2022

Anesthetic Management of Patients with Post COVID-19 Syndrome: A Quality Improvement Project

Joseph Benson
Florida International University, jbens031@fiu.edu

Jorge Valdes
Florida International University

Dr. Alexander Rodriguez-Diaz DNP, CRNA, APRN

Anesthetic Management of Patients with Post

COVID-19 Syndrome: A Quality Improvement Project

A DNP Project Presented to the Faculty of the
Nicole Wertheim College of Nursing and Health Sciences

Department of Nurse Anesthesia, Florida International University

In partial fulfillment of the requirements for the degree of
Doctor of Nursing Practice

By

Joseph Benson, MSN, RN

Supervised by

Jorge Valdes, DNP, CRNA, APRN, FAANA

Alexander Rodriguez, DNP, CRNA

Approval Acknowledged DocuSigned by: Jorge Valdes F0E0FDAF17314D5..., DNA Program Director

Date: 11/30/2022

Approval Acknowledged: DocuSigned by: Charles Buscemi 5D65DFEB12C74F7..., DNP Program Director 11/30/2022

TABLE OF CONTENTS

Abstract

Background: Millions of people have been infected with the novel Coronavirus 2019, creating a global pandemic. Despite the high mortality rate of this viral infection, millions of people have recovered, and are now presenting for surgical procedures with a history of COVID-19 infection. Residual effects of COVID-19 infection have been observed for several after diagnosis and are referred to as post COVID-19 syndrome. Post COVID-19 sequela can alter multisystem physiological processes that may alter anesthetic care throughout the perioperative period.
Objectives: The purpose of this quality improvement project is to improve anesthesia provider knowledge on the management of patients who have post COVID-19 syndrome.
Methods: The primary methodology of the proposed quality improvement project is to administer an educational intervention to anesthesia providers which discusses the management of patients undergoing elective surgery and have a history of COVID-19 infection. Pre- and post-assessment surveys will be used to measure the effectiveness of the educational intervention.
Results: Overall, there was an improvement in anesthesia provider knowledge following the educational intervention. Participants also answered they would "always" or "often" consider additional pre-operative testing compared to "sometimes" prior to the educational intervention.

Keywords: Post COVID-19 syndrome, Post COVID-19 Sequela, Coronavirus 2019, Anesthesia, Anesthesia Implications

Problem Identification

The novel coronavirus disease 2019 (COVID-19) has been a leading cause of death worldwide.[1] Clinical symptoms of COVID-19 vary from asymptomatic to multiorgan systems affected including respiratory failure, cardiomyopathy, renal failure, liver function abnormalities, thromboembolic disease, and neurologic manifestations.[2] Despite the severity of the disease and high mortality rate, several million people have recovered from COVID-19 but may have residual side effects from the viral disease. This is now referred to as post-COVID syndrome, defined as recovered from the viral infection, but continued symptoms such as fatigue, inflammation, chest tightness, dyspnea, and headaches several months after diagnosis.

At the peak of the pandemic, several healthcare systems reduced the number of elective surgeries performed as a means to limit patient exposure to the virus, conserve personal protective equipment, and utilize staff elsewhere within the hospital.[3] As healthcare systems resume elective procedures, patients are presenting for surgical services with post-COVID syndrome. As anesthesia providers continue to learn more about the virus and how to manage the care of acute COVID-19 infection, little is known about the anesthetic implications of patients who have recovered from COVID-19. The goal of this project is to improve anesthesia providers' knowledge of anesthetic implications throughout the perioperative period for patients previously diagnosed with COVID-19.

Background

Anesthesia providers perform a wide variety of anesthetic techniques such as general, monitored anesthesia care (MAC), regional, and local anesthesia depending on what is appropriate for the patient and type of surgical procedure. Additionally, several considerations are incorporated into the anesthetic care plan as each patient is unique with varying

comorbidities altering their anesthetic management. For example, regional anesthesia is preferred over general anesthesia for patients with chronic obstructive pulmonary disease (COPD) as this method minimizes respiratory complications such as barotrauma or bronchospasm.[4] Furthermore, if a patient with COPD is under general anesthesia, the anesthesia provider should deliver ventilation at a low respiratory rate to allow for sufficient expiratory time to minimize auto-peep or air trapping. Conversely, the management of a patient with acute respiratory distress syndrome (ARDS) requires general anesthesia, low tidal volumes, a higher respiratory rate, and the use of positive end-expiratory pressure (PEEP). These are only two brief examples of how the management of anesthesia is altered depending on the patient's preexisting comorbidities.

The COVID-19 pandemic has continued to evolve, several governmental agencies and professional organizations have developed protocols to assist in the management of care for patients infected with COVID-19. The American Association of Nurse Anesthesiology (AANA) provides guidelines for elective surgery of patients with diagnosed with COVID-19. These guidelines include preoperative COVID-19 testing, patient visitor limitation, operating room processing, and aftercare of staff members exposed.[5] Furthermore, the National Institute of Health has developed several treatment guidelines to provide clinicians the most current updates in treatment regimens.[6] In respect to anesthesia management, the American Society of Anesthesiologists (ASA) and the Anesthesia Patient Safety Foundation (APSF) have developed a joint statement for elective surgery and anesthesia for patients after COVID-19 infection.[7] Within this statement, the ASA and APSF provide guidelines for preoperative testing and the timing of elective procedures after diagnosis. The organizations also recognize residual symptoms after COVID-19 infection can exist for more than 60 days after diagnosis, requiring a

thorough preoperative evaluation focusing on the cardiopulmonary system. However, there are no recommendations for the management of anesthesia.

Scope of the Problem

On March 11, 2020, the World Health Organization (WHO) declared the COVID-19 outbreak a global pandemic.[8] Since then, millions of deaths have occurred worldwide. Among those diagnosed with COVID-19, research identified post-COVID syndrome to exist in 50.9% (n=277) of those who have recovered.[9] Furthermore, it has been estimated that 15% to 20% of the patients requiring surgery have previously been infected with COVID-19.[10] Given the large scale of patients presenting for surgical services with post-COVID syndrome, it is imperative that appropriate measures are taken throughout the perioperative period for the best possible patient outcome.

Consequences of the Problem

After initially restricting the number of elective and non-urgent surgeries performed during the COVID-19 pandemic, several healthcare facilities have resumed surgical procedures. Studies have indicated patients experience significantly higher morbidity and mortality rate after surgical procedures while positive for COVID-19, irrespective of comorbidities.[11] However, limited data exist on patients with post COVID-19 syndrome as it relates to patient outcomes. The COVID Surg-Cancer study reported patients previously infected with COVID-19 were associated with an increased incidence of postoperative pulmonary complications compared to those who had not been diagnosed with COVID-19, 10.7% and 3.6% respectively.[12] Zhao et al. described pulmonary function tests (PFTs) abnormalities in 25.45% of patients 3 months after discharge from COVID-19 infection.[13] Among PFTs, there was an observed decrease in total

lung capacity (TLC), Forced expiratory capacity at the first second of exhalation (FEV_1), forced vital capacity (FVC), and diffusion capacity of the lung for carbon monoxide (DLCO). These studies suggest impaired lung function months after infection.

Preoperative abnormalities in PFTs have been reported as strong indicators for postoperative complications. Reddi et al. associated decreased DLCO and FVC with prolonged postoperative ventilation and length of hospital stay in patients undergoing elective cardiac surgery.[14] Although evidence is limited, current research suggests patients are at an increased risk of postoperative complications when previously infected with COVID-19. Therefore, anesthesia providers must understand the clinical implications to care for patients who have previously been infected with COVID-19.

Knowledge Gaps

Several major medical events warrant a designated period for recovery prior to elective or non-emergent procedures. Evidence-based research suggests a minimum time of 8 weeks after myocardial infarction, 1 month after an upper respiratory infection, and 3-9 months after a cerebral vascular accident to allow for best patient outcomes after surgery.[2] In the same way, COVID-19 infection could be classified as a major medical event. However, a safe time for recovery before elective procedures has yet to be determined. The ASA and APSF joint statement guidelines on elective surgery timing after COVID-19 infection are broad and generalized. The statement recommends a lapsed time of 4, 6, 8, and 12 weeks for asymptomatic patients, symptomatic but required no hospitalization, symptomatic and hospitalized, or admitted to intensive care unit respectively.[7] There is limited data on the anesthetic management of patients who were previously infected and now exhibit signs of post COVID-19 syndrome.

To safely administer anesthesia, providers must first understand a patient's underlying medical comorbidities and how the pathophysiology may alter the anesthetic plan of care. While the knowledge of the pathophysiology of post COVID-19 syndrome is sparse, perioperative anesthetic management of patients previously infected with COVID-19 has been extrapolated from other medical conditions which have similar symptoms.[15] Anesthetic considerations of neuromuscular disorders such as cautious use of opioids and neuromuscular blockers may be indicated when post COVID-19 syndrome patients exhibit neuromuscular deconditioning symptoms. In COVID-19 patients, the cardiopulmonary system should be thoroughly evaluated with a low threshold for preoperative electrocardiogram, transthoracic echocardiography, pulmonary function tests, or chest radiographs. Other preoperative assessments should include considerations of renal and hematologic systems such as lab values, avoidance of nephrotoxic medication, and thromboprophylaxis.

These anesthetic considerations for post COVID-19 syndrome are grounded on available evidence and information from other post-viral syndromes. As the COVID-19 pandemic continues, millions of people remain at risk for long-term sequela of post COVID-19 syndrome. Anesthesia providers need to carefully assess individual patients who are de-conditioned after COVID-19 infection since specific anesthetic implications for this patient population are not yet well defined.

Proposal Solution

Various quality improvement projects have been initiated in response to the COVID-19 pandemic to keep healthcare providers informed and improve patient outcomes. For example, the Cleveland Clinic educated healthcare workers by increasing the frequency of team meetings, formed quality committees to deliver education on specific clinical skills, and created various

protocols for clinical scenarios such as patient transport, airway management, and medication use.[16] Several quality improvement efforts were developed to improve patient outcomes of acutely infected COVID-19 patients. Little information is available to educate anesthesia providers on the implications of patients with post COVID-19 syndrome. To improve perioperative patient outcomes, anesthesia providers should be educated on post COVID-19 syndrome and associated anesthetic implications.

Objective

This literature review first summarizes relevant research describing symptoms of post COVID-19 syndrome sequela. The review provides evidence for anesthetic implications throughout the perioperative period for patients who have recovered from COVID-19. The last objective is to describe how these symptoms may alter an anesthesia provider's plan of care.

PICO Question

Population (P): Anesthesia providers

Intervention (I): Educational presentation on anesthetic management for patients with post COVID-19 syndrome

Comparison (C): No education

Outcomes (O): Improved provider knowledge of anesthetic management for patients who have post COVID-19 syndrome

Methodology

A comprehensive literature search was performed using The Cumulative Index to Nursing and Allied Health Literature (CINAHL), Google Scholar, and PubMed databases. Searches with the following keywords were included in the search strategies using appropriate Boolean operators and search symbols: "post covid syndrome" OR "post covid-19 syndrome"

OR “post covid-19” OR “after covid-19” OR “post coronavirus” OR “after coronavirus” AND “symptoms” OR “anesthesia” OR “anesthesia management.” The search results were restricted to full text, English language, peer-reviewed, and within the time from 2019-2021. Database sources used for the research were accessed via Florida International University (FIU) library services.

Preliminary search results yielded 146 articles total, CINAHL, Google Scholar, and PubMed databases representing 109, 89, and 61 articles respectively. Articles were excluded if they did not relate to the PICO question. Articles describing care of the patient with an acute COVID-19 infection were omitted because this literature review is examining the anesthesia implications of post-COVID-19 infection. Other articles removed included those that described the management of resuming elective surgery during the pandemic and protocols to minimize the spread of infection among staff. After exclusions, 30 articles remained and were analyzed. Only 7 articles described the anesthetic management or perioperative care of patients, whereas the remaining 23 highlighted symptoms and physiological changes of post COVID-19 syndrome.

Review of Literature

The articles selected for this literature review described several sequelae present among patients with post COVID-19 syndrome. While some articles examined multiorgan system symptoms, other articles described only specific systems such as cardiovascular system compromise. Eight articles were used to describe the pulmonary system, 6 for cardiovascular, 8 for neurological, 2 for renal, 4 for gastrointestinal and liver, 3 for endocrine, 5 for mental health, and 7 for anesthetic implications. Further detail describing an overview of the literature results are listed in Table 1.

Pulmonary System

Pulmonary compromise was among the most prevalent sequela among patients with post COVID-19 syndrome. Frija-Masson and colleagues reported 51.9% of patients experienced residual lung function abnormalities 30 days after COVID-19 infection.[17] These patients demonstrated a mix of restrictive and low diffusion patterns. Median interquartile ranges of FVC, TLC, DLCO, FEV_1/FVC were 93%, 91.5%, 80%, and 81% of predicted values respectively. Zhao et al. conducted a multicenter retrospective cohort study examining the pulmonary function of COVID-19 survivors 3 months after discharge from the hospital.[13] Spirometry abnormalities including decreased TLC, FEV_1, FVC, and DLCO were observed in 25.45% of patients. Similarly, Huang et al detected abnormal pulmonary function tests (PFTs) in patients 6 months after diagnosis.[18] Among the 349 participants, DLCO impairment was the most evident, with decreases in 22% of patients who required no supplemental oxygen, 29% who required supplemental oxygen, and 56% who required more invasive support such as non-invasive or mechanical ventilation during hospital admission. Other spirometry studies indicated 6 months after diagnosis of COVID-19, patients still exhibited decreases in $FEV_1 < 80\%$ of predicted (6%), FVC < 80% of predicted (4%), FEV_1/FVC < 70% of predicted (6%), TLC < 80% of predicted (16%), FRC < 80% of predicted (7%), and RV < 80% of predicted (25%). Raman et al observed equal spirometry changes 2-3 months after COVID-19 with significant decreases in FEV_1, FVC, and higher FEV_1/FVC ratio than the control group.[19] Additionally, Moreno-Perez and colleagues described spirometry abnormalities in 9.3% of patients 72-85 days after disease onset.[9] Majority of the spirometry measurements in this study were found to be an obstructive pattern, which improved after 16-18 weeks.

Other pulmonary findings of post COVID-19 syndrome have been evidenced on radiological imaging or computed tomography (CT) scans. Zhao et al. reported 70.9% of patients

showed radiological abnormalities 3 months after discharge.[13] Pulmonary CT changes such as ground-glass opacities, interstitial thickening, and crazy paving involved bilateral, right lower lobe, left lower lobe, and left upper lobe in 23%, 41%, 22%, and 20% of patients respectively. Ding and associates analyzed CT scans of 112 COVID-19 positive patients at 6 different time intervals to monitor the progression of infection.[20] Among these patients, the most common CT findings included ground-glass opacifications, crazy paving, consolidation, and linear opacities. These manifestations of pulmonary imaging were observed in 98.1% of patients 28 days after symptom onset. Additional CT findings after 28 days from symptoms included air bronchogram, bronchiectasis, and pleural effusion, occurring 24.5%, 45.2%, and 15.1% respectively. Consistent with these CT results, Huang et al reported ground-glass opacity and irregular lines as the most common features of CT imaging 6 months after discharge from COVID-19 infection.[18] Interestingly, ground-glass opacities were more common in patients who required supplemental oxygen during hospital admission (48%) when compared to patients who did not require oxygen (41%) with an odds ratio of 1.19. Patients who required more invasive ventilation support during hospital admission displayed ground-glass opacities more frequently (45%) when compared to patients who did not require supplemental oxygen, however, there was no significant difference between these two groups with an odds ratio of 0.93.

The use of chest X-rays were also used to assess the pulmonary status of patients after COVID-19 infection. Taylor and colleagues performed chest X-rays on 545 COVID-19 survivors 12 weeks after discharge.[21] Patients were categorized as "high-risk" if during hospital admission they required intensive care, received high flow nasal oxygen, continuous positive airway pressure (CPAP), mechanical, or non-invasive ventilation. All other patients in the study

were categorized as "low-risk." Resolution of COVID-19 associated lung changes were found in 69% of high-risk patients and 83% of low-risk patients.

Despite the apparent resolution of radiologic changes in the majority of patients after COVID-19, D'Cruz et al argue that chest radiography is a poor indicator of pulmonary function in COVID-19 survivors.[22] Implementing the Radiographic Assessment of Lung Edema (RALE) scoring system, researchers found 87% of patients exhibited resolution of COVID-19, defined by a RALE score less than 5, on chest radiography 2 months after severe COVID-19 infection. However, 75% of these same patients demonstrated CT abnormalities consistent with COVID related interstitial lung disease. Furthermore, only 21% of patients with abnormal CT results also had abnormal chest radiographs. For this reason, the researchers suggest chest radiographs 2 months after COVID-19 infection were not a reliable indicator of physiological status. Only Raman et al. examined magnetic resonance imaging (MRI) 2-3 months after infection and observed parenchymal abnormalities in 60% of patients.[19]

Cardiovascular System

Acute COVID-19 infection has been shown to compromise the cardiovascular system as the disease can cause myocarditis, reduced systolic function, myocardial injury, or ischemia.[23] Studies have indicated chest pain (5%) and palpitations (9%) exist 6 months after diagnosis.[18] Huang et al performed cardiac magnetic resonance (CMR) on 26 patients an average of 47 days after symptoms.[24] Patients reported precordial chest pain, chest distress, and palpitations in 12%, 23%, and 88% respectively. Myocardial edema was detected in 54% of patients, and of these patients, 50% were diagnosed with small pericardial effusions. While left ventricular ejection fraction (LVEF) was within normal limits in 96.2% of patients, right ventricular (RV) function was impaired due to sustained increased pulmonary vascular resistance. Significant differences

in RV ejection fraction, stroke volume, stroke volume index, cardiac output, and cardiac index of patients with positive CMR findings existed when compared to the control group.

Another CMR study revealed similar findings of patients who recovered from COVID-19. Puntmann et al performed CMR exams an average of 71 days after positive COVID-19 results in 100 patients.[25] Cardiac involvement was detected in 78% of participants. Cardiac symptoms reported by patients included chest pain and palpitations 17% and 20% respectively. Compared to the control group, the recovered COVID-19 patients had decreased LVEF, RV ejection fraction, and increased LV volume. The most frequent anomaly was myocardial inflammation, which was identified in 60% of patients who recovered from COVID-19.

Cardiovascular system changes after Covid-19 infection can also be seen on an electrocardiogram (ECG). Eiros et al assessed ECGs of 139 participants approximately 10 weeks after COVID-19 symptoms began.[26] Electrocardiogram abnormalities included bundle branch block, intraventricular conduction delay, ST-segment depression or T-wave inversion, ST-segment elevation, and PR-segment depression in 6%, 11%, 16%, 9%, and 24% respectively.

Echocardiographic measures have also been implicated in post COVID-19 syndrome. Fayol and colleagues conducted echocardiogram evaluations of patients 6 months after diagnosis.[27] At rest, echocardiographic values were normal for all patients, however, patients with myocardial injury secondary to COVID-19 infection experienced LV diastolic markers such as higher E/e' ratios and increased pulmonary artery pressure resulting in pulmonary hypertension in 27% of patients when performing low-level exercise.

Laboratory values such as troponin, C-reactive protein (CRP), and b-type natriuretic peptide (BNP) have historically been used as cardiac associated inflammatory biomarkers. After approximately 71 days, elevated troponins levels occurred 71% of the time in patients recovered

from COVID-19, indicating inflammation and myocardial damage.[25] However, other studies performed 3-6 months after COVID-19 indicated no significant increases in cardiac biomarkers.[19,24]

Nervous System

COVID-19 infection affects the central nervous system (CNS) in several ways including persistent neuroinflammation, prolonged ICU and mechanical ventilation requiring sedation medication, sepsis, and hippocampal atrophy.[28] The most frequently reported CNS symptoms reported by COVID-19 survivors included headache, memory loss, sleep disturbance, loss of taste or smell, and musculoskeletal weakness.[9,18,21,29,30] Three months after symptom onset, 55% of patients still report these neurological manifestations.[31] While these symptoms may be vague, there have also been several case reports of Guillain-Barre syndrome, status epilepticus, and cerebrovascular accidents.[29] Cerebrovascular accidents have been reported to occur in 1.4% of COVID-19 survivors and are mostly of ischemic origin. Incidences of Guillain-Barre syndrome mostly occurred in the acute phase of COVID-19 infection, however, the disease led to decreased muscle strength, prolonging recovery time. The presence of seizure activity secondary to COVID-19 is attributed to viral infection of the CNS as well as acute hypoxic brain injury from severe pneumonia.

Neurological changes associated with acute COVID-19 infection have been well documented, however, post COVID-19 syndrome neurological sequela is limited due to the infancy of the viral infection. Lu and colleagues performed MRI scans on COVID-19 patients 3 months after symptom onset.[31] Patients were found to have a significantly higher amount of bilateral gray matter volume in olfactory, hippocampi, insulas, left Rolandic operculum, left Heschl's gyrus, and right cingulate gyrus. Patients exhibited a decrease of mean, axial, and radial

diffusivity, and an increase of fractional anisotropy in white matter. These imaging results correlate with loss of memory and smell. Other MRI studies with similar time frames from infection reported changes in the thalamus, posterior thalamic radiations, and sagittal stratum.[19]

Renal

The renal system has also been shown to be affected by COVID-19 infection due to the virus' high affinity for the Angiotensin-converting enzyme 2, which is heavily present in the proximal tubules of the kidney, leading to cytotoxicity and inflammation.[18] Researchers reported a decrease in estimated glomerular filtration rate (eGFR) in 13% of patients 6 months after diagnosis. These patients did not suffer acute kidney injury when admitted with COVID-19 and were discharged with normal eGFR levels. Other studies indicated 3% of patients who experienced acute kidney injury secondary to the viral infection continued to have renal impairment 3 months after discharge.[19] While Raman et al revealed no significant difference in eGFR values, evidence of renal injury and inflammation was present in 29% of patients.

Gastrointestinal and Liver

Gastrointestinal (GI) symptoms are frequently reported as a long-term sequela after COVID-19 infection. Among patients surveyed after 6 weeks from symptom onset, 34.6% reported experiencing GI symptoms including nausea, diarrhea, abdominal pain, and anorexia.[32] Similarly, 12 weeks after symptoms, more than 13% of patients continued to report GI symptoms.[21] Liver dysfunction after COVID-19 infection is rare. However, MRI results 2-3 months after the viral infection indicated signs of hepatic fibro-inflammation in 10% of patients.[19] Despite these imaging results, no other significant differences were reported in patients who had recovered from COVID-19 when compared to the control group. Korompoki et al recommend post COVID-19 infection follow up care to include assessment of liver function

tests and abdominal imaging in some patients as these long-term GI symptoms can lead to dyspepsia and irritable bowel syndrome.[28]

Endocrine

Limited research exists related to long-term sequela of COVID-19 infection and endocrine pathologies. Given the pandemic is an ongoing problem, researchers recommend extrapolating information from the previous outbreak of severe acute respiratory syndrome (SARS) in 2003.[33] Endocrine changes observed secondary to SARS infection included adrenal insufficiency, hypocortisolism, and hypothyroidism.

As research is published, some endocrine function similarities between SARS and COVID-19 have been reported. Chen et al examined thyroid function of COVID-19 patients 3 months after diagnosis and found 64% of patients had abnormal thyroid function laboratory values.[34] Majority of these patients had decreased thyroid stimulating hormone (TSH) and triiodothyronine (T3) levels. A positive correlation existed between the decrease in TSH and T3 and the severity of COVID-19. These thyroid function laboratory values returned to normal levels 3 months after recovery.

Other endocrine laboratory values have been linked to COVID-19 recovery as a result of hospitalization and home-isolation. Eight weeks after onset of COVID-19, vitamin D deficiency and insufficiency were present in 12% and 41% respectively for patients recovering at home and 38%, 27% during hospitalization.[35], Parathyroid hormone was increased in 13% of patients. These laboratory values did not correlate to the persistence of symptoms but remained throughout the recovery period.

Diabetes mellitus (DM) has been strongly identified to increase morbidity and mortality of COVID-19 infection, but effects on DM after infection are limited.[28] COVID-19 infection

causes inflammation within the pancreas leading to pancreatic *beta*-cell damage, insulin resistance, and hyperglycemia. Medications such as antivirals and steroids used to treat the infection have been known to cause hyperglycemia.[28,33] Huang et al reported 3% of patients were newly diagnosed with DM 6 months after COVID-19 infection.[18]

Mental health

While research on COVID-19 survivors is heavily focused on the physiological sequela, significant changes in mental health cannot go unnoticed. Psychological sequela of COVID-19 infection results from elevated cytokines, social isolation, the experience of a potentially fatal illness, stigma, and fear of infecting others.[36] Approximately 1 month after infection, patients self-reported mental health disorders including post-traumatic stress disorder (PTSD), depression, anxiety, insomnia, and obsessive-compulsive behavior 28%, 31%, 42%, 40%, 20% respectively. Among these patients, females were significantly more likely to report feelings of anxiety and depression. Comparably, the diagnosis of anxiety (12.8%) and mood (9.9%) disorders were described in patients during the first 14-90 days following the diagnosis of COVID-19. [37] A self-report survey indicated COVID-19 survivors experienced a significantly higher frequency of depression, anxiety, and reduced quality of life 3 months after diagnosis.[19] Huang et al reported in a 6 month follow up study that 23% of patients reported anxiety or depression, signifying these as more long-term mental health sequela from COVID-19 infection.[18]

While not specific to post COVID-19 survivors, an increase in substance abuse throughout the general public has been recorded throughout the pandemic. Adult alcohol consumption increased 14% from 2019 to 2020.[38] Significant increases occurred among women, younger adults, and non-Hispanic white populations. Increased alcohol consumption may

exacerbate mental health problems, including anxiety and depression, which are present in patients recovered from COVID-19 infection.

Anesthesia Implications

As millions of people have recovered from COVID-19 infection, patients are now presenting for surgery with a history of COVID-19. As previously described, those who have recovered from COVID-19 may have lasting sequela that may affect several different biological processes. The development of post COVID-19 syndrome may have substantial implications for anesthesia providers throughout the perioperative period. Published data is limited on the management of anesthesia for previously infected patients. Therefore, it is imperative anesthesia providers understand the potential residual effects of COVID-19 infection.

Given the lack of evidence of anesthetic care throughout the perioperative period for post COVID-19 syndrome, anesthesia practice varies by provider. These fluctuations were evident in a survey conducted of 154 anesthesiologists regarding alterations to preoperative evaluation of COVID-19 recovered patients.[39] Within the survey, the majority of anesthesiologists believed 0-2 weeks after a negative COVID-19 test was the ideal timing for elective surgeries. The majority of these responders agreed the preoperative evaluation should include chest X-ray, EKG, and coagulation laboratory values. Preoperative evaluation of asymptomatic patients included chest CT, PFTs, and echocardiograms for those surveyed 24%, 18.8%, and 23.4% respectively. The occurrence of preoperative testing increased based on the severity of COVID-19 infection.

Preoperative evaluation recommendations by the Indian Society of Anaesthesiologist (ISA) include a complete blood count, coagulation profile, EKG, and electrolytes for every patient with a history of COVID-19.[40] Additional preoperative testing included chest X-ray for major procedures and symptomatic American Society of Anesthesiologist Physical Status

(ASAPS) II or higher. Chest CT, PFTs, arterial blood gases, and echocardiograms, were only recommended for patients of moderate/severe hypoxia, presence of cardiac symptoms, geriatric, or major abdominal, thoracic, cardiac, or vascular surgery.

Timing of elective procedures is an important factor when considering risks of postoperative complications in patients after COVID-19 infection. El-Boghdadly et al express an increased morbidity and mortality associated with surgery within 7 weeks of COVID-19 infection.[10] The research recommends elective surgery should be delayed at least 7 weeks after diagnosis unless postponing the procedure leads to disease progression. Meanwhile, the ASA and APSF utilize a symptom-based stratification for the timing of elective procedures after recovery from COVID-19.[7] Within the ASA and APSF joint statement, a delay in elective procedures is recommended in asymptomatic, symptomatic, hospitalized, or admitted to intensive care units for 4, 6, 8-10, or 12 weeks respectively. The ASA and ASPF acknowledge these timeframes are not definitive, and each patient should be assessed individually to determine perioperative risks. Comparably, Oregon Health and Science University recently published a protocol for elective surgery of previously COVID-19 positive patients.[2] Within this protocol, patients must have a resolution of symptoms and a minimum recovery time of 4 weeks for asymptomatic and 6-8 weeks for symptomatic patients. Similar results were produced by Kovoor et al, who recommended a delay of at least 4 weeks for minor surgery and 8-12 weeks for major surgery.[41]

The optimal choice of anesthetic for patients exhibiting symptoms of post COVID-19 sequela has yet to be determined. Hoyler et al suggest if a patient presents with neurological symptoms such as neuropathy, loss of taste, or loss of smell, the anesthesia provider should apply anesthetic techniques similar to other neuromuscular disorders.[15] Cautious administration of opioid and neuromuscular blockers, as well as avoidance of regional anesthesia. Contrary to

Hoyler et al., the ISA advocates for the use of regional anesthesia over general anesthesia if possible given the decreased pulmonary reserves detected in post COVID-19 syndrome.[40] Other researchers state there is no evidence to support a superior anesthetic technique as there has been no difference in postoperative complications.[10] However, if general anesthesia is administered, the ISA recommends the use of propofol or etomidate as induction agents, and neuromuscular blockade be accomplished with the administration of cisatracurium, atracurium, vecuronium, rocuronium, or succinylcholine.[40]

Discussion

Millions of people worldwide have been diagnosed with the novel COVID-19 viral infection. Patients diagnosed with COVID-19 experience a variety of symptoms involving multiorgan systems such as respiratory compromise, cardiomyopathy, renal dysfunction, and neurological changes.[2] Residual effects of COVID-19 have been observed up to 6 months after diagnosis and are referred to as post COVID-19 syndrome.[18,19,24,27] The physiological sequela of post COVID-19 syndrome can have significant effects on PFTs, cardiac function, EKG and echocardiogram changes, neurological, renal, GI, and endocrine function. Mental health is also of concern as patients experienced increased levels of anxiety, depression, and PTSD.[18,19,36,37] When patients with a history of COVID-19 infection present for surgical services, it is imperative to consider the long-term effects of the infection and how patient outcomes may be affected.

Vital for surgical services is the need for anesthesia care. Therefore, anesthesia providers need to understand post COVID-19 syndrome sequela and associated anesthesia implications. Data is limited in the recommended anesthetic management of these patients, so a thorough preoperative assessment should be performed as symptoms vary on an individual basis.

Preoperative evaluation varies widely as evidenced by surveyed anesthesiologists and the ISA's recommendations.[39,40] A common theme appears to be delaying elective surgery until at least 4 weeks if not longer.[2,7,10,41] There is conflicting evidence regarding anesthetic technique when considering regional or general anesthesia, so the anesthesia provider must consider possible sequela of previous COVID-19 infection when selecting the most appropriate anesthetic.[10,15,40]

Conclusion

The severity of post COVID-19 sequela differs significantly between patients and evidence of residual effects of the viral infection are still not fully understood. As more people recover from COVID-19 and variants of the virus develop, more patients are presenting for surgical procedures with a history of COVID-19 infection. Guidance for the anesthetic management of these patients is limited, so it is crucial for anesthesia providers to understand post COVID-19 syndrome and associated symptoms.

This literature review explored residual symptoms after COVID-19 infection, which most significantly related to the cardiopulmonary system, as well as other organ systems including neurological, renal, GI, endocrine, and mental health. This literature review's goal was to define sequela associated with previous infection and discuss anesthetic implications for these patients. The information obtained in this literature review establishes a foundation for a quality improvement (QI) project to educate anesthesia providers on post COVID-19 syndrome associated symptoms and anesthetic implications. By providing education to anesthesia providers using the most recent evidence-based research, the QI project is expected to improve anesthesia providers' knowledge of the management for patients with post COVID-syndrome.

Primary DNP Project Goal

The World Health Organization (WHO) declared Coronavirus 2019 a global pandemic on March 11, 2020.[8] Since then, several million have been infected worldwide. Approximately half of those diagnosed with COVID-19 experienced what is known as post COVID-19 syndrome, or symptoms affecting multiorgan systems that may remain for several months.[2] Post COVID-19 syndrome sequelae include but are not limited to fatigue, inflammation, chest tightness, dyspnea, and headaches several months after diagnosis.

Many healthcare systems initially ceased elective procedures at the beginning of the pandemic but have since resumed elective surgeries.[3] As healthcare facilities resume surgical procedures, patients are presenting with a medical history of COVID-19 infection. It is estimated that 15% to 20% of patients requiring surgery have previously been infected with COVID-19.[10] Little is known about post COVID-19 syndrome and the anesthetic implications of patients recovered from COVID-19 infection. Therefore, it is thought that an educational presentation on the anesthetic management of patients with post COVID-19 syndrome will improve anesthesia provider knowledge of the anesthetic management for patients who have post COVID-19 syndrome.

At a large, level 1 trauma center in southeast Florida, the current process for elective procedures of patients with a history of COVID-19 infection includes a minimum 3-week time period after a positive test. The patient must also be considered asymptomatic, defined as afebrile and absence of cough or shortness of breath. There is no preferred anesthetic technique or preoperative testing, and the anesthetic plan of care is considered on an individual basis.

The primary goal of this quality improvement project is to assess the anesthesia provider's knowledge on post COVID-19 syndrome and associated anesthetic implications. An

educational intervention will be delivered to anesthesia providers with the goal to improve clinician knowledge as evidenced by a pre- and post-educational presentation survey. The objective of this quality improvement project is to increase awareness of post COVID-19 syndrome sequelae and improve patient outcomes for elective procedures after COVID-19 infection.

Goals and Outcomes

Direction of the goals and objectives were derived from the SMART template.[42] The SMART acronym is a frequently used template to create goals and objectives that are specific, measurable, attainable, realistic, and timely.

Specific

After an educational presentation, anesthesia providers will demonstrate improved knowledge of anesthetic management for patients with post COVID-19 syndrome.

Measurable

The efficacy of the educational presentation will be analyzed by a questionnaire completed by participants before and after an educational intervention. Results will be quantified by measuring anesthesia providers' knowledge of post COVID-19 sequelae and anesthetic implications pre- and post-educational intervention. Qualtrics® software will be implemented to create and analyze the results of the pre and post questionnaire.

Attainable

Anesthesia providers, project team leader, and faculty from Florida International University will collaborate using current evidence-based research to develop the educational presentation.

Realistic

Anesthesia providers will be educated on post COVID-19 syndrome sequela and associated anesthetic implications.

Timely

The pre-educational intervention questionnaire will be distributed among anesthesia providers prior to the educational presentation and a post-intervention questionnaire delivered immediately following the presentation. Results will be collected within a two-week time frame. The outcome objective will be as follows: after an educational presentation, anesthesia providers will improve knowledge of anesthetic management for patients who have post COVID-19 syndrome.

Description of the Program Structure

In collaboration with Florida International University faculty and an anesthesia provider, the project leader will develop the educational presentation on post COVID-19 syndrome and anesthetic implications. A detailed needs assessment will be executed using a SWOT analysis.[42] A SWOT analysis discerns strengths of the project, address weaknesses, opportunities, and acknowledges threats.

Identification of individuals, groups, or organizations who have vested interest in the project are known as stakeholders.[42] Internal stakeholders include anesthesia providers, project teams members, surgeons, and patients. External stakeholders include people in the community, anesthesia organizations, and insurers. Project team members will develop the educational

intervention on post COVID-19 syndrome and associated anesthetic implications. Participants will first be provided with a pre-educational intervention questionnaire consisting of 10 questions to assess anesthesia providers' current knowledge of post COVID-19 syndrome and anesthetic implications. Participants will then be provided with an educational presentation on post COVID-19 sequelae and associated anesthetic implications. The presentation will be provided to anesthesia providers through email. After the educational presentation, participants will take a post-presentation questionnaire.

Strengths

More evidence-based research is being produced on post COVID-19 syndrome sequelae and the associated anesthetic management. One strength of the project is that the healthcare organization has resumed elective procedures after initially stopping them during the pandemic. Another strength is the project supports the healthcare facility's vision, to provide research and innovation for the benefit of the community. Evidence-based research is provided to the anesthesia providers in the educational presentation. The objective of the project, to improve anesthesia providers' knowledge on post COVID-19 syndrome, is aligned with the vision of the organization of interest.

Weaknesses

Weaknesses are areas for improvement within the project.[42] One major weakness is the development of COVID-19 infection, recovery, and variation. Several factors of the disease are yet to be understood as the infection is relatively new. As Korompoki et al describe, mutations of the virus may carry different risks or may vary in severity of illness when compared to what is now known of the disease.[28] As the fluidity of COVID-19 infection changes, so too might the post COVID-19 syndrome sequelae and anesthetic management. Another weakness is that

current evidence-based research available has several limitations such as low sample sizes, which lowers the level of evidence. An anesthesia provider's previous experience with patients who have recovered from COVID-19 infection is also identified as a weakness. A provider's current knowledge of the disease and previous experience in administering anesthesia to patients recovered from COVID-19 can lead to varying practice.[39] This preconceived knowledge may create disbelief of evidence provided in the education presentation.

Opportunities

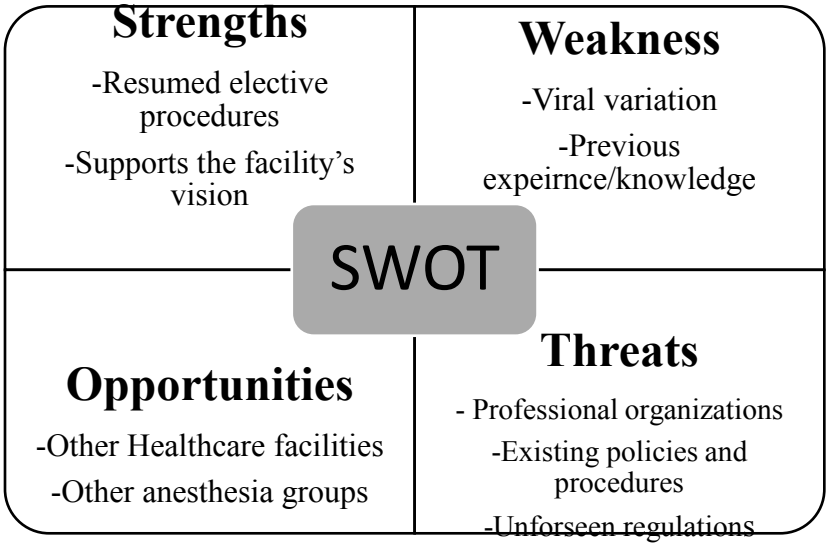
Opportunities are derived from the assessment of strengths and weaknesses.[42] The educational presentation can be used for other healthcare facilities or anesthesia groups providing surgical services to patients who have recovered from COVID-19 infection. Implementation of the project within other organizations would improve provider knowledge of anesthesia for patients with COVID-19 syndrome. Elimination of any weaknesses would not create additional opportunities as COVID-19 infection continues to be an evolving situation.

Threats

Threats are barriers to the project, business, or organization that can impede outcomes.[42] One threat is the recommendations from several different organizations involved. For example, professional organizations such as the ASA or AANA may provide guidance on the anesthetic management of patients with post COVID-19 syndrome, which may differ from what is presented in the educational presentation. These recommendations could alter the anesthesia provider's pre- or post-intervention questionnaire answers.

Other threats include the existing policies and procedures for surgical services for patients who have a history of COVID-19. Both the healthcare facility and anesthesia group publish webinars or information related to the novel COVID-19 virus. Information that is

accessible to the participants from other sources could negatively impact the project. Additional unforeseen threats include the potential for societal or political regulations. Further lockdowns enforced by the governments, or an increase of infection rates could cause another cessation of elective procedures.



Methodology

Setting and Participants

Proper implementation of this quality improvement project requires a particular group of study participants to receive an educational presentation on anesthetic implications of post COVID-19 syndrome. The main setting of this quality improvement project will take place at a large, level 1 trauma center in southeast Florida. Primary participants include all anesthesia providers employed at this facility. The participants will be recruited voluntarily, and the anticipated sample size will be between 5-15 participants.

The principal methodology of the proposed project is to administer an online educational presentation to anesthesia providers encompassing the anesthetic implications of post COVID-19 syndrome. Participants will first complete an online pre-intervention test, evaluating current

knowledge of post COVID-19 syndrome sequelae. Participants will then be given a 10 minute online educational presentation on post COVID-19 syndrome and related anesthetic implications. Participants will then be evaluated on knowledge gained as evidenced by a post-intervention test.

Results obtained in the post-intervention test will provide feedback regarding the impact of the educational presentation. The pre/post-testing provides relevant information regarding the efficacy of the educational presentation and seeks to improve anesthetic care of patients who have recovered from COVID-19. Outcomes will also demonstrate if additional anesthesia provider education is needed.

Protection of Human Subjects

For this quality improvement project, the recruitment population will include anesthesia providers at a large, level 1 trauma center in southeast Florida. This population is significant because they deliver anesthesia care to patients who have recovered from COVID-19 infection. Participant recruitment will be conducted via email invitation to all anesthesia providers at this location. Participation will be voluntary with no penalty for withdrawing from the project. There are no perceived risks to the study as it only requires the time spent by each participant in the education intervention.

Data Collection

Data collection will include a pre- and post-test to determine the effects of the educational intervention. Both assessments will be conducted using surveys consisting of approximately 12 questions focusing on knowledge and practice using Qualtrics. The pre-test will assess knowledge of post COVID-19 anesthetic implications, while the post-test survey will determine if the participants gained knowledge from the intervention. The instrument reliability and validity will be measured in accordance with the intervention provided and its effectiveness

for the participants. The data collected will be confidential and no subject identifiers will be recorded during any component of the study.

Data Management and Analysis Plan

The DNP student will be responsible for administering the pre-test, educational intervention, and post-test. Results will be kept using Microsoft Excel software and only accessible to the DNP student and FIU faculty members. This data will be stored on a password protected computer, ensuring confidentiality. Pre- and post-test results will be recorded to identify knowledge base before and after the educational intervention. Statistical analysis will be performed to determine effectiveness of the educational presentation and its impact to the anesthesia provider.

Results

Demographics

A total of 42 invitations were distributed via email to anesthesia providers to participate in the pre- and post-test educational intervention. Nine participants consented to participate, however 3 surveys were incomplete, resulting in 6 participants for the quality improvement project. The demographics of those who participated are represented by the following: male (n = 2, 33.3%), female (n = 4, 66.7%), age in years 25-35 (n = 4, 66.7%), age 36-45 (n = 2, 33.3%), Hispanic (n = 1, 16.7%), Caucasian (n = 4, 66.7%), African American (n =1, 16.7%). All participants were certified registered nurse anesthesthetists (n = 6), with either a Master's degree (n = 1, 16.7%), or Doctorate (n = 5, 83.3%), and less than 5 years experience (n = 5, 83.3%) or 5-10 years experience (n = 1, 16.7%) as an anesthesia provider. The demographics of participants surveyed are represented below.

Consent to participate

Answer	%	Count
Consent to participate	100.00%	9
Withdraw from survey	0.00%	0
Total	100%	9

Gender

Answer	%	Count
Male	33.33%	2
Female	66.67%	4
Non-binary	0.00%	0
Prefer not to say	0.00%	0
Total	100%	6

Age in years

Answer	%	Count
25-35	66.67%	4
36-45	33.33%	2
46-55	0.00%	0
56-65	0.00%	0
>65	0.00%	0
Total	100%	6

Ethnicity

Answer	%	Count
Hispanic	16.67%	1
Caucasian (non-Hispanic)	66.67%	4
African American	16.67%	1
Asian	0.00%	0
Other	0.00%	0
Total	100%	6

Position/Title

Answer	%	Count
Certified Registered Nurse Anesthetist	100.00%	6
MD anesthesia	0.00%	0
Total	100%	6

Highest level of education

Answer	%	Count
Associates	0.00%	0
Bachelors	0.00%	0
Masters	16.67%	1
Doctorate	83.33%	5
Other	0.00%	0
Total	100%	6

Years of practice as an anesthesia provider

Answer	%	Count
Less than 5	83.33%	5
5-10	16.67%	1
10-15	0.00%	0
Greater than 15	0.00%	0
Total	100%	6

Pre-Test Knowledge of post COVID-19 Anesthetic Implications

The pre-test consisted of 12 questions that assessed the current knowledge of post-COVID-19 anesthesia implications. No participants correctly identified the American Society of Anesthesiologist Physical Status (ASAPS) recommendation for preoperative chest radiographs. Three participants (50%) selected ASAPS I, whereas ASAPS III and IV were selected by

1(16.7%) and 2 (33.3%) participants respectively. Three (50%) participants correctly identified the minimum recommended length of time for an elective procedure after COVID-19 infection. The majority (n = 4, 66.7%) of those surveyed correctly identified the recommended induction agent for patients with post-COVID-19 syndrome. However, only 1 participant correctly selected the preferred neuromuscular blocker. Two (33.3%) participants were able to identify recommended anesthetic techniques. Selection of the best volatile inhalational agent was evenly split between Isoflurane (n=3) and Sevoflurane (n=3). Interestingly, all participants (n = 6) correctly identified cardiac sequela of right ventricular dysfunction. However, only 1 participant answered appropriate electrocardiogram (ECG) findings of PR depression. Half (n = 3) of the participants incorrectly answered ST depression as the most frequent ECG finding. No participants correctly identified which pulmonary function test was most frequently reduced.

All 6 participants answered "sometimes" to consider additional preoperative testing for patients after previous COVID-19 infection. When questioned if their anesthetic plan changes for patients with previous COVID-19 infection, 2 (33.3%) participants stated "sometimes" and 4 (66.7%) answered "never." However, 5 (83.3%) participants responded "sometimes" and 1 responded "often" to considering previous COVID-19 infection when performing a preoperative evaluation.

Post-Test Knowledge of post COVID-19 Anesthetic Implications

After the voiceover PowerPoint educational intervention, participants answered a post-intervention questionnaire consisting of the same questions found in the pre-test. Results assessed the knowledge gained from the educational intervention and are listed below (Table 1). All questions demonstrated an increase in the correct answer when the pre- and post-intervention tests were compared. Most significantly, the response to the selection of volatile agents. In the

pre-test, 0 anesthesia providers selected the appropriate volatile anesthetic agent compared to 5 (83.3%) correctly identifying that any agent is acceptable in the post-intervention test. Another dramatic increase in knowledge was correctly identifying preoperative chest X-ray recommendations for ASAPS II after COVID-19 infection. Four respondents answered this question correctly post-intervention, compared to 0 in the pre-intervention test. Both the selection of pulmonary function test reduction and preferred neuromuscular blocker resulted in a 50% increase in the post-intervention questionnaire.

No difference was observed in the pre-and post-test with two questions. The first, concerning right ventricular dysfunction. All participants answered this question correctly in both the pre- and post-tests. The other question which resulted in no change was pertaining to the timing of elective procedures.

When asked questions about the attitude toward the anesthetic management of recovering COVID-19 patients, results varied. After the educational intervention, 50% of respondents stated they would "always" (n = 1, 16.7%) or "often" (n = 2, 33.3%) consider additional pre-operative testing compared to answering "sometimes" in the pre-intervention questions. There was a 75% decrease in "never" changing an anesthetic plan with previously COVID-19 infected patients. Lastly, there was an increase in "always" (n = 1, 16.7%) and "often" (n = 3, 50%) considering previous COVID-19 infection during preoperative evaluation.

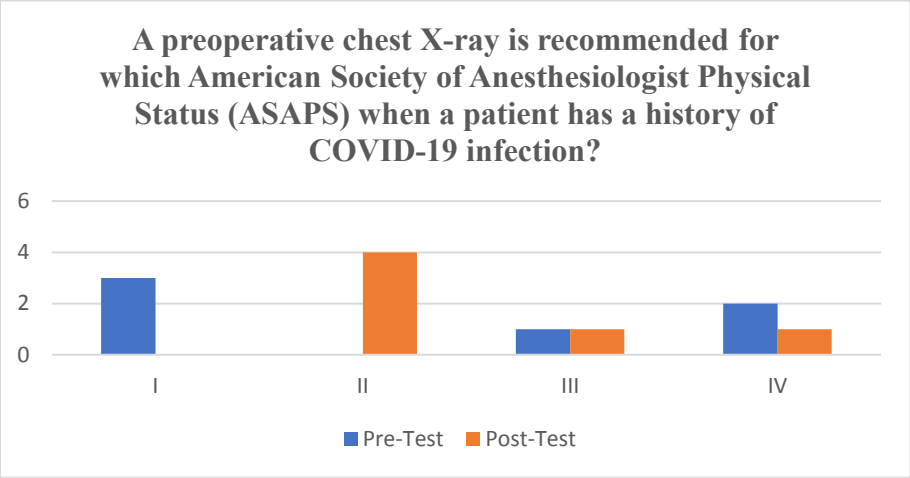
Table 1

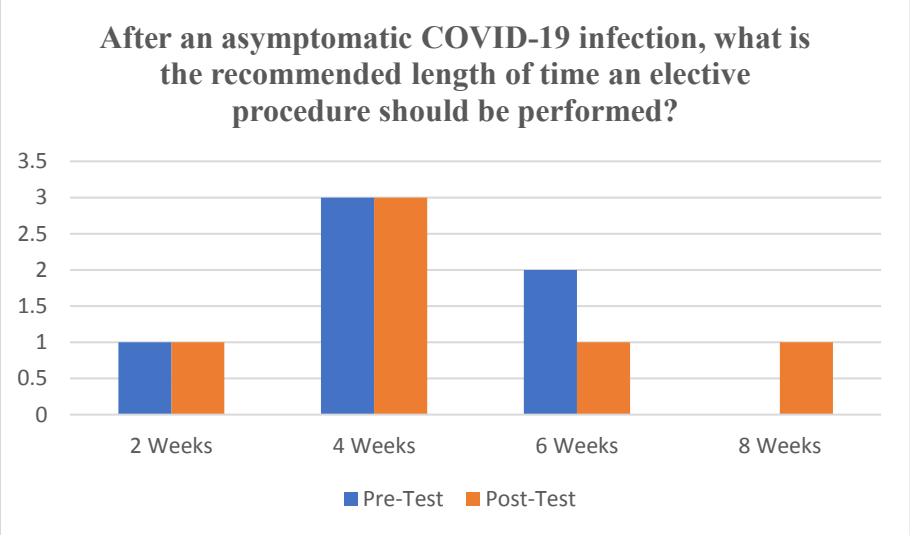
Question	**Pre-Test** (n=6)	**Post-Test** (n=6)	**Difference** (%)
A preoperative chest X-ray is recommended for which American Society of Anesthesiologist Physical Status (ASAPS) when a patient has a history of COVID-19 infection?	0	4	66.7

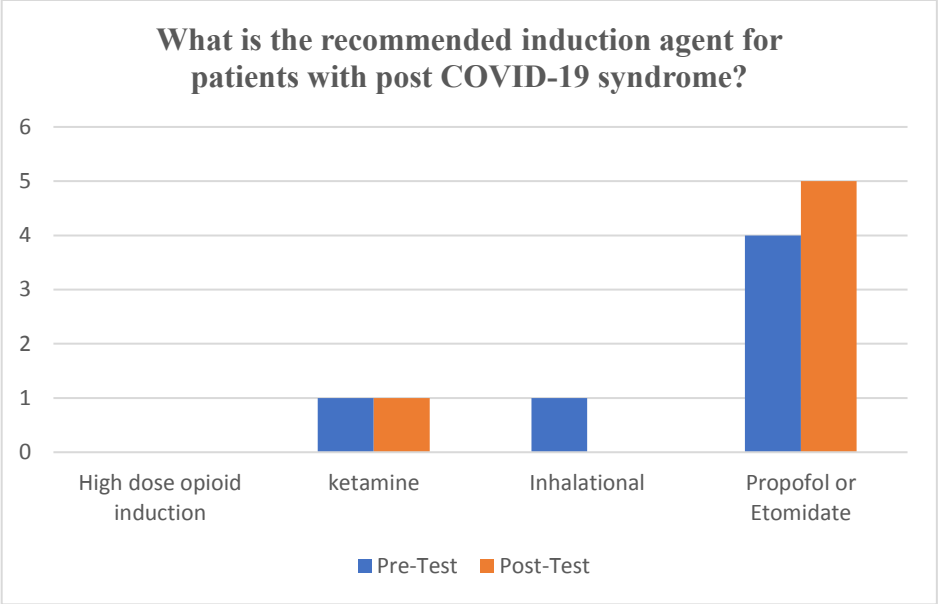
After an asymptomatic COVID-19 infection, what is the recommended length of time an elective procedure should be performed?	3	3	0
What is the recommended induction agent for patients with post COVID-19 syndrome?	4	5	16.7
What is the preferred neuromuscular blocker for patients with COVID-19 syndrome?	1	4	50
What is the recommended anesthetic technique for patients with post COVID-19 syndrome?	2	4	33.3
Which cardiac sequela may exist among patients who have had previous COVID-19 infection?	6	6	0
What is the most frequently associated electrocardiogram (ECG) finding in patients after COVID-19 infection?	1	3	33.3
Which volatile inhalational agent is the preferred inhalational gas when delivered to a patient with a history of COVID-19?	0	5	83.3
Six (6) months after COVID-19 infection, which pulmonary function test is most frequently reduced (<80% predicted)?	0	3	50

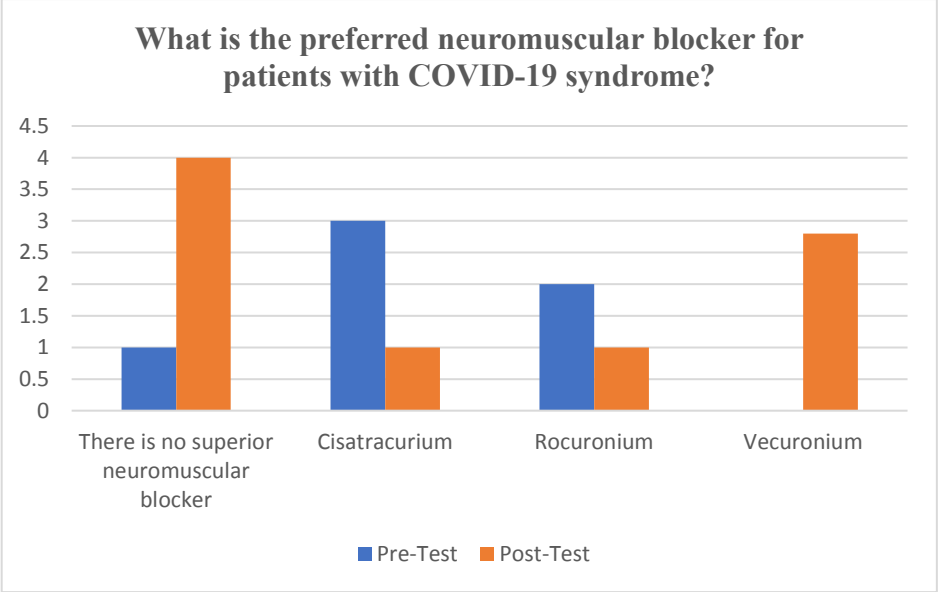
Summary of Data

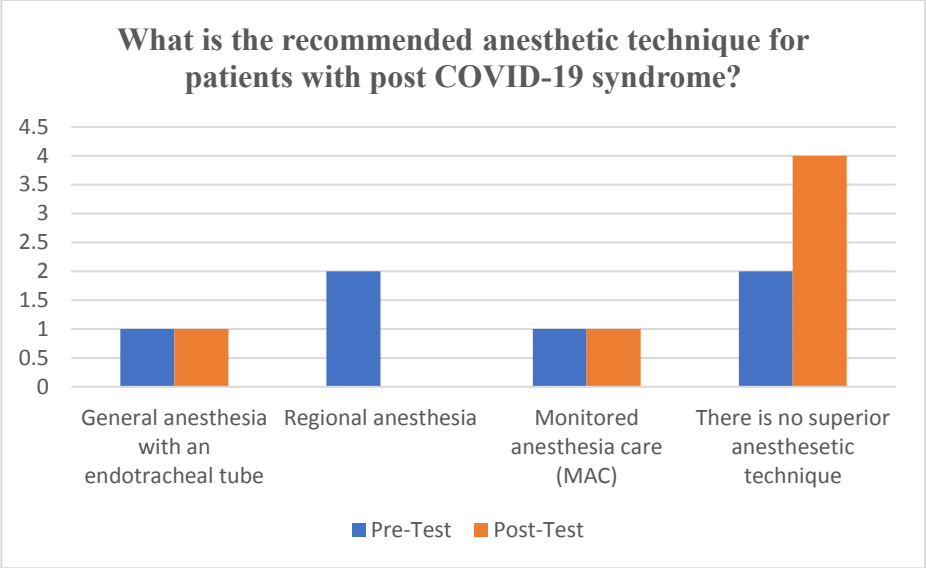
Overall, the results of the educational intervention demonstrated an increase in knowledge between the pre-test and post-tests, except for right ventricular dysfunction and the timing of elective procedures after infection. The most significant increase in knowledge was observed by correctly identifying minimum ASAPS for chest X-ray, and for volatile agent selection. The graphs below illustrate the difference between the pre- and post-test answers for each question.

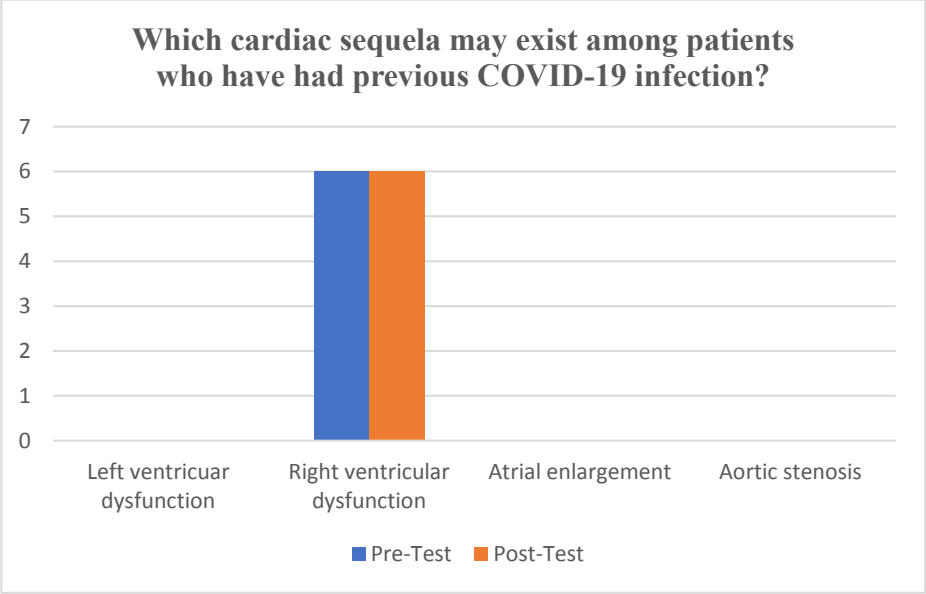


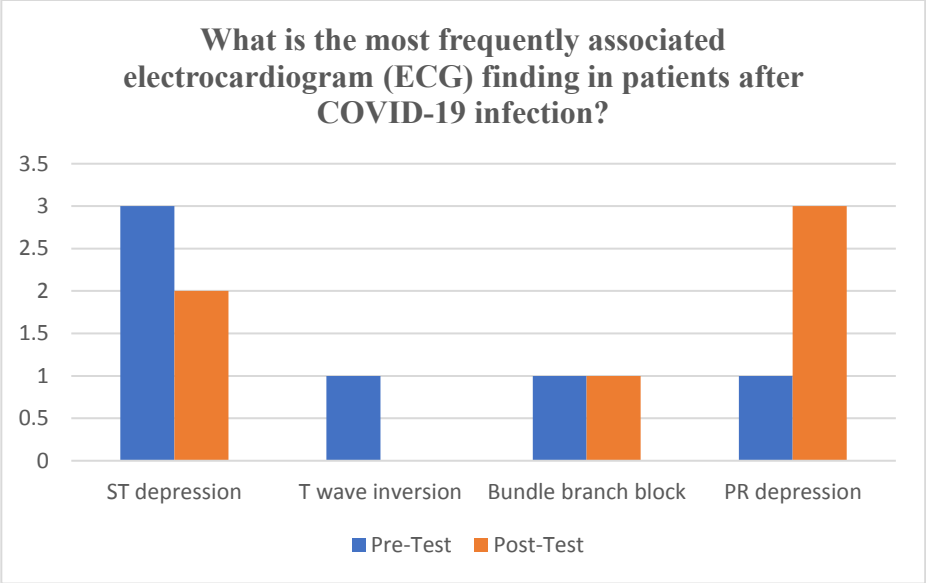


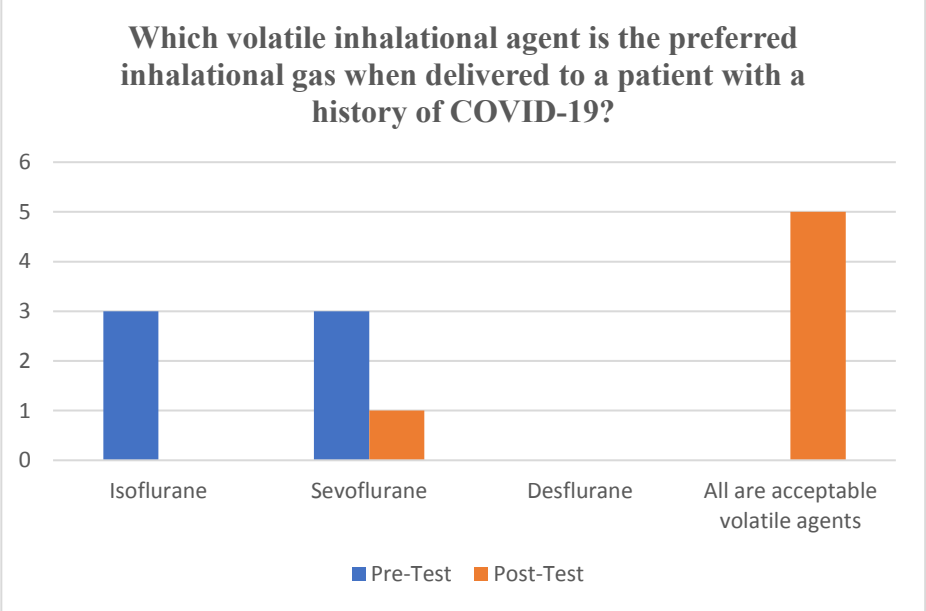

What is the recommended induction agent for patients with post COVID-19 syndrome?
6
5
4
3
2
1
0
High dose opioid induction
ketamine
Inhalational
Propofol or Etomidate
Pre-Test
Post-Test

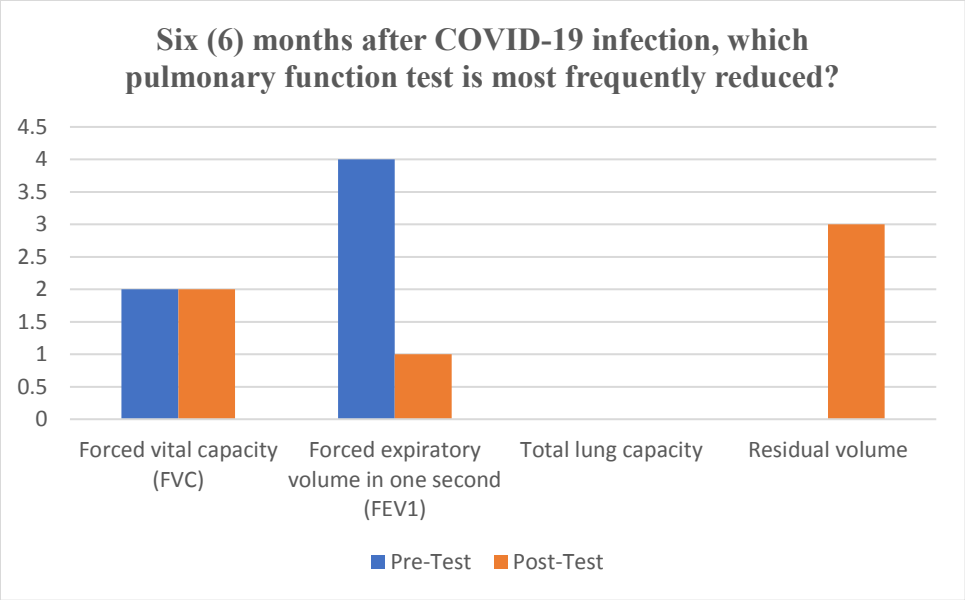

What is the preferred neuromuscular blocker for patients with COVID-19 syndrome?
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
There is no superior neuromuscular blocker
Cisatracurium
Rocuronium
Vecuronium
Pre-Test
Post-Test

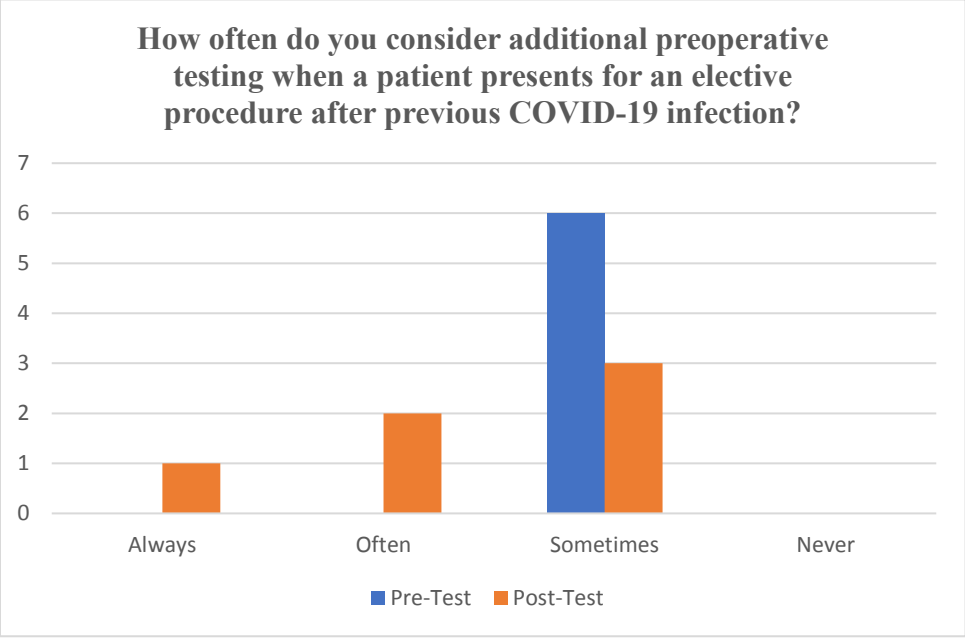

What is the recommended anesthetic technique for patients with post COVID-19 syndrome?
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
General anesthesia with an endotracheal tube
Regional anesthesia
Monitored anesthesia care (MAC)
There is no superior anesthesetic technique
Pre-Test
Post-Test

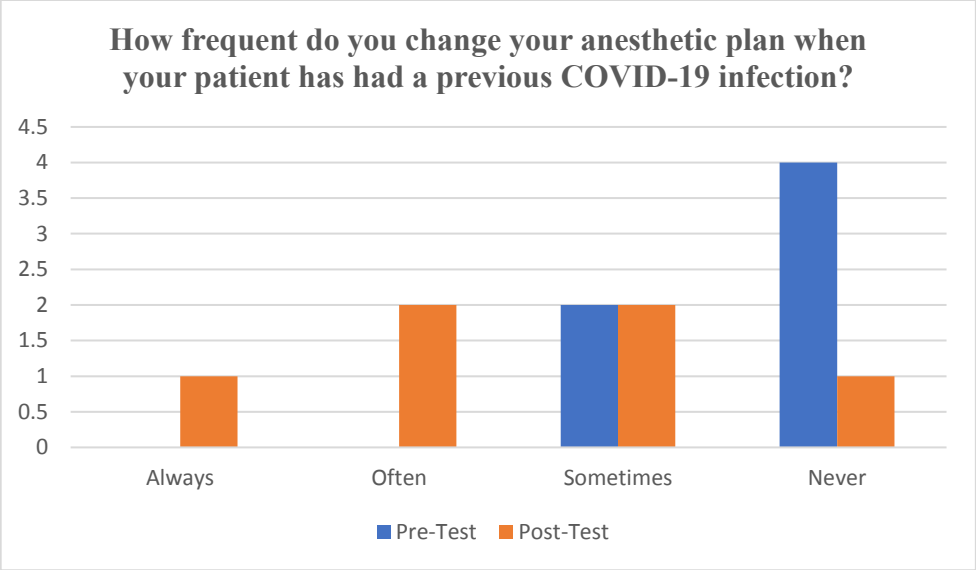

Which cardiac sequela may exist among patients who have had previous COVID-19 infection?
7
6
5
4
3
2
1
0
Left ventricuar dysfunction
Right ventricular dysfunction
Atrial enlargement
Aortic stenosis
Pre-Test
Post-Test

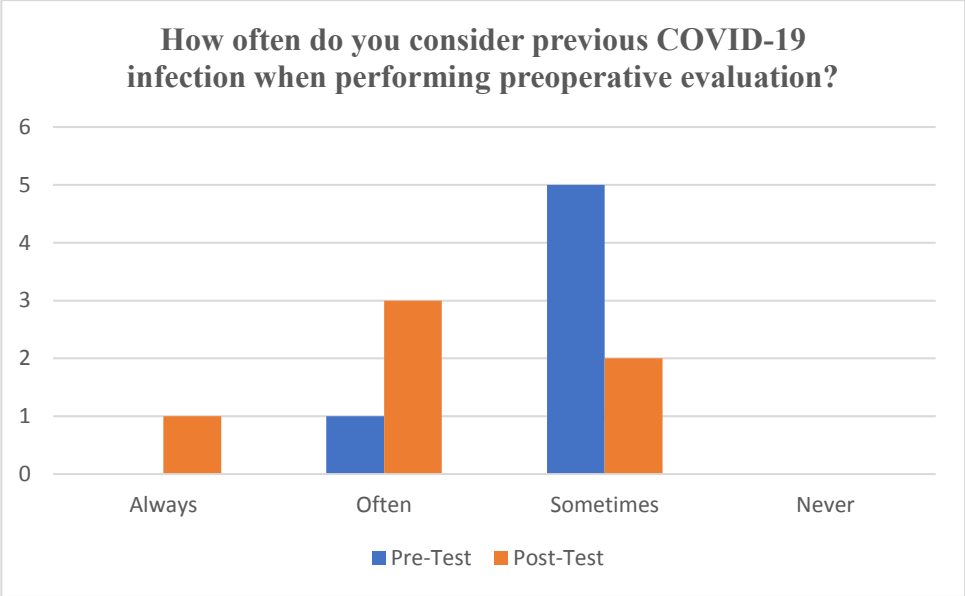

What is the most frequently associated electrocardiogram (ECG) finding in patients after COVID-19 infection?
3.5
3
2.5
2
1.5
1
0.5
0
ST depression
T wave inversion
Bundle branch block
PR depression
Pre-Test
Post-Test


Which volatile inhalational agent is the preferred inhalational gas when delivered to a patient with a history of COVID-19?
6
5
4
3
2
1
0
Isoflurane
Sevoflurane
Desflurane
All are acceptable volatile agents
Pre-Test
Post-Test


Six (6) months after COVID-19 infection, which pulmonary function test is most frequently reduced?
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Forced vital capacity (FVC)
Forced expiratory volume in one second (FEV1)
Total lung capacity
Residual volume
Pre-Test
Post-Test


How often do you consider additional preoperative testing when a patient presents for an elective procedure after previous COVID-19 infection?
7
6
5
4
3
2
1
0
Always
Often
Sometimes
Never
Pre-Test
Post-Test





Discussion

Limitations

This quality improvement project had several limitations including small sample size. Forty-two surveys were distributed via email to anesthesia providers at one location, however only 6 participants completed the pre-test, educational intervention, and post-test in its entirety. A larger, more diverse sample size would allow for a more accurate representation of the

preexisting knowledge of the anesthetic management for patients recovered from COVID-19 infection. Additionally, a larger sample size would validate the efficacy of the educational intervention. Another limitation is the time frame. Participants were allowed two weeks to complete the survey. Additional time may have allowed for an increased response rate. Lastly, it is recognized that this quality improvement project only took place at one facility. If distributed to other locations, results would more accurately reflect anesthesia providers, instead of just one community.

Future Implications for Advanced Nursing Practice

The novel Coronavirus 2019 has infected millions of patients worldwide and at one point was declared a global pandemic. Despite the new research, more patient awareness, and access to vaccinations, the virus continues to spread. Several new variants have developed since the publication of the research articles used in this quality improvement project, and more are likely to come. Residual effects of COVID-19 can be observed several months after diagnosis, affecting multisystem physiological processes. These post-COVID-19 sequela can alter the anesthetic management of these patients. As healthcare workers continue to care for patients who present with a history of COVID-19 infection, it is vital for anesthesia providers to understand possible implications as it relates to anesthetic management. As new variants of the infection continue to emerge, new guidelines will be provided. For example, the ASA and APSF joint statement was updated on June 15, 2022.[43] Within this statement, the organization recommends screening for COVID prior to presenting to healthcare facilities and canceling elective surgery for positive test results. Staying informed with current research is necessary and more research will need to be conducted to provide safe, quality care to patients.

Conclusion

As the COVID-19 virus continues to evolve, more patients are presenting for surgery with a history of COVID-19 infection. Recovery can vary patient to patient, but can have significant sequela related to post COVID-19 syndrome. Without the knowledge of associated sequela of post COVID-19 syndrome and related anesthesia implications, anesthesia providers may not be able to provide the best quality care for these patients. Therefore, it would be prudent for the anesthesia provider to take into consideration the patient's history of COVID-19 infection. Educational interventions such as this quality improvement project can effectively increase provider knowledge and the likelihood of utilizing current evidence-based research to provide safe, quality care and improve overall patient outcomes.

References

1. Organization WH. WHO Coronavirus (COVID-19) Dashboard. https://covid19.who.int/. Published 2021. Accessed September 1, 2021.
2. Bui N, Coetzer M, Schenning KJ, O'Glasser AY. Preparing previously COVID-19-positive patients for elective surgery: a framework for preoperative evaluation. *Perioperative Medicine.* 2021;10(1):1.
3. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. *Br J Surg.* 2020;107(11):1440-1449.
4. Hines RL, Marschall K. *Stoelting's Anesthesia and Co-Existing Disease.* 7th ed. ed. London: Elsevier Health Sciences; 2018.
5. Anesthesiology AAoN. Guidelines for elective surgery in patients with covid-19. . https://www.aana.com/docs/default-source/marketing-aana-com-web-documents-(all)/covid-19/2020_guidelines_for_elective_surgery_in_patents_with_covid-19.pdf?sfvrsn=5cfd8264_6. Published 2020. Accessed September 26, 2021.
6. Health NIo. COVID-19 Treatment Guidelines. In:2021.
7. Anesthesiologists ASo. American Society of Anesthesiologists and Anesthesia Patient Safety Foundation Joint Statement on Elective Surgery and Anesthesia for Patients after COVID-19 Infection https://www.asahq.org/about-asa/newsroom/news-releases/2020/12/asa-and-apsf-joint-statement-on-elective-surgery-and-anesthesia-for-patients-after-covid-19-infection. Published 2020. Updated December 8, 2020. Accessed September 4, 2021.
8. Organization WH. WHO director-General's opening remarks at the media briefing on COVID-19-11 March 2020. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020. Published 2020. Updated 2021. Accessed September 5, 2021.
9. Moreno-Pérez O, Merino E, Leon-Ramirez J-M, et al. Post-acute COVID-19 syndrome. Incidence and risk factors: A Mediterranean cohort study. *J Infect.* 2021;82(3):378-383.
10. El-Boghdadly K, Cook TM, Goodacre T, et al. SARS-CoV-2 infection, COVID-19 and timing of elective surgery: A multidisciplinary consensus statement on behalf of the Association of Anaesthetists, the Centre for Peri-operative Care, the Federation of Surgical Specialty Associations, the Royal College of Anaesthetists and the Royal College of Surgeons of England. *Anaesthesia.* 2021;76(7):940-946.
11. Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study. *Lancet.* 2020;396(10243):27-38.
12. Delaying surgery for patients with a previous SARS-CoV-2 infection. *Br J Surg.* 2020;107(12):e601-e602.
13. Zhao YM, Shang YM, Song WB, et al. Follow-up study of the pulmonary function and related physiological characteristics of COVID-19 survivors three months after recovery. *EClinicalMedicine.* 2020;25:100463.
14. Reddi BAJ, Johnston SD, Bart S, Chan JCY, Finnis M, Reddi BA. Abnormal pulmonary function tests are associated with prolonged ventilation and risk of complications following elective cardiac surgery. *Anaesthesia & Intensive Care.* 2019;47(6):510-515.
15. Hoyler MM, White RS, Tam CW, Thalappillil R. Anesthesia and the "post-COVID syndrome": Perioperative considerations for patients with prior SARS-CoV-2 infection. In. Vol 72. Philadelphia, Pennsylvania: Elsevier B.V.; 2021:N.PAG-N.PAG.

16. Oesterreich S, Cywinski JB, Elo B, Geube M, Mathur P. Quality improvement during the COVID-19 pandemic. *Cleveland Clinic Journal of Medicine.* 2020.
17. Frija-Masson J, Debray M-P, Gilbert M, et al. Functional characteristics of patients with SARS-CoV-2 pneumonia at 30 days post-infection. *European Respiratory Journal.* 2020;56(2):2001754.
18. Huang C, Huang L, Wang Y, et al. 6-month consequences of COVID-19 in patients discharged from hospital: a cohort study. *The Lancet.* 2021;397(10270):220-232.
19. Raman B, Cassar MP, Tunnicliffe EM, et al. Medium-term effects of SARS-CoV-2 infection on multiple vital organs, exercise capacity, cognition, quality of life and mental health, post-hospital discharge. *EClinicalMedicine.* 2021;31:100683.
20. Ding X, Xu J, Zhou J, Long Q. Chest CT findings of COVID-19 pneumonia by duration of symptoms. *Eur J Radiol.* 2020;127:109009.
21. Taylor RR, Trivedi B, Patel N, et al. Post-COVID symptoms reported at asynchronous virtual review and stratified follow-up after COVID-19 pneumonia. *Clinical Medicine.* 2021;21(4):e384-e391.
22. D'Cruz RF, Waller MD, Perrin F, et al. Chest radiography is a poor predictor of respiratory symptoms and functional impairment in survivors of severe COVID-19 pneumonia. *ERJ Open Res.* 2021;7(1):00655-02020.
23. Madjid M, Safavi-Naeini P, Solomon SD, Vardeny O. Potential Effects of Coronaviruses on the Cardiovascular System: A Review. *JAMA Cardiology.* 2020;5(7):831-840.
24. Huang L, Zhao P, Tang D, et al. Cardiac Involvement in Patients Recovered From COVID-2019 Identified Using Magnetic Resonance Imaging. *JACC Cardiovasc Imaging.* 2020;13(11):2330-2339.
25. Puntmann VO, Carerj ML, Wieters I, et al. Outcomes of Cardiovascular Magnetic Resonance Imaging in Patients Recently Recovered From Coronavirus Disease 2019 (COVID-19). *JAMA Cardiology.* 2020;5(11):1265-1273.
26. Eiros R, Barreiro-Perez M, Martin-Garcia A, et al. Pericarditis and myocarditis long after SARS-CoV-2 infection: a cross-sectional descriptive study in health-care workers. *medRxiv.* 2020:2020.2007.2012.20151316.
27. Fayol A, Livrozet M, Boutouyrie P, et al. Cardiac performance in patients hospitalized with COVID-19: a 6 month follow-up study. *ESC Heart Failure.* 2021;8(3):2232-2239.
28. Korompoki E, Gavriatopoulou M, Hicklen RS, et al. Epidemiology and organ specific sequelae of post-acute COVID19: A narrative review. *Journal of Infection.* 2021;83(1):1-16.
29. Camargo-Martínez W, Lozada-Martínez I, Escobar-Collazos A, et al. Post-COVID 19 neurological syndrome: Implications for sequelae's treatment. *Journal of Clinical Neuroscience.* 2021;88:219-225.
30. Carfì A, Bernabei R, Landi F, Group ftGAC-P-ACS. Persistent Symptoms in Patients After Acute COVID-19. *JAMA.* 2020;324(6):603-605.
31. Lu Y, Li X, Geng D, et al. Cerebral Micro-Structural Changes in COVID-19 Patients – An MRI-based 3-month Follow-up Study. *EClinicalMedicine.* 2020;25:100484.
32. Cellai M, O'Keefe JB. Characterization of Prolonged COVID-19 Symptoms in an Outpatient Telemedicine Clinic. *Open Forum Infect Dis.* 2020;7(10):ofaa420-ofaa420.
33. Pal R, Banerjee M. COVID-19 and the endocrine system: exploring the unexplored. *J Endocrinol Invest.* 2020;43(7):1027-1031.

34. Chen M. ZW, Xu W. Thyroid Function Analysis in 50 Patients with COVID-19: A Retrospective Study. *Thyroid.* 2021;31(1):8-11.
35. Pizzini A, Aichner M, Sahanic S, et al. Impact of Vitamin D Deficiency on COVID-19—A Prospective Analysis from the CovILD Registry. *Nutrients.* 2020;12(9):2775.
36. Mazza MG, De Lorenzo R, Conte C, et al. Anxiety and depression in COVID-19 survivors: Role of inflammatory and clinical predictors. *Brain, Behavior, and Immunity.* 2020;89:594-600.
37. Taquet M, Luciano S, Geddes JR, Harrison PJ. Bidirectional associations between COVID-19 and psychiatric disorder: retrospective cohort studies of 62 354 COVID-19 cases in the USA. *The Lancet Psychiatry.* 2021;8(2):130-140.
38. Pollard MS, Tucker JS, Green HD, Jr. Changes in Adult Alcohol Use and Consequences During the COVID-19 Pandemic in the US. *JAMA Network Open.* 2020;3(9):e2022942-e2022942.
39. Wajekar AS, Solanki SL, Divatia JV. Pre-Anesthesia Re-Evaluation in Post COVID-19 Patients Posted for Elective Surgeries: an Online, Cross-Sectional Survey. *Indian J Surg Oncol.* 2021:1-6.
40. Malhotra N, Bajwa SJS, Joshi M, et al. Perioperative management of post-COVID-19 surgical patients: Indian Society of Anaesthesiologists (ISA National) Advisory and Position Statement. *Indian J Anaesth.* 2021;65(7):499-507.
41. Kovoor JG, Scott NA, Tivey DR, et al. Proposed delay for safe surgery after COVID-19. *ANZ Journal of Surgery.* 2021;91(4):495-506.
42. Zaccagnini ME, White KW. *The doctor of nursing practice essentials: a new model for advanced practice nursing.* Third edition. ed. Burlington, Massachusetts: Jones & Bartlett Learning; 2017.
43. Foundation. ASoAAPS. ASA and APSF Statement on Perioperative Testing for the COVID-19 Virus. https://www.asahq.org/about-asa/newsroom/news-releases/2022/06/asa-apsf-statement-on-perioperative-testing-for-covid. Published 2022. Updated June 15, 2022. Accessed.

Appendix A: IRB Exemption

FIU | FLORIDA INTERNATIONAL UNIVERSITY

Office of Research Integrity
Research Compliance, MARC 414

MEMORANDUM

To:	Dr. Jorge Valdes
CC:	Joseph Benson
From:	Elizabeth Juhasz, Ph.D., IRB Coordinator EJ
Date:	March 23, 2022
Protocol Title:	**"Anesthetic management of patients with post covid-19 syndrome: a quality improvement project"**

The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

IRB Protocol Exemption #:	IRB-22-0097	**IRB Exemption Date:**	03/23/22
TOPAZ Reference #:	111574		

As a requirement of IRB Exemption you are required to:

1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
3) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A

For further information, you may visit the IRB website at http://research.fiu.edu/irb.

EJ

Appendix B: QI Project Consent

FIU | FLORIDA INTERNATIONAL UNIVERSITY

CONSENT TO PARTICIPATE IN A QUALITY IMPROVEMENT PROJECT

"Anesthetic Management of Patients with Post COVID-19 Syndrome"

SUMMARY INFORMATION
Things you should know about this study:

- **Purpose:** Educational module concerning the anesthetic management of patients who have recovered from COVID-19 infection.
- **Procedures**: Participate in a pre-test, view an Educational Module via voice over PowerPoint, then participate in a post test
- **Duration:** This will take about a total of 20 minutes.
- **Risks**: The main risk or discomfort from this research is minimal
- **Benefits:** The main benefit to you from this research is increase the participant's knowledge on perioperative management of patients recovered from COVID-19 and anesthetic implications.
- **Alternatives:** There are no known alternatives available to you other than not taking part in this study.
- **Participation:** Taking part in this research project is voluntary.

Please carefully read the entire document before agreeing to participate.

PURPOSE OF THE PROJECT

The goal of this project is to improve health care provider knowledge on anesthetic implications throughout the perioperative period for patients who have recovered from COVID-19. You are being asked to participate in this quality improvement project

DURATION OF THE PROJECT

Your participation will require about 20 minutes of your time, you will be one of 10 people in this study

PROCEDURES

If you agree to be in the project, we will ask you to do the following things: Participate in a pretest view, an Educational Module via voice over PowerPoint, then participate in a post test.

RISKS AND/OR DISCOMFORTS

Minimal risk, risk not greater than if participant was conducting similar activity. Physical, psychological, social, legal, and economic risks minimal and no greater than if a participant was participating in a similar activity. Similar activity such as filling out an online survey and watching voice over PowerPoint.

BENEFITS

The following benefits with your participation in this project: An increase in your knowledge of post COVID-19 syndrome and related anesthetic implications throughout the perioperative period.

ALTERNATIVES

There are no known alternatives available to you other than not taking part in this project. However, if you would like to receive the educational material given to the participants in this project, it will be provided to you at no cost.

CONFIDENTIALITY

The records of this project will be kept private and will be protected to the fullest extent provided by law. If, in any sort of report, we might publish, we will not include any information that will make it possible to identify you as a participant. Records will be stored securely, and only the project team will have access to the records.

PARTICIPATION: Taking part in this research project is voluntary.

COMPENSATION & COSTS

There is no cost or payment to you for receiving the health education and/or for participating in this project.

RIGHT TO DECLINE OR WITHDRAW

Your participation in this project is voluntary. You are free to participate in the project or withdraw your consent at any time during the project. Your withdrawal or lack of participation will not affect any benefits to which you are otherwise entitled. The investigator reserves the right to remove you without your consent at such time that they feel it is in the best interest.

RESEARCHER CONTACT INFORMATION

If you have any questions about the purpose, procedures, or any other issues relating to this

research project, you may contact Joseph Benson at 630-636-1720, Jbens031@fiu.eduj or Dr. Jorge Valdes at 305-348-7729/jvalde@fiu.edu.

IRB CONTACT INFORMATION

If you would like to talk with someone about your rights pertaining to being a subject in this project or about ethical issues with this project, you may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

PARTICIPANT AGREEMENT

I have read the information in this consent form and agree to participate in this study. I have had a chance to ask any questions I have about this study, and they have been answered for me. By clicking on the "consent to participate" button below I am providing my informed consent.

Appendix C: Recruitment Letter

Anesthetic Management of Patients with Post COVID-19 Syndrome: A Quality Improvement Project

Dear Memorial Regional Envision anesthesia provider,

My name is Joseph Benson, and I am a student from the Anesthesiology Nursing Program Department of Nurse Anesthetist Practice at Florida International University. I am writing to invite you to participate in my quality improvement project. The goal of this project is to improve health care provider knowledge on anesthetic implications throughout the perioperative period for patients who have recovered from COVID-19. You are eligible to take part in this project because you are an anesthesia provider at Memorial Regional Hospital.

If you decide to participate in this project, you will be asked to complete and sign a consent form for participation. Next, you will complete a pre-test questionnaire, which is expected to take approximately 5 minutes. You will then be asked to view an approximately 15 minute long educational presentation online. After watching the video, you will be asked to complete the post-test questionnaire, which is expected to take approximately 5 minutes. No compensation will be provided.

Remember, this is completely voluntary. You can choose to be in the study or not. If you'd like to participate or have any questions about the study, please email or contact me at jbens031@fiu.edu or 630-636-1720.

Thank you very much.

Sincerely,

Joseph Benson

Appendix D: Letter of Support

Envision

PHYSICIAN SERVICES

February 1, 2022

Jorge A. Valdes, DNP, CRNA, APRN
Clinical Associate Professor,
Department of Nurse Anesthesiology
Florida International University

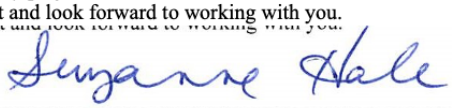
Dr. Valdes,

Thank you for inviting Memorial Regional to participate in the Doctor of Nursing Practice (DNP) project conducted by Joseph Benson entitled "Educational Module on Anesthetic Management of Patients with Post COVID-19 Syndrome." in the Nicole Wertheim College of Nursing and Health Sciences, Department of Nurse Anesthetist Practice at Florida International University. I have warranted his permission to conduct the project using our providers.

Evidence-based practice's primary aim is to yield the best outcomes for patients by selecting interventions supported by the evidence. This project intends to evaluate if a structured education targeting providers will increase knowledge on the Anesthetic Management of Patients with Post COVID-19 Syndrome.

We understand that participation in the study is voluntary and carries no overt risk. All Anesthesiology providers are free to participate or withdraw from the study at any time. The educational intervention will be conveyed by a 15-minute virtual PowerPoint presentation, with a pretest and posttest questionnaire delivered by a URL link electronically via Qualtrics, an online survey product. Responses to pretest and posttest surveys are not linked to any participant. The collected information is reported as an aggregate, and there is no monetary compensation for participation. All collected material will be kept confidential, stored in a password-encrypted digital cloud, and only be accessible to the investigators of this study: Joseph Benson and Dr. Valdes. We expect that Joseph Benson will not interfere with normal hospital performance, behave in a professional manner, and follow standards of care.

Prior to the implementation of this educational project, the Florida International University Institutional Review Board will evaluate and approve the procedures to conduct this project. Once the Institutional Review Board's approval is achieved, this scholarly project's execution will occur over two weeks. We support the participation of our Anesthesiology providers in this project and look forward to working with you.



Suzanne Hale, MSN, CRNA, ARNP
Advanced Practice Provider Director, Broward and Dade
Chief, Memorial Regional Hospital
Envision Physician Services
954-265-2044 3501 Johnson Street I Hollywood, FL 33021

Appendix E: Pretest and Posttest Questionnaire

Pretest and Posttest Questionnaire:

Anesthetic Management of Patients with Post COVID-19 Syndrome

INTRODUCTION

The primary aim of this QI project is to improve the knowledge of on anesthetic implications throughout the perioperative period for patients who have recovered from COVID-19.

Please answer the question below to the best of your ability. The questions are either in multiple choice or true/false format. These questions are meant to measure knowledge and perceptions on identification, referral, management, and patient education on patients recovered from post COVID-19.

PERSONAL INFORMATION

1. Gender
    a. Male
    b. Female
    c. Non-binary
    d. Prefer not to answer
2. Age in years
    a. 25-35
    b. 36-45
    c. 46-55
    d. 56-65
    e. > 65
3. Ethnicity:
    a. Hispanic
    b. Caucasian (non-Hispanic)
    c. African American
    d. Asian
    e. Other

4. Position/Title
    a. Certified Registered Nurse Anesthetist
    b. MD anesthesia
5. Highest level of education
    a. Associates
    b. Bachelors
    c. Masters
    d. Doctorate
    e. Other
6. Years of practice as an anesthesia provider
    a. Less than 5
    b. 5-10
    c. 10-15
    d. Greater than

QUESTIONNAIRE

A preoperative chest X-ray is recommended for which American Society of Anesthesiologist Physical Status (ASAPS) when a patient has a history of COVID-19 infection?

e. I
f. II
g. III
h. IV or higher

1. After an asymptomatic COVID-19 infection, what is the recommended length of time an elective procedure should be performed?
    a. 2 weeks
    b. 4 weeks
    c. 6 weeks
    d. 8 weeks or greater

2. What is the recommended induction agent for patients with post COVID-19 syndrome?
    a. High dose opioid induction
    b. Ketamine
    c. Inhalational
    d. Propofol or Etomidate

3. What is the preferred neuromuscular blocker for patients with COVID-19 syndrome?
    a. There is no superior neuromuscular blocker
    b. Cisatracurium
    c. Rocuronium
    d. Vecuronium

4. What is the recommended anesthetic technique for patients with post COVID-19 syndrome?

a. General anesthesia with an endotracheal tube
b. Regional anesthesia
c. Monitored anesthesia care (MAC)
d. There is no superior anesthetic technique

5. Which cardiac sequela may exist among patients who have had previous COVID-19 infection?
a. Left ventricular dysfunction
b. Right ventricular dysfunction
c. Atrial enlargement
d. Aortic stenosis

6. What is the most frequently associated electrocardiogram (ECG) finding in patients after COVID-19 infection?
a. ST depression
b. T wave inversion
c. Bundle branch block
d. PR depression.

7. Which volatile inhalational agent is the preferred inhalational gas when delivered to a patient with a history of COVID-19?
a. Isoflurane
b. Sevoflurane
c. Desflurane
d. All are acceptable volatile agents

8. Six (6) months after COVID-19 infection, which pulmonary function test is most frequently reduced (<80% predicted)?
a. Forced vital capacity (FVC)
b. Forced expiratory volume in one second ($FEV_{1)}$
c. Total lung capacity (TLC)
d. Residual volume (RV)

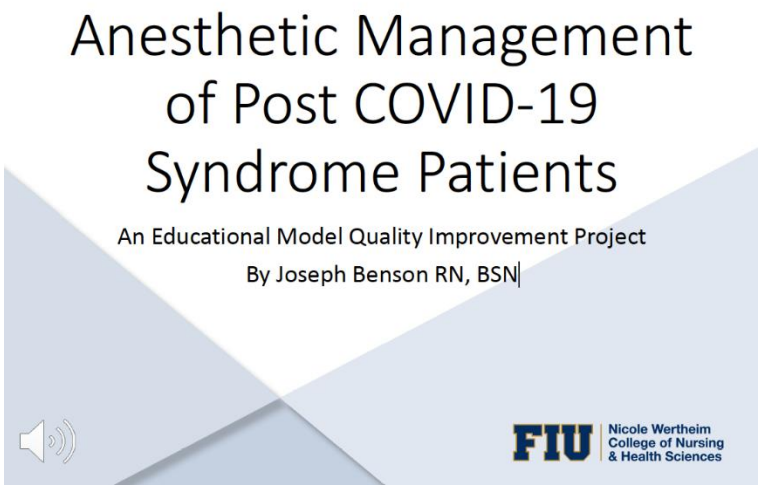
9. How often do you consider additional preoperative testing when a patient presents for an elective procedure after previous COVID-19 infection?
a. Always
b. Often
c. Sometimes
d. Never

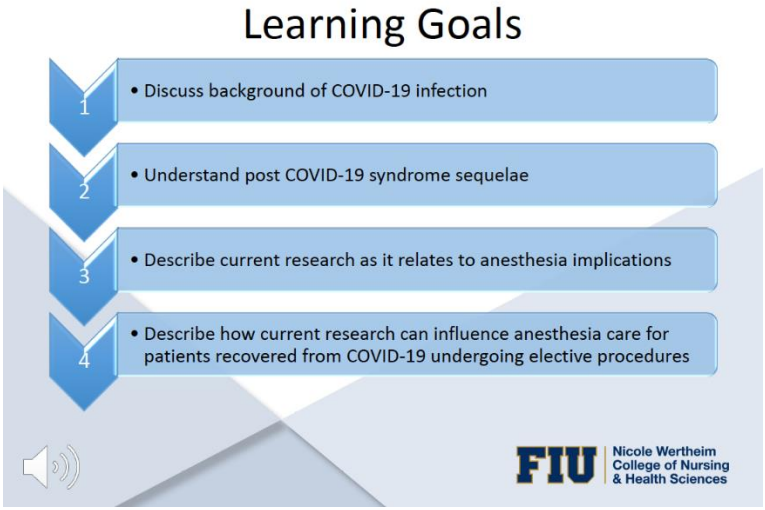
10. How frequent do you change your anesthetic plan when your patient has had a previous COVID-19 infection?
a. Always
b. Often
c. Sometimes
d. Never

11. How often do you to consider previous COVID-19 infection when performing preoperative evaluation?

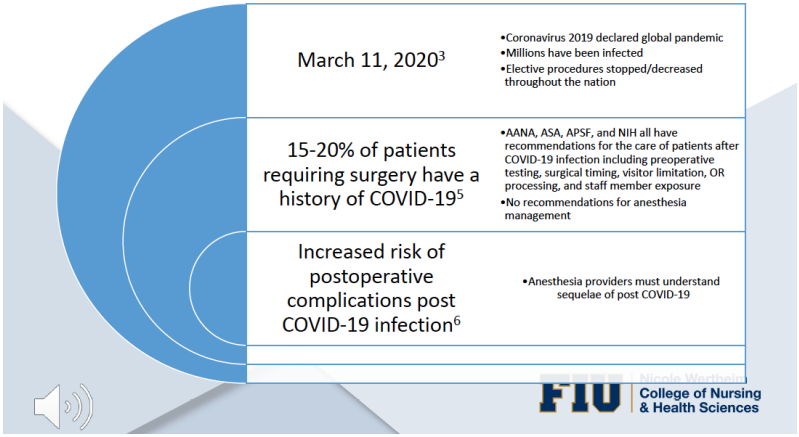
a. Always
b. Often
c. Sometimes
d. Never

Appendix F: QI Educational Module





Background


March 11, 2020[3]
•Coronavirus 2019 declared global pandemic
•Millions have been infected
•Elective procedures stopped/decreased throughout the nation
15-20% of patients requiring surgery have a history of COVID-19[5]
•AANA, ASA, APSF, and NIH all have recommendations for the care of patients after COVID-19 infection including preoperative testing, surgical timing, visitor limitation, OR processing, and staff member exposure
•No recommendations for anesthesia management
Increased risk of postoperative complications post COVID-19 infection[6]
•Anesthesia providers must understand sequelae of post COVID-19
FIU College of Nursing & Health Sciences

Post COVID-19 syndrome Sequela

Pulmonary system [4,7,9-14]

- Both obstructive and restrictive disease exists
- Spirometry demonstrates decreased TLC, FEV_1, FVC, FEV_1/FVC, FRC, RV (Most frequently)
- Ground glass opacities, interstitial thickening, crazy paving observed on CT up to 6 months after infection
- Chest X-ray determined to be poor indicator of pulmonary function[4-11]

FIU Nicole Wertheim College of Nursing & Health Sciences

Post COVID-19 syndrome Sequela

Cardiovascular system[10,11,15-18]

- Pt reports of chest pain, chest distress, and palpitations in 12%, 23%, and 88% respectively
- Myocardial edema was detected in 54% of patients an average of 47 days post infection
- Recovered COVID-19 patients exhibit decreased RV dysfunction
- Myocardial inflammation was identified in 60% of patients recovered from COVID-19.
- EKG abnormalities included bundle branch block, intraventricular conduction delay, ST-segment depression or T-wave inversion, ST-segment elevation, and PR-segment depression (most common)

FIU Nicole Wertheim College of Nursing & Health Sciences

Post COVID-19 syndrome Sequela

Neurological system[4,10,11,13,19-22]

- Pt reports of headache, memory loss, sleep disturbance, loss of taste or smell, and musculoskeletal weakness are the most common
- MRI 3 months after infection show increased bilateral gray matter volume in olfactory, hippocampi, insulas, left Rolandic operculum, left Heschl's gyrus, and right cingulate gyrus.
- Decrease of mean, axial, and radial diffusivity, and an increase of fractional anisotropy in white matter.

Renal system[10,11]

- COVID-19 virus has a high affinity for the Angiotensin-converting enzyme 2, which is heavily present in the proximal tubules of the kidney, leading to cytotoxicity and inflammation.
- Decreased estimated glomerular filtration rate (eGFR) in 13% of patients 6 months after diagnosis.
- 3% of patients who experienced acute kidney injury secondary to the viral infection continued to have renal impairment 3 months after discharge.

FIU Nicole Wertheim College of Nursing & Health Sciences

Post COVID-19 syndrome Sequela

Endocrine system[19,23,24]

- Decreased TSH and T3 levels. A positive correlation existed between the decrease in TSH and T3 and the severity of COVID-19.
- These thyroid function laboratory values returned to normal levels 3 months after recovery.
- 8 weeks after onset of COVID-19, vitamin D deficiency , Parathyroid hormone was increased in 13% of patients.
- 3% of patients were newly diagnosed with DM 6 months after COVID-19 infection.

Mental Health[10,11,25-27]

- 1 month after infection, patients self-reported mental health disorders including post-traumatic stress disorder (PTSD), depression, anxiety, insomnia, and obsessive-compulsive behavior 28%, 31%, 42%, 40%, 20% respectively
- Adult alcohol consumption increased 14% from 2019 to 2020

FIU Nicole Wertheim College of Nursing & Health Sciences

Anesthesia implications[1,2,5,8,29-30]

Preoperative testing

- CBC, coagulation profile, EKG, and electrolytes
- Chest X-ray for ASA II or higher
- Chest CT, PFTs, arterial blood gases, and echocardiograms, were only recommended for patients of moderate/severe hypoxia, presence of cardiac symptoms, geriatric, or major abdominal, thoracic, cardiac, or vascular surgery

Timing of surgery

- Increased morbidity and mortality associated with surgery within 7 weeks of COVID-19 infection
- ASA and APSF joint statement, a delay in elective procedures is recommended in asymptomatic, symptomatic, hospitalized, or admitted to intensive care units for 4, 6, 8-10, or 12 weeks respectively

FIU Nicole Wertheim College of Nursing & Health Sciences

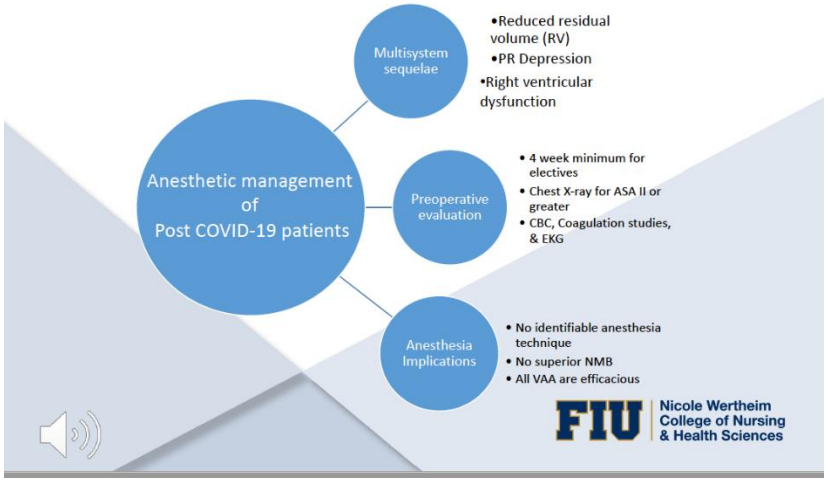
Anesthesia implications

Anesthetic delivery

- No superior anesthetic technique determined
- If neurological symptoms present (neuropathy, loss of taste, or loss of smell) the anesthesia provider should apply anesthetic techniques similar to other neuromuscular disorders. Cautious administration of opioid and neuromuscular blockers, as well as avoidance of regional anesthesia
- ISA advocates for the use of regional anesthesia over general anesthesia, given the decreased pulmonary reserves detected
- Propofol or Etomidate safe
- Volatile inhalational agents (Des, Iso, Sevo) all acceptable
- Neuromuscular blockade be accomplished with the administration of cisatracurium, atracurium, vecuronium, rocuronium, or succinylcholine.

FIU Nicole Wertheim College of Nursing & Health Sciences

Take Home Points



FIU Nicole Wertheim College of Nursing & Health Sciences

References

1) Bui N, Coetzer M, Schenning KJ, O'Glasser AY. Preparing previously COVID-19-positive patients for elective surgery: a framework for preoperative evaluation. *Perioperative Medicine*. 2021;10(1):1.

2) Anesthesiologists ASo. American Society of Anesthesiologists and Anesthesia Patient Safety Foundation Joint Statement on Elective Surgery and Anesthesia for Patients after COVID-19 Infection https://www.asahq.org/about-asa/newsroom/news-releases/2020/12/asa-and-apsf-joint-statement-on-elective-surgery-and-anesthesia-for-patients-after-covid-19-infection. Published 2020. Updated December 8, 2020. Accessed September 4, 2021.

3) Organization WH. WHO director-General's opening remarks at the media briefing on COVID-19-11 March 2020. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020. Published 2020. Updated 2021. Accessed September 5, 2021.

4) Moreno-Pérez O, Merino E, Leon-Ramirez J-M, et al. Post-acute COVID-19 syndrome. Incidence and risk factors: A Mediterranean cohort study. *J Infect*. 2021;82(3):378-383.

5) El-Boghdadly K, Cook TM, Goodacre T, et al. SARS-CoV-2 infection, COVID-19 and timing of elective surgery: A multidisciplinary consensus statement on behalf of the Association of Anaesthetists, the Centre for Peri-operative Care, the Federation of Surgical Specialty Associations, the Royal College of Anaesthetists and the Royal College of Surgeons of England. *Anaesthesia*. 2021;76(7):940-946.

6) Delaying surgery for patients with a previous SARS-CoV-2 infection. *Br J Surg*. 2020;107(12):e601-e602.

7)) Zhao YM, Shang YM, Song WB, et al. Follow-up study of the pulmonary function and related physiological characteristics of COVID-19 survivors three months after recovery. *EClinicalMedicine*. 2020;25:100463.

8) Hoyler MM, White RS, Tam CW, Thalappillil R. Anesthesia and the "post-COVID syndrome": Perioperative considerations for patients with prior SARS-CoV-2 infection. In. Vol 72. Philadelphia, Pennsylvania: Elsevier B.V., 2021:N.PAG-N.PAG.

9) Frija-Masson J, Debray M-P, Gilbert M, et al. Functional characteristics of patients with SARS-CoV-2 pneumonia at 30 days post-infection. *European Respiratory Journal*. 2020;56(2):2001754.

10) Huang C, Huang L, Wang Y, et al. 6-month consequences of COVID-19 in patients discharged from hospital: a cohort study. *The Lancet*. 2021;397(10270):220-232.

11) Raman B, Cassar MP, Tunnicliffe EM, et al. Medium-term effects of SARS-CoV-2 infection on multiple vital organs, exercise capacity, cognition, quality of life and mental health, post-hospital discharge. *EClinicalMedicine*. 2021;31:100683.

12) Ding X, Xu J, Zhou J, Long Q. Chest CT findings of COVID-19 pneumonia by duration of symptoms. *Eur J Radiol*. 2020;127:109009.

13) Taylor RR, Trivedi B, Patel N, et al. Post-COVID symptoms reported at asynchronous virtual review and stratified follow-up after COVID-19 pneumonia. *Clinical Medicine*. 2021;21(4):e384-e391.

FIU | Nicole Wertheim College of Nursing & Health Sciences

References

14) D'Cruz RF, Waller MD, Perrin F, et al. Chest radiography is a poor predictor of respiratory symptoms and functional impairment in survivors of severe COVID-19 pneumonia. *ERJ Open Res*. 2021;7(1):00655-02020.

15) Huang L, Zhao P, Tang D, et al. Cardiac Involvement in Patients Recovered From COVID-2019 Identified Using Magnetic Resonance Imaging. *JACC Cardiovasc Imaging*. 2020;13(11):2330-2339.

16) Puntmann VO, Carerj ML, Wieters I, et al. Outcomes of Cardiovascular Magnetic Resonance Imaging in Patients Recently Recovered From Coronavirus Disease 2019 (COVID-19). *JAMA Cardiology*. 2020;5(11):1265-1273.

17) Eiros R, Barreiro-Perez M, Martin-Garcia A, et al. Pericarditis and myocarditis long after SARS-CoV-2 infection: a cross-sectional descriptive study in health-care workers. *medRxiv*. 2020:2020.2007.2012.20151316.

18) Fayol A, Livrozet M, Boutouyrie P, et al. Cardiac performance in patients hospitalized with COVID-19: a 6 month follow-up study. *ESC Heart Failure*. 2021;8(3):2232-2239.

19) Korompoki E, Gavriatopoulou M, Hicklen RS, et al. Epidemiology and organ specific sequelae of post-acute COVID19: A narrative review. *Journal of Infection*. 2021;83(1):1-16.

20) Camargo-Martínez W, Lozada-Martínez I, Escobar-Collazos A, et al. Post-COVID 19 neurological syndrome: Implications for sequelae's treatment. *Journal of Clinical Neuroscience*. 2021;88:219-225.

21) Carfì A, Bernabei R, Landi F, Group ftGAC-P-ACS. Persistent Symptoms in Patients After Acute COVID-19. *JAMA*. 2020;324(6):603-605.

22) Lu Y, Li X, Geng D, et al. Cerebral Micro-Structural Changes in COVID-19 Patients – An MRI-based 3-month Follow-up Study. *EClinicalMedicine*. 2020;25:100484.

23) Chen M. ZW, Xu W. Thyroid Function Analysis in 50 Patients with COVID-19: A Retrospective Study. *Thyroid*. 2021;31(1):8-11.

24) Pizzini A, Aichner M, Sahanic S, et al. Impact of Vitamin D Deficiency on COVID-19—A Prospective Analysis from the CovILD Registry. *Nutrients*. 2020;12(9):2775.

25) Mazza MG, De Lorenzo R, Conte C, et al. Anxiety and depression in COVID-19 survivors: Role of inflammatory and clinical predictors. *Brain, Behavior, and Immunity*. 2020;89:594-600.

26) Taquet M, Luciano S, Geddes JR, Harrison PJ. Bidirectional associations between COVID-19 and psychiatric disorder: retrospective cohort studies of 62 354 COVID-19 cases in the USA. *The Lancet Psychiatry*. 2021;8(2):130-140.

27) Pollard MS, Tucker JS, Green HD, Jr. Changes in Adult Alcohol Use and Consequences During the COVID-19 Pandemic in the US. *JAMA Network Open*. 2020;3(9):e2022942-e2022942.

28) Wajekar AS, Solanki SL, Divatia JV. Pre-Anesthesia Re-Evaluation in Post COVID-19 Patients Posted for Elective Surgeries: an Online, Cross-Sectional Survey. *Indian J Surg Oncol*. 2021:1-6.

29) Malhotra N, Bajwa SJS, Joshi M, et al. Perioperative management of post-COVID-19 surgical patients: Indian Society of Anaesthesiologists (ISA National) Advisory and Position Statement. *Indian J Anaesth*. 2021;65(7):499-507.

30) Kovoor JG, Scott NA, Tivey DR, et al. Proposed delay for safe surgery after COVID-19. *ANZ Journal of Surgery*. 2021;91(4):495-506.

FIU | Nicole Wertheim College of Nursing & Health Sciences

Table 2. Overview of Literature Review Results

Authors	Research Design (Sample size)	Timing after COVID-19	Findings
Frija-Masson et al.[17]	Retrospective study (n = 50)	30 days after onset	>50% display abnormal lung function
Zhao et al.[13]	Retrospective study (n = 55)	3 moths after discharge	Decreased PFTs Abnormal radiologic results
Huang et al.[18]	Ambidirectional cohort study (n = 390)	6 months	Decreased PFTs Abnormal CT results Patients report chest pain (5%) and palpitations (9%) 6 months after diagnosis patients report Muscle weakness 63% Headache 2% Sleep difficulty 26% Smell disorder 11% 13% of patients experience decreased GFR Increased anxiety or depression
Raman et al.[19]	Observational (n = 58)	2-3 months	64% of patients reported breathlessness 60% showed MRI lung abnormalities No increase in cardiac biomarkers MRI changes in thalamus, posterior thalamic radiations, and sagittal stratum 29% of patients have renal inflammation MRI shows hepatic fibro-inflammation in 10% of patients Increased depression, anxiety, and reduced quality of life
Huang et al.[24]	Retrospective observational study (n= 26)	1-2 months	Abnormal Cardiac magnetic resonance imaging evidenced as myocardial edema
Moreno-Pérez et al.[9]	Prospective Cohort study (n = 277)	77 days after disease onset	Decreased PFTs Radiological abnormalities Headache, memory disorder or cognitive deterioration present in 11.9% of patients
Puntmann et al.[25]	Prospective observational study (n= 100)	71 days	78% of patients had cardiac involvement identified on Cardiac magnetic resonance
Ding et al.[20]	Retrospective (n = 112)	6 different stages after onset (0->28 days)	CT abnormalities rapidly evolved, and 98% remained at 28 days
Eiros et al.[26]	Observational cohort study (n=139)	10 weeks	Pericarditis and myocarditis present in asymptomatic patients
Fayol et al.[27]	Prospective cohort study (n= 48)	6 months	Cardiac diastolic abnormalities observed on echocardiogram

Taylor et al.[21]	Online/telephone questionnaire and follow up chest X-ray (n = 675)	12 weeks after discharge	Chest X-ray showed resolution in 69% of high-risk patients and 83% of low-risk patients Difficulty reported in sleep, memory, concentration, musculoskeletal taste and smell reported in 19-36% of patients 13% report GI symptoms
Korompoki et al. [28]	Literature review	N/A	CNS and PNS effects may be related to prolonged ICU stay, sepsis, and medications. Recommendation of Liver function test and abdominal imaging during evaluation Long term effects on DM is limited, Covid treatment may cause hyperglycemia
D'Cruz et al.[22]	Prospective observational cohort study (n = 119)	61 days	Chest X-ray poor indication of recovery
Camargo-Martínez et al. [29]	Non-systematic review		Case reports of Guillain-Barre syndrome, status epilepticus, and cerebrovascular accidents
Carfì et al.[30]	Prospective study (n= 143)	60 days after onset	Patient report headache on follow up survey
Lu et al.[31]	Prospective study (n= 60)	3 months	55% of patients showed neurological symptoms on MRI
Cellai et al.[32]	Chart review (n= 26)	Greater than 6 weeks	34.6% reported nausea, diarrhea, abdominal pain, and anorexia
Chen et al.[34]	Retrospective study (n= 50)	3 months	64% of patients had abnormal thyroid function
Pizzini et al.[35]	Prospective, observational study (n= 109)	8 weeks	Decreased vitamin D and increased PTH
Mazza et al.[36]	Prospective cohort study (n = 402)	30 days	Self-report of PTSD, depression, anxiety, and obsession compulsion
Taquet et al.[37]	Electronic health record cohort study (n = 62354)	14-90 days	Covid-19 survivors are at increased risk of psychiatric sequela such as anxiety and mood disorders
Pollard et al.[38]	Survey (n = 1540)	N/A	Increased alcohol consumption with onset of pandemic
Wajekar et al.[39]	Cross sectional survey (n= 154)	N/A	Varied preoperative assessments
Malhotra et al.[40] (ISA advisory and position statement)	N/A	N/A	Recommended anesthesia management
El-Boghdadly et al.[10]	Multidisciplinary consensus statement	N/A	Delay elective surgery >7 weeks
American Society of Anesthesiologists and	Position statement	N/A	Four weeks for an asymptomatic patient or recovery from only mild, non-respiratory symptoms.

Anesthesia Patient Safety Foundation Joint Statement [7]			• Six weeks for a symptomatic patient (e.g., cough, dyspnea) who did not require hospitalization. • Eight to 10 weeks for a symptomatic patient who is diabetic, immunocompromised, or hospitalized. •Twelve weeks for a patient who was admitted to an intensive care unit due to COVID-19 infection.
Bui et al.[2]	Preoperative evaluation framework	N/A	Delay in surgery 4 weeks for asymptomatic 6-8 weeks for symptomatic patients
Kovoor et al.[41]	Clinical expert advice and grey literature review	3-16 weeks	Delay 4 weeks for minor surgery 8-12 weeks for major surgery
Hoyler et al.[15]	Letter to the editor	N/A	Perioperative considerations with post Covid-19 syndrome