



Factors affecting 30-day postoperative complications after emergency surgery during the COVID-19 outbreak: A multicentre cohort study

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ABSTRACT

Introduction: Coronavirus disease 2019 (COVID-19) has influenced (surgical) care worldwide. Measures were taken to prioritize surgical care in order to maintain capacity for COVID-19 healthcare. However, the influence of these measures on emergency surgery is limited. Therefore, the aim of this study is to describe the trends in emergency surgery and determine the factors influencing the risk of postoperative complications during the first wave of the COVID-19 pandemic.

Methods: This multicentre retrospective cohort study investigated all emergency patients operated on from March 9th to June 30th, 2020. The primary endpoint was identifying the number of emergency surgical procedures performed. Secondary endpoints were determining the number of postoperative complications and factors determining the risk of postoperative complications, which were calculated by multivariate analysis with odds ratio (OR) and 95% confidence (CI) intervals.

Results: In total, 1399 patients who underwent an emergency surgical procedure were included. An increase in the number of emergency vascular and trauma surgical procedures occurred during the study period. In contrast, the number of emergency general and oncological surgical procedures performed remained stable. An increased age (OR 1.01, 95% CI 1.00–1.02; $p = 0.024$), American Society of Anaesthesiologists (ASA) (OR 1.34, 95% CI 1.09–1.64; $p = 0.005$), and surgical discipline were independent predictors for an increased risk of postoperative complications.

Conclusion: The performance of emergency vascular and trauma surgical procedures increased. The performance of emergency general and oncological surgical procedures remained stable. In addition, increased age, ASA, and surgical discipline were independent predictors for an increased risk of postoperative complications.

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1. Introduction

Emergency surgical care accounts for more than 50% of surgical admissions, representing a significant part of healthcare [1]. In addition, postoperative care after emergency surgery may require Intensive Care Unit (ICU) admission in 4.8–24.2% of patients, depending on the type of emergency procedure [2,3]. However,

during the Coronavirus disease 2019 (COVID-19) pandemic, ICU capacity for elective (surgical) patients was scarce since hospitals preferentially provided ICU capacity to COVID-19 patients. In order to reduce the pressure on healthcare providers, hospitals implemented several measures, including the postponement of elective (surgical) care [4–7]. One of the other measures implemented to reduce pressure on hospitals was the temporary halt of the national screening programs for breast, colorectal and cervical cancer from March 16th to June 15th, 2020 [8–11].

During the pandemic, a reduction in the number of surgical procedures performed was observed in several disciplines [11–14].

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Postponing surgery may increase surgical patients' morbidity and mortality, resulting in an undesirable increased pressure on healthcare capacity [15–17].

Evaluation of the implemented measures, including the postponement of surgical procedures, is essential in order to determine the net pressure on surgical emergency care. Consequently, the aim of this study is to describe the characteristics of the emergency surgical procedures performed during the COVID-19 pandemic.

2. Materials and methods

2.1. Study design

This retrospective multicentre cohort study included all consecutive patients older than 18 years and who underwent an emergency surgical procedure during the first wave of the COVID-19 pandemic (March 9th and June 30th, 2020) in four, one academic, three general public hospitals across the Netherlands. The ethics committee of all participating centres approved this study and there was no need for informed consent. Research has been reported in line with the STROCCS criteria [18]. The study is part of the trial registered in the research registry (www.researchregistry.com, unique identifying number: researchregistry5720).

2.2. Diagnosis of COVID-19

Reverse transcriptase PCR for SARS-CoV-2 was used in all centres, according to European guidelines [19]. The genes used for analysis were the RdRp gene, E gene, and the N gene. The E gene assay was used first, followed by confirmatory testing with the RdRp gene assay. Patients could be tested for COVID-19 prior to or after surgery.

2.3. Endpoints and definitions

The primary endpoint was to identify the number of emergency surgical procedures performed throughout the study period. Secondary endpoints were to establish the number of COVID-19 tested and positive patients prior to or during the course of the surgical admission and to determine the complication rates and its risk factors.

Symptoms associated with COVID-19 infection were fever, dyspnoea, cough, chest pain, fatigue, and/or other flu-like symptoms. Prior to surgery, the general condition of patients was assessed with the American Society of Anesthesiologists (ASA) classification [20]. The severity of complications was classified according to the Clavien-Dindo classification [21]. Major complications were defined as Clavien-Dindo class III or higher.

Emergency surgical procedures were stratified into four disciplines; general surgery, oncological surgery, trauma surgery, and vascular surgery. General surgical procedures included but were not limited to cholecystectomy, appendicectomy, (inguinal) hernia repair, and non-oncological bowel procedures.

2.4. Statistical analysis

Descriptive statistics were used to specify patient and treatment characteristics. Continuous data are described as means and standard deviation (SD) or median and interquartile range (IQR), depending on the distribution.

Imputation of the missing data was filled in by using the Multiple imputation by chained equation (MICE) package in R. Missing data was compared to non-missing data to determine whether data were missing at random. The imputation was repeated 50 times, followed by the application of Rubin's rule to combine parameter

estimates and standard errors [22,23]. To ascertain the validity of the imputation model, imputed data were compared to data of complete cases. These imputed data were used in the analysis.

Multivariate logistic regression analysis was performed to ascertain the risk of developing complications in patients who underwent an emergency surgical procedure. Two-sided P-values less than 0.05 were considered statistically significant.

All statistical analyses were conducted using RStudio February 1, 5001 (R version: x64 3.6.3). Illustration of plots was performed using the *ggplot2* package.

3. Results

3.1. Baseline characteristics

Between March 9th and June 30th, 2020, 1399 patients underwent an emergency surgical procedure in four hospitals in the Netherlands. The mean age of the study population was 58.07 years with a mean Body Mass Index (BMI) of 26.14 kg/m², 733 (52.4%) patients were men. Of the 1399 patients, 364 (26.0%) patients had a history of cardiovascular disease and 244 (17.4%) patients had diabetes mellitus. Most patients (1,315, 94.0%) were classified as ASA I-III. Most commonly performed surgical procedures were general surgery in 709 (50.7%) patients and trauma surgery in 483 (34.5%) patients. Three hundred and forty-three patients (24.5%) developed complications, of which 193 (13.8%) were minor complications and 150 (10.7%) major complications. In total, 212 patients (15.2%) were tested for COVID-19 with PCR, 8 (0.6%) of whom tested positive (Table 1).

3.2. Emergency surgery during study period

There was an increased number of emergency trauma surgical procedures after week 16 (Fig. 1). The number of emergency

Table 1
Baseline characteristics (N = 1399).

Parameter	Value
Age years, mean (SD)	58.07 (20.96)
Sex male, N (%)	733 (52.4)
BMI kg/m ² , mean (SD)	26.14 (5.26)
Co-morbidities	
Cardiovascular disease, N (%)	364 (26.0)
Diabetes, N (%)	244 (17.4)
Malignancy, N (%)	121 (8.6)
Pulmonary disease, N (%)	40 (2.9)
Renal disease, N (%)	6 (0.4)
ASA classification	
ASA I, N (%)	391 (27.9)
ASA II, N (%)	520 (37.2)
ASA III, N (%)	404 (28.9)
ASA IV, N (%)	79 (5.6)
ASA V, N (%)	5 (0.4)
Surgical discipline	
General surgery, N (%)	709 (50.7)
Oncological surgery, N (%)	25 (1.8)
Trauma surgery, N (%)	483 (34.5)
Vascular surgery, N (%)	182 (13.0)
Tested for COVID-19, N (%)	212 (15.2)
Positive for COVID-19, N (%)	8 (0.6)
Hospital admission days, median (IQR)	2 (5)
Complications	
None, N (%)	1056 (75.5)
Minor, N (%)	193 (13.8)
Major, N (%)	150 (10.7)

SD = standard deviation; ASA = American Society of Anesthesiologists; BMI = body mass index; ASA = American Society of Anesthesiologists; COVID-19 = coronavirus disease 2019; IQR = interquartile range.

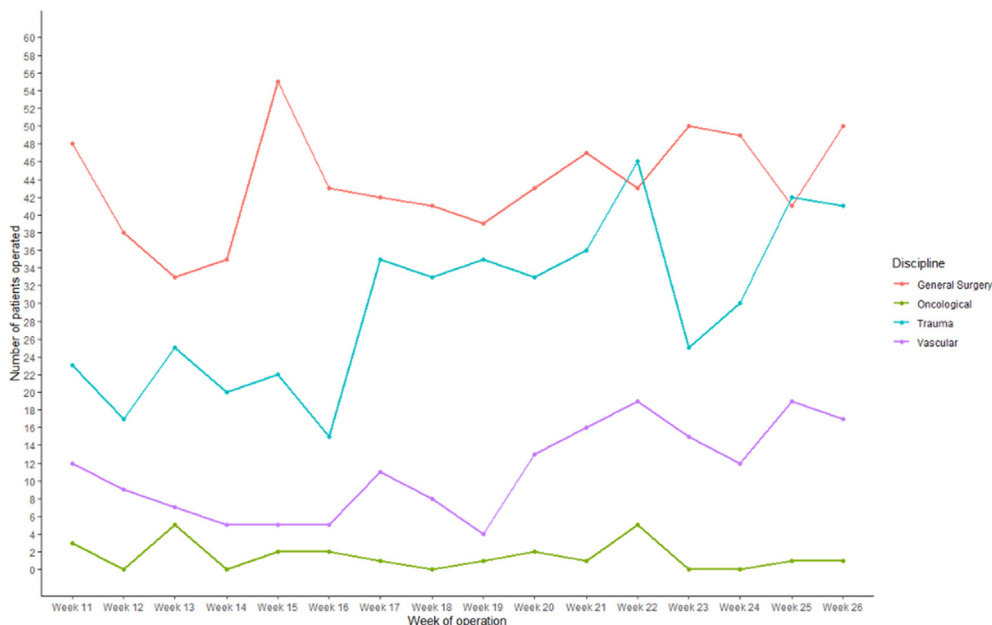


Fig. 1. Emergency surgical procedures over time during the first wave of the COVID-19 pandemic.

vascular surgical procedures increased after week 16 as well. An initial decrease in general emergency surgical procedures during week 11 to week 14 occurred, followed by an increase during the remaining study period resulting in an overall stable number of general emergency procedures performed. The number of emergency oncological surgical procedures remained stable during follow-up period (Fig. 1).

3.3. Postoperative complications

There were no significant changes in complication rates during the course of the study period (Fig. 2). Multivariate analysis showed that age (OR 1.01, 95% CI 1.00–1.02; $p = 0.024$) and ASA

classification (OR 1.34, 95% CI 1.09–1.64; $p = 0.005$) were risk factors for determining the risk of postoperative complications (Table 2). Furthermore, Table 2 showed that the type of surgical procedure is a significant predictor for the risk of postoperative complications.

4. Discussion

This multicentre retrospective cohort analysed 1399 consecutive patients undergoing surgical procedures in the emergency setting during the first wave of the COVID-19 pandemic. The number of patients undergoing general surgical procedures and patients undergoing oncological surgical procedures in the acute

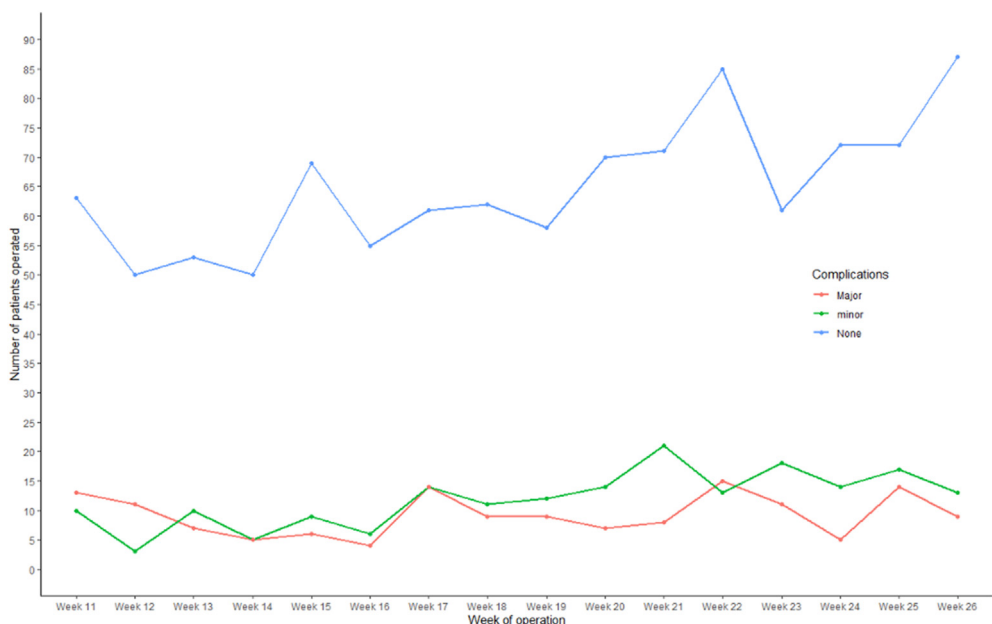


Fig. 2. Postoperative complications over time during the first wave of the COVID-19 pandemic.

Table 2
Multivariate analysis of different factors contributing to the risk of developing postoperative complications (N = 1399).

Parameter	Estimate	OR (95% CI)	Standard error	z-value	p-value
Age	0.01	1.01 (1.00–1.02)	0.004	2.265	0.024
Sex					
Female	NA	1.00 (reference)	NA	NA	NA
Male	0.239	1.27 (0.97–1.65)	0.135	1.771	0.077
BMI	–0.008	0.99 (0.97–1.02)	0.013	–0.59	0.555
Comorbidities					
Cardiovascular disease	0.023	1.02 (0.73–1.43)	0.17	0.135	0.893
Diabetes mellitus	–0.144	0.87 (0.59–1.26)	0.192	–0.752	0.452
Pulmonary	–0.112	0.89 (0.63–1.26)	0.176	–0.638	0.524
Kidney disease	–0.151	0.86 (0.57–1.29)	0.208	–0.727	0.467
Malignancy	0.216	1.24 (0.87–1.77)	0.18	1.203	0.229
Surgical setting					
General surgery	NA	1.00 (reference)	NA	NA	NA
Oncological surgery	0.647	1.91 (0.80–4.55)	0.442	1.464	0.143
Trauma surgery	–0.002	1.00 (0.74–1.35)	0.155	–0.013	0.990
Vascular surgery	0.631	1.88 (1.24–2.84)	0.21	3.001	0.003
ASA classification	0.290	1.34 (1.09–1.64)	0.104	2.784	0.005
Week number	0.021	1.02 (0.99–1.05)	0.014	1.484	0.138
COVID-19 test					
Positive compared to untested	–0.063	0.94 (0.18–4.94)	0.847	–0.074	0.941
Positive compared to negative	–1.011	0.36 (0.07–1.94)	0.853	–1.185	0.236

OR = odds ratio, CI = confidence interval, BMI = body mass index, ASA = American Society of Anesthesiologists, COVID-19 = coronavirus disease 2019, NA = not applicable.

setting remained stable during the study period. However, an increase in the number of vascular and trauma surgical procedures performed during the first wave of the COVID-19 pandemic was observed. In addition, 343 (24.5%) patients developed one or more postoperative complications. Multivariate analysis showed that increased age, higher ASA classification, and surgical discipline were independent predictors for the risk of developing postoperative complications. Finally, the number of postoperative complications after emergency surgery during the first wave of the pandemic remained stable as the pandemic progressed.

In the Netherlands, the government has put many measures in place to reduce the spreading of SARS-CoV-2. This meant that only the more urgent surgical procedures were performed during the first wave of the COVID-19 pandemic [4]. Nationwide measures, including the advice to remain at home if possible, were implemented in the Netherlands as of March 16th, 2020, corresponding with our second study period week [24].

The increase in trauma surgical procedures occurred in the second half of the first wave of the COVID-19 pandemic. This increase may result from an increase in falls and household injuries, which was seen in other studies [25–27]. Additionally, an increase in bicycle accidents during the lockdown, as described previously, may be attributed to the increase in surgical trauma procedures as well [27]. Especially since Dutch residents cycle frequently and increased recreational cycling was observed during the pandemic [28].

The current study showed an increase in the number of emergency vascular procedures performed after the second half of the first wave of the COVID-19 pandemic. This may be due to the postponement of vascular surgical procedures during the COVID-19 pandemic. This delay may have resulted in more vascular patients presenting at a more advanced stage of the disease. Furthermore, this delay may have led to more vascular patients presenting in the emergency setting. These findings are in line with a previous Dutch study illustrating that the COVID-19 pandemic resulted in a delay in the presentation of vascular surgery patients, causing them to present with worse pathology [29].

The current study shows that in contrast to vascular and trauma surgical procedures, no increase was observed during the first wave of the pandemic in the overall number of emergency oncological surgical procedures, even though the national screening programs

for colon-, breast and cervical cancer were temporarily halted from March 16th, 2020 to June 15th, 2020 [8–11,31]. A possible explanation may be that patients identified through the screening programs often are at a lower oncological stage and are therefore less likely to present at the emergency department [12,32–35]. In addition, possible delayed colorectal cancer diagnosis due to the halted screening programs may increase an acute presentation in the long term. However, since the postponement of the screening programs is too recent, it is not yet possible to make well-founded statements.

The overall number of emergency general surgical procedures performed remained stable during the study period. This may be attributed to the acute nature, along with acute treatment, of many diseases related to general surgical procedures, such as appendicitis, cholecystitis, and internal herniations [36–38].

The current study showed that age, higher ASA classification, and surgical discipline were independent predictors for developing postoperative complications, which is in line with previous studies [39–43]. Furthermore, multivariate analysis showed that a positive COVID-19 test was not significantly associated with an increased risk of postoperative complications in patients undergoing surgical procedures in the acute setting. However, the current study has only 8 COVID-19 positive patients, as only patients with COVID-19-like symptoms were tested during the first wave of the pandemic in the Netherlands. Therefore, the immediate risk of COVID-19 on postoperative complications in this study population may be challenging to assess. However, this study showed no change in the risk of developing postoperative complications as the pandemic progressed. Nevertheless, the long-term effects of the pandemic on healthcare are unknown. However, a recently published report by the Dutch National Institute for Public Health and Environment assessed the impact of the first wave of COVID-19 on regular healthcare. This report describes an estimated loss between 34,000 and 50,000 healthy years of life resulting from postponed treatment [44]. Furthermore, the Dutch Cancer Registration reported a decrease in cancer diagnosis of 4,000 patients in 2020, compared to the previous year, indicating that the COVID-19 pandemic has noticeable consequences [45].

In December 2020, the Dutch government decided to scale down non-urgent care due to the increased strain on healthcare caused by the ongoing pandemic. This decision resulted in a partial

deferral of healthcare, including procedures that were not critical to be treated within six weeks [46]. The current study showed that postponement of elective care to reduce the pressure on healthcare might lead to an increase in emergency surgical procedures across different disciplines, resulting in further pressure on the healthcare system, creating a counter-effective outcome. Therefore, the continuation of surgical, especially vascular, procedures during the COVID-19 pandemic is of great importance. In addition, explicit attention to maintain the lowest possible referral threshold in primary care during the pandemic is essential.

This study has some limitations. Direct changes in the number of specific surgical procedures were not possible to determine due to the absence of extensive pre-pandemic data. However, this current study included data of one-week pre-COVID-19 measures. Thereby, changes in the trends of four major surgical disciplines as a response to the pandemic were illustrated. More research is warranted to determine which surgical procedures are ineligible for postponement in the event of a new COVID-19 wave or similar pandemics.

In conclusion, suppose possible future pandemics arise, or measures have to be taken that affect the surgical capacity, we recommend being cautious in postponing surgical procedures, especially vascular and trauma surgical procedures. In addition, including ASA classification and age in selecting surgical patients may be considered to reduce the strain on healthcare.

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Ethical approval

The ethics committee of all participating centres approved this study and there was no need for informed consent. 20/207.

Consent

The ethics committee of all participating centres approved this study and there was no need for informed consent.

Author contributions

E. de Bock: conception and design, data collection, analysis and interpretation, writing the article, critical revision of the article. M.D. Filipe: conception and design, data collection, analysis and interpretation, writing the article, critical revision of the article. A. Pronk: analysis and interpretation, data collection, critical revision of the article. D. Boerma: analysis and interpretation, data collection, critical revision of the article. J.T. Heikens: analysis and interpretation, data collection, critical revision of the article. P.M. Verheijen: analysis and interpretation, data collection, critical revision of the article. M.R. Vriens: conception and design, analysis and interpretation, writing the article, critical revision of the article. M.C. Richir: conception and design, analysis and interpretation, writing the article, critical revision of the article.

Registration of research studies

The study is part of the trial registered in the research registry (www.researchregistry.com, unique identifying number: research registry5720).

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Declaration of competing interest

None.

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Not applicable.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijso.2021.100397>.

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