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Impacts of Conventional Oxygen Therapy on COVID-19 Patient in Intensive Care Unit (ICU)

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Abstract

Conventional oxygen therapy (COT) is the main supportive treatment administered to patients after planned extubation and has conventionally been delivered using nasal prongs, cannula or masks. The maximal oxygen flow rate delivered by COT is only 15 L/min, which is far lower than the demands of post-extubation patients with acute respiratory failure. We conducted a retro-prospective study of 63 patients with COVID-19 admitted to the ICU (Intensive Care Unit) of COVID-19 dedicated Mugda Medical College and Hospital, Dhaka, Bangladesh from May 1 to June 30, 2020. Treatment with 1-5 L oxygen/min through pipe (3, 4.76%), 6-10 L oxygen/min through pipe (5, 7.94%) and concentrator (3, 4.76%), 11-15 L oxygen/min through pipe (32, 50.79%) and through concentrator (4, 6.35%) were in close collaboration with intensive care associates and >15 L oxygen/min through pipe (16, 25.4%) was preferably done in intensive care units. High-flow nasal cannula (HFNC) has been used to supply 11-15L oxygen per minute (6, 9.52%) and more than 15L Oxygen per minute (5, 7.94%)whereas long-term Continuous Positive Airway Pressure (CPAP) has been used to supply 6-10L Oxygen per minute (2, 3.17%), 11-15L Oxygen per minute (6, 9.52%) and more than 15L Oxygen per minute (5, 7.94%)were administrated for patients not responding to conventional oxygen therapy. Oxygen therapy is the most basic and critical treatment for the patients admitted in intensive care unit. High-flow nasal cannula may reduce the need for invasive ventilation and escalation of therapy compared with COT in COVID-19 patients with acute hypoxemic respiratory failure.

Keywords: *Conventional Oxygen Therapy, ICU, High-flow Nasal Cannula, Continuous Positive Airway Pressure, Mechanical Ventilation.*

Introduction

Conventional oxygen therapy (COT) is the main supportive treatment administered to patients after planned extubation and has conventionally been delivered using nasal prongs, cannula or masks[1]. However, the maximal oxygen flow rates that these devices can deliver are limited[2]. The maximal oxygen flow rate delivered by COT is only 15 L/min, which is far lower than the demands of post-extubation patients with acute respiratory failure[1,2]. Acute respiratory failure can be life-threatening and that conventional oxygen support, usually by nasal cannula or face mask, is standard treatment[2]. In some hospitals in the United States, >25% of hospitalized patients require ICU care, mostly due to acute respiratory failure.[3,4,5] In adults with COVID-19 and acute hypoxemic respiratory failure, conventional oxygen therapy may be insufficient to meet the oxygen needs of the patient[5]. Options include HFNC, NIPPV, or intubation and invasive mechanical ventilation[6]. HFNC and NIPPV are preferable to conventional oxygen therapy based on data from non-COVID-19 clinical trials and meta-analyses that showed reductions in the need for therapeutic escalation and the need for intubation in patients who received HFNC or NIPPV.[6,7]

Proning is a recommended strategy in non-COVID-19-related ARDS for improving oxygenation and reducing the heterogeneity of lung ventilation[8]. Proning has been used to treat patients with COVID-19, although there is currently not enough clinical experience with this strategy to draw conclusions about its effect on long-term outcomes[9]. Non-invasive oxygen therapy can be administered in different ways, for example, through an oronasal mask or using nasal cannulas. However, non-invasive oxygen therapy has a number of limiting factors that condition its efficacy and therefore the correction of hypoxemia and the clinical manifestations associated to ARF (Acute respiratory failure). The main limiting factors are tolerance of the application system on one hand, and limitation of the administered oxygen flow on the other. The latter is generally limited to 15 L/min,[10] and the flow is normally administered under conditions that do not coincide with the ideal temperature and humidity specifications (37°C and 100% relative humidity).[11,12] An alternative that would overcome these limitations of conventional oxygen therapy is the use of non-invasive mechanical ventilation (NIMV) systems–though the main problem with these systems is patient discomfort and poor tolerance of the interfaces.[13]

Materials and Methodology

Study Population, Setting, and Design

We conducted a retro-prospective study of 63 patients with COVID-19 admitted to the ICU (Intensive Care Unit) of COVID-19 dedicated Mugda Medical College and Hospital, Dhaka, Bangladesh from May 1 to June 30, 2020. This is a tertiary level hospital with ten ICU beds. Admission into the ICU occurred at the discretion of the attending critical care physician, but general criteria included all patients with confirmed COVID-19 infection who were requiring rapidly increasing oxygen therapy. All consecutive patients with laboratory confirmed COVID-19 infection who were admitted to the selected ICU during the study period were enrolled.

Data collection

Data were obtained from patient charts and the hospitals' admission records using a structured questionnaire which was adopted from Novel Coronavirus (COVID-19 Rapid Version) by Global COVID-19 Clinical Platform which was previously used in United Kingdom[14] and China[15]. Demographic data, information related to oxygen therapy like, source of oxygen, patient's required volume of oxygen, interface of supplied oxygen and impacts of oxygen therapy on clinical outcomes were collected throughout each patient's hospital admission records and registry.

Results

We report the condition of 63 severe COVID-19 patients admitted to intensive care unit between May and June 2020, who had either conventional oxygen therapy (COT) or high-flow nasal oxygen (HFNO). All patients had laboratory-confirmed SARS-CoV-2 infection, defined as a positive result of real-time reverse transcriptase-polymerase chain reaction (RT-PCT) from nasal and/or pharyngeal swabs. All patients presented rapid worsening of dyspnoea and oxygenation, defined as $SpO2 \leq 92\%$ despite increasing oxygen supply to more than ≥ 5 L/min. Target oxygen saturation should be more than 92% with oxygen therapy in critical patients which is approved by WHO (World Health Organization)[16]. About 12 (19.0%) patients could maintain more than 92% oxygen saturation with oxygen therapy. Treatment with 1-5 L oxygen/min through pipe (3, 4.76%), 6-10 L oxygen/min through pipe (5, 7.94%) and concentrator (3, 4.76%), 11-15 L oxygen/min through pipe (32, 50.79%) and through concentrator (4, 6.35%) were in close collaboration with intensive care associates and >15 L oxygen/min through pipe (16, 25.4%) was preferably done in intensive care units **(Table 01).** Oxygen supply was maintained through piped source (56, 88.89%), and oxygen concentrator (7, 11.11%) **(Table 01).** High-flow nasal cannula (HFNC) has been used to supply 11-15L oxygen per minute (6, 9.52%) and more than 15L Oxygen per minute (5, 7.94%) **(Table 02)** whereas long-term Continuous Positive Airway Pressure (CPAP) has been used to supply 6-10L Oxygen per minute (2, 3.17%), 11-15L Oxygen per minute (6, 9.52%) and more than 15L Oxygen per minute (5, 7.94%) were administrated for patients not responding to conventional oxygen therapy **(Table 02).**

Remaining patients were supplied through nasal prongs (5, 7.94%), mask (15, 23.81%), and mask with reservoir (19, 30.16%) **(Table 02, 03).** Non-invasive ventilation (NIV) was only recommended for selected patients (10, 15.87%), such as those with a ceiling of treatment or patients presenting with hyper-capnic failure **(Table 03).** Forty-Eight patients died (discharge mortality, 76.2%%) and fourteen patients were discharged alive from the ICU with a rate of 22.2%. One patient transferred (Palliative discharge, 1.6%) to other facilities for palliative care purpose. Relationship between variables related to Oxygen therapy and health related outcomes of patients were shown in **Table 03.**

Table 01: Relationship between volume of Oxygen and Source of supplied Oxygen

	Source of Oxygen		
Oxygen Flow Volume	Piped	Concentrator	Total
1-5L/min	3 (4.76)	0 (0.00)	3 (4.76)
6-10L/min	5 (7.94)	3 (4.76)	8 (12.70)
11-15L/min	32 (50.79)	4 (6.35)	36 (57.14)
>15L/min	16 (25.40)	0 (0.00)	16 (25.40)

Table 02: Relationship between volume of Oxygen and Interface of supplied oxygen

	Interface of supplied Oxygen					
Oxygen Flow Volume	Nasal Prongs	HF Nasal Cannula	Mask	Mask with reservoir	CPAP/NIV Mask	Total
1-5L/min	1 (1.58)	0 (0.00)	2 (3.17)	0 (0.00)	0 (0.00)	3 (4.76)
6-10L/min	1 (1.58)	0 (0.00)	3 (4.76)	2 (3.17)	2 (3.17)	8 (12.70)
11-15L/min	3 (4.76)	6 (9.52)	10 (15.87)	11 (17.46)	6 (9.52)	36 (57.14)
>15L/min	0 (0.00)	5 (7.94)	0 (0.00)	6 (9.52)	5 (7.94)	16 (25.40)

Table 03: Relationship between variables related to Oxygen therapy and Health related outcomes of patients

		Health related outcome of respondents			
		Discharge Alive	Death	Palliative Discharge	Total
Oxygen Flow Volume	1-5L/min	1 (1.58)	1 (1.58)	1 (1.58)	3 (4.76)
	6-10L/min	3 (4.76)	5 (10.4)	0 (0.00)	8 (12.70)
	11-15L/min	10 (15.87)	26 (41.27)	0 (0.00)	36 (57.14)
	>15L/min	0 (0.0)	16 (25.40)	0 (0.00)	16 (25.40)
Source of Oxygen	Piped	12 (19.04)	43 (68.25)	1 (1.58)	56 (88.89)
	Concentrator	2 (3.17)	5 (7.94)	0 (0.00)	7 (11.11)
Interface of supplied Oxygen	Nasal Prongs	1 (1.58)	4 (6.35)	0 (0.00)	5 (7.94)
	HF Nasal Cannula	1 (1.58)	10 (15.87)	0 (0.00)	11 (17.46)
	Mask	4 (6.35)	10 15.87)	1 (1.58)	15 (23.81)
	Mask with reservoir	5 (7.94)	14 (22.22)	0 (0.00)	19 (30.16)
	CPAP/NIV Mask	3 (4.76)	10 (15.87)	0 (0.00)	13 (20.63)
Non-invasive Ventilation	Yes	4 (6.35)	5 (7.94)	1 (1.58)	10 (15.87)
	No	9 (14.29)	42 (66.67)	0 (0.00)	51 (80.95)
	Unknown	1 (1.58)	1 (1.58)	0 (0.00)	2 (3.17)
Invasive Ventilation	Yes	0 (0.00)	15 (23.81)	0 (0.00)	15 (23.81)
	No	13 (20.63)	32 (50.79)	1 (1.58)	46 (73.02)
	Unknown	1 (1.58)	1 (1.58)	0 (0.00)	2 (3.17)

Discussions

A study showed that in China, among 2087 critically ill patients with COVID-19 about 49% were died during the course of their treatment in ICU.[17,18] Small, single-ICU studies found mortality rates of 62% (in Wuhan, China) and 67% (in Washington State, USA), but these figures had not accounted for many who were still in the ICU.[19,20] Although 97% of patients on invasive mechanical ventilation died in a multicentre study conducted early in the Wuhan outbreak.[21] HFNC and NIPPV are preferable to conventional oxygen therapy based on data from non-COVID-19 clinical trials and meta-analyses that showed reductions in the need for therapeutic escalation and the need for intubation in patients who received HFNC or NIPPV.[22,23]

HFNC is preferred over NIPPV in patients with acute hypoxemic respiratory failure based on data from an un-blinded clinical trial that was performed prior to the COVID-19 pandemic. This trial found more ventilator-free days with HFNC than with conventional oxygen therapy or NIPPV (24 days vs. 22 days vs. 19 days, respectively; P = 0.02) and lower 90-day mortality with HFNC than with both conventional oxygen therapy (hazard ratio [HR] 2.01; 95% confidence interval [CI], 1.01–3.99) and NIPPV (HR 2.50; 95% CI, 1.31–4.78).[24]

In the subgroup of more severely hypoxemic patients with PaO2/FiO2 ≤200, HFNC reduced the rate of intubation compared to conventional oxygen therapy or NIPPV (HRs 2.07 and 2.57, respectively). These findings were corroborated in a meta-analysis that showed a lower likelihood of intubation (odds ratio [OR] 0.48; 95% CI, 0.31–0.73) and ICU mortality (OR 0.36; 95% CI, 0.20–0.63) with HFNC than with NIPPV.[25] In situations where the options for respiratory support are limited, reducing the need for intubation may be particularly important[26].

A study in patients with acute respiratory distress syndrome (ARDS), randomized to intensive care and SpO2 88–92% versus SpO2 > 96%, indicated an increased mortality at the lower SpO2 target, and the study was terminated before enrolment was completed.[27] One retrospective cohort study[28] showed that the 41 of the 191 patients in the cohort used HFNC for oxygen treatment, and only 26 patients were treated with NIV[28].

Conclusions

Oxygen therapy is the most basic and critical treatment for these patients admitted in intensive care unit. High-flow nasal cannula may reduce the need for invasive ventilation and escalation of therapy compared with COT in COVID-19 patients with acute hypoxemic respiratory failure. This benefit must be balanced against the unknown risk of airborne transmission.

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Limitations

We did not approach patients to obtain additional history or biologic samples for laboratory measurement.

Declarations

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Conflict of Interest: No competing interests relevant to this study to disclose for all authors. Full forms submitted and on file for all authors.

Ethical Approval: All the procedures were conducted following the ethical guidelines of institution's ethical committee (Institutional Review Board) at Mugda Medical College Hospital, Bangladesh (Memo No/MUMC/2020/596). The ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards will be followed wherever applicable.

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