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Review

International guidelines and recommendations for surgery during Covid-19 pandemic: A Systematic Review

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ABSTRACT

Background: During the COVID-19 pandemic, surgical departments were forced to re-schedule their activity giving priority to urgent procedures and non-deferrable oncological cases. There is a lack of evidence-based literature providing clinical and organizational guidelines for the management of a general surgery department. Aim of our study was to review the available recommendations published by general Surgery Societies and Health Institutions and evaluate the underlying Literature.

Materials and methods: A review of the English Literature was conducted according to the AMSTAR and to the 2009 Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.

Results: After eligibility assessment, a total of 22 papers and statements were analyzed. Surgical societies have established criteria for triage and prioritization in order to identify procedures that can be postponed after the pandemic and those that should not. Prioritization among oncologic cases represents a difficult task: clinicians have to balance a possible delay in cancer diagnosis or treatment against the risk for a potential COVID-19 exposure. There is broad agreement among guidelines that indication to proceed with surgery should be discussed in virtual Tumor Boards taking into consideration alternative therapeutic approaches. Several guidelines deal with the role of laparoscopic surgery during the pandemic: a tailored approach is currently suggested, with a case-by-case evaluation provided that appropriate personal protective equipment is available in order to minimize the potential risk of transmission. Finally, there is a considerable agreement in the published Literature concerning the management of the personnel during the peri- and intraoperative phase and on the technical advices regarding the induction, operative and recover maneuvers in COVID-19 cases.

Conclusions: During COVID-19 pandemic, it is of paramount importance to face the emergency in the most effective and efficient manner, retrieving resources from non-essential settings and, at the same time, providing care to high priority non-COVID-19 related diseases.

1. Introduction

In December 2019, the outbreak of a novel and highly contagious coronavirus infection has been identified in Wuhan, China. The pathogen, named SARS-CoV-2 by the World Health Organization (WHO) [1], is responsible for a novel pneumonia affecting the lower respiratory tract, referred to as Coronavirus Disease 2019 (COVID-19). COVID-19 represents a global pandemic, affecting 212 countries and territories around the world, with over 3.200.000 infected subjects and more than 228.000 deaths [2]. The exponential afflux of patients in need of sub-intensive or intensive care represents, for most of the healthcare systems around the globe, a crisis of unprecedented magnitude in the post-world war era. While the population continues to be affected by the

whole spectrum of pre-existing diseases, hospitals were swamped with a massive number of COVID-19 patients to the point that prompted the Administrations to create COVID-19 dedicated wards, ICUs and hospitals with redistribution of healthcare workers (HCW) from non-COVID-19 to COVID-19 intensive and sub-intensive units. In this context, majority of surgical departments were forced, both due to reduced manpower/facilities and to limit the viral spread, to re-schedule their activity giving priority to urgent/emergent and non-deferrable oncological cases. The prioritization of patients is a complex strategy that poses several organizational and ethical issues.

While several clinical commentaries and management indications have been published by research groups working in highly affected areas, there is a lack of evidence-based literature providing clinical and

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organizational guidelines for the management of a general surgery department during the COVID-19 epidemic. Aim of our study was to collect and review the available guidelines and recommendations published by general Surgery Societies and Health Institutions and evaluate the underlying literature.

2. Materials and Methods

The review of the Literature was reported according to the AMSTAR and the 2009 Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [3].

An extensive search was performed to identify papers and statements dealing with management of surgical patients during pandemic. MEDLINE, PubMed, Embase and the Cochrane Library databases were searched up to April 24th 2020. The following terms were searched, individually or in combination: 'pandemic', 'coronavirus', 'COVID-19', and 'surgery' or 'surgical'. Moreover, a Google search of the topic related key words was also conducted along with national and international Surgical Societies and Health Institutions websites. References of the included papers were checked to identify any additional study and the related articles function was used. After eliminating double hits, two authors independently screened the titles and abstracts for eligibility. For potentially relevant records, the full-text guidelines were obtained, and the inclusion and exclusion criteria were applied. Articles and guidelines in English language, reporting practical indications on operative and perioperative management during pandemics were included. Given the lack of high-quality evidence on the COVID-19 and the rapid evolution of the pandemic, we included guidelines irrespective of their methodological level and their development process. In fact, most of decision-making and guideline development on this topic are based on the limited available data and information inferred from other viruses and similar epidemics. Moreover, expert opinions and author's experiences in endemic areas were considered. Editorial, commentaries, duplicated and non-English articles were excluded. We analyzed statements and recommendations regarding elective/oncologic/emergency surgery, laparoscopy, and operations in COVID-19 positive patients.

3. Results

The initial search returned 1076 records. After eligibility assessment, a total of 22 papers and statements were included (Fig. 1): three Institutional guidelines, 10 Societies' guidelines and 9 original articles were analyzed [1,4–24].

3.1. Elective surgery

3.1.1. Literature review

On March 1st, the Centers for Disease Control and Prevention (CDC) recommended rescheduling elective surgeries and shifting elective inpatient surgical procedures to outpatient settings, when feasible [4]. In order to guide the decision-making process, surgical societies have established criteria for triage and prioritization. Triage criteria are intended to guide surgical scheduling according to the hospital burden of the pandemic phase. Surgical prioritization is intended to identify the procedures that can be postponed and those that should not, balancing the risk between disease progression and viral exposure.

Triage criteria were reported by the American College of Surgeons (ACS) [25] and by Ross et al. [23] ACS [25] distinguishes three acute pandemic phases based on hospital resources availability and COVID-19 patients burden: a progressive restriction of surgical activity follows the pandemic escalation and the potential impairment of survivorship if surgery is not performed in a determinate interval of time (Table 1). While in phase I (few COVID-19 cases), elective surgery is still performed but restricted to patients with survivorship possibly compromised if not operated within 3 months, in phase II and III only urgent/

emergent operations are performed. Ross et al. [23] distinguishes four different pandemic phases according to the number of COVID-19 cases and Hospital/ICU capacity. In the alert phase (no COVID-19) elective surgery is performed as usual; with COVID-19 cases skyrocketing, reduction by 50% should be started and eventually totally suspended performing only urgent/emergent cases.

Criteria for surgical prioritization are reported by British National Health Service (NHS) [5], ACS [26] and European Society for Medical Oncology (ESMO) [11] guidelines. The NHS guidelines [5] suggest to classify patients requiring surgery according to four levels of surgical priority (Table 2). Operations are distinguished in emergent (< 24 h), urgent (< 72 h) and elective (deferrable for up to 4 weeks, 3 months and beyond 3 months), providing a detailed list of surgical procedures for each category [5]. During the pandemic, surgery that can be deferred for up to 4 weeks might still be performed, balancing the risk between the underlying condition and the viral spread. This category includes some cancer operations and surgery for complicated benign conditions unresponsive to medical therapy. ACS [26] identifies different tiers of surgical procedures according to acuity of surgery (high, intermediate and low according to Elective Surgery Acuity Scale) and patient's general condition. High acuity surgery (most cancers and highly symptomatic patients) should not be delayed during the pandemic. ESMO [11] identifies three levels of priority (high, medium and low), defined by incorporating the evaluation of the patient's overall clinical condition and the expected benefit provided by the intervention in terms of survival and quality of life.

3.1.2. Discussion

Before the pandemic declaration by the WHO, it was already clear that postponing elective activities was a fundamental step, in order to preserve patients' safety and to limit the viral spread. This measure increases the resources for COVID-19 patients, clearing ward and intensive care unit (ICU) beds. Moreover, it avoids unnecessary patient traffic in the hospital and reduces the risk of cross-infection between elective patients, hospital visitors and COVID-19 patients, preventing spread of infection from the hospital to the community [19,27]. If on one hand, postponing elective procedures is necessary, on the other, every delay in treatment, may lead to adverse outcomes. Clinicians should assess the risk of proceeding and delaying surgery considering that a possible time of 6–7 weeks could be necessary to see a decrease in COVID-19 prevalence [26]. As suggested by all Authors, a clear surgical strategy and a plan for providing essential operations during the pandemic should be developed, in order to keep the system effective. Due to a rapidly changing environment, keeping the Triage criteria in mind, all surgical systems will need to constantly adapt to the continuously evolving situation. In particular, surgical planning must take local resources constraints into account as a means to understand the potential impact of each decision [28].

3.2. Oncologic surgery

3.2.1. Literature review

Four Society Guidelines (Society of Surgical Oncology – SSO [12], ACS [25], ESMO [29–33] and International Society for Diseases of the Esophagus – ISDE [13]) contain detailed indications on oncologic surgery. Recommendations comprise operations that should be performed during and despite the pandemic and surgical treatments that can be safely postponed.

3.2.1.1. Breast cancer. In newly evaluated invasive cancers, the tumor board may decide, case by case, whether to proceed with upfront surgery versus neoadjuvant chemotherapy (NAT), depending also on institutional resources [29]. Alternative approaches to be considered are hormonal therapy for some ER-positive invasive cancers and NAT for triple negative-HER2 positive tumors [25]. Primary surgery is deemed non-deferrable when the patient cannot undergo

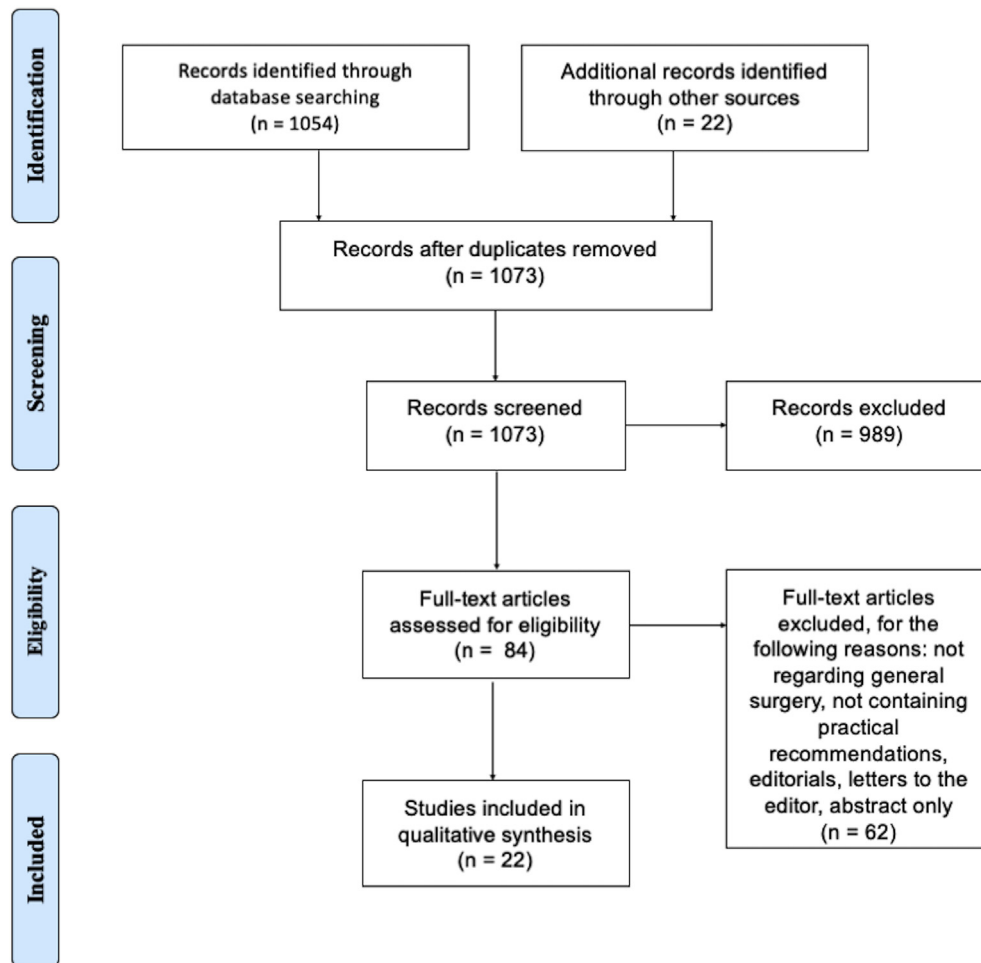


Fig. 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) flow diagram.

chemotherapy or when pathological examination of small tumors can guide medical treatment [29]. ACS encourages the use of breast conserving strategies whenever possible, reserving definitive mastectomy only for patients whose survivorship is likely to be compromised if not operated within 3 months (provided that radiation oncology services are available) [25]. For clinically low-risk primary breast cancers, clinicians may consider starting neoadjuvant/preoperative endocrine therapy according to menopausal status and delaying surgery [29]. Inflammatory and locally advanced breast cancers should receive NAT prior to surgery [25]. High priority should be given to patients who have completed NAT and to those progressing on NAT [12,25,29]. Other indications to non-deferrable

surgery are: breast cancer in pregnancy [29], excision of malignant recurrence (depending on phenotype and extent) [25,29], and discordant biopsies likely to be malignant [25,29]. In situation where hospital resources are all directed to COVID-19 patients, surgery should be limited to urgent/emergent situations such as breast abscesses, evacuation of hematomas, revision of an ischemic flap [25,29]. The following scenarios can be safely postponed for the duration of the pandemic: benign lesions and duct excision, discordant biopsies likely to be benign, non-invasive breast cancer (in situ) except for extended high-grade DCIS, breast reconstruction, prophylactic surgery [25,29]. Consider adjuvant hormone/chemotherapy and radiation for minimal margin involvement, delaying margin re-resection. Same principles

Table 1
Triage criteria for elective surgery during COVID-19 pandemic.

Guidelines	Type of recommendation	Pandemic phase	Definition	Action
ACS [25]	Society guidelines	Acute phase I	Semi-urgent setting or preparation phase (few COVID-19 patients with hospital resources not exhausted)	Operate if surgery needed within 3 months (survivorship otherwise compromised).
		Acute phase II	Urgent setting, escalation phase (many COVID-19 patients with limited hospital resources)	Operate if surgery needed within few days.
		Acute phase III	Hospital resources are all directed to COVID-19 patients (lack of ICU and ventilator capacity)	Operate if surgery needed within few hours.
Ross et al. [23]	Expert opinions	ALERT	No patients with COVID-19	Normal operations
		LEVEL 2	First patient with COVID-19	- Decrease elective cases by 50% - Prioritize surgical urgency - Cancel high risk cases
		LEVEL 1	Facility at ≥ 100% capacity; ICU capacity ≥ 90%	- Stop ALL elective operations - Urgent and emergent surgeries only
		CONDITION ZERO	Facility at > 125% capacity; ICU capacity ≥ 100%	Only urgent/emergent surgeries

Table 2
Prioritization criteria for elective surgery during COVID 19 pandemic.

Guidelines	Type of recommendation	Priority	Definition	Action
NHS [5]	Society guidelines	Level 1a/1b	1a: Emergency operation (< 24 h) 1b: Urgent operation (< 72 h)	Do not postpone
		Level 2	Deferrable for up to 4 weeks: - Cancer according to MDT decision; - Crohn's disease-related complications; - goiter (mild moderate stridor); - medically resistant thyrotoxicosis/hyperparathyroidism/adrenal pathology	Balance the risk from the underlying condition with the need of viral containment to maximize safety
		Level 3	Deferrable for up to 3 months: - Cancer according to MDT decision; - Cholecystectomy post-acute pancreatitis; - Hernia presenting with complications; - Parathyroidectomy – with medically resistant complications	Postpone
		Level 4	Deferrable beyond 3 months: - Uncomplicated hernias (hiatal, incisional); - Stomas closure included Hartmann's reversal; - Proctology procedures; - Upper UGI benign conditions (eg gallstones. MRGE, others); - Benign uncomplicated endocrine diseases - Breast reconstruction/prophylactic surgery/benign diseases	Postpone
ACS [26]	Society guidelines	Tier 1a	Low acuity surgery/healthy patient; (Outpatient surgery; Not life-threatening illness)	Postpone surgery or perform at ASC
		Tier 1b	Low acuity surgery/unhealthy patient	Postpone surgery or perform at ASC
		Tier 2a	Intermediate acuity surgery/healthy patient (Not life threatening but potential for future morbidity and mortality. Requires in-hospital stay)	Postpone surgery if possible or consider ASC
		Tier 2b	Intermediate acuity surgery/unhealthy patient	Postpone surgery if possible or consider ASC
		Tier 3a	High acuity surgery/healthy patient	Do not postpone
ESMO [11]	Society guidelines	Tier 3b	High acuity surgery/unhealthy patient	Do not postpone
		High priority	- Life threatening condition - The magnitude of benefit qualifies for high priority (e.g. significant OS gain and/or substantial improvement in QoL)	
		Medium priority	- Not life threatening condition but delay beyond 6 weeks could potentially impact overall outcome - The magnitude of benefit qualifies for intermediate priority	
		Low priority	- Patient stable to be delayed for the duration of the COVID-19 pandemic - Intervention non-priority based on the magnitude of benefit (e.g. no survival gain with no change nor reduced QoL).	

MDT = multidisciplinary team; ASC = ambulatory surgery center; OS = overall survival; QoL = quality of life.

should be followed in breast cancers candidates to additional axillary surgery [25].

3.2.1.2. Colorectal cancer. Urgent surgery should be performed for: obstructive or nearly-obstructing colorectal cancer (prefer diversion in rectal cancer), acutely transfusion-dependent tumors, cancers with pending evidence of local perforation and sepsis, post-surgical and post-colonoscopy complications [25]. For resectable colon cancer, curative intent surgery should be carried out, while NAT could be considered for locally advanced colon cancer [12]. For rectal cancer, all options for NAT should be considered. In post-neoadjuvant rectal cancer, priority should be given to those with no response to therapy [25]. In situation where hospital resources are all directed to COVID-19 patients, surgery should be limited to emergent situations (perforation, peritonitis, massive gastrointestinal bleeding, sepsis), considering patients' transfer to hospital with capacity in all other cases [25].

The following scenarios can be safely postponed: malignant polyps, prophylactic surgery for hereditary conditions, large, benign, asymptomatic polyps, small, asymptomatic colon and rectal carcinoids [12,30].

3.2.1.3. Gastric and esophageal cancer. Priority should be given to surgical resection of cT1b lesions and patients with ongoing peri-operative treatment. cT1a tumors should undergo endoscopic management if feasible while patients with cT2 cancer or higher should undergo NAT [12,25]. Timing of surgery after NAT should be individualized by balancing the risk of progression with the risk of

surgery and SARS-CoV-2 infection [13]. The capacity of ICU has to be considered prior to perform esophagectomy, especially in patients who are at higher risk of prolonged ICU stay [13,25]. If the COVID-19 pandemic escalates, patients should prolong chemotherapy, if tolerating and responding, or switched to definitive chemoradiation, offering salvage surgery only in case of failure [12,25]. In situation where hospital resources are limited, surgery should be restricted to emergencies such as perforated cancers, tumor associated infection/sepsis, surgical complications management. Transfer of patients to other centers should be considered [25,31]. Procedure that can be postponed after the pandemic are: functional operations, bariatric surgery, surgery for benign non-aggressive tumors of the GI tract [13].

3.2.1.4. Hepatopancreatobiliary cancer. Potentially curable pancreatic adenocarcinoma (included those who have completed NAT and those with biliary/gastric obstruction), pancreatic cystic lesions with confirmed high grade dysplasia, duodenal cancer, ampullary cancer, potentially curable large/multifocal hepatocellular carcinoma and cholangiocarcinoma should undergo surgical resection [12,25,32,33].

When resources are limited, patient can prolong NAT when responding and tolerating [12]. If pandemic escalates, only emergent life-saving interventions should be performed (e.g. drainage for cholangitis, gastric outlet obstruction and bleeding management) [25].

3.2.1.5. Neuroendocrine tumors (NET), thyroid and adrenal cancer. Surgery should be restricted to symptomatic or growing small bowel/pancreatic NET [12]. Surgery should not be postponed in

thyroid cancer with a current or impending threat to life, morbidity due to local invasion and aggressive biology and in adrenocortical cancer, pheochromocytoma, paraganglioma and medically resistant Cushing's syndrome [12]. Most uncomplicated endocrine operations can be delayed [12].

3.2.2. Discussion

At present, it is not possible to establish with certainty if cancer patients are at higher risk of contracting COVID-19 or experiencing severe outcomes. According to the Italian National Institute of Health, out of 1738 verified COVID-19 related deaths occurred in Italy up to April 16th, 16.2% had a history of active cancer in the last 5 years [34]. A nationwide analysis from China reported 18 out of 1590 COVID-19 cases with a history of cancer (1%; 95% CI 0.61–1.65) [35]. Cancer patients were reported to have a higher risk of severe clinical events, requiring invasive ventilation or leading to death, when compared with patients without cancer (HR 3.56 [95%CI, 1.65 to 7.69]). Clinicians have to balance a possible delay in cancer diagnosis or treatment against the risk for a potential COVID-19 exposure, taking into account limitation of healthcare resources that need to be allocated properly [36,37]. All Authors agree that indication to proceed with surgery should be discussed in virtual Tumor Boards taking into consideration that alternative therapeutic approaches should be pursued, especially in very early- or very advanced-stage diseases as tumor biology and probability of cure should always be balanced. Turaga et al. [38] conducted a comprehensive study involving almost 4 million cancer patients who underwent definitive cancer and examined the estimated effect for each 1-week delay in definitive surgery from diagnosis. They found that most cancer surgeries can be safely delayed beyond the current waiting time for at least 4 weeks without having a significant impact on patient survival or cancer progression [38].

3.3. Emergency surgery

3.3.1. Literature review

Three society guidelines [14,15,39] and one paper [24] contain practical indications in emergency surgery management. Guidelines agree that all acute patients should be considered COVID-19 suspected cases until proven otherwise: thorough medical and close contacts history must be collected along with swab testing, chest x ray and, in patients undergoing abdominal CT scan, a chest CT scan should also be performed [14,15,39].

Non-operative or conservative management of acutely ill patients should be considered when feasible and safe, and it is strongly encouraged with COVID-19 patients [14,15,24,39].

3.3.1.1. Trauma surgery. To properly allocate trauma patients, clinicians should always be aware of the local and regional status of resources with daily updates with local authorities. A constant communication should be present regarding regional distribution of patients, ICU capacity, ventilators allocation [14,15]. Status of blood stocks should be regularly checked [15]. In case of reduced availability of red blood concentrates (RBC), plasma-first approach using an inverse ratio of fresh frozen plasma (FFP) to blood (2 FFP to 1 RBC) can be adopted [14]. Anyhow, the consultant in transfusion medicine has to be involved in decision-making as early as possible [14]. Evaluation of trauma patients should not be delayed to determine COVID-19 status, but rigorous use of personal protective equipment (PPE) is recommended for all patients [14].

3.3.1.2. Emergency colorectal surgery. Only life-threatening emergencies should be treated with surgical operations (intestinal perforation/ischemia, loop obstruction, incarcerated hernia, bleeding unresponsive to conservative/radiological approaches) [24,39]. Conservative management for adhesive small bowel obstruction can be attempted as usual practice [39]. Note that naso-gastric tube

placement may be an aerosol-generating procedure and appropriate precautions are recommended [6]. For large bowel perforation, open approach is preferable. In complicated diverticulitis, conservative approach should be maximized: IV antibiotics and percutaneous drainage for Hinchey class 1 and 2 [24,39]. Surgery should be restricted to purulent or fecal peritonitis [39]. Hartmann procedure should be preferred over an anastomosis [24]. Colorectal anastomosis should be avoided in patients with suspected or confirmed COVID-19, due to high risk of complications and subsequent consumption of healthcare resources [24]. Non-complicated appendicitis can be treated with non-operative management [24,39]. However, sparing of operating room (OR) resources should balance with the potential longer length of stay of conservative management [39]. In case of failure, surgical intervention should be promptly performed [39]. Appendicular abscess should be managed by percutaneous drainage if technically feasible [39]. Finally, perforated appendicitis requiring urgent surgery should be performed using an open approach in proven COVID-19 patients. Laparoscopy can be considered if adequate devices are available [24]. Regarding proctologic emergencies, any attempt should be made to manage the condition conservatively, especially in known or suspected COVID-19 positive [24]. Alternatively, management under local anesthesia in an outpatient setting should be preferred [39]. Emergency surgery should be restricted to bleeding and severe disease, or failure of conservative approach [24,39].

3.3.2. Discussion

During a pandemic, it is essential to ensure emergency surgery care [14]. If non-operative management failed and surgery is deemed necessary, there is unanimous agreement that appropriate PPE and precautions should be adopted and surgery should not be delayed whilst waiting for the swab results [24,39]. Initial assessment of a potentially surgical candidate should be conducted by a senior clinician with the expertise to promptly recognize whether surgery is required [6]. Decision to proceed should be shared and discussed with the anesthesia team given the possible paucity of ICU resources and surgery should be performed by the team most experienced member [40]. Lastly, it should be reminded that gastrointestinal symptoms are a possible manifestation of COVID-19: therefore, a COVID-19 infection should be considered when assessing patients with diarrhea, abdominal pain and/or fever [27].

3.4. Laparoscopy

3.4.1. Literature review

Five society guidelines [6–8,13,41] and 4 original articles [16–18,24] deal with the use of laparoscopy during the pandemic (Table 3). The Association of Laparoscopic Surgeons of Great Britain and Ireland (ALSGBI) [8] supports the use of laparoscopy when there are clear benefit to the patients and resources guarantee safety for the OR team. According to the Intercollegiate General Surgery Guidance [6] and ISDE guidelines [13], laparoscopy should be performed only in selected cases, when clinical benefit evidently outweighs the risk of viral transmission. Di Saverio et al. [24] suggests that laparoscopy should be carefully considered in COVID-19 confirmed patients and only when appropriate equipment and full PPE are available and properly installed in OR. Cohen et al. [18] restricts minimally invasive surgery in COVID-19 negative patients and caution is recommended in patients with unknown COVID-19 status. No absolute contraindications on laparoscopy emerge from the Literature review, but appropriate PPE for OR team and smoke evacuation/filtration systems are unanimously recommended [6,8,41].

3.4.2. Discussion

Laparoscopy is based upon the creation and maintenance of a pneumoperitoneum and the use of energy devices with a subsequent

Table 3
Recommendations on minimally invasive surgery in COVID-19 pandemic.

	SAGES [7]	ACS[41]	ALSGBI [8]	Zheng et al. [16]	Di Saverio et al. [24]	Cohen et al. [18]	Morris et al. [17]
Closed-circuit smoke evacuation/ultra-low particulate air filtration systems	✓		✓		✓		✓
Low power setting of electrocautery	✓			✓			
Minimal use of energy devices			✓	✓			✓
Small port incisions	✓				✓		
Balloon/self-sealing trocars			✓		✓		
Low CO2 pressure	✓		✓	✓			✓
Pneumoperitoneum evacuation via filtration system	✓		✓				✓
Avoid using 2-way pneumoperitoneum insufflators		✓		✓			
Liberal use of suction devices		✓		✓			
Close evacuation of all gas at the end of the procedure			✓		✓	✓	✓
Reduce Trendelenburg position time				✓			

creation of a smoke bioproduct [42]. Aerosolization of blood born viruses has been previously detected in surgical smoke during laparoscopy [43,44]. Therefore, a potential risk of aerosol exposure must be considered also for SARS-CoV-2 even though there isn't current demonstration of SARS-CoV-2 RNA presence in the surgical smoke [16]. On the other hand, proven benefits of laparoscopy should be considered during COVID-19 pandemic, such as reduced length of stay and complications (and a potential minor burden on healthcare system). Moreover, at the present, there is very little evidence about the relative risks of laparoscopy versus open surgery, specific to COVID-19 [7]. While laparoscopy has the potential for ultrafiltration of the majority if not all aerosolized particles, open surgery has a similar potential to generate aerosols without the possibility of safely containing the surgical smoke [7,17,45]. From the Literature review, we can conclude that a tailored approach is currently suggested, with a case-by-case evaluation considering surgeon expertise, patient- and disease-related factors provided that appropriate PPE and OR equipment are available in order to minimize the potential risk of transmission.

3.5. Surgical procedures in COVID-19 confirmed patients

3.5.1. Literature review

Two Institutional guidelines [1,46], 5 Surgical Societies' guidelines [6,7,9,13,41,47] and 6 original articles [16,19–22,24] were identified, reporting practical indications on the organization of the operative and perioperative setting during the COVID-19 pandemic (Table 4).

3.5.1.1. Preoperative management. Transportation of all suspected and confirmed cases from and to ICU/ward/OR should take place using dedicated hospital staff [20,24,41,47] following the shortest predetermined, dedicated route, avoiding common spaces and stalling. Non-intubated patients should wear a surgical mask [20], disposable gloves, cap and shoe covers. The use of a dedicated transport ventilator is advised for intubated patients [21,22]. The hospital staff is responsible for route clearing and sanitization of the stretcher and utilized elevators [21].

In accordance with the WHO and the CDC statement [1,46], aerosol generating procedures (intubation, non-invasive/manual ventilation, bronchoscopy) should be performed in negative pressure anterooms [7,9,21,22,41,47]. Whenever not available, such procedures should be conducted in the OR [6,13] and taped off areas should be clearly marked to drop off the supplies [19]. The HCWs involved in these phases should be limited, surgical team should wait outside.

3.5.1.2. OR management. The majority of Authors suggests the use of a dedicated OR, preferably located out of high-traffic areas and close to the block entrance [7,9,19–22]. Negative pressure ORs are considered ideal [21,46]; however, most ORs work at positive pressure and their use is therefore obviously permitted [7,9,20,41,47]. An air exchange

rate ≥ 25 cycles/hour is considered sufficient to effectively reduce the viral load within the OR [22].

Only essential members of the staff should be admitted in the OR, limiting in/out traffic, doors should be kept closed. A HCW should remain outside the OR for supplies that should be delivered through charts to avoid handling-related contamination. Only essential equipment should be kept in, patients' records should be kept outside [6,7,9,19–22,41,47]. All operators involved in the procedure should be tracked to identify HCWs at risk of infection [20].

The use of energy devices should be limited and at the lowest possible setting and long dissection in the same spot should be avoided [7,16]. The Authors recommend a thorough use of smoking evacuators and avoidance of leakage through port incisions [6,7,13,16,47]. Pneumoperitoneum should be kept at the lowest possible levels and electromedical units' surfaces should be covered [16,20,22].

3.5.1.3. Postoperative management. Extubation should occur, with essential personnel, in a negative pressure ICU/ward room or, if not available, in the OR [19–21,24,41,48]. The PPE should be discarded in a dedicated doffing area. Scrubs should be changed after each procedure and showering is encouraged [20–22].

At the end of the operation the breathing circuit and the canister of soda lime should be discarded [22]. The OR should be kept empty to allow air exchange (from 15 to 20/hour to ≥ 25 /hour for approximately 30 min), cleaning service can then follow [9,13,20,21]. The CDC advocates the appropriateness of EPA-registered disinfectants contained in the List N for routine cleaning and disinfection [46].

3.5.2. Discussion

While there is a considerable agreement in the published literature concerning the management of the personnel during the peri- and intraoperative phase and on the technical advices regarding the induction, operative and recover maneuvers, the literature's statements on the use of the surgical spaces is more controversial. In accordance with the WHO and the CDC [1,46], aerosol generating procedures (tracheal intubation, non-invasive ventilation, manual ventilation, bronchoscopy) should be performed in negative pressure ante-rooms, subsequently transferring the patient to the OR. Since such logistical resources are rarely available in the surgical departments, several authors prompt the use of the OR for patients' induction and recovery, in order to overcome this issue [6,13,19,20,22,24]. Similarly, while negative pressure ORs are considered ideal to minimize the infection risk [21,46], given their greater availability the use of positive pressure ORs is widely accepted for the for the treatment of COVID-19 cases [7,9,19,20,22,24], provided that an adequate air exchange rate is utilized [20,22]. From our review of the literature we can conclude that the viral spread through aerosol generating procedures and direct/indirect contact can be efficiently reduced by a rational use of the available spaces, even in absence of more advanced containment

Table 4
Recommendations on perioperative management of suspected/confirmed cases in COVID-19 pandemic.

	CDC [46]	WHO [1]	SAGES [7]	AGS [41,48]	ISDE [13]	Intercollegiate [6]	AORN [9]	Di Saverio et al. [24]	Zheng et al. [16]	Coccolini et al. [20]	Brindle et al. [19]	Ti et al. [21]	Wong et al. [22]
Preoperative Management													
Consider all patients needing emergency surgery as COVID-19 positive until proven otherwise		✓	✓		✓			✓					
Develop a dedicated transport route to the OR		✓	✓	✓				✓		✓	✓	✓	✓
Perform AGP in negative pressure rooms when available	✓						✓						
If negative pressure anterooms are not available, perform review, induction and recovery in the OR					✓			✓		✓			✓
Operative Management													
Use negative pressure ORs if available or positive pressure ORs with 20–25 air exchanges/h							✓			✓			✓
Limit personnel number, equipment and traffic in/out of the OR	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓
Outside the OR develop a dedicated area as a drop off point and a dedicated runner for supplies				✓			✓	✓		✓		✓	
Use energy devices at the lowest possible setting and evacuate smoke using suction devices			✓	✓	✓	✓			✓				
Postoperative Management													
Plan and adequate time between procedures to allow deposition of aerosolized viral particles							✓			✓		✓	
Routine cleaning/disinfection with EPA list N disinfectants are appropriate for SARS-CoV-2	✓			✓					✓	✓	✓	✓	✓

MIS: minimally invasive surgery; OR: operating room; HCW: health care worker; AGP: aerosol generating procedure; AIIR: airborne infection isolation room; PPE: personal protective equipment; HEPA: high efficiency particulate air; ICU: intensive care unit.

structures.

3.6. Reopening of elective procedures

As the rate of new COVID-19 cases decrease, a progressive reopening of elective procedures will be necessary. HCWs and institutions must prepare for a substantial demand of surgical care, for all those patients who could not be treated during the pandemic. ACS provided a Joint Statement together with ASA, EORN, AHA with general principles to guide resumption of elective surgery [48]. A substantial reduction of new COVID-19 cases for at least 14 days is deemed necessary before the reopening. Institutions have to guarantee patients and staff safety through an appropriate COVID-19 testing policy and adequate provision of PPE. Facilities should implement social distancing policies for staff, patient and patient visitors following local and national recommendations. Prioritization of cases requires a collegial discussion between surgeons, anesthesiologists and nurses and principles such as specialities prioritization (cancer, transplants, cardiac surgery) should be considered. Post-COVID-19 patients who require operation should be carefully evaluated: readiness for surgery require a multidisciplinary evaluation (surgeon and anesthesiology) and appropriate peri and postoperative policies have to be established.

This study has two main limitations: since the COVID-19 pandemic is still a developing crisis, our knowledge and, as a consequence, the published evidence are constantly evolving, thus the indications reported in this review could be subject to future revision. Moreover, most of the published guidelines and authors' publications are based on personal expertise and experience derived from previous similar epidemics.

4. Conclusion

COVID-19 pandemic is demanding an enormous effort to Health Systems around the Globe. It is of paramount importance to face the emergency in the most effective and efficient manner, retrieving resources from non-essential settings and, at the same time, providing care to high priority non-COVID-19 related diseases. Surgeons were called to act upon delicate choices, based on individual discernment, experience and available knowledge.

The present paper, that summarize the few available recommendations and guidelines, tries to facilitate those involved in facing the intricate decisions.

Ethical Approval

Ethical Approval was given by the Institutional Review Board of our Department.

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Author contribution

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