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Anaesthetic and Critical Care Challenges in Managing COVID-19 Respiratory Failure in a Low-Resource West African Centre

Ojum, S.
Department of Anaesthesia, Rivers State University Teaching Hospital, Port Harcourt

Otokwala, J. G.
Department of Anaesthesia, University of Port Harcourt Teaching Hospital, Port Harcourt

Abstract: The COVID-19 pandemic exposed substantial gaps in respiratory care delivery across low-resource regions, where anaesthetists often serve as frontline critical-care physicians. Managing acute respiratory failure in such environments required adapting global recommendations to local realities with limited oxygen infrastructure and ventilatory equipment. This study assessed anaesthetic-led respiratory support strategies and clinical outcomes among patients with severe and critical COVID-19 managed at the Rivers State COVID-19 Treatment Centre, Eleme, Nigeria. A retrospective review of 900 hospitalised COVID-19 cases between March and September 2020 was conducted. After applying exclusion criteria, 305 eligible patients were analysed and classified according to the Nigerian Centre for Disease Control (NCDC) case definitions. Data on demographics, comorbidities, oxygen therapy, non-invasive ventilation (NIV), and outcomes were extracted and statistically analysed. All patients received oxygen therapy as first-line treatment, while 61 (20%) required escalation for persistent hypoxaemia. NIV was successful in 54 (88.5%) of these cases, primarily among younger patients with fewer comorbidities. Seven patients (2.3%) failed NIV and required invasive mechanical ventilation (IMV), all of whom subsequently died. The IMV group was characterised by higher mean age, body mass index, and comorbidity burden, with a mean PaO_2/FiO_2 ratio of 136.3 ± 91.1 mmHg. Early initiation of oxygen therapy and timely NIV markedly reduced the need for intubation and improved overall survival. Effective respiratory management of COVID-19 in low-resource settings depends on early oxygen supplementation, vigilant monitoring, and prompt escalation of non-invasive support. Delayed transition to invasive ventilation remains associated with poor outcomes. Strengthening anaesthesia-led critical-care capacity and oxygen infrastructure is therefore essential to improving survival in future respiratory pandemics.

Keywords: COVID-19: Anaesthesia, Respiratory Failure, Non-invasive Ventilation, Oxygen Therapy, West Africa.

1.0 Introduction

Coronavirus disease 2019 (COVID-19) is a highly infectious illness caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The World Health Organisation (WHO) declared the outbreak a pandemic on 11 March 2020 (WHO Director Council Opening Remark Media Briefing on COVID-19, 2020). The most common initial symptoms include dyspnoea, cough, fever, fatigue, headache, myalgia, and gastrointestinal disturbances [1,2]. Severe disease can develop rapidly, often within one week of symptom onset. Dyspnoea is a key indicator of disease severity and is frequently associated with hypoxaemia [3]. Respiratory failure may progress quickly, particularly when hypoxaemia and dyspnoea coexist, leading to acute respiratory distress syndrome (ARDS). Bilateral pulmonary infiltrates may develop, accompanied by severe hypoxaemia and pulmonary oedema not attributable to cardiac failure or fluid overload from increased hydrostatic pressure [4,5].

In adults, severe COVID-19 is diagnosed by the presence of dyspnoea (respiratory rate ≥ 30 breaths per minute), oxygen saturation ≤ 93% (NCDC), a PaO_2/FiO_2 ratio < 300 mmHg, or lung involvement exceeding 50% of pulmonary tissue [6]. In children, severe disease may present with cough or difficulty in breathing and at least one of the following: central cyanosis or SpO_2 < 92%, severe respiratory distress such as grunting, very severe chest indrawing, or clinical signs of pneumonia (NCDC).

Early cohort studies of COVID-19 patients reported that 81% experienced mild disease, 14% developed severe illness, and 5% progressed to critical disease with multi-organ failure. Among critically ill patients, in-hospital mortality reached 49% [6]. A defining feature of the pandemic was the sudden surge in critically ill patients with respiratory failure, particularly within certain geographic regions [7]. Healthcare systems were overwhelmed, resulting in shortages of trained personnel, mechanical ventilators, intensive-care beds, and oxygen-supply capacity—resources essential for managing severe COVID-19 [8].

At the onset of the pandemic, oxygen was typically delivered via nasal prongs or face masks, using either concentrators or cylinders. These provided oxygen concentrations of approximately 80–92%, depending on flow rate. With time, treatment capabilities improved following the introduction of antiviral therapy, corticosteroids, immunomodulators, and vaccination campaigns. Mechanical ventilation remained reserved for those with severe disease requiring intensive interventions [9,10]. Despite global progress, optimal strategies for oxygen escalation, timing of intubation, PEEP titration, and weaning remain controversial, especially in resource-limited settings where standard ICU facilities are scarce.

The West African sub-region, including Nigeria, experienced additional challenges such as limited access to ventilators, inadequate medical oxygen infrastructure, and a shortage of trained anaesthesia and critical-care professionals. Anaesthetists, who traditionally lead airway and peri-operative management, were consequently thrust into frontline roles of intensive respiratory support during the pandemic. Their ability to adapt global guidelines to local realities became crucial to patient survival.

This study, therefore, examines airway-management strategies and outcomes for severe and critical COVID-19 patients at a low-resource treatment centre in Rivers State, Nigeria. It evaluates patterns of oxygen administration, use of non-invasive ventilation, and clinical outcomes, highlighting anaesthetic and critical-care challenges encountered in managing respiratory failure during the pandemic.

2.0 Materials and Methods

2.1 Study Design and Setting

This was a retrospective observational study conducted at the Rivers State COVID-19 Treatment Centre, located within Eleme General Hospital, Nigeria. The hospital served as one of the designated isolation and management centres during the first wave of the pandemic. It functioned under a low-resource context, equipped with basic oxygen-delivery infrastructure, pulse oximeters, and limited mechanical ventilators. The study assessed respiratory management strategies and outcomes among hospitalised patients with confirmed COVID-19 infection managed between March and September 2020.

2.2 Study Population and Eligibility Criteria

A total of 900 patients with confirmed SARS-CoV-2 infection, verified by polymerase chain reaction (PCR), were admitted during the study period. After applying the eligibility criteria, 305 patients were included in the analysis. Inclusion criteria comprised adult patients ($\geq$18 years) with severe or critical COVID-19 as defined by the Nigerian Centre for Disease Control (NCDC, 2020). Severe disease was characterised by a respiratory rate $\geq$30 breaths per minute, oxygen saturation (SpO_2) $\leq$92%, PaO_2/FiO_2 <300 mmHg, or pulmonary infiltrates exceeding 50% of the lung fields. Critical disease included those presenting with respiratory failure requiring ventilatory support, multi-organ dysfunction, or altered level of consciousness assessed by the Glasgow Coma Scale (GCS). Exclusion criteria included early in-hospital mortality within 24 hours of admission, patients with incomplete medical records, and those with advanced comorbidities reflected by a high Charlson Comorbidity Index (CCI).

2.3 Oxygen Therapy and Respiratory Support Protocol

Oxygen therapy served as the primary intervention for all hypoxaemic patients. Oxygen was administered using nasal cannulas, simple face masks, or reservoir masks, depending on the degree of respiratory compromise. The therapeutic target was to maintain oxygen saturation above 92%, monitored continuously via pulse oximetry. Flow rates were titrated individually to achieve the desired oxygenation level, and patients demonstrating desaturation or increased work of breathing were escalated to reservoir masks with one-way valves to improve FiO_2 delivery.

2.4 Non-Invasive Ventilation (NIV)

Patients who remained hypoxaemic (SpO_2 <92% on FiO_2 $\geq$0.4) or exhibited clinical signs of respiratory fatigue were commenced on non-invasive ventilation. NIV was applied using bilevel positive airway pressure (BiPAP) or continuous positive airway pressure (CPAP) modes. Pressure support was set between 8–12 cm H_2O with positive end-expiratory pressure (PEEP) maintained at 6–8 cm H_2O. The interface type (full-face or oronasal mask) was selected based on patient tolerance. NIV settings were adjusted in response to clinical improvement, reduction in respiratory rate, and improved PaO_2/FiO_2 ratio. Patients were closely observed for agitation, mask leak, and gastric distension.

2.5 Mechanical Ventilation Strategy

Invasive mechanical ventilation (IMV) was reserved for patients who failed NIV, defined by worsening hypoxaemia (PaO_2/FiO_2 <150 mmHg), persistent respiratory acidosis (pH <7.30), or progressive fatigue. However, due to the limited number of ventilators and concerns about poor prognosis in severe ARDS, intubation was used sparingly. Where implemented, lung-protective ventilation strategies were adopted, targeting tidal volumes of 6 mL/kg predicted body weight and maintaining plateau pressures below 30 cm H_2O. Permissive hypercapnia was tolerated (pH $\geq$7.20) to reduce barotrauma risk.

2.6 Monitoring and Clinical Evaluation

Patients were assessed daily by the anaesthesia-led critical care team. Monitoring parameters included respiratory rate, SpO_2, heart rate, non-invasive blood pressure, temperature, and level of consciousness. Arterial blood gas (ABG) analysis was performed periodically to evaluate gas exchange, with PaO_2/FiO_2 ratio used to guide therapy escalation. Signs of clinical improvement included reduced respiratory effort, improved oxygen saturation, and stabilised haemodynamic parameters.

2.7 Data Collection and Statistical Analysis

Clinical data were extracted from patient case notes, monitoring charts, and laboratory reports using a structured data form. Variables included age, sex, comorbidities, body mass index (BMI), oxygen therapy duration, NIV settings, PaO_2/FiO_2 ratios, and outcomes (discharge or death). Data were entered into Microsoft Excel and analysed using STATISTICA version 16.1 (StatSoft Inc., USA). Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range), while categorical variables were summarised as frequencies and percentages. The Shapiro–Wilk test assessed normality. Between-group comparisons were performed using the Mann–Whitney U test for continuous variables and Chi-square or Fisher's exact test for categorical variables. A p-value <0.05 was considered statistically significant.

2.8 Ethical Considerations

Ethical clearance for the study was obtained from the Rivers State Ministry of Health Research Ethics Committee. The study complied with the principles of the Declaration of Helsinki. Patient confidentiality was maintained by anonymising data before analysis. Since the research was retrospective and based on existing records, the requirement for individual informed consent was waived by the ethics committee.

3.0 Results

3.1 Clinical Characteristics of Patients on Admission

A total of 305 patients with confirmed COVID-19 were analysed after applying the inclusion criteria. Among them, 61 (20%) met the criteria for severe or critical disease and were admitted for advanced respiratory support. The mean age of the entire cohort was 49.6 ± 13.4 years (range: 18–77), and males represented 64.3% of all admissions. Hypertension (26.2%) and diabetes mellitus (8.1%) were the most frequent comorbidities, while obesity (BMI >30 kg/m^2) was recorded in 11.8% of patients.

Baseline clinical characteristics are summarised in Table 1. Patients in the severe group presented with an average respiratory rate of 27 breaths per minute (range: 25–29) and oxygen saturation (SpO_2) of 85% (83–97%). The mean PaO_2/FiO_2 ratio on admission was 180.0 ± 37.7 mmHg, consistent with moderate hypoxaemia. Mean systolic and diastolic blood pressures were 130 ± 13.2 mmHg and 85 ± 12.3 mmHg, respectively. The mean Sequential Organ Failure Assessment (SOFA) score was 4 (IQR: 2–5), reflecting early organ dysfunction but preserved haemodynamic stability.

Table 1. Clinical Characteristics of Patients upon Admission

Parameter	Mean ± SD (or Range)
Respiratory rate (breaths/min)	27 (25–29)
Oxygen saturation (%)	85 (83–97)
PaO_2/FiO_2 ratio	180.0 ± 37.7
SOFA score	4 (2–5)
Pulse (beats/min)	86.0 ± 7.2
Temperature (°C)	36.5 ± 0.4
Systolic blood pressure (mmHg)	130 ± 13.2
Diastolic blood pressure (mmHg)	85 ± 12.3

3.2 Oxygen Therapy and Respiratory Support Outcomes

All 305 patients (100%) received supplemental oxygen as first-line therapy. Of these, 244 (80%) were successfully managed using conventional oxygen delivery methods such as nasal prongs or simple face masks. The remaining 61 patients (20%) experienced persistent hypoxaemia and required escalation to non-invasive ventilation (NIV).

Among those initiated on NIV, 54 (88.5%) showed clinical improvement, characterised by reduced respiratory rate, improved SpO_2 (>94%), and enhanced PaO_2/FiO_2 ratio. NIV was particularly effective among younger patients with fewer comorbidities and lower body mass index (BMI). However, 7 patients (2.3%) failed NIV due to worsening hypoxaemia or respiratory fatigue and were subsequently intubated for invasive mechanical ventilation (IMV). All seven patients in the IMV group succumbed to respiratory failure despite aggressive supportive care, resulting in an overall mortality rate of 2.3%.

Table 2. Summary of Oxygen Therapy, NIV, and IMV Outcomes

Parameter	Nasal Prongs/Face Mask (n=244)	Non-Invasive Ventilation (n=54)	Failed NIV → IMV (n=7)
Male/Female	157/87	36/18	7/0
Age (years, mean ± SD)	48 ± 12.9	54.1 ± 11.3	65 ± 12.3
BMI (kg/m^2, mean ± SD)	24.8 ± 4.7	28.0 ± 3.2	32.5 ± 4.2
Charlson Comorbidity Index	2.2 ± 1.8	2.9 ± 2.2	3.2 ± 3.3
Duration of oxygen therapy (days)	6.9 ± 1.3	3.2 ± 2.0	5.6 ± 2.2
PaO_2/FiO_2 ratio	160 ± 35.0	136 ± 52.1	127 ± 46.0
Duration of mechanical ventilation (days)	Nil	6.8 ± 3.3	8.2 ± 4.1
Mortality (%)	0 (0%)	0 (0%)	7 (100%)

3.3 Clinical Observations and Mortality Patterns

Gender distribution showed a predominance of males across all categories, with a notable absence of females in the IMV group. Patients who failed NIV were significantly older (mean age 65.0 ± 12.3 years), had higher BMI values, and a greater burden of comorbidities (mean CCI = 3.23 ± 3.32). The mean PaO_2/FiO_2 ratio of 136.3 ± 91.1 mmHg among these patients reflected moderate to severe ARDS.

NIV success was associated with early initiation ($PaO_2/FiO_2 \geq 170$ mmHg at commencement) and adequate patient tolerance. Conversely, delayed escalation to IMV correlated with poor outcomes, consistent with international findings that prolonged hypoxaemia before intubation worsens mortality. The absence of advanced ventilatory monitoring systems and limited ICU capacity further constrained patient survival once invasive ventilation became necessary.

3.4 Stepwise Respiratory Support Strategy

The local management algorithm for respiratory support followed a four-step escalation model summarised in Table 3. This approach prioritised early oxygen therapy and non-invasive support, advancing to IMV only when clearly indicated by clinical or gas exchange deterioration.

Table 3. Stepwise Strategy for Respiratory Support in COVID-19 ("Respiratory Chain")

Stage	Method of Support	Indication	Contraindication	Criteria for Escalation
1	Conventional oxygen (nasal cannula, face mask)	$SpO_2 \leq 95\%$, RR ≥20/min	—	No improvement in SpO_2 or persistent respiratory distress
2	High-flow nasal oxygen (HFNO)	Moderate hypoxaemia, RR >20/min	Acidosis (pH <7.3), haemodynamic instability	Failure to improve oxygenation
3	Non-invasive ventilation (NIV)	Moderate ARDS unresponsive to HFNO	Reduced consciousness, severe acidosis	Clinical deterioration or persistent desaturation
4	Invasive mechanical ventilation	Refractory hypoxaemia or respiratory failure	—	

4.0 Discussion

Dyspnoea was among the most frequent and distressing symptoms observed in patients with COVID-19. An increased respiratory rate and profound hypoxaemia were the major reasons for hospital admission among patients with severe disease, particularly when oxygen saturation levels fell below 92% [16]. For patients with SpO_2 values under this threshold, the combined use of reservoir-bag masks, repositioning, and breathing exercises enhanced oxygenation by improving the ventilation of dependent lung regions. Continuous monitoring of respiratory rate, SpO_2, and arterial blood gases was crucial for early detection of deterioration and guided timely escalation of therapy.

Most patients responded favourably to conventional oxygen therapy delivered via nasal prongs or simple face masks. However, 20% required higher-level respiratory support through non-invasive ventilation (NIV). Adjusting positive end-expiratory pressure (PEEP) in continuous positive airway pressure (CPAP) or bilevel positive airway pressure (BiPAP/PS) modes helped maintain alveolar recruitment and improve lung compliance [18]. The high success rate of NIV in this study (88.5%) aligns with international findings that early initiation of NIV in moderate hypoxaemia can avert intubation and reduce mortality [15,16].

The reluctance to proceed rapidly to invasive mechanical ventilation (IMV) during the early pandemic was influenced by emerging global reports describing poor survival rates among ventilated COVID-19 patients. Some centres documented mortality rates exceeding 80–90% once intubation became necessary [14,17]. At the Eleme Centre, IMV was reserved for only seven patients, all of whom succumbed to respiratory failure. These findings mirror those from Lombardy, Italy, where critically ill patients exhibited similarly high fatality rates due to severe ARDS and limited effective rescue therapies [6].

Although IMV remains a cornerstone in the management of refractory respiratory failure, its success depends heavily on timing, patient selection, and the availability of experienced personnel. Several authors have emphasised that delayed intubation—after prolonged hypoxaemia or excessive NIV use—can exacerbate lung injury and worsen outcomes [14,15]. Nevertheless, in resource-limited environments where ventilator availability and ICU capacity are constrained, anaesthetists often prioritise non-invasive modalities to optimise resource allocation and reduce exposure risk to healthcare workers [12,13].

The application of lung-protective ventilation strategies in COVID-19 has been widely advocated. However, the atypical pulmonary mechanics of SARS-CoV-2 pneumonia—characterised by heterogeneous alveolar involvement—complicate the use of uniform ventilation protocols. High PEEP levels may reopen collapsed alveoli but simultaneously over-distend unaffected lung units, precipitating ventilator-induced lung injury [19]. Consequently, expert consensus has shifted toward individualised settings that maintain oxygenation while avoiding excessive airway pressures. This study adopted moderate PEEP (6–8 cm H_2O) and accepted permissive hypercapnia ($pH \geq 7.20$), in accordance with lung-protective principles [20].

The findings of this study reaffirm the importance of a **stepwise respiratory support algorithm**, progressing from conventional oxygen therapy to NIV before resorting to IMV [20]. Early recognition of deteriorating respiratory function through simple bedside tools such as pulse oximetry and respiratory rate monitoring was pivotal in achieving favourable outcomes [5, 21]. Importantly, the 0% mortality among patients managed exclusively with oxygen therapy or NIV demonstrates that structured escalation, close monitoring, and anaesthetist-led oversight can markedly improve survival even in resource-limited contexts.

Beyond clinical management, the study underscores systemic and infrastructural limitations faced by anaesthetists in sub-Saharan Africa during the pandemic. Shortages of oxygen concentrators, flow meters, and skilled critical-care nurses hampered standardised implementation of oxygen therapy protocols. In some cases, delays in switching from face mask oxygenation to NIV were due to power interruptions or limited machine availability. These constraints highlight the urgent need for investment in sustainable oxygen infrastructure and training of anaesthesia personnel in ventilatory management and infection-control procedures.

The high fatality rate observed among patients who required IMV (100%) also suggests that invasive ventilation was frequently a marker of late disease progression rather than a purely therapeutic decision. Similar reports from Europe and North America have shown that once multi-organ failure develops, outcomes remain poor despite maximal ventilatory support [5,6,14]. Future preparedness must therefore focus on early triage, timely referral, and structured escalation algorithms within national pandemic response plans.

Conclusion

This study highlights the critical role of timely respiratory intervention in the management of COVID-19-related respiratory failure, particularly within resource-limited healthcare environments. Early initiation of oxygen therapy and non-invasive ventilation (NIV) proved highly effective in stabilising most patients and preventing the need for invasive mechanical ventilation (IMV). However, delayed escalation of respiratory support among non-responders was strongly associated with poor outcomes, as all patients requiring IMV experienced fatality.

The findings emphasise the need for anaesthetist-led critical-care teams to prioritise early recognition of hypoxaemia, continuous patient monitoring, and adherence to a structured, stepwise oxygen-therapy algorithm. In low-resource settings, strengthening oxygen infrastructure, ensuring the availability of functional ventilators, and providing regular training in ventilatory management are essential to improving survival outcomes during pandemics or respiratory crises.

Furthermore, this study demonstrates that even under constrained conditions, evidence-based oxygen therapy and non-invasive ventilatory techniques—implemented by trained anaesthetists—can markedly enhance patient prognosis. Future preparedness strategies across sub-Saharan Africa should integrate these lessons to reinforce the resilience and responsiveness of anaesthesia-led critical-care services.

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