

**Air Superiority for the Pandemic War:
Aviation Can Breathe Life into Our Nation and the World**

**Roger A. Strand MAE, CRNA, ARNP, Jack Hoover MBA, MACA, Edward di Girolamo PE, Janelle Cass,
Maddie Philips**

Contributors:

**Michael D. Jacobson DO, MPH, USAF Col. (Ret.), James G. Jones MD, Jason Trudell MHA, MSN,
MAJ USAR, CRNA, Anthony Young MAE, CRNA, ARNP, Charles Giordano MSN CRNA, DNP,
USAF LtCol., Edward Fogarty MD, Katheryn Jansky MS, CRNA, USA LtCol. (Ret.), Janet L.
Setnor MSN, CRNA, USAF Col. (Ret.), Mary Lawlor MAE, CRNA, ARNP, Joanna Starratt MSN,
CRNA, ARNP**

Endorsers:

**M. C. Richardson, Edward A. Betts PE, Xavier A. Figueroa PhD, Allison W. Bowden RN, BSN,
MHA, USAF Col. (Ret.), Michael Lewis MD, USA Col. (Ret.)**

6/18/20

Overview

After its initial discovery in China in December 2019, the novel corona virus, SARS-CoV-2 (Covid-19) continues to spread around the world. While many are asymptomatic or only have minor symptoms, a large number of coronavirus patients are severely affected and end up being hospitalized. Of those who require emergency treatment, many end up struggling with oxygen deprivation and are put on ventilators which, frequently, are unsuccessful at helping them recover. In response to the difficulties found in treating the virus, our coalition suggests Hyperbaric Oxygen Therapy (HBOT) as a non-invasive and effective way to help patients maintain their oxygen levels so that the difficult and oftentimes damaging mechanical ventilation is not required. HBOT has already been shown, in US hospitals and elsewhere, to be a successful treatment for the virus. While purpose-built hyperbaric chambers should be used to their maximum capacity for this treatment, they are limited in availability relative to the anticipated number of Covid-19 patients. Fortunately, aircraft have the ability to be utilized as hyperbaric chambers and are currently readily available. Through the adaptation of aircraft around the world, many of which currently sit idle, into hyperbaric chambers, we hope that HBOT will be brought to any community that needs it in order to save thousands of lives.

Background

Millions of people remain locked in their homes, for fear of contracting Covid-19 which, as of June 18, has infected more 8.3 million people worldwide, and in the United States alone is projected to have killed more than 117,000.^{1 2} This is just the tip of the iceberg. Based on the infection rate, experts who spoke at a UC San Francisco panel in March projected that up to 70% of the US population may contract Covid-19 over the next year.³ Up to this point, the aim has been to “flatten the curve,” meaning

¹ Johns Hopkins University, “COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU),” (Johns Hopkins University, 2020).

² Institute for Health Metrics and Evaluation, “COVID-19 Projections” (University of Washington, 2020).

³ Shlain, Jordan, “Notes from UCSF Expert Panel – March 10” (University of San Francisco, 2020).

to maintain a consistent number of cases over time so as not to overwhelm local healthcare systems.⁴ To accomplish this, government officials around the world have enacted “stay at home” directives to prevent the spread of the disease. While as of now, in some areas these attempts have appeared to have been successful, the economic impact has been devastating. In the United States alone, the Coronavirus Aid, Relief and Economic Security (CARES) Act was passed unanimously by the senate on March 25th in an attempt to relieve the monetary burden on individuals, a little more than a month after the Dow Jones Industrial Average fell by more than 12%, the biggest weekly percentage loss since the 2008 financial crisis.^{5 6} Meanwhile, millions of people continue to be isolated from each other. The ongoing fear of the disease, for which a cure has not been found, means that those with sick family members are unable to keep in contact even as they are afraid for their loved ones’ lives. When one considers the devastation that the introduction of the novel coronavirus has caused, the sense of fear and urgency is compounded by CDC Director Robert Redfield’s statement to the *Washington Post* on April 21: “There’s a possibility that the assault of the virus on our nation next winter will even be more difficult than the one we just went through... We’re going to have the flu epidemic and the coronavirus epidemic at the same time.”⁷

Treating Acute Respiratory Distress Syndrome (ARDS)?

Doctors treating Covid-19 are instructed to treat it as a virus-causing pneumonia, which begins with mild symptoms such as a cough or sore throat, and then progresses to Acute Respiratory Distress Syndrome (ARDS).⁸ Due to the projected urgent need of treatment for ARDS, ventilators are being mass produced by companies such as Ford and General Motors, but there were fears that even with added sources of production, there still would not be enough to treat this year’s patients.⁹ One physician from an

⁴ Center for Disease Control and Prevention, “Lesson 1: Introduction to Epidemiology,” (Center for Disease Control and Prevention, 2012).

⁵ McConnell, Mitch, “S.3548 CARES Act” (Washington, D.C., 2020).

⁶ Fred Imbert and Eustance Huang, “Dow falls 350 points Friday to cap the worst week for Wall Street since the financial crisis,” *CNBC* (2020).

⁷ Sun, Lena H. “CDC director warns second wave of coronavirus is likely to be even more devastating,” *The Washington Post* (2020).

⁸ Kyle-Sidell, Cameron, “FROM NYC ICU: DOES COVID-19 REALLY CAUSE ARDS??!!,” (2020).

⁹ Reed Albergotti and Faiz Siddiqui, “Ford and GM are undertaking a warlike effort to produce ventilators. It may fall short and come too late.,” *The Washington Post* (2020).

Intensive Care Unit in New York City, the epicenter of the coronavirus outbreak, believes that doctors are in fact treating the wrong disease. Dr. Cameron Kyle-Sidell, states that,

Covid-19 lung disease, as far as I can see, is not a pneumonia and should not be treated as one. Rather it appears as some sort of viral-induced disease most resembling high-altitude sickness... I fear that if we are using a false paradigm to treat a new disease... one based on the notion of respiratory failure as opposed to oxygen failure... [the ventilator treatment method] is actually doing more harm than good.¹⁰

Dr. Kyle-Sidell is not the only physician who has found the symptoms of Covid-19 to be atypical of ARDS. Five European doctors led by Dr. Luciano Gattinoni, of the Medical University of Göttingen, co-authored a letter titled “Covid-19 Does Not Lead to a ‘Typical’ Acute Respiratory Distress Syndrome.” Like Dr. Kyle-Sidell, the group noted that “the primary characteristics we are observing (confirmed by colleagues in other hospitals), is the dissociation between their relatively well preserved lung mechanics and the severity of the hypoxemia.”¹¹ Evidently, outside of the United States as well, it would appear that there is less of an issue of breathing difficulties, which call for mechanical ventilation, and instead more of an issue with oxygenation overall. Dr. Gattinoni went on to say in an interview with *Reuters* that, “Ventilating some COVID-19 sufferers as if they were standard patients with ARDS is not appropriate... It’s like using a Ferrari to go to the shop next door, you press on the accelerator and you smash the window.”¹² Researchers believe rather that Covid-19 is a systemic endotheliitis, not only pneumonia, meaning that endothelial cell inflammation causes damage in multiple organ systems.¹³

Based on the observations of these medical professionals, there have been clear problems with coronavirus treatment up to this point. It is well known that the use of ventilators can damage the lungs,

¹⁰ Kyle-Sidell, Cameron, “FROM NYC ICU: DOES COVID-19 REALLY CAUSE ARDS??!!”

¹¹ Gattinoni et al., “Covid-19 Does Not Lead to a ‘Typical’ Respiratory Distress Syndrome,” *American Journal of Respiratory and Critical Care Medicine* (2020): 2.

¹² Aloisi et al. “Special Report: As virus advances, doctors rethink rush to ventilate,” *Reuters* (2020).

¹³ Varga et al. “Endothelial cell infection and endotheliitis in COVID-19” *The Lancet* 395, 10234 (2020): 1417-1418.

creating ventilator-induced lung injury (VILI).¹⁴ With so many hospitals and doctors needing to begin using ventilators due to the pandemic, the likelihood that certain medical professionals are improperly prepared or undertrained to administer ventilation to a patient becomes higher, and could lead to an even further increased risk of VILI. Lung damage to an already oxygen-deprived patient is devastating, and potentially fatal. Dr. Kyle-Sidell acknowledges this danger, and warns that “the ARDS that we are seeing, that the whole world is seeing, may be nothing more than lung injury caused by the ventilator.”¹⁵ This is not to say that ventilators are not important for the treatment of Covid-19, and in some patients who do experience respiratory failure, the use of ventilators may be lifesaving. Even so, it is evident that an alternative treatment must be used in order to avoid the more high-risk intubation.

Benefits of Hyperbaric Oxygen Therapy (HBOT)

To understand how HBOT can overcome the lack of oxygen found in Covid-19 patients, consider “Henry’s Law,” which states that the amount of dissolved gas in a liquid is proportional to the pressure of the gas upon the liquid. This law applies to how oxygen dissolves into the human body’s fluids. Increased partial pressure of oxygen around the human body results in increased oxygen in the plasma and fluids of the body.¹⁶ Currently, when patients develop critically low oxygen levels, doctors typically use invasive measures such as intubation and mechanical ventilation. Since SARS-CoV-2 infection reduces the body’s ability to absorb and carry oxygen, the VILI caused by mechanical ventilation further reduces circulating oxygen levels.¹⁷ HBOT offers the distinct advantage of increasing blood oxygen levels by non-invasively increasing the atmospheric pressure of oxygen external to the patient. This treatment was first utilized on a large scale in 1918, during the Spanish Flu pandemic, when Dr. Orval Cunningham of Kansas City found that moving patients with lung disease from Denver to Kansas City aided their recovery. He believed that these improvements were directly correlated to the increased levels of oxygen at lower

¹⁴ Kneyber et al. “Ventilator-induced Lung Injury,” *American Journal of Respiratory Critical Care Medicine* 1, 190 (2014): 258.

¹⁵ Kyle-Sidell, Cameron, “FROM NYC ICU: DOES COVID-19 REALLY CAUSE ARDS?!!,” (2020).

¹⁶ Harch, Paul G. “Hyperbaric oxygen treatment of novel coronavirus (COVID-19) respiratory failure,” *Medical Gas Research* [Epub ahead of print] (2020).

¹⁷ Harch, Paul G. “Hyperbaric oxygen treatment of novel coronavirus (COVID-19) respiratory failure.”

altitudes. Consequently, Dr. Cunningham constructed a hyperbaric air tank and found much success using one-hour treatments at 1.68 atmospheres absolute (ATA) with ambient air for the treatment of patients with lung problems.^{18 19} Since Dr. Cunningham's pioneering work, HBOT is regularly used as a treatment for a range of issues, from carbon monoxide poisoning to flesh eating infections and non-healing wounds.²⁰ Because HBOT reduces inflammation, promotes tissue regrowth and inhibits infection, it stands to reason that HBOT could be a rapid response treatment for many other casualties. It was this line of reasoning which first led HBOT to be considered as a treatment for the hypoxia and lung damage associated with Covid-19

After the initial outbreak of Covid-19 in Wuhan, China, the Wuhan Yangtze River Shipping General Hospital treated patients suffering from the virus with HBOT, following the same premise as Dr. Cunningham. Zhong Yangling, the director of the hospital's Department of Hyperbaric Oxygen released a report on the findings. The report optimistically stated, "[HBOT] has practical significance for further accelerating the overall victory of this epidemic" and elaborated that "Early intervention of HBOT can reduce the use of mechanical ventilation and accelerate the cure of critically ill patients."²¹ Such a promising report drew worldwide interest from doctors familiar with HBOT, including Dr. Paul G. Harch, whose analysis supporting the use of HBOT in Covid-19 treatment was published in *Medical Gas Research* on April 13th. Since then, Dr. Harch sought clearance from the Louisiana State University Health Sciences Center to begin a formal study.²² Similar studies are already in progress at the Karolinska Institutet in Sweden (in collaboration with the University of California, San Diego), Oschner Medical Center in New Orleans, New York University Langone Health, the Assof-Harofeh Medical Center in Israel, and the Sainte Anne Military Teaching Hospital in France, and others, on top of the ongoing

¹⁸ Ibid.

¹⁹ Anthony L. Kovac and George S. Bause, "Orval Cunningham: The Man, His Machine, His Tank in Kansas City and Cleveland" (Kansas City: University of Kansas Medical Center, 2013).

²⁰ Leach et al. "Hyperbaric oxygen therapy," *BMJ* 317, 7166 (1998): 1140.

²¹ Zhong, Mangling, "Demonstration report on inclusion of hyperbaric oxygen therapy in treatment of COVID-19 severe cases" (International Hyperbarics Association, 2020) 1, 16.

²² Cretchain, Brittany, "Dr. Paul G. Harch Seeks to Examine the Effectiveness of Hyperbaric Treatment on COVID-19 Symptoms," *KADN News 15* (2020).

studies in Wuhan, China.^{23 24 25 26 27} Preliminary results are promising, showing a 100% survival rate.²⁸ Extivita, an American HBOT Clinic, is pursuing its own study with the Food and Drug Administration (FDA) to examine the potential of treating patients with an ambient air protocol between 1.5 and 2.0 ATA to determine the optimal pressure needed to arrest the disease.²⁹

In spite of the fact that Covid-19 has only been a known danger since December 2019, medical advancements are moving rapidly due to a sense of urgency behind such studies. Not only is the goal to prevent deaths in the short term, but also ensure that healthcare systems are prepared for the future. One of the reasons that HBOT in particular has garnered so much interest, beyond its demonstrated success and multifaced uses, is that it is non-invasive and very low-risk. Based upon the evidence above, it is clear that HBOT is proving to be a safe and effective therapy that raises the patient's blood oxygen levels. While hyperbaric treatment is available in most communities for the treatment of many other health conditions, the ultimate roadblock, similar to that of mechanical ventilation, is the available treatment capacity of HBOT systems to meet the predicted pandemic level of Covid-19. Thankfully, there are thousands of potential hyperbaric chambers located throughout the United States, and the world – airplanes.

How the Aviation Industry Can Save Lives

Like many other industries, the airline industry was hit hard by the proliferation of Covid-19. There has been a 95% reduction in air travel and as a result, almost two-thirds of the world's passenger

²³ Karolinska Institutet, *Safety and Efficacy of Hyperbaric Oxygen for ARDS in Patients With COVID-19 (COVID-19-HBO)*, (U.S. National Library of Medicine, 2020).

²⁴ Oschner Medical Center, *Hyperbaric Oxygen Therapy (HBOT) as a Treatment for COVID-19 (COVID-19) Infection*, (U.S. National Library of Medicine, 2020).

²⁵ NYU Langone Health, *Hyperbaric Oxygen for COVID-19 Patients*, (U.S. National Library of Medicine, 2020).

²⁶ Assaf-Harofeh Medical Center, *Hyperbaric Oxygen Therapy Effect in COVID-19 RCT (HBOTCOVID19) (HBOTCOVID19)*, (U.S. National Library of Medicine, 2020).

²⁷ Direction Centrale du Service de Sante des Armees, *Management by Hyperbaric Oxygen Therapy of Patients with Hypoxaemic Pneumonia With SARS-CoV-2 (COVID-19) (OHB10cov)*, (U.S. National Library of Medicine, 2020).

²⁸ Serena et al. "The Role of Hyperbaric Oxygen In the Treatment of COVID-19," (Association for the Advancement of Wound Care, 2020).

²⁹ Edward R. di Girolamo and James Stevens, "Minimize Loss of Life from COVID-19 with HBOT," (Extivita, 2020).

aircraft have been grounded.^{30 31} While these aircraft are not needed for air travel, our coalition, guided by experts in aviation and medicine, believes that within them lies the solution to meet the HBOT Covid-19 demand. The fuselage of a commercial airplane is designed to sustain the pressures of up to 9 psi.³² While this pressurization ability is intended to compensate for the lack of air pressure and oxygen at high flight altitudes, ground-based pressurization is an established safety testing procedure.³³ With modifications and the use of the cockpit manual control settings, pressures of 1.5 – 1.6 ATA (7.34 or 8.81 added psi) are achievable on the ground. These pressure levels are well within safe and reasonable structural tolerance. Notably, the Boeing 787 Dreamliner has a unique cabin pressurization system which utilizes internal electric compressors, and therefore does not rely on engines or ground-based units for pressure or air conditioning, making it an ideal candidate for conversion.^{34 35} Alternatively, soon-to-be retired aircraft such as American Airlines' 757s and 767s, or Delta's MD-88s and MD-90s, to name just a few, could also be converted into "Aircraft HBOT" (AHBOT) units using ground pressurization, power and air handling units.^{36 37} These passenger aircraft deployed to regional and executive airports would provide easy access for EMS transport to and from local hospitals. Remote hospitals could be established for patient support during HBOT treatment periods. These aircraft could mobilize and treat hundreds if not thousands of patients per day in the regions with greatest need.

Commercial airliners are not the only candidates for conversion either. Cargo, military, and other, smaller aircraft all have the potential to be converted into HBOT chambers provided they have the pressurization capability. Cargo aircraft could utilize shuttles to transport patients in and out of the plane and be fitted with temporary seating for the patients. Smaller regional or county airports could also be

³⁰ Ellwood, Mark "Coronavirus Air Travel: These Numbers Show the Massive Impact of the Pandemic," *Conde Nast Traveler* (2020).

³¹ Whitley, Angus, "How Coronavirus Will Forever Change Airlines and the Way We Fly," *Bloomberg* (2020).

³² Aeronautics Guide, "Control of Cabin Pressure – Aircraft Pressurization Systems," n.d.

³³ TEST-FUCHS Pneumatics, "Cabin Pressurization Trolley KDP8," n.d.

³⁴ Zhang, Benjamin "Boeing is making a major change to its planes that could end jet lag as we know it," *Business Insider* (2016).

³⁵ Sinnett, Mike "787 No-Bleed Systems: Saving Fuel and Enhancing Operational Efficiencies" *Aero Magazine* (2007).

³⁶ Pallini, Thomas, "Iconic planes are disappearing from the sky earlier than planned as coronavirus wreaks havoc not seen since 9/11" *Business Insider* (2020).

³⁷ Lomax. Chris P. J., "Aircraft Characteristics," (2020).

used solely for treatment purposes. Military aircraft could likewise bring AHBOT care to military personnel with Covid-19 stationed both at home and abroad. The Civil Reserve Air Fleet (CRAF), created in 1951 to aid in times of crisis, is another resource option.³⁸ Although the CRAF was established to transport passengers during emergencies, their Aeromedical Evacuation Segment, which consists of converted civil Boeing 767 passenger aircraft, is made up of air ambulances fitted with aeromedical equipment kits.³⁹ This therefore establishes a precedent for converting airliners into medical treatment areas. As of April 2019, 443 aircraft were enrolled in the CRAF.⁴⁰ When considering the treatment capacity of that many planes, without even taking into account the number aircraft not involved in the CRAF, it is obvious that there is an enormous opportunity to treat on a mass casualty scale.

There are thousands of airports around the world, and most hospitals are within a reasonable distance of at least one. This means that HBOT airplanes are able to reach virtually any community. Because the size and number of airports located in a city are often proportionate to the region's population, the ability to provide the corresponding volume of treatment is built in. Implementing AHBOT chambers at airports empowers cities to effectively treat their anticipated growing number of patients.

As Covid-19 has demonstrated, it peaks in communities at different times and overwhelms the physical capacity of the hospitals in those areas as well as the human capacity of the healthcare providers. AHBOT as a large-scale mass casualty treatment option would increase care capacity in the areas of greatest need and decrease the need for mechanical ventilation, which is burdensome and, in many cases, unsuccessful. Per the current studies, patients succeeded with one 90-minute treatment session of HBOT per day for five to seven days.⁴¹ ⁴² Leveraging this large treatment capacity for the

³⁸ William Knight and Christopher Bolkcom, "Civil Reserve Air Fleet (CRAF)," (Congressional Research Service, 2008).

³⁹ Ibid.

⁴⁰ Air Mobility Command, "Civil Reserve Air Fleet," (U.S. Air Force, 2019).

⁴¹ Karolinska Institutet, *Safety and Efficacy of Hyperbaric Oxygen for ARDS in Patients With COVID-19*.

⁴² Direction Centrale du Service de Sante des Armees, *Management by Hyperbaric Oxygen Therapy of Patients with Hypoxaemic Pneumonia With SARS-CoV-2*.

projected number of sick individuals is vital. By being better prepared to treat this volume of patients, the economic impact of Covid-19 may be lessened. Increased care capacity would mean that a peak influx of patients would likely not overwhelm the medical system, creating an automatic achievement of the goal of “flattening the curve.”

What’s Next?

There is no simple solution to the threat that diseases like Covid-19 presents to economies, healthcare systems, and individuals around the world. That said, there is a clear path forward in AHBOT. While several clinical studies on the benefits of HBOT for Covid-19 patients have been undertaken at an unbelievable pace, studies take time, and the majority expect to be finished by mid-2021 or even later.^{43 44} Unfortunately, the virus will continue to infect and kill people, and it is necessary for a better solution to be reached immediately. Nearly 17,000 patients were treated with mechanical ventilation on April 19th, a peak day of the crisis this year.⁴⁵ According to physicians like Dr. Kyle-Sidell, it is necessary to consider all the facts when dealing with a completely new disease, and the current standard of care is not sufficient for Covid patients. If even a fraction of those 17,000 intubated patients had been able to take advantage of an alternative treatment before ventilation became necessary, thousands of lives could have already been saved. When this is put into the perspective of the potential for a combined outbreak of the flu and Covid-19 next year, or other hypoxia-related illnesses, it is clear that there is an urgent need to come up with a high-capacity solution. HBOT has proven itself to be effective in treating those with lung diseases and even Covid-19 itself, and it should be considered as a treatment option before reverting to mechanical ventilation, since the vast majority of those who are intubated never recover.⁴⁶

Governments and private industries are capable of working together to utilize aircraft as AHBOT chambers. Our work group includes representatives from members of the active and retired military,

⁴³ Ibid.

⁴⁴ Karolinska Institutet, *Safety and Efficacy of Hyperbaric Oxygen for ARDS in Patients With COVID-19*.

⁴⁵ Institute for Health Metrics and Evaluation, “COVID-19 Projections.”

⁴⁶ Langreth, Robert, “New Study Shows Nearly 9 in 10 Covid-19 Patients on Ventilators Don't Make It,” *Bloomberg* (2020).

multiple business industries, including aviation, as well as medical specialists from critical care and emergency, hyperbaric, and aerospace medicine, along with advanced practice nurses from anesthesia and flight transport. The assistance of the FDA and the Pressure Vessel for Human Occupancy (PVHO) and National Fire Protection (NFP) code bodies is critical for the success of this effort. We believe that AHBOT as a large-scale treatment is the solution and are working together to help make it a reality. Preliminary study results may lead to emergency use authorization of HBOT for Covid-19. Once HBOT is an accepted treatment, our hope is the aviation industry will deliver this life saving measure against this pandemic. A widespread adoption of AHBOT will give armament to, as the doctors of Wuhan put it, “an overall victory [over] this epidemic.” That will only be possible, though, if there is a way to make this treatment widely available. We believe that the only hope for the sufferers of this, and future illnesses, is through the swift coordinated action of the aviation, business, and medical communities to turn this goal into a reality. Together, we can breathe life into our nation, and the world.

About the Authors and Contributors

Name	Bio
Janelle Cass	Janelle Cass, BS in Environmental Engineering with advanced study in Bioenvironmental Engineering USAF School of Aerospace Medicine, is President of Ohana Hyperbarics.
Edward F. Fogarty	Edward F. Fogarty, MD, Assistant Professor, North Dakota School of Medicine. Interventional Radiologist at Sakakawea Medical Center, Hazen, North Dakota.
Edward di Girolamo	Edward di Girolamo, CEO of The Steel Network. CEO of Applied Science International LLC. Founder of Extivita LLC. Board Member for Hyperbaric Medical International.
Charles Giordano	Charles David Giordano, MSN, CRNA, DNP, LtCol. USAF is a Certified Registered Nurse Anesthetist (CRNA) Specialist in York, Pennsylvania.
Jack Hoover	Jack Hoover, BBA, MBA, MACA is President of the Foundation for International Services in Edmonds, Washington.
Michael D. Jacobson	Michael D. Jacobson, D.O., M.P.H., Col. USAF, SFS, clinical assistant professor of the Residency in Aerospace Medicine (RAM) program at the U.S. Air Force School of Aerospace Medicine.
Kathryn (Kate) Jansky	Kathryn (Kate) Jansky, MHS, CRNA, APRN, USAF LtCol. (Ret), President of the American Association of Nurse Anesthetists (AANA).
James G. Jones	Greg Jones, MD, Medical Director, Deaconess Regional Hyperbaric Center, Spokane, WA. Dr. Jones is currently Board Certified in Family Medicine and Undersea and Hyperbaric Medicine
Mary Lawlor	Mary Lawlor MAE, CRNA, RNP is currently a staff Certified Registered Nurse Anesthetist (CRNA) at the VA Medical Center in Spokane, Washington.
Maddie Philips	Maddie Philips, BA in History is an analyst at the Foundation for International Services in Edmonds, Washington and has been actively involved in the commercial publishing industry since 2013.
Janet L. Setnor	Janet L. Setnor, MSN, CRNA, Col. (Ret), USAFR. She is a provider established in Reston, Virginia and her medical specialization is Certified Registered Nurse Anesthetist (CRNA).
Joanna Starratt	Joanna Starratt MSN, CRNA, ARP is currently a self-employed Certified Registered Nurse Anesthetist (CRNA).
Roger Strand	Roger A Strand, MAE, CRNA, ARNP is a Certified Registered Nurse Anesthetist (CRNA) Specialist in Shoreline, Washington.

Jason Trudell	Jason Trudell, CRNA, MSN, Cpt. U.S. Army is a Certified Registered Nurse Anesthetist (CRNA) Specialist in Land O Lakes, Florida.
Anthony Young	Anthony T. Young, MAE, CRNA, ARNP CPC. Cpt. U.S. Army is a Certified Registered Nurse Anesthetist (CRNA) registered in Ronan, MT.

Bibliography

- Aeronautics Guide. n.d. *Control of Cabin Pressure - Aircraft Pressurization Systems*. Accessed April 24, 2020. <https://www.aircraftsystemstech.com/2017/05/control-of-aircraft-cabin-pressure.html?m=1>.
- Air Mobility Command. 2019. "Civil Reserve Air Fleet." *U.S. Air Force*. Accessed April 29, 2020. <https://www.amc.af.mil/About-Us/Fact-Sheets/Display/Article/144025/civil-reserve-air-fleet/>.
- Anthony L. Kovac, M.D., George S. Bause, M. D. 2013. *Orval Cunningham: The Man, His Machine, His Tank in Kansas City and Cleveland*. Kansas City: University of Kansas Medical Center.
- Assaf-Harofeh Medical Center. 2020. *Hyperbaric Oxygen Therapy Effect in COVID-19 RCT (HBOTCOVID19) (HBOTCOVID19)*. U.S. National Library of Medicine.
- Center for Disease Control and Prevention. 2012. "Lesson 1: Introduction to Epidemiology." *Principles of Epidemiology in Public Health Practice, Third Edition An Introduction to Applied Epidemiology and Biostatistics*. May 18. Accessed 4 24, 2020. <https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section11.html>.
- Cretchain, Brittany. 2020. "Dr. Paul G. Harch Seeks to Examine the Effectiveness of Hyperbaric Treatment on COVID-19 Symptoms." *KADN News 15*, April.
- Daniel Patrone, David Resnik. 2011. "Pandemic Ventilator and Appeals Processes." *Health Care Analysis* 165-179.
- Direction Centrale du Service de Sante des Armees. 2020. "Management by Hyperbaric Oxygen Therapy of Patients with Hypoxaemic Pneumonia With SARS-CoV-2 (COVID-19) (OHB10cov)." U.S. National Library of Medicine, April 21.
- Edward R. di Girolamo, James Stevens. 2020. *Minimize Loss of Life From COVID-19 with HBOT*. April 6. Accessed 24 2020, April. <https://www.extivita.org/minimize-loss-of-life-from-covid-19-with-hbot/>.
- Ellwood, Mark. 2020. "Coronavirus Air Travel: These Numbers Show the Massive Impact of the Pandemic." *Conde Nast Traveler*, April 13.
- Fred Imbert, Eustance Huang. 2020. "Dow falls 350 points Friday to cap the worst week for Wall Street since the financial crisis." *CNBC*, February 27.
- Gattinoni, Luciano, Silvia Coppola, Massimo Cressoni, Mattia Busana, Sandra Rossi, and Davide Chiumello. 2020. "Covid-19 Does Not Lead to a "Typical" Acute Respiratory Distress Syndrome." *American Journal of Respiratory and Critical Care Medicine*.
- Harch, Paul G. 2020. "Hyperbaric oxygen treatment of novel coronavirus (COVID-19) respiratory failure." *Medical Gas Research*.
- Institute for Health Metrics and Evaluation. 2020. *COVID-19 Projections*. April 28. Accessed April 29, 2020. <https://covid19.healthdata.org/united-states-of-america>.
- International Board of Undersea Medicine, Undersea Oxygen Clinic. 2020. "HBOT for COVID-19." *Undersea Oxygen Clinic*. April 22. Accessed April 29, 2020. <https://www.underseaoxygenclinic.com/>.

- Johns Hopkins University . 2020. *COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU)*. April 29. Accessed 29 2020, April. <https://coronavirus.jhu.edu/map.html>.
- Karolinska Institutet. 2020. "Safety and Efficacy of Hyperbaric Oxygen for ARDS in Patients With COVID-19 (COVID-19-HBO)." U.S. National Library of Medicine, March 31.
- Kyle-Sidell, Cameron. 2020. *FROM NYC ICU: DOES COVID-19 REALLY CAUSE ARDS??!* New York, March 31.
- Langreth, Robert. 2020. "New Study Shows Nearly 9 in 10 Covid-19 Patients on Ventilators Don't Make It." *Bloomberg*, April 22.
- Lomax, Chris P. J. 2020. *Aircraft Characteristics*. March 6. Accessed 8 2020, May. <http://mrcabinpressure.com/aircraft.htm>.
- Martin C. J. Kneyber, Haibo Zhang, Arthur S. Slutsky. 2014. "Ventilator-induced Lung Injury." *American Journal of Respiratory Care Medicine* 258-265.
- NYU Langone Health. 2020. "Hyperbaric Oxygen for COVID-19 Patients." U.S. National Library of Medicine, April 9.
- Oschner Medical Center. 2020. *Hyperbaric Oxygen Therapy (HBOT) as a Treatment for COVID-19 (COVID-19) Infection*. U.S. National Library of Medicine.
- Pallini, Thomas. 2020. "Iconic planes are disappearing from the sky earlier than planned as coronavirus wreaks airline havoc not seen since 9/11." *Business Insider*, May 4.
- R. M. Leach, P. J. Rees, P. Wilmshurst. 1998. "Hyperbaric oxygen therapy." *BMJ* 1140-1143.
- Sen. McConnell, Mitch [R-KY]. 2020. "S.3548 CARES Act." *116th Congress (2019-2020)*. Washington, D.C.
- Shlain, Jordan. 2020. "Notes from UCFS Conference Panel." *University of California, San Francisco BioHub Panel on COVID-19*. San Francisco.
- Siddiqui, Reed Albergotti and Faiz. 2020. "Ford and GM are undertaking a warlike effort to produce ventilators. It may fall short and come too late." *The Washington Post*, April 4.
- Silvia Aloisi, Deena Beasley, Gabriella Borter, Thomas Escritt, Kate Kelland. 2020. "Special Report: As virus advances, doctors rethink rush to ventilate." *Reuters*, April 23.
- Sinnett, Mike. 2007. "787 No-Bleed Systems: Saving Fuel and Enhancing Operational Efficiencies." *Aero Magazine* 6-11.
- Sun, Lena H. 2020. "CDC Director warns second wave of coronavirus is likely to be even more devastating." *The Washington Post*, April 21.
- TEST-FUCHS Pneumatics. n.d. "Cabin Pressurization Trolley KDP8." https://www.test-fuchs.com/sites/default/files/dateien/bereich/kdp8_cabin-pressurization-trolley_e.pdf.
- Thomas Serena, Kerry Thibodeaux, Marcus Speyrer. 2020. "The Role of Hyperbaric Oxygen In the Treatment of COVID-19." Association for the Advancement of Wound Care, May 1. Accessed

- May 7, 2020. <https://www.hbotnews.org/the-role-of-hyperbaric-oxygen-in-the-treatment-of-covid-19/>.
- Whitley, Angus. 2020. "How Coronavirus Will Forever Change Airlines and the Way We Fly." *Bloomberg*, April 24.
- William Knight, Christopher Bolkcom. 2008. *Civil Reserve Air Fleet*. Foreign Affairs, Defense, and Trade Division, Congressional Research Service. Accessed April 29, 2020.
- Zhang, Benjamin. 2016. "Boeing is making a major change to its planes that could end jet lag as we know it." *Business Insider*, September 10.
- Zhong, Mangling. 2020. *Demonstration report on inclusion of hyperbaric oxygen therapy in treatment of COVID-19 severe cases*. Wuhan: International Hyperbarics Association. <https://www.ihausa.org/covid19-hyperbaric-therapy/>.
- Zsuzsanna Varga, Andreas J. Flammer, Peter Steiger, Martina Habrecker, Rea Andermatt, Annelies S. Zinkernagel, Mandeep R. Mehra, Reto A. Schuepbach, Franck Ruschitzka, Holger Moch. 2020. "Endothelial cell infection and endotheliitis in COVID-19." *The Lancet* 1417-1418.