Effect of the SARS-CoV-2 pandemic on mortality related to high-risk emergency and major elective surgery

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These data show large reductions in both elective and emergency activity that are concerning for unmeasured morbidity and mortality within the community. The risk of mortality following high-risk EGS and major elective surgery during the first wave of the pandemic did not differ when compared with date-matched patient cohorts from 2019. The prevalence of concomitant SARS-CoV-2 infection in this surgical population is low.

Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic has had a significant impact on the provision of surgery globally. Early reports 1–3 of significant morbidity and mortality in surgical patients with SARS-CoV-2 has led to treatment delays and secondary harm in some cases. There is an urgent need to establish the true impact of SARS-CoV-2 on the risks associated with major elective and emergency surgery in comparison with 'normal' practice.

The aim of this study was to compare the case mix and mortality of major elective and high-risk emergency surgery in England during the pandemic against the preceding year.

Methods

The Hospital Episode Statistics (HES) Admitted Patient Care database was interrogated to identify admitted care episodes for adult patients with diagnostic codes relating to high-risk emergency general surgical (EGS) conditions (defined by an associated crude mortality rate greater than 5 per cent 4–11 including gastrointestinal ulcer, hernia, bowel ischaemia, bowel obstruction, diverticulitis, peritonitis, liver and biliary conditions, and miscellaneous; Table S1 and Appendix S1), and major elective surgery across several surgical subspecialties (colectomy, any rectal resection (proctectomy) 6, cystectomy (bladder) 7, oesophagectomy, gastrectomy, pancreatectomy, coronary artery bypass graft 8, open abdominal aortic aneurysm (AAA) repair 9, endovascular aortic aneurysm repair (EVAR) 10, and carotid endarterectomy 11, Table S2 and Appendix S1 11, 12).

Full details of the study methodology, including statistical analysis, are described in Appendix S1.

The cohorts were matched by calendar date, diagnostic codes, procedural codes and admission method. Patients with invalid data recorded for age or sex were excluded. The start date was 3 February 2020 before the national lockdown. The end date was 2 August 2020, 12 weeks after the national lockdown. A date-matched cohort from 2019 was compared. Case mix and mortality in 2020 were compared with values in 2019.

Concurrent SARS-CoV-2 was identified, in any secondary diagnostic field within the same episode, by the emergency ICD-10 codes: U071 (SARS-CoV-2 confirmed by laboratory testing) or U072 (clinical or epidemiological SARS-CoV-2 where laboratory confirmation was inconclusive or not available).

Thirty-day mortality was defined as a death occurring in hospital within 30 days of admission.

Logistic regression analysis was performed to adjust for potential confounders of mortality. Adjusted odds ratios (ORs) for SARS-CoV-2 infection and year of admission were calculated.

Results

High-risk emergency general surgical admissions

Between February and August 2020, 49 889 patients were admitted, representing a 15.0 per cent reduction in high-risk EGS admissions compared with 2019 (Fig. 1 and Table 1). The rate of laparoscopy was proportionally less in 2020 (3.0 per cent versus 3.6 per cent in 2019; P < 0.0001). The 30-day mortality rate was unchanged between 2020 and 2019 (8.8 versus 8.5 per cent respectively; P = 0.068). In the 2020 cohort, 2.1 per cent of patients (1027 of 49 889) were diagnosed with SARS-CoV-2 infection. The 30-day mortality rate for high-risk EGS admissions was 8.8 per cent overall, compared with 16.7 per cent in patients with concurrent SARS-CoV-2 infection (Table 3).

Logistic regression analysis was performed to investigate the impact of concurrent SARS-CoV-2 on 30-day mortality. Adjusting for potential confounders of age, sex, ethnicity, Carstairs quintile,
Lay summary

The coronavirus pandemic has had a significant impact on the provision of surgery globally. This research looked at how the pandemic has affected rates of surgery in England using administrative data. Specifically, it examined the characteristics of patients who were admitted and mortality when patients contracted coronavirus. It found that the overall risk of death did not change in 2020 compared with the same time period in 2019. It did find that the risk of death increased with coronavirus infection. The authors recommend preventive measures to ensure patient safety when restarting elective surgery during the pandemic.

![Admissions for emergency surgical diagnosis by week from February to June 2020](image)

Fig. 1 Admissions for emergency surgical diagnosis by week from February to June 2020
National lockdown was announced by the UK government on 23 March 2020 (week 8). GI, gastrointestinal.

Charlson score, surgical diagnosis, operative treatment and year of admission, the adjusted OR for death at 30 days with SARS-CoV-2 infection was 2.03 (95 per cent c.i. 1.70 to 2.43; P < 0.001) (Table 3). Year of admission was not a significant confounder.

Major elective surgery

Some 14 721 patients were admitted in 2020, a reduction of 37.6 per cent from 2019 (Fig. 2 and Table 2). The volume of carotid endarterectomy decreased by 42.5 per cent, open AAA repair by 51.7 per cent, EVAR by 51.6 per cent, gastrectomy by 62.2 per
cent, colectomy by 28.3 per cent, and rectal resection by 27.7 per cent. In-hospital 30-day elective mortality did not differ between 2020 and 2019 (1.0 per cent versus 1.0 per cent respectively; \(P = 0.740\)). Concurrent SARS-CoV-2 infection was diagnosed in 0.8 per cent (116 of 14 721), with an associated 30-day mortality rate of 15.5 per cent (Table 3). Deaths in patients with concurrent SARS-CoV-2 represented 0.1 per cent of all major elective operations. Adjusting for the potential confounders of age, sex, ethnicity, Carstairs quintile, Charlson score, and year of admission, the adjusted OR for death at 30 days in patients with concurrent SARS-CoV-2 infection was 18.23 (95 per cent c.i. 10.44 to 32.63; \(P < 0.001\)) (Table 3). Year of admission was not a significant confounder. SARS-CoV-2 cases amongst high-risk EGS admissions and major elective surgery by week before and during the pandemic are shown in Fig. S1. Additional analyses are presented in full in Appendix S2.

**Discussion**

This study has suggested that mortality associated with high-risk EGS admissions and major elective surgery undertaken during the first wave of the pandemic was not increased. Although the number of patients with concurrent SARS-CoV-2 infection was extremely low, mortality was significantly increased in this group, justifying preventive measures. In SARS-CoV-2-positive patients, or patients with significant co-morbidity, the findings of this study support consideration of non-surgical management strategies, where safe.

The mortality rate associated with SARS-CoV-2 was significantly less than reported previously, although the populations are not directly comparable\(^1\)–\(^3\),\(^13\). This is possibly due to a lack of inclusion bias in HES data. Second, these data did not aggregate outcomes from different healthcare systems, at different stages of their pandemic curve. Most of the reported literature has originated from North America and Europe, but some are from healthcare systems without equivalent resources to mitigate risk. Finally, this study encompasses a longer period, not relying solely on data from early in the pandemic, when there was less testing and under-representation of patients with minimally symptomatic SARS-CoV-2 infection. The present experience is, however, congruent with smaller, statistically matched, cohort studies from the literature\(^14\).

It is unclear why SARS-CoV-2 infection results in proportionally greater mortality in elective compared with emergency surgery, although this may be multifactorial.

This study used administrative healthcare data with quantified accuracy\(^15\),\(^16\). These data must be interpreted with caution given the novelty of the SARS-CoV-2 ICD-10 code\(^17\). It is feasible that the code was not employed consistently during the pandemic (used for major pulmonary complications not due to SARS-CoV-2), as this study found that one-quarter of SARS-CoV-2 diagnoses were not based on laboratory

**Table 1 Characteristics of 108 603 patients admitted with a high-risk emergency general surgical diagnosis in 2019 and 2020**

|                          | 2019 (n=58 714) | 2020 (n=49 889) | \(P^*\) |
|--------------------------|-----------------|-----------------|---------|
| Mean age (years)         | 67.8            | 68.0            | 0.117\(^1\) |
| Sex ratio (M : F)        | 27 041 : 31 673 | 23 628 : 26 261 | <0.001  |
| Charlson score           |                 |                 | 0.090   |
| \(\leq 2\)               | 23 748 (40.4)   | 19 926 (39.9)   |         |
| \(> 2\)                  | 34 966 (59.6)   | 29 963 (60.1)   |         |
| Ethnicity                |                 |                 | <0.001  |
| White                    | 49 693 (84.6)   | 41 953 (84.1)   |         |
| Mixed                    | 278 (0.5)       | 240 (0.5)       |         |
| Asian                    | 1949 (3.3)      | 1516 (3.0)      |         |
| Black                    | 1108 (1.9)      | 844 (1.7)       |         |
| Chinese or other         | 844 (1.4)       | 829 (1.7)       |         |
| Not known/not stated     | 4842 (8.2)      | 4507 (9.0)      |         |
| Deprivation quintile     |                 |                 | <0.001  |
| 1 (least deprived)       | 11 842 (20.2)   | 10 139 (20.3)   |         |
| 2                        | 12 346 (21.0)   | 10 820 (21.7)   |         |
| 3                        | 12 033 (20.5)   | 10 173 (20.4)   |         |
| 4                        | 11 099 (18.9)   | 9514 (19.1)     |         |
| 5 (most deprived)        | 10 931 (18.6)   | 8963 (18.0)     |         |
| 6 (not assigned)         | 463 (0.8)       | 280 (0.6)       |         |
| Emergency surgical diagnosis |             |                 | <0.001  |
| Bowel ischaemia          | 4196 (7.1)      | 3507 (7.0)      |         |
| Bowel obstruction         | 21 219 (36.1)   | 18 612 (37.3)   |         |
| Diverticulitis           | 5510 (9.4)      | 4586 (9.2)      |         |
| Gastrointestinal ulcer   | 1677 (2.9)      | 1341 (2.7)      |         |
| Hernia                   | 3436 (5.9)      | 2854 (5.7)      |         |
| Liver and biliary        | 13 728 (23.4)   | 11 839 (23.7)   |         |
| Peritonitis              | 4244 (7.2)      | 3130 (6.3)      |         |
| Miscellaneous            | 4704 (8.0)      | 4020 (8.1)      |         |
| Treatment                |                 |                 | <0.001  |
| Non-operative            | 24 222 (41.3)   | 20 000 (40.1)   |         |
| Operative                | 34 492 (58.7)   | 29 889 (59.9)   |         |
| Surgical approach        |                 |                 | <0.001  |
| Open                     | 33 250 of 34 492 (96.4) | 28,988 of 29 889 (97.0) |         |
| Laparoscopic             | 1242 of 34 492 (3.6) | 901 of 29 889 (3.0) |         |
| Status at 30 days        |                 |                 | 0.068   |
| Alive                    | 53 725 (91.5)   | 45 494 (91.2)   |         |
| Dead                     | 4989 (8.5)      | 4395 (8.8)      |         |

Values in parentheses are percentages. \(^*\)\(\chi^2\) test, except independent-samples \(t\) test.
confirmation. HES data do not include BMI, which influences prognosis.18 This study was unable to differentiate whether patients acquired SARS-CoV-2 before or during hospital inpatient admission. Patients may have contracted SARS-CoV-2 in the community after discharge and therefore were not captured by this methodology, potentially leading to under-reporting. It was also impossible to differentiate between symptomatic and asymptomatic patients, along with the possible impact of a gradual increase in routine preoperative swabbing.19 The primary outcome measure was mortality. Morbidity associated with SARS-CoV-2 was not investigated. Several strategies

| Characteristic                      | 2019 (n=23 606) | 2020 (n=14 721) | P*    |
|------------------------------------|-----------------|-----------------|-------|
| Mean age (years)                   | 65.1            | 65.4            | 0.060†|
| Sex ratio (M : F)                  | 14 631 : 8975   | 9005 : 5716     | 0.113 |
| Charlson score                     |                 |                 | 0.181 |
| ≤2                                 | 10 542 (44.7)   | 6677 (45.4)     |       |
| >2                                 | 13 064 (55.3)   | 8044 (54.6)     |       |
| Ethnicity                          |                 |                 | <0.001|
| White                              | 18 286 (77.5)   | 11 006 (74.8)   |       |
| Mixed                              | 89 (0.4)        | 46 (0.3)        |       |
| Asian                              | 728 (3.1)       | 336 (2.3)       |       |
| Black                              | 322 (1.4)       | 157 (1.1)       |       |
| Chinese or other                   | 328 (1.4)       | 216 (1.5)       |       |
| Not known/not stated               | 3853 (16.3)     | 2960 (20.1)     |       |
| Deprivation quintile               |                 |                 |       |
| 1 (least deprived)                | 5568 (23.6)     | 3605 (24.5)     |       |
| 2                                  | 5633 (23.9)     | 3445 (23.4)     |       |
| 3                                  | 4701 (19.9)     | 3052 (20.7)     |       |
| 4                                  | 4006 (17.0)     | 2515 (17.1)     |       |
| 5 (most deprived)                 | 3519 (14.9)     | 2006 (13.6)     |       |
| 6 (unassigned)                    | 179 (0.8)       | 98 (0.7)        |       |
| Operation                          |                 |                 | <0.001|
| Colectomy                          | 6636 (28.1)     | 4756 (32.3)     |       |
| Rectal resection                   | 5374 (22.8)     | 3883 (26.4)     |       |
| Gastrectomy                        | 1926 (8.2)      | 728 (4.9)       |       |
| Oesophagectomy                     | 796 (3.4)       | 533 (3.6)       |       |
| Pancreatectomy                     | 886 (3.8)       | 623 (4.2)       |       |
| Cystectomy                         | 880 (3.7)       | 621 (4.2)       |       |
| CABG                               | 4222 (17.9)     | 2066 (14.0)     |       |
| Carotid endarterectomy             | 1265 (5.4)      | 727 (4.9)       |       |
| Open AAA repair                    | 532 (2.3)       | 257 (1.7)       |       |
| EVAR                               | 1089 (4.6)      | 527 (3.6)       |       |
| Status at 30 days                  |                 |                 | 0.740 |
| Alive                              | 23 367 (99.0)   | 14 577 (99.0)   |       |
| Dead                               | 239 (1.0)       | 144 (1.0)       |       |

Values in parentheses are percentages. CABG, coronary artery bypass graft; AAA, abdominal aortic aneurysm; EVAR, endovascular repair. \( \chi^2 \) test, except independent-samples \( t \) test.

| Status at 30 days*                  | Total | Adjusted odds ratio† | P     |
|-------------------------------------|-------|----------------------|-------|
|                                    | Alive | Dead                 |       |
| High-risk emergency surgery         |       |                      |       |
| Year                                |       |                      |       |
| 2019                                | 53 725 (91.5) | 4989 (8.5) | 58 714 | 1.00 (reference) |
| 2020                                | 45 494 (91.2) | 4395 (8.8) | 49 889 | 1.03 (0.99, 1.08) | 0.193 |
| SARS-CoV-2                          |       |                      |       |
| Negative                            | 44 639 (91.4) | 4223 (8.6) | 48 862 | 1.00 (reference) |
| Positive                            | 855 (83.3) | 172 (16.7) | 1027 | 2.03 (1.70, 2.43) | <0.001 |
| Total                               | 45 494 | 4395 | 49 889 |       |
| Major elective surgery              |       |                      |       |
| Year                                |       |                      |       |
| 2019                                | 23 367 (99.0) | 239 (1.0) | 23 606 | 1.00 (reference) |
| 2020                                | 14 577 (99.0) | 144 (1.0) | 14 721 | 0.87 (0.70, 1.09) | 0.233 |
| SARS-CoV-2                          |       |                      |       |
| Negative                            | 14 479 (99.1) | 126 (0.9) | 14 605 | 1.00 (reference) |
| Positive                            | 98 (84.5) | 18 (15.5) | 116 | 18.23 (10.44, 31.83) | <0.001 |
| Total                               | 14 577 | 144 | 14 721 |       |

Values in parentheses are *percentages and †95 per cent confidence intervals. SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.
were advocated during the first wave of the pandemic to mitigate surgical risk, including non-operative strategies where appropriate, avoidance of laparoscopy, and minimizing anastomosis in favour of defunctioning stomas in colorectal surgery. The extent to which these strategies were adopted, and their efficacy, was not investigated. Although the relationship between geographical region and mortality was beyond the scope of this study, it will be the focus of future research.

There was a marked volume reduction for high-risk emergency general and major elective surgery. No evidence was found to support a change in patient demographics. It is likely that some high-risk surgery was deferred either by patients or by the health service. It is unknown to what extent harm has occurred within the latter patient groups.

There were large reductions in both elective and EGS activity that are concerning for unmeasured morbidity and mortality. Concurrent SARS-CoV-2 infection in patients undergoing surgery significantly increased the mortality risk. However, infection rates in surgical pathways during the first wave of the pandemic in England were low. Continued safe operating throughout the pandemic will be important to mitigate indirect harm to patients incurred through treatment delays, and work must continue to develop safe pathways for this to happen. The overall mortality risk associated with high-risk emergency general and major elective surgery in the first wave of the pandemic did not differ from that in historical controls.

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Supplementary material
Supplementary material is available at BJ Surgery online.

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