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Title: The first Australian experience with ward-based CPAP for COVID19 respiratory failure: A retrospective cohort study

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ABSTRACT

We present the first Australian cohort of patients with COVID-19 respiratory failure managed with escalating respiratory support including Continuous Positive Airway Pressure (CPAP) on a standard medical ward at a tertiary Sydney hospital during the 2021 COVID-19 Delta

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variant outbreak. We demonstrate an equivalent mortality to CPAP delivered in ICU and outline our ward structure and management during the pandemic.

Introduction

Despite early success in controlling community transmission of COVID-19, some Australian jurisdictions succumbed to disease spread attributed to quarantine failures and the emergence of highly-transmissible variants (e.g. Delta variant).[1,2] Unfortunately peak transmission commenced before vaccine rates were high enough to temper the rates of severe illness.

In Australia, 13% of COVID-19 cases in 2021 required hospitalisation for respiratory illness.[3] Approximately 10% of hospitalised COVID-19 patients required intensive care unit (ICU) admission[4] and concern existed regarding Australian hospital capacity under COVID-19 disaster conditions.[5] At the beginning of the pandemic modelling indicated the number of available ICU beds would be insufficient to meet demand.[5] Although physical resources (e.g. ventilators) were bolstered, staffed bed capacity was stagnant (due to furloughs and attrition)..[6] Australian clinicians hence faced pressure to develop and implement alternative strategies for managing COVID-19 respiratory failure patients when ICU capacity was reached.

The use of continuous positive airway pressure (CPAP) in severe or critical COVID-19 disease is established within European clinical guidelines for treatment of the associated hypoxic respiratory failure, although the recommendation is conditional with very low evidence quality.[7] The HENIVOT trial demonstrated a reduced need for intubation with helmet bilevel ventilation administered in an ICU compared with high flow nasal cannulae (HFNC),[8] whilst the Recovery Respiratory-Support trial showed a reduction in need for intubation in patients who received CPAP therapy when compared to high flow conventional oxygen therapy.[9] However CPAP interface and level of ward support (i.e. medical ward, high dependency unit or ICU) was heterogenous across the study sites.[9] Ideally management of severe respiratory failure typically occurs in a respiratory high dependency unit or ICU where deterioration can be detected early and additional measures initiated. However in times of mismatch between supply and demand such traditions need to be challenged.

In this observational study we report the first Australian implementation of a ward-based model of care that included CPAP (full face mask interface) for severe COVID19 respiratory failure. We compare the premorbid characteristics, treatments and proportion of survival to hospital discharge across 3 retrospectively defined cohorts to assess the safety and efficacy of CPAP therapy in a ward environment.

All patients admitted via the Emergency Department (ED) to the COVID medical wards of Nepean Hospital between July 1st 2021 and September 30th 2021 with the diagnosis of COVID-19 were included in this retrospective analysis. Patients admitted directly from ED to ICU were excluded.

Patients were divided into three cohorts (figure 1): cohort 1, managed on a medical ward for the duration of admission with HFNC or Hudson mask as maximal oxygen support. Cohort 2 were those patients who were managed on a medical ward for the duration of admission and required CPAP for respiratory support, including if patients commenced on and subsequently intolerant of CPAP therapy.

Cohort 3 were those patients initially admitted to a medical ward but subsequently required ICU admission due to progressive respiratory failure despite maximal ward therapies (including CPAP). Patients that were transitioned on to extra-corporeal membrane oxygenation (ECMO) (not performed at this hospital) were followed and had their outcomes included within cohort 3. Patients that were transferred to the ICU and subsequently stabilised without the use of CPAP or invasive ventilation were still included in cohort 3.

Oxygen therapy was escalated as per state-wide guidelines.[10] Unless contraindicated all patients were proned, with HFNC or CPAP continuing whilst proned.[8] Therapeutics for COVID-19 were administered according to contemporaneously updated national guidelines[11] including remdesivir, glucocorticoids (predominately dexamethasone), tocilizumab and baricitinib. Referral to ICU occurred in the setting of haemodynamic instability (e.g. persistent hypotension despite appropriate fluid resuscitation) or an inability to maintain adequate oxygenation despite maximal or approaching maximal (with a progressively downward trajectory) ward-based treatment. A trial of ward CPAP was not mandatory prior to ICU referral. Maximum ward oxygen delivery was 15L wall oxygen flow, as is standard in most non-critical care inpatient wards. Referral to ICU was not made if it contradicted a pre-existing ceiling of care or if it was deemed futile by the treating clinician. No patient had an absolute contraindication to the administration of CPAP.

Statistical analysis was performed with Microsoft Excel and Jamovi V2.0.0.0.[12] Data is presented as median (interquartile range), whilst Kruskall-Wallis, Mann-Whitney U and chi-squared contingency tests (for binomial data) were used for comparative testing. This study

was approved by the Nepean and Blue Mountains Local Health District Ethics Committee (2021/ETH11687).

There were 137 relevant admissions during the time period. The baseline, biochemical and therapeutic characteristics are outlined in Table 1.

The 3 cohorts were similar in age, BMI, vaccination status and most comorbidities. Peak median CRP (110.5 mg/L, 92mg/L and 128mg/L, p=0.041 for cohorts 1-3 respectively) and procalcitonin (0.16ng/mL, 0.11ng/mL and 0.33ng/mL, p=0.045, for cohorts 1-3) were highest in those that went to the ICU.

There was no difference in the proportion of patients that received glucocorticoids or remdesivir. Significantly more patients received tocilizumab in ICU than on the medical wards (1 patient in cohorts 1 and 2, 9 patients in cohort 3, p=0.006), whilst the highest proportion of patients who received baricitinib was in cohort 2 (24, 21 and 30 patients for cohorts 1-3, p=0.042).

Of the patients admitted to ICU, 22 (43%) had CPAP as their maximal required therapy whilst 19 (37.3%) required intubation for progressive respiratory failure, of which 17 (89%) had been on CPAP prior to intubation. All patients transitioned to ECMO died (n=7).

In-hospital mortality was 7.1%, 13.3% and 39.2% for cohorts 1-3 respectively. When looking only at those in cohort 3 who received CPAP without intubation the mortality was 13.6% (3 deaths). There was no significant difference in in-hospital mortality between ward CPAP and ICU CPAP (p=0.97).

Of the total 28 deaths, 21 were unvaccinated, 3 had received one vaccination and 1 had received 2 vaccinations, with the vaccination status of the remaining 3 patients unknown. 6 of the 8 patients across cohorts 1 and 2 who died had care limitations (including not for referral to the ICU) in place prior to death.

Eleven patients (8% of the study population) were diagnosed with pulmonary emboli during the admission, with no significant between group difference.

Discussion

We've described the successful implementation of ward CPAP for COVID19 associated respiratory failure, showing no difference in mortality between ward CPAP delivery and ICU CPAP delivery.

This is the first description of an Australian cohort managed with ward based CPAP for COVID-19 respiratory failure. Compared to overseas, this cohort had a higher BMI and more diabetes, both risk factors for severe COVID19 respiratory disease.[13,14] As expected with the vaccine roll-out timeline, most patients were unvaccinated.

Our patients were treated with glucocorticoids, remdesivir and immunomodulatory therapy (predominately baricitinib). The higher use of tocilizumab in the ICU is chronologically concordant with a lower threshold for ICU admission at the start of the Delta outbreak (less resource pressure) and prior to a nationwide tocilizumab shortage.[15]

The similar mortality rates between ward CPAP and ICU CPAP provide a reassuring signal that this therapy can be delivered safely during a pandemic in a medical ward environment, with a lower mortality than that seen in the HENIVOT trial.[8] As CPAP can reduce progression to invasive ventilation,[9] our data suggests we can take steps on a medical ward to reduce the need for more invasive and resource hungry therapies.

The implementation of ward-based CPAP in the context of a pandemic required a hospital-wide approach. At peak COVID19 admissions we allocated 4 medical wards (each with a maximum capacity of 28 patients) to COVID positive patients: Two wards for higher acuity patients (including those requiring CPAP) which were overseen by respiratory and infectious diseases physicians. A respiratory physician was on call 24 hours/day and was consulted regarding each case potentially requiring ward CPAP. Initial pressure was typically 10 +/- 2cm H2O based on expected patient tolerance and overseas experience. Maximum deliverable oxygen was limited by the wall regulators at 15L/min.

Nursing support was vital: a core group of experienced respiratory nursing staff facilitated upskilling regarding CPAP and respiratory failure to nursing staff on other wards. Ward

patients on CPAP were initially cared for in a 1:2 ratio (1 nurse per 2 patients). However as the number of patients requiring CPAP increased and staff availability declined this expanded to a 1:4 ratio, including with less experienced ('new grad') nurses assisting in CPAP provision. Where possible CPAP patients were grouped in multi-bed bays to help maintain appropriate supervision.

This study has limitations. It is single centre (limiting generalisability and giving smaller numbers) and the retrospective nature introduces bias. The escalation of respiratory support therapies generally occurred according to recommended practice,[10] although clinical gestalt on occasion took precedence reflecting pragmatic practice in an evolving health crisis. A minority of patients had ceilings of care which limited the extent to which their care was escalated and potentially reduced the amount of ICU admissions.

We've described the first successful implementation of advanced ward-based respiratory support therapy for COVID-19 associated respiratory failure in an Australian cohort. This data demonstrates a safety and efficacy signal for management of severe COVID-19 respiratory failure in a medical ward, which can assist clinicians in geographically isolated areas with limited access to ICU support such as Central, Northern and Western Australia.

Table 1: Baseline physiological, vaccination, biochemical and treatment characteristics of the patients grouped by respiratory therapies administered

	Cohort 1 (n=56)	Cohort 2 (n=30)	Cohort 3 (n=51)	P value
Age (years)	54	55.5	54	0.29
Male	34 (60.7)	18 (60)	31 (60.8)	1.0
BMI - BMI ≥30 (n)	35 - 34 (60.7)	31.5 - 19 (63.3)	33.5 - 29 (56.9)	0.72
Diabetes	17 (30.3)	10 (33.3)	21 (41.2)	0.49
Chronic cardiac disease[a]	9 (16.1)	10 (33.3)	14 (27.5)	0.16
Chronic renal disease[b]	8 (14.3)	5 (16.7)	3 (5.9)	0.25
Chronic pulmonary disease[c]	16 (28.6)	11 (36.7)	5 (9.8)	0.011
Vaccination - 0 dose - 1 dose - 2 doses - Unknown	 41 (73.2) 12 (21.4) 3 (5.9) 0 (0)	 22 (73.3) 5 (16.7) 3 (10) 0 (0)	 39 (76.5) 7 (13.7) 1 (2) 4 (7.8)	0.53
Admission duration (days)	9 (6.5)	10 (6.75)	15 (13)	0.0017
Duration of ward HFNP/Hudson (days)	4 (4)	8.5 (8.3)	4 (5)	0.0051
Duration of ward CPAP (days)	n/a	3 (3.8)	1 (0.8)	0.74
Peak CRP (mg/L)	110.5 (76.8)	92 (88.8)	128[d] (82)	0.041
Peak ferritin (µg/L)	1212 (1369.3)	1680.5 (1748.5)	1386[d] (1320.5)	0.67
Peak procalcitonin (ng/mL)	0.16 (0.2)	0.11 (0.36)	0.33[d] (0.7)	0.045
Glucocorticoid	55 (98.2)	30 (100)	51 (100)	0.48
Remdesivir	49 (87.5)	24 (80)	45 (88.2)	0.54
Baricitinib	24 (42.9)	21 (70)	30 (58.8)	0.042
Tocilizumab	1 (1.7)	1 (3.3)	9 (17.6)	0.006
Sotrovimab	1 (1.7)	4 (13.3)	1 (2)	0.025
Pulmonary embolus	2 (3.6)	2 (6.7)	7 (13.7)	0.14
In hospital death	4 (7.1)	4 (13.3)	20 (39.2)	0.0001

Data presented as number (percentage) or median (interquartile range)

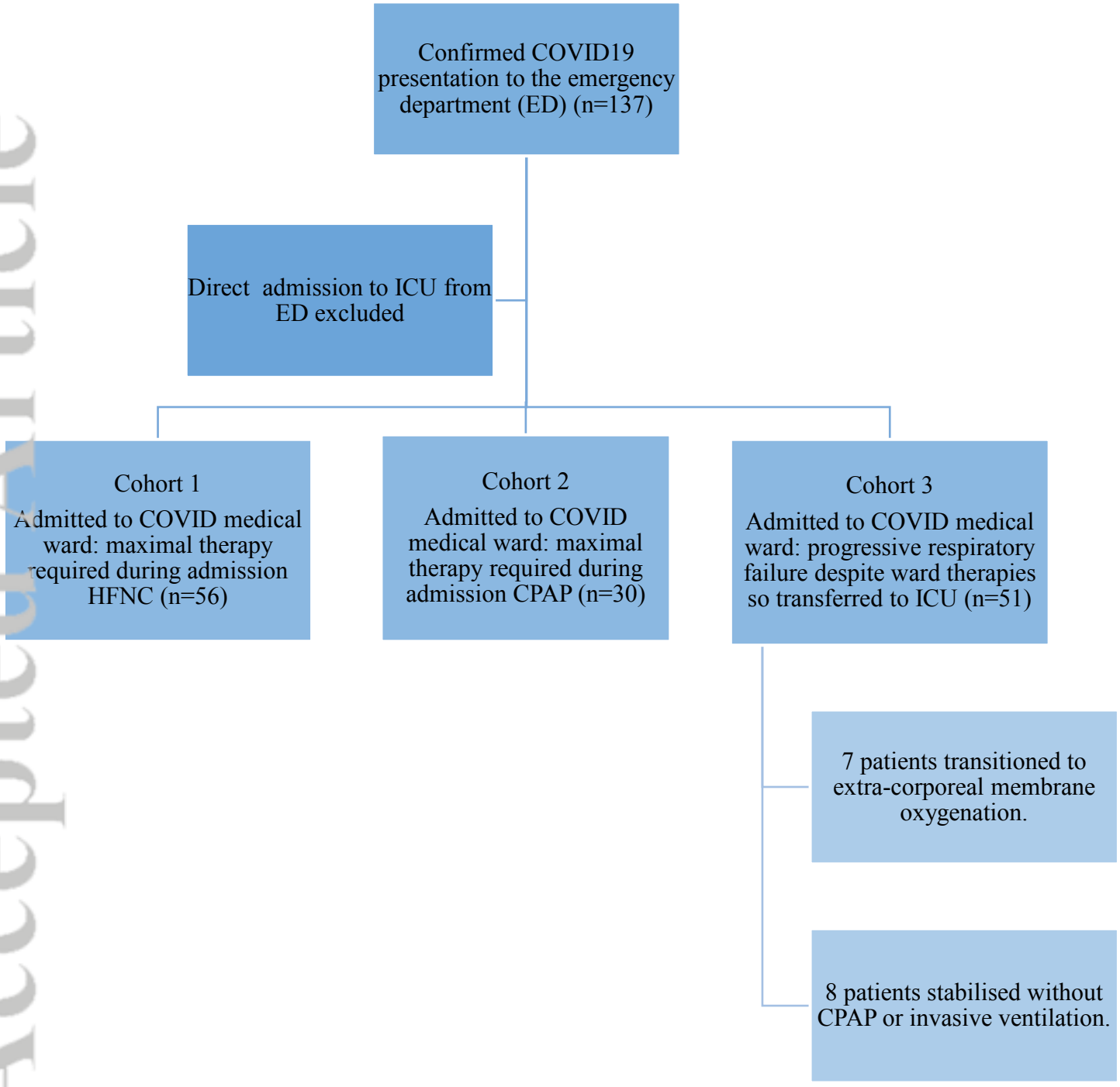
[a]Chronic cardiac disease includes pre-existing ischaemic, dilated or restrictive cardiomyopathy or known conducting system disease.

[b]Chronic renal disease defined as estimated glomerular filtration rate when well of <60 mL/min.

[c]Chronic pulmonary disease includes pre-existing obstructive or restrictive lung disease.

[d]Highest value recorded prior to admission to ICU.

Figure 1: Flow diagram of cohort allocation



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