

# The Impact of the COVID-19 Pandemic on Surgical Activities: A Single-Center Experience and Literature Review

Review began 10/16/2022  
Review ended 10/22/2022  
Published 10/27/2022

© Copyright 2022

Mylonakis et al. This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Adam Mylonakis <sup>1</sup>, Areti Kalfoutzou <sup>2</sup>, Andreas Panagakos <sup>1</sup>, Markos Despotidis <sup>1</sup>, John Yfantopoulos <sup>3</sup>

1. First Department of Surgery, Laiko General Hospital, National and Kapodistrian University of Athens, Athens, GRC 2. Oncology Department, 251 Air Force General Hospital, Athens, GRC 3. Health Economics, University of Athens, Athens, GRC

Corresponding author: Adam Mylonakis, adam.mylonakis@gmail.com

## Abstract

### Aim

The aim of this article is to investigate the effect of the coronavirus disease 2019 (COVID-19) pandemic on our surgical department, which is situated in Athens, Greece, as well as to review published literature on the COVID-19 pandemic's impact on surgical activities in our department.

### Material and methods

We retrospectively reviewed the surgical procedures that were performed in the surgical department of a tertiary University hospital in Athens, Greece, before and during the pandemic. Furthermore, we performed a literature review evaluating articles on surgical activity and COVID-19 published from the beginning of the pandemic up until the January of 2022 on the PubMed database.

### Results

In total, 894 patients were included in the study. Of those, 264 (29.5%) underwent surgery during the control period and 630 (70.5%) in the pandemic period. Overall, we performed 20.5% fewer surgeries in the post-sanitary period. In particular, elective surgeries decreased on average by 23.9%, emergency procedures decreased by 8.9%, and oncology surgeries increased by an average of 6.4% after the year 2020. Concerning the review of literature, 51 studies were selected for this review. According to them, the main effect of the pandemic on the surgical sector was reflected in the reduction of total surgeries, mainly due to the postponement of elective surgical procedures, which showed a median reduction of 54% compared to the pre-COVID-19 period. A smaller decrease was observed in the number of emergency and oncological surgeries.

### Conclusions

Reduced surgical activity during the pandemic, due to the health measures imposed, requires courageous corrective interventions to avoid its adverse effects, such as disease progression, increased treatment costs, reduced quality of life, and ultimately the survival of the patients.

**Categories:** General Surgery, Infectious Disease, Public Health

**Keywords:** surgical oncology, emergency surgery, elective surgery, surgical activity, covid-19

## Introduction

Following a series of cases of pneumonia of unknown etiology in Hubei province, China, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was isolated as the cause of coronavirus disease 2019 (COVID-19) [1]. The virus spread rapidly worldwide and led the World Health Organization to declare the novel coronavirus (COVID-19) outbreak a global pandemic on 11 March 2020 [2].

COVID-19 has proven to be a complex entity, having a high rate of transmissibility, numerous mutations, and causing multisystem disorder [3]. The often-exponential spread of the pandemic has highlighted the greatest challenge: the increased need for health services in health systems with finite resources. This mismatch of resources and needs has led to not only radical changes in the supply of health services but also in socio-economic relationships in general.

The impact of the pandemic on the surgical sector is multifaceted and concerns the surgical staff and practice, the risk of transmission between patients and medical personnel, and lastly, medical education. In response to these challenges, the following guidelines were issued for the safe practice of surgical practice [4,5]: preparation of a surgical case management plan in case of deterioration of the

### How to cite this article

Mylonakis A, Kalfoutzou A, Panagakos A, et al. (October 27, 2022) The Impact of the COVID-19 Pandemic on Surgical Activities: A Single-Center Experience and Literature Review. Cureus 14(10): e30785. DOI 10.7759/cureus.30785

epidemiological picture, postponement of elective surgeries, conversion of operating rooms into intensive care units, ensuring a safe response to surgical emergencies, training of staff in the use of personal protective equipment and protocols, minimizing staff exposure, early identification, and treatment of COVID-19 infections in surgical patients and development of septic operating rooms for the surgical treatment of positive cases.

The aim of this article is to investigate how the COVID-19 pandemic outbreak affected surgical activities in our surgical department as reflected in the number and type of surgical procedures performed before and during the pandemic. In addition, we reviewed published literature concerning the COVID-19 pandemic's impact on surgical activities worldwide.

## Materials And Methods

The electronic medical records of the patients included in this survey were collected from the First Department of Surgery of "Laikon" General Hospital, a tertiary University hospital in Athens, Greece. Patients' records were retrospectively reviewed in regard to their age, gender, and reason for admission/surgical procedure performed. We compared two time periods, i.e., before the pandemic from January until April 2019 (control group), and during the pandemic from January until April of the years 2020-2022 (pandemic period). Exclusion criteria were all patients that did not undergo a surgical procedure under general anaesthesia. This study was exempted from Hospital Review Board as it involved the collection and study of existing recorded data so that subjects cannot be identified, directly or through identifiers linked to the subjects.

The literature review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A systematic web-based search using Medline was performed reviewing literature published between 1st December 2019 and 31st January 2022. We limited the search to English language articles using two sets of keywords: (COVID-19) AND ({surgery} OR {surgical department}) and (COVID-19) AND ({operations} OR {surgical volume} OR {emergency procedure}).

After screening and identification of the relevant studies, detailed information was extracted from the full-text articles regarding the following: type of study, number of patients, country of origin, medical specialty, change in the volume of the total, elective, emergency, and oncological surgical procedures.

Statistical analysis was performed using the statistical package SPSS, version 25.0 (IBM Corp., Armonk, NY). The normality of numerical data distribution was tested using the Kolmogorov-Smirnov test. To examine the statistical difference, we used the independent t-test for continuous variables and the Chi-square test for categorical variables. The level of statistical significance was set at  $p < 0.05$  (two-tailed).

## Results

In total, 894 patients were included in the study. Of those, 264 (29.5%) underwent surgery during the control period and 630 (70.5%) in the pandemic period. No significant differences in mean age (62.1 years in the COVID-19 cohort vs 63.4 years in the control group,  $p = 0.146$ ) or gender distribution (58% males within the COVID-19 cohort vs 52.1% among the control cohort,  $p = 0.107$ ) were noted (Table 1).

		Control Period	Pandemic Period	p-value
Number of patients		264	630	
Gender (%)	Female	111 (42%)	302 (47.9%)	P= 0.107
	Male	153 (58%)	328 (52.1%)	
Age, years mean $\pm$ SD		63.4 $\pm$ 13.7	62.1 $\pm$ 11.5	P= 0.146

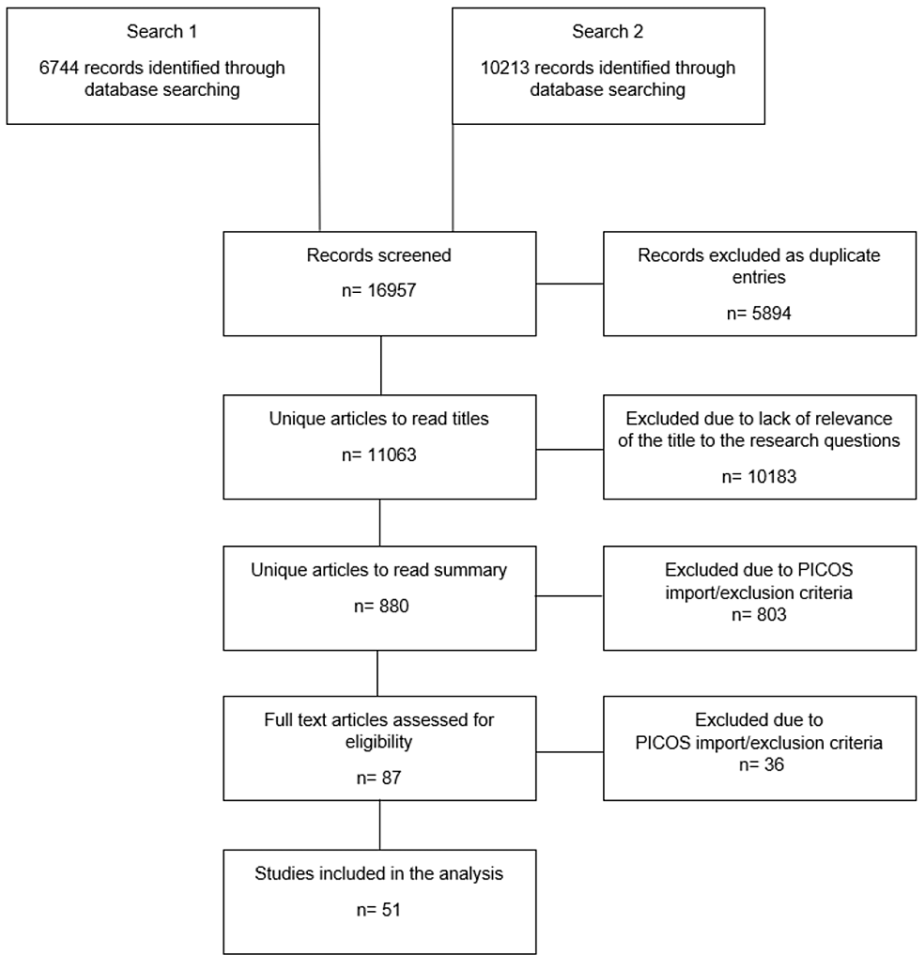
**TABLE 1: Demographic data of patients operated in the First Department of Surgery, National and Kapodistrian University of Athens, Laikon General Hospital**

Overall, we performed 20.5% fewer surgeries in the post-sanitary period. In particular, elective surgeries showed a decrease of 23.9%, while emergency procedures were less affected, with an average decrease of 8.9%. Oncology surgeries did not show a decrease but instead, increased by an average of 6.4% after the year 2020. From the statistical study of the above sample, there is no statistically significant change between the control and the pandemic cohort, except for the category of elective surgical operations ( $p = 0.044$ ) (Table 2).

	Jan- April 2019	Jan- April 2020	Jan- April 2021	Jan- April 2022	% Mean change 2020-2022 v 2019	p-value (Calculated based on monthly operations)
Total operations	264	231	186	213	-20.5%	0.052
Elective operations	204	177	135	157	-23.9%	0.044
Emergency operations	60	54	54	56	-8.9%	0.592
Oncological operations	94	129	84	87	+6.40%	0.739

**TABLE 2: Surgical operations performed in the First Department of Surgery, National and Kapodistrian University of Athens, Laikon General Hospital**

The literature review search produced 11063 unique PubMed results. Articles matching our selection criteria were 51 and were used for data collection [6-56] (Figure 1).



**FIGURE 1: PRISMA flowchart**

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

The majority of the researchers collected samples from a surgical department of a hospital, while 14

researchers drew data from national databases. With regard to the surgical specialty, general surgery was the most represented specialty, with 13 of the articles studying the whole surgical sector (Table 3).

	n	%
By sample size		
Surgical Department	28	55%
Hospital	5	10%
Series of Hospitals	4	8%
National Registry	14	27%
By Surgical Specialty		
Vascular Surgery	4	8%
General Surgery	18	35%
Gynecology	3	6%
Cardiac Surgery	3	6%
Neurosurgery	2	4%
Orthopaedics	3	6%
Urology	2	4%
Surgical Oncology	2	4%
ENT	1	2%
Surgical Sector	13	25%

**TABLE 3: Studies included in the review by sample size and surgical specialty**

ENT: Ear, Nose, Throat

We observed a decrease in the total surgical activity after the pandemic outbreak compared to the pre-COVID-19 period in 23 of the 24 studies, The reduction was significant in all surgical specialties and the median decrease was 50.7% (Table 4).

Author	Specialization-Sector	Change in the total volume of operations
Dallan et al. 2021 [14]	Cardiac surgery	-65.8%
Mejia et al. 2021 [34]	Cardiac surgery	-62%
Ralli et al. 2020 [45]	ENT	-50.7%
Alsaoudi et al. 2020 [7]	General Surgery	42.5%
Kreis et al. 2021 [26]	General Surgery	-11.3%
Yoon et al. 2021 [55]	General Surgery	-74%
Piketty et al. 2021 [44]	Gynaecology	-65%
Spurlin et al. 2021 [50]	Gynaecology	-79.3%
Raneri et al. 2020 [46]	Neurosurgery	-30%
Wali et al. 2021 [54]	Neurosurgery	Unchanged
Koch et al. 2021 [25]	Orthopaedics	-35%
Magnusson et al. 2021 [30]	Orthopaedics	-70%
Shih et al. 2021 [49]	Orthopaedics	-29%
Vissio et al. 2021 [53]	Surgical Oncology	-11.8%
Dias et al. 2021 [17]	Vascular Surgery	-64.7%
Abram et al. 2021 [6]	Surgical Sector	-65.4%
Di Marzo et al. 2020 [16]	Surgical Sector	-68%
Farid et al. 2020 [56]	Surgical Sector	-80%
Gomez et al. 2021 [22]	Surgical Sector	-78 to -83%
Ikeda et al. 2021 [23]	Surgical Sector	-10 to -15%
Luizeti et al. 2021 [29]	Surgical Sector	-14.9%
Mazahreh et al. 2020 [32]	Surgical Sector	-88.7%
Miyawaki et al. 2021 [36]	Surgical Sector	-9.4%
Rose et al. 2021 [47]	Surgical Sector	-75%

**TABLE 4: Change in the total volume of operations**

ENT: Ear, Nose, Throat

Furthermore, we reported a decrease in elective surgical procedures in all the articles studying this topic. The median decrease was 54% and exceeded 90% in certain cases (Table 5).

Author	Specialization-Sector	Change in volume of elective operations
Salenger et al. 2020 [48]	Cardiac surgery	-54%
Metelmann et al. 2020 [35]	General Surgery	-34.9%
Kreis et al. 2021 [26]	General Surgery	-85%
Raneri et al. 2020 [46]	Neurosurgery	-34%
Shih et al. 2021 [49]	Orthopaedic Surgery	-31%
Leung et al. 2021 [28]	Vascular Surgery	-42.8%
Dias et al. 2021 [17]	Vascular Surgery	-87%
Abram et al. 2021 [6]	Surgical Sector	-89%
Mazahreh et al. 2020 [32]	Surgical Sector	-92.8%
Gomez et al. 2021 [22]	Surgical Sector	-36 to -49%
Sutherland et al. 2020 [51]	Surgical Sector	-32.6%
Luizeti et al. 2021 [29]	Surgical Sector	-34.8%
Di Marzo et al. 2020 [16]	Surgical Sector	-75%

**TABLE 5: Change in volume of elective operations**

With regard to emergency surgical procedures, the data of the literature review indicate a reduction in 18 of the 22 relevant studies, with a median decrease of 30% (Table 6).

Author	Specialization-Sector	Change in volume of emergency operations
Karlafti et al. 2021 [24]	General Surgery	-51%
D'Urbano et al. 2020 [18]	General Surgery	-41.3%
Tartaglia et al. 2020 [52]	General Surgery	-42.8%
Malik et al. 2021 [31]	General Surgery	18%
O'Connell et al. 2021 [39]	General Surgery	-25.4%
Castoldi et al. 2021 [12]	General Surgery	-60%
Kreis et al. 2021 [26]	General Surgery	52.3%
Palisi et al. 2020 [42]	General Surgery	Unchanged
Patriti et al. 2020 [43]	General Surgery	-86%
Piketty et al. 2021 [44]	Gynaecology	-64%
Spurlin et al. 2021 [50]	Gynaecology	Unchanged
Raneri et al. 2020 [46]	Neurosurgery	-23%
Shih et al. 2021 [49]	Orthopaedic	-13.3%
Ralli et al. 2020 [45]	Otolaryngology	-60%
Motterle et al. 2021 [37]	Urology	-52%
Correia et al. 2020 [13]	Vascular Surgery	Unchanged
Leung et al. 2021 [28]	Vascular Surgery	-31.6%
Dias et al. 2021 [17]	Vascular Surgery	Unchanged
Abram et al. 2021 [6]	Surgical Department	-35.3%
Mazahreh et al. 2020 [32]	Surgical Department	-60.4%
Luizeti et al. 2021 [29]	Surgical Department	-1.1%
Di Marzo et al. 2020 [16]	Surgical Department	-30%

**TABLE 6: Change in volume of emergency operations**

Concerning oncological surgery, we noticed a statistically significant decrease in surgical activity in three out of nine articles, reaching up to a reduction of 56% in a general surgery clinic in Parma, Italy [21] (Table 7).

Author	Specialization-Sector	Change in volume of oncological operations
Giuffrida et al. 2021 [21]	General Surgery	-56%
Nogami et al. 2022 [38]	Gynaecology	-3.9%
Ralli et al. 2020 [45]	Otolaryngology	Unchanged
Vissio et al. 2021 [53]	Surgical Oncology	-11.8%
Kuitunen et al. 2021 [27]	Surgical Oncology	Unchanged
Abram et al. 2021 [6]	Surgical Department	-47.8%
de Pelsemaeker et al. 2020 [15]	Surgical Department	Unchanged
Luizeti et al. 2021 [29]	Surgical Department	-5%
Okuno et al. 2021 [40]	Surgical Sector	Unchanged

**TABLE 7: Change in volume of oncological operations**

## Discussion

In our surgical department, we observed an average decrease of 20.5% in the total number of surgical procedures performed after the COVID-19 outbreak, mainly due to the postponement of elective surgeries. Emergency cases were less affected and in regard to oncological procedures, we noted an average increase of 6.4%. This data aligns with the current literature suggesting that the surgical sector worldwide prioritized emergency and oncological over elective non-life-threatening cases.

COVID-19 is manifested mainly as an acute respiratory disease, which can be complicated by Acute Respiratory Distress Syndrome (ARDS) and multi-organ failure. Its global spread has put severe pressure on Health Systems worldwide, resulting, among other things, in the transfer of resources from the surgical sector to the medical units directly involved in the fight against the pandemic. The release of personnel and equipment from surgical units is not without negative effects, the results of which will be revealed over a horizon of years or even decades.

Following the recommendation to postpone non-life-threatening surgeries issued by WHO and major surgical colleges [57-60], a reduction of surgical operations for benign or non-life-threatening diseases was expected. It is worth noting that delaying the treatment of such conditions is not free of consequences, as it can lead to a worsening of the state of health, an increasing disability and a decrease in the working capacity of patients. These effects entail significant social costs, especially in low-middle-income countries, where costs related to the surgical condition can lead to impoverishment [61].

Similar to elective surgical procedures, the observed decrease in emergency surgical operations needs to be investigated. On the one hand, the change may be due to a real decrease in emergencies due to the recommendation to stay at home and avoid social activity. These measures have resulted in a shrinking number of sports [62], road accidents [63] injuries and the spread of communicable diseases [64] other than COVID-19.

At the same time, the issued guidelines to avoid unnecessary attendance at hospitals have led patients to seek late medical help possibly awaiting later stages of the disease before attending the emergency department [6,9,13,26,31,52,55]. Their aggravated condition was associated with increased complication rates [18,31,43] and mortality rate [14,17,24]. Taking into account the inherent inability of the patients to evaluate the severity of their condition, it is crucial to inform the population about the nature of emergency surgical conditions as well as to prepare for an outbreak of surgical cases during the periods of remission of the pandemic.

The management of oncological cases is a major priority of health systems, as a delay in their treatment has serious consequences for patients and society in general. Therefore, health authorities must ensure the proper and incessant function of screening, diagnosis and treatment of oncology patients. According to the research of Yun et al. [65] a postponement in the treatment of malignancy of more than one month is related to a worse prognosis for rectal and breast cancer in high-volume centers. In addition to increased mortality, delays also result in increased costs of care in the form of surgery and/or chemotherapy. More resources will be required if a patient presents with an emergency such as perforation, acute bleeding or gastrointestinal obstruction.



Another major issue, which is being overlooked with unknown long-term consequences is the training of medical staff. The reduction of surgical operations has a negative effect on the development of specialized surgeons, whose training requires a high number of surgeries, in order to acquire the necessary skills and techniques. Indicatively, Inzunza et al. [66] report a decrease of 61.7% in the total number of surgical procedures of the third-year surgical residents, possibly requiring an extension of the training programme of the affected trainees by at least one year.

Eventually with the expected recession of the pandemic, the health systems will face the accumulated volume of elective surgical cases which have been postponed since the beginning of 2020. Performing these operations will require funding from the surgical sector for an extended period of time. Indicatively, to carry out the postponed surgeries for a period of 12 weeks, with an increase of the basic activity by 20%, will require an average of 45 weeks (range 43-48 weeks) [61]. It is thus clear that a return to normal surgical practice and the clearance of the backlog of surgical work within a reasonable period of time requires major changes that go beyond the return of surgical personnel and equipment and extend to the reform of health systems expenditures.

The current study has some limitations. Firstly, it involved a single center in a tertiary referral hospital in Athens, Greece, so it does not reflect the pandemic impact across the country. Secondly, the literature review excluded data from non-English papers; Asian countries, which were particularly affected during the first wave of the pandemic, were represented in a limited number of surveys. In addition, it only included articles published in the PubMed database, thus missing data from other databases. Furthermore, the majority of studies included data for a specific time period, usually outbreaks, rather than for the entire pandemic. Finally, it is noted that the pandemic is still ongoing and despite the accumulated experience of the last two years, its course and impact on the health systems worldwide is still difficult to predict.

## Conclusions

The impact of the COVID-19 pandemic worldwide is apparent in all areas of surgical activity. It is reflected mainly in the reduction of elective surgical procedures and to a lesser extent in emergency and oncological cases, a trend that we also noticed in our surgical department. Reduced surgical activity has various adverse effects including disease progression, increased treatment costs, reduced quality of life, and ultimately the survival of the patients.

In this setting, it is vital for all nations around the globe to take into account the malfunctions that occurred in the surgical sector during the pandemic to recognize the weaknesses of the health systems and draw up a plan based on the lessons learned to deal with a possible future epidemic disease.

## Additional Information

### Disclosures

**Human subjects:** Consent was obtained or waived by all participants in this study. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

## References

1. Zhu N, Zhang D, Wang W, et al.: A novel coronavirus from patients with pneumonia in China, 2019. *N Engl J Med.* 2020, 382:727-33. [10.1056/NEJMoa2001017](https://doi.org/10.1056/NEJMoa2001017)
2. WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. (2020). Accessed: June 5, 2022: <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-....>
3. Roberts CM, Levi M, McKee M, Schilling R, Lim WS, Grocott MP: COVID-19: a complex multisystem disorder. *Br J Anaesth.* 2020, 125:238-42. [10.1016/j.bja.2020.06.013](https://doi.org/10.1016/j.bja.2020.06.013)
4. Brindle ME, Gawande A: Managing COVID-19 in surgical systems. *Ann Surg.* 2020, 272:e1-2. [10.1097/SLA.0000000000003923](https://doi.org/10.1097/SLA.0000000000003923)
5. Global guidance for surgical care during the COVID-19 pandemic. *Br J Surg.* 2020, 107:1097-103. [10.1002/bjs.11646](https://doi.org/10.1002/bjs.11646)
6. Abram J, Gasteiger L, Putzer G, Spraidner P, Mathis S, Hell T, Martini J: Impact of COVID-19 related lockdown on the frequency of acute and oncological surgeries-lessons learned from an Austrian University Hospital. *Front Public Health.* 2021, 9:625582. [10.3389/fpubh.2021.625582](https://doi.org/10.3389/fpubh.2021.625582)
7. Alsaoudi T, Chung WY, Isherwood J, Bhardwaj N, Malde D, Dennison AR, Garcea G: HPB surgery in the time of COVID. *Br J Surg.* 2020, 107:e588-9. [10.1002/bjs.12030](https://doi.org/10.1002/bjs.12030)
8. Atri S, Hadad A, Makni A, Kacem MJ: Digestive surgical emergencies during the COVID-19 pandemic are deeply affected and more advanced. *J Visc Surg.* 2021, 158:92-3. [10.1016/j.jviscsurg.2020.11.011](https://doi.org/10.1016/j.jviscsurg.2020.11.011)
9. Aviran E, Laks S, Benvenisti H, et al.: The impact of the COVID-19 pandemic on general surgery acute

- admissions and urgent operations: a comparative prospective study. *Isr Med Assoc J*. 2020, 11:673-9.
10. Björns K, Blomgren L, Holsti M, Jonsson M, Smidfelt K, Mani K: Editor's choice - the impact of Covid-19 on vascular procedures in Sweden 2020. *Eur J Vasc Endovasc Surg*. 2021, 62:136-7. [10.1016/j.ejvs.2021.04.027](https://doi.org/10.1016/j.ejvs.2021.04.027)
  11. Callan R, Assaf N, Bevan K: Impact of the COVID-19 pandemic on acute general surgical admissions in a district general hospital in the United Kingdom: a retrospective cohort study. *Surg Res Pract*. 2020, 2020:2975089. [10.1155/2020/2975089](https://doi.org/10.1155/2020/2975089)
  12. Castoldi L, Solbiati M, Costantino G, Casiraghi E: Variations in volume of emergency surgeries and emergency department access at a third level hospital in Milan, Lombardy, during the COVID-19 outbreak. *BMC Emerg Med*. 2021, 21:59. [10.1186/s12873-021-00445-z](https://doi.org/10.1186/s12873-021-00445-z)
  13. Correia M, Constâncio V, Silva JC, Lima P, Moreira M, Antunes LF, Fonseca M: Is there an impact of COVID-19 on admission of patients to the emergency department for vascular surgery?. *Ann Vasc Surg*. 2020, 69:100-4. [10.1016/j.avsg.2020.08.002](https://doi.org/10.1016/j.avsg.2020.08.002)
  14. Dallan LA, F Lisboa LA, Dallan LR, Jatene FB: Impact of COVID-19 on coronary artery surgery: hard lessons learned. *J Card Surg*. 2021, 36:3294-5. [10.1111/jocs.15769](https://doi.org/10.1111/jocs.15769)
  15. de Pelsemaeker MC, Guiot Y, Vanderveken J, Galant C, Van Bockstal MR: The impact of the COVID-19 pandemic and the associated Belgian governmental measures on cancer screening, surgical pathology and cytopathology. *Pathobiology*. 2021, 88:46-55. [10.1159/000509546](https://doi.org/10.1159/000509546)
  16. Di Marzo F, Gemmi F, Cennamo R, Forni S, Bachini L, Collini F, Cardi M: Impact of SARS-CoV-2 on elective surgical volume in Tuscany: effects on local planning and resource prioritization. *Br J Surg*. 2020, 107:e391-2. [10.1002/bjs.11832](https://doi.org/10.1002/bjs.11832)
  17. Dias RR, Santiago JA, Madrini V Junior, Mady C, Jatene FB: Impact of COVID-19 pandemic in a Brazilian high-volume aortic center. *Braz J Cardiovasc Surg*. 2021, 36:145-9. [10.21470/1678-9741-2020-0567](https://doi.org/10.21470/1678-9741-2020-0567)
  18. D'Urbano F, Fabbri N, Koleva Radica M, Rossin E, Carcoforo P: Emergency surgery in COVID-19 outbreak: has anything changed? Single center experience. *World J Clin Cases*. 2020, 8:3691-6. [10.12998/wjcc.v8.i17.3691](https://doi.org/10.12998/wjcc.v8.i17.3691)
  19. Fahrner R, Bähler S, Lindner G: COVID-19 lock-down significantly reduced number of surgical presentations in an emergency department. *Wien Klin Wochenschr*. 2021, 133:399-402. [10.1007/s00508-021-01810-5](https://doi.org/10.1007/s00508-021-01810-5)
  20. Fallara G, Sandin F, Styrke J, et al.: Prostate cancer diagnosis, staging, and treatment in Sweden during the first phase of the COVID-19 pandemic. *Scand J Urol*. 2021, 55:184-91. [10.1080/21681805.2021.1910341](https://doi.org/10.1080/21681805.2021.1910341)
  21. Giuffrida M, Cozzani F, Rossini M, Bonati E, Del Rio P: How COVID-19 pandemic has changed elective surgery: the experience in a general surgery unit at a COVID-hospital. *Acta Biomed*. 2021, 92:e2021304. [10.23750/abm.v92i5.10296](https://doi.org/10.23750/abm.v92i5.10296)
  22. Gomez D, Dossa F, Sue-Chue-Lam C, Wilton AS, de Mestral C, Urbach D, Baxter N: Impact of COVID 19 on the provision of surgical services in Ontario, Canada: population-based analysis. *Br J Surg*. 2021, 108:e15-7. [10.1093/bjs/znaa043](https://doi.org/10.1093/bjs/znaa043)
  23. Ikeda N, Yamamoto H, Taketomi A, et al.: The impact of COVID-19 on surgical procedures in Japan: analysis of data from the National Clinical Database. *Surg Today*. 2022, 52:22-35. [10.1007/s00595-021-02406-2](https://doi.org/10.1007/s00595-021-02406-2)
  24. Karlafti E, Benioudakis ES, Paramythiotis D, et al.: Does the COVID-19 pandemic affect morbidity and mortality rates of emergency general surgery? A retrospective study from a single-center tertiary Greek hospital. *Medicina (Kaunas)*. 2021, 57:[10.3390/medicina57111185](https://doi.org/10.3390/medicina57111185)
  25. Koch M, Popp D, Freigang V, et al.: Knee surgery during the COVID-19 lockdown-experiences of a level-one trauma center in Germany. *Biomed Res Int*. 2021, 2021:8875643. [10.1155/2021/8875643](https://doi.org/10.1155/2021/8875643)
  26. Kreis CA, Ortmann B, Freistuehler M, Hartensuer R, Van Aken H, Raschke MJ, Schliemann B: Impact of the first COVID-19 shutdown on patient volumes and surgical procedures of a level I trauma center. *Eur J Trauma Emerg Surg*. 2021, 47:665-75. [10.1007/s00068-021-01654-8](https://doi.org/10.1007/s00068-021-01654-8)
  27. Kuitunen I, Ponkilainen VT, Uimonen MM, Paloneva J, Launonen AP, Mattila VM: Postponing elective surgery due to COVID-19 did not decrease the oncological surgery rate in Finland. *Br J Surg*. 2021, 108:e191-3. [10.1093/bjs/znab046](https://doi.org/10.1093/bjs/znab046)
  28. Leung S, Al-Omran M, Greco E, et al.: Monitoring the evolving impact of COVID-19 on institutional surgical services: imperative for quality improvement platforms. *Br J Surg*. 2021, 108:e7-8. [10.1093/bjs/znaa016](https://doi.org/10.1093/bjs/znaa016)
  29. Luizeti BO, Santos Perli VA da Costa GG, Eckert IC, Roma AM, da Costa KM: Impact of the COVID-19 pandemic on surgical procedures in Brazil: a descriptive study. *Iniciac Cientifica Cesumar*. 2021, 23:139-48. [10.17765/2176-9192.2021v23n2e10408](https://doi.org/10.17765/2176-9192.2021v23n2e10408)
  30. Magnusson K, Helgeland J, Gröslund M, Telle K: Impact of the COVID-19 pandemic on emergency and elective hip surgeries in Norway. *Acta Orthop*. 2021, 92:376-80. [10.1080/17453674.2021.1898782](https://doi.org/10.1080/17453674.2021.1898782)
  31. Malik A, Zohdy M, Ahmad A, Seretis C: Single-centre experience of emergency hernia surgery during COVID-19 pandemic: a comparative study of the operative activity and outcomes before and after the outbreak. *Med Glas (Zenica)*. 2021, 18:463-7. [10.17392/1383-21](https://doi.org/10.17392/1383-21)
  32. Mazahreh TS, Aleshawi AJ, Al-Zoubi NA, Hatamleh M, Hmedat A: The impact of COVID-19 on the surgical operations. *Ann Med Surg (Lond)*. 2020, 57:49-51. [10.1016/j.amsu.2020.06.042](https://doi.org/10.1016/j.amsu.2020.06.042)
  33. McGuinness MJ, Harmston C: The effect of national public health interventions for COVID-19 on emergency general surgery in Northland, New Zealand. *ANZ J Surg*. 2021, 91:329-34. [10.1111/ans.16562](https://doi.org/10.1111/ans.16562)
  34. Mejia OA, Borgomoni GB, Silveira LM, et al.: The arrival of COVID-19 in Brazil and the impact on coronary artery bypass surgery. *J Card Surg*. 2021, 36:3070-7. [10.1111/jocs.15712](https://doi.org/10.1111/jocs.15712)
  35. Metelmann IB, Busemann A: Elective surgery in times of COVID-19: a two-centre analysis of postponed operations and disease-related morbidity and mortality. *Z Evid Fortbild Qual Gesundhwes*. 2020, 158-159:62-5. [10.1016/j.zeq.2020.10.003](https://doi.org/10.1016/j.zeq.2020.10.003)
  36. Miyawaki A, Tomio J, Nakamura M, Ninomiya H, Kobayashi Y: Changes in surgeries and therapeutic procedures during the COVID-19 outbreak: a longitudinal study of acute care hospitals in Japan. *Ann Surg*. 2021, 273:e132-4. [10.1097/SLA.0000000000004528](https://doi.org/10.1097/SLA.0000000000004528)
  37. Motterle G, Morlacco A, Iafrate M, et al.: The impact of COVID-19 pandemic on urological emergencies: a single-center experience. *World J Urol*. 2021, 39:1985-9. [10.1007/s00345-020-03264-2](https://doi.org/10.1007/s00345-020-03264-2)
  38. Nogami Y, Komatsu H, Makabe T, et al.: Impact of COVID-19 on gynecologic cancer treatment in Japan: a

- nationwide survey by the Japan Society of Gynecologic Oncology (JSGO). *J Gynecol Oncol.* 2022, 33:e8. [10.3802/jgo.2022.33.e8](#)
39. O'Connell RM, Khan MA, Amir M, Bucheeri M, Khan W, Khan IZ, Barry KM: The impact of COVID-19 on emergency general surgery admissions and operative volumes: a single centre experience. *Surgeon.* 2021, 19:e207-12. [10.1016/j.surge.2020.09.013](#)
40. Okuno T, Takada D, Shin JH, Morishita T, Itoshima H, Kunisawa S, Imanaka Y: Surgical volume reduction and the announcement of triage during the 1st wave of the COVID-19 pandemic in Japan: a cohort study using an interrupted time series analysis. *Surg Today.* 2021, 51:1843-50. [10.1007/s00595-021-02286-6](#)
41. Okuno T, Takada D, Shin JH, Morishita T, Itoshima H, Kunisawa S, Imanaka Y: Impact of the early stage of the coronavirus disease 2019 pandemic on surgical volume in Japan. *Br J Surg.* 2021, 108:e173-4. [10.1093/bjs/znab028](#)
42. Palisi M, Massucco P, Mineccia M, Celano C, Giovanardi F, Ferrero A: The disappearing of emergency surgery during the COVID 19 pandemic. Fact or fiction?. *Br J Surg.* 2020, 107:e508-9. [10.1002/bjs.11971](#)
43. Patriti A, Eugeni E, Guerra F: What happened to surgical emergencies in the era of COVID-19 outbreak? Considerations of surgeons working in an Italian COVID-19 red zone. *Updates Surg.* 2020, 72:309-10. [10.1007/s13304-020-00779-6](#)
44. Piketty J, Carbonnel M, Murtada R, Revaux A, Asmar J, Favre-Inhofer A, Ayoubi JM: Collateral damage of COVID-19 pandemic: the impact on a gynecologic surgery department. *J Gynecol Obstet Hum Reprod.* 2022, 51:102255. [10.1016/j.jogoh.2021.102255](#)
45. Ralli M, Minni A, Candelori F, Cialente F, Greco A, de Vincentiis M: Effects of COVID-19 pandemic on otolaryngology surgery in Italy: the experience of our university hospital. *Otolaryngol Head Neck Surg.* 2020, 163:86-8. [10.1177/0194599820928970](#)
46. Raneri F, Rustemi O, Zambon G, et al.: Neurosurgery in times of a pandemic: a survey of neurosurgical services during the COVID-19 outbreak in the Veneto region in Italy. *Neurosurg Focus.* 2020, 49:E9. [10.3171/2020.9.FOCUS20691](#)
47. Rose L, Mattingly AS, Morris AM, Trickey AW, Ding Q, Wren SM: Surgical procedures in veterans affairs hospitals during the COVID-19 pandemic. *Ann Surg.* 2021, 273:e129-31. [10.1097/SLA.0000000000004692](#)
48. Salenger R, Etchill EW, Ad N, et al.: The surge after the surge: cardiac surgery post-COVID-19. *Ann Thorac Surg.* 2020, 110:2020-5. [10.1016/j.athoracsur.2020.04.018](#)
49. Shih CL, Huang PJ, Huang HT, Chen CH, Lee TC, Hsu CH: Impact of the COVID-19 pandemic and its related psychological effect on orthopedic surgeries conducted in different types of hospitals in Taiwan. *J Orthop Surg (Hong Kong).* 2021, 29:2309499021996072. [10.1177/2309499021996072](#)
50. Spurlin EE, Han ES, Silver ER, et al.: Where have all the emergencies gone? The impact of the COVID-19 pandemic on obstetric and gynecologic procedures and consults at a New York City Hospital. *J Minim Invasive Gynecol.* 2021, 28:1411-1419.e1. [10.1016/j.jmig.2020.11.012](#)
51. Sutherland K, Chessman J, Zhao J, et al.: Impact of COVID-19 on healthcare activity in NSW, Australia. *Public Health Res Pract.* 2020, 30:10.17061/phrp3042030
52. Tartaglia N, Pavone G, Lizzi V, Vovola F, Tricarico F, Pacilli M, Ambrosi A: How emergency surgery has changed during the COVID-19 pandemic: a cohort study. *Ann Med Surg (Lond).* 2020, 60:686-9. [10.1016/j.amsu.2020.12.001](#)
53. Vissio E, Falco EC, Collelli G, et al.: Impact of COVID-19 lockdown measures on oncological surgical activity: analysis of the surgical pathology caseload of a tertiary referral hospital in Northwestern Italy. *J Surg Oncol.* 2021, 123:24-31. [10.1002/jso.26256](#)
54. Wali AR, Ryba BE, Kang K, et al.: Impact of COVID-19 on a neurosurgical service: lessons from the University of California San Diego. *World Neurosurg.* 2021, 148:e172-81. [10.1016/j.wneu.2020.12.103](#)
55. Yoon DH, Koller S, Duldulao PM, Ault GT, Lee SW, Cologne KG: COVID-19 impact on colorectal daily practice-how long will it take to catch up?. *J Gastrointest Surg.* 2021, 25:260-8. [10.1007/s11605-020-04722-3](#)
56. Farid Y, Schettino M, Kapila AK, Hamdi M, Cuylits N, Wauthy P, Ortiz S: Decrease in surgical activity in the COVID-19 pandemic: an economic crisis. *Br J Surg.* 2020, 107:e300. [10.1002/bjs.11738](#)
57. Strengthening the health systems response to COVID-19: technical guidance #2: creating surge capacity for acute and intensive care. (2020). <https://apps.who.int/iris/handle/10665/333072>.
58. Strengthening the health system response to COVID-19: technical guidance #1: maintaining the delivery of essential health care services while mobilizing the health workforce for the COVID-19 response. (2020). Accessed: June 5, 2022: <https://apps.who.int/iris/handle/10665/332559>.
59. COVID-19: recommendations for management of elective surgical procedures. (2020). Accessed: June 5, 2022: <https://www.facs.org/for-medical-professionals/covid-19/clinical-guidance/elective-surgery/>.
60. COVID-19: good practice for surgeons and surgical teams. (2021). Accessed: June 5, 2022: <https://www.rcseng.ac.uk/standards-and-research/standards-and-guidance/good-practice-guides/coronavirus/covid-19-good...>
61. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. *Br J Surg.* 2020, 107:1440-9. [10.1002/bjs.11746](#)
62. Sabbagh RS, Shah NS, Kanhere AP, Hoge CG, Thomson CG, Grawe BM: Effect of the COVID-19 pandemic on sports-related injuries evaluated in US emergency departments. *Orthop J Sports Med.* 2022, 10:23259671221075373. [10.1177/23259671221075373](#)
63. Katrakazas C, Michalaraki E, Sekadakis M, Yannis G: A descriptive analysis of the effect of the COVID-19 pandemic on driving behavior and road safety. *Transp Res Interdiscip Perspect.* 2020, 7:100186. [10.1016/j.trip.2020.100186](#)
64. Maffeo M, Mazziotta F, Pierini É, et al.: Infectious diseases other than Covid-19 in 2020, a report from Lombardy Region. *Eur J Public Health.* 2021, 31: [10.1093/eurpub/ckab165.486](#)
65. Yun YH, Kim YA, Min YH, et al.: The influence of hospital volume and surgical treatment delay on long-term survival after cancer surgery. *Ann Oncol.* 2012, 23:2731-7. [10.1093/annonc/mds101](#)
66. Inzunza M, Besser N, Bellolio F: Decrease in operative volume in general surgery residents in Chile: effects of the COVID-19 pandemic. *Br J Surg.* 2021, 108:e226-7. [10.1093/bjs/znab082](#)