Developing an Algorithm to Guide Resumption of Operative Activity in the COVID-19 Pandemic and Beyond

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The COVID-19 pandemic forced a shutdown of normal New York City hospital operations and created enormous strain on healthcare infrastructure.[1,2] On March 16, there were 463 confirmed cases in New York City, soaring to 98,715 by April 11, with 27,475 cumulative hospitalizations.[3] The impact of the rapid influx of hundreds of critically ill patients on hospital personnel, critical care delivery, and operative resources was tremendous. In an effort to minimize unnecessary exposure and conserve ever more scarce resources, elective and even time-sensitive operations were postponed during the COVID-19 surge.

As we witness the decline of new cases in New York City, we face the challenge of how to resume operative activity at a pace that mirrors the gradual loosening of restrictions on resources. Given that the demand for operating room time will far exceed the available supply for some time, it is essential to develop an algorithm to equitably address the backlog of postponed elective and semi-urgent cases.[4] To be relevant, the algorithm must take into account the case urgency and its associated perioperative resource requirements. The algorithm must be applied consistently to all patients, without regard for demographic factors, and across surgical departments, without regard for financial motivations.

We demonstrate the algorithm that Columbia University Irving Medical Center (CUIMC) is employing in the recovery phase of the COVID-19 response to organize and prioritize the long waiting list of surgical patients in a landscape of dynamic resource availability and case urgency.

OUR INSTITUTION

CUIMC is a 745-bed, quaternary academic hospital with 117 ICU beds and 32 operating rooms. All elective surgery was cancelled effective March 16, 2020, heeding recommendations by the Centers for Disease Control[5] and the Center for Medicare & Medicaid Services,[6] to focus resources where they would be needed most. Along with recommendations from The American College of Surgeons that suggested nonoperative management of uncomplicated cases of diseases such as appendicitis and cholecystitis which are typically treated with surgery,[7] the operating rooms fell fallow.

Subsequently, over several weeks, nearly all surgical and medical ICUs were repurposed for COVID-19 patients, and 23 operating rooms were converted into ICUs. Only 3 operating rooms were available for emergency surgery, with few postoperative beds. Moreover, surgeons, anesthesiologists, nurses, and other operating room staff were redeployed to other roles and locations, further constraining the ability to perform operations. In recent weeks, we have begun to repatriate our redeployed staff, dismantle our makeshift ICUs, and create a process for scheduling elective and semiurgent cases.

Initial Triage

In the initial phase of the surge response, when elective cases were cancelled, all divisions within the Department of Surgery were asked to assess their postponed caseload and organize them according to how long the patients could safely wait: <2 weeks, 2 to 4 weeks, and >4 weeks. These lists allowed the divisions both to carefully track waiting patients as well as to work with the operating rooms to schedule the more urgent among them. Because normal outpatient office hours were cancelled during the crisis, very few patients were added to these waiting lists.

DEVELOPMENT OF RESOURCE INTENSITY CLASS SYSTEM

Early in the surge, when resources such as personal protective equipment (PPE) and ICU beds were extremely scarce and operating rooms had little time for anything other than emergencies, our department developed a Resource Intensity Class (RIC) system. The system assigned a resource intensity classification to proposed operations and created a common language that any surgeon could use to describe the level of resources required for a proposed operation. The RIC system assigned classes based on the intensity of use of 4 resource categories: personnel/space (P), devices (D), expendables (E), and postoperative/recovery resources (R) (Table 1). Each major resource category lists corresponding component resources for which an ‘‘intensity’’ subscore was given from 1 (low) to 3 (high). Subscores were compiled to generate a single score for each main category, which were used to assign a Resource Intensity Class (RIC) (Table 2). Overall resource intensity of a given operation ranged from Class I (least resource intensive) through Class IV-B (most intensive). Of note, depending on the anticipated complexity of a case, the same operation could be categorized differently for different patients. Furthermore, depending on available resources at a given time, certain components of the RIC may have more impact on feasibility than others. Throughout the crisis, the RIC classes were combined with knowledge of immediately available resources to help delineate the cases we could reasonably accommodate.

TRIAGE FOR RESUMPTION OF OPERATIVE ACTIVITY

As we eased out of crisis capacity and resources became less strained, certain elements of the RIC became less relevant such as PPE, ventilators, and dialysis. For this reason, the RIC system was modified and the Urgency Intensity Grid was developed. This grid maps the resource intensity of a case on the x-axis and the urgency of a case on the y-axis. An example of an Urgency Intensity Grid

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TABLE 1. Major Categories of Surgical Resources, and Factors Used to Assign Intensity Scores

Resource Intensity Categories and Factors

Category	Resource	Intensity Score 1 (Low)	Intensity Score 2 (Medium)	Intensity Score 3 (High)
Personnel/space (P)	Surgical staff	Supervised resident	One surgeon	Multiple surgeons
	Anesthesiology staff	Supervised resident/CRNA	General anesthesiologist	Specialized anesthesiologist
	Nursing staff	Minimal (0–1)	Moderate (1–2)	Extensive (3+)
	Location	ICU Bedside/Treatment Room	Small/Unspecialized OR	Large/specialized OR
	Duration	Short (<2 hours, skin-to-skin)	Medium (2–4 hours, skin-to-skin)	Long (>4 hours, skin-to-skin)
Devices (D)	Ventilator required?	No (local/MAC)	Yes (simple GA)	Yes (complex GA)
	HD machine?	No	Maybe (borderline renal function)	Yes (established HD patient)
	Perfusion/CPB/cell-saver	No	Maybe (liver surgery)	Yes (cardiac surgery)
Expendables (E)	PPE	Low intensity use	Medium intensity use	High intensity use
	Blood product need	Unlikely	Possible	Probable
	Blood product intensity	Low (0–2 pRBCs, 0 plt)	Moderate (3–4 pRBCs, 6 plt)	High (>4 pRBCs, >6 plt)
Postoperative resources (R)				
	Postoperative ICU stay	None	1–2 days	3+ days
	Postoperative ICU intensity	Low (no ICU or ventilator)	Moderate (ICU + ventilatory)	High (ICU + ventilator+ CVVH)
	Need for additional trip(s) to OR	Unlikely	Possible	Probable

CPB indicates cardiopulmonary bypass; CRNA, certified respiratory nurse anesthetist; CVVH, continuous veno-venous hemofiltration; GA, general anesthesia; HD, hemodialysis; ICU, intensive care unit; MAC, monitored anesthesia care; OR, operating room; plt, platelets; PPE, personal protective equipment; pRBCs, packed red blood cells.

TABLE 2. Resource Intensity Class Levels I to IV-B Based on Scoring of Individual Categories as Defined in Table 1

Resource Intensity Classification (RIC)

	RESOURCE INTENSITY CLASS	MAIN CLASS DESCRIPTORS	PERSONNEL/SPACE (P)	DEVICES (D)	EXPENDABLES (E)	POSTOPERATIVE RESOURCES (R)
Low Resource Intensity	I	No OR or ventilator	1	1	1	1
	II-A	Need OR & intraoperative ventilator, but no ICU/postoperative ventilator and only low expendables	2	2	1	1
			3	2	1	1
	II-B	Same as II-A plus medium expendables	2	2	2	1
			3	2	2	1
Medium Resource Intensity	III-A	Need ICU/postoperative ventilator, plus possible high intensity devices (intraoperative HD/CPB), but postoperative ICU time ≤ 2 days	2	2	2	2
			3	2	2	2
			2	3	2	2
			3	3	2	2
	III-B	Same as III-A plus high intensity expendables	2	2	3	2
			3	2	3	2
			2	3	3	2
			3	3	3	2
High Resource Intensity	IV-A	High intensity postoperative resources (ICU 3+ days, ± CVVH) but only moderate expendables	2	2	2	3
			3	2	2	3
			2	3	2	3
			3	3	2	3
	IV-B	Same as IV-A plus high intensity expendables	2	2	3	3
			3	2	3	3
			2	3	3	3
			3	3	3	3

CVVH indicates continuous veno-venous hemofiltration; ICU, intensive care unit; OR, operating room.

TABLE 3. The Urgency Intensity Grid Assigns Proposed Cases Into 1 of 9 Categories, According to the Combination of Case Urgency and Resource Intensity

Urgency Intensity Grid

DIVISION: ADULT CARDIAC SURGERY		RESOURCE INTENSITY		
URGENCY	**PROCEDURE**	**LOW (ICU LOS 1-3 DAYS)**	**MEDIUM (ICU LOS 4-6 DAYS)**	**HIGH (ICU LOS > 7+ DAYS)**
STATUS I	CABG			
SURGERY REQUIRED IN 0-1 MONTHS	AVR			
	MVR/r			
CRITERIA	CABG/VALVE			
CAD w/ CCS Class III-IV angina	MULTI VAVLE			
Symptomatic severe AS (AHA Stage D)	PROX AORTA			
Severe/mod-severe MR/AI/TR with NYHA Class III-IV CHF	ARCH AORTA			
Symptomatic/rapidly enlarging aneurysm	VAD			
Endocarditis w/acute indications (embolization, CHF, failed ABX)	OHT			
Acute decompensation of CHF or arrhythmia in VAD candidate	MYECTOMY			
HOCM with angina, syncope, or NYHA Class III-IV CHF	ADULT CONG			
	OTHER			
TOTAL STATUS I CASES	**TOTAL**			
STATUS II	CABG			
SURGERY REQUIRED IN 1-2 MONTHS	AVR			
	MVR/r			
CRITERIA	CABG/VALVE			
CAD w/ CCS Class II angina and worsening EF	MULTI VAVLE			
Asymptomatic severe AS (AHA Stage C)	PROX AORTA			
Severe/mod-severe MR/AI/TR without CHF but with new AF or LV pathology	ARCH AORTA			
Asymptomatic aneurysm exceeding size/growth limits, syndromic	VAD			
Endocarditis with severe MR/AI/TR but without acute indications	OHT			
Subacute decompensation of CHF in VAD candidate (e.g. renal dysfunction)	MYECTOMY			
HOCM Class II CHF intolerant of medical therapy	ADULT CONG			
	OTHER			
TOTAL STATUS II CASES	**TOTAL**			
STATUS III	CABG			
SURGERY REQUIRED IN 2-3 MONTHS	AVR			
	MVR/r			
CRITERIA	CABG/VALVE			
CAD meeting criteria for surgery in stable patient	MULTI VAVLE			
Moderate AS	PROX AORTA			
Severe/mod-severe MR/AI/TR without CHF, AF, LV pathology	ARCH AORTA			
Asymptomatic aneurysm exceeding size/growth limits, non-syndromic	VAD			
Endocarditis with less than severe AI/MR/TR and without acute indications	OHT			
Stable CHF or controlled arrythmias in VAD candidate	MYECTOMY			
HOCM with Class III CHF	ADULT CONG			
	OTHER			
TOTAL STATUS III CASES	**TOTAL**			

The specific criteria for urgency and resource intensity categories are tailored to each specialty, such as adult cardiac surgery in this example. AF, atrial fibrillation; AI, aortic insufficiency; AS, aortic stenosis; AVD, aortic valve disease; CAD, coronary artery disease; CABG, coronary artery bypass graft; MR, mitral regurgitation; TR, tricuspid regurgitation; CHF, congestive heart failure; OHT, orthotopic heart transplate; MVR, mitral valve regurgitation; VAD, ventricular assist device; LV, left vetricular; HOCM, hypertrophic obstructive cardiomyopathy.

completed by the Division of Adult Cardiac Surgery is seen in Table 3.

When completed, the grid provides a snapshot of the patients on the waitlist and can be used to help distribute available operating room time and perioperative resources among divisions. The availability of operating rooms, staff, and perioperative resources are described in regular communications with hospital administration. The divisions can then propose cases from their grids that match available resources. If the total number of proposed cases or the distribution of resource intensity exceeds the available resources on a given day, cases can be scheduled over a period of several days. Because case length is a component of intensity, shorter cases would be given a lower intensity score and might be prioritized over longer cases of similar urgency.

DISCUSSION

The COVID-19 global pandemic has had an unprecedented effect on hospital operations and an outsized impact on surgical volume. At our institution, operating room time was slashed to 10% of normal to accommodate the necessary physical and staff changes during the surge response. Here, we first describe our approach to allocation of extremely scarce operating room resources during the worst weeks of the surge. This RIC system zooms in on the perioperative details that are often overlooked when resources are readily available. Having such a detail-focused system allowed us to maximize our ability to operate on all of the emergent as well as the most urgent cases during the pandemic.

This system worked because of the steadfast commitment that surgeons made to follow their patients remotely and the remarkable loyalty and understanding of the patients themselves who remained on the waiting list. As the pandemic ebbs, it is important to honor this achievement by creating as equitable and fair a system of triaging patients on the waiting list as possible. Although we may be tempted to operate first on those who have waited longest or those with the most serious diseases, we must consider the impact of proposed operations on currently available resources. Although some resources, such as PPE, are no longer scarce, others, such as operating rooms and ICU beds, still are. We cannot overwhelm the fragile system in a rush to clear the waiting list. Rather, we must temper our excitement at the prospect of reopening our doors and carefully balance the urgency of a case as well as the resources required and available as is represented by the Urgency Intensity Grid. In this way, we will continue to maximize the number of operations done and ensure that resources will continue to be available to all patients on the waiting list.

There are benefits to these triage systems that may outlast the COVID-19 pandemic. A key component of the triage system was accurate and up-to-date knowledge of current resource utilization and close communication with hospital administration. The assessment was incredibly dynamic as resource availability changed even throughout the day. Although we may look ahead to being resource-rich once again, incorporating a more resource-conscious approach will be a worthwhile paradigm shift. The RIC system and the Urgency Intensity Grid create a common language that can be used going forward to help frame scheduling and prioritization schemes.

There are limitations to our algorithms. They serve as a guideline to make operative booking decisions and facilitate system-level decision-making. The guidelines do not attempt to weigh other important patient specifics, such as operative risk, potential benefit, and life-years saved. Such ethical judgments were purposely not built into the algorithms and, fortunately, were never required.

CONCLUSION

During public health emergencies, hospital resources are strained. When the demand for certain resources exceeds supply, some hospital services must be curtailed or suspended. In response, we created a roadmap that combines active surveillance of resource availability and case urgency with the ultimate goal of maintaining operating room throughput for the emergent and most urgent cases throughout the worst days of the pandemic and of creating a fair system that mindfully uses perioperative resources as they become more available. We also hope that in this period of re-building and re-imagining what a post-COVID operating room system could look like, this focus on resource-consciousness becomes embedded in our approach.

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