Major adverse cardiovascular events and all-cause mortality after emergency general surgery among kidney failure patients

Benjamin Anderson¹, Xiaoxu Zou², Felicity Evison², Suzy Gallier²,³, Nicholas Inston¹ and Adnan Sharif⁴,⁵* ¹

Introduction

Excess mortality is observed in the UK after emergency general surgery (EGS), with risk for death more than 10-fold higher compared with elective surgery (5.4 per cent versus 0.44 per cent respectively)¹. EGS also accounts for 11 per cent of hospital admissions in the USA but approximately 50 per cent of deaths, with many risk factors using various pre- or postoperative variables identifying high-risk classification⁴. One significant risk factor is chronic kidney disease, with greater postoperative morbidity and mortality attributed to people living with kidney failure on renal replacement therapy⁵,⁶. This may relate to risk factors for increased peri- and postoperative mortality (for example anaemia, bleeding risk, cardiovascular disease, and/or fluid overload) that are common for people living with kidney failure⁷.

To date, no study has specifically explored the incidence and mortality after EGS for patients with kidney failure. The most frequent form of renal replacement therapy for people living with kidney failure is kidney transplantation, which is associated with a survival advantage compared with dialysis⁸,⁹, but incidence and survival outcomes after EGS stratified by form of renal replacement therapy are not available in comparison with the general population. Most surgical deaths occur within days of emergency or major surgery, with pneumonia reported as the commonest cause of death¹⁰. Patients with kidney failure have immunological dysfunction, either due to kidney failure itself¹¹ or necessary immunosuppression to prevent allograft rejection¹², which could increase the risk for post-EGS infection; however, the increased and pathophysiologically unique burden of cardiovascular disease in patients with kidney failure¹³ means that the aetiology of mortality after EGS may differ for patients with kidney failure and between different renal replacement therapies.
The hypothesis was that cardiovascular events and all-cause mortality risk will be higher for patients with kidney failure after EGS, and causality skewed in comparison with the general population, and this was investigated in a population-cohort study utilizing national hospital administration data.

Methods

Study population

A retrospective, population-cohort study of every person who had emergency surgery performed in England between 1 April 2004 and 31 March 2019 (follow-up to 22 December 2020) was undertaken. Exclusion criteria included the following: age under 18 years and residence outside of England. In the situation of repeat EGS procedures over the study interval, only the initial EGS procedure was selected for statistical analysis.

Data sources

Data were obtained from Hospital Episode Statistics, an administrative data warehouse containing admissions to all National Health Service hospitals in England. Data were extracted utilizing codes on procedural classifications (OPCS-4) and medical classifications (ICD-10). Mortality data were obtained from national civil registration death data held by NHS Digital, which collects information on all registered deaths in England.

Extraction of study variables

Patients with kidney failure were identified as follows. Patients with kidney failure who were receiving dialysis at the time of EGS procedure were identified by either an ICD-10 code of Y84.1 or Z99.2 or a procedure code of X40.1 or X40.3 in the 3 months preceding the EGS procedure. Kidney transplant recipients were identified by an OPCS-4 code (M01.2–M01.9) or an ICD-10 code of Z94.0 (transplanted kidney status) and no subsequent ICD-10 code of T86.1 (kidney transplant failure and rejection) preceding the EGS procedure.

The following patient demographics were also extracted for the study cohort: age, sex, ethnicity, socioeconomic deprivation (index of multiple deprivation (IMD)), previous diabetes, previous ischaemic heart disease, recent cardiovascular hospital admissions within 1 year of EGS (myocardial infarct, stroke, unstable angina, heart failure, coronary revascularization, and major adverse cardiovascular events (MACEs)) and modified Charlson co-morbidity score (with renal disease and diabetes excluded).

Definition of emergency surgery

Any secondary care episode for emergency surgery (defined as partial colectomy, small bowel resection, cholecystectomy, appendicectomy, lysis of peritoneal adhesions, surgery for peptic ulcer, and laparotomy) in England. Associated procedure and diagnosis codes, with corresponding exclusions, are shown in Table S1. Surgeries with a code that could have been associated with laparotomy and another category were assigned to the other category for descriptive and univariable analyses and to laparotomy for the extended laparotomy analyses.

Definition of major adverse cardiovascular event

MACEs were defined as any of the following (with associated ICD-10 unless otherwise stated): any hospitalization with a diagnosis of myocardial infarction in any territory (I21–I22); any hospitalization with a diagnosis of stroke in any territory (I60–I64); any hospitalization with a primary diagnosis of unstable angina requiring an overnight stay (I200); any hospitalization with a primary diagnosis of heart failure (I50) requiring an overnight stay; any coronary revascularization procedure undertaken (OPCS-4 code K75); and any cardiovascular death (I21, I24–I26, I42, I44, I48–I50, I63, I64, I67, and I69).

Statistical analysis

The primary objectives of this study were to determine the incidence of MACEs and all-cause mortality after EGS procedures in England stratified by kidney failure status. Due to differential prevalence of high-risk EGS procedures among patients with kidney failure versus low-risk EGS procedures for the general population, the focus was on MACE outcomes after emergency laparotomy to minimize heterogeneity across EGS procedures.

Differences between groups were compared using chi-squared tests for categorical variables and Kruskal–Wallis tests for all continuous variables. Survival analyses were performed by Kaplan–Meier curve estimates, using Stata 15 (StataCorp, College Station, TX, USA). The proportional hazard assumption was checked and satisfied using Schoenfeld residuals. A competing risk model based on Fine and Gray’s proportional sub-hazard model was performed with non-MACE-related deaths designated as the competing risk and cause-specific cumulative incidence plots generated. Multivariable logistic regression was performed to understand what factors were associated with a MACE at 3, 6, and 12 months after surgery. To account for the expected significant demographic differences between the cohorts, a sensitivity analysis was planned whereby the data were matched using the propensity-score methodology with nearest neighbour matching and a calliper of 0.05 and a 1:1 matching ratio, and the balance statistics assessed following the generation of the matched data set. The following variables were included in the logistic model used to generate the propensity score, and the multivariable logistic regression analysis: Charlson score, sex, age group, pre-existing ischaemic heart disease and diabetes diagnosis, IMD quintile, and ethnic group, and were chosen for use in the model before analysis. Patients with missing age or sex were excluded from the analysis, as these variables were historically used to generate the patient ID. A P value less than 0.05 was considered statistically significant.

Ethical approval

This study did not require ethical approval due to the pseudo-anonymized nature of the data retrieved; data were linked by the Department of Health Informatics utilizing a special Hospital Episode Statistics (HES) ID code and no patient-identifiable data were obtained. Small numbers were suppressed in agreement with data usage. The study was approved by the institutional review board and registered as an audit with University Hospitals Birmingham NHS Trust (audit identifier: CARMS-15615). This cohort study was reported in accordance with the STROBE statement.

Results

Study cohort

In total, 691,064 emergency surgical procedures were undertaken, with 0.16 per cent (n = 1097) performed on kidney transplant recipients and 0.23 per cent (n = 1567) on dialysis patients. The follow-up interval was 5106950 patient-years.
Table 1 gives a breakdown of EGS procedures stratified by kidney failure status and shows wide variation in type of procedures undertaken. The most frequent procedure in the general population was appendicectomy (49 per cent of procedures, n = 336648), with laparotomy the most frequent in kidney transplant recipients (46 per cent of procedures, n = 507) and dialysis patients (45 per cent of procedures, n = 704).

Length of stay and emergency re-admission rates

Table 2 gives a breakdown of post-EGS procedure length of stay and emergency re-admission rates within 90 days. Length of stay was significantly different for most EGS procedures, although not consistently longer for patients with kidney failure compared with the general population; however, risk for emergency re-admission within 90 days was significantly higher for kidney failure patients for every EGS procedure compared with the general population. For every procedure, patients with kidney failure on dialysis had a higher risk for emergency re-admission than kidney transplant recipients.

Mortality (unadjusted analyses)

Crude 30-day and 1-year mortality rates were explored for the cohort and are shown in Table 3, with cumulative mortality rates shown in Fig. 1. Analysing the study cohorts, 30-day and 1-year mortality rates were highest in dialysis patients followed by transplant recipients, with the lowest mortality rates observed in the general population. For the entire cohort, mortality was highest after laparotomy (13.4 per cent and 26.7 per cent for 30-day and 1-year mortality respectively), and lowest after appendicectomy (0.2 per cent and 0.4 per cent for 30-day and 1-year mortality respectively). Dialysis patients were the most likely cohort to experience mortality within 30 days of EGS (65.8 per cent of all deaths within 30 days of EGS) compared with other time points beyond 30 days after surgery. Long-term mortality rates after EGS differed across the study cohort. Compared with the general population (144935 deaths; 21 per cent mortality rate), deaths were more frequent among transplant patients (546 deaths, mortality rate 50 per cent) and dialysis patients (1183 deaths, mortality rate 75 per cent).

Cause of death after EGS evolved over time (Table S2). Exploring 30-day mortality after surgery, a significant difference in cause of death was only observed after small bowel resection. For dialysis patients, 55.4 per cent of deaths were due to an underlying cause of death was more likely to be observed in dialysis patients compared with either transplant recipients or the general population.

MACE outcomes (adjusted analyses)

In view of the heterogenous nature of EGS, the focus was on MACE after emergency laparotomy as the most frequent EGS among patients with kidney failure compared with the general population.

Logistic regression was undertaken to compare the kidney failure population with the general population for MACEs at various time points within the first postoperative year. Compared with the general population, both kidney failure cohorts had higher risk for experiencing MACEs in the postoperative interval after emergency laparotomy, within 3 months (dialysis; OR 2.44 (95 per cent c.i. 2.08 to 2.87), P < 0.001 and transplant; OR 2.05 (95 per cent c.i. 1.57 to 2.68), P < 0.001), within 6 months (dialysis; OR 2.35 (95 per cent c.i. 2.01 to 2.74), P < 0.001 and transplant; OR 2.09 (1.63 to 2.67), P < 0.001) and within 1 year (dialysis; OR 2.59 (95 per cent c.i. 2.06 to 2.77), P < 0.001 and transplant; OR 2.21 (95 per cent c.i. 1.76 to 2.77), P < 0.001). At each time point, dialysis patients had a marginally higher risk for experiencing MACEs compared with kidney transplant patients.

Due to significant differences in baseline demographics and burden of medical co-morbidities (Table S3), MACE probability after EGS was explored after adjustment for baseline differences. This was performed with a propensity-score-matched analysis, comparing risk for MACEs after emergency laparotomy for kidney failure cohorts with the general population with non-MACE-related death as a competing risk. A propensity-score-matched cohort was created, with 780 kidney transplant recipients matched to 788 general population individuals and 1199 dialysis patients matched to 1204 general population individuals based on important demographics as highlighted in the methods. An increased risk for MACEs was observed among dialysis patients after emergency laparotomy (HR 2.10 (95 per cent c.i. 1.82 to 2.43), P < 0.001) but not among kidney transplant recipients (HR 1.17 (95 per cent c.i. 0.97 to 1.41), P = 0.096) as shown in Figs. 2 and 3. Overall survival, whether early 30-day deaths are included or not, was worse for dialysis patients and confirmed that the high-risk interval is the early postoperative interval for dialysis patients as shown in Fig. 4. A detailed breakdown of clinical outcomes after emergency laparotomy stratified by kidney failure status in the propensity-score-matched cohorts is shown in Table 4.

Discussion

In this large population-cohort study of EGS outcomes across a 15 year interval in England, a different prevalence of EGS procedures for kidney failure cohorts versus the general population was observed. Regardless of procedure, patients with kidney failure had higher risk for emergency re-admission within 90 days of EGS procedures. 

| Emergency general surgery procedure | Kidney transplant (n = 1097) | Dialysis (n = 1567) | General population (n = 688400) | Total (n = 691064) |
|-------------------------------------|-----------------------------|---------------------|-------------------------------|-------------------|
| Partial colectomy                   | 126 (11)                    | 252 (16)            | 63199 (9)                     | 63577             |
| Small bowel resection               | 137 (12)                    | 190 (12)            | 33994 (5)                     | 34321             |
| Cholecystectomy                     | 128 (12)                    | 107 (7)             | 92499 (13)                    | 92734             |
| Appendicectomy                      | 95 (9)                      | 84 (5)              | 336648 (49)                   | 336827            |
| Lysis of peritoneal adhesions       | 14 (1)                      | 10 (1)              | 5214 (1)                      | 5238              |
| Surgery for peptic ulcer            | 90 (8)                      | 220 (14)            | 41748 (6)                     | 42058             |
| Laparotomy                          | 507 (46)                    | 704 (45)            | 115098 (17)                   | 116309            |

Values are n (%).
Table 2 Postoperative duration of hospital stay and emergency re-admission rates after emergency general surgery stratified by patient cohort

| Procedure                      | Hospitalization outcome                                      | Transplant | Dialysis | General | P       |
|--------------------------------|--------------------------------------------------------------|------------|----------|---------|---------|
| Partial colectomy              | Postoperative duration of stay (days), median (i.q.r.)       | 11 (6–22) | 13 (4–28) | 13 (4–28) | <0.001  |
|                                | Emergency re-admission within 90 days                        | 306 (46.4) | 280 (39.5) | 52 176 (25.5) | <0.001  |
| Small bowel resection          | Postoperative duration of stay (days), median (i.q.r.)       | 12 (7–25) | 12 (7–25) | 14 (5–28) | 0.022   |
|                                | Emergency re-admission within 90 days                        | 48 (43.6)  | 45 (41.3)  | 7400 (25.2) | <0.001  |
| Cholecystectomy                | Postoperative duration of stay (days), median (i.q.r.)       | 5 (2–9.5)  | 11 (3–27) | 2 (1–4)  | <0.001  |
|                                | Emergency re-admission within 90 days                        | 39 (33.3)  | 33 (38.4)  | 14 094 (15.4) | <0.001  |
| Appendicectomy                 | Postoperative duration of stay (days), median (i.q.r.)       | 4 (3–8)    | 7.5 (3–13) | 2 (1–3)  | <0.001  |
|                                | Emergency re-admission within 90 days                        | 22 (23.4)  | 27 (35.1)  | 38 410 (11.4) | <0.001  |
| Lysis of peritoneal adhesions   | Postoperative duration of stay (days), median (i.q.r.)       | 8.5 (6–14) | 8 (2–13)   | 5 (2–10)  | 0.063   |
| Surgery for peptic ulcer       | Postoperative duration of stay (days), median (i.q.r.)       | * ( )      | 4 (3–12)   | 1192 (23.4) | 0.003   |
|                                | Emergency re-admission within 90 days                        | 37 (46.8)  | 77 (46.1)  | 7140 (19.2) | <0.001  |
| Laparotomy                     | Postoperative duration of stay (days), median (i.q.r.)       | 11 (6–22)  | 13 (4–28)  | 13 (4–28) | <0.001  |
|                                | Emergency re-admission within 90 days                        | 306 (46.4) | 280 (39.5) | 52 176 (25.5) | <0.001  |

Values are \( n \) (%) unless otherwise indicated. The data for re-admission within 90 days exclude patients who died in hospital or where the patient had no discharge data. *Small numbers are suppressed.

Table 3 Mortality after emergency general surgery stratified by patient cohort

| Variable                        | Total no. | Mortality within 30 days | Mortality within 1 year |
|---------------------------------|-----------|--------------------------|-------------------------|
| Cohort                          | Transplant| 1097                     | 131 (11.9)              | 262 (23.9)              |
|                                 | Dialysis  | 1567                     | 501 (32.0)              | 754 (48.1)              |
|                                 | General   | 688 400                  | 32 457 (4.7)            | 65 903 (9.5)            |
| Type of EGS                     | Partial colectomy | 63 577                  | 7172 (11.3)            | 15 439 (24.3)          |
|                                 | Small bowel resection | 34 321                  | 4361 (12.7)            | 77 999 (22.7)          |
|                                 | Cholecystectomy   | 92 734                   | 808 (0.9)              | 2005 (2.2)             |
|                                 | Appendicectomy   | 336 827                  | 512 (0.2)              | 1399 (0.4)             |
|                                  | Lysis of peritoneal adhesions | 5238                   | 125 (2.5)              | 275 (5.3)              |
|                                  | Surgery for peptic ulcer | 42 058                  | 4526 (10.8)            | 8 992 (19.7)           |
|                                  | Laparotomy       | 116 309                  | 15 587 (13.4)          | 31 110 (26.7)          |
| Total                           | 691 064     | 33 089 (4.8)             | 66 319 (9.6)           |                        |

Values are \( n \) (%).

and increased postoperative mortality versus the general population, with dialysis patients suffering worse outcomes compared with kidney transplant recipients. In logistic regression models, all patients with kidney failure had increased mortality risk compared with the general population (dialysis worse than transplant) but in propensity-score-matched analyses only patients with kidney failure treated with dialysis showed increased risk for MACES after emergency laparotomy. While important from a patient counselling and service provision perspective, these results provide some insight into the stratified postoperative MACE outcomes seen among patients with kidney failure based upon treatment modality worthy of further discussion.

One of the most significant risk factors for mortality after major surgery is level of kidney function. Mooney et al. performed a systematic review and meta-analysis of 49 studies and observed an almost three-fold increase in 30-day mortality after cardiac and non-cardiac surgery with an estimated glomerular filtration rate (eGFR) below 60 ml/min/1.72 m² (Rick Ratio 2.98, 95 per cent c.i. 1.95 to 4.56)\(^5\). This study provides two insights that complement explanations. Successful kidney transplantation, by restoring kidney function, can lower the risk of cardiovascular disease and most of these deaths occurred within 30 days after surgery. Only after small bowel resection was a significant difference in causality observed for dialysis patients dying within 30 days of EGS, with an underlying cardiovascular cause more predominant for dialysis patients.

There are many causative explanations for increased mortality after EGS for patients with kidney failure, especially those on dialysis. Recognized risk factors for postoperative mortality after EGS procedures, such as emergency laparotomy, include preoperative anaemia, increased bleeding risk, underlying cardiovascular disease burden, fluid overload, and many others\(^{19}\). Many of these risks occur with greater prevalence in dialysis patients than the general population\(^{16–19}\), while kidney failure status itself is recognized as a major risk factor for EGS outcomes\(^{14}\), and supports inclusion of kidney failure status in peri- and postoperative risk-score stratification\(^{20}\). The stratified MACES and mortality outcomes between patients with kidney failure have different explanations. Successful kidney transplantation, by restoring kidney function, can lower the risk of cardiovascular disease for patients with kidney failure\(^{21}\). Another possibility is selection bias that prompts ‘fitter’ patients with kidney failure being selected for kidney transplantation and thereby influencing postoperative outcomes; however, selection bias is likely to also affect the dialysis cohort, with only patients deemed likely to survive EGS proceeding with surgery. This can be extrapolated from the minimally divergent long-term survival curves for dialysis patients once 30-day postoperative
deaths are excluded (as shown in Fig. 3b), which would be inconsistent with divergent survival outcomes that are observed from registry data. This suggests fitter dialysis patients being selected after risk stratification to proceed with EGS who, if they survive the early postoperative interval, have a reasonable long-term survival trajectory.

The present study demonstrates that not all EGS procedures are prevalent equally, with patients with kidney failure having a higher incidence of undergoing high-risk EGS procedures and lower incidence of undergoing low-risk EGS procedures (risk defined by mortality probability). Combined with increased postoperative mortality risk compared with patients with normal kidney function, it is surprising to observe a paucity of literature investigating the perioperative management of those with kidney failure receiving dialysis. Strategies for management of patients with kidney failure in the perioperative interval might involve individualized risk stratification and preoperative risk-factor optimization, interventions to mitigate postoperative risk for those who have surgery, protocolized care for this specific population, or closer monitoring for postoperative complications. Frailty is strongly associated with increased risk for mortality after EGS, with an observed OR for 30-day postoperative mortality in pooled studies of 2.91 (95 per cent c.i. 2.00 to 4.23). Frailty is far more common in patients with kidney failure compared with an age-matched general population cohort, with greater severity in dialysis versus transplant patients, but no robust evidence-based intervention strategy has been shown to mitigate frailty status.

How translatable the current findings are to other cohorts outside England is debatable. For example, a retrospective
cohort analysis using administration data from Chana et al. showed similar 7-day outcomes but increased length of stay, re-admission rates, and mortality 30 days after EGS in England versus both the USA and Australia.28 The authors attribute this difference to variation in allocation of resources and infrastructure design that caters for EGS activity across countries. While data on co-morbidities were not available, and therefore stratification by kidney failure status not possible, it is important to note that survival of patients with kidney failure is inferior in the USA when compared with other countries such as England.29–33 Combined with varying degrees of country-specific disease, demographics, and social deprivation,34 it is important that country-specific validation of these findings is undertaken to ensure that similar observations are observed in other patient-cohorts.

The increased mortality after EGS for dialysis patients may seem intuitive. Dialysis patients requiring emergency surgery will probably accept the increased mortality risk of proceeding with surgery versus an even higher risk of not proceeding; however, by quantifying the significant mortality risk for dialysis patients, this should lead to targeted research for strategies to mitigate such postoperative survival disadvantage. Harrison et al. have published a protocol conducting a scoping review of the literature to identify existing perioperative strategies, protocols, pathways, and interventions for dialysis patients undergoing major surgery.7
postoperative outcomes compared with patients with normal kidney function, there is a paucity of literature that has systematically investigated the perioperative management of those with kidney failure receiving dialysis. Strategies for management in the perioperative interval might involve risk stratification and preoperative risk-factor optimization, interventions to mitigate postoperative risk for those who have surgery, protocolized care for this specific population, or monitoring for complications. From a service delivery perspective, this work raises logistical challenges for healthcare providers. On the one hand, patients with kidney failure (especially those receiving dialysis) with a hospital admission requiring an EGS procedure should ideally be admitted to centres with specialist cardiology support and cardiac catheterization facilities. This would be akin to delivery of stroke services, where hospitals with higher levels of organization demonstrate better quality care as measured by audited process measures of acute stroke care\(^{35}\); however, this could lead to potential delays in transfer or lifesaving treatment for patients with kidney failure in need of EGS and contribute to inequity of access and/or care based upon geography. Clarifying treatment pathways for patients with kidney failure requiring EGS, and support structures for those requiring interventional cardiology input, should be encouraged.

This is the first analysis exploring outcomes after EGS stratified by kidney failure status and requires further investigation.

This population-cohort study demonstrates that patients with kidney failure have different prevalence, morbidity, and mortality after undergoing EGS procedures compared with the general population. Within the kidney failure cohort, patients on dialysis have inferior outcomes compared with kidney

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### Table 4 Clinical outcomes within the first year after emergency laparotomy stratified by kidney failure status

| Clinical outcome                                      | Transplant | Dialysis | General | P     |
|-------------------------------------------------------|------------|----------|---------|-------|
| Duration of stay after procedure (days), median (i.q.r.) | 11 (6–22)  | 13 (4–28) | 13 (4–28) | <0.001 |
| Death within 30 days                                   |            |          |         | 0.009 |
| Restricted cardiac death                               | 23 (20.2)  | 125 (28.0) | 7983 (27.6) |       |
| Cardiac death                                          | 18 (15.8)  | 56 (12.6)  | 2682 (9.3)  |       |
| Other cause of death                                   | 73 (64.0)  | 265 (59.4) | 18306 (62.2) |       |
| Emergency re-admission within 90 days*                | 306 (46.4) | 280 (39.5) | 57176 (25.5) | <0.001 |
| Myocardial infarction within 3 months                  | 6 (0.8)    | 20 (1.7)   | 1927 (0.8)  | 0.005 |
| Stroke within 3 months                                 | † (*)      | 9 (0.7)    | 1367 (0.6)  | 0.359 |
| Unstable angina diagnosis within 3 months              | 3 (0.5)    | 6 (0.5)    | 473 (0.2)   | 0.012 |
| Heart failure diagnosis within 3 months                | 36 (4.6)   | 68 (5.7)   | 5641 (2.4)  | <0.001 |
| Coronary revascularization within 3 months             | † (*)      | † (*)      | 189 (0.1)   | 0.353 |
| Major adverse cardiovascular event within 3 months     | 69 (8.8)   | 225 (18.7) | 17048 (7.3) | <0.001 |
| Myocardial infarction within 6 months                  | 8 (1.0)    | 25 (2.1)   | 2248 (1.0)  | <0.001 |
| Stroke within 6 months                                 | † (*)      | 13 (1.1)   | 1746 (0.7)  | 0.292 |
| Unstable angina diagnosis within 6 months              | 6 (0.8)    | 10 (0.8)   | 614 (0.3)   | <0.001 |
| Heart failure diagnosis within 6 months                | 43 (5.5)   | 80 (6.7)   | 6737 (2.9)  | <0.001 |
| Coronary revascularization within 6 months             | † (*)      | † (*)      | 307 (0.1)   | 0.012 |
| Major adverse cardiovascular event within 6 months     | 83 (10.5)  | 248 (20.6) | 19571 (8.3) | <0.001 |
| Myocardial infarction within 12 months                 | 16 (2.0)   | 38 (3.2)   | 2738 (1.2)  | <0.001 |
| Stroke within 12 months                                | 7 (0.9)    | 23 (1.9)   | 2373 (1.0)  | 0.007 |
| Unstable angina diagnosis within 12 months             | 9 (1.1)    | 19 (1.6)   | 849 (0.4)   | <0.001 |
| Heart failure diagnosis within 12 months               | 54 (6.9)   | 95 (7.9)   | 8249 (3.5)  | <0.001 |
| Coronary revascularization within 12 months            | † (*)      | 11 (0.9)   | 523 (0.2)   | <0.001 |
| Major adverse cardiovascular event within 12 months    | 105 (13.3) | 289 (24.1) | 22958 (9.8) | <0.001 |
| Death within 12 months                                 |            |           | <0.001   |       |
| Restricted cardiac death                               | 42 (19.5)  | 175 (27.7) | 13055 (22.8) |       |
| Cardiac death                                          | 26 (12.1)  | 79 (12.5)  | 3994 (7.0)  |       |
| Other cause of death                                   | 147 (68.4) | 378 (59.8) | 40134 (70.2) |       |

Values are n (%). *Excluding patients who died in hospital or where patient had no discharge date. †Small numbers are suppressed.
transplant recipients, experiencing significantly more MACE episodes and deaths in the postoperative setting after EGS. These data provide evidence to inform counselling of patients with kidney failure with regard to morbidity and mortality after EGS, while providing insights into the high-risk status of dialysis patients versus kidney transplant recipients or the general population. Further work and specialist guidance is warranted to inform best practice for peri- and postoperative care for patients with kidney failure after EGS. Future research streams should aim to bridge the gap in clinical outcomes for the kidney failure cohort with the general population, but also reinforces the reduced cardiovascular burden associated with kidney transplantation for patients living with kidney failure.

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Disclosure
The authors declare no conflict of interest.

Supplementary material
Supplementary material is available at BJS Open online.

Data availability
Data may be obtained from a third party (NHS Digital) and are not publicly available.

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