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The coronavirus disease (COVID-19) outbreak started in Wuhan, China, in December 2019, and evolved into a global problem in a short period. The pandemic has led to many social and health-care challenges. In this context, surgery is an area that is facing the need for many adaptations. In this systematic literature review, we analyzed different perspectives concerning this situation, aiming to provide recommendations that could guide surgeons and entities toward screening, elective and emergency surgeries, decision making, and operating room management. A computerized search in PubMed, Scopus, and Scientific Electronic Library Online (SciELO) for relevant literature up to April 4, 2020, was performed. Articles were included if they were related to surgery dynamics in the context of the COVID-19 pandemic. Of the 281 articles found in our initial search and 15 articles from alternative sources, 39 were included in our review after a systematic evaluation. Concerning preoperative testing for severe acute respiratory syndrome coronavirus 2 infection, 29 (74.4%) articles recommended some kind of screening. Another major suggestion was postponing all (or at least selected) elective operations (29 articles, 74.4%). Several additional recommendations with respect to surgical practice or surgical staff were also assessed and discussed, such as performing laparoscopic surgeries and avoiding the use of electrocauterization. On the basis of the current literature, we concluded that any surgery that can be delayed should be postponed. COVID-19 screening is strongly recommended for all surgical cases. Moreover, surgical staff should be reduced to the essential members and provided with institutional psychological support.

KEYWORDS: Surgery; Operation; SARS-CoV-2; COVID-19; Coronavirus; Recommendations.
of surgical staff and modifying the organization of the operating room) (7). Many societies and authors have published different guidelines with respect to surgical protocols in this pandemic situation. In this review, we aimed to analyze different perspectives concerning this situation, with the objective of providing recommendations that could guide surgeons and entities toward screening, elective and emergency surgeries, decision making, and operating room management.

**MATERIAL AND METHODS**

We performed a systematic literature review based on an online search in the PubMed (from the National Center for Biotechnology Information), Scientific Electronic Library Online (SciELO), and Scopus databases. The following terms were used in the search engine to find matching articles: (OPERATION OR SURGERY) AND (SARS-COV-2 OR COVID-19 OR CORONAVIRUS). Our initial search yielded 281 articles. Other articles sent to the authors by societies or colleagues were also included in the sample (n=15). Duplicates were initially deleted using the Endnote (Clarivate Analytics) reference engine. Articles that were not in English (Portuguese, Spanish, or German) were translated using online translation service. All article titles and abstracts were read by at least one author, and selected if relevant. For this review, an article was considered relevant if it (a) is related to the COVID-19 pandemic, (b) suggested approaches directly affecting surgery dynamics (e.g., reducing staff numbers, remodeling the circulation of staff and patients in the operating room, using different protection methods for patients and staff, and adapting different equipment usage), (c) suggested any kind of screening for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) for surgical patients, or (d) had any kind of recommendation about elective procedures. Papers focused on anesthetics and general hospital management were excluded.

**RESULTS**

**Records**

Of the 281 articles found in our initial search and 15 articles from alternative sources, 39 were included in our review after a systematic evaluation (Figure 1). Of the 39 selected publications, 21 were research articles, 5 were opinion papers, 4 were editorials, and 9 were grouped as “others” (Figure 2).
Most of the articles were related to surgical interventions in the gastrointestinal tract, followed by articles on head and neck and general surgeries. Other, less frequent, surgeries were vascular, trauma, oral and maxillofacial and thoracic (Figure 3).

**COVID-19 Screening**

Twenty-nine articles recommended screening for SARS-CoV-2 in patients elected for surgery (Figure 4). The most prevalent recommendation was to perform polymerase chain reaction (PCR) testing of nasal swabs in all surgical patients. Other suggestions included screening through computed tomography, clinical examination, temperature measurement, and measurement of immune cells in blood samples, as well as testing only symptomatic patients (Figure 5).

**Surgical Recommendations**

With respect to surgical schedules, a little fewer than one-half of the articles recommended postponing all elective surgeries (Figure 6). Another prevalent suggestion was to select, from the group of elective surgeries, those that could be postponed. Around 13% of the articles did not offer any direct recommendations with respect to elective surgeries.
The articles also offered recommendations about surgical practice, including reorganization of the operating room schedule to provide only essential surgical services, guaranteeing psychological support to surgical staff, increasing protective measures to level 3 standards, and utilizing telemedicine for consultations that do not require physical evaluation. Table 1 summarizes the 10 most frequent and relevant recommendations and the article(s) that suggested them. (Note: Not all recommendations are included in the table.)

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**DISCUSSION**

The coronavirus pandemic is an unprecedented scenario for the field of surgery. Surgery for high-risk cases cannot be postponed; however, the SARS-CoV-2 virus has a high transmissibility and techniques that could allow surgeons to perform safer surgeries in the operating room are warranted. Isolation is impossible to practice in the operating room because an anesthetist has to stand close to the patient to adequately perform intubation (40), which increases the
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Table 1 - General recommendations for surgical practice.

| Recommendation                                                                 | Number of articles | References |
|--------------------------------------------------------------------------------|--------------------|------------|
| Reduce the circulation of health-care workers                                  | 23                 | 8–30       |
| Increase the personal protective equipment (PPE) indications                   | 23                 | 8, 11, 12, 15–18, 20, 22–24, 28, 29, 31, 32, 37, 38 |
| Designate specific spaces for invasive/surgical treatments for all patients with COVID-19 | 17                 | 8, 11, 12, 15–18, 20, 22–24, 28, 29, 31, 32, 37, 38 |
| Operate on suspected or confirmed cases in negative-pressure operating rooms  | 15                 | 11, 15–19, 26, 27, 32–34, 36, 38–40 |
| Adopt level 3 protective measures                                              | 15                 | 12, 15, 16–18, 21, 22, 24, 28, 32, 35, 36, 38, 40, 41 |
| Develop a plan for providing essential operations                              | 14                 | 8, 13–16, 18–21, 27, 29, 32, 33, 42 |
| Educate surgical staff about PPE and/or basic hygiene principles               | 13                 | 8, 11–13, 15–18, 20, 25, 26, 29, 31 |
| Adhere to online consultations/telemedicine                                     | 13                 | 10, 13, 14, 20, 23–28, 34, 35, 39 |
| Optimize the surgery time                                                      | 12                 | 8, 11, 13, 17, 22–25, 27, 35, 36, 41, 42 |
| Offer psychological support to surgical staff                                  | 3                  | 10, 15, 20 |

Other reviewed articles did not bring any of those recommendations (43–47), but were included in the review as they at least mentioned how to approach surgeries during the COVID-19 epidemic.

exposure to aerosols that may be contaminated by the virus. Further, the virus also spreads through biological fluids, thus compromising the safety of the surgical environment in most cases.

Methods used to reduce contact have been suggested. Laparoscopies have been considered as a good way to diminish risks, because, in theory, a closed abdomen, which prevents the spread of gas or liquid, would decrease the possibility of contamination (36). Nonetheless, incidents during the exit of the trocar were reported, in which leakage of gas occurred in many cases, suggesting that laparotomy with extensive fluid drainage would be safer (26). Most hospitals agree that isolating the operating area is a better approach; however, this is difficult to accomplish. Operating inside closed doors can help reduce the number of infections among surgical staff members (15).

An article also suggested that SARS-CoV-2 could penetrate traditional surgical masks and gowns, thus necessitating the use of N95 masks and level 3 protection suits (23). Another significant concern is the procedure time, as greater exposure in the operating room leads to a higher risk of infection. Therefore, an article suggested that a team comprising the minimum number of experienced professionals should perform the surgery to optimize the procedure and reduce the surgery time (11). Another recommended approach for enhancing safety is selecting only known and reliable methods to reduce the risk of postoperative complications and prolonged hospitalization.

Trainee involvement must be reevaluated, as it can lead to an increase in procedure time and, consequently, the risk of exposure (12). The involvement of medical students in the clerkship and subinternship periods in teaching hospitals also leads to a similar problem as trainee involvement. The use of electrocautery is controversial because it produces a high concentration of contaminated gases (20). Therefore, an article suggested avoiding its use in a pandemic setting (28). Another article suggested allowing the use of electrocautery with some modifications, such as adjusting to the lowest possible effective power and employing a smoke absorption device (15).

Our review also found that it is relevant to strengthen the knowledge of health-care workers about hygiene measures during their shift. The constant stress caused by imminent contamination is known to make professionals more likely to experience mental health issues (20). Therefore, we advise hospitals to offer psychological support to their staff.

Most centers advise doctors to postpone elective surgeries for two main reasons: the risk of contamination is too high in the current epidemiological situation and medical equipment should be reserved for managing COVID-19 emergency cases (26). Online consultations are strongly recommended instead of hospital or clinic visits (27).

## CONCLUSION

Our main conclusion from this review is that any elective surgery that can be delayed should be postponed, taking into consideration that it may take 2–3 months for the health-care situation to return to normal. We also conclude that all surgical patients should be screened for COVID-19, with preference given to PCR tests. Regarding surgical practice recommendations, we believe that surgical staff should be reduced to the minimum, without compromising the procedure and any operation should be performed by the most experienced surgeon, so that the procedure time is reduced. An institutional workflow to assist medical staff in decision making and in dealing with mental health issues should also be established.

## AUTHOR CONTRIBUTIONS

Hojaij FC contributed to the conception and design of the study and provided advice to all other authors. Chinelatto LA, Boog GHP, Lopes JYZ, Kasimirski JA and Sacramento FM performed the literature search and wrote the manuscript. Hojaij FC reviewed the manuscript. All authors read and approved the final version of the manuscript.

## REFERENCES

1. Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, et al. A Novel Coronavirus from Patients with Pneumonia in China, 2019. N Engl J Med. 2020;382(8):727-33. https://doi.org/10.1056/NEJMoa2001017
2. Rothan HA, Byrareddy SN. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. J Autoimmun. 2020;109:102433. https://doi.org/10.1016/j.jaut.2020.102433
3. World Health Organization. Coronavirus disease 2019 (COVID-19) Situation Report - 75. Available from: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200404-sitrep-75-covid-19-pandemic.pdf?sfvrsn=99251b2b_4 [cited Apr 11th, 2020]
4. World Health Organization. Coronavirus disease 2019 (COVID-19) Situation Report - 51. Available from: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-covid-19.pdf?sfvrsn=1b6a2e57_10 [cited Apr 11th, 2020]
5. Gt Walker P, Whittaker C, Watson O, Baguelin M, Ainslie KEC, Bhatia S, et al. The Global Impact of COVID-19 and Strategies for Mitigation and Suppression. Available from: https://doi.org/10.25561/77735 [cited Apr 11th, 2020]
6. World Health Organization. Coronavirus disease 2019 (COVID-19) Situation Report - 74. Available from: https://www.who.int/docs/
Surgery in the COVID-19 Pandemic

24. Chen YH, Peng JS. [Treatment strategy for gastrointestinal tumor under COVID-19]. Zhonghua Wai Ke Za Zhi. 2020;58(4):273-7. https://doi.org/10.3760/cma.j.issn.0529-5815.2020.03.005

23. Zou J, Yu H, Song D, Niu J, Yang H. Advice on Standardized Diagnosis and Treatment of Colorectal Cancer During the COVID-19 Pandemic. J Gastroenterol Hepatol. 2020;58(3):178-82. https://doi.org/10.1111/jgh.15053

22. Zheng MH, Boni L, Fingerhut A. Minimally Invasive Surgery and the COVID-19 Pandemic. Neurosurgery. 2020. pii: nyaa116. https://doi.org/10.1093/neuros/nyaa116

21. Patel ZM, Fernandez-Miranda J, Hwang PH, Nayak JV, Dodd R, Sajjadi SM, et al. Pathways for urology patients during the COVID-19 pandemic. Minerva Urol Nefrol. 2020. https://doi.org/10.23736/S0393-2249.20.03861-8

20. Correia MITD, Ramos RF, Bahten LCV. The surgeons and the COVID-19 pandemic. Asian J Surg. 2020;43(3):223-7. https://doi.org/10.1016/j.asjsur.2020.04.030

19. Lui RN, Wong SH, Sánchez-Luna SA, Pellino G, Bollipo S, Wong MY, et al. Urology practice during COVID-19 pandemic. Minerva Urol Nefrol. 2020. https://doi.org/10.23736/S0393-2249.20.03846-1

18. Luo Y, Zhong M. [Standardized diagnosis and treatment of colorectal cancer during the outbreak of corona virus disease 2019 in Renji hospital]. Zhonghua Wai Ke Za Zhi. 2020;58(3):178-82. https://doi.org/10.3760/cma.j.issn.0529-5815.2020.03.004

17. Lee DH, Lee J, Kim E, Woo K, Park HY, An J. Emergency cesarean section on severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) confirmed patient. Korean J Anesthesiol. 2020. https://doi.org/10.4097/kja.20116

16. Luo Y, Zhong M. [Standardized diagnosis and treatment of colorectal cancer during the outbreak of corona virus disease 2019 in Renji hospital]. Zhonghua Wei Chang Kai Ke Za Zhi. 2020;23(3):211-6. https://doi.org/10.3760/cma.j.cn41530-20200217-00057

15. Tao KX, Zhang BX, Zhang P, Zhu P, Wang GB, Chen XP, et al. [Recommendations for the patients with breast diseases in the central epidemic area of 2019 coronavirus disease]. Zhonghua Jin Jie He Hu Xi Za Zhi. 2020;23(1):57-62. https://doi.org/10.3969/j.issn.1671-0274.2020.03.003

14. Ross SW, Lauer CW, Miles WS, Green JM, Christmas AB, May AK, et al. Maximizing care after the storm: Tiered Surgical Response Plan for Novel Coronavirus (COVID-19). J Am Coll Surg. 2020. pii: S1072-7515(20)30263-5. https://doi.org/10.1016/j.jamcollsurg.2020.03.019

13. Simonato A, Giannarini G, Abrate A, Bartoletti R, Crestani A, De Nunzio C, et al. Urology practice during COVID-19 pandemic. Acta Neurochir. 2020. https://doi.org/10.1007/s00701-020-04305-w

12. Soetikno R, Teoh AY, Kaltenbach T, Lau JY, Asokkumar R, Cabral-Prodi GALIDAD P, et al. Considerations in performing endoscopy during the COVID-19 pandemic. Int J Gastrointest Canc. 2020;42(0):E004. https://doi.org/10.3760/cma.j.cn112152-20200221-00116

11. Tay JK, Khoo ML, Loh WS. Surgical Considerations for Tracheostomy During the COVID-19 Pandemic: Lessons Learned From the Severe Acute Respiratory Syndrome Outbreak. JAMA Otolaryngol Head Neck Surg. 2020. https://doi.org/10.1001/jamaoto.2020.0764

10. Alto risco de infecc...hino( S B C C P ).

9. Burke JF, Chan AK, Mummaneni V, Chou D, Lobo EP, Berger MS, et al. Management of Patients with COVID 19 Infections during Emergency Procedures. J Cardiothorac Vasc Anesth. 2020;34(5):1125-31. https://doi.org/10.1093/jvca.2020.02.039

8. Brindle M, Gawande A. Managing COVID-19 in Surgical Systems. Ann Am. 2020. https://doi.org/10.2106/JBJS.20.00236

7. Lee DJ, Jung HY, Cai ZG, Peng X, Zhang Y, Guo CB. Experience of Diagnosis and Managing Patients in Oral Maxillofacial Surgery during the Prevention and Control Period of the New Coronavirus Pandemic. Chin J Dent Res. 2020;23(1):57-62. https://doi.org/10.3929/j. cjdrr.2020.0197

6. Yu GY, Lou Z, Zhang W. [Several suggestion of operation for colorectal cancer during the outbreak of Corona Virus Disease 19 in China]. Zhonghua Wei Chang Kai Ke Za Zhi. 2020;23(3):211-6. https://doi.org/10.3760/cma.j.cn41530-20200217-00057

5. Lui Y, Qin J, Wang Z, Yu Y, Wen YY, Chen XK, et al. [Surgical treatment for esophageal cancer during the outbreak of COVID-19]. Zhonghua Zhong Liu Za Zhi. 2020;42(2):E003.

4. Udo RN, Wong SF, Sánchez-Luna SA, Pellingo C, Bellipo S, Wong MY, et al. Overview of guidance for endoscopy during the coronavirus disease 2019 pandemic. J Gastroenterol Hepatol. 2020. https://doi.org/10.1111/jgh.15053

3. Correia MTTD, Ramos RF, Baltven LCV. The surgeons and the COVID-19 pandemic. Rev Col Bras Cir. 2020;47:e20202536. https://doi.org/10.1590/2019-mp.pdf?sfvrsn=4e043d03_14 [cited April 11th, 2020]

2. Patel ZM, Fernandez-Miranda J, Hwang PH, Nayak JV, Dodd R, Sajjadi H, et al. Letter: The Coronavirus Disease 2019 Global Pandemic: A Neurosurgical Proposal for the Patients with Breast Diseases in the Central Epidemic Area of 2019 Coronavirus Disease. Zhonghua Wei Za Za Zhi. 2020;58(5):E005. https://doi.org/10.1036/j.mner.16.2020.03.003

1. Tao KX, Zhang BX, Zhang P, Zhu P, Wang GB, Chen XP, et al. [Recommendations for general surgery clinical practice in 2019 coronavirus disease]. Zhonghua Wai Ke Za Zhi. 2020;58(3):178-82. https://doi.org/10.3760/cma.j.issn.1671-0274.2020.03.002