Cholecystectomies in the COVID-19 Pandemic During and After the First Lockdown in Germany: an Analysis of 8561 Patients

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Abstract

Purpose The COVID-19 pandemic has led to global changes in healthcare systems. The purpose of this study was to investigate the effects on surgical care of patients.

Methods We performed a retrospective analysis of routine data from the largest hospital group in Germany (68 acute hospitals). Included were inpatients who underwent cholecystectomy between March 19, 2020 (beginning of the first lockdown in Germany) and September 22, 2020. These patients were compared with those treated in the same interval in 2019.

Results In the 2020 study period, 4035 patients met the inclusion criteria (2019: 4526 patients). During the first lockdown, there was a significant reduction in the number of cholecystectomies performed (51.1% decrease). More patients with a higher risk profile underwent urgent operations, which were accompanied by a significant increase in conversion from laparoscopic to open cholecystectomy. The patients were treated as inpatients for a longer duration than 2019, and the mortality rate increased significantly to 1.3% (2019: 0.1%). The complication rate also showed a significant increase. After the end of the first lockdown, daily admission rates normalized very quickly. However, it was not possible to fully address the backlog of operations.

Conclusion There is still a "patient stagnation" 6 months after the first German lockdown. Extrapolated to the national level, this corresponds to almost 21,000 fewer cholecystectomies performed in Germany in 2020. It remains to be seen whether surgical rates will return to pre-pandemic levels and whether complications will arise in the future due to the lack of operations.

Keywords COVID19 · Cholecystectomie · Lockdown

Introduction

The COVID-19 pandemic has led to a worldwide change in life in 2020 and, consequently, to relevant changes in the healthcare system. At the beginning of the COVID-19 pandemic, hospital admissions fell sharply worldwide.[1–3] This decrease in admissions has been examined primarily for cardiovascular and emergency diagnoses. More detailed considerations of surgical diseases are missing, as is the

development of procedures after the first European peak phase of the pandemic in spring 2020. Therefore, the aim of this study was to use a nationwide dataset to investigate whether the pandemic led to changes in the admission process, operative technique, and patient outcomes. This was examined using the example of cholecystectomy, as this procedure is carried out frequently and as both elective and urgent operation. In particular, the number of operations, ratio of elective to urgent operations, operative procedure, and results were compared to those in the same time window before the pandemic.

Materials and Methods

Routine data from 68 Helios hospitals in Germany were retrospectively analyzed. We included inpatients diagnosed with cholecystolithiasis (K80) according to the International Statistical Classification of Diseases and Related Health

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Problems [ICD-10-GM (German Modification)]. Additionally, we documented procedural codes for cholecystectomy as an independent intervention (5–511.0, 5–511.1, 5–511.2) according to the German procedure classification ("Operations and procedure key"). All patients treated between March 19, 2020, and September 22, 2020, were considered. These patients were compared with those treated during the same interval in the year prior to the lockdown (March 20, 2019, to September 23, 2019). The study period was defined using locally estimated scatterplot smoothing (LOESS) with a degree of smoothing of $\alpha = 0.25$. Gray areas represent 95% confidence intervals. Based on the 95% confidence intervals of the LOESS curves (Fig. 1) of the daily 2019 and 2020 admission data, we defined a deficit period starting on the first day with nonoverlapping intervals and ending on the last day with nonoverlapping intervals. The first day at which the intervals overlapped again was the start of the resumption period.

The cases were evaluated with regard to the following parameters:

– Number of operations
– Ratio of elective to urgent operations
– Access route (i.e., laparoscopy or laparotomy or conversion)
– Morbidity (i.e., reoperation rate, wound infection, pneumonia, injury of common bile duct, hemorrhage)
– In-hospital mortality
– Need for postoperative intensive care
– Length of hospital stay

The number of percutaneous cholecystectomies and acute cholecystectomies were also evaluated as possible consequences of delayed operations.

Patients with a proven COVID19 infection were evaluated as a separate subgroup. To increase the number of COVID19 patients, inpatients were included between February 12th, 2020 and November 30th, 2020 for this analysis.

COVID-positive patients were compared with COVID-negative patients.

For the comparison of proportions of selected treatments, outcomes, and comorbidities between the pre-lockdown and lockdown periods, we used logistic generalized linear mixed models (GLMM)s with a logit link function. We reported the proportions, odds ratios, confidence intervals, and p values. The analysis of the outcome variable length of stay was performed using linear mixed models. We reported the median, interquartile range, and p values. For linear mixed models, the computation of p values was performed via the Satterthwaite approximation. Statistical significance was defined as $p < 0.05$.

Administrative data were extracted from QlikView (Qlik-Tech, Radnor, Pennsylvania, USA). Incidence rates (IR) for admissions were calculated by dividing the number of cumulative admissions by the number of days for each time period. Incidence-rate ratios (IRR) comparing the study period to each of the control periods were calculated using Poisson regression to model the number of hospitalizations per day. We calculated the number of admissions for all combinations of (a) main diagnoses, (b) hospitals, and (c) admission dates (of the corresponding period). These frequencies were used to create the dependent variables of the statistical models.

Inferential statistics were based on generalized linear mixed models (GLMM) specifying hospitals as random factor.[4,5] We employed Poisson GLMMs with log link function for count data. Effects were estimated with the lme4 package (version 1.1–21)[6] in the R environment for statistical computing (version 3.6.1, 64-bit build).[7] In all models, we specified varying intercepts for the random factor. The IRR values for the different factor levels are based on different models comparing the periods. Additionally, we employed another model for each factor with the variables (a) period, (b) treatment contrasts for the factor levels (for comparisons with the baseline level), and (c) the corresponding interactions. We report incidence-rate ratios (calculated by exponentiation

Fig. 1 The smoothed curves are based on daily admission data. The shaded areas represent 95% confidence intervals. The dashed vertical bars represent begin of deficit and resumption period, respectively
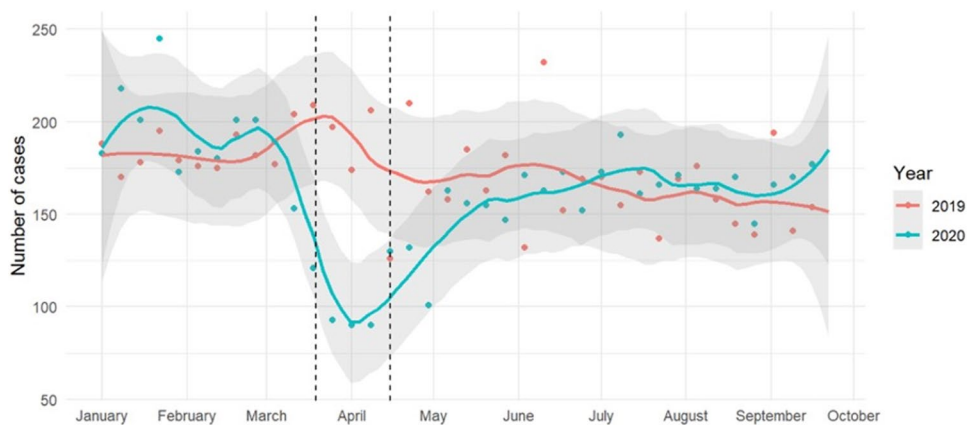
of the regression coefficients) together with 95% confidence intervals (for the comparisons of the two periods) and *p* values (for the interactions). For all tests we apply a two-tailed 5% error criterion for significance.

This study was approved by the Ethics Committee of the Medical Faculty, Leipzig University (#490/20-ek). Due to the retrospective nature of the study, informed consent was not obtained. Helios Health and Helios Hospitals have strict rules regarding data sharing because health claims data have ethical restrictions imposed due to privacy concerns. Access to anonymized data that support the findings of this study are available upon request from the Leipzig Heart Institute (www.leipzig-heart.de).

Results

In the 2020 study period, 4035 patients met the inclusion criteria, compared to 4526 patients in the 2019 period. Detailed data of the previously defined deficit phase and the resumption phase are presented in Table 1. The characteristics of the cohorts are shown in Table 2. There was no shift

Table 1 Dates and number of cases for the periods

Period	Year	Number of cases	First date	Last date
Deficit phase	2019	745	2019–03–20	2019–04–15
Deficit phase	2020	372	2020–03–19	2020–04–14
Resumption phase	2019	3782	2019–04–16	2019–09–23
Resumption phase	2020	3663	2020–04–15	2020–09–22

in age or gender distribution between the compared groups. In both, the deficit and resumption phase 2020, however, there were statistically significantly more patients with an Elixhauser comorbidity index ≥ 5 than 2019. In the deficit phase, for example, 26.6% of the patients had an index of ≥ 5 in 2020, compared to only 18.4% in 2019 ($p < 0.01$).

The number of daily admissions declined at all clinical levels (Table 3). Hospital volume was categorized according to the number of admissions per hospital during the 2019 control period. We divided the hospitals into tertiles based on the admission volume of patients meeting the inclusion criteria: low-volume hospitals had ≤ 80, intermediate hospitals had 81–108 admissions, and high-volume hospitals had > 108 admissions. In all three hospital groups, a halving of the daily number of admissions in the deficit phase was detectable. This decrease in admissions was mainly due to a reduction in elective admissions and, thus, a change in the ratio of regular to urgent admissions ($p < 0.01$). While the daily regular admissions fell from 17.0 to 5.1, the daily urgent admissions remained almost constant at 8.7 in 2020 compared to 10.5 in 2019. In the resumption phase, all hospitals reached the previous year's level of daily admissions. The ratio of urgent to regular procedures was also comparable in both the years.

In the deficit phase 2020, significantly fewer laparoscopic cholecystectomies were performed than in the comparison period 2019 (93.3% to 97.2%; $p < 0.01$; Table 4). At the same time, the number of procedures converted from laparoscopic to open cholecystectomy increased significantly (0.5% in 2019 to 2.4% in 2020; $p < 0.01$), and the number of primarily open cholecystectomies remained stable. In the resumption phase, there were no differences with regard to access routes.

Table 2 Comparison of patient cohorts

Group	Deficit period		P value	Resumption period		P value
	Proportion (*n*)			Proportion (*n*)		
	2019	2020		2019	2020	
Age						
18–59 years	54.5% (406)	52.4% (195)	0.51	54.1% (2047)	52.5% (1923)	0.16
60–69 years	21.1.% (157)	18.5% (69)	0.32	19.4% (735)	19.9% (730)	0.59
70–79 years	16.1% (120)	18.5% (69)	0.31	15.5% (586)	16.1% (591)	0.45
≥ 80 years	8.3% (62)	10.5% (39)	0.24	10.9% (414)	11.4% (419)	0.50
Sex						
Male	40.7% (303)	44.1% (164)		36.8% (1393)	39.2% (1437)	
Female	59.3% (442)	55.9% (208)	0.28	63.2% (2389)	60.8% (2226)	0.03
Elixhauser comorbidity index						
<0	37.0% (276)	34.1% (127)	0.34	35.2% (1333)	34.4% (1260)	0.44
0	37.7% (281)	33.9% (126)	0.21	35.7% (1349)	34.0% (1246)	0.13
1–4	6.8% (51)	5.4% (20)	0.34	6.6% (251)	6.6% (241)	0.92
≥ 5	18.4% (137)	26.6% (99)	<0.01	22.4% (849)	25.0% (916)	<0.01

Table 3 Comparison of hospital admissions for different groups

Group	Deficit period				Resumption period			
	Daily admissions		IRR (95% CI)	P value	Daily admissions		IRR (95% CI)	P value
	2019	2020			2019	2020		
Hospital volume[a]								
Low	4.5	2.3	0.51 (0.38–0.70)		4.0	3.7	0.92 (0.82–1.03)	
Intermediate	10.1	5.5	0.54 (0.44–0.66)	0.77	8.1	8.0	0.98 (0.91–1.06)	0.39
High	13.0	6.0	0.46 (0.38–0.56)	0.57	11.3	11.1	0.98 (0.92–1.04)	0.36
Admisson type[b]								
Regular	17.0	5.1	0.30 (0.25–0.36)		13.0	12.1	0.93 (0.88–0.99)	
Urgent	10.5	8.7	0.82 (0.70–0.98)	< 0.01	10.5	10.7	1.02 (0.95–1.09)	0.06

IRR incidence rate ratio. *P* values are based on interaction analyses

[a]Based on tertiles of average admissions in 2019; i.e., low ≤ 80, intermediate 81–108, and high volume > 108 admissions

[b]For 4 cases (0%), information of admission type is unavailable

Table 4 Comparison of outcomes and treatments in different cohorts

Variable	Deficit period				Resumption period			
	Proportion (n)		Odds ratio (95% CI)	P value	Proportion (n)		Odds ratio (95% CI)	P value
	2019	2020			2019	2020		
Treatments								
Open surgical cholecystectomy	2.3% (17)	4.3% (16)	1.92 (0.96–3.85)	0.06	2.1% (78)	1.9% (68)	0.90 (0.65–1.25)	0.54
Laparoscopic cholecystectomy	97.2% (724)	93.3% (347)	0.40 (0.22–0.73)	< 0.01	96.2% (3640)	96.9% (3548)	1.20 (0.93–1.54)	0.16
Switch laparoscopic—open surgical cholecystectomy	0.5% (4)	2.4% (9)	5.06 (5.04–5.08)	< 0.01	1.7% (64)	1.3% (47)	0.75 (0.51–1.10)	0.15
Intensive care	1.7% (13)	2.7% (10)	1.73 (0.73–4.09)	0.22	2.1% (78)	2.4% (88)	1.18 (0.87–1.60)	0.29
Outcomes								
In-hospital mortality	0.1% (1)	1.3% (5)	10.14 (1.18 − 87.08)	0.03	0.4% (16)	0.5% (20)	1.29 (0.67–2.50)	0.45
Reoperation with complication	1.2% (9)	1.3% (5)	1.20 (0.39–3.70)	0.75	1.2% (46)	1.2% (45)	1.01 (0.67–1.53)	0.96
Reoperation without complication	1.7% (13)	4.8% (18)	2.85 (1.35–6.01)	< 0.01	2.9% (111)	3.2% (119)	1.12 (0.86–1.45)	0.41
Disruption of operation wound or infection following a procedure	0.4% (3)	1.3% (5)	4.91 (0.92 − 26.14)	0.06	1.1% (40)	0.9% (33)	0.85 (0.53–1.35)	0.49
Pneumonia	1.5% (11)	2.2% (8)	1.45 (0.56–3.73)	0.44	1.0% (37)	1.0% (35)	0.98 (0.62–1.56)	0.93
Peritonitis due to bile	0.3% (2)	1.9% (7)	9.55 (1.69 − 54.08)	0.01	0.5% (19)	0.6% (21)	1.14 (0.61–2.14)	0.68
Injury of common bile duct	0.1% (1)	0.0% (0)	0.00 (0.00–Inf)	1.00	0.1% (4)	0.1% (2)	0.55 (0.10–3.07)	0.50
Hemorrhage	1.2% (9)	0.8% (3)	0.64 (0.17–2.42)	0.51	1.6% (60)	1.7% (61)	1.09 (0.76–1.57)	0.64
Endoscopic retrograde cholangiopancreatography (ERCP)	1.2% (9)	3.2% (12)	2.70 (1.11–6.58)	0.03	2.6% (98)	2.4% (88)	0.93 (0.70–1.24)	0.62

The need for intensive care was stable at all times. However, mortality in the deficit phase 2020 was significantly higher (1.3%) than in 2019 (0.1%, $p = 0.03$; Table 4). In the resumption phase, the mortality rates were comparable in both years. Table 4 provides an overview of the other recorded outcome parameters. Significant differences were only found in the deficit phase with regard to the number of necessary reoperations without use of the T81 code ($p < 0.01$), the number of coded bilious peritonitis cases ($p = 0.01$), and the need for postoperative ERCP ($p = 0.03$).

The deficit phase also showed an increase in length of stay ($p < 0.01$; Table 5). The median length of stay in both years was 3.0 days. However, the range in 2019 of 2 days (min. 2 days, max. 4 days) was significantly smaller than in 2020 (4 days; min. 2 days, max. 6 days). This change is due to a longer length of stay in the laparoscopic cholecystectomy group, while no differences were visible in the other access routes and in the resumption phase.

The number of percutaneous cholecystostomies remained constant over time. In the 2020 study period, 8 patients got a percutaneous cholecystostomies, compared to 9 patients in the 2019 period. The number of acute cholecystectomies also remained constant. In the 2020 study period, an average of 369.6 patients were operated on for acute cholecystitis each month, compared to 372.3 patients in the 2019 period.

Seventeen patients with a COVID-19 infection were included in the analysis. Further, 47.1% of the COVID-19-positive patients who underwent cholecystectomy received intensive medical care, whereas only 14.1% of COVID-19-negative patients who underwent the same surgery ($p < 0.01$, Table 6). Approximately 17.6% of COVID-19-positive patients with cholecystectomy received invasive ventilation, whereas only 2.7% of COVID-19-negative patients ($p < 0.01$). The length of hospital stay was significantly longer with an average of 18.8 ± 23.7 days in COVID-19-positive patients than that in COVID-19-negative patients (5.4 ± 6.9 days; $p < 0.01$). The mortality rates of 1.4% in the COVID-19-positive and 0.0% in the COVID-19-negative patients who underwent cholecystectomy were comparable ($p = 0.99$).

Table 5 Comparison of length of stay (nights in hospital), median [min, max]

	Deficit period			Resumption period		
	2019	2020	P value	2019	2020	P value
Total						
	3.0 [2, 4]	3.0 [2, 6]	< 0.01	3.0 [2, 5]	3.0 [2, 5]	0.39
Open surgical cholecystectomy						
	10.0 [7, 16]	8.5 [6, 12]	0.85	11.0 [6, 17]	11.0 [7, 19]	0.96
Laparoscopic cholecystectomy						
	3.0 [2, 4]	3.0 [2, 5]	< 0.01	3.0 [2, 5]	3.0 [2, 5]	0.70
Switch laparascopic—open surgical						
	7.0 [6, 8]	13.0 [6, 14]	0.18	10.5 [6, 16]	9.0 [5, 15]	0.42

Discussion

The results of this study reveal four important points. First, the COVID-19 pandemic and the postponement of all elective operations ordered by the German government have led to a significant reduction in the number of cholecystectomies performed in the deficit phase in March and April 2020 (51.1% decrease or 373 fewer patients). According to the Federal Statistical Office, 203,563 cholecystectomies were performed in Germany in 2019.[8] This corresponds to 16,964 operations per month. An extrapolation of our results for Germany indicates that a gap of 8600 cholecystectomies has arisen in the first lockdown alone. Compared to the same period in the previous year, more patients with a higher risk profile underwent urgent operation, which was accompanied by a significant increase in conversion to

Table 6 Comparison of a) outcomes and b) length of stay of patients with operations

A

Outcome	Covid− Proportion (n)	Covid+ Proportion (n)	Odds ratio (95% CI)	P value
Gallbladder and bile duct—surgery				
Intensive Care	14.1% (1099)	47.1% (8)	5.29 (1.97–14.26)	< 0.01
Mechanical Ventilation	2.7% (213)	17.6% (3)	6.85 (1.88–24.97)	< 0.01
In-hospital mortality	1.4% (107)	0.0% (0)		0.99

B

Cohort	Mean (SD)	Median (IQR)	Ratio (95% CI)	P value
Gallbladder and bile duct—surgery				
Covid−	5.4 ± 6.9	3.0 [2, 6]		
Covid+	18.8 ± 23.7	7.0 [3, 24]	3.50 (3.13–3.90)	< 0.01

open cholecystectomy. The patients were treated as inpatients for a longer duration, and the mortality rate increased significantly to 1.3% during this period (2019, 0.1%). The complication rate, especially with regard to reoperations and postoperative ERCP, also showed a significant increase during this period. However, there was no increase in acute cholecystitis. These changes can therefore be explained by the fact that the so-called diluent cases (elective cholecystectomies in patients with a low-risk profile) have been postponed. The increase in converted cholecystectomies and the increased complication and mortality rates as an expression of the advanced stages of the disease can, as has already been done in the example of acute coronary syndrome,[9] probably be explained by the fact that patients only went to the doctor or the emergency room after a delay due to fear of the pandemic. Similarly, it is also conceivable that the consulted doctors initially attempted non-operative therapy to avoid hospitalization. However, this interpretation cannot be substantiated by the available data.

Second, daily admissions quickly returned to pre-lockdown levels. From the end of April to the end of September 2020, figures comparable to the same period in the previous year were achieved despite the ongoing pandemic. After a slow increase in the number of operations, an excessive number of cholecystectomies were performed in July, August, and September. Outcome parameters such as mortality, length of stay, and complication rate also returned to the previous year's level.

Third, a COVID-19 infection was associated with a significantly higher proportion of intensive care and invasive ventilation. In addition, the length of hospital stay was significantly longer. However, hospital mortality did not increase in this group.

Finally, it was not possible to fully compensate for the backlog of operations in the resumption phase. Among the 68 hospitals examined here, there were 492 fewer surgical procedures over the entire observation period than during the previous year. This corresponds to a gap of 20.3%. Therefore, there is still a "patient stagnation" 6 months after the first lockdown. Extrapolated to the national level, this corresponds to almost 21,000 fewer cholecystectomies performed in 2020.

Conclusion

It remains unclear whether the rate of cholecystectomies will completely return to the pre-pandemic level or if the pandemic has resulted in changes in patient behavior or caused more critical consequences in the future. This study is only a snapshot in the context of the very dynamic COVID-19 pandemic. Long-term consequences cannot be derived. Future studies should investigate whether a possible long-term decrease in the frequency of operations in cholecystolithiasis patients leads to increased recurrent bile colic or causes other complications.

Declarations

Conflict of Interest The authors declare no conflict of interest.

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