Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Factors affecting 30-day postoperative complications after emergency surgery during the COVID-19 outbreak: A multicentre cohort study

Ellen de Bock, BSc a, *, Mando D. Filipe, MD PhD a, Apollo Pronk, MD PhD b, Djamil Boerma, MD PhD c, Joost T. Heikens, MD PhD c, d, Paul M. Verheijen, MD PhD c, Menno R. Vriens, MD PhD a, Milan C. Richir, MD PhD a

a Department of Surgery, Cancer Centre, University Medical Centre Utrecht, the Netherlands
b Department of Surgery, Diakonessenhuis, Utrecht, the Netherlands
c Department of Surgery, St. Antonius Hospital, Nieuwegein, the Netherlands
d Department of Surgery, Rivierenland Hospital, Tiel, the Netherlands
e Department of Surgery, Meander Medical Centre, Amersfoort, the Netherlands

Article info

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.

© 2021 The Author(s). Published by Elsevier Ltd on behalf of Surgical Associates Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

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].

* Corresponding author. PO Box 85500, 3508 GA, Utrecht, the Netherlands.
E-mail address: E.deBock-2@umcutrecht.nl (E. de Bock).
Postponing surgery may increase surgical patients’ morbidity and mortality, resulting in an undesirable increased pressure on healthcare capacity \cite{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 \cite{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 \cite{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 \cite{20}. The severity of complications was classified according to the Clavien-Dindo classification \cite{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 \cite{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, 2021 (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

\begin{table}[h!]
\centering
\caption{Baseline characteristics (N = 1399).}
\begin{tabular}{ll}
\hline
Parameter & Value \\
\hline
Age years, mean (SD) & 58.07 (20.96) \\
Sex male, N (%) & 733 (52.4) \\
BMI kg/m², 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) & 3 (2.5) \\
Complications & \\
None, N (%) & 1056 (75.5) \\
Minor, N (%) & 193 (13.8) \\
Major, N (%) & 150 (10.7) \\
\hline
\end{tabular}
\end{table}
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
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 COVID-19 pandemic is in line with previous studies [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 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].

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

| 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 | 0.011  | 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.
deferment 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.

**Funding**

This study has not received any funding.

**Provenance and peer review**

Not commissioned, externally peer-reviewed.

**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. M. Verheijen: 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. D. Boerma: analysis and interpretation, data collection, 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).

**Guarantor**

Dr. M.C. Richir.

**Declaration of competing interest**

None.

**Acknowledgements**

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.

**References**

[1] Davies MG, Shine MF, Lennon F. Surgical emergencies in Ireland. Ir J Med Sci 1993 Oct;160(10):303–6.
[2] Vester-Andersen M, Lundstrom LH, Meller MH, Waldau T, Rosenberg J, Meller AM. Mortality and postoperative care pathways after emergency gastrointestinal surgery in 2004 patients: a population-based cohort study. Br J Anaesth 2014 May;112(5):860–70.
[3] Clarke A, Murdoch H, Thomas MJ, Cook TM, Peden CJ. Mortality and postoperative care after emergency laparotomy. Eur J Anaesthesiol 2011 Jan;28(1):16–9.
[4] NVVH. Handle for surgical procedures during Corona crisis [Internet]. 2020 [cited 2021 May 22]. Available from: https://heelkunde.nl/nieuws/nvvh/consent-sleutenelementen-surgicale-procedures.html
[5] Al-Jabir A, Kerwan A, Nicola M, Alsafi Z, Khan M, Sohrabi C, et al. Impact of the Coronavirus (COVID-19) pandemic on surgical practice - Part 1. Int J Surg 2020 Jul;79:168–79.
[6] Al-Jabir A, Kerwan A, Nicola M, Alsafi Z, Khan M, Sohrabi C, et al. Impact of the Coronavirus (COVID-19) pandemic on surgical practice - Part 2 (surgical prioritisation). Int J Surg 2020 Jul;79:233–48.
[7] Zangrillo A, Beretta L, Silvani P, Colombo S, Scandroglio AM, Dell'Acqua A, et al. Fast reshaping of intensive care unit facilities in a large metropolitan hospital in Milan, Italy: facing the COVID-19 pandemic emergency. Crit Care Resusc 2020 Apr 1;22(2):91–4.
[8] National Institute for Health and Environment. Letter to Parliament about stopping cancer screening programs related to COVID-19 [Internet]. 2020. Available from: https://www.rijksoverheid.nl/documenten/kamerstukken/2020/03/16/kamerbrief-over-stopzetten-bevolkingsonderzoeken-kanker-in-verband-met-covid-19.
[9] National Institute for Health and Environment. Questions and answers temporarily halt cancer screening programs [Internet]. 2020. Available from: https://www.nieuwsbrieven.nl/nieuwsbrieven/2020/03/16/kamerbrief-over-stopzetten-bevolkingsonderzoeken-vragen-en-antwoorden.
[10] National Institute for Health and Environment. Newsletter population screening for cancer - breast cancer screening program, population screening started again in mid-June [Internet]. Available from: https://www.nvnh.nl/nieuwsbrieven/2020/03/16/kamerbrief-over-stopzetten-bevolkingsonderzoeken-vragen-en-antwoorden.
[11] Filipe MD, van Deukeren D, Kip M, Doeksen A, Pronk A, Verheijen PM, et al. Effect of the COVID-19 pandemic on surgical breast cancer care in The Netherlands: a multicenter retrospective cohort study. Clin Breast Canc 2020 Dec;20(6):616–619.
[12] Filipe M, de Bock E, Geitenbeek R, Boerma D, Pronk A, Heikens J, et al. Impact of the COVID-19 pandemic on surgical colorectal cancer care in The Netherlands: a multicenter retrospective cohort study. J Gastrointest Canc 2020 Feb;73:97–106.
[13] Duarte A, Gouveia e Melo R, Lopes A, Rato JP, Valente J, Pedro LM. Lessons learned from the impact of the COVID-19 pandemic in a vascular surgery department and preparation for future outbreaks. Ann Vasc Surg 2020 May;73:97–106.
[14] Forahman S, Dural AC, Aydin H, Sahbaz NA, Akarsu C, Peker KD, et al. Analysis of general surgery outpatient clinic admissions and operations during COVID-19 pandemic in Turkey: reactions of 12728 patients. Bratisl Lek Listy 2020;121(7):475–80.
[15] Correoso Castellanos S, Lajara Marco F, Díez Galán MM, Blay Dominguez E, Bernálidez Silvetti PF, Palazon Banegas MA, et al. Analysis of surgical delay and its influence on morbimortality in patients with hip fracture. Rev Esp Anal Cirugía Ortopédica Traumatol 2019 May;63(3):246–51.
[16] Hannia TP, King WD, Thibodeau S, Jalink M, Paulin GA, Harvey-Jones E, et al. Mortality due to cancer treatment delay: systematic review and meta-analysis. BMJ 2020 Nov 4;340:k2877.
video-assisted thoracoscopic lobectomy cohort. Sci Rep 2021 Dec 1;11(1): 4914.

[18] Agha R, AbdAll-Razak A, Crossley E, Dowlut N, Iossifidis C, Mathew G, et al. STROCSS 2019 Guideline: Strengthening the reporting of cohort studies in surgery. Int J Surg 2019 Dec;72:156–65.

[19] Corman VM, Landt O, Kaiser M, Molenkamp R, Meijer A, Chu DK, et al. Detection of 2019 novel coronavirus (2019-nCoV) by real-time RT-PCR. Euro Surveill 2020 Jan;25(3).

[20] Owens WD. American society of Anesthesiologists physical status classification system in not a risk classification system. Anesthesiology 2001 Feb;94(2): 378.

[21] Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004 Aug;240(2):205–13.

[22] Beaulieu-Jones BK, Lavage DR, Snyder JW, Moore JH, Pendergrass SA, Bauer CR. Characterizing and managing missing structured data in electronic health records: data analysis. JMIR Med informatics 2018 Feb;6(1):e11.

[23] Zhang Z. Multiple imputation with multivariate imputation by chained equation (MICE) package. Ann Transl Med. 2016 Jan 15;4(2):30–38S. 12.63.

[24] National Institute for Health and Environment. New measures to reduce the spreading of the coronavirus in The Netherlands [Internet]. 2020. Available from: https://www.rijksoverheid.nl/actueel/nieuws/2020/03/12/nieuwe-maatregelen-tegen-verspreiding-coronavirus-in-nederland.

[25] Chiba H, Lewis M, Benjamin ER, Jakob DA, Liasidis P, Wong MD, et al. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004 Aug;240(2):205–13.

[26] Ruiz-Medina PE, Ramos-Melíbar E, Navarro-Pérez A, De la Pera J, Chonan-Segal P, et al. The effect of the COVID-19 lockdown on surgical breast cancer care in The Netherlands: a multicenter retrospective cohort study. Clin Breast Cancer 2020 Dec;20(6):454–61.

[27] Panhuysen FH, Willems SM, et al. Fewer cancer diagnoses during the COVID-19 epidemic in The Netherlands. Lancet Oncol 2020 Jun;21(6):750–757.

[28] Nivelle MA, Hwang J, Taylor AW, et al. Impact of the COVID-19 pandemic on regular healthcare and health: assessment of the extent of the first and second waves of the COVID-19 pandemic in the Netherlands. GRLV 2020 Dec;69:74–87.

[29] Hachtel NJ, de Oliveira GS, Jain UK, Kim JYS. ASA class is a reliable independent predictor of medical complications and mortality following surgery. Int J Surg 2015 Jun;18:184–90.

[30] Schuiver BJ, de Graan PN, de Jonge WJ, et al. COVID-19 pandemic impact on colorectal surgery: lessons from a single institution. Surg Endosc 2021 Feb;35(2):513–20.

[31] Beaulieu-Jones BK, Lavage DR, Snyder JW, Moore JH, Pendergrass SA, Bauer CR. Characterizing and managing missing structured data in electronic health records: data analysis. JMIR Med informatics 2018 Feb;6(1):e11.

[32] Zhang Z. Multiple imputation with multivariate imputation by chained equation (MICE) package. Ann Transl Med. 2016 Jan 15;4(2):30–38S. 12.63.

[33] National Institute for Health and Environment. New measures to reduce the spreading of the coronavirus in The Netherlands [Internet]. 2020. Available from: https://www.rijksoverheid.nl/actueel/nieuws/2020/03/12/nieuwe-maatregelen-tegen-verspreiding-coronavirus-in-nederland.

[34] Bayar R, Yılmaz KB, Akinli M, Sahin A, Kularoglu H. An evaluation of treatment results of emergency versus elective surgery in colorectal cancer patients. Turkish J Surg 2016 Feb;32(1):11–7.

[35] McPhail S, Ellis-Brookes L, Shetton J, Ives A, Greenslade M, Vernon S, et al. Emergency presentation of cancer and short-term mortality. Br J Canc 2013 Oct;109(8):2027–34.

[36] Filipe MD, van Deukeren D, Kip M, Doeksen A, Pronk A, Verheijen PM, et al. Effect of the COVID-19 pandemic on surgical breast cancer care in The Netherlands: a multicenter retrospective cohort study. Clin Breast Cancer 2020 Dec;20(6):454–61.

[37] Bhanu A, Sareide K, Di Saverio S, Assarsson JH, Drake FT. Acute appendicitis: modern understanding of pathogenesis, diagnosis, and management. Lancet 2015 Sep;386:1278–87. 10000.

[38] Bagla P, Sarria JC, Riall TS. Management of acute cholecystitis. Curr Opin Infect Dis 2016 Oct;29(5):508–13.

[39] Corey B, Grannis J. Internal hernias: prevention, diagnosis, and management. In: Bariatric surgery complications and emergencies. Cham: Springer International Publishing; 2016. p. 133–45.

[40] McPhail S, Elliss-Brookes L, Shelton J, Ives A, Greenslade M, Vernon S, et al. Emergency presentation of cancer and short-term mortality. Br J Canc 2013 Oct;109(8):2027–34.

[41] Filipe MD, van Deukeren D, Kip M, Doeksen A, Pronk A, Verheijen PM, et al. Effect of the COVID-19 pandemic on surgical breast cancer care in The Netherlands: a multicenter retrospective cohort study. Clin Breast Cancer 2020 Dec;20(6):454–61.

[42] Hatchimonji N, Hwadejire J, Kongwibulwut M, Lee JM, Kongkaewpaisan N, Velmahos G, et al. No news is good news? Three-year postdischarge mortality of octogenarian and nonagenarian patients following emergency general surgery. J Trauma Acute Care Surg 2020 Jul;89(1):230–7.

[43] Hatchimonji N, Swediman RA, Kaufman EJ, Scantling D, Passman JE, Yang W, et al. Multiple complications in emergency surgery. Am Surg 2020 Jul;86(7):787–95.

[44] National Institute for Health and Environment. Impact of the first wave of COVID-19 on regular healthcare and health : assessment of the extent of the problem and first estimation of the health effects [Internet]. 2020. Available from: https://www.rijksoverheid.nl/actueel/nieuws/2020/03/12/nieuwe-maatregelen-tegen-verspreiding-coronavirus-in-nederland.

[45] Integral cancer center in The Netherlands. Number of new cancer patients decreased in 2020 due to corona crisis, first decrease in thirty years [Internet]. Available from: https://www.kncv.nl/verslag-maatregelen-ontbreken-kankerpatiënten-in-2020-gedaald-door.

[46] Dutch Broadcasting Foundation. Non-urgent care will be scaled down, consultation hours and urgent care will continue as usual [Internet] [cited 2021 Apr 12]. Available from: https://nos.nl/article/2361625-net-urgent-zorg-wordt-afgeschaald-spreukeren-en-urgent-zorg-gaan-gewoon-door.html.