Short Term Home Oxygen Therapy for COVID-19 patients: The COVID-HOT algorithm

Indrani Sardesai¹, Joydeep Grover², Manish Garg³, P.W.B. Nanayakkara⁴, Salvatore Di Somma⁵, Lorenzo Paladino⁶, Harry L. Anderson III⁷, David Gaireski⁸, Sagar C. Galwankar⁹, Stanislaw P. Stawicki¹⁰

¹Department of Emergency Medicine, Queen Elizabeth Hospital, Gateshead, ²Department of Emergency Medicine, Southmead Hospital, Bristol, England, United Kingdom, ³Section General and Acute Internal Medicine, Amsterdam Public Health Research Institute, Amsterdam UMC, Amsterdam, The Netherlands, ⁴Department of Medical-Surgery Sciences and Translational Medicine, University of Rome Sapienza, Rome, Italy, ⁵Weill Cornell Medicine, Columbia University Vagelos College of Physicians and Surgeons, ⁶SUNY Downstate and Kings County Medical Center, New York, ⁷Department of Surgery, St. Joseph Mercy Ann Arbor, Ann Arbor, Michigan, ⁸Department of Emergency Medicine, Sidney Kimmel Medical College at Thomas Jefferson University, Philadelphia, ⁹Department of Emergency Medicine, Sarasota Memorial Hospital, Florida State University, Sarasota, Florida, ¹⁰Department of Research and Innovation, St. Luke’s University Health Network, Bethlehem, Pennsylvania, USA

ABSTRACT

Innovative solutions are required to effectively address the unprecedented surge of demand on our healthcare systems created by the COVID-19 pandemic. Home treatment and monitoring of patients who are asymptomatic or mildly symptomatic can be readily implemented to ameliorate the health system burden while maintaining safety and effectiveness of care. Such endeavor requires careful triage and coordination, telemedicine and technology support, workforce and education, as well as robust infrastructure. In the understandable paucity of evidence-based, protocolized approaches toward HOT for COVID-19 patients, our group has created the current document based on the cumulative experience of members of the Joint ACAIM-WACEM COVID-19 Clinical Management Taskforce. Utilizing available evidence-based resources and extensive front-line experience, the authors have suggested a pragmatic pathway for providing safe and effective home oxygen therapy in the community setting.

Keywords: COVID-19, COVID-HOT, home monitoring, oxygen therapy, outpatient therapy, triage

Introduction

In many acutely affected hot spots of COVID-19 (COVID-19), the capacity of local and regional healthcare systems, and in particular the availability of emergency department (ED) and inpatient beds, may be insufficient during epidemic surge conditions.¹,² To adequately manage the high volume of patient encounters and hospital admissions in the setting of exaggerated imbalances within critical resource
availability, special considerations and unconventional measures must be entertained. Furthermore, given our increasing knowledge of the somewhat unpredictable COVID-19 clinical progression, it is prudent to institute an active observation regimen to detect early signs of deterioration that can occur in a non-trivial proportion of patients who may not initially require hospital admission. As the current COVID-19 inpatient strategy relies heavily on managing oxygenation, selected patients could be discharged home if oxygen administration could be addressed in a safe manner, under well-designed and appropriately implemented regimens. The need for diligent and close monitoring of COVID-19 patients who are discharged home arises due to the occurrence of clinically silent and unpredictable hypoxia, and thus an increased risk of potentially preventable mortality. Consequently and understandably, there is some degree of controversy surrounding this topic, mandating a properly structured and highly regimented approach.

Clinical Rationale

Given the rapidly evolving pandemic, there is an acute need for a standardized, evidence-based, algorithmic approach to home oxygen therapy (HOT) and monitoring for COVID-19 infection (COVID-HOT) to adequately address both patient care requirements and current healthcare resource limitations. The Joint ACAIM-WACEM COVID-19 Clinical Management

Figure 1: Determination of eligibility for short-term home oxygen therapy in COVID-19. Legend: LFNC = Low flow nasal cannula, CBG = Capillary blood gas, STOT = Short term oxygen therapy, \( \text{SpO}_2 \) = Peripheral capillary oxygen saturation, ABG = Arterial blood gas, COPD = Chronic obstructive pulmonary disease, OSA = obstructive sleep apnea)
Taskforce (CCMT) presents the comprehensive COVID-HOT protocol [Figures 1 and 2][17-21] along with important risk stratification definitions, such as the SCRB-60 score [Table 1],[22] as well as the Breathlessness Screening Tool [Table 2].[22-30] As with any other clinical assessment platform, the evaluation of each patient should always begin with, and be based on, a careful medical history and a detailed clinical examination. It is recognized herein that telepresence may not provide as robust of a clinical assessment as an in-person visit; however, we must acknowledge that the overall risk-benefit equation of in-person encounters in the midst of a pandemic is generally unfavourable.[8,9,23]

Building upon the foundation of a well-structured and reliable telemedicine service, the managing healthcare provider (HCP) should be familiar with essential remote patient assessment tools and their limitations [Tables 1 and 2].[22,30]

**Figure 2:** Tele-follow up of patients on home oxygen therapy in COVID-19.[18-21] Legend: RR = Respiratory Rate, OPD = Out-patient Department, ED = Emergency Department

**Point-of-Care Capabilities**

Successful implementation of the COVID-HOT protocol is heavily reliant on the availability and applicability of various

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**Table 1: Clinical Parameter Values requiring clinical risk stratification**

<table>
<thead>
<tr>
<th>Clinical Parameter</th>
<th>Values requiring clinical risk stratification</th>
<th>Equipment required</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>SpO2</td>
<td>&lt; 93%</td>
<td>Portable (battery operated) pulse oximeter</td>
<td>Incorrect use; Equipment malfunction</td>
</tr>
<tr>
<td>Heart rate</td>
<td>&lt; 45 beats/min or &gt; 120 beats/min</td>
<td>As above</td>
<td>As above + Rate-limiting medications explaining bradycardia; Anxiety exaggerating tachycardia</td>
</tr>
<tr>
<td>Temperature</td>
<td>&lt; 35°C or &gt; 38.5°C</td>
<td>Thermometer</td>
<td>Variance; Incorrect use; Equipment malfunction</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>&lt; 12 breaths/min or &gt; 20 breaths/min</td>
<td>Video feature</td>
<td>Connection issues; Difficult visualization</td>
</tr>
</tbody>
</table>

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from the perspective of the COVID-19 pandemic, such tools may include POC diagnostic testing; point-of-care ultrasonography (POCUS); as well as some form of telemetry capability consisting of pulse oximetry.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Mild Risk Features</th>
<th>Moderate Risk Features</th>
<th>Severe Risk Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptoms</td>
<td>As these can be significantly variable, consider an absence of moderate and severe symptoms.</td>
<td>Abdominal symptoms, syncope, falls, seizures, confusion.</td>
<td>Moderate symptoms + hypoxic agitation, coma, respiratory fatigue/failure, cardiac arrest.</td>
</tr>
<tr>
<td>Risk stratification score</td>
<td>SCRUB-60 score of 0-1</td>
<td>SCRUB-60 score of 2-3</td>
<td>SCRUB-60 score of 4-5</td>
</tr>
<tr>
<td>Labs</td>
<td>Normal or mild derangement (lymphopenia expected)</td>
<td>Elevated liver enzymes (greater than twice normal value), elevated CRP (&gt;50), AKI grade I-II.</td>
<td>Moderate labs + AKI grade III or more, elevated hs-troponin and/or d-dimer, respiratory and/or metabolic acidosis, Type 2 respiratory failure, elevated lactate</td>
</tr>
<tr>
<td>Imaging (X-ray, POCUS, CT-scan)</td>
<td>No changes/minimal changes</td>
<td>Evidence of small regions of pneumonia (early) or fibrosis (late), Patchy or multifocal B-lines on POCUS.</td>
<td>Multi-lobar pneumonia or pulmonary infarction. Confluent B-lines on POCUS.</td>
</tr>
<tr>
<td>Oxygen requirement at rest</td>
<td>No</td>
<td>Managed with titration through LFNC or facemask</td>
<td>Requirement for HFNC/reservoir bag mask/assisted ventilation/invasive ventilation/ECLS</td>
</tr>
<tr>
<td>Oxygen requirement on ambulation (for 1 minute or longer)</td>
<td>No or ≤2 L/min to maintain saturation ≥ 93%</td>
<td>As above to maintain saturation ≥ 93%</td>
<td>As above to maintain saturation above ≥ 93%</td>
</tr>
</tbody>
</table>

Presence of moderate to severe infection will require admission and treatment based on the above, thus though the presence of comorbidities may be significant to disease progression and prognosis, it will not change decision for admission. On the other hand, in the presence of mild disease as described above, due consideration should be given to the impact of comorbidities when deciding appropriate and safe disposition.

<table>
<thead>
<tr>
<th>S</th>
<th>SpO₂ &lt; 93%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Confusion</td>
</tr>
<tr>
<td>R</td>
<td>Respiratory Rate &gt; 30 breaths/min</td>
</tr>
<tr>
<td>B</td>
<td>Blood pressure: systolic &lt; 90 or diastolic &lt; 60 mmHg</td>
</tr>
<tr>
<td>60</td>
<td>Age ≥ 60 years</td>
</tr>
</tbody>
</table>

CRP = C reactive protein, AKI = Acute kidney injury, POCUS = Point of care ultrasound, LFNC = Low flow nasal cannula, HFNC = High flow nasal cannula, ECLS = Extracorporeal life support, hs troponin = high sensitivity troponin, SCRUB-60 = (modified risk stratification tool)²³
oximetry (SpO2) and potentially heart rate and blood pressure monitoring. Of utmost importance is the availability of family members or other reliable caretakers who are available to assist with most of the fundamental, non-emergency home care scenarios. Such individuals require education about staying safe and reducing their own risk of contracting the infection while providing support needed to care for their loved one, including the on-going management of comorbid health conditions and maintenance of some level of physical activity. Both the patients and their closest contacts need to be aware of the importance of recognizing ‘silent hypoxia’, which represents a difficult-to-detect disease acuity escalation, as well as the logistical considerations associated with supplemental oxygen therapy and respiratory maneuvers such as awake proning. As always, patient safety is of paramount importance, and thus detailed HOT safety education must be provided to all stakeholders. The ACAIM-WACEM CCMT emphasizes strongly that the COVID-HOT protocol should only be used with utmost caution, fully leveraging the collective clinical team experience and hardwired secondary confirmatory assessment by a senior provider before proceeding, and never in the setting of a single HCP acting in isolation. It is strongly recommended that one of the two certifying providers be trained in either Critical Care or Emergency Medicine. Consequently, the COVID-HOT protocol should never be employed in a single-provider setting or a setting where second-provider confirmation is not feasible. Moreover, the protocol should only be applied in situations where patients had already undergone a non-trivial period of observation (e.g., ≥6 hours), thus resulting in sufficient levels of HCP confidence regarding case-specific illness acuity “trajectory”. Finally, the COVID-HOT protocol should not be implemented in health-care systems without an understanding of, and experience in, managing ambulatory home oxygen treatments at the

### Risk Assessment and Determination of Safe Transition to COVID-HOT Status

Patient should undergo a thorough clinical risk assessment before the decision to implement the COVID-HOT protocol is made. Table 1 provides a highly granular framework for the determination of relative risk regarding the decision to admit to a hospital, observe temporarily, or discharge to home under the COVID-HOT algorithm. The decision tool is relatively complex and requires careful analysis of each component, with the likelihood of potentially serious consequences of mis-triage increased by rushing through the process. Non-COVID-19 diagnoses must be carefully considered, including seasonally appropriate testing for influenza and other viral and non-viral illnesses. Careful physical exam, COVID-19-specific biomarker testing and appropriate confirmatory viral testing constitute an essential part of this assessment.

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community level. This, in turn, involves appropriate expertise and understanding of supply chains, pertinent safety measures and system dynamics (beyond the scope of this article).\[43-47\] It is important to recognize that COVID-19 can produce a fairly heterogeneous array of signs and symptoms, and thus may mimic a variety of different diseases and/or syndromes (and vice-versa).\[48-50\] Furthermore, COVID-19 can co-exist with other acute illnesses.\[9,42\] Therefore, careful consideration is critical when discharging patients from ED, limited-duration observation, or inpatient environments to receive active, on-going treatment at home.

### Initiation of At-Home Services, Including Technological and Logistical Considerations

Providers must assume that patients and/or their families may not be familiar with modern tele-presence tools. Consequently, appropriate education should be provided to all stakeholders. It is recommended that “practice runs” are conducted, where experimentation with the platform is encouraged and the user has the opportunity to “break the system” in a simulated setting. Appropriate, easy-to-access technical support should be available

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**Figure 3: Home oxygen safety poster**

- Ensure your home has working smoke detectors that are checked regularly.
- Ensure your home has a working fire extinguisher and household members have training to use it.
- No one should smoke in your home.
- Stay at least 10 feet away from heat sources (candles, pilot lights, electrical appliances, fireplaces).
- Do not use flammable products like hairspray, other aerosol sprays, rubbing alcohol, paint thinner; or petroleum-based products such as lip-balm, lotions, oils etc while oxygen is in use.
- Ensure you get fire safety education, or attend a fire safety course, and have a fire safety plan.
- Place the oxygen cannister in a well-ventilated area free of smoke and away from direct sunlight; ensure that the air intake and exhaust ports are not obstructed.
It is important that patients and their caregivers be instructed on monitoring clinical parameters as outlined in this paper [Figure 2].

Long-Term Versus Short-Term Oxygen Therapy

Long-term oxygen therapy (LTOT) is an established safe and effective treatment for patients with chronic pulmonary conditions. Its primary aims include the improvement of quality of life and reduction in morbidity and mortality. In contrast, short-term oxygen therapy (STOT) is generally less well studied, and its applications are fairly heterogeneous. More specifically, the use of STOT in COVID-19 patients is based on the primarily hypoxic pathophysiology of SARS-CoV-2 pulmonary damage. The eligibility criteria for referral to the HOT team for STOT administration have been extrapolated from existing LTOT regimens, to create a novel treatment algorithm [Figure 1]. We therefore propose STOT as novel therapy in COVID-19, and while management objectives remain the same, there is an added benefit of providing safe care while reducing hospital burden in the context of an on-going pandemic.

Establishment of a Specialty Follow-Up Team

Due to the specific needs for follow-up of this cohort of patients, as well as the elevated risk of at-home adverse events, institutions are strongly advised to establish a dedicated HOT follow-up team. Such teams should be empowered to systematically implement the current recommendations, act as point of contact for patients, organize HCP and patient education, oversee referrals to other specialties or teams (e.g., smoking cessation services, rehabilitation teams, physiotherapy, occupational therapy, etc.), and serve to liaise with respective teams for any concerns to HOT logistics, including equipment issues or patient non-compliance. This follow-up team can further develop dedicated institutional referral documentation, necessary educational materials, and patient information contact points. Assigning clear roles and responsibilities within the follow-up team will reduce confusion and streamline communication for both HCPs and patients.

Oxygen Sources: Concentrators, Cylinders, Liquid Oxygen

A dedicated team should be responsible for deciding the mode of oxygen delivery and dosing. Concentrators are commonly...
used for LTOT delivery and can either be stationary at home, or portable with the patient.\textsuperscript{[68–70]} An oxygen concentrator is an electrically powered device which filters room air, removing nitrogen, to provide an oxygen-enriched gas mixture. Home concentrators require installation and regular maintenance by specialized vendors. In the context of the current pandemic, this is not ideal as it potentially increases infectious exposure risk to both household members and the company personnel. Transportable and portable concentrators are similar to home concentrators, but generally smaller in size and weight.\textsuperscript{[71–73]} Cylinder oxygen comes in a reinforced metal container with compressed gas under high pressure which is safely and steadily released via its regulator (tap). Liquid oxygen is oxygen that is cooled such that it condenses from gaseous to liquid form and can be stored in appropriately insulated containers; however, this approach requires training to reduce problems with gas leakage and burns.\textsuperscript{[74]} In the context of the COVID-HOT algorithm, we recommend the use of transportable or portable oxygen concentrators at flow rates of 4 L/min or less.\textsuperscript{[17]} At all times, users of any concentrated oxygen must keep in mind the so-called “fire triangle” and be mindful of the dangers of any potential co-presence of fuel (e.g., alcohol, textiles, bedding materials); heat (e.g., electrical equipment, space heaters); and oxygen in close proximity.\textsuperscript{[75]}

### Patients with Assisted Ventilation at Home

Special consideration should be made for oxygen use in patients who already use continuous positive airway pressure therapy (CPAP) for conditions such as obstructive sleep apnoea (OSA), obesity hypoventilation syndrome (OHS), chronic obstructive pulmonary disease (COPD) or overlap syndrome (a combination of the above pathologies). This is because patients who rely on baseline respiratory support may be at higher risk of developing hypoxemia and hypercapnia. There is paucity of clinical research supporting HOT in the treatment of OHS or overlap syndrome. Oxygen has been used as an add-on therapy to non-invasive ventilation (NIV).\textsuperscript{[17]}

### Venous Thromboembolism (VTE) Prophylaxis

A comprehensive discussion of VTE in COVID-19 is beyond the scope of this manuscript as it is a complex topic.\textsuperscript{[18]} We encourage that there is due consideration for VTE prophylaxis in this group of patients. Any implementations of VTE prophylaxis should be consistent with established local/institutional policies and should be evaluated in the context of risk-benefit equation associated with observed epidemiological patterns.

### Conclusion

Novel and future-oriented solutions are needed to effectively address the unprecedented pressure on the healthcare systems created by the COVID-19 pandemic. Home treatment and monitoring of patients who are asymptomatic or mildly symptomatic can be readily implemented to ameliorate the health system burden without sacrificing safety or effectiveness. As a result, carefully implemented HOT paradigm may help optimize the utilization of scarce resources in response to a surge in patients requiring urgent medical attention. Due to the paucity of evidence-based, protocolized approaches toward home oxygen therapy for COVID-19 patients, our group created the current document. Based on the cumulative experience of members of the Joint ACAIM-WACEM CCMT, combined with available evidence-based resources, the authors created a pathway for providing safe and effective HOT care in the community setting. Effective implementations of this approach require a combination of excellent clinical judgement on the part of the treating HCP, availability of POC tools, real-time remote patient monitoring, and ongoing education of HCPs, patients, and their caretakers.

### Cautionary Note

The ACAIM-WACEM CCMT emphasizes strongly that the COVID-HOT protocol should only be used with utmost caution, fully leveraging the collective clinical team experience and hardwired secondary confirmatory assessment by a senior provider before proceeding, and never in the setting of a single HCP acting in isolation. Consequently, the COVID-HOT protocol should never be employed in a single-provider setting or a setting where second-provider confirmation is not feasible. It is strongly recommended that one of the two determining providers be trained in Critical Care and/or Emergency Medicine. In all cases, each team decision should be thoroughly documented in the medical record, with all involved/responsible providers clearly identified and a justification provided for proceeding with the COVID-HOT care pathway. Such documentation should include the following mandatory components: (a) patient identification, clinical status, and diagnosis; (b) provider identification, specialty background (e.g., Critical Care), and appropriate seniority/training level (e.g., attending physician); (c) availability of required resources prior to discharge; (d) clear documentation of patient and caretaker information, including detailed instructions on when to seek further assistance/escalate care; (e) required oxygen safety training; and (f) appropriate treatment consent documentation, with clearly documented risk-benefit-alternative discussion. Finally, it is strongly recommended that regularly scheduled reviews of all COVID-HOT determinations are conducted at the institutional level, with focus on protocol compliance, clinical outcomes, any unexpected events, and patient safety.

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### Conflicts of interest

There are no conflicts of interest.

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