COVID-19 and the PAH patient: A retrospective chart review

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Abstract

The COVID-19 pandemic has highlighted the need for additional health precautions in medically fragile populations. COVID-19 is a respiratory virus demonstrating increased mortality in individuals with risk factors such as pulmonary and cardiac disease. Pulmonary arterial hypertension, WHO group 1, is a rare condition that leads to cardiopulmonary symptoms. Pulmonary arterial hypertension, WHO group 1 (PAH), leads to constriction of the pulmonary vasculature which increases pressure in the right ventricle, and eventually leads to right heart failure. Additional research is needed to understand the risk PAH patients have with COVID-19 and if they are at a greater risk for disease worsening as evidenced by increased need for medical intervention, hospitalization, or even death.

This project explores the relationship between the COVID-19 pandemic and pulmonary arterial hypertension, WHO group 1, patients at a single center. Adult patients diagnosed with PAH prior to March 1, 2019, at the Ascension St. Vincent Pulmonary Hypertension Clinic will be included in the study. A retrospective chart review will index hospitalization events, markers of disease worsening, and mortality in established patients and compare if there is statistical significance between the pre-pandemic period of March 1, 2019, through February 29, 2020, and during the COVID-19 pandemic period of March 1, 2020, through February 28, 2021. This study will increase the information known about the impact of COVID-19 on patients with PAH.

Keywords: pulmonary arterial hypertension, PAH, COVID-19

COVID-19 Pandemic Impact on Pulmonary Arterial Hypertension Patients

Severe acute respiratory syndrome Coronavirus 2 has dominated every aspect of healthcare in the United States in 2020. This syndrome, Sars-CoV2, which became known as the coronavirus 2019, or COVID-19, has a higher rate of morbidity and mortality on medically compromised individuals such as individuals with underlying cardiac or pulmonary disease (Wang et al., 2020). Patients with pulmonary arterial hypertension, World Health Organization (WHO) Group 1, would seem to have a greater risk of poor outcomes from COVID-19 infection. Research is needed to understand the consequences of COVID-19 on patients with pulmonary arterial hypertension, WHO Group 1.

Background

Pulmonary arterial hypertension, WHO Group 1, is a chronic, uncurable, and progressive disease of the pulmonary vasculature. Pulmonary hypertension is the over-arching term for elevated right heart pressure and is classified into five WHO groups (Galiè et al., 2015). WHO group 1 is pulmonary hypertension specific to the pulmonary arteries with hemodynamics from right heart catheterization demonstrating a mean pulmonary artery pressure of greater than or equal to 25 mmHg, a pulmonary arterial wedge pressure or left ventricular end diastolic pressure of less than or equal to 15 mmHg, and a pulmonary vascular resistance of greater than or equal to 3 Wood units, along with no overt lung disease (Gailè et al., 2016). The other WHO groups do not include these specific definitions. WHO group 2 pulmonary hypertension is due to left heart disease such as heart failure or valvular disease, WHO group 3 is due to lung disease corresponding with chronic obstructive pulmonary disease (COPD) or interstitial lung disease, WHO group 4 is related to chronic thromboembolic pulmonary hypertension, and WHO group 5 is pulmonary hypertension associated to multifactorial causes (Galiè et al., 2016). Pulmonary

arterial hypertension, WHO Group 1 (PAH), can be the result of idiopathic or hereditary causes, or associated with underlying connective tissue disease, portal hypertension, schistosomiasis, weight loss medication, or substance abuse and is the only WHO Group for which targeted therapy is appropriate (Klinger et al., 2019). Symptoms of PAH include syncope, dyspnea, chest pain, edema in the lower extremities, and ascites (Klinger et al., 2019). It is often undetected or overlooked until symptoms are severe (Klinger et al., 2019). Currently PAH is uncurable, but it can be successfully managed with medication therapy consisting of prostacyclins, endothelin receptor antagonists, phosphodiesterase type 5 inhibitors and/or guanylate cyclase stimulators (Gailè et al., 2016). PAH treatment can consist of oral, inhaled, subcutaneous, and intravenous medications that are managed by specialized providers, nurse coordinators, and specialty pharmacies (Gailè et al., 2016). Medication therapy is adjusted based on patients' symptoms, New York Heart Association (NYHA) functional class, N-terminal pro-brain natriuretic peptide level (NT-proBNP), six-minute walk distance, right ventricular function on echocardiogram, and hemodynamics from right heart catheterization (RHC) (Klinger et al., 2019). PAH can be treated with medication therapy to improve heart function and quality of life for the individual, although patients with PAH may be more susceptible to respiratory and cardiac diseases due to the tenuous nature of their chronic illness even with appropriate treatment.

COVID-19 is a novel coronavirus that originated in China in December 2019. This respiratory virus quickly spread around the globe and a pandemic was declared by the World Health Organization on January 30, 2020 (Hu et al., 2020). The COVID-19 virus is highly transmissible through the air and highly infectious (Pascarella et al., 2020). Pascarella et al. note that symptomatic individuals can display cough, fever, loss of taste, loss of smell, fatigue, headache, sore throat, and dyspnea that can lead to respiratory distress (2020). Individuals with

comorbidities and the elderly, when infected with COVID-19, are extremely susceptible to developing pneumonia, respiratory distress, organ failure, and death (Pascarella et al., 2020). According to Pascarella et al., 80-90% of cases are mild or asymptomatic, while 5% of cases are critical and can end in death (2020). One difficulty with the COVID-19 virus is the infected individual can spread the virus prior to symptoms, or possibly be asymptomatic and still spread the virus (Hu et al., 2020). The symptom free period of infection creates a window for the virus to be unknowingly transmitted and spread exponentially with catastrophic consequences to unsuspecting individuals.

The COVID-19 pandemic has challenged researchers to understand the populations most at risk for increased morbidity and mortality from the infection. Wang et al. (2020) completed a meta-analysis on comorbidities most likely to be at increased risk of morbidity and mortality from COVID-19 infection. Wang et al. found diabetes, COPD, hypertension, cardiovascular disease, and cerebrovascular disease were risk factors associated with increased severity of COVID-19 infection outcome (2020). Wang et al. also discovered the conditions of cancer, liver disease, or renal disease were not risk factors of worsened outcome from COVID-19 infection (2020). A study by Potus et al. evaluated the similarities at the molecular level between COVID-19 and pulmonary hypertension (2020). Potus et al. performed a systematic literature review to assess how pulmonary vasculature was damaged from respiratory illnesses and found that vasoconstriction, inflammation, and emboli were hallmarks of PAH and COVID-19 (2020). Potus et al. theorized underlying pulmonary vascular disease may increase mortality from COVID-19 infection and that COVID-19 infection may increase risk of subsequent pulmonary vascular disease. The poor outcomes of patients with the comorbidities of cardiovascular disease or COPD highlights the need to identify how the PAH patient population is compromised

by the COVID-19 pandemic. Current research supports the idea that comorbidities, such as cardiovascular and pulmonary disease, increase the risk of morbidity and mortality from COVID-19 infection.

Purpose

Problem Statement

The consequence of COVID-19 on PAH must be understood to better educate the PAH patient population on COVID-19 disease risk and mitigation strategies. Increased knowledge can also assist in how patients should be monitored and if lower thresholds for appointments and testing is needed to prevent PAH disease worsening and hospitalization. This project researched whether adult patients diagnosed with pulmonary arterial hypertension, WHO group 1, cared for at the Ascension St. Vincent Pulmonary Hypertension Clinic required an increased need in medical interventions and/or hospitalizations for cardiopulmonary issues due to the COVID-19 pandemic when compared to the previous non-COVID-19 year. Comparing the time frame of March 2019 through February 2020 to the time frame of March 2020 through February 2021 provided understanding of disease stability for PAH patients prior to and during the COVID-19 pandemic. The proposed project reviewed the impact of COVID-19 on PAH patients utilizing a retrospective chart review. The sample was comprised of adult patients with known PAH receiving care at the Ascension St. Vincent Pulmonary Hypertension Clinic in Indianapolis, Indiana from March 1, 2019, until February 28, 2021. The charts were audited for hospitalizations and instances of disease worsening as evidenced by escalation in PAH targeted therapy. Increased insight into the significance of the COVID-19 pandemic on adult patients with PAH can help the medical community make informed decisions regarding patient care.

Organizational "Gap" Analysis of Project Site

Research into the significance of the COVID-19 pandemic on the PAH population is appropriate for the St. Vincent Pulmonary Hypertension Clinic site. Currently, there are no robust guidelines specific to the PAH population on the significance of COVID-19 and how to manage these chronically ill and medically fragile patients. Currently, clinicians are evaluating available data and applying it to the PAH population, which coincides with the PARiHS framework. The PARiHS acronym stands for "Promoting Action on Research Implementation in Health Services" and indicates that robust research, clinician expertise, and a receptive environment increases the likelihood of successful implementation of change (Melnyk et al., 2019). Collecting information on the health of PAH patients at the Ascension St. Vincent Pulmonary Hypertension Clinic prior to and during the COVID-19 pandemic will improve the ability to discuss risk with PAH patients and guide decision making.

Review of Literature

The COVID-19 pandemic has placed great medical strain on the global community. Medical providers are searching how to understand which patients are at a greatest risk of morbidity and mortality from COVID-19 infection. Patients with underlying chronic conditions including hypertension and lung disease have been found to have worse outcomes with COVID-19 infection (Wang et al., 2020; Zheng et al., 2020). Pulmonary arterial hypertension, WHO Group 1, (PAH) is a rare, chronic, progressive, disease of the pulmonary vasculature that leads to right heart failure (Klinger et al., 2019). Due to the fragile pulmonary and respiratory status of PAH patients, additional research is needed to understand the risk COVID-19 has on morbidity and mortality in this patient population. In addition to the physical ramifications of COVID-19 on the patient, the evaluation and treatment of the PAH patient at pulmonary hypertension

centers is also a considering factor during the pandemic. The COVID-19 pandemic has interrupted all processes for patient care, and increased understanding is needed.

Research on COVID-19 and PAH was completed in a systematic manner to locate the most current articles. The literature search consisted of the PubMed, Ovid, and CINAHL search engines and was conducted on April 14, 2021. Search terms included for all three search engines were "COVID-19" or "coronavirus" AND "pulmonary hypertension," "PAH," or "pulmonary arterial hypertension." PubMed returned a total of 22 articles with these search terms, CINAHL returned a total of 146, and OVID returned 93. Articles were only included from Jan 1, 2020, to April 14, 2021. Only articles in English were included in the results. Articles were removed if they did not address the PAH, WHO group 1 population. Articles were removed if they were not case series, studies, trials, or consensus from an expert committee. With these limitations, ten articles addressed the consequences of COVID-19 on the PAH patient and community.

PAH Patient Mortality

PAH patient mortality from COVID infection was examined by several authors. Nuche et al. compiled a case series of ten PAH patients in Spain that contracted COVID-19 and noted that seven patients required hospitalization, none required intensive care therapy, and all survived (2020). Scuri et al. compiled a case series of four Italian PAH patients requiring hospitalization due to COVID-19 infection and all patients survived (2020). The research noted that prior to infection some of the patients were described as having New York Heart Association functional class two to three symptoms indicating continued cardiopulmonary compromise. Interestingly, escalation of PAH targeted therapy was not required for any patient (Nuche et al., 2020, Scuri et al., 2020). Sulica et al. (2021) completed a case series of 11 known PAH patients that contracted COVID-19 in the beginning of the pandemic in New York City,

with a reported 46% mortality rate, which is much higher than any other reported mortality rate for this population. Greater details such as hemodynamics or PAH medications prior to infection were not included and would have been helpful to make larger connections to the PAH community. A national survey of pulmonary hypertension centers conducted by Lee et al. found rate of infection from COVID-19 was the same as the general population, but the mortality was much higher at 30% (2020). Belge et al. completed a survey of 47 international PH centers which found a low incidence of COVID-19 infection, only 70 reported cases, but a case-fatality rate of 19% (2020). The disconnect between the case studies and PH center surveys highlights the need for additional research.

Pulmonary Hypertension Centers

The largest group of research concerned how the pulmonary hypertension community was navigating managing patients during the pandemic. A patient centered study by Zhou et al. (2020) demonstrated that patients were staying healthy at home, with the largest concern being disruption in medication therapy supply. Lee et al. (2020) and Ryan et al.'s (2020) investigation of PAH care highlighted how centers moved from in-person evaluation to virtual visits to bridge the gap required to stay socially distant and still provide care. Tamura et al. (2020) investigated the use of telemedicine with PAH patients and found it was helpful in decreasing anxiety caused by the pandemic lockdowns. Yogeswaran et al. (2020) stated a near 50% reduction in therapy starts occurred due to the COVID-19 lockdown in Germany. The research by Lee et al., Ryan et al., and Yogeswaran et al. (2020) conclude the delays in evaluation and treatment for PAH patients could have very detrimental effects and the utmost care is needed to prevent delay in time to treatment or disruption in therapy. The consensus statements by Lee et al. and Ryan et al. state access to PAH evaluation and therapy must still be maintained by pulmonary

hypertension centers while maintaining safety restrictions. Therapy access is always a great concern, and this is emphasized by patient, program, and expert apprehension for disruption.

Currently, there is no consensus on how COVID-19 affects the PAH patient from a disease standpoint. There are concerns of the worsening of PAH due to COVID-19 infection but there are not large studies to investigate this. Studies do show the result of COVID-19 lockdowns can decrease access to healthcare which is a great concern for the PAH patient. A single center study by Kopeć et al. (2020) demonstrated patients were less likely to contact their PH center with symptoms of disease worsening due to the COVID-19 pandemic and in some cases, this delay of care precipitated a worsened PAH prognosis. Understanding the careful balance between access to therapy and minimizing risk will be the only path forward for PAH patients during the COVID-19 pandemic. The lack of robust research highlights the need for additional studies to evaluate the significance of the COVID-19 pandemic on the PAH patient population. Due to the novel characteristics of COVID-19 this is an evolving area of study and additional research insights should be attained in the months to come.

Theoretical Framework

A theoretical framework can help guide a research project and assist in implementation of the research findings. The theoretical framework best suited to guide this project is the PARiHS framework. The PARiHS framework was originally created in 1998 by Kitson, Harvey, and McCormack and has subsequently been refined and developed since that time (Melnyk et al., 2019). According to Kitson et al. (2008), the PARiHS framework allows for evaluation of the strength of the individual variables of evidence, context, and implementation (see appendix). Successful implementation occurs when there is strong evidence, a context or environment that is open to change, and it is easy to integrate change in practice (Melnyk et al., 2019).

The PARiHS framework encases the current project goal which is understanding how COVID-19 is affecting the pulmonary arterial hypertension (PAH) population at St. Vincent Pulmonary Hypertension Clinic in Indianapolis, Indiana. The framework allows for the evaluation of strength of evidence and environment of susceptibility to decide the success of implementation (Melnyk et al., 2019). Since the project focuses on the results of the new and evolving condition of COVID-19 in a single institution with a culture receptive to research there should be few barriers to implement recommendations.

Framework Elements

Evidence

The PARiHS framework defines evidence as research, clinical experience, patient and family experience, and local data (Melnyk et al., 2019). This is appropriate for the PAH population due to the rarity of the disease and the need for highly trained providers to balance research and experience with shared decision making with patients and families. High levels of evidence increase the likelihood of successful implementation.

Context

The PARiHS framework characterizes context, or environment, as the culture, leadership, and feedback (Melnyk et al., 2019). A strong environment for the project would include a culture that promotes learning, effective organizational structures, and the use of multiple sources of feedback (Melnyk et al., 2019). A weak project environment would be resistant to change and have poor leadership (Kitson et al., 2008). The dynamic assessment of the environment interconnects with the way the medical community has had to adapt to COVID-19 and how patient outcomes will be measured by multiple data points to determine patient response.

Implementation

Facilitating research into practice successfully requires high quality evidence and a culture receptive to new knowledge. According to Kitson et al., a thorough understanding of the environment and evidence can help tailor the implementation to create success (2008). The environment for the research project is well known to the author, and hopefully will assist in successful implementation of gained knowledge.

The complexities of translating research into practice are daunting, especially when dealing with new illnesses or rare diseases. The PARiHS framework is dynamic enough to consider research, clinician and patient experience, leadership, and culture to foster successful implementation of evidence (Melnyk et al., 2019). Conceptual frameworks assist in guiding research to allow for easier implementation of outcomes. The PARiHS framework complements the research on the effects of COVID-19 on the PAH population due to the dynamic approach to evidence and environment.

Goals, Objectives, and Expected Outcomes

The goal of this study was to quantify the effect of the COVID-19 pandemic on the PAH patient population at the Ascension St. Vincent Pulmonary Hypertension Clinic. The hypothesis is the COVID-19 pandemic negatively affected the health and care of PAH, WHO group 1 patients. The objective was to evaluate for signs of PAH disease worsening as evidenced by worsening functional class, hospitalizations for cardiopulmonary issues, the addition of PAH targeted therapy, or the need for adjustments to diuretics or PAH targeted medicines. This was achieved through a retrospective chart review of the PAH patients of the Ascension St. Vincent Pulmonary Hypertension Clinic completed by this writer. The chart review covered dates March 1, 2019- February 28, 2021. These time frames were compared to see if there was an increase in

disease worsening because of the COVID-19 pandemic as evidenced by escalation of therapy, additional therapy, increased rate of hospitalization, or death.

Project Design and Methods

Project Design

This project was a program evaluation to increase knowledge on how patients with PAH are affected by the COVID-19 pandemic. The retrospective chart review used the year between March 1, 2019, to February 29, 2020, as a baseline need of medical services and compared it to the March 1, 2020 – February 28, 2021, timeframe when the COVID-19 pandemic occurred. Understanding how medical needs and services changed from 2019 to 2021 can help distinguish the impact, if any, on the PAH population.

Project Site

The project site was the Ascension St. Vincent Pulmonary Hypertension Clinic located in Indianapolis, Indiana. The program was directed by a single PAH-trained cardiologist with the support of full-time and part-time pulmonary hypertension registered nurse coordinators. The site has treated over 170 patients with PAH in the last 8 years. The Ascension St. Vincent Pulmonary Hypertension Clinic was the first program in the state of Indiana to receive accreditation from the Pulmonary Hypertension Association for demonstrating excellence in PAH diagnosis and treatment. All PAH targeted medication therapies are available to patients including oral, inhaled, subcutaneous, and intravenous prostacyclins. The Ascension St. Vincent Pulmonary Hypertension Clinic is also an active site for several PAH research trials. The chosen project site was amenable to a significant catchment of patients to evaluate for the purpose of this retrospective chart review within the chosen time frame.

Methods

A Google spreadsheet was created to track the patients and variables that were studied. The y-axis listed the chart numbers for each patient to allow for patient privacy, data on the patient included age, race, and sex, PAH WHO group 1 subtype, and PAH targeted medication regimen. The x-axis listed the variables being studied, first for the year starting March 2019 and then for the year starting March 2020.

Measurement Instruments

In order to measure the outcomes of this DNP project a Google spreadsheet to track the variables was used. The variables examined were call with cardiopulmonary concern, start of new PAH targeted therapy, increase in PAH targeted therapy, increase in diuretics, need for urgent appointment (virtual or in-person), testing completed, hospitalization for cardiopulmonary reasons, BNP, NT-proBNP, six-minute walk distance, and New York Heart Association functional class. The 2019 and 2020 variables were compared for each patient.

Data Collection

Chart reviews were completed by this author. A list of all past and present PAH patients at the Ascension St. Vincent Pulmonary Hypertension Clinic was utilized to identify subjects for the review. Data collection occurred with the use of the electronic medical record utilized by the clinic.

Timeline

The timeline for this project started with submission to the Institutional Review Board (IRB) and completed with the final report of findings. Submission of the project to the Marian University IRB occurred January 2021. Submission of the project to the Ascension St. Vincent

IRB occurred February 2021 and was approved April 2021. Completion of data collection occurred in June 2021. The final submission of findings occurred in August 2021.

Ethical Considerations

The Marian Internal Review Board (IRB) and Ascension St. Vincent IRB approved the proposal prior to data collection. All data collected was aggregated and no personal identifiers were used. No change in care occurred due to the nature of the study.

Data Results

The purpose of this study was to determine if the COVID-19 pandemic had a negative impact on individuals with PAH due to the increased risk of the disease in individuals with pulmonary and cardiac issues as well as the disruptions to regular medical care as a result of lockdown procedures.

Demographics

The sample included 64 patients with PAH, WHO group 1, receiving care from the start of March 1, 2019, through February 28, 2021. The sample was 86% female, 14% male. The group was 82.8% white, 15.6% black, and 1.6% Hispanic. Cause of PAH, WHO group 1 was 56.3% idiopathic, 26.6% connective tissue disease, 6.3% drug/toxin induced, 7.8% congenital heart disease, 1.6% portopulmonary, 1.6% heritable. Of the 64 patients, three died during the first year and their data was unable to be matched. Four patients died in the second year, only one from COVID-19 infection.

Information on the medication therapy at the beginning of 2019 shows 98.4% were on nitric oxide targeted therapy (64.1% tadalafil, 17.2% sildenafil, 15.6% riociguat, and 1.6% amlodipine), 81.2% of patients were on endothelin receptor antagonists (65.6% macitentan, 14.1% ambrisentan, 1.6% bosentan), and 64.1% of patients were on prostacyclin therapy (34.4%

selexipag, 20.3% orenitram, 7.8% intravenous or subcutaneous treprostinil, and 1.6% inhaled treprostinil).

Results

The data obtained from the chart reviews was to track PAH disease worsening. Paired analysis was completed on 61 patients to determine differences between pre-pandemic 2019 and pandemic 2020 markers. These measures are often used in PAH trials as clinical endpoints, such as six-minute walk, NT-proBNP, New York Heart Association (NYHA) functional class, and hospitalization. Six-minute walk distance showed no statistical difference in 15 patients, median walk distance was 1118 ft in 2019 and 1120 ft in 2020 (z=-0.17, p0.87). 60 patients had walks in 2019 compared to 15 in 2020 due to increase in virtual appointments. NT-proBNP data was paired for 30 patients, 2019 median 353, 2020 median 333.5 indicating slight improvement in NT-proBNP in 2020 (z=-2.18, p=0.03). Of note if an individual had more than one NT-proBNP measure, the average was used. Several patients had BNP measurements, but no analysis was performed due to only one patient with BNP in both years. Paired analysis of NYHA functional class was completed using the first documented NYHA class for each patient in the year. Statistics indicated statistically significant worsening from 2019 to 2020 (57 pairs, z=-2.07, p=0.04). In 2019, 17.7% NYHA 1, 53.2% NYHA 2, 22.6% NYHA 3, and 6.5% NYHA 4. In 2020, 16.9% NYHA 1, 44.1% NYHA 2, 35.6% NYHA 3, and 3.4% NYHA 4. The average functional class for both years was NYHA class 2, but there was shifting of patients between classes.

Additional information was gathered on the ability to continue to see and manage the patient as evidenced by the number of appointments, calls to the clinic for symptoms, diuretics changes, therapy increase, therapy initiation, and testing. Again, analysis was completed looking

for statistical difference within each patient. Number of appointments had no statistical difference between 2019 and 2020, with a median of 2 appointments per patient ($z=-1.23$, $p=0.22$). Virtual appointments did not occur in 2019, but patients had an average of 1 virtual appointment in 2020. Hospitalizations or emergency room visits had no statistical difference between 2019 and 2020, median of 0 for 61 pairs ($z=-0.14$, $p=0.89$). Call-ins to the office with worsening PAH symptoms had no statistical difference between 2019 and 2020, even though there was a median of 1 call-in for 2019 and 0 for 2020 ($z=0.16$, $p=0.87$). No statistical difference was found between 2019 and 2020 for the need for increase in diuretics ($p=0.52$), PAH targeted therapy increase ($p=0.99$), or PAH targeted therapy add ($p=0.44$). No statistical difference the number of patients receiving echocardiograms was seen, 57.8% had echocardiograms in 2019 and 55.7% had the test in 2020 ($p=0.71$). Heart catheterizations did see a statistically significant decrease, with 37.5% of patients having the procedure in 2019 compared to 18% in 2020 ($p=0.03$).

Data Analysis

The hypothesis that the COVID-19 pandemic would negatively affect PAH, WHO group 1 patients was incorrect. Paired patient analysis shows minimal statistical difference between pre-pandemic 2019 and pandemic 2020. Patients did not have an increase in hospitalizations or emergency room visits. Six-minute walk distance was unchanged, but there was a significant decrease in the ability to complete the test due to an increase in virtual visits in 2020. Patient stability was also seen by a slight improvement in NT-proBNP marker, but only 30 patients had this test in both years. NYHA functional class did show changes between 2019 and 2020, but the average patient was still NYHA functional class 2.

Patients were able to have continued access to medical care as evidenced by no change in number of office visits or echocardiograms. The number of heart catheterizations did decrease, most likely due to restricted catheterization laboratory access in the beginning of the pandemic. No statistical difference in the ability to adjust diuretics, add targeted PAH therapy, increase targeted PAH therapy, or have echocardiograms. Also, important to note is only one patient died from COVID-19 during the 2020 year.

Discussion

The ability to continue to provide access to medical care for the medically complex PAH patient during the COVID-19 pandemic was demonstrated by no statistically significant worsening of the patient's health or decreased access to care overall. Decreased access to six-minute walks with the initiation of virtual visits should encourage the PAH community to find other means for assessment.

Limitations of this project are due to the novelty of the COVID-19 pandemic and the evolving medical response to balance care of medically fragile populations and risk of viral exposure. This was a small sample size and did not include patients at this center with chronic thromboembolic pulmonary hypertension. Additionally, there are no benchmarks for how many hospitalizations, emergency room visits, or how often patients need medication adjustment. Another limitation is the length of time of the study. As the COVID-19 pandemic continues, a larger length of time prior to and during the pandemic may give a more accurate patient picture to the true affects.

Research on at-risk populations is on-going, as is the best course of treatment. As the COVID-19 pandemic continues to evolve, the PAH community will need to be guided by research to provide appropriate and personalized care. The use of virtual visits to provide care

allows for increased access to medical care, but also limits the ability to notice subtle changes in physical assessment or decreases in six-minute walk distance.

Conclusion

The COVID-19 pandemic has greatly altered how medical care is delivered and it is necessary to understand the impact on patients living with complex cardiopulmonary conditions due to their increased risk of morbidity and mortality. Research is evolving to understand how individuals with pulmonary arterial hypertension, WHO group 1, are compromised by the COVID-19 virus. Comparison of the PAH patients at the Ascension St. Vincent Pulmonary Hypertension clinic prior to and during the COVID-19 pandemic will provide needed insight into the impact of the virus on this population. This single center study indicates no significant clinical worsening due to the COVID-19 pandemic.

References

Belge, C., Quarck, R., Godinas, L., Montani, D., Escribano Subias, P., Vachiéry, J. L., Nashat, H., Pepke-Zaba, J., Humbert, M., & Delcroix, M. (2020). COVID-19 in pulmonary arterial hypertension and chronic thromboembolic pulmonary hypertension: A reference centre survey. *ERJ open research, 6*(4), 00520-2020. https://doi.org/10.1183/23120541.00520-2020

Galiè, N., Humbert, M., Vachiery, J., Gibbs, S., Lang, I., Torbicki, A., Simonneau, G., Peacock, A., Noordegraaf, A. V., Beghetti, M., Ghofrani, A., Gomez Sanchez, M. A., Hansmann, G., Klepetko, A., Lancellotti, P., Matucci, M., McDonagh, T., Pierard, L. A., Trindade, P. T., Zompatori, M., Hoeper, M., ESC Scientific Document Group. (2016). 2015 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension: The Joint Task Force for the Diagnosis and Treatment of Pulmonary Hypertension of the European Society of Cardiology (ESC) and the European Respiratory Society (ERS): Endorsed by: Association for European Paediatric and Congenital Cardiology (AEPC), International Society for Heart and Lung Transplantation (ISHLT), *European Heart Journal, 37*(1), 67–119. https://doi-org.forward.marian.edu/10.1093/eurheartj/ehv317

Hu, Y., Sun, J., Dai, Z., Deng, H., Li, X., Huang, Q., Wu, Y., Sun, L., & Xu, Y. (2020). Prevalence and severity of corona virus disease 2019 (COVID-19): A systematic review and meta-analysis. *Journal of Clinical Virology: The Official Publication of the Pan American Society for Clinical Virology*, *127*, 104371. https://doi.org/10.1016/j.jcv.2020.104371

Kitson, A., Harvey, G., & McCormack, B. (1998). Enabling the implementation of evidence based practice: A conceptual framework. *Quality in Health Care: QHC*, *7*(3), 149–158. http://dx.doi.org.forward.marian.edu/10.1136/qshc.7.3.149

Kitson, A. L., Rycroft-Malone, J., Harvey, G., McCormack, B., Seers, K., & Titchen, A. (2008). Evaluating the successful implementation of evidence into practice using the PARiHS framework: Theoretical and practical challenges. *Implementation Science: IS*, *3*, 1. https://doi-org.forward.marian.edu/10.1186/1748-5908-3-1

Klinger, J. R., Elliott, C. G., Levine, D. J., Bossone, E., Duvall, L., Fagan, K., Frantsve-Hawley, J., Kawut, S. M., Ryan, J. J., Rosenzweig, E. B., Sederstrom, N., Steen, V. D., & Badesch, D. B. (2019). Therapy for pulmonary arterial hypertension in adults: Update of the CHEST guideline and expert panel report. *Chest*, *155*(3), 565–586. https://doi.org/10.1016/j.chest.2018.11.030

Kopeć, G., Tyrka, A., Jonas, K., Magoń, W., Waligóra, M., Stępniewski, J., & Podolec, P. (2020). The coronavirus disease 2019 pandemic prevents patients with pulmonary hypertension from seeking medical help. *Polish Heart Journal / Kardiologia Polska, 78*(9), 916–918. https://doi.org/10.33963/KP.15488

Lee, J. D., Burger, C. D., Delossantos, G. B., Grinnan, D., Ralph, D. D., Rayner, S. G., Ryan, J. J., Safdar, Z., Ventetuolo, C. E., Zamanian, R. T., & Leary, P. J. (2020). A survey-based estimate of COVID-19 incidence and outcomes among patients with PAH or CTEPH and impact on the process of care. *Annals of the American Thoracic Society,* 10.1513/AnnalsATS.202005-521OC. Advance online publication. https://doi.org/10.1513/AnnalsATS.202005-521OC

Melnyk, B., Fineout-Overholt, E. (2019). *Evidence-based practice in nursing & healthcare: A guide to best practice* (4th ed.). Wolters Kluwer Health.

Nuche, J., Pérez-Olivares, C., Segura de la Cal, T., Jiménez López-Guarch, C., Arribas Ynsaurriaga, F., & Escribano Subías, P. (2020). Clinical course of COVID-19 in pulmonary arterial hypertension patients. *Revista Espanola de Cardiologia (English ed.), 73*(9), 775–778. https://doi.org/10.1016/j.rec.2020.05.015

Pascarella, G., Strumia, A., Piliego, C., Bruno, F., Del Buono, R., Costa, F., Scarlata, S., & Agrò, F. E. (2020). COVID-19 diagnosis and management: A comprehensive review. *Journal of Internal Medicine*, *288*(2), 192–206. https://doi.org/10.1111/joim.13091

Potus, F., Mai, V., Lebret, M., Malenfant, S., Breton-Gagnon, E., Lajoie, A. C., Boucherat, O., Bonnet, S., & Provencher, S. (2020). Novel insights on the pulmonary vascular consequences of COVID-19. American Journal of Physiology. *Lung Cellular and Molecular Physiology, 319*(2), L277–L288. https://doi.org/10.1152/ajplung.00195.2020

Ryan, J. J., Melendres-Groves, L., Zamanian, R. T., Oudiz, R. J., Chakinala, M., Rosenzweig, E. B., & Gomberg-Maitland, M. (2020). Care of patients with pulmonary arterial hypertension during the coronavirus (COVID-19) pandemic. *Pulmonary Circulation, 10*(2), 2045894020920153. https://doi.org/10.1177/2045894020920153

Scuri, P., Iacovoni, A., Abete, R., Cereda, A., Grosu, A., & Senni, M. (2020). An unexpected recovery of patients with pulmonary arterial hypertension and SARS-CoV-2 pneumonia: A case series. *Pulmonary Circulation, 10*(3), 2045894020956581. https://doi.org/10.1177/2045894020956581

Sulica, R., Cefali, F., Motschwiller, C., Fenton, R., Barroso, A., & Sterman, D. (2021). COVID-19 in Pulmonary Artery Hypertension (PAH) Patients: Observations from a large PAH

center in New York City. *Diagnostics, 11*(1), 128. https://doi.org/10.3390/diagnostics11010128

Tamura, Y., Takeyasu, R., Furukawa, A., Takada, H., Takechi, M., Taniguchi, H., Kawamura, A. (2020). How covid-19 affected the introduction of telemedicine and patient reported outcomes among patients with pulmonary hypertension - A report from a referral center in Japan. *Circulation Reports, 2*, 526-530. https://dx.doi.org/10.1253/circrep.CR-20-0088

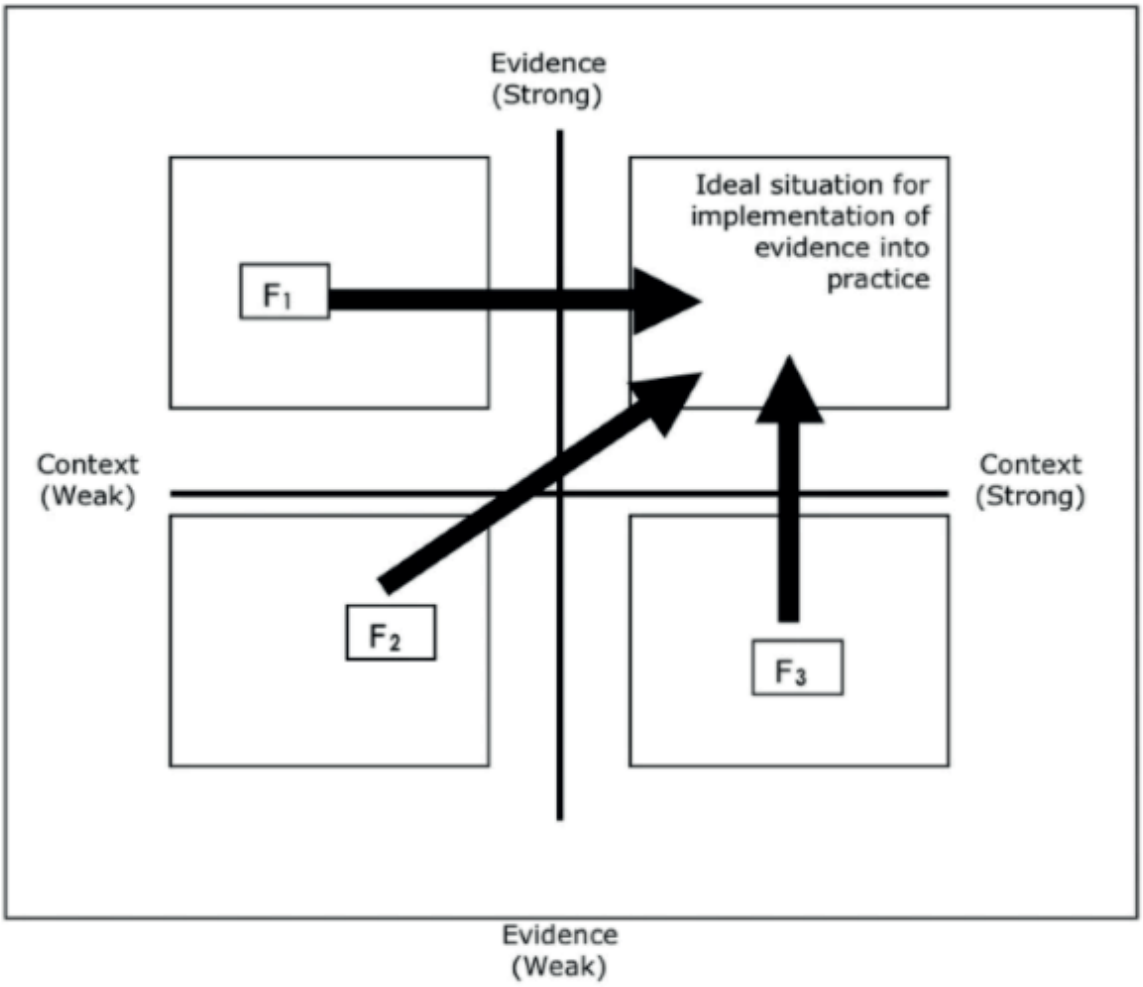
Wang, B., Li, R., Lu, Z., & Huang, Y. (2020). Does comorbidity increase the risk of patients with COVID-19: evidence from meta-analysis. *Aging*, *12*(7), 6049–6057. https://doi.org/10.18632/aging.103000

Yogeswaran A, Gall H, Tello K, Grunig E, Xanthouli P, Ewert R, et al. (2020). Impact of SARS-CoV-2 pandemic on pulmonary hypertension out-patient clinics in Germany: a multi-centre study. *Pulmonary Circulation, 10*, 2045894020941682. https://doi.org/10.1177/2045894020941682

Zheng, Z., Peng, F., Xu, B., Zhao, J., Liu, H., Peng, J., Li, Q., Jiang, C., Zhou, Y., Liu, S., Ye, C., Zhang, P., Xing, Y., Guo, H., & Tang, W. (2020). Risk factors of critical & mortal COVID-19 cases: A systematic literature review and meta-analysis. *The Journal of Infection, 81*(2), e16–e25. https://doi.org/10.1016/j.jinf.2020.04.021

Zhou, H., Zhang, G., Deng, X., Jin, B., Qiu, Q., Yan, M., Wang, X., & Zheng, X. (2020). Understanding the current status of patients with pulmonary hypertension during COVID-19 outbreak: a small-scale national survey from China. *Pulmonary Circulation, 10*(2), 2045894020924566. https://doi.org/10.1177/2045894020924566

Appendix



(Kitson et al., 2008)