

Non-Invasive Ventilation with the Vortran GO₂VENT During Covid-19: Case Studies of Successes and Failures

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Objective

In 2020, the COVID-19 pandemic quickly overwhelmed hospital resources around the world. Hospitals including Hospital del IESS Quito Sur in Quito, Ecuador began using the VORTRAN GO₂VENT to supplement a limited supply of mechanical ventilators by providing patients with non-invasive ventilatory support using a full face mask in order to avoid the complications associated with intubation.

Methods

Data were collected for 350 COVID-19 patients who received ventilatory support from the GO₂VENT at Hospital del IESS Quito Sur. The patients were fitted with a non-vented bilevel/CPAP full face mask and connected to the GO₂VENT for a duration of 4 hours. The data collected included vitals, such as heart rate, blood pressure, and respiratory rate, as well as a blood gas analysis. The ROX Index, RASS score, and HACOR score were further used to document the patients' tolerance to the GO₂VENT.

Results

This case study focuses on 4 patients with varying experiences. Patient 1 saw an overall increase in ROX score and made a full recovery after 10 days of care. Patient 2 saw a moderate decrease in ROX score, indicating the need to transfer the patient to mechanical ventilation, which eventually led to death. Patient 3 saw very low ROX scores, which served as a predictor for the patient's severe condition, which eventually led to death. Patient 4 experienced lessening degrees of respiratory distress when on the GO₂VENT and was eventually transferred to a high flow oxygen mask.

Conclusion

The developed protocol proved useful in directing each patient to the proper treatment limb based on their ROX scores, HACOR scores, and ABG analyses. While the GO₂VENT performed its role sufficiently when used non-invasively, some patients with declining ROX scores required a higher level of support via

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intubation and mechanical ventilation. The protocol can be used as a predictor to determine which patients will benefit from the GO₂VENT, avoiding the complications associated with mechanical ventilation.

Background

Hospital del IESS Quito Sur, one of Ecuador's newest hospitals, opened in December 2017 as a 450 bed (increased to 700 beds during the pandemic) secondary and referral hospital. Starting on February 26, 2020, Dr. Hugo Espejo (the Deputy Director of Critical Care Medicine of the hospital) was faced with managing the quickly evolving COVID-19 outbreak. The Ecuadorian government had predicted an eight-fold increase in fatalities¹ and demand for critical care services. The numbers quickly exceeded these predictions and created a significant shortfall in available mechanical ventilators.

The Quito Sur medical team utilized conventional therapies to manage the rapid influx of COVID-19 patients, but the numbers of critically ill patients soon overwhelmed existing resources. The hospital had purchased GO₂VENT disposable ventilators (VORTRAN Medical²) and decided to put them into use providing non-invasive support using non-vented bilevel/CPAP full face masks to avoid patient deterioration to the point of needing mechanical ventilation. Faced with these challenges, Dr. Espejo developed the GO₂VENT COVID-19 Non-invasive Protocol to address their needs.

The protocol considers initial assessment at triage, oxygen saturations, oxygen requirements (utilized in ROX scoring³) and arterial blood gases to direct the patient into a treatment limb. Using the HACOR⁴ score and P/F ratio, the patient's placement in the protocol was further refined.

ROX Index

The ROX Index is calculated at triage and each hour (ROX Index score = $[\text{SpO}_2/\text{FiO}_2]/\text{breath rate}$). An increasing score reflects success, while a declining score reflects continued decline requiring more aggressive support. A score of ≤ 4 reflects the need for mechanical ventilation.

HACOR Score

The HACOR score is used once arterial blood gases are drawn. Higher scores are used to predict probable failure in the therapy currently being utilized. A total possible score of 25 points is available. At the 1-hour mark, the score is calculated. A HACOR score of >5 is indicative of probable failure which requires a

review of the current therapy to prevent deterioration that leads to mechanical ventilation.

Table 1. HACOR Score

Variables	Category	Points
Heart Rate (BPM)	≤120	0
	≥121	1
pH (ABG)	≥7.35	0
	7.30-7.34	2
	7.25-7.29	3
	<7.25	4
Glasgow Coma Scale (GCS)	15	0
	13-14	2
	11-12	5
	≤10	10
PaO ₂ /FiO ₂	≥201	0
	176-200	2
	151-175	3
	126-150	4
	101-125	5
	≤100	6
Respiratory Rate (BPM)	≤30	0
	31-35	1
	36-40	2
	41-45	3
	≥46	4

RASS Scale

The Richmond Agitation-Sedation Scale is a medical scale used to measure sedation effectiveness in patients.⁵ Pharmacologic agents are utilized to maintain a RASS score between 0 and 1 while the patient is on the GO₂VENT during non-invasive support, while lower scores are maintained before facilitating mechanical ventilation.

Table 2. RASS Scale

Patient Description	RASS Score
Combative	+4
Very agitated	+3
Agitated	+2
Restless	+1
Alert and calm	0
Drowsy	-1
Light sedation	-2
Moderate sedation	-3
Deep sedation	-4
Unarousable sedation	-5

Case Studies: A total of 350 patients' data were documented as part of the development of the protocol to support the effective use of the GO₂VENT in a non-invasive application. Four patients were chosen for this case study to highlight the successes and failures encountered during the development of the protocol.

During use of the GO₂VENT, the flowmeter is adjusted to supply the device with 30-40 LPM when the entrainment knob is set to 100% FiO₂ (which supplies the patient with the flow indicated on the flowmeter), and 15 LPM when the entrainment knob is set to 50% FiO₂ (which supplies the patient with a combined flow of approximately 40 LPM).

In all cases, the GO₂VENT was set to “assist mode.” This mode is intended for patients who are still exerting their own respiratory efforts and will provide them with breathing support. No timed breaths are delivered, as the breath rate depends on the patients' own breathing efforts. To set the GO₂VENT into assist mode, the rate knob is dialed clockwise until it does not automatically cycle but rather triggers when the patient exhales. If more resistance is required to slow down the patients' exhalation, the rate knob can be dialed clockwise even further as needed.

Patient 1

Patient Background: A 54-year-old male was presented to the hospital with COVID-19 symptoms.

Triage Conditions:

- Heart Rate: 120 BPM
- Blood Pressure: 171/85 mm-Hg
- Respiratory Rate: 28 BPM
- O₂ Saturation: 40%
- ROX Score: 6.8

Treatment was initiated immediately by placing the patient on the GO₂VENT with the rate control knob turned into assist mode (no timed breaths delivered, all are spontaneously triggered). The pressure knob was set to approximately 20 cm-H₂O and FiO₂ was set to the 50% setting. Pulse was observed to drop to 105 BPM, blood pressure to 127/82 mm-Hg, respiratory rate to 22 BPM, and an oxygen saturation of 95%. An arterial blood gas sample was immediately drawn resulting in:

- pH: 7.50
- PaCO₂: 29.6 mm-Hg
- PaO₂: 74 mm-Hg

Condition at 1 Hour: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 96 BPM
- Blood Pressure: 140/93 mm-Hg
- Respiratory Rate: 20 BPM
- O₂ Saturation: 98%
- pH: 7.47
- PaCO₂: 32.4 mm-Hg
- PaO₂: 137.5 mm-Hg
- ROX Score: 9.8

Condition at 2 Hours: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 102 BPM
- Blood Pressure: 122/78 mm-Hg
- Respiratory Rate: 25 BPM
- O₂ Saturation: 97%
- ROX Score: 7.8

Condition at 3 Hours: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 98 BPM
- Blood Pressure: 129/84 mm-Hg
- Respiratory Rate: 24 BPM
- O₂ Saturation: 96%
- pH: 7.48
- PaCO₂: 31.7 mm-Hg
- PaO₂: 91.1 mm-Hg
- ROX Score: 8.0

Condition at 4 Hours: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 98 BPM
- Blood Pressure: 126/77 mm-Hg
- Respiratory Rate: 22 BPM
- O₂ Saturation: 96%
- ROX Score: 8.7

The patient was admitted to a medical floor after being removed from the GO₂VENT and recovered before being discharged after 10 days.

Patient 2

Patient Background: A 54-year-old male was presented to the hospital with COVID-19 symptoms.

Triage Conditions:

- Heart Rate: 120 BPM
- Blood Pressure: 152/80 mm-Hg
- Respiratory Rate: 28 BPM
- O₂ Saturation: 76%
- ROX Score: 12.9

Treatment was initiated immediately by placing the patient on the GO₂VENT with the rate control knob turned into assist mode. The pressure knob was set to approximately 20 cm-H₂O and FiO₂ was set to 100%. Pulse was observed to drop to 109 BPM, blood pressure to 132/85 mm-Hg, and respiratory rate to 31 BPM, and an oxygen saturation of 94%. An arterial blood gas sample was immediately drawn resulting in:

- pH: 7.45
- PaCO₂: 27 mm-Hg
- PaO₂: 57 mm-Hg

Condition at 1 Hour: The GO₂VENT's FiO₂ was reduced to 50%.

- Heart Rate: 107 BPM
- Blood Pressure: 147/85 mm-Hg
- Respiratory Rate: 32 BPM
- O₂ Saturation: 94%
- pH: 7.36
- PaCO₂: 36 mm-Hg
- PaO₂: 96.5 mm-Hg
- ROX Score: 5.9

Condition at 2 Hours: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 109 BPM
- Blood Pressure: 154/77 mm-Hg
- Respiratory Rate: 34 BPM
- O₂ Saturation: 92%
- ROX Score: 5.4 (declining)

Condition at 3 Hours: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 98 BPM
- Blood Pressure: 142/80 mm-Hg
- Respiratory Rate: 34 BPM
- O₂ Saturation: 92%
- pH: 7.36
- PaCO₂: 36 mm-Hg
- PaO₂: 85.3 mm-Hg
- ROX Score: 5.4

Condition at 4 Hours: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 99 BPM
- Blood Pressure: 142/80 mm-Hg
- Respiratory Rate: 34 BPM
- O₂ Saturation: 94%
- ROX Score: 5.5

The patient was transferred to the ICU for closer monitoring and mechanical ventilation via intubation. 17 days after being transferred, the patient suffered respiratory failure and died.

Patient 3

Patient Background: A 64-year-old male was presented to the hospital with COVID-19 symptoms.

Triage Conditions:

- Heart Rate: 116 BPM
- Blood Pressure: 112/70 mm-Hg
- Respiratory Rate: 33 BPM
- O₂ Saturation: 40%
- ROX Score: 5.8

Treatment was initiated immediately by placing the patient on the GO₂VENT with the rate control knob turned into assist mode. The pressure knob was set to approximately 30 cm-H₂O and FiO₂ was set to the 100% setting. Pulse was observed to drop to 97 BPM, blood pressure to 101/67 mm-Hg, respiratory rate to 38 BPM, and oxygen saturation of 85%. An arterial blood gas sample was immediately drawn resulting in:

- pH: 7.37
- PaCO₂: 26.8 mm-Hg
- PaO₂: 72.5 mm-Hg

Condition at 1 Hour: The GO₂VENT's pressure knob was adjusted to approximately 20 cm-H₂O.

- Heart Rate: 89 BPM
- Blood Pressure: 115/79 mm-Hg
- Respiratory Rate: 36 BPM
- O₂ Saturation: 93%
- pH: 7.37
- PaCO₂: 24.3 mm-Hg
- PaO₂: 82.9 mm-Hg
- ROX Score: 2.6 (rapid decline)

Condition at 2 Hours: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 102 BPM
- Blood Pressure: 112/77 mm-Hg
- Respiratory Rate: 36 BPM
- O₂ Saturation: 91%
- ROX Score: 2.5

Condition at 3 Hours: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 92 BPM
- Blood Pressure: 127/69 mm-Hg
- Respiratory Rate: 30 BPM
- O₂ Saturation: 96%
- pH: 7.37
- PaCO₂: 29.8 mm-Hg
- PaO₂: 115.4 mm-Hg
- ROX Score: 3.2

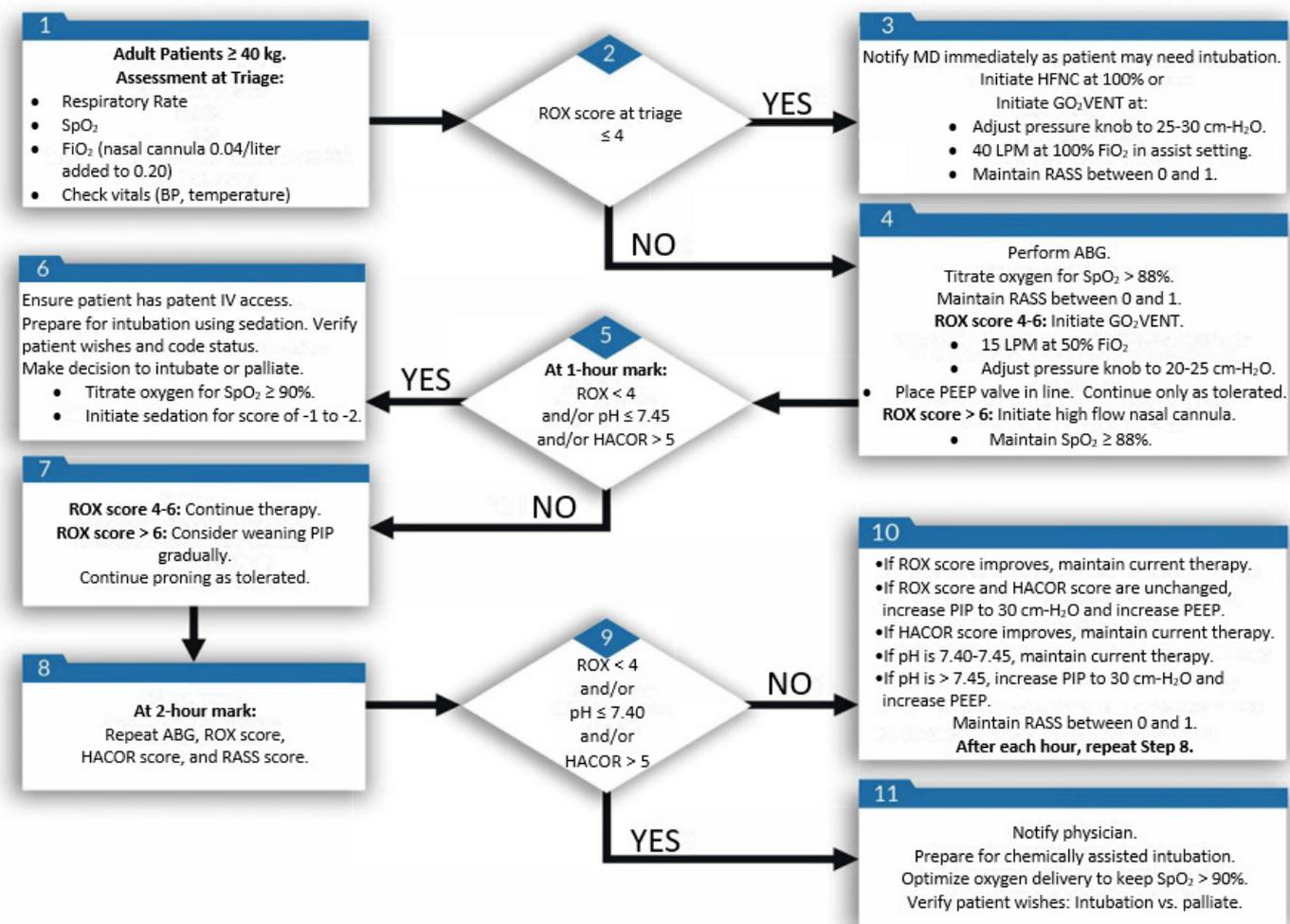


Figure 1. GO₂VENT COVID-19 Non-Invasive Protocol

Condition at 4 Hours: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 87 BPM
- Blood Pressure: 121/85 mm-Hg
- Respiratory Rate: 28 BPM
- O₂ Saturation: 95%
- ROX Score: 3.4

Discussions were held with the family surrounding goals of care to clarify that the patient was not a candidate for mechanical ventilation, but aggressive medical treatment would continue.

Despite medical recommendations, the patient was intubated. After 12 days of mechanical ventilation, the patient suffered a cardiopulmonary arrest. The patient did not respond to resuscitative efforts and died.

Patient 4

Patient Background: A 71-year-old male was presented to the hospital with COVID-19 symptoms.

Triage Conditions:

- Heart Rate: 104 BPM
- Blood Pressure: 110/63 mm-Hg
- Respiratory Rate: 20 BPM
- O₂ Saturation: 70%
- ROX Score: 16.7

Treatment was initiated immediately by placing the patient on the GO₂VENT with the rate control knob turned into assist mode. The pressure knob was set to approximately 30 cm-H₂O and FiO₂ was set to the 50% setting. Pulse was observed to drop to 86 BPM, respiratory rate to 30 BPM, and oxygen saturation of 88%. Blood pressure remained at 110/63. An arterial blood gas sample was immediately drawn resulting in:

- pH: 7.49
- PaCO₂: 28.2
- PaO₂: 52.4

Condition at 1 Hour: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 74 BPM
- Blood Pressure: 110/70 mm-Hg
- Respiratory Rate: 30 BPM
- O₂ Saturation: 93%
- pH: 7.42
- PaCO₂: 35.6 mm-Hg
- PaO₂: 121.4 mm-Hg
- ROX Score: 6.2

Condition at 2 Hours: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 73 BPM
- Blood Pressure: 119/77 mm-Hg
- Respiratory Rate: 30 BPM
- O₂ Saturation: 96%
- ROX Score: 6.4

Condition at 3 Hours: The patient remained on the GO₂VENT with the established settings.

- Heart Rate: 68 BPM
- Blood Pressure: 104/73 mm-Hg
- Respiratory Rate: 26 BPM
- O₂ Saturation: 97%
- pH: 7.34
- PaCO₂: 46 mm-Hg
- PaO₂: 127.6 mm-Hg
- ROX Score: 7.5

Condition at 4 Hours: The patient remained on the GO₂VENT, and the flow was reduced to 15 LPM.

- Heart Rate: 60 BPM
- Blood Pressure: 100/75
- Respiratory Rate: 26 BPM
- O₂ Saturation: 95%
- ROX Score: 7.3

The patient was transitioned to an oxygen mask at 50% FiO₂ and transferred to the in-patient medical ward.

Discussion

The use of the GO₂VENT to provide respiratory assistance in a non-invasive mode, coupled with the developed protocol (Figure 1), provides an effective COVID-19 response in a resource-challenged environment to effectively predict outcomes, sustain patients, and guide clinicians in making treatment decisions. The ROX score provided a demonstrably accurate prediction of the success or failure of the use of the GO₂VENT in its non-invasive mode and allowed clinicians to direct the treatment of the patient into the options of the conventional mechanical ventilation treatment arm, continuing to provide noninvasive support, or transfer the patient to comfort care.

Knowing the documented outcomes associated with mechanical ventilation of the COVID-19 patients encouraged clinicians to use the GO₂VENT in higher support settings (higher PIP and PEEP) to avoid intubations.

When using the protocol, the ROX score is recalculated, along with the HACOR score and arterial blood gas analysis, to direct the clinician to adjust the GO₂VENT or transfer the patient to a different mode of ventilation as needed. Declining ROX scores will eventually lead to a determination of mechanically ventilating the patient, while increasing ROX scores to greater than 6 leads to a justification for weaning the patient off the GO₂VENT.

The use of the COVID-19 non-invasive protocol allows for more judicious use of scarce resources while providing effective support of COVID-19 patients and avoiding the effects associated with intubation and mechanical ventilation.

References

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