associated with mortality in mechanically ventilated critically ill patients [Internet]. 2020 [cited 2020 Nov 13]. Available from: http://www.roaic.eg.net/article.asp?issn=23569115;year=2020;volume=7;issue=2;spage=197;epage=204;aulast=Harvey
5. Ridler N, Plumb J, Grocott M. Oxygen Therapy in Critical Illness: Friend or Foe? A Review of Oxygen Therapy in Selected Acute Illnesses. *J Intensive Care Soc* SAGE Publications; 2014; **15**: 190–8
6. Rawal G, Kumar R, Yadav S, Singh A. Anemia in Intensive Care: A Review of Current Concepts. *J Crit Care Med* 2016; **2**: 109–14
7. Lower verus higher haemoglobin threshold for transfusion in septic shock. TRISS Trials Group. N Engl J Med 2014; **371**:1381-1391
8. Hunsicker, O., Materne, L., Bünger, V. *et al.* Lower versus higher hemoglobin threshold for transfusion in ARDS patients with and without ECMO. *Crit Care* **24,** 697 (2020)