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Systematic review and meta-analysis determining the effect of implemented COVID-19 guidelines on surgical oncology volumes and clinical outcomes

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Title: Systematic review and meta-analysis determining the effect of implemented COVID-19 guidelines on surgical oncology volumes and clinical outcomes

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Abstract

Background
To provide for Coronavirus Disease 2019 (COVID-19) healthcare capacity, (surgical oncology) guidelines were established, forcing to alter the timing of performing surgical procedures. It is essential to determine whether these guidelines have led to disease progression. This study aims to give an insight into the number of surgical oncology procedures performed during the pandemic and provide information on short-term clinical outcomes.

Materials and methods
A systematic literature search was performed on all COVID-19 articles including operated patients, published before March 21, 2022. Meta-analysis was performed to visualize the number of performed surgical oncology procedures during the pandemic compared to the pre-pandemic period. Random effects models were used for evaluating short-term clinical outcomes.

Results
Twenty-four studies containing 6762 patients who underwent a surgical oncology procedure during the pandemic were included. The number of performed surgical procedures for an oncological pathology decreased (-26.4%) during the pandemic. The number of performed surgical procedures for breast cancer remained stable (+0.3%). Moreover, no difference was identified in the number of ≥T2 (OR 1.00, P=0.989), ≥T3 (OR 0.95, P=0.778), ≥N1 (OR 1.01, P=0.964) and major postoperative complications (OR 1.55, P=0.134) during the pandemic.

Conclusion
The number of performed surgical oncology procedures during the COVID-19 pandemic decreased. In addition, the number of performed surgical breast cancer procedures remained stable. Oncological staging and major postoperative complications showed no significant difference compared to pre-pandemic practice. During future pandemics, the performed surgical oncology practice during the first wave of the COVID-19 pandemic seems appropriate for short-term results.

Key words: Surgical Oncology, COVID-19, SARS-CoV-2
Introduction

During the pandemic Coronavirus disease-19 (COVID-19), the non-COVID-19 healthcare system was adjusted through newly developed measures, including the identification of surgical prioritization in the oncological field to deliver adequate Intensive Care Unit (ICU) capacity and available healthcare providers (1–4). Due to the sudden emergence of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and its rapid spread, the above-mentioned measures were developed with limited knowledge of SARS-CoV-2’s viral behavior (5). In addition, in the Netherlands, several guidelines were developed based on expert advice and limited knowledge of COVID-19, including in the field of surgical oncology (6). The Dutch oncology-oriented guideline consisted of surgical prioritization recommendations. Identifying levels of surgical priority is necessary to determine if procedures can be postponed, balancing the risk between viral exposure and disease progression. The consequences of these implemented measures were noticeable in surgical and non-surgical oncological practice (7,8).

Currently, various vaccines are available to reduce the risk of mortality or severe illness caused by COVID-19 (9–11). However, as long as COVID-19 continues to spread, there is a risk that new variants will emerge. In addition to the mutating nature of viruses, several factors contribute to an increased risk of developing new variants, including people’s reluctance to receive COVID-19 vaccinations and limited or no access to vaccinations (12–14). The aftermath of the COVID-19 pandemic may be extensive, and future pandemics are plausible, resulting in additional pressure on healthcare, and a subsequent scale reduction in surgical care may be insurmountable. Therefore, it is essential to determine whether surgical oncology decisions during the COVID-19 pandemic have led to disease progression and associated additional care. A revision of surgical oncology measures may be possible, if necessary, by evaluating this clinical surgical data. Therefore, this systematic review and meta-analysis aims to provide
insight into the number and clinical outcomes of the performed surgical oncology procedures
during the COVID-19 pandemic.
Materials and Methods

Search strategy

This systematic review and meta-analysis was performed according to the guidelines of the PRISMA Checklist for meta-analysis (15). A systematic literature search was performed in the PubMed and Embase databases, including all articles published before March 21, 2022. The search strategy contained a combination of keywords (and their synonyms), including “COVID-19”, “SARS-CoV-2”, and “surgical”. The complete search strategy is available in the supplementary data (Supplementary Table 1).

Study selection

After removing duplicates, four reviewers (EB, OB, EH, and MF) independently screened articles by title and abstract for eligibility. The four reviewers discussed discordant judgments until consensus was reached. All articles meeting the following inclusion criteria were selected for full-article review: surgical procedures involving oncological surgery which provided data on oncological outcomes and/or the number of performed surgical procedures. Studies were excluded from the systematic review for the following reasons: articles including recommendations only based on opinions and guidelines; articles without comparison to pre-COVID-19 cohort, non-human biological sample usage; non-English language articles, case reports, case series, editorials, commentaries, short communications, letters, review articles, conference abstracts; no full text available. The reviewers (EB, MF) reviewed the retrieved full-text articles. Agreement for eligibility was obtained for all articles.
Data extraction and definitions

The following data were extracted from each eligible study: first author’s surname, publication year, type of malignancy, study period (pre-)pandemic cohort, number of performed surgical procedures, waiting time in days between operation-indication and surgical procedure, if possible.

The influence of the COVID-19 pandemic on performed surgical oncology procedures was evaluated by comparing the total number of performed pre-pandemic surgical procedures to the total number of performed pandemic surgical procedures. To compare as reliably as possible between pre-COVID-19 and COVID-19 groups, most studies cover the same pre-COVID-19 and COVID-19 study period or consist of the same number of days. The author of the included study determined the timeframe of the (pre-)pandemic cohort. To compare the studies as reliable as possible, studies were only included if the COVID-19 cohort underwent a surgical procedure during the first wave of the pandemic.

Of the included studies, data of the most commonly shared clinical outcomes were determined. These clinical outcomes included the pathological T- and N-stages of the TNM classification and the complication rate (16). Pathological T-stage cut-offs were ≥T2 and ≥T3 to provide inside into short-term disease progression. In addition, for the pathological N-stage, ≥N1 was used as the cut-off for evaluating the difference in clinical outcomes. Moreover, the Clavien-Dindo classification was used to classify the severity of reported major postoperative complications (17). For this meta-analysis, major postoperative complications Clavien-Dindo classification ≥3 was used as the cut-off for evaluating the clinical outcomes.
Bias assessment

The risk of bias for each eligible study was evaluated by two reviewers (EB, MF) using the ROBINS-I Tool (18). The tool consists of seven domains; confounding, selection of participants, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of the reported result. Each domain was rated on three levels of bias: low risk, intermediate/unclear risk, or high risk of bias. The two authors discussed discordant judgments until consensus was reached. The summary of the risk of bias is shown in the supplementary data (Supplementary Fig 1). The full risk of bias assessment is displayed in the supplementary data as well (Supplementary Table 2).

Statistical analysis

Descriptive statistics were used to describe patient characteristics. Meta-analysis was performed to visualize the number of performed surgical oncology procedures before and during the COVID-19 pandemic using the ggplot2 package in R. The effect of heterogeneity was quantified using $I^2$, where a p-value < 0.05 indicated significant heterogeneity across the studies. In addition, a random-effects model was used to assess pooled oncological outcomes. The odds ratio (OR) was estimated with its variance and 95% confidence interval (CI). Statistical significance was defined as a p-value <0.05. Statistical analyses were carried out using the meta package in the R statistical software (version 4.0.2).
Results

A total of 12,782 articles were identified after duplicate removal. Of these, 12,406 were excluded during the titles and abstract screening, 376 articles were screened in full text (Fig 1).

PRISMA 2009 Flow Diagram
Fig 1. Flow chart showing literature search and study selection with fourteen relevant studies included.

Overall, 24 studies were included, 6762 surgical oncology procedures were reviewed. Table 1 summarizes the main characteristics of the included studies. Study publication dates ranged from 2020 to 2022, with most studies being published in 2020 and 2021.
| Author                | Country  | Malignancy                                      | Pre-COVID-19 study period   | COVID-19 study period      | No. of performed procedures pre-COVID-19 | No. of performed procedures COVID-19 | Difference in % | Waiting time in days pre-COVID-19 | Waiting time in days COVID-19 |
|-----------------------|----------|------------------------------------------------|----------------------------|---------------------------|----------------------------------------|-------------------------------------|-----------------|-------------------------------|----------------------------|
| Akhtar et al. 2021 (16) | India    | Head and neck, GI, hepatobiliary, genitourinary, thorax, breast, sarcoma, skin | April – September 2019     | April – September 2020    | 598                                    | 410                                 | -31%            | NR                            | NR                        |
| Amoo et al. 2021 (17)   | Ireland  | Glial tumors                                    | 1 March – 31 May 2019      | 1 March – 31 May 2020     | 56                                     | 60                                  | +7%             | 2.89                          | 2.39                      |
| Araujo et al. 2020 (18) | Brazil   | Not specified                                   | March – May 2019           | March – May 2020          | 607                                    | 242                                 | -60%            | NR                            | NR                        |
| Blache et al. 2021 (19) | France   | Gynecology                                      | 21 January – 16 March 2020 | 17 March – 12 May 2020    | 127                                    | 85                                  | -33%            | NR                            | NR                        |
| Cadili et al. 2020 (20) | Canada   | Breast                                          | 16 March – 30 April 2019   | 16 March – 30 April 2020  | 99                                     | 162                                 | +64%            | 23                            | 27                        |
| Drysdale et al. 2020 (21) | Australia | Upper GI, Breast, colorectal, endocrine         | 1 April – 19 May 2019      | 30 March – 17 May 2020    | 51                                     | 44                                  | +0%             | 14.7                          | 11.7                      |
| Fancelllu et al. 2020 (22) | Italy    | Breast                                          | 1 March – 30 April 2019    | 1 March – 30 April 2020   | 41                                     | 42                                  | +2%             | 46.4                          | 49.1                      |
| Hübner et al. 2020 (23)  | Switzerland | Major visceral, not specified                  | 3 Feb – 13 March 2020      | 16 March – 24 April 2020  | 52                                     | 38                                  | -27%            | NR                            | NR                        |
| Kiong et al. (24)       | USA      | Head and neck                                   | 23 March – 9 April 2019    | 23 March – 9 April 2020   | 111                                    | 59                                  | -47%            | NR                            | NR                        |
| Leung et al. 2021 (25)  | UK       | Gynecology                                      | 1 January – 12 August 2019 | 1 January – 12 August 2020 | 296                                    | 289                                 | -2%             | NR                            | NR                        |
| McLean et al. 2020 (27) | UK       | GI                                              | 16 Feb – 15 March 2020     | 16 March – 15 April 2020  | 7                                      | 9                                   | +29%            | NR                            | NR                        |
| Study                        | Country  | Disease Area                  | Start Date | End Date     | Cases 1 | Cases 2 | Change% | C 1 / C 2 | C 1 / C 2 |
|------------------------------|----------|-------------------------------|------------|--------------|---------|---------|---------|-----------|-----------|
| Perrone et al. 2021 (28)    | Italy    | Gynecology                    | 9 March - 4 May 2019 | 9 March - 4 May 2020 | 55      | 51      | -7%     | NR        | NR        |
| Piketty et al 2022 (29)     | France   | Gynecology and breast         | 14 March - 11 May 2019 | 14 March - 11 May 2020 | 23      | 20      | -13%    | NR        | NR        |
| Salzano et al. 2021 (30)    | Italy    | Head and neck                 | 21 Feb - 25 March 2019 | 21 Feb - 25 March 2020 | 101     | 113     | +12%    | NR        | NR        |
| Santambrogio et al. 2020 (31)| Italy    | Hepatocellular                | 28 Feb - 14 April 2019 | 28 Feb - 14 April 2020 | 9       | 11      | +22%    | NR        | NR        |
| Shah et al. 2021 (32)       | USA      | Head and neck                 | February - May 2019  | February - May 2020  | 60      | 66      | +10%    | NR        | NR        |
| Stevens et al. 2022 (33)    | USA      | Head and neck                 | March - July 2019    | March - July 2020    | 79      | 69      | -13%    | NR        | NR        |
| Subbiah et al. 2021 (34)    | India    | Head and neck, breast, GI, STS, gynecology and others | October 2019 - February 2020 | March - July 2020 | 234     | 151     | -35%    | NR        | NR        |
| Tan et al. 2021 (35)        | Australia| Head and neck                 | 6 August - 27 October 2020 | 6 August - 27 October 2020 | 33      | 26      | -21%    | NR        | NR        |
| Vanni et al. 2020 (36)      | Italy    | Breast                        | 11 March - 30 March 2019 | 11 March - 30 March 2020 | 172     | 203     | +18%    | 56        | 42        |
| Vanni et al. 2021 (37)      | Italy    | Breast                        | 30 January - 29 February 2020 | 1 March - 30 March 2020 | 39      | 37      | -5%     | 11.8      | 12.2      |
| Vissio et al. 2021 (38)     | Italy    | Breast, CNS, colorectal, lung, ovary, pancreas, prostate, uterus and thyroid | 9 March - 8 May 2019 | 9 March - 8 May 2020 | 420     | 372     | -11%    | NR        | NR        |
Table 1. Characteristics of the included studies.
COVID-19 = Coronavirus disease 2019, No. = Number, CNS = Central nervous system, GI = Gastrointestinal, STS = Soft tissue sarcomas, UK = United Kingdom, NR = Not reported.

|                | Location                      | Discipline          | Date 1          | Date 2          | No. 1 | No. 2 | Difference | % Difference | Country 1 | Country 2 | Country 3 | Country 4 |
|----------------|-------------------------------|---------------------|-----------------|-----------------|-------|-------|------------|--------------|-----------|-----------|-----------|-----------|
| Yiğit et al.   | Turkey                        | Breast, thyroid,   | 11 March – 31   | 11 March – 31   | 143   | 57    | -60%       | NR           | NR        | NR        | NR        | NR        |
| 2020 (39)      |                               | colon, gastric,    | May 2019        | May 2020        |       |       |            |              |           |           |           |           |
| Zhang et al.   | China, South Korea, Iran,     | Thyroid            | 26 Feb – 20     | 26 Feb – 20     | 531   | 293   | -45%       | NR           | NR        | NR        | NR        | NR        |
| 2020 (40)      | Italy                         |                     | April 2019      | April 2020      |       |       |            |              |           |           |           |           |
|                |                               |                     |                 |                 |       |       | Total      |              |           |           |           |           |
|                |                               | Surgical oncology  |                 |                 |       |       | difference |              |           |           |           |           |
|                |                               |                     |                 |                 |       |       | -26.4%     |              |           |           |           |           |
|                |                               | Surgical breast    |                 |                 |       |       | difference |              |           |           |           |           |
|                |                               | cancer procedures  |                 |                 |       |       | +0.3%      |              |           |           |           |           |

The eligible studies delivered data on variant oncological disciplines including central nervous system (CNS), thyroid, thoracic, breast, colorectal, hepatocellular, endocrine, genitourinary, prostate cancer, skin and soft tissue sarcomas (19–28,30–43). Of these included studies, eight evaluated surgical procedures for breast cancer (23,25,32,37,39–42). In addition, six studies described the waiting time between pathological examination or diagnosis of cancer and the date the surgical procedure was performed (20,23–25,39,40). Of these studies, three described shorter waiting times compared to pre-pandemic practice, of 0.5, 3 and 14 days, respectively (20,24,39). The remaining three studies showed minimally prolonged waiting times compared to pre-pandemic practice, of 4.0, 2.7 and 0.4 days, respectively (23,25,40). In addition, all of these studies reported information regarding performed breast cancer procedures (23,25,40).
All studies were classified as overall methodological sufficient quality according to ROBINS-I Tool. The more comprehensive risk assessment of all included studies is presented in supplementary table 2.

Surgical oncology volumes

The total number of performed surgical oncology procedures during the COVID-19 pandemic was 2867, compared to 3895 during pre-pandemic practice (total decrease 26.4%) (Table 1). Moreover, 614 oncological breast procedures were performed during the pandemic, compared to 612 before the pandemic (total increase 0.3%) (Fig 2B and Table 1).

Fig 2B. Bar chart of the number of surgical breast cancer procedures performed during and before the COVID-19 pandemic.
Clinical oncological outcomes

Five studies with a total of 2608 patients included data on pathological ≥T2 staged tumors (28,36,39,41,43). No difference was identified in the proportion of ≥T2 in the pandemic group compared to the pre-pandemic group (OR 1.00; 95% CI 0.72-1.38, P=0.989) (Fig 3A, Table 3).

| Author          | Odds Ratio | OR    | 95% CI     | Weight |
|-----------------|------------|-------|------------|--------|
| Leung et al. 2021 | 2.91       | [1.20; 7.02] | 10.2%     |
| Stevens et al. 2022 | 0.80       | [0.38; 1.69] | 12.9%     |
| Vanni et al. 2020 | 0.81       | [0.50; 1.31] | 21.3%     |
| Vissio et al. 2021 | 1.14       | [0.82; 1.59] | 28.1%     |
| Zhang et al. 2020 | 0.76       | [0.54; 1.08] | 27.5%     |

Fig 3A. Forest plot of the odds ratio of ≥T2 stage during the COVID-19 pandemic compared to the pre-pandemic control group.

| Parameter                  | OR  | 95% CI         | p-value |
|----------------------------|-----|----------------|---------|
| ≥T2                        | 1.00| 0.72-1.38      | 0.989   |
| ≥T3                        | 0.95| 0.69-1.32      | 0.778   |
| ≥N1                        | 1.01| 0.68-1.50      | 0.964   |
| Postoperative complications| 1.55| 0.87-2.74      | 0.134   |

Table 3. Odds ratios of oncological outcomes and major postoperative complications during the pandemic compared to pre-pandemic practice. OR = Odds ratio, CI = Confidence interval, T = Tumor, N = Node

Four studies describing 1986 patients included pathological ≥T3 data (36,39,41,43). No difference was observed in the number of ≥T3 tumors during the pandemic compared to pre-pandemic practice (OR 0.95; 95%CI 0.69-1.32, P= 0.778) (Fig 3B, Table 3).
Furthermore, four studies with a total of 1951 patients included data on a pathological ≥N1 stage (36,39,41,43). No difference in ≥N1 during the COVID-19 pandemic compared to the pre-pandemic group was observed. (OR 1.01; 95% CI 0.68-1.50, P= 0.964) (Fig 3C, Table 3).

In addition, five studies describing 1901 patients included the number of major postoperative complications Clavien-Dindo ≥3 during the pandemic compared to the pre-pandemic cohort (19,22,28,34,40). No significant difference in the number of major postoperative complications was identified (OR 1.55; 95% CI 0.87-2.74, P= 0.134) (Fig 3D, Table 3).
Fig 3D. Forest plot of the odds ratio of major postoperative complications (Clavien-Dindo ≥3) during the COVID-19 pandemic compared to the pre-pandemic control group.
Discussion

The current meta-analysis analyzed the number of performed surgical procedures for oncological pathologies during the COVID-19 pandemic. In total, the number of performed surgical procedures for an oncological pathology decreased (2867 vs. 3895, -26.4%) during the pandemic compared to pre-pandemic practice. In addition, the number of performed surgical procedures for breast cancer remained stable during the pandemic (578 vs. 569, +1.6%).

Furthermore, no difference was identified in the proportion of ≥T2, ≥T3, ≥N1 during the pandemic compared to pre-pandemic practice, with OR’s 1.00, 0.95, and 1.01, respectively.

Finally, the number of major postoperative complications (Clavien-Dindo ≥3) was slightly, however not significantly, higher during the pandemic (OR 1.55, P=0.134) compared to pre-pandemic performance.

During the COVID-19 pandemic, several guidelines have been established to triage the performance of (surgical oncology) procedures to determine within which time frame surgical procedures should occur. Different triage methods were used for the clinical implementation of non-COVID care, including the stratification of acute, semi-acute, and elective procedures, or by emergency-, urgent-, elective with the expectation of cure and elective with no predictive harmful outcome procedures or by low-, intermediate- or high acuity (1,44–46). In addition, some guidelines specifically described deferrable- or prioritizing surgical oncology procedures (4,6). The common denominator in these guidelines was to provide the maximal care capacity for the COVID-19 patient with as little disease progression as possible in non-COVID-19 pathologies. It is essential to investigate whether these guidelines are implemented in daily surgical practice and if short-term clinical outcomes are reported. This enables to determine whether disease progression may occur during possible future changes in operating room capacities, for example, if new pandemics arise.
This current systematic review and meta-analysis showed that the number of performed surgical oncology procedures declined (2867 vs. 3895, 26.4% total decrease) during the pandemic compared to pre-pandemic clinical practice. This is in line with the Dutch Integral Cancer Registration (IKNL), which showed a decrease in the number of performed surgical oncology procedures during the first pandemic wave in the Netherlands (47). In contrast to the overall number of performed surgical oncology procedures and the IKNL data, this meta-analysis showed a stable number of performed surgical breast cancer procedures during the pandemic compared to previous pre-pandemic volumes (614 vs. 612, 0.3% total increase). Therefore, this study’s decreased number of performed surgical oncology procedures may not be attributed to breast cancer practice. It is possible that, in order to reduce the pressure on healthcare, the operating time freed up by postponed elective surgical procedures was more easily filled by breast cancer procedures, in which patients are discharged faster postoperatively than by complex oncological procedures requiring intensive care unit admission. Moreover, postponement in surgical oncology procedures may or may not lead to disease progression; however, this depends on multiple factors (48–50). IKNL has estimated that due to stable chemotherapy performances, catch-up in cancer diagnosis, and surgical procedures, enough (non-)surgical patients have received cancer treatment in the Netherlands (47).

This systematic review and meta-analysis included six studies reporting the waiting time between histological- or cytological- examination or diagnosis of cancer and date of performed surgical procedure, or time between surgical consult and surgical procedure. Of these studies, three showed a minimally longer waiting time during the pandemic than before the pandemic (mean difference 2.4 days, range 0.4-4.0). The tumors are not expected to have grown clinically relevant in this short time (51). Additional data is necessary to inventory each
hospital’s waiting time since previous literature states that increased waiting time for oncological procedures may lead to a lower overall survival rate (49,52). Moreover, this meta-analysis showed no significantly increased number of patients presenting with pathological ≥T2, ≥T3, ≥N1 tumors or major postoperative complications during the COVID-19 pandemic compared to pre-pandemic cohorts. These results may indicate that no disease progression occurred during the COVID-19 pandemic in the included oncological studies, a possible conclusion also seen in a recent Dutch COVID-19 study focusing on stage distribution of colorectal cancers (53). This may be explained by some solid cancers being years old when noticed and requiring a surgical procedure (54). However, caution is advised as calculations anticipate diagnostic delays due to the COVID-19 pandemic may increase the number of preventable cancer deaths (55).

This systematic review and meta-analysis has some limitations. First, separating surgical oncology volumes by type of oncology discipline was only possible for breast cancer. In addition, the majority of the breast cancer studies included data from Italy. Therefore, extrapolating the number of performed surgical breast cancer procedures to other countries may be difficult. Further research is necessary to determine the net summary of the number of performed surgical procedures for each country to allow for a more realistic representation of the delayed healthcare. Second, the current meta-analysis is limited by the data’s heterogeneity. The COVID-19 pandemic severity differed between countries and regions, leading to heterogenic approach of oncological guidelines. As a result, inevitable variation is observed in chosen pre-pandemic and pandemic phases, chronology and management between the included studies. Specifically, some studies determined the start date of their COVID-19 cohort before the official WHO declaration of the COVID-19 pandemic, which may be explained by the varying incidence of COVID-19 between countries and/or regions (56,57).
Third, this study was unable to review whether the observed reduction in surgical volumes was related to the deferral of surgical procedures due to altered hospital approach or patient-driven avoidance of care. Finally, more research is essential to determine whether people have been treated on time to have well-founded information for possible future pandemics.

In conclusion, this meta-analysis showed a decrease (-26.4%) in the number of performed surgical oncology procedures during the COVID-19 pandemic (3895 vs. 2867). In addition, the number of performed surgical breast cancer procedures remained stable (+0.3%). Moreover, reported short-term oncological staging and major postoperative complications showed no significantly increased disease progression compared to pre-pandemic practice. In the event of future pandemics, the performed surgical oncology care during the first wave of the COVID-19 pandemic appears appropriate regarding short-term outcomes. Further research should determine long-term and country-specific clinical outcomes.
Declarations

- Funding statement: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

- Declarations of interest: None.

- Informed consent: Not applicable.

- Data presentation: Research data is available upon reasonable request.
Supplementary data

Supplementary Table 1. Literature search Pubmed and Embase databases

| Database | Search |
|----------|--------|
| Pubmed   | ((("COVID-19"[Mesh]) OR "SARS-CoV-2"[Mesh]) OR ((("COVID-19"[Supplementary Concept] OR "severe acute respiratory syndrome coronavirus 2"[Supplementary Concept] OR (("Coronavirus"[MeSH Terms] OR "Coronavirus Infections"[Mesh:NoExp] OR pneumonia virus*[tiab] OR cov*[tiab]) AND (outbreak[tiab] OR wuhan[tiab] OR novel[all] OR 19[tiab] OR 2019[tiab] OR epidemic*[tiab] OR epidemic[all] OR epidemic*[all] OR new[tiab]) OR coronavirus*[tiab] OR corona virus*[tiab] OR ncov[tiab] OR 2019ncov[tiab] OR covid19*[tiab] OR "covid 19*[tiab] OR "sars cov 2*[tiab] OR sarscov2[tiab] OR sarscov-2[tiab] OR sars2[tiab] OR "ncov 2019*[tiab] OR "sars coronavirus 2*[tiab] OR "sars corona virus 2*[tiab] OR "severe acute respiratory syndrome cov 2*[tiab] OR "severe acute respiratory syndrome cov2*[tiab] OR severe acute respiratory syndrome cov*[tiab] OR cov2[tiab])) OR (("COVID-19"[Mesh]) OR "SARS-CoV-2"[Mesh])) AND (("Specialties, Surgical"[Mesh]) OR (surgical*[Title/Abstract]))) AND ("2019/01/01"[Date - Publication] : "2022/03/21"[Date - Publication]) |
| Embase   | 'coronavirus disease 2019'/exp OR 'severe acute respiratory syndrome coronavirus 2'/exp OR ('coronavirinae'/exp OR 'coronavirus infection'/de OR coronavirus*:ti,ab,kw OR 'corona virus*':ti,ab,kw OR 'pneumonia virus*':ti,ab,kw OR cov*:ti,ab,kw OR ncov:ti,ab,kw) AND (outbreak:ti,ab,kw OR wuhan:ti,ab,kw) OR covid19*:ti,ab,kw OR 'covid 19*':ti,ab,kw OR ((coronavirus*:ti,ab,kw OR 'corona virus*':ti,ab,kw) AND 2019:ti,ab,kw) OR 'sars cov 2*:ti,ab,kw OR sars2:ti,ab,kw OR 'coronavirus*':ti,ab,kw OR 'corona virus*':ti,ab,kw OR 'ncov 2019*:ti,ab,kw OR 'sars coronavirus 2*:ti,ab,kw OR 'sars corona virus 2*:ti,ab,kw OR 'severe acute respiratory syndrome cov 2*:ti,ab,kw OR 'severe acute respiratory syndrome cov2*:ti,ab,kw) AND [2019-2022]/py AND 'surgery'/exp AND [(article)/lim OR [article in press]/lim OR [editorial]/lim OR [erratum]/lim OR [letter]/lim OR [note]/lim OR [review]/lim OR [short survey]/lim) AND ([embase]/lim OR [medline]/lim OR [pubmed-not-medline]/lim) |
## Supplementary Table 2. Risk of bias assessment

| Author           | D1  | D2  | D3             | D4  | D5  | D6  | D7  |
|------------------|-----|-----|----------------|-----|-----|-----|-----|
| Akhtar et al.    | Low | Low | Moderate       | Low | Low | Low | Low |
| Amoo et al.      | Low | Low | Low            | Low | Low | Low | Low |
| Araujo et al.    | Low | Low | Low            | Low | Low | Low | Low |
| Blache et al.    | Low | Low | Moderate       | Low | Low | Low | Low |
| Cadili et al.    | Low | Low | Low            | Low | Low | Low | Low |
| Drysdale et al.  | Low | Low | Low            | Low | Low | Low | Low |
| Fancellu et al.  | Low | Low | Low            | Low | Low | Low | Low |
| Hübner et al.    | Low | Low | Moderate       | Low | Low | Low | Low |
| Kiong et al.     | Low | Low | Low            | Low | Low | Low | Low |
| Leung et al.     | Low | Low | Low            | Low | Low | Low | Low |
| McLean et al.    | Low | Low | Moderate       | Low | Low | Low | Low |
| Perrone et al.   | Low | Low | Low            | Low | Low | Low | Low |
| Piketty et al.   | Low | Low | Low            | Low | Low | Low | Low |
| Salzano et al.   | Low | Low | Low            | Low | Low | Low | Moderate | Low |
| Santambrogio et al. | Low | Low | Low | Low | Low | Low | Low |
| Shah et al.      | Low | Low | Low            | Low | Low | Low | Low |
| Stevens et al.   | Low | Low | Low            | Low | Low | Low | Low |
| Subbiah et al    | Low | Low | Moderate       | Low | Low | Low | Low |
| Tan et al.       | Low | Low | Moderate       | Low | Low | Low | Low |
| Vanni et al. 2020 | Low | Low | Low           | Low | Low | Low | Low |
| Vanni et al. 2021 | Low | Low | Moderate       | Low | Low | Low | Low |
| Vissio et al.    | Low | Low | Low            | Low | Low | Low | Low |
| Yiğit et al.     | Low | Low | Low            | Low | Low | Low | Low |
| Zhang et al.     | Low | Low | Low            | Low | Low | Low | Low |
Supplementary Fig 1. Summary of the risks of bias and applicability domains. D1 = Bias due to confounding; D2 = Bias in selection of participants into the study; D3 = Bias in classification of interventions; D4 = Bias due to deviations from intended interventions; D5 = Bias due to missing data; D6 = Bias in measurements of outcomes; D7 = Bias in selection of the reported result.
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Highlights

- The number of performed surgical oncology procedures decreased during the pandemic.
- The number of performed surgical breast cancer procedures remained stable during the pandemic.
- Oncological staging showed no significant difference compared to pre-pandemic care.
- No significant difference was seen in major postoperative complications compared to the pre-pandemic.