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Vascular surgery triage during the coronavirus disease 2019 pandemic

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ABSTRACT

Objective: The coronavirus disease 2019 (COVID-19) pandemic has resulted in a marked increase in hospital usage, medical resource scarcity, and rationing of surgical procedures. This has created the need for strategies to triage surgical patients. We have described our experience using the American College of Surgeons (ACS) COVID-19 guidelines for triage of vascular surgery patients in an academic surgery practice.

Methods: We used the ACS guidelines as a framework to direct the triage of vascular surgery patients during the COVID-19 pandemic. We retrospectively analyzed the results of this triage during the first month of surgical restriction at our hospital. Patients undergoing surgery were identified by reviewing the operating room schedule. We reviewed the electronic medical records (EMRs) and assigned an ACS category, condition, and tier class to each completed surgery. Surgeries that were postponed during the same period were identified from a prospectively maintained list. We reviewed the EMRs for all postponed surgeries and assigned an ACS category, condition, and tier class to each surgery. We reviewed the EMRs for all postponed procedures to identify any adverse events related to the treatment delay.

Results: We performed 69 surgeries in 52 patients during the study period. All surgeries were performed to treat emergent, urgent, or time-sensitive elective diagnoses. Of the 69 surgeries, 47 (68%) were from tier 3 and 22 (32%) from tier 2b. We did not perform any surgeries from tier 1 or 2a. We postponed surgery for 66 patients during the same period, of which 36 (55%) were from tier 1, 22 (33%) from tier 2a, 5 (8%) from tier 2b, and 3 (5%) could not be assigned a tier class. No tier 3 surgeries were postponed. Of the 66 patients, 3 (4.5%) experienced an adverse event that could be attributed to the treatment delay.

Conclusions: The ACS triage guidelines provided an effective method to decrease vascular surgical volumes during the COVID-19 pandemic without an increase in patient morbidity. We believe the clinical utility of the guidelines would be strengthened by incorporating the SURGCON/VASCCON (surgical activity condition/vascular activity condition) threat level alert system. (J Vasc Surg 2021;73:1858-68.)

Keywords: American College of Surgeons COVID-19 guidelines for triage of vascular surgery patients; COVID-19; Elective surgery triage; Triage; Vascular surgery triage

The coronavirus disease 2019 (COVID-19) pandemic has caused wide-ranging disruption throughout the healthcare system. A marked increase in hospital usage and resulting resource scarcity has affected the allocation of care to patients with COVID-19 and to patients without this infection.[1] In particular, the ability to treat patients with elective or nonelective surgical conditions has been profoundly affected. To conserve healthcare resources in anticipation of a surge of patients with COVID-19, governmental authorities and hospital systems implemented restrictions on elective, or scheduled, surgeries. These restrictions created a need for strategies to triage surgical patients. The American College of Surgeons (ACS), in collaboration with members of the Society for Vascular Surgery, has provided guidance in a document entitled "COVID-19 Guidelines for Triage of Vascular Surgery Patients."[2] We have described our experience using the ACS guidelines to triage surgical care in an academic vascular surgery practice.

INSTITUTIONAL CONTEXT

Our facility is a 425-bed academic medical center that serves a geographically large catchment area within the Intermountain West. The division of vascular surgery clinical staff includes five faculty surgeons, two vascular surgery fellows, and nine advanced practice clinicians. Our annual surgical volume is ~1100 procedures, of which 30% are arterial reconstructions and 40% for hemodialysis access.

On March 11, 2020, the World Health Organization designated COVID-19 a global pandemic, and the President of the United States declared a national emergency on March 13. The first case of COVID-19 in our state was

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reported on March 6, and our hospital first admitted a patient with COVID-19 on March 13. Community spread of the novel coronavirus, SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), was documented on March 14, 2020.

In early February, our hospital leadership initiated a coordinated effort to prepare for an anticipated surge of patients with COVID-19. The objective of this effort was to expand hospital capacity to care for COVID-19 patients and allow for the continued care of patients requiring hospitalization for non–COVID-19 diagnoses. The specific measures included increasing the number of acute care and intensive care unit (ICU) beds, increasing the number of ventilators, ensuring the availability of adequate amounts of personal protective equipment (PPE), stockpiling and conserving other hospital resources, and developing processes for the care of patients with COVID-19. These efforts were effective and resulted in a doubling of acute care and ICU bed capacity and a tripling of ventilator availability.

ARTICLE HIGHLIGHTS

- **Type of Research:** A single-center, retrospective, observational study
- **Key Findings:** We describe our experience using the American College of Surgeons coronavirus disease 2019 guidelines for triage of vascular surgery patients. A total of 69 surgical procedures were performed in 52 patients to treat emergent, urgent, or time-sensitive elective conditions. Another 66 surgical procedures were postponed. Of the 66 patients whose surgery was postponed, 3 (4.5%) experienced an adverse event that could be attributed to the delay.
- **Take Home Message:** The American College of Surgeons coronavirus disease 2019 guidelines for triage of vascular surgery patients was easy to use and effective in decreasing surgical volumes without an increase in patient morbidity. The utility of the guidelines could be strengthened by incorporating the VASCCON (vascular activity condition) threat-alert framework.

TRIAGE OF VASCULAR SURGERY PATIENTS IN RESPONSE TO SURGICAL RATIONING

On March 14, our hospital operating room executive committee enacted restrictions on elective, or scheduled, surgical procedures. These restrictions were enacted to conserve hospital resources, reduce the inpatient hospital census, preserve PPE, and promote physical distancing among our patients and staff. Emergent, urgent, and medically necessary time-sensitive scheduled surgeries were allowed. A surgical procedure was defined as time-sensitive if a delay of >6 weeks would result in an increased risk of patient harm or death. All other scheduled surgeries were postponed.

In response to this directive, we developed a tiered approach to triage surgical patients using the ACS guidelines (Table I). The guidelines have designated broad disease categories that were further divided into specific conditions or diagnoses. The conditions were then assigned to one of four triage tiers (tiers 1, 2a, 2b, and 3). Tier 3 designates emergent or urgent conditions that should not be postponed. A ruptured abdominal aortic aneurysm (AAA) would be assigned to tier 3. Surgeries assigned to tier 1 are elective and should be postponed under conditions of resource scarcity. Tier 1 conditions include asymptomatic carotid stenosis, claudication, asymptomatic AAAs <6.5 cm in diameter, and varicose veins. Tier 2 is further divided into subgroups (2a and 2b). The surgeon should consider postponing operations for tier 2a conditions. Tier 2b conditions are considered more urgent but should be postponed if possible. We prospectively applied the ACS guidelines to triage decisions but we did not prospectively record the tier assignments.

We agreed that most tier 2a procedures could be safely postponed for 6 weeks but had considerable debate regarding the appropriate triage of patients with tier 2b conditions. Tier 2b includes large (>6.5 cm) asymptomatic aortic aneurysms, chronic lower extremity ischemia with stable rest pain or tissue loss, chronic mesenteric ischemia, malfunctioning dialysis access, inferior vena cava (IVC) filter placement, soft tissue necrosis and infection requiring debridement, and transcatheter embolization for bleeding without hemodynamic instability. We acknowledged that many of the tier 2b conditions could be time-sensitive and decided to treat them on a case-by-case basis. Triage decisions for tier 2b would be influenced by patient presentation in context with our assessment of current institutional resources, inpatient census and bed capacity, the predicted likelihood of postoperative hospital admission, and our estimated position on the epidemiologic curve. Our state had a low prevalence of COVID-19 and a low rate of hospitalization during the period covered in in the present study. In addition, our hospital inpatient census was consistently at ~50%, primarily because of surgical rationing and a decrease in emergency department visits for non–COVID-19–related diagnoses. Because of the local conditions, we relaxed our indications for time-sensitive scheduled surgeries, although we anticipated that these procedures would be curtailed as we progressed through the pandemic and the number of COVID-19 admissions increased.

Appropriate triage of hemodialysis access surgeries during the pandemic has been debated among vascular surgeons and nephrologists and was the subject of a March 26, 2020 communication from the Centers for Medicare and Medicaid Services.[3] We identified hemodialysis access surgeries as the largest procedural group in our practice affected by the restrictions on scheduled

Table I. American College of Surgeons COVID-19 guidelines for triage of vascular surgery patients

Category	Condition	Tier class
AAA	Ruptured or symptomatic TAAA or AAA	3, Do not postpone
	Aneurysm associated with infection or Prosthetic graft infection	3, Do not postpone
	AAA > 6.5 cm	2b, Postpone if possible
	TAAA > 6.5 cm	2b, Postpone if possible
	AAA < 6.5 cm	1, Postpone
Aneurysm peripheral	Peripheral aneurysm, symptomatic	3, Do not postpone
	Peripheral aneurysm, asymptomatic	2a, Consider postponing
	Pseudoaneurysm repair, not a candidate for thrombin injection or compression, rapidly expanding, complex	3, Do not postpone
	Symptomatic non–aortic intra-abdominal aneurysm	3, Do not postpone
	Asymptomatic non–aortic intra-abdominal aneurysm	2a, Consider postponing
Aortic dissection	Acute aortic dissection with rupture or malperfusion	3, Do not postpone
Aortic emergency, NOS	AEF with septic/hemorrhagic shock, or signs of impending rupture	3, Do not postpone
Bypass graft complications	Infected arterial prosthesis with overt sepsis, or hemorrhagic shock, or impending rupture	3, Do not postpone
	Revascularization for high-grade restenosis of previous intervention	2b, Postpone if possible
	Asymptomatic bypass graft/stent restenosis	1, Postpone
Carotid	Symptomatic carotid stenosis: CEA and TCAR	3, Do not postpone
	Asymptomatic carotid artery stenosis	1, Postpone
Dialysis	Thrombosed or nonfunctional dialysis access	3, Do not postpone
	Infected dialysis access	3, Do not postpone
	Fistula revision for ulceration	3, Do not postpone
	Renal failure with need for dialysis access	3, Do not postpone
	Tunneled dialysis catheter	3, Do not postpone
	Fistula revision for malfunction/steal	2b, Postpone if possible
	Fistulagram for malfunction	2b, Postpone if possible
	AVF and AVG placement for dialysis (ESRD, CKD 4 and CKD 5 only)	2a, Consider postponing
Mesenteric	Symptomatic acute mesenteric occlusive disease	3, Do not postpone
	Chronic mesenteric ischemia	2b, Postpone if possible
PVD	Acute limb ischemia	3, Do not postpone
	Limb ischemia with progressive tissue loss, wet gangrene, ascending cellulitis	3, Do not postpone
	Fasciotomy for compartment syndrome	3, Do not postpone
	Chronic limb threatening ischemia with rest pain or tissue loss	2b, Postpone if possible
	Peripheral angiograms and endovascular therapy for claudication	1, Postpone
	Surgical procedures for claudication	1, Postpone
Thrombolysis	Lysis, arterial and venous	2b, Postpone if possible
TOS	Symptomatic venous TOS with acute occlusion and marked swelling	2b, Postpone if possible
	Arterial TOS with thrombosis	2b, Postpone if possible
	Neurogenic TOS	1, Postpone
	TOS, venous otherwise	2a, Consider postponing
Trauma	Traumatic injury with hemorrhage and/or ischemia	3, Do not postpone
Venous	Acute iliofemoral DVT with phlegmasia	3, Do not postpone
	IVC filter placement	2b, Postpone if possible
	Massive symptomatic iliofemoral DVT in low risk patient	2b, Postpone if possible
	Procedures for ulceration secondary to venous disease	2a, Consider postponing
	Asymptomatic May-Thurner syndrome	1, Postpone
	IVC filter removal	1, Postpone
	Varicose veins, GSV ablation	1, Postpone

Table I. Continued.

Category	Condition	Tier class
Wound; gangrene; amputation	Amputation for infection/necrosis (TMA, BKA, AKA)	3, Do not postpone
	Lower extremity disease with nonsalvageable limb (amputation)	3, Do not postpone
	Deep debridement of surgical wound infection or necrosis	2b, Postpone if possible
	Wounds requiring skin grafts	2b, Postpone if possible
	Amputation for infection/necrosis (toes)	2b, Postpone if possible
Spine	ALIF exposure	2a, Consider postponing
Other	Surgery/embolization for uncontrolled bleeding in unstable patient	3, Do not postpone
	Surgery/embolization for bleeding in stable patient	2b, Postpone if possible
	MediPort for immediate infusion needs	2b, Postpone if possible
	Port removal for complication	2b, Postpone if possible

AAA, Abdominal aortic aneurysm; *AEF*, aortoenteric fistula; *AKA*, above-the-knee amputation; *ALIF*, anterior lumbar interbody fistula; *AVF*, arteriovenous fistula; *AVG*, arteriovenous graft; *BKA*, below-the-knee amputation; *CEA*, carotid endarterectomy; *CKD*, chronic kidney disease (stage); *DVT*, deep vein thrombus; *ESRD*, end-stage renal disease; *GSV*, great saphenous vein; *IVC*, inferior vena cava; *NOS*, not otherwise specified; *PVD*, peripheral vascular disease; *TAAA*, thoracoabdominal aortic aneurysm; *TCAR*, transcarotid artery revascularization; *TMA*, transmetatarsal amputation; *TOS*, thoracic outlet syndrome.

surgery. We, therefore, developed a comprehensive approach for the triage of dialysis access procedures in collaboration with our nephrologists. This treatment algorithm was informed by contemporaneous discussions in the broader vascular surgery and nephrology community but was ultimately based on our own clinical judgment. We sought to balance the risk of line-related complications with emerging concern for COVID-19–related complications in the dialysis population. In addition, there was an institutional imperative to preserve PPE during the study period. Thus, preemptive arteriovenous fistula (AVF) placement or an AVF requested for patients with some form of working dialysis access would not be scheduled until the restrictions on surgery were lifted. New patients requiring dialysis would receive a tunneled dialysis catheter (TDC) and be placed on a call-back list for AVF placement once elective surgery resumed. Thrombosed AVFs or grafts would receive intervention to attempt to restore functional patency. If unsuccessful, these patients would receive a TDC. Patients with malfunctioning extremity access would undergo angiographic evaluation and endovascular intervention. We decided that surgeries to treat malfunctioning dialysis access were time-sensitive in almost all cases. We reasoned that timely angiographic evaluation and endovascular intervention of a failing access could prevent access thrombosis and consequent urgent evaluation, hospital admission, and the need for new access creation.

METHODS

Our institutional review board reviewed the protocol and granted our study an exempt status, including a waiver of patient informed consent. We retrospectively reviewed the operating room schedule for our hospital and identified all surgeries performed by the vascular surgery service between March 14 and April 14, 2020 (32 days). This period coincided with the first month of elective surgery restriction at our hospital. We then reviewed the electronic medical record (EMRs) to identify the preoperative diagnosis, procedure performed, procedure type (ie, open, endovascular, hybrid), anesthesia technique, and hospital admission. All surgeries were assigned an ACS category, condition, and tier class. We also reviewed the operating room schedule and identified the number of surgical procedures performed by all other surgical specialties during the same period.

All completed surgeries were assigned an admission status (ie, inpatient, same day admission, outpatient). A procedure was labeled inpatient if the patient was in the hospital at the diagnosis or had been admitted from the emergency department or clinic before an urgent or emergent operation. Same day admission designated a patient admitted to the hospital after a scheduled surgery. Outpatient denoted patients undergoing surgery without hospital admission. Differences in admission status were compared using the χ^2 test.

We prospectively maintained a list of all postponed surgeries. This list included elective surgeries that had been scheduled as of March 14 but were subsequently cancelled. This list also included elective surgeries that were identified during the study period but had not yet been scheduled. We reviewed the EMRs for each patient and identified the preoperative diagnosis and the planned surgical procedure. We then assigned an ACS category, condition, and tier class to each postponed surgery.

We reviewed the EMRs for all postponed patients to identify any adverse events related to a delay in surgery. The patients were interviewed by telephone if the EMRs lacked documentation of recent patient contact by a vascular surgery provider. An adverse event was

attributed to a delay in surgery if disease progression or hospitalization, urgent surgery, or death related to the index procedure or diagnosis had been documented.

We also collected data for surgeries performed before the period of surgical rationing. We retrospectively reviewed the operating room schedule for our hospital and identified all surgeries performed by the vascular surgery service from February 11 to March 13, 2020. This period coincided with the 32 days before elective surgery restriction at our hospital. We then reviewed the EMRs to identify the preoperative diagnosis, procedure performed, procedure type (ie, open, endovascular, hybrid), anesthesia technique, and hospital admission. All surgeries were assigned an ACS category, condition, and tier class. Surgical activity before and after surgical rationing was compared using the χ^2 test.

RESULTS

Our group performed 69 surgeries during the study period. Dialysis access procedures accounted for 33% of the surgeries, with the remainder distributed across 11 other ACS categories (Table II). Of the 69 surgeries, 47 (68%) were from tier 3 and 22 (32%) from Tier 2b. We did not perform any surgeries from tier 1 or 2a. Overall, 56.5% of the procedures were inpatient, 27.5% were outpatient, and 16% were same day admission. Of the tier 3 procedures, 60% were inpatient, 21% were outpatient, and 19% were same day admission. Of the tier 2b procedures, 50% were inpatient, 41% were outpatient, and 9% were same day admission. Patients undergoing tier 2b procedures were more likely to be discharged after surgery (41% vs 21%; $P = .03$). Patients undergoing tier 3 surgery were more commonly admitted postoperatively; however, the difference was not statistically significant (19% vs 9%; $P = .31$).

A total of 480 surgeries were performed by all specialties during the study period, with vascular surgery performing 14% of the procedures. Vascular surgery had the third greatest procedural volume, exceeded only by the orthopedic (n = 108) and trauma/acute care (n = 103) services. The remaining 200 surgeries were distributed among 12 other specialties, with a median case number of 11 and a range of 1 to 52 procedures per specialty. Vascular surgeons accounted for two of the five busiest surgeons as measured by the number of procedures.

Tier 3 surgeries. Forty-seven tier 3 surgeries were performed to treat a range of vascular emergencies, including ruptured, symptomatic, and infected aneurysms, aortic dissection with malperfusion, acute and chronic limb threatening ischemia, acute mesenteric ischemia, symptomatic carotid stenosis, extensive tissue necrosis in an unsalvageable limb, and uncontrolled hemorrhage (Table III). Dialysis access surgeries comprised 34% of the tier 3 procedures. Most (81%) of the dialysis patients had presented with an inability to undergo dialysis because of a nonfunctional catheter or failed extremity access and underwent placement of a TDC.

Table II. Completed surgeries

ACS category	Surgeries, No. (%)		
	Total	Tier 2b	Tier 3
AAA	5 (7)	1	4
Aneurysm peripheral	3 (4)	0	3
Aortic dissection	1 (1)	0	1
Bypass graft complication	7 (10)	2	5
Carotid	1 (1)	0	1
Dialysis	23 (33)	7	16
Mesenteric	5 (7)	0	5
PVD	5 (7)	1	4
Trauma	4 (6)	0	4
Venous	3 (4)	3	0
Wound; gangrene; amputation	6 (9)	4	2
Other	6 (9)	4	2
Total	69 (100)	22 (32)	47 (68)

AAA, Abdominal aortic aneurysm; *ACS*, American college of Surgeons; *PVD*, peripheral vascular disease.

Tier 2b surgeries. Twenty-two tier 2b surgeries were performed to treat time-sensitive elective conditions (Table IV). Endovascular intervention for a malfunctioning fistula was performed in seven patients and accounted for 32% of all tier 2b procedures. Of the fistula interventions, 86% were performed without a general anesthetic, and none of these patients had required hospital admission. Overall, 16 of the 22 surgeries (73%) were performed using an endovascular technique. One patient underwent endovascular aneurysm repair (EVAR) to treat an asymptomatic 10-cm AAA. One patient underwent endovascular revision of severely compressed iliac limbs after EVAR. Three patients had an IVC filter placed for pulmonary embolus or proximal deep vein thrombus and a contraindication to anticoagulation therapy. The remaining endovascular procedures were performed to treat a symptomatic lower extremity vein graft stenosis, chronic upper extremity ischemia with motor and sensory loss, an iatrogenic innominate artery injury, and a splenic artery pseudoaneurysm. Six patients required an open surgical procedure, including two amputations for gangrene and infection, two wound debridements for tissue necrosis and infection, one phlebectomy for bleeding, and one hematoma evacuation.

Table III. Tier 3 surgeries

ACS category	Surgeries, No. (%)	Diagnosis	Procedure
AAA	4 (9)	Aortic graft infection	Graft excision, in situ reconstruction
		Mycotic iliac aneurysm	EVAR
		Ruptured TAAA	TEVAR
		Ruptured AAA (Ehlers-Danlos)	Open repair
Aneurysm, peripheral	3 (6)	Symptomatic popliteal aneurysm	Open repair
		Symptomatic brachial aneurysm	Open repair
		Symptomatic radial aneurysm	Open repair
Aortic dissection	1 (2)	Acute dissection with malperfusion after open repair of ruptured AAA (Ehlers-Danlos)	Aortic stent
Bypass graft complication	5 (11)	Graft infection, bleeding[a]	Graft revision, muscle flap
		Graft infection, bleeding[a]	Control of bleeding
		Graft infection, bleeding[a]	Graft ligation
		Graft infection[b]	Incision and drainage
		Graft infection[b]	Graft excision, replacement with homograft
Carotid	1 (2)	Stroke	Carotid endarterectomy
Dialysis	16 (34)	Nonfunctional dialysis access (n = 13)	TDC
		Acute need for dialysis	TDC
		Thrombosed arteriovenous graft	Open thrombectomy, fistulagram, angioplasty
		Infected AVF, bleeding	Open revision of AVF
Mesenteric	5 (11)	Acute mesenteric ischemia secondary to graft thrombosis[c]	Thrombolysis
		Acute mesenteric ischemia secondary to graft thrombosis[c]	Laparotomy, pharmacomechanical thrombolysis
		Acute mesenteric ischemia secondary to graft thrombosis[c]	Thrombolysis
		Acute mesenteric ischemia[d]	Mesenteric bypass
		Acute mesenteric ischemia[d]	Second-look laparotomy
PVD	4 (9)	Acute lower extremity ischemia	Femoral–femoral bypass, fasciotomy
		Compartment syndrome	Fasciotomy
		CLTI with tissue loss, rest pain	Diagnostic angiogram
		CLTI with tissue loss, rest pain	Tibial bypass
Trauma	4 (9)	Spleen injury	Splenic artery embolization
		Spleen injury	Splenic artery embolization
		Spleen injury	Splenic artery embolization
		Expanding retroperitoneal hematoma	Diagnostic angiogram
Wound; gangrene; amputation	2 (4)	CLTI with tissue loss, rest pain	Angiogram, ankle disarticulation
		CLTI with tissue loss, rest pain	Completion BKA
Other	2 (4)	Bleeding AVF	Control of bleeding, TDC
		Iatrogenic subclavian artery injury	Diagnostic angiogram

AAA, Abdominal aortic aneurysm; *ACS*, American College of Surgeons; *AVF*, arteriovenous fistula; *BKA*, below-the-knee amputation; *CLTI*, chronic limb threatening ischemia; *EVAR*, endovascular aneurysm repair; *PVD*, peripheral vascular disease; *TAAA*, thoracoabdominal aortic aneurysm; *TDC*, tunneled dialysis catheter; *TEVAR*, thoracic endovascular aneurysm repair.
[a]Patient underwent multiple procedures.
[b]Patient underwent multiple procedures.
[c]Patient underwent multiple procedures.
[d]Patient underwent multiple procedures.

Table IV. Tier 2b surgeries

ACS category	Surgeries, No. (%)	Diagnosis	Procedure
AAA	1 (5)	Asymptomatic 10-cm AAA	EVAR
Bypass graft complication	2 (9)	Endograft stenosis	Revision of EVAR
		Symptomatic vein graft stenosis	Graft angioplasty
Dialysis	7 (32)	Malfunctioning AVF (n = 7)	Fistulagram, angioplasty
PVD	1 (5)	Subclavian artery occlusion, brachial embolus, rest pain	Subclavian stent, brachial thrombectomy
Venous	3 (14)	Proximal DVT and contraindication to anticoagulation (n = 2)	IVC filter
		PE and contraindication to anticoagulation	IVC filter
Wounds, gangrene, amputation	4 (18)	Muscle necrosis after fasciotomy	Debridement
		Forefoot gangrene	Transmetatarsal amputation
		Toe gangrene, osteomyelitis	Toe amputation
		Surgical site infection	Debridement
Other	4 (18)	Bleeding varicose veins	Phlebectomy
		Iatrogenic innominate artery injury	Innominate stent
		Postoperative hematoma after pacemaker placement	Hematoma evacuation
		Splenic artery pseudoaneurysm	Splenic artery stent-graft

AAA, Abdominal aortic aneurysm; *ACS*, American College of Surgeons; *AVF*, arteriovenous fistula; *DVT*, deep vein thrombosis; *EVAR*, endovascular aneurysm repair; *IVC*, inferior vena cava; *PE*, pulmonary embolism; *PVD*, peripheral vascular disease.

Table V. Postponed surgeries

	Surgeries, No. (%)				
ACS category	Total	Tier 1	Tier 2a	Tier 2b	Unassigned
AAA	4 (6)	2	0	2	0
Aneurysm, peripheral	1 (1.5)	0	1	0	0
Dialysis	21 (32)	0	20	1	0
Mesenteric	1 (1.5)	0	0	1	0
PVD	2 (3)	1	0	1	0
TOS	1 (1.5)	0	1	0	0
Venous	33 (50)	33	0	0	0
Unassigned	3 (4.5)	0	0	0	3
Total	66 (100)	36 (55)	22 (33)	5 (8)	3 (5)

AAA, Abdominal aortic aneurysm; *ACS*, American College of Surgeons; *PVD*, peripheral vascular disease; *TOS*, thoracic outlet syndrome.

Postponed surgery. Sixty-six surgical procedures were postponed during the study period (Tables V and VI). Of the 66 procedures, 36 (55%) were from tier 1, 22 (33%) from tier 2a, 5 (8%) from tier 2b, and 3 (5%) could not be assigned a tier class. No tier 3 surgeries were postponed. The two most commonly postponed surgeries were saphenous vein ablation or stripping and creation of an upper extremity hemodialysis access, accounting for 47% and 30% of the total, respectively. The tier 1 surgeries included saphenous vein ablation or stripping for symptomatic varicose veins (n = 31), EVAR for AAAs <6.5 cm (n = 2), removal of an IVC filter (n = 2), and diagnostic angiography to evaluate claudication (n = 1). The tier 2a surgeries included creation of an AVF or arteriovenous graft (n = 20), lower extremity bypass for an asymptomatic popliteal aneurysm (n = 1), and first rib resection for venous thoracic outlet syndrome (n = 1). The tier 2b surgeries included fenestrated endovascular aortic aneurysm repair of an 8-cm AAA, open repair of a 7.7-cm thoracoabdominal aortic aneurysm, revascularization for chronic limb threatening ischemia (n = 1), revascularization for chronic mesenteric ischemia (n = 1), and angiographic evaluation of a malfunctioning AVF (n = 1). We did not recommend postponing the

Table VI. Postponed surgeries

ACS category	ACS tier class	Diagnosis	Planned procedure
AAA	1	AAA, 5 cm	EVAR
		AAA, 5.6 cm	EVAR
	2b	AAA, 8 cm	FEVAR
		TAAA, 7.7 cm	Open repair
Aneurysm peripheral	2a	Asymptomatic popliteal aneurysm	Open repair
Dialysis	2a	CKD 4, 5 or ESRD (n = 20)	AVF/AVG
	2b	AVF malfunction	Fistulagram
Mesenteric	2b	Chronic mesenteric ischemia	Mesenteric stent or bypass
PVD	1	Claudication	Arteriogram
	2b	CLTI	Femoral endarterectomy, iliac stent
TOS	2a	Venous TOS	First rib resection
Venous	1	Varicose veins (n = 31)	EVLT/stripping
		DVT (n = 2)	IVC filter removal
Unassigned	Unassigned	Carotid paraganglioma	Resection
		Jugular vein branch aneurysm	Resection
		Pelvic congestion	Venogram

AAA, Abdominal aortic aneurysm; *ACS,* American College of Surgeons; *AVF,* arteriovenous fistula; *AVG,* arteriovenous graft; *CKD,* chronic kidney disease (stage); *CLTI,* chronic limb threatening ischemia; *DVT,* deep vein thrombosis; *ESRD,* end-stage renal disease; *EVAR,* endovascular aneurysm repair; *EVLT,* endovenous laser treatment; *FEVAR,* fenestrated endovascular aortic aneurysm repair; *IVC,* inferior vena cava; *PVD,* peripheral vascular disease; *TOS,* thoracic outlet syndrome.

fenestrated endovascular aortic aneurysm repair or the open repair of the thoracoabdominal aortic aneurysm. However, both surgeries were delayed because the patients feared exposure to COVID-19 during hospitalization. Three surgeries did not have a corresponding ACS condition and could not be assigned a tier class (resection of a carotid paraganglioma, resection of an external jugular vein aneurysm, and venography to evaluate pelvic congestion).

We searched the EMRs for evidence of patient harm related to delayed surgery. Follow-up data were obtained for 63 of 66 patients (95%). We identified several opportunities to capture adverse events. First, 46 patients had completed the postponed surgery, and a faculty vascular surgeon had interviewed the patient on the day of surgery. Second, seven patients had at least one documented clinic encounter with a vascular surgery provider between August 7 and September 22. Third, the first author interviewed nine patients by telephone on September 23. Follow-up data were unavailable for three patients (5%). One patient awaiting removal of an IVC filter was discharged from the hospital on May 4, moved out of state, and could not be interviewed. Two patients awaiting treatment for varicose veins could not be reached. A total of six adverse events were identified, three of which could be attributed to the postponed surgery. Two patients required an unplanned placement of a TDC while awaiting AVF surgery (tier 2a) and one patient experienced thrombosis in a jugular vein branch aneurysm (unable to assign a tier). Three other adverse events were identified in patients awaiting an AVF (tier 2a) but were not attributed to the postponed surgery. Two patients were diagnosed with COVID-19 and one patient died of an acute coronary event. In summary, 3 of 66 patients with postponed surgery had an adverse event attributable to the treatment delay (4.5%). In addition, 11 patients had a prolonged TDC implant time while awaiting construction of an AVF; however, no patient experienced a line-related adverse event.

Surgical activity before period of elective surgery restriction. A comparison between the surgeries performed before and after the surgical restriction is presented in Table VII. Total surgical activity decreased during the period of surgical rationing. We performed 107 surgeries during the month preceding elective surgery restriction, and 69 surgeries during the COVID-19 restrictions. Surgical activity during the period of surgical restriction was skewed toward the higher tier classes. Tier 2b and 3 surgeries accounted for 100% of the procedures during COVID-19 but only 65% before COVID-19 ($P < .001$). During the time of surgical restriction, a greater proportion of surgeries were from tier 3 (68% vs 37%; $P < .001$) and a lower proportion from tier 1 and 2a (0% vs 12%; $P = .003$; and 0% vs 14%; $P = .001$). A greater proportion of surgeries during the COVID-19 restrictions were performed using endovascular techniques (58% during COVID-19 vs 41% before COVID-19; $P = .046$). The total number of patients requiring hospitalization (inpatient and same-day admissions) was lower during the COVID-19 restrictions (50 during rationing and 61 before

Table VII. Surgical activity before and during surgical rationing

Variable	Before COVID-19[a] (n = 107)	During COVID-19[b] (n = 69)	*P* value[c]
ACS tier class			
1	13 (12)	0 (0)	.003
2a	15 (14)	0 (0)	.001
2b	30 (28)	22 (32)	.585
3	40 (37)	47 (68)	<.001
Unassigned	9 (8)	0 (0)	.013
2b plus 3	70 (65)	69 (100)	<.001
Procedure type			
Open	45 (42)	25 (36)	.564
Endovascular	44 (41)	40 (58)	.046
Hybrid (open and endovascular)	18 (17)	4 (6)	.031
Admission status			
Inpatient	44 (41)	45 (65.2)	.02
Outpatient	46 (43)	19 (27.5)	.038
Same day admission	17 (16)	5 (7)	.091
Inpatient and same day admission	61 (57)	50 (72)	.038
Dialysis procedures			
Total	43	23	
TDC	14 (32)	12 (52)	.120
New AVF or AVG	15 (35)	1 (4)	.006
Fistulagram and angioplasty	9 (21)	7 (30)	.391
Other	5 (12)	3 (13)	.867

ACS, American College of Surgeons; *AVF*, arteriovenous fistula; *AVG*, arteriovenous graft; *COVID-19*, coronavirus disease 2019; *TDC*, tunneled dialysis catheter.
[a]Surgery performed before rationing (February 11 to March 13).
[b]Surgery performed during rationing (March 14 to April 14).
[c]All *P* values refer to a comparison of percentages from the two groups analyzed using the χ^2 test.

rationing) likely reflecting the decreased case volume during the pandemic. However, the proportion of patients requiring inpatient care was greater during the pandemic (72% during rationing and 57% before rationing; $P = .038$) possibly owing to the greater acuity of patients undergoing surgery during the time of rationing. We performed fewer dialysis surgeries during the period of restriction (23 vs 43). This likely reflects our decision to postpone preemptive fistula creation in patients not yet receiving dialysis. A larger proportion of patients received a TDC during the period of rationing; however, the difference did not reach statistical significance (52% vs 35%; $P = .12$). A smaller proportion of patients received a new AVF or AV graft during COVID-19 (4% vs 35%; $P = .006$).

DISCUSSION

Rationing of surgical care in response to the COVID-19 pandemic created a need for a systematic approach to triage surgical patients. The ACS COVID-19 guidelines for triage of vascular surgery patients provides a useful framework to organize and prioritize triage decisions. We found the guidelines easy to use and effective in decreasing surgical volumes without an increase in patient morbidity. A review of the case mix for the procedures we performed and the procedures we postponed showed that appropriate triage decisions can result from using the ACS guidelines.

During the first month of surgical rationing at our institution, 68% of the surgeries were performed to treat tier 3 conditions. These procedures were all performed to treat conditions that posed an immediate threat to life or limb from hemorrhage, ischemia, or infection. Postponement of any of those surgeries would have likely resulted in death, limb loss, or other significant patient harm. Triage decisions are relatively straightforward for tier 3 procedures; they should be performed under all but the most extreme circumstances. No tier 3 surgeries were postponed in our series. Difficult decisions regarding withholding surgical treatment for tier 3 conditions would be necessary if the healthcare system was overwhelmed with critically ill COVID-19 patients to the point that demand exceeded the ability to deliver care. Under these circumstances, crisis standards of care would be implemented.

Likewise, triage decisions for tier 1 conditions are also straightforward. These are elective procedures that can be delayed without causing significant patient harm. Appropriately, no tier 1 surgeries were performed during

Fig. Triage matrix combining American College of Surgeons (ACS) tier class and vascular activity condition (*VASCCON*). *Green,* proceed with surgery; *yellow,* case-by-case decision to proceed or postpone; *red,* postpone surgery.

the study period. More than one half of the postponed surgeries in our patients were from tier 1. Tier 1 includes AAAs <6.5 cm but we recommend reclassifying this condition to tier 2a. Unlike the other conditions in tier 1, a prolonged treatment delay for these patients could be unsafe.

Tier 2 conditions pose the most challenging triage decisions. In general, tier 2a procedures are less urgent and can be delayed without subjecting the patient to significant risk. All the tier 2a surgeries in our series were postponed. Of these patients, 91% had experienced no adverse events attributable to the delay, although two patients had required replacement of a malfunctioning TDC. Tier 2b procedures are more likely to be time-sensitive, and significant treatment delays can place patients at increased risk of a poor outcome. Only 5 of 27 tier 2b surgeries (19%) were postponed, 2 of which were because of patient preference. None of these patients had experienced an adverse event related to the delay.

Triage decisions for time-sensitive tier 2 surgeries should be made in the context of patient, institutional, and regional epidemiologic factors. Patient-specific factors include disease severity at presentation, expected time course for disease progression, anticipated duration of treatment delay, estimated procedural resource usage, and the likelihood of postoperative hospital admission. Institutional factors include hospital resource availability, acute care and ICU bed capacity, ventilator availability, and PPE and anesthetic agent availability. Epidemiologic factors include the community prevalence of COVID-19, position on the epidemiologic curve, estimated timing and magnitude of a COVID-19 patient surge, and the capacity of other local health care facilities. Nationwide shortages of PPE and other resources were difficult to quantify and were not a primary consideration in our institutional triage plan. Consideration of epidemiologic conditions and resource availability at a national level would be important if a nationwide plan was available for resource sharing. Triage decisions in tier 2 are complex and require integration of multiple factors. Other triage tools, such as the recently described MeNTS (medically necessary time-sensitive procedures) scoring system, could assist with triage decisions for this group. However, this hypothesis was not tested in the present study.[4]

Based on an assessment of local pandemic conditions and institutional resources, our hospital leadership permitted time-sensitive elective surgery. A surgery was considered time sensitive if a delay of >6 weeks would result in patient harm. We decided that most tier 2b conditions were time sensitive and most tier 2a conditions were not. Accordingly, we performed surgery for 81% of tier 2b patients and postponed all tier 2a procedures. More stringent rationing would have resulted in more postponed surgeries for the tier 2b patients possibly resulting in increased morbidity and mortality in this group. The likelihood of a poor outcome for patients with delayed surgery would be influenced by the specific diagnosis, natural history of the condition without surgical treatment, and the duration of the delay.

We preferentially chose endovascular procedures to reduce resource usage and hospital admission. One patient with a ruptured thoracoabdominal aortic aneurysm was treated with thoracic endovascular aneurysm repair as a temporizing measure to avoid a more resource-intensive open repair. Furthermore, we also preferentially performed TDC placement rather than creating a new AVF/AV graft for patients needing acute dialysis access. Despite the increased usage of TDCs, we did not identify any acute catheter-related complications during follow-up.

Our study was limited by the potential bias inherent to retrospective medical record reviews. In addition, conclusions regarding the safety of delayed treatment were limited by the small sample size and the large proportion of varicose vein patients in the postponed group. Our results might have been skewed by the large number of hemodialysis access procedures. We chose to include these surgeries because they comprised a large proportion of the patients treated during the study period. Furthermore, we believed it was important to include these data because the management of hemodialysis access was controversial, especially during the early stages of pandemic-related surgical rationing. The findings from a similar analysis applied to a larger prospective data set with a greater proportion of arterial diagnoses from tiers 1, 2a, and 2b would be instructive.

Vascular surgeons are a critical component of the healthcare system. In our hospital, our group performed a significant proportion of the emergent, urgent, and

time-sensitive elective surgeries during this period of surgical rationing. This is likely true at many other hospitals. This observation highlights the important role played by vascular surgeons and also illustrates the need for a system to triage vascular surgery patients.

The ACS guideline is a useful tool to make these triage decisions but could be strengthened by adding a simple modification. The ACS tiers create a graduated hierarchy of treatment urgency, where life- and limb-threatening conditions are assigned the highest priority and are the least subject to restriction during times of resource scarcity. As one moves from tier 3 to tier 1, a progressive decrease occurs in priority and a progressive increase in restrictions due to resource scarcity. Consideration of institutional resources and local epidemiologic factors will then influence the decision to proceed or postpone surgery within a given tier class. However, the ACS guidelines lack any consideration of the local epidemiologic threat level or resource availability that should be integrated into surgical decision-making. These institutional and local epidemiologic factors can be succinctly communicated using a color-coded threat level alert system. Military threat level alert systems exist, and this model has been adapted for use during a medical disaster response. Our state hospital association developed an alert system to guide medical practice during the COVID-19 pandemic. However, this system was cumbersome and did not provide granular advice for surgical triage.[5] In contrast, the SURGCON (Surgical Activity Condition) and VASCCON (vascular activity condition) framework, as articulated by Forbes,[6] provides specialty-specific and clinically relevant guidance for vascular surgery triage. The VASCCON system describes five levels of graduated surgical activity with increased restrictions as one moves from VASCCON 5 to VASCCON 1. Normal surgical practice is permitted for VASCCON 5. VASCCON 4 and 3 describe increasing restrictions on elective surgeries. VASCCON 2 restricts surgery to treat life- and limb-threatening emergencies. All surgical activities, including those for life- and limb-threatening emergencies, are prohibited in VASCCON 1. We recommend combining the ACS guidelines and the VASCCON framework. The ACS guidelines would provide a system to organize and prioritize procedures at the patient level. The VASCCON framework would then superimpose a tier-level go/no-go cutpoint responsive to changes in pandemic-related stress to the healthcare system. An example of this integration is illustrated in the Fig. We recognize that this system could also be used to guide triage decisions because surgical restrictions are relaxed and non–time-sensitive scheduled surgical activities are resumed. Additionally, this construct could be helpful during other situations in which surgery is rationed. We acknowledge that the VASCCON framework has not been validated, and the present study was not intended to evaluate the effectiveness of combining the ACS guidelines with VASCCON. Rather, we are proposing a conceptual framework to make triage decisions. Under this construct, triage decisions are made using a two-stage process. First, a surgery is assigned to a tier class, which establishes a relative priority. Second, a decision is made to proceed or postpone surgery within a given tier according to local epidemiologic and institutional factors as summarized in the threat alert system. Although a variety of threat alert systems could be used, we believe that the VASCCON system is appropriate for vascular surgeons because it has a specialty-specific focus.

CONCLUSIONS

The ACS triage guidelines provide an effective method to decrease vascular surgical volumes during the COVID-19 pandemic without an increase in patient morbidity. The clinical utility of the ACS guidelines would be strengthened by incorporating the SURGCON/VASCCON threat level alert system.

AUTHOR CONTRIBUTIONS

Conception and design: MS
Analysis and interpretation: MS, CG, LK, BS, BB
Data collection: MS
Writing the article: MS
Critical revision of the article: MS, CG, LK, BS, BB
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