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Review article

The impact of the COVID-19 pandemic on vascular surgery: Health care systems, economic, and clinical implications

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ABSTRACT

The novel severe acute respiratory syndrome coronavirus-2 (coronavirus disease 2019 [COVID-19]) pandemic is responsible for more than 500,000 deaths in the United States and nearly 3 million worldwide, profoundly altering the landscape of health care delivery. Aggressive public health measures were instituted and hospital efforts became directed at COVID-19–related concerns. Consequently, routine surgical practice was virtually halted, resulting in billions of dollars in hospital losses as pandemic costs escalated. Navigating an uncertain new landscape of scarce resource allocation, exposure risk, role redeployment, and significant practice pattern changes has been challenging. Furthermore, the overall effect on the financial viability of the health care system and vascular surgical practices is yet to be elucidated. This review explores the economic and clinical implications of COVID-19 on the practice of vascular surgery in addition to the health care system as a whole.

1. Introduction

The severe acute respiratory syndrome coronavirus-2 (coronavirus disease 2019 [COVID-19]) was first identified in December 2019 in Wuhan, China, before spreading to the United States and starting a rapid national breakout by March 2020 [1]. To date, this has resulted in nearly 3 million global deaths and more than 500,000 deaths in the United States [1]. In the wake of patients deferring hospital exposure and diversion of health care resources to emergent care, demand for non–COVID-19 care plummeted, resulting in US hospitals collectively losing approximately $50 billion per month during the peak months of the pandemic [2]. Furthermore, the deferral of usual care in addition to COVID-19–related sequelae has significantly impacted the health of vascular surgery patients. Herein, we describe the effects of COVID-19 on health care and specifically vascular surgery from a systems, economic, and clinical care perspective, as well as offer insights into the ongoing recovery phase of the pandemic.

2. Methods

Common resource databases were used and searched to identify current literature on the subject of financial sequelae from the COVID-19 pandemic. Search terms included

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economic, *financial*, *health systems*, and *clinical impact from COVID-19*. We reviewed the identified articles and the most representative of these works were included in order to provide a thorough review for the purpose of this article. This review was intended to be a contemporary perspective of the known economic, health systems, and clinical implications of the COVID-19 pandemic encompassing the most up-to-date information, with known limitations due to the available data and the ongoing nature of this health crisis.

2.1. *Health care systems impact of COVID-19*

The global pandemic of COVID-19 has led to unprecedented public health challenges due to the severity of the disease, the breadth of its impact, and the rapidity of its infectious spread. Within a few weeks, the COVID-19 public health emergency (PHE) overwhelmed current health care resources, especially in densely populated cities, forcing clinicians to make very difficult triage decisions about the types of care and interventions offered to patients during a time of resource scarcity. Not surprisingly, these effects transcend national borders onto the global scale—a recent report by the CovidSurg Collaborative projected that 28.4 million operations worldwide would be canceled or postponed in 2020 [3]. In order to stratify the urgency of procedures and surgical care, tier classifications were designed to focus on preserving scarce resources and human capital, maintaining optimal patient outcomes, reducing exposure risk, and upholding the necessary public health measures of physical distancing [4–7].

2.2. *Surgical triage systems and access to surgical care*

Vascular surgery procedures can require a significant amount of equipment and resource allocation, not only in the operating suite but postoperatively in critical care units—a particularly scarce resource during the COVID-19 PHE. Therefore, there was early recognition of the need to limit operative capacity to only emergent and/or urgent procedures. In some geographic regions affected disproportionately worse, for example, Michigan, guidelines were developed by independent health systems that were ultimately shared with national programs [8]. Rapidly, however, guidelines were set forth by national surgical and specialty societies, such as the American College of Surgeons (ACS) and the Society for Vascular Surgery to triage vascular surgical care during the time of resource scarcity [4,6,7]. These tier systems created a graduated hierarchy of treatment urgency in which life- and limb-threatening procedures take precedence for intervention and were assigned a high priority; this served as an effective method to decrease vascular surgical volumes during the pandemic with minimal increase in patient morbidity. Attaching this system to surgical activity condition (SURGCON) and vascular activity condition (VASCCON) frameworks has been suggested to provide more granular specialty-specific and relevant clinical guidance for vascular surgery triage, although the combination has not yet been validated [7,9].

Mouawad et al [10] conducted a cross-sectional survey of more than 530 practicing vascular surgeons in the United States during the height of the pandemic. The overwhelming majority of respondents (>91%) noted elective surgery cancellations, despite no regional variation in the presence of COVID-19 operating room protocols, availability of personal protective equipment (PPE), and adherence to national surgical standards [10]. In the in-hospital setting, only 8.3% of respondents were still performing elective cases, focused primarily on dialysis access, followed by aortic repair and lower extremity revascularization (Fig. 1). Outpatient vascular surgical care was affected, with most vascular surgeons reporting disruption to their outpatient laboratory/ambulatory center schedules—in this setting, most were performing urgent procedures focused only on advanced peripheral arterial disease and dialysis access. Not surprisingly, prioritization of life over limb was clearly demonstrated, with the majority of elective cases focused on aortic repair and maintenance of dialysis function rather than peripheral arterial disease or venous procedures.

Along with other specialties, vascular surgeons were redeployed to perform critical activities outside of their routine clinical practice [11–14]. The most common redeployment was to the intensive care unit, and central line teams were formed to minimize multiprovider exposure and leverage the expertise of vascular surgeons; in all, 34% of vascular surgeons were redeployed to new roles (Fig. 2) [10,15]. Geographic variation was identified with redeployment highest in areas most affected by the pandemic. Globally, however, 5.5% of senior surgeons were redeployed to support other specialties, compared with 53.5% of junior vascular surgical staff [16].

Vascular surgical services and access to care have been severely challenged due to the pandemic. There have been profound changes in the way vascular care is delivered [17–19]. The Vascular and Endovascular Research Network (VERN) is an established vascular research collaborative that responded rapidly to the pandemic by delivering the COVER (COVID-19 Vascular Service) study, an international prospective mixed methodology project [20–23]. Findings noted significant changes to peripheral arterial disease practice, in which the majority of units offered major amputation or palliation rather than attempting revascularization for chronic limb-threatening ischemia, and 60.4% of groups promoted an endovascular-first treatment strategy particularly in critical limbs [17]. Furthermore, thresholds for intervention on abdominal aortic aneurysms were raised and 45.8% of facilities halted aortic screening [17].

The COVID-19 PHE also caused a dramatic shift in most vascular surgeons' practices. Aziz et al [24] found that 82% of vascular surgeons were operating at VASCCON 3 ("severe limitations of non-emergency surgery") or lower during the early pandemic, indicating higher acuity with greater limitations in surgical care. Many reported decreases in clinic referrals, inpatient consultations, and emergency department consultations [24]. Although the majority noted that these limitations lasted 4 weeks or less, survey respondents in lower VASCCON levels reported longer durations of practice changes as well [24]. Providers in COVID surge areas seemed disproportionately affected by these disruptions.

For vascular surgeons practicing in outpatient clinics and ambulatory care, 89.2% had reported changes in their practice, including limited hours (71%) and use of telehealth services (81.1%) [10]. Expansion of telemedicine has particularly been

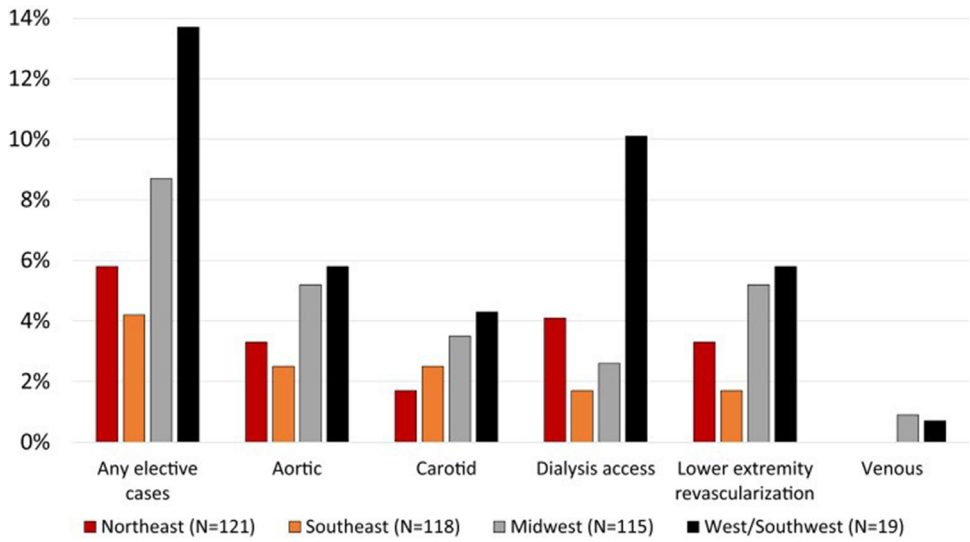

Fig. 1 – Regional distribution of elective vascular surgical cases reported by 41 respondents. From Mouawad et al [10], reprinted with permission.

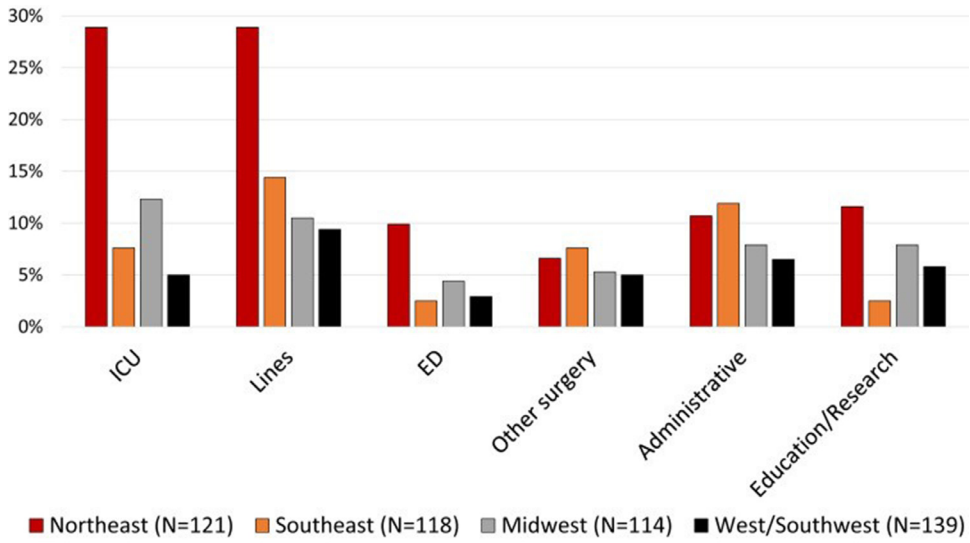

Fig. 2 – Regional distribution of vascular surgeon redeployment. From Mouawad et al [10], reprinted with permission.

supported by the Department of Health and Human Services and Centers for Medicare and Medicaid Services through reimbursement parity for in-person and virtual patient visits and expanding telehealth coverage to a wider array of visits [25]. For surgeons with office-based laboratories, only 48.8% remained open and were largely limited to emergent procedures, such as dialysis access and peripheral arterial disease [10]. However, 74.4% of respondents reported continuing vascular laboratory activity, although many reported adjusting their usual practices in response to the pandemic [10]. Inpatient services were also significantly impacted. Hemingway et al [26] reported the Harborview Medical Center experience, where clinical volume decreased by 96.5%, surgical volume decreased by 71.7%, and inpatient consultations decreased to only 1.81 per day. When comparing clinical activity from 2019 to 2020, Fang et al [27] found that professional productivity decreased by 51%, professional claims reimbursement decreased by 54%, and hospital claims reimbursement decreased by 47% [27]. Clearly, the overall impact on vascular surgery has been profound.

2.3. *Economic impact of COVID-19*

The severity of the COVID-19 PHE required an unprecedented mobilization of national health care resources and workforce in response. However, this also resulted in a dramatic shift in the allocation of such resources within medicine. The need to minimize exposures and limit valuable items, such as PPE, necessitated an extensive triage of common medical problems on a national and global scale. As such, many medical practices shut down, both temporarily and permanently, and most hospitals limited non-COVID care to emergencies only.

Although these measures in response to the COVID-19 PHE were appropriate, it has caused a tremendous and historic negative economic impact on the health care industry.

2.4. *Financial impact on the US health care system*

Early in the COVID-19 PHE, estimated losses in US hospitals were $50.7 billion per month [2]. The most recent estimate of total losses sustained by the US health care system is more than $320 billion—a staggering amount [28]. In March 2020, an unprecedented 42,500 jobs were lost in the health care sector [29]. A report by the Medical Group Management Association found that 97% of medical group practices experienced a negative financial impact during the COVID-19 pandemic. In US hospitals, inpatient admissions decreased by 30%, emergency department visits decreased by 40%, and observation services decreased by 47% [30]. Practices reported an average 60% reduction in patient volume [31]. Providers experienced pay cuts, furloughs, layoffs, or early retirement due to the financial pressures of the pandemic, and many remain at risk of losing their practices, given the lack of revenue [32]. In addition to lost revenue, the need for PPE, screening and testing of patients and staff, and capital costs related to the expansion of telehealth technology are all novel expenses now essential to practicing medicine in the COVID-19 era [33]. Furthermore, caring for patients with COVID-19 has come at significant expense; the cost for treating a patient with COVID-19 begins at around $20,000 and can increase to more than $80,000 if ventilator support is required [2]. However, reimbursement for their care often does not match their complexity and the loss from COVID-19 care alone was $36.6 billion from March to June 2020 in US hospitals [2].

On March 14, 2020, the US Surgeon General recommended ceasing all elective procedures [34]. This was in line with several societal recommendations, as well as local governmental mandates to limit exposures and concentrate valuable health care resources toward the care of patients with COVID-19 [6,35]. Although a necessary intervention, the cessation of nearly all elective operations had a major financial impact on the US health care system. During the first 4 months for the COVID-19 PHE, US hospitals lost an estimated $161.4 billion in revenue from the cancellation of elective services, including surgical procedures [2]. Generally, elective operations involve the highest margin of reimbursement and surgical volume often accounts for nearly half of a hospital's revenue [33]. In addition, overhead related to operating room facilities and equipment persisted despite the lack of surgical revenue. Considering the median operating margin of 2% for US hospitals, this has resulted in a precarious financial situation; ambulatory surgery centers, the profitability of which similarly relies on operative volumes, remain even more vulnerable due to their smaller budgetary margins [30,36].

2.5. *Federal response to the health care industry's financial crisis*

The Coronavirus Aid, Relief, and Economic Security (CARES) Act included several measures intended to lessen the financial burden on the health care system. It allocated $100 billion in emergency funds distributed to providers with lost revenue due to COVID-19, of which $10 billion will go directly to hospitals in high COVID areas and $10 billion to rural health clinics and hospitals [36,37]. It also increased reimbursement for inpatient COVID-19 admissions by 20% and reduced payroll taxes by 50% for improved employee retention [38]. Through the Paycheck Protection Program and Health Care Enhancement Act, an additional $75 billion was added to the relief fund for health care providers [39,40]. Furthermore, independent physician practices might be eligible for small business loans through several programs created through the CARES Act [38].

The Department of Health and Human Services was responsible for the distribution of federal funds; however, in an effort to quickly implement distribution of funds to prevent insolvency of hospitals nationwide, the distribution of funds was far from equitable [41]. In distributing at least the first $50 billion of funds to hospitals, hospitals received funds proportional to their previous years' revenue. This caused a much higher proportion of bailout funds to flow to large academic centers and hospital chains with profitable patient-payer mixes and much less going to safety-net hospitals supporting poor and diverse communities. Per a review of hospital finances by the *Washington Post* and Kaiser Health News, Baylor Scott & White in Dallas received $454 million in emergency federal funding before turning over an $815 million surplus in 2020—$20 million higher than in 2019. Meanwhile, the University of Pittsburgh Medical Center received $460 million in federal bailout funding while increasing their revenue from 2019 to 2020 by $2.5 billion [41]. However, hospitals with less favorable patient-payer mix, such as New York-Presbyterian Hospital, posted a nearly $500 million deficit in 2020, despite almost $1 billion in federal relief [41]. Clearly, the distribution of CARES Act bailout funds must be restructured to provide more equitable relief.

In addition, several major policy changes were instated by the Centers for Medicare and Medicaid Services (CMS) in direct response to COVID-19. The CMS Accelerated and Advanced Payment Program was expanded, allowing qualifying providers access to nearly $34 billion to increase their cash flow during the COVID-19 PHE [38]. However, this is a loan program and requires providers to eventually pay back these disbursements. The requirements allowing providers to perform telehealth were also rapidly expanded, as were reimbursement codes for telehealth [40]. This included codes for previously uncovered telehealth services, as well as reimbursing telephone-only consultations. Many of these expanded telehealth codes have now been finalized in the 2021 Physician Fee Schedule as permanent additions [42]. Unfortunately, few of these measures were mirrored by private insurers and the growing levels of unemployment have drastically increased the uninsured population [33,43]. Provider reimbursement remains overall negatively affected by the COVID-19 PHE.

CMS further acknowledged the impact of the COVID-19 pandemic in their proposed updates for the Quality Payment Program for 2021 [44]. This year's proposed rule addressed the need for more gradual implementation of changes that were previously mandated as part of the Medicare Access and CHIP Reauthorization Act. Reporting of performance measures was also adjusted as an acknowledgment of the disruption in care from the COVID-19 PHE. However, performance thresholds were still increased and the weight of performance categories

shifted; specifically, the cost performance category's weight was increased [45]. These changes were meaningful, as failure to meet thresholds can result in a reimbursement deduction for underperforming providers despite COVID-19.

Added to this, the initial CMS proposed rule for the 2021 Physician Fee Schedule included a deduction of the conversion factor by >10% to maintain budget neutrality for the increased evaluation and management codes implemented during the COVID-19 PHE [46]. This would have resulted in a disproportionate impact on procedural providers due to reduced relative value unit–based reimbursement. Through extensive political efforts, this proposed action was mitigated by the Consolidated Appropriations Act of 2021 via an additional transfer of funds into the CMS budget, reducing the cut to 3.3% [47]. However, surgical specialties remain vulnerable in the federal response to the COVID-19 PHE as we attempt to recover from this crisis.

2.6. *Path to financial recovery*

The greatest financial losses sustained were in the first 4 months of the COVID-19 PHE [28]. Encouragingly, many markers of health care productivity have returned to prepandemic levels. One major hospital's vascular surgery division found that their margins returned to within 1% of pre-COVID levels by month 4 of the PHE [28]. However, to regain financial equipoise will still require ongoing efforts to counter those losses. Increased productivity to recover these losses has been encouraged. One group estimated that a 10% increase in productivity would require 15 to 16 months to recover the financial losses from the first 3 months of the pandemic [28]. With a more realistic increased productivity of 5%, this would still require 31 to 32 months [28]. A separate financial modeling study of an academic university vascular surgery practice determined that increasing revenue by 10%, 5%, or 3% above prepandemic levels would lead to recovery of pandemic-associated losses by 9 months, 19 months, or 31 months, respectively [27].

However, these estimates do not consider the burden on providers to sustain this level of productivity, as well as their preexisting fatigue from providing health care through a national emergency. In addition to taking care of others, COVID-19 has taken a personal toll on vascular surgeons, as assessed by a global survey by Shalhub et al [16] (Fig. 3). More than 1,600 vascular surgeons globally responded anonymously to the Pandemic Practice, Anxiety, Coping and Support Survey for Vascular Surgeons disseminated and amplified over several platforms. More than 50% of the respondents reported some degree of anxiety, and just under one-quarter reported moderate or severe anxiety. Factors associated with increased self-reported anxiety levels included staying in a separate room at home or staying at the hospital or a hotel after work, donning and doffing PPE, financial concerns, and worrying about potential adverse patient outcomes due to care in delay [16].

Added to this is the mounting pressure to address the surgical backlog created by the COVID-19 PHE [48]. As surgical services recover and expand in an attempt to address this backlog and recover financial losses, consideration must be given to creating transparent algorithms for patient prioritization, increased surgical capacity through utilization of outpatient care, and increased perioperative efficiency while maintaining safe COVID-19 operating protocols [49]. Ongoing advocacy efforts for continued aid for the health care workforce remain critical, as the path to financial recovery is clearly a long and arduous one.

2.7. *Clinical impact of COVID-19*

At the peak of the pandemic, demand for health care beyond COVID-19 fell as patients worried about COVID-19 exposure in health care facilities [50]. Kaiser Permanente reported a 48% reduction in myocardial infarction presentations among their 21 medical centers in Northern California [51], and out-of-hospital cardiac arrests increased by 56% in England [52]. Woolf et al [53] found that one-third of excess deaths, beyond the baseline death rate during the same period in previous years, were related to non-COVID causes, totaling more than 30,000 excess deaths in just the first 2 months of the pandemic [53]. New York City experienced a decrease in type A aortic dissections admission, as well as an increase in at-home deaths [23]. Although no causal relationship can be confirmed, several observations can explain this—patient fear of contracting COVID-19 if they present to the health care facility; overburdened first responders who cannot reach patients in time due to delays; or overstretched emergency departments causing missed or delayed diagnoses [23].

Similar trends associated with postponement of care were identified among vascular surgery patients, and national organizations, such as the ACS, assisted with guidelines indicating what cases could be postponed during the pandemic. In addition, vascular surgery patients were affected by the thrombogenic effects of COVID-19 that increased the likelihood of ischemic events. Coagulopathy in COVID-19 results from endothelial damage, complement activation, and cytokine release, and can cause acute limb ischemia (ALI) by worsening a chronic vasculopathy or causing peripheral embolization from newly formed thrombus [54–56]. Numerous studies have demonstrated the increased incidence of ALI during the pandemic and the devastating associated outcomes [56–60]. Multiple studies reported an increased ALI incidence during the pandemic in Lombardy, Italy, one of the hardest struck COVID-19 regions in the world; 305 referred vascular surgery patients at the peak of the pandemic were analyzed, and although only 21% were found to have COVID-19, two-thirds of ALI cases occurred in COVID-19–positive patients [56,59]. COVID-19 ALI patients were more likely to die or incur a major adverse event, including amputation, than ALI patients without COVID-19 [56]. In another epicenter of COVID-19, New York City, 12,630 patients were treated at Northwell Health System and 49 patients were diagnosed with ALI; 45% of the patients had ALI as their presenting symptom before COVID-19 diagnosis. A staggering 46% of ALI patients died in the hospital and limb loss occurred in 18% of patients [57]. Patients with chronic limb-threatening ischemia (CLTI) also fared worse during the pandemic, with increased limb loss during the pandemic [61]. Reports of other sequelae from COVID-19–associated hypercoagulability and endothelial damage have also been reported, such as increased aortic thrombus and aortitis [55,62].

Typical standards of care were not always achievable during the pandemic, and alteration of normal protocols

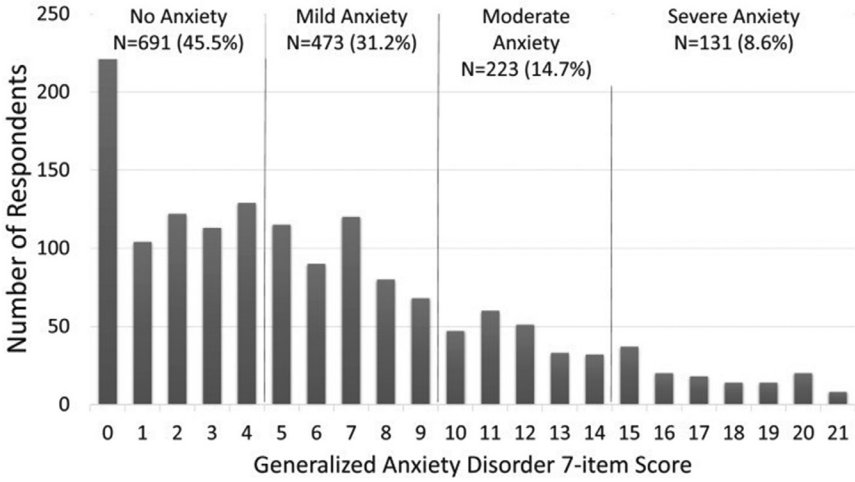

Fig. 3 – Distribution of generalized anxiety disorder 7-item survey scores among vascular surgeons. From Shalhub et al [16], reprinted with permission.

was necessary. To assist in appropriately triaging care during the pandemic, surgical societies, such as the ACS and the Society for Vascular Surgery, provided guidelines that were implemented in many institutions nationwide, as noted previously [9]. During this period, alterations were also made to treatment algorithms, such as expanding the use of thoracic endovascular aortic repair over open approach for aortic aneurysms in patients Marfan syndrome and elderly patients with aortic rupture in order to minimize exposure and conserve intensive care unit beds [63–65].

Vascular surgery patients were also affected through their reliance on health care facilities in general. For example, the COVID-19 pandemic disproportionately impacted patients with end-stage kidney disease. During peak periods of the pandemic, mortality rates of patients with end-stage kidney disease dialysis increased by 37% compared to the same time period in previous years. Among patients with end-stage kidney disease, those undergoing peritoneal dialysis were hospitalized for COVID-19 at a rate 3 to 4 times lower than patients undergoing hemodialysis, reflecting the additional social distancing that peritoneal dialysis at home offers over in-facility hemodialysis [66].

This unique clinical situation has led to the inception of the Vascular Surgery COVID-19 Collaborative (VASCC), a combined international effort to help obtain prospective data on the impact of widespread vascular surgical care delays due to the COVID-19 pandemic that is currently ongoing [67].

3. Conclusion

3.1. *The impact of COVID-19 in 2021 and beyond*

As we look forward to recovery with increasing vaccination rates in the United States available to all Americans by the summer 2021, we also must contend with the enormous financial losses and multifaceted negative effects on patient health that occurred during the pandemic. A 35-hospital analysis of vascular surgery groups found a 90% backlog averaging 700 cases that could take up to 8 months to rebound [68]. At the same time, dropping reimbursements, which have been criticized by the Society for Vascular Surgery and ACS, could result in significant revenue decreases and place additional financial strain on surgical operations [69–70]. However, certain lessons from the pandemic stand to improve vascular surgery care, including using space and staff flexibility to care more efficiently for more patients; implementing previously underused technology; such as telemedicine, to reach more patients; and internalizing the need to make extra efforts to extend our medical care to the most disadvantaged individuals in our communities [71]. As hospital systems' financial recovery is underway, it is likely that process improvement and value-based health care will be foundational in addressing the need for increased efficiency and revenue generation. In this coming period, it is essential that the field of vascular surgery continues to advocate the valuable care that vascular surgeons provide to hospitals. As outlined by Powell et al [72], the wide scope of practice and interventional nature of the field makes vascular surgery the fourth highest grossing surgical specialty, bringing in $1.6 million of hospital revenue per full-time surgeon; in addition, vascular surgery facilitates difficult cases in other surgical specialties and provides the critical service of operative crisis management when another surgeon requires urgent assistance [72]. These value propositions will allow vascular surgeons to continue to be indispensable assets to hospitals as we navigate the state of post-pandemic health care.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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