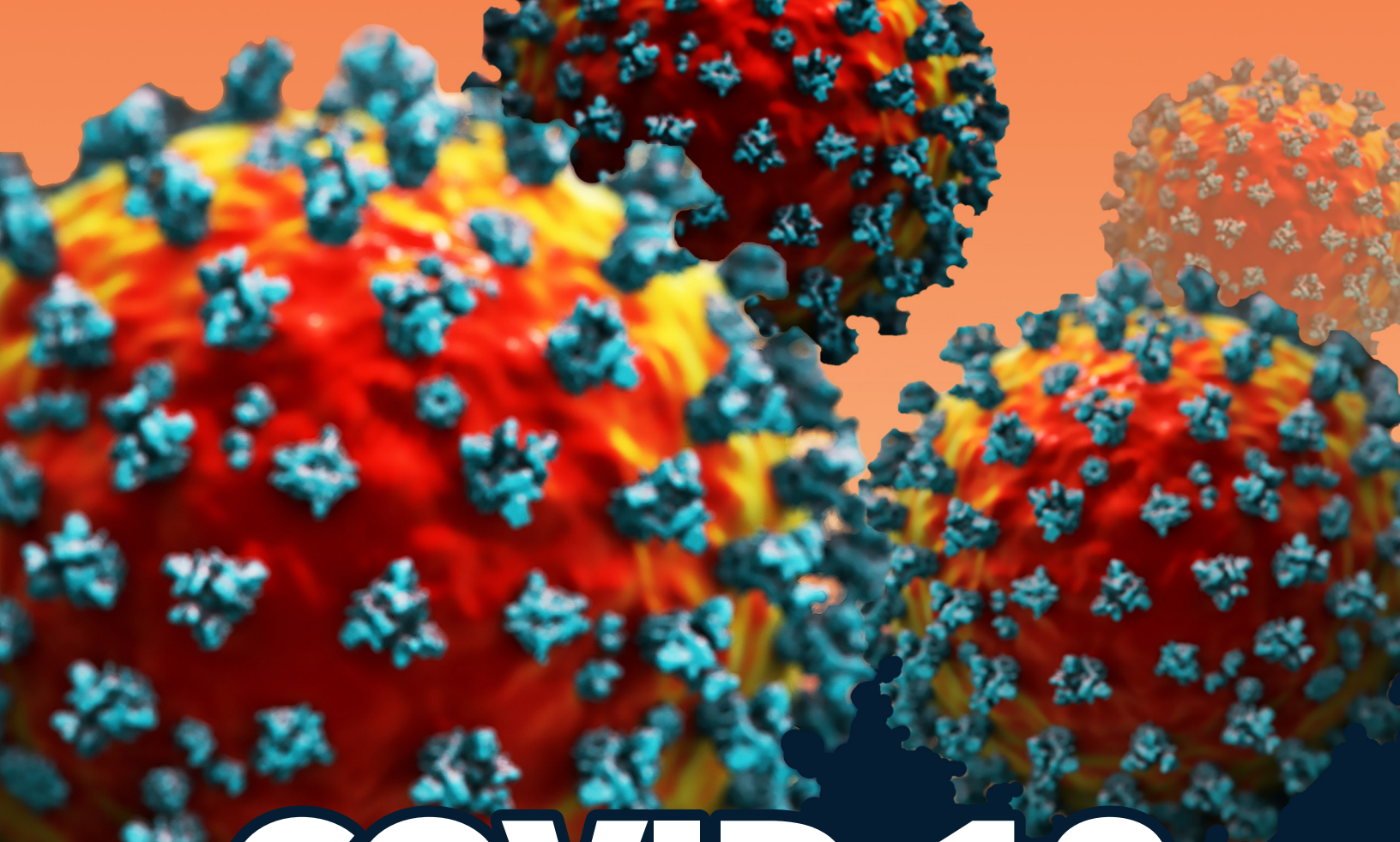

COVID-19 FRONTLINE:

Evolving Strategies in the Management and Prevention of **COVID-19**

Michael Niederman MD, MACP, FCCP, FCCM, FERS

This activity is provided by Med Learning Group.
This activity is co-provided by Ultimate Medical Academy/Complete Conference Management (CCM).

This activity is supported by educational grants from AbbVie, Astellas, Genentech, Merck & Co., Inc., and Pfizer.

Agenda

I. COVID-19: An Overview

a. Pathophysiology of the SARS-CoV-2 virus and COVID-19
b. Clinical presentation of COVID-19
c. Epidemiology of COVID-19
d. Risk factors for severe disease
e. Potential role of hyperinflammation in COVID-19

II. Treatment of COVID-19

a. Medical management of:
    i. Severe and critical COVID-19
    ii. Acute respiratory distress syndrome in COVID-19
    iii. Septic shock in critically ill patients
    iv. Extrapulmonary manifestations
b. Prevention of complications in critically ill patients
c. Persistent symptoms after COVID-19 infection

III. Emerging Therapies

a. Incorporating recommended treatment options into clinical care
b. Clinical trial data on the efficacy and safety of:
    i. Recommended treatment options
    ii. Emerging and off-label treatment options
    iii. Emerging vaccines

IV. Case Studies

COVID-19 Frontline TeleECHO Series: Evolving Strategies in the Management and Prevention of COVID-19

FACULTY

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PROGRAM OVERVIEW

The COVID-19 FRONTLINE TeleECHO series provides a comprehensive and up-to-date perspective on the ever-changing management of patients with COVID-19. Each TeleECHO session features in-depth case studies to encourage retention of the lessons and provide new perspectives on the management of patients during the COVID-19 pandemic. The case studies will focus on different issues facing clinicians, such as the management of severe and critically ill patients, the treatment of pulmonary and extrapulmonary manifestations, and the impact of comorbidities on treatment.

TARGET AUDIENCE

This activity is designed to meet the educational needs of a variety of specialties, including infectious disease specialists, pulmonary medicine specialists, emergency room practitioners, advanced practitioners, nurses, and other healthcare professionals to help support them in their effort to optimize care of patients with COVID-19.

LEARNING OBJECTIVES

Upon the completion of this program, attendees should be able to:

- Identify clinical predictors of disease severity and discuss the pathophysiology of COVID-19
- Evaluate clinical trial data on the efficacy and safety of emerging therapies and vaccines for the management of COVID-19
- Apply current treatment guidelines, clinical trial data, and patient-specific factors to the management of patients with COVID-19

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Purpose: This program would be beneficial for nurses involved in the treatment of patients with COVID-19.

Credits: 1.0 ANCC Contact Hour.

CNE Accreditation Statement: Ultimate Medical Academy/CCM is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center's Commission on Accreditation. Awarded 1.0 contact hour of continuing nursing education of RNs and APNs.

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CME Content Review

The content of this activity was independently peer reviewed.

The reviewer of this activity has nothing to disclose.

CNE Content Review

The content of this activity was peer reviewed by a nurse reviewer.

The reviewer of this activity has nothing to disclose.

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1. Read the CME/CNE information and faculty disclosures.
2. Participate in the web-based live activity.
3. Submit the evaluation form to Med Learning Group.

You will receive your certificate upon completion.

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COVID-19 Front Line: Evolving Strategies in the Management and Prevention of COVID-19

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1

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2

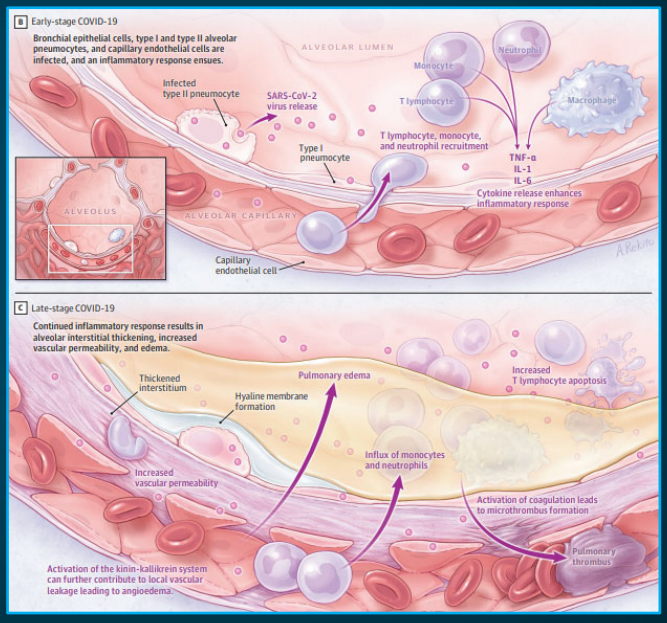
Learning Objectives

- Identify clinical predictors of disease severity and discuss the pathophysiology of COVID-19
- Evaluate clinical trial data on the efficacy and safety of emerging therapies and vaccines for managing COVID-19
- Apply current treatment guidelines, clinical trial data, and patient-specific factors to managing patients with COVID-19

3

Pathophysiology of COVID-19

- COVID-19 is caused by the SARS-CoV-2 virus
- The virus is spread primarily via respiratory droplets during face-to-face contact
- Average time from exposure to symptom onset is 5 days
- Symptoms develop within 11.5 days in 97.5% of patients with symptoms



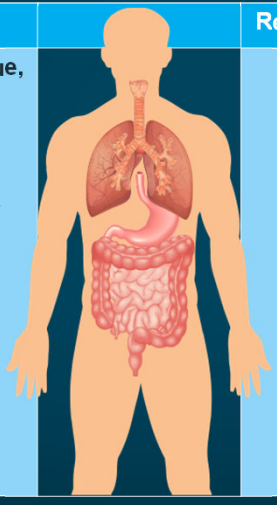
Joost Wiersinga W, et al. *JAMA*. 2020 July 10. Epub.

4

Clinical Presentation of COVID-19

Systemic and Respiratory Disorders Caused by COVID-19

Systemic Disorders	Respiratory Disorders
Fever, Cough, Fatigue, Sputum Production, Headache	Rhinorrhea, Sneezing, Sore Throat
Hemoptysis, Acute Cardiac Injury	Pneumonia
Hypoxemia	Ground-Glass Opacities
Dyspnea, Lymphopenia	RNAemia, Acute Respiratory Distress Syndrome
Diarrhea	



Most Common Symptoms of COVID-19 at Presentation

Symptom	% of Patients Presenting with Symptom (N = 1420)
Headache	70.3
Loss of smell	70.2
Nasal obstruction	67.8
Asthenia	63.3
Cough	63.2
Myalgia	62.5
Rhinorrhea	60.1
Taste dysfunction	54.2
Sore throat	52.9
Fever (>38°C)	45.4

Guan WJ, et al. *N Engl J Med*. 2020;382:1708-1720. Rothan HA, et al. *J Autoimmun*. 2020;109:102433. Lechien JR , et al. *J Intern Med*. 2020; Epub. Wang WW, et al. *J Med Virol*. 2020;92:441-447.

5

COVID-19 Disease Severity

- A large study of 44,672 confirmed COVID-19 cases identified by the Chinese Centers for Disease Control and Prevention found that:
  - 14% of cases were severe
  - 5% of cases were critical, with a case-fatality rate of 49%

	Disease Characteristics
Mild illness	Various symptoms (eg, fever, cough, sore throat, headache, malaise, muscle pain) without shortness of breath, dyspnea, or abnormal chest imaging
Moderate illness	SpO_2 ≥94% on room air and lower respiratory disease evidenced by clinical assessment or imaging
Severe illness	SpO_2 <94% on room air, PaO_2/FiO_2 <300, respiratory rate >30 breaths/min, or lung infiltrates >50%
Critical illness	Respiratory failure, septic shock, and/or multiorgan dysfunction

Wu Z, et al. *JAMA*. 2020;323:1239-1242. NIH. Management of Persons with COVID-19.

6

Risk Factors for Severe Disease

- Case series of 5700 hospitalized patients in NYC, Long Island, and Westchester County, NY found:
  - Median number of total comorbidities at admission: 4 (IQR: 2-8)
  - 87.6% of patients had more than one comorbidity
  - Most common comorbidities were hypertension (56.6%), obesity (41.7%), and diabetes (33.8%)

Case-fatality Rate in an Observational Study of COVID-19 Cases in China (n = 72,314)

Characteristics	Case-fatality Rate, %
All confirmed cases	2.3
• **Critical cases**	**49.0**
• ≥80 years of age	14.8
• Cardiovascular disease	10.5
• 70-79 years of age	8.0
• Diabetes	7.3
• Chronic respiratory disease	6.3
• Hypertension	6.0
• Cancer	5.6

Richardson S, et al. *JAMA*. 2020 May 26;323(20):2052–2059. Wu Z, et al. *JAMA*;2020:323:1239-1242.

7

Clinical Predictors of Disease Severity

- A study comparing severe and critically ill COVID-19 patients with those with mild or moderate disease found significant changes in several laboratory parameters
- Specific IgG to SARS-CoV-2 in severe and critically ill patients was significantly lower than in other COVID-19 patients (P <.05)

Commonly Altered Laboratory Parameters in Patients with Severe or Critical COVID-19	
↑ D-dimer	↓ lymphocyte count
↑ fibrinogen	↓ red blood cells
↑ white blood cell count	↓ hemoglobin
↑ neutrophil count	
↑ IL-6	
↑ c-reactive protein	
↑ procalcitonin	
↑ ESR	
↑ ferritin	
↑ lactate dehydrogenase	

ESR, erythrocyte sedimentation rate; IL, interleukin; IgG, immunoglobulin G
Yuan X, et al. *Int J Hematol*. 2020. Jul 12;1-7. Epub.

8

Management of COVID-19

9

Medical Management of Severe COVID-19

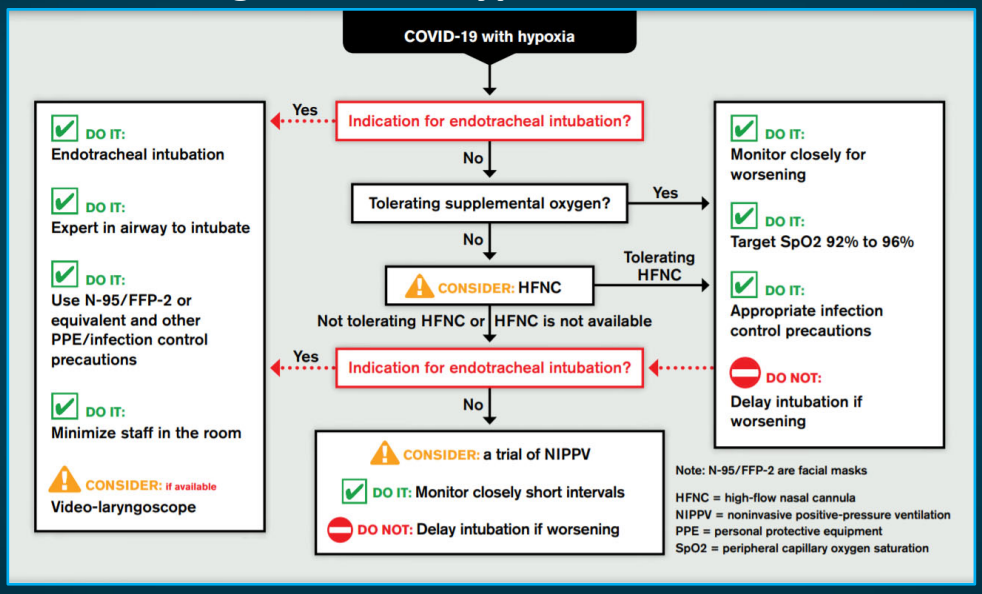
- Provide immediate supplemental O_2, targeting SpO_2 >94%, to patients with severe acute respiratory illness (SARI) and respiratory distress, hypoxemia, or shock
- Monitor for clinical deterioration (eg, rapidly progressive respiratory failure, sepsis) and provide immediate supportive care
- Review comorbidities, assess current chronic therapies, and monitor for drug-drug interactions
  - ACE inhibitors and ARBs may be continued as they do not affect mortality or risk of infection
- Practice conservative fluid management in patients with SARI if no shock
- Consider administration of remdesivir or dexamethasone
- Administer empiric antimicrobials within 1 hour of sepsis identification
- De-escalate empiric therapy based on microbiology results and clinical judgment

ACE, angiotensin converting enzyme; ARB, angiotensin receptor blocker

WHO. Clinical Management of COVID-19. Version 1.3. 9. Fosbol EL, et al. *JAMA*. 2020;324:168-177.
Bhimraj A, et al. *IDSA Guidelines*. V2.1.0.

10

Surviving Sepsis Campaign: Initial Management of Hypoxic COVID-19 Patients



Alhazzani W, et al. *Intensive Care Med*. 2020;46:854-887.

11

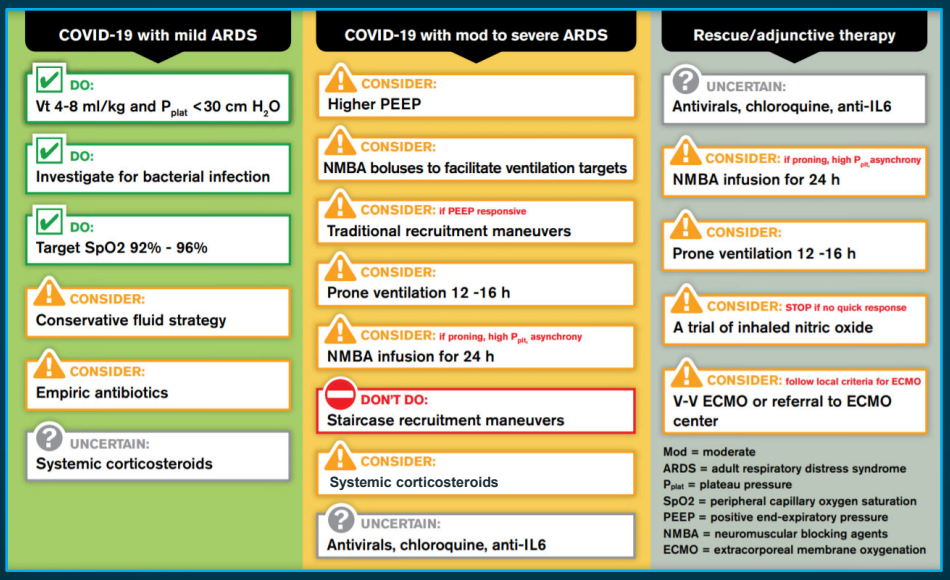
Medical Management of ARDS in Critically Ill COVID-19 Patients

All patients with ARDS	▪ Provide advanced oxygen/ventilatory support if patient in respiratory distress does not respond to standard oxygen therapy and develops severe hypoxemic respiratory failure ▪ Reserve performance of endotracheal intubation with airborne precautions for trained and experienced providers
Mechanically ventilated patients	▪ Use lower tidal volumes (4-8 mL/kg), inspiratory pressures (plateau pressure < 30 cmH_2O) ▪ Apply prone ventilation 12-16 hours/day in adults with severe ARDS ▪ Practice conservative fluid management if no tissue hypoperfusion ▪ In case of moderate to severe ARDS, higher vs lower PEEP suggested; avoid neuromuscular blockade by continuous infusion ▪ Avoid disconnecting ventilator; clamp endotracheal tube if transferring to transport ventilator ▪ Use inline catheters for airway suctioning ▪ Consider ECMO referral if refractory hypoxemia persists despite lung-protective ventilation
Patients receiving noninvasive or high-flow oxygen	▪ Reserve high-flow nasal cannula (HFNO) and noninvasive ventilation (NIV) for select patients with hypoxemic respiratory failure ▪ Monitor patients receiving HFNO or NIV for clinical deterioration

ARDS, acute respiratory distress syndrome; PBW, predicted body weight; PEEP, positive end-expiratory pressure; ECMO, extracorporeal membrane oxygenation
WHO. Clinical management of COVID-19. Version 1.3.

12

Surviving Sepsis Campaign: Recommendations on the Management of Patients with COVID-19 and ARDS



Alhazzani W, et al. *Intensive Care Med*. 2020;46:854-887.

13

Prevention of Complications in Critically Ill COVID-19 Patients

Days of invasive mechanical ventilation	• Assess daily for readiness to breathe spontaneously • Minimize sedation (continuous or intermittent) with specific titration targets in mind
Ventilator-associated pneumonia	• Use oral vs nasal intubation in adolescents/adults • Maintain semirecumbent patient positioning (ie, head of bed elevation 30-45°) • Use closed suctioning system; drain condensate periodically • Use new ventilator circuit per patient; exchange for same patient only if soiled/damaged • Replace heat moisture exchanger if malfunctioning or soiled, or every 5-7 days
Venous thromboembolism	• Administer low molecular-weight heparin (alternatively, heparin 5000 units SQ BID); if heparin contraindicated, use intermittent pneumatic compression devices
Catheter-related bloodstream infection	• Use checklist and real-time observer to confirm steps for sterile insertion, as daily reminder to remove catheter if unneeded
Pressure ulcers	• Turn patient every 2 hr
Stress ulcers and GI bleeds	• Administer enteral nutrition within 24-48 hr of admission, H2RAs or PPIs if risk for GI bleed
Side effects and DDIs	• Consider pharmacokinetic and pharmacodynamic effects of all medications

WHO. Clinical management of COVID-19. Version 1.3.

14

Medical Management of Septic Shock in Critically Ill COVID-19 Patients

Resuscitation Strategies
▪ **Adults**: Give 250-500 mL crystalloid fluid rapid bolus in first 15-30 min; give vasopressors if shock continues during/after fluid resuscitation
▪ **Children**: Give 10-20 mL/kg crystalloid fluid bolus in first 30-60 min; give vasopressors if signs of fluid overload or if shock persists/blood pressure targets not met after two fluid boluses
▪ Assess for fluid overload after each bolus; if present (or no response to fluid), reduce or discontinue fluid
▪ Avoid hypotonic crystalloids, starches, or gelatins
▪ Norepinephrine recommended as first-choice vasopressor
▪ Use central venous catheter for vasopressors; alternatively, peripheral IV in large vein (stop infusion for extravasation) or intraosseous needle
▪ Consider inotrope if poor perfusion/ cardiac dysfunction persist after reaching MAP target

WHO. Clinical management of COVID-19. Version 1.3. https://www.who.int/publications-detail/clinical-management-of-covid-19.
NIH COVID-19 Treatment Guidelines. Last updated June 11, 2020.

15

Extrapulmonary Manifestations

Renal dysfunction	• When renal replacement therapy is indicated, continuous renal replacement therapy (CRRT) is recommended, if available • If CRRT is unavailable or not possible, prolonged intermittent renal replacement therapy rather than intermittent hemodialysis is recommended
Hematological	• Anticoagulant thromboprophylaxis is recommended for critically ill patients with COVID-19 – LMWH is preferred – Use of LMWH or UFH is recommended over fondaparinux or direct oral anticoagulants (DOACs) • In acutely ill hospitalized patients with COVID-19, prophylaxis with LMWH or fondaparinux is recommended over UFH; prophylaxis with LMWH, fondaparinux or UFH is recommended over DOACs • COVID-19 diagnosis should not influence the recommendation for VTE prophylaxis in hospitalized children • Anticoagulant or antiplatelet therapy should not be used to prevent arterial thrombosis outside of the usual standard of care

LMWH, low molecular-weight heparin; UFH, unfractionated heparin; VTE, venous thromboembolism
NIH COVID-19 Treatment Guidelines. Last updated June 11, 2020. Moores LK, et al. *Chest*. 2020 June 2.

16

Clinical Trial Data on Emerging Treatment Options

17

IDSA: Recommended Treatment Options

Treatment Option	Guidance
Remdesivir	• Recommended for hospitalized patients with severe COVID-19 • Most benefit seen in those with severe COVID-19 on supplemental oxygen rather than patients on mechanical ventilation or ECMO • 5 days of treatment recommended for patients on supplemental oxygen • 10 days of treatment recommended for patients on mechanical ventilation or ECMO
Glucocorticoids	• Recommended for hospitalized patients with severe COVID-19 • Dexamethasone 6 mg IV or PO for 10 days or equivalent • Not recommended for hospitalized patients without hypoxemia requiring supplemental oxygen

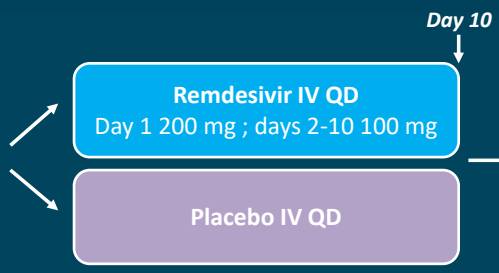
Bhimraj A, et al. IDSA Guidelines. V2.1.0.

18

Adaptive COVID-19 Treatment Trial (NIAID ACTT-1): Trial Design

- Multicenter, adaptive, randomized, double-blind, placebo-controlled phase 3 trial

Inclusion criteria (N = 1063):
- Adult patients ≥ 18 yrs of age
- Hospitalized with symptoms of COVID-19/SARS-CoV-2 infection and ≥ 1 of following:
  - Radiographic infiltrates by imaging
  - SpO_2 ≤ 94% on room air
  - Requiring supplemental oxygen
  - Requiring mechanical ventilation



Daily assessment for time to clinical improvement while hospitalized to day 29; assessments at days 15, 22, and 29 if discharged

- Primary endpoint: time to recovery by day 29 according to 8-point ordinal scale
- Secondary endpoints: treatment-related improvements in ordinal scale at day 15

Beigel JH, et al. *N Engl J Med*. 2020 May 22; Epub. NCT04280705.

19

COVID-19 Clinical Status Ordinal Scale

Clinical Status Ordinal Scale	Clinical Status Description for Assessment
1	Not hospitalized, no limitations on activities
2	Not hospitalized, limitation on activities, and/or requiring home oxygen
3	Hospitalized, not requiring supplemental oxygen and no longer requires ongoing medical care (if hospitalization extended for infection-control purposes)
4	Hospitalized, not requiring supplemental oxygen; requiring ongoing medical care (COVID-19 related or otherwise)
5	Hospitalized, requiring supplemental oxygen
6	Hospitalized, on noninvasive ventilation or high-flow oxygen devices
7	Hospitalized, on invasive mechanical ventilation or ECMO
8	Death

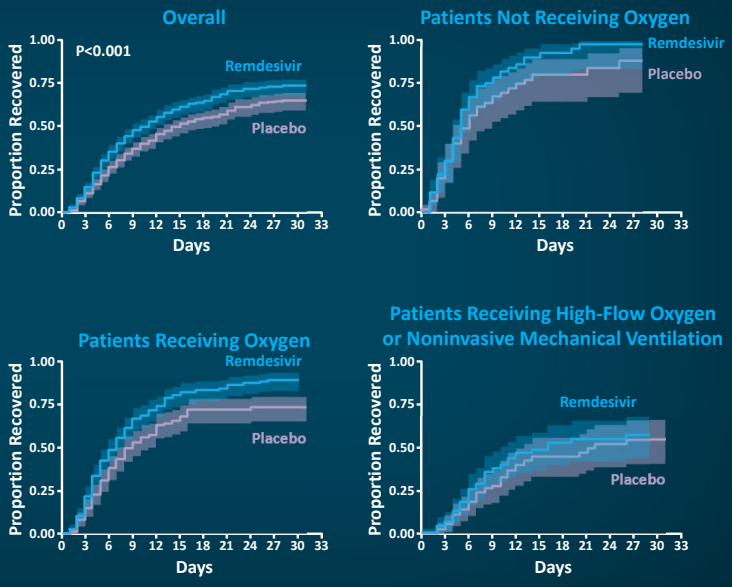
Beigel JH, et al. *N Engl J Med*. 2020. Epub.

20

NIAID ACTT-1 Results

- Faster median recovery with remdesivir (11 days vs 15 days; *P* <.001)
- Kaplan-Meier estimates of mortality by 14 days:
  - 7.1% with remdesivir
  - 11.9% with placebo

    (HR, 0.70; 95% CI, 0.47-1.04)



Beigel JH, et al. *N Engl J Med*. 2020

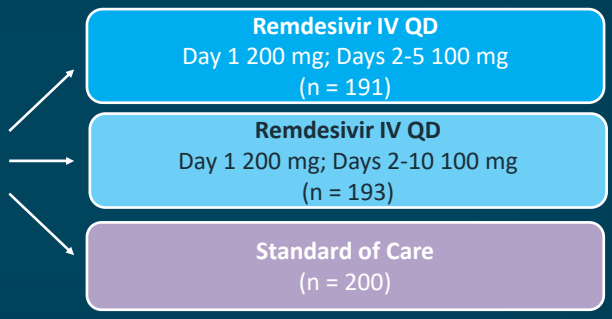
21

SIMPLE-Moderate Study: Trial Design

- Multicenter, randomized, open-label phase III trial of remdesivir in patients with moderate COVID-19

Inclusion criteria (N = 584)

- Patients ≥ 12 yrs of age
- Hospitalized with SARS-CoV-2 infection confirmed by RT-PCR
- Radiographic infiltrates by imaging
- SpO_2 > 94% on room air



- Primary endpoint: improvement on 7-point ordinal scale on Day 11
- Secondary endpoint: treatment-emergent adverse events

RT-PCR, reverse transcriptase-polymerase chain reaction
NCT04292730.

22

SIMPLE-Moderate Study: Efficacy

- Patients receiving 5-day remdesivir were 65% more likely to have clinical improvement at Day 11 vs standard of care (OR: 1.65; 95% CI: 1.09-2.48; *P* = .017)
  - No significant improvement noted with 10-day remdesivir vs standard of care: (OR: 1.31; 95% CI: 0.88-1.95; *P* = .18)

Clinical Efficacy at Day 11	Remdesivir 5-Day, n (%) (n = 191)	Remdesivir 10-Day, n (%) (n = 193)	Standard of care, n (%) (n = 200)
≥ 2-point improvement on ordinal scale	134 (70)	126 (65)	121 (61)
≥ 1-point improvement on ordinal scale	146 (76)	135 (70)	132 (66)
Requiring any oxygen support	12 (6)	13 (7)	22 (11)
≥ 1-point worsening in ordinal scale	6 (3)	12 (6)	22 (11)
Death	0	2 (1)	4 (2)

Gilead. Press release. June 01, 2020. https://www.gilead.com/news-and-press/press-room/press-releases/2020/6/gilead-announces-results-from-phase-3-trial-of-remdesivir-in-patients-with-moderate-covid-19

23

Remdesivir Safety Information and Warnings

- Most common AEs are nausea, diarrhea, and headache
- Recommended daily monitoring: serum chemistries, hematology, ALT, AST, renal function tests, bilirubin, ALP
- Infusion-related reactions have occurred in patients receiving remdesivir; immediately discontinue if signs of clinically significant infusion reaction occur
- Transaminase elevations have occurred in healthy controls and patients with COVID-19 receiving remdesivir
  - Do not administer if ALT ≥ 5 x ULN at baseline
  - Discontinue if ALT ≥ 5 x ULN; resume treatment when ALT elevation resolves

Adverse Events	Remdesivir 5 Days (%) (n = 200)	Remdesivir 10 Days (%) (n = 197)
Any	71	74
Serious	21	35
Grade ≥ 3	31	43
Discontinued due to AE	5	10
All-cause mortality at day 28	10	13

AE, adverse event; ALT, alanine aminotransferase; AST, aspartate aminotransferase; ALP, alkaline phosphatase; ULN, upper limit normal
Remdesivir EUA Provider Fact Sheet.

24

RECOVERY Trial Design

- Eligible patients (hospitalized with clinically suspected or laboratory-confirmed SARS-CoV-2 infection) were randomized to:

No additional treatment | **Dexamethasone** | **Hydroxychloroquine**

Lopinavir/ritonavir | **Azithromycin**

- Factorial design with simultaneous randomization to no additional therapy or **convalescent plasma**
- Patients with progressive disease (hypoxia and an inflammatory state) may undergo second randomization to no additional treatment or **tocilizumab**
- Primary endpoint: 28-day mortality

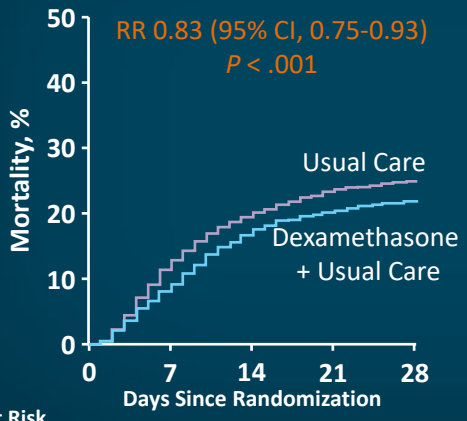
https://www.recoverytrial.net/files/recovery-protocol-v7-0-2020-06-18.pdf

25

RECOVERY Trial: Mortality With Dexamethasone + Usual Care vs Usual Care Alone

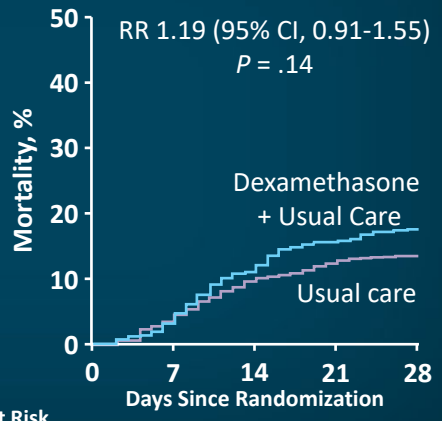
2104 patients randomized to dexamethasone 6 mg QD for up to 10 days; 4321 patients received usual care alone

All Participants (n = 6425)



No. at Risk					
Usual Care	4321	3754	3427	3271	3205
Dexamethasone	2104	1903	1725	1659	1621

No Oxygen (n = 1535)

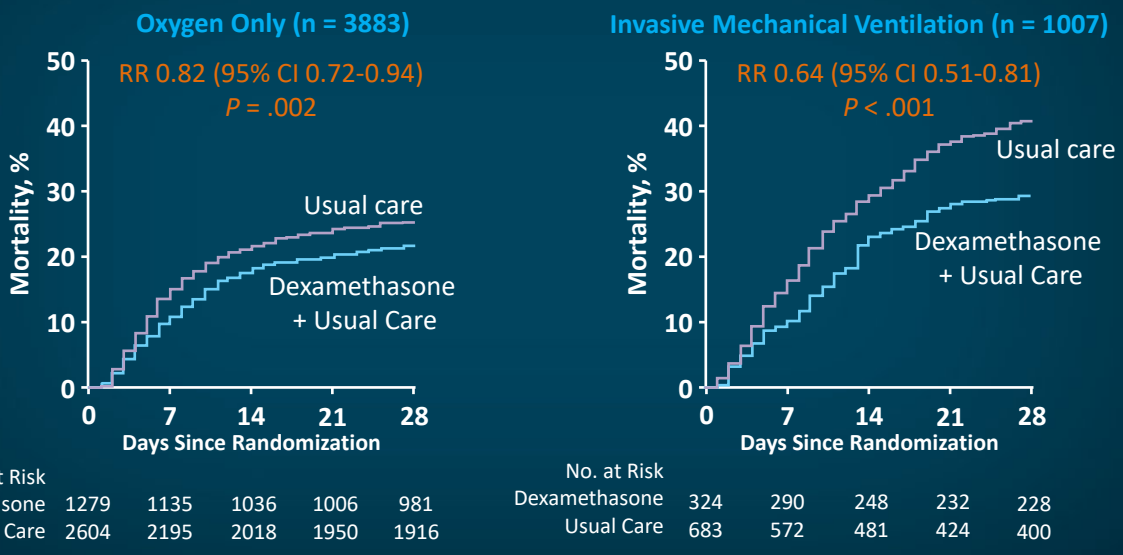


No. at Risk					
Usual Care	501	463	420	394	383
Dexamethasone	1034	969	890	856	832

RECOVERY Collaborative Group. *N Engl J Med.* 2020;Epub ahead of print.

26

RECOVERY Trial: Mortality in Patients On Oxygen or Mechanical Ventilation ± Dexamethasone



RECOVERY Collaborative Group. *N Engl J Med.* 2020;Epub ahead of print.

27

RECOVERY Trial: Secondary Outcomes

Outcome	Dexamethasone + Usual Care	Usual Care Only	RR (95% CI)
Discharged from hospital within 28 days	67.2%	63.5%	1.10 (1.03-1.17)
Receipt of invasive mechanical ventilation or death	25.6%	27.3%	0.92 (0.84-1.01)
▪ Invasive mechanical ventilation	5.7%	7.8%	0.77 (0.62-0.95)
▪ Death	21.7%	22.7%	0.93 (0.84-1.03)

RECOVERY Collaborative Group. *N Engl J Med.* 2020;Epub ahead of print.

28

Hydroxychloroquine

- Randomized RECOVERY trial:
  - 1542 patients randomized to hydroxychloroquine and 3132 patients to usual care alone
  - No significant difference in the primary endpoint of 28-day mortality (25.7% hydroxychloroquine vs 23.5% usual care; HR, 1.11; *P* =.10)
  - No beneficial effect on hospital stay duration or other outcomes

- Observational study:
  - No benefit with hydroxychloroquine in 1376 hospitalized patients
  - 45.8% received hydroxychloroquine within 24 hours of presentation, and 85.9% within 48 hours

Associations between Hydroxychloroquine Use and the Composite End Point of Intubation or Death

Analysis	Intubation or Death
No. of events/no. of patients at risk (%)	
Hydroxychloroquine	262/811 (32.3)
No hydroxychloroquine	84/565 (14.9)
Crude analysis — hazard ratio (95% CI)	2.37 (1.84-3.02)
Multivariable analysis — hazard ratio (95% CI)	1.00 (0.76-1.32)
Propensity-score analyses — hazard ratio (95% CI)	
With inverse probability weighting	1.04 (0.82-1.32)
With matching	0.98 (0.73-1.31)
Adjusted for propensity score	0.97 (0.74-1.28)

Geleris J, et al. *N Engl J Med*. 2020. Statement from the Chief Investigators of the Randomised Evaluation of COVid-19 thERapY (RECOVERY) Trial on hydroxychloroquine, 5 June 2020.

29

IDSA: Treatment Options for Clinical Trials Only

- Treatment options that should only be used in clinical trials
  - Hydroxychloroquine/chloroquine
  - Hydroxychloroquine/chloroquine plus azithromycin
  - Lopinavir/ritonavir
  - Tocilizumab
  - Convalescent plasma
  - Famotidine for the sole purpose of treating COVID-19

Bhimraj A, et al. IDSA Guidelines. V2.1.0. https://www.idsociety.org/COVID19guidelines

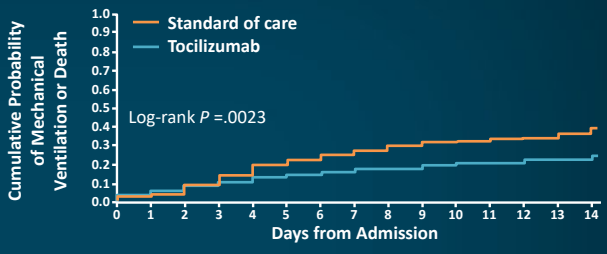
30

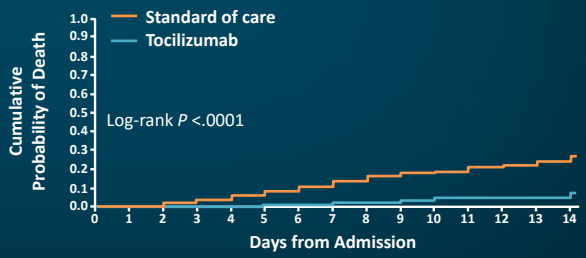
COVID-19 Animation

31

Tocilizumab

- Retrospective, observational cohort study of 544 patients with severe COVID-19 pneumonia
- 20% of patients in the standard care group died, compared to 7% in the tocilizumab group (*P* <.0001)
- Tocilizumab treatment was associated with a reduced risk of invasive mechanical ventilation or death (aHR, 0.61; 95% CI, 0.40-0.92; *P* =.02)



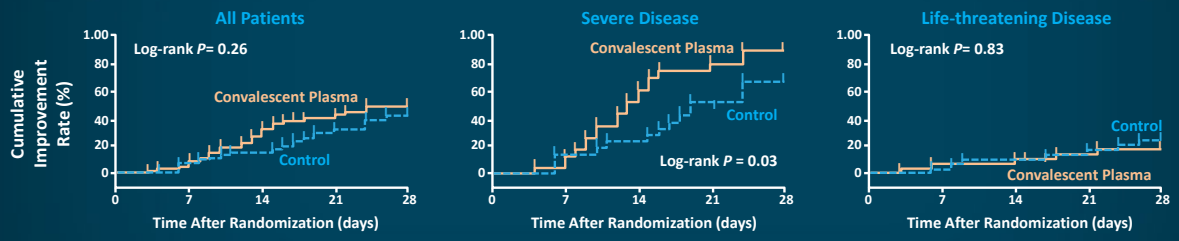


Guaraldi G, et al. *Lancet Rheumatol*. 2020. Epub.

32

Convalescent Plasma

- Open-label, randomized trial of 103 patients with severe (respiratory distress and/or hypoxemia) or life-threatening (shock, organ failure, or mechanical ventilation) disease



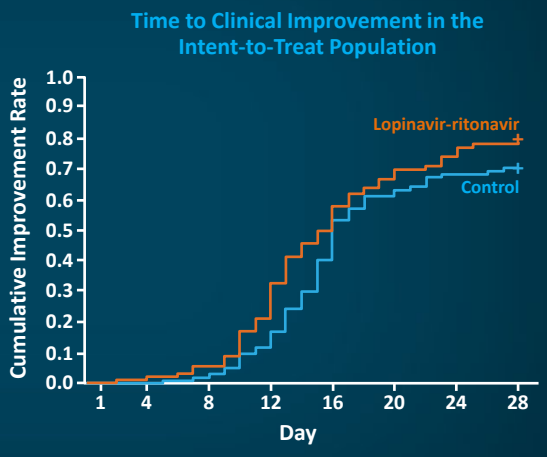
- Clinical improvement occurred within 28 days in 51.9% of the convalescent plasma group vs 43.1% in the control group (HR, 1.40; 95%, 0.79-2.49; *P* =.26)
- No significant difference in 28-day mortality or time from randomization to discharge between groups

Li L, et al. *JAMA*. 2020;doi:10.1001/jama.2020.10044.

33

Lopinavir/Ritonavir

- 199 hospitalized COVID-19 patients with O_2 sat ≤94% on room air or PaO_2/FiO_2 <300 mmHg
- Primary endpoint: time to clinical improvement
  - No differences in time to clinical improvement between treatment groups
- 28-day mortality was numerically lower in the lopinavir/ritonavir group (19.2% vs 25.0%)
- Patients in the lopinavir/ritonavir group had a shorter stay in the ICU (6 days vs 11 days)



Cao B, et al. *N Engl J Med*. 2020;382:1787-1799.

34

Other Randomized Clinical Trials for COVID-19

Agent	N	Population	Comparator	Primary Outcome
Lopinavir/ritonavir/ interferon β-1b/ ribavirin	127	Adults, mild to moderate	Lopinavir/ritonavir	▪ Patients in the combination group showed faster viral clearance and more rapid clinical improvement
Sofosbuvir/ daclatasvir	66	Adults, severe	Lopinavir/ritonavir	▪ 88% achieved clinical recovery ≤14 days vs 67% with control (*P*= .076)
Hydroxychloroquine	150	Adults, mild to moderate	Standard of care alone	▪ No difference in negative conversion of SARS-CoV-2 by day 28
Tocilizumab	129	Moderate or severe pneumonia	Standard care alone	▪ Improvement in composite endpoint of death or need for ventilation at day 14 with tocilizumab vs standard care
Sarilumab (200 or 400 mg)	457	Severe or critical	Placebo	▪ CRP decline: 77% and 79% vs 21% ▪ Recommended continuing phase III only in critical subgroup with 400 mg sarilumab vs placebo

SOC, standard of care

Hung IFN, et al. *Lancet*. 2020;395:1695-1704. Li L, et al. Med. 2020; Epub. Wang Y. *Lancet*. 2020;395:1569-1578. Goldman. *N Engl J Med*. 2020 May 27; Epub. Chen C, et al. MedRxiv. 2020 April 15. Tang W, et al. MedRxiv. 2020 May 7. Assistance Publique - Hôpitaux de Paris/Universities/INSERM-REACTing COVID-19 academic research collaboration. Press Release. 2020 April 27. NCT04331808. NCT04315298. Regeneron. Press Release. 2020 April 27. Sadeghi. IAS COVID-19. Abstr 11125.

35

Vaccine Candidates

Vaccine Candidate	Vaccine Type	Key Data from Clinical Trials
BNT162	4 candidate vaccines: BNT162b1 and BNT162b2 are lipid nanoparticle-encapsulated mRNA vaccines encoding the spike RBD and full-length spike, respectively	Phase 1/2 study found neutralizing antibodies in the blood that were 1.8-2.8x greater than convalescent sera
AZD1222/ ChAdOx1	Simian adenovirus vector containing DNA coding for the spike glycoprotein	Neutralizing antibodies were detected in 91-100% of participants after a single dose (depending on assay used), and in 100% after a booster dose
Ad5	Non-replicating adenovirus type-5 vector containing spike DNA	Phase 1 study showed humoral responses peaked at day 28 post-vaccination and rapid specific T-cell responses were noted from day 14 post-vaccination
mRNA-1273	Lipid nanoparticle-encapsulated mRNA encoding the spike glycoprotein	Phase 1 study found that all patients seroconverted with binding antibody levels at or greater than levels in convalescent sera after 2 doses in both dose cohorts

RBD = receptor binding domain

Folegatti PM, et al. *Lancet*. 2020;Epub. Jackson LA, et al. *N Engl J Med*. 2020;Epub. Zhu FC, et al. *Lancet*. 2020;395:1845-1854. Graham SP, et al. *BioRxiv*. 2020 June 20. Mulligan MJ, et al. *MedRxiv*. 2020 July 1. Moderna. Press Release. 2020 April 27.

36

Monoclonal Antibodies

Candidate	Patient Population	Top-line Results
REGN-COV2	• Non-hospitalized patients with COVID-19 • 45% were seropositive (measurable antiviral antibodies) • 41% were seronegative (no measurable antiviral antibodies)	• REGN-COV2 reduced viral load through day 7 in seronegative COVID-19 patients • Among seronegative patients, median time to symptom alleviation was 13 days with placebo, 8 days with the high dose, and 6 days in the low dose • Medical visits for COVID-19 were needed for 15.2% of placebo-treated patients, 7.7% of high-dose patients, and 4.9% of low-dose patients
LY-CoV555	• Mild-to-moderate COVID-19 patients in outpatient setting • Recently diagnosed: positive test ≤3 days prior to infusion	• LY-CoV555 reduced hospitalization or ER visits compared to placebo (1.7% vs 6%)

REGN-COV2 press release (https://investor.regeneron.com/news-releases/news-release-details/regenerons-regn-cov2-antibody-cocktail-reduced-viral-levels-and). LY-CoV555 press release (https://investor.lilly.com/news-releases/news-release-details/lilly-announces-proof-concept-data-neutralizing-antibody-ly). URLs accesses 10/19/2020.

37

Persistent Symptoms After COVID-19 Infection

- Recovered COVID-19 patients discharged from acute care may need continued monitoring for long-lasting effects

- In a study of 143 previously hospitalized patients in Rome, Italy:
  - 87.4% had at least one persistent symptom 2 months or longer after initial onset and at more than a month after discharge
  - 32% of patients had 1 or 2 symptoms and 55% had 3 or more
  - None had fever or signs and symptoms of acute illness
  - Most commonly reported persistent symptoms included fatigue (53%), dyspnea (43%), joint pain (27%), and chest pain (21%)

Carfi A, et al. *JAMA*. 2020;Epub.

38

Case Study

Severe COVID-19 in the ICU

39

Severe COVID-19 in the ICU

- **CC:** A 62-year old female presents with a 10 day history of fever, cough, diarrhea and shortness of breath
  - Found to be positive for SARS-CoV-2 on nasal PCR testing and admitted
- **Past medical history:** type 2 diabetes and hypertension
- **Family history:** diabetes
- **Medications:** Lisinopril, metformin, calcium, omeprazole

40

41

Severe COVID-19 in the ICU

Examination

- Vitals on admission:
  - T = 37°C, BP = 104/74, HR=110 and regular, RR=29/min
  - Oxygen saturation of 91% on room air
- Exam showed a patient in mild respiratory distress, diminished basal breath sounds with no rhonchi or wheezes. She had tachycardia and soft abdomen with no skin rashes or edema.
- She had progressive hypoxemia, with oxygen saturation of 82% on room air and 93% on a nonrebreather mask, and then high flow nasal cannula
- She was then intubated due to progressive respiratory failure

41

42

Severe COVID-19 in the ICU

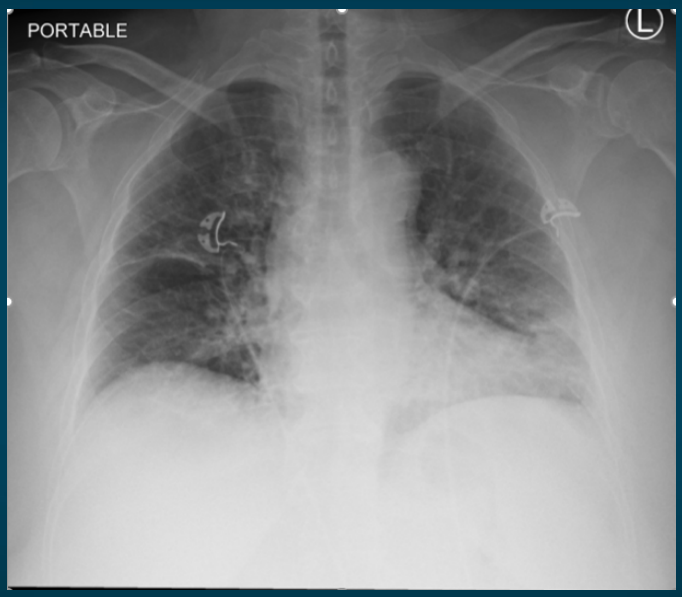
Labs

Labs:

- Normal renal function and coagulation profile
- WBC: 3500 cells/ml *(normal: 4500-11,000 cells/mL)*
- Lactate: 3.0 mmol/L *(normal: 0.5-1 mmol/L)*
- Ferritin: 1537 ng/mL *(normal: 20-250 ng/mL)*
- CRP: 8.9 mg/dL *(normal: 0.3-1.0 mg/dL)*
- D-dimer: 0.4 mcg/mL
- Procalcitonin: 0.18 ng/mL

42

Chest Radiograph April 16



43

Severe COVID-19 in the ICU

Continued Treatment

- After admission, she was given one dose of tocilizumab, but she remained ill with increasing oxygen needs on 80% on mechanical ventilation
- Minimal improvement in oxygenation with a trial of proning
- She remained afebrile with a WBC of 5900 cell/mL on ceftriaxone, doxycycline, and hydroxychloroquine

44

Severe COVID-19 in the ICU

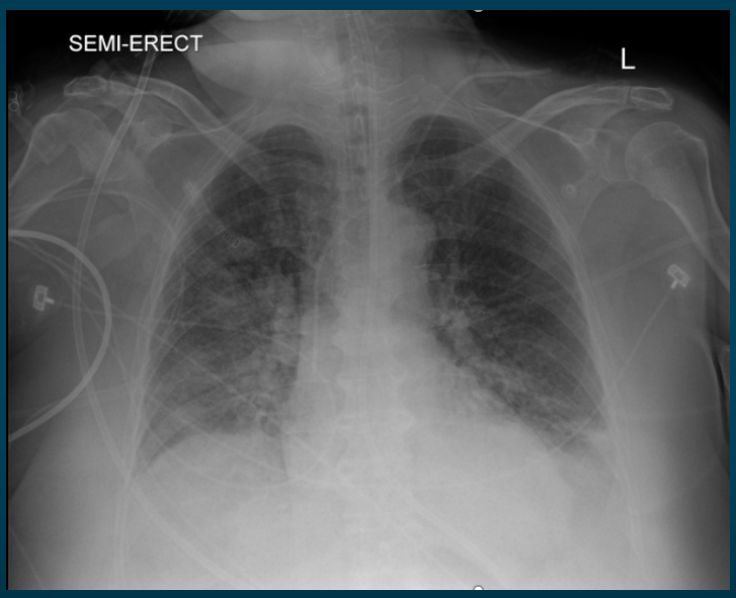
Should the patient receive adjunctive corticosteroids?

Is she safe from an infection standpoint?

45

Chest Radiograph 4 Days After Corticosteroids

Procalcitonin stayed at 0.18 ng/mL or lower during and after therapy with steroids



46

Severe COVID-19 in the ICU

What therapies can we use in this patient?

47

Adjunctive Therapies for COVID: When and for Whom?

- Systemic corticosteroids: nonintubated patients? Patients intubated with ARDS?
- Anticytokine therapies: IL-1, IL-6, JAK inhibitors
- Prone ventilation
- Hydroxychloroquine
- Antibiotics
- ACE inhibitors, ARBs
- NSAIDs vs Tylenol
- Antivirals: Lopinavir/ritonavir, remdesivir, interferon
- Hyperimmune/convalescent serum

48

Case Study

Bacterial Pneumonia in a Patient with COVID-19

49

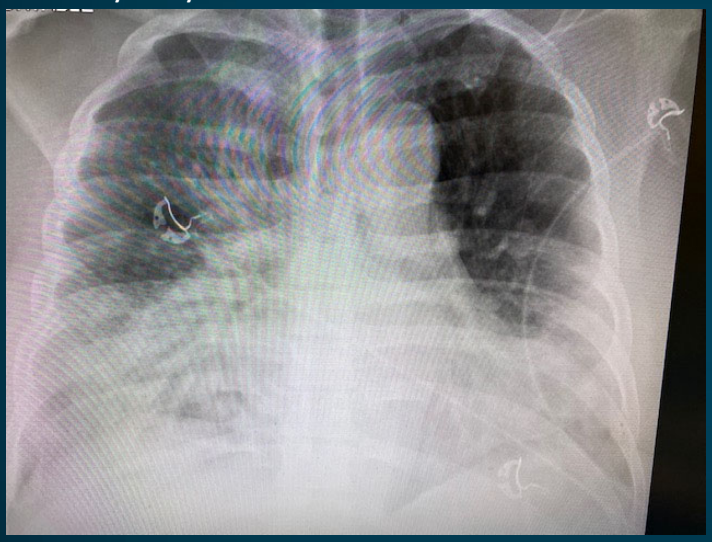
Initial Presentation

- 53-year old man presents to the ED with progressive shortness of breath and headache persisting for 3 weeks
  - Patient reports close contact with a family member with COVID-19 one month ago
  - He was found to be positive for SARS-CoV-2 on nasal PCR testing and admitted
- Prior medical history significant for hypertension, type 2 diabetes, and asthma
- Medications: lisinopril, fluticasone/salmeterol, metformin, liraglutide

50

Worsening of Symptoms

Chest x-ray on day 1



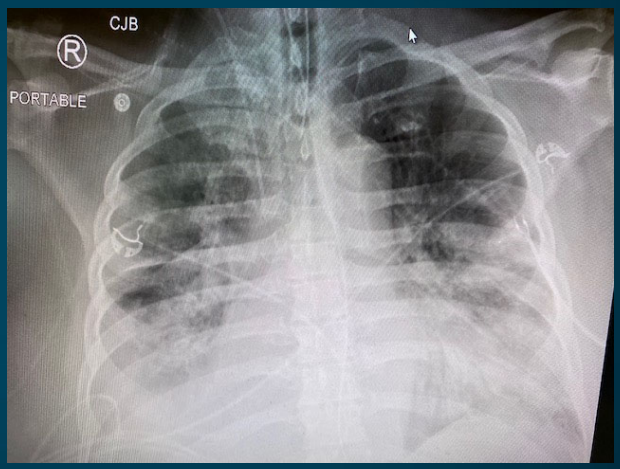
- Nasal swab is positive for MRSA
- Patient experienced acute hypoxemic respiratory failure on day 3

How would you manage this patient?

51

Day 3: ICU Admission

- He was admitted to the ICU and was intubated
  - Patient was treated with oxygen, steroids, BiPAP, and bronchodilators
- Tracheal aspirate cultures positive for MRSA >10^4 cfu/mL
- Patient found to have blood pressure of 180/120 mmHg on day 3 with AKI on CKD

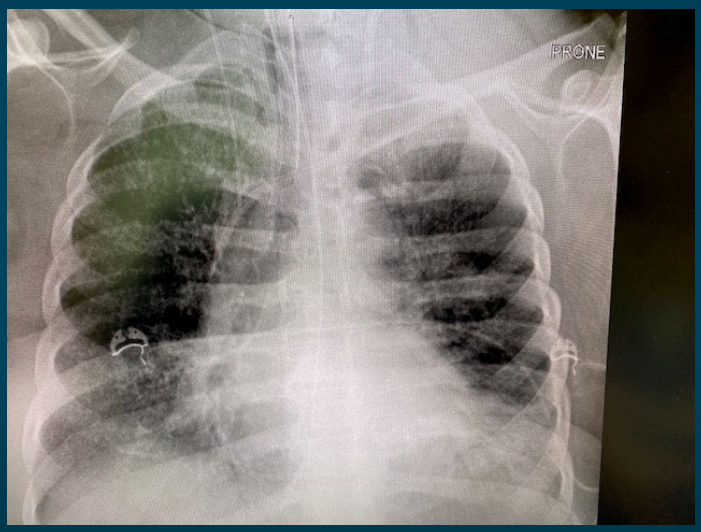


How would you manage this patient?

BiPAP = bilevel positive airway pressure; MRSA = methicillin-resistant staphylococcus aureus; AKI = acute kidney injury; CKD = chronic kidney disease

52

Day 15
Patient was extubated on day 16



53

Case Summary

- ~8% of patients with COVID-19 experience bacterial/fungal co-infection during hospital admission, yet ~70% of COVID-19 patients receive antimicrobials
  - Difficult to distinguish between COVID-19 and bacterial pneumonia
- Empiric coverage for bacterial pathogens is recommended for patients with CAP without confirmed COVID-19 but is not required in all patients with confirmed COVID-19-related pneumonia
  - Rapid de-escalation of antimicrobials recommended once SARS-CoV-2 confirmed
  - Bacterial pathogens are likely similar in patients with CAP without COVID-19 and those with COVID-19; no changes to empiric therapy required
  - Procalcitonin could be helpful in limiting overuse of antibiotics in patients with COVID-19-related pneumonia
- For patients with hypertensive emergency, gradually lower BP by approximately 10-20% in the first hour and another 5-15% over the next 23 hours, unless ischemic stroke or acute aortic dissection

Metlay JP, et al. *Ann Intern Med*. 2020;M20-2189. Rawson TM, et al. *Clin Infect Dis*. 2020;Epub.

54

COVID-19 Frontline website

https://covid-frontline.com

55

COVID-19 Frontline: Evolving Strategies in the Management and Prevention of COVID-19

Resource	Address
Joost Wiersinga W, et al. **Pathophysiology, transmission, diagnosis, and treatment of coronavirus disease 2019 (COVID-19): A review.** *JAMA.* 2020;10.1001/jama.2020.12839.	https://pubmed.ncbi.nlm.nih.gov/32648899/
Guan WJ, et al. **Clinical characteristics of coronavirus disease 2019 in China.** *N Engl J Med*. 2020;382:1708-1720.	https://pubmed.ncbi.nlm.nih.gov/32109013/
Rothan HA, et al. **The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak.** *J Autoimmun*. 2020;109:102433.	https://pubmed.ncbi.nlm.nih.gov/32113704/
Lechien JR, et al. **Clinical and epidemiological characteristics of 1420 European patients with mild-to-moderate coronavirus disease 2019.** [published online ahead of print, 2020 Apr 30]. *J Intern Med*. 2020; 10.1111/joim.13089.	https://pubmed.ncbi.nlm.nih.gov/32352202/
Wang W, et al. **Updated understanding of the outbreak of 2019 novel coronavirus (2019-nCoV) in Wuhan, China.** *J Med Virol*. 2020;92:441-447.	https://pubmed.ncbi.nlm.nih.gov/31994742/
Wu Z, et al. **Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: Summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention.** *JAMA*. 2020;323:1239-1242.	https://jamanetwork.com/journals/jama/fullarticle/2762130
Richardson S, et al. **Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area.** *JAMA*. 2020 May 26;323:2052–2059.	https://pubmed.ncbi.nlm.nih.gov/32320003/
Yuan X, et al. **Changes of hematological and immunological parameters in COVID-19 patients.** [published online ahead of print, 2020 Jul 12]. *Int J Hematol*. 2020;1-7.	https://pubmed.ncbi.nlm.nih.gov/32656638/
Fosbøl EL, et al. **Association of angiotensin-converting enzyme inhibitor or angiotensin receptor blocker use with COVID-19 diagnosis and mortality.** *JAMA*. 2020;324:168-177.	https://pubmed.ncbi.nlm.nih.gov/32558877/
Bhimraj A, et al. **Infectious Diseases Society of America Guidelines on the Treatment and Management of Patients with COVID-19**. *IDSA Guidelines*. V2.1.0.	https://www.idsociety.org/practice-guideline/covid-19-guideline-treatment-and-management/
Alhazzani W, et al. **Surviving Sepsis Campaign: Guidelines on the management of critically ill adults with coronavirus disease 2019 (COVID-19).** *Intensive Care Med*. 2020;46:854-887.	https://pubmed.ncbi.nlm.nih.gov/32222812/
World Health Organization (WHO). **Clinical management of COVID-19.** Interim Guidance. 2020 May 27.	https://www.who.int/publications/i/item/clinical-management-of-covid-19

National Institutes of Health (NIH). **COVID-19 Treatment Guidelines.**	https://www.covid19treatmentguidelines.nih.gov/
Beigel JH, et al. **Remdesivir for the treatment of Covid-19 - Preliminary report.** [published online ahead of print, 2020 May 22].*N Engl J Med*. 2020;NEJMoa2007764.	https://pubmed.ncbi.nlm.nih.gov/32445440/
Campochiaro C, et al. **Efficacy and safety of tocilizumab in severe COVID-19 patients: A single-centre retrospective cohort study.** *Eur J Intern Med. 2020;76:43-49*	https://pubmed.ncbi.nlm.nih.gov/32482597/
Li L, et al. **Effect of convalescent plasma therapy on time to clinical improvement in patients with severe and life-threatening COVID-19: A randomized clinical trial.** [published online ahead of print, 2020 Jun 3].*JAMA*. 2020;e2010044..	https://pubmed.ncbi.nlm.nih.gov/32492084/
Geleris J, et al. **Observational study of hydroxychloroquine in hospitalized patients with Covid-19.** *N Engl J Med*. 2020;382:2411-2418.	https://pubmed.ncbi.nlm.nih.gov/32379955/
Cao B, et al. **A Trial of lopinavir-ritonavir in adults hospitalized with severe Covid-19.** *N Engl J Med*. 2020;382:1787-1799.	https://pubmed.ncbi.nlm.nih.gov/32187464/
Folegatti PM, et al. **Safety and immunogenicity of the ChAdOx1 nCoV-19 vaccine against SARS-CoV-2: a preliminary report of a phase 1/2, single-blind, randomised controlled trial.** *Lancet.* 2020 Jul 20;Epub. doi:10.1016/S0140-6736(20)31604-4	https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31604-4/fulltext
Jackson LA, et al. **An mRNA Vaccine against SARS-CoV-2 - Preliminary Report**. [published online ahead of print, 2020 Jul 14].*N Engl J Med*. 2020;10.1056/NEJMoa2022483..	https://pubmed.ncbi.nlm.nih.gov/32663912/