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## Research paper

# Preoperative kidney function linked to mortality and readmission outcomes at Day 90 and 30 in older emergency surgical patients



L.A. Evans<sup>a,1</sup>, J. Goeteyn<sup>b</sup>, B. Carter<sup>a,2</sup>, M. Greig<sup>c</sup>, H.S. Tay<sup>c</sup>, C. McCormack<sup>c</sup>, W. Ceelen<sup>b</sup>, L. Pearce<sup>d</sup>, K. McCarthy<sup>e</sup>, P.K. Myint<sup>c</sup>, S.J. Moug<sup>f</sup>, M. Stechman<sup>g</sup>, J. Hewitt<sup>a,\*</sup>

<sup>a</sup> Cardiff University, Cardiff CF10 3XQ, Wales, United Kingdom

<sup>b</sup> University Hospital Gent, De Pintelaan 185, 9000 Gent, Belgium

<sup>c</sup> Aberdeen Royal Infirmary, Foresterhill, Aberdeen AB25 2ZN, Scotland, United Kingdom

<sup>d</sup> Central Manchester University Hospital, Grafton Str, Manchester M13 9WL, England, United Kingdom

<sup>e</sup> North Bristol NHS Trust, Southmead Hospital, Southmead Way, Bristol BS10 5NB, England, United Kingdom

<sup>f</sup> Royal Alexandra Hospital, Corsebar Rd, Paisley PA2 9PN, Scotland, United Kingdom

<sup>g</sup> University Hospital of Wales, Heath Park, Cardiff CF14 4XW, Wales, United Kingdom

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## ABSTRACT

**Introduction:** Impaired preoperative kidney function is associated with an increase in post-procedural major complications and mortality in older elective surgical population. However, little is known about the impact of poor kidney function on outcomes in emergency surgical setting in this age group. This study aimed to quantify the effect of impaired kidney function on 30 and 90 days mortality; and readmission within 30 days following an acute surgical admission in older patients.

**Material and methods:** The Older Persons Surgical Outcomes Collaboration 2015 cohort study, in four UK centres and one in Belgium, examined the above relationships. A logistic regression model was used to assess the odds of outcomes when comparing impaired eGFR to normal eGFR. A total of 402 patients were included with a mean age of 76.2 years (range 65–103 years), of which 209 (52%) were male.

**Results:** The prevalence of eGFR <60 ml/min/1.73 m<sup>2</sup> was 34.1% (N = 137). Patients with an eGFR of <60 ml/min/1.73 m<sup>2</sup> on admission were more likely to die at 30 and 90 days when compared to patients with eGFRs ≥60 ml/min/1.73 m<sup>2</sup>; respective adjusted OR = 2.98 (95%CI 1.38–6.43, P = 0.006) and 3.37 (95%CI 1.82–6.27, P < 0.001). No differences were observed for 30-day readmission to hospital.

**Conclusions:** Admission eGFR provides prognostic information which is useful to clinicians in an acute surgical setting. Whether closer monitoring and focused management at improving kidney function improves outcome in this patient population warrants further investigation.

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## 1. Introduction

The prevalence of Chronic Kidney Disease (CKD) stages 3–5 in the UK is reported to be between 5.8% [1] and 8.5% [2], with the prevalence increasing with age [1–3]. Estimates of over 40% have commonly been described in Europe and the United States, in community dwelling older people aged over 80 years [4,5]. Patients with CKD have been found to have a poor self-awareness of their

disease and its implications [6] and recognition amongst medical professionals has been found to be deficient [7,8].

Impaired kidney function is associated with a high hospital admission rate and subsequently higher risk of adverse outcomes after medical interventions [9,10] and surgical interventions [8,11,12].

There are few studies assessing the effect of eGFR in the general surgical setting and none have been conducted in an elderly emergency general surgical setting. In 2008, a systematic review on CKD and short term postoperative mortality found that patients with CKD undergoing elective non-cardiac surgery, which encompassed general surgical and vascular procedures, demonstrated a two to five fold higher risk of mortality or cardiovascular events compared to those with normal renal function [13]. Early stages of CKD were found to have a detrimental effect on survival and morbidity. For example, a general and vascular surgical population, with a mean age of 58 years and CKD stage 3, death within 30 days

\* Corresponding author at: Division of Population Medicine, Cardiff University, 5th Floor Neuadd Meirionnydd, Heath Park, Cardiff, United Kingdom. Tel.: +44 02920 71698.

E-mail address: [hewittj2@cardiff.ac.uk](mailto:hewittj2@cardiff.ac.uk) (J. Hewitt).

<sup>1</sup> Presently with the University Hospital of Wales, Heath Park, Cardiff CF14 4XW, Wales, United Kingdom.

<sup>2</sup> Presently with Kings College London, Strand, London WC2R 2LS, United Kingdom.

of an operation was 2.3 times higher and post-operative complications 1.2 times higher, when compared to normal renal function [8].

To date, little is known about the impact of impaired eGFR on outcomes in the emergency surgical setting in older patients. The objective of this international prospective study was to consider the relationship between renal impairment on a range of clinically significant outcomes in an elderly emergency general surgical population.

## 2. Methods

### 2.1. Study population and data sources

Data collection was performed in 4 UK hospitals (University Hospital of Wales; Royal Alexandra Hospital Paisley; Aberdeen Royal Infirmary; Central Manchester Foundation Trust) and one Belgian Hospital (Ghent University Hospital). All hospitals are part of the Older Persons Surgical Outcomes Collaboration [[www.opsoc.eu](http://www.opsoc.eu)].

Data were collected prospectively using hospital electronic records or physical records and stored securely with patient identifiable data removed. The relevant institutional approvals were acquired in all participating centres.

Inclusion criteria were:

- all patients aged 65 years or older;
- unplanned admission to a general surgery ward.

There were no exclusion criteria and all acute surgical emergency admissions were consecutively included during the study period.

Baseline demographic data were collected on participating patients; haemoglobin (<130 g/L classified as anaemia); albumin ( $\leq 35$  g/L classified as low), number of medications (grouped as either being <5 or  $\geq 5$  medications); diabetic history; multi-morbidity (defined using 20 pre-specified conditions) [14] and categorised as  $\leq 2$  or 3 or more; and whether the patient had surgery or not.

### 2.2. Outcomes

The primary outcome of interest was Day 90 mortality, and secondary outcomes were mortality at Day 30 and admission to hospital within 30 days of discharge.

### 2.3. Categorising renal function

Patient's eGFR were acquired in one of two ways; manually calculated using an online calculator; found here <http://egfrcalc.renal.org/>, which uses the modification for diet in renal disease equation and required the input of the patient's admission creatinine, age, sex and race. The other method involved recording the eGFR value automatically calculated from an admission blood electrolyte test.

For the purpose of this study, eGFR was categorised into the CKD stages according to the guidelines set out by the National Kidney Foundation (NKF) [3]. CKD stages 1 and 2 require evidence of kidney damage to differentiate correctly, data which were not routinely available on the hospital electronic systems. All eGFR records that were  $\geq 60$  ml/min/1.73 m<sup>2</sup>, were categorised as CKD stage 1–2. The remaining stages were defined along the criteria of the NKF.

### 2.4. Statistical analysis

A descriptive analysis of the patient demographic and clinical data on admission was performed on the primary outcome

(mortality at Day 90). Primary and secondary outcomes were analysed using a multivariable logistic regression base model to determine the effect of eGFR, adjusted for clinically important covariates of albumin and age group. Subsequently, a forward stepping multivariable logistic model fitting approach using a likelihood ratio test of clinical covariates after adjustment of the base model (age group, albumin and eGFR) was performed. As an exploratory analysis, comparison of the effects of eGFR partitioned into the established kidney function categories, against the binary partition of greater than, versus less than 60, was carried out. All adjusted odds ratios (ORs) were reported with their associated 95% confidence interval (95% CI) and P-values. Statistical analysis was carried out using Stata version 13.0.

## 3. Results

A total of 402 patients admitted as an acute surgical emergency in five participating centres were included in the study and their baseline characteristics summarised in Table 1. Mean age was 76.2 years (range 65–103 years), with 209 (52%) being male. A total of 65.9% and 34.1% of patients were classified as having normal renal function (eGFR  $\geq 60$  ml/min/1.73 m<sup>2</sup>) or impaired renal function (eGFR < 60 ml/min/1.73 m<sup>2</sup>) respectively.

Missing data for albumin, poly-pharmacy, length of stay and diabetic status, which individually were missing in <3% of participants, which were considered to be missing at random.

Table 1 also summarises the outcomes of patients presenting as acute surgical emergency. In total, there were 22 and 40 deaths within 30 and 90 days of presentation respectively, and 95 readmissions within 30 days of discharge.

The proportion of patients who died within 90 days of first presentation at hospital was significantly greater in patients with renal impairment (16.1%), when compared to patients with normal eGFR (6.8%,  $P < 0.01$ ). A similar trend was seen with 30 day mortality, with 9.5% of renal impaired patients experiencing the outcome when compared to non-renal impaired patients (3.4%,  $P = 0.01$ ). No difference in readmission between those with renal impairment (24.8%) and patients with normal renal function (23%,  $P = 0.48$ ).

Multivariable analyses showing predictors of 90 day mortality; 30 day mortality and Readmission within 30 days of discharge are shown in Tables 2 and 3. Table 3 shows a summary of additional covariates, which were adjusted for age group, albumin and eGFR.

### 3.1. Outcome 1: mortality within 90 days

After adjustment of age group and albumin; the odds of mortality at 90 days was higher in patients with an admission eGFR of <60 ml/min/1.73 m<sup>2</sup> (OR = 3.37, 95%CI 1.82–6.27,  $P \leq 0.001$ ) when compared to patients with normal eGFR.

Stratifying admission eGFR into the CKD classification, mortality was again higher and worsened with decreasing eGFR when compared to normal eGFR. The following adjusted ORs were demonstrated in the corresponding CKD classifications; CKD 3a (OR = 2.99, 95%CI 1.36–6.57,  $P = 0.006$ ), CKD 3b (OR = 3.24, 95%CI 1.31–8.05,  $P = 0.11$ ) and CKD 4 + 5 (OR = 4.57, 95%CI 1.81, 11.50,  $P = 0.001$ ), when compared to the normal eGFR group. Supplementary Table 1 summarises the multivariable analysis of stratified eGFR on outcomes.

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**Table 1**  
Characteristics of 402 patients comparing baseline characteristics against outcomes.

	Total in cohort	Mortality at 90 days		Mortality at 30 days		Readmission at 30 days	
		Dead	Alive	Dead	Alive	Yes	No
Patients, n (%)	402 (100)	40 (10)	358 (89.1)	22 (5.5)	378 (94.0)	95 (23.6)	296 (73.6)
Surgery, n (%)	141 (35.1)	8 (5.7)	131 (92.9)	5 (3.5)	134 (95.0)	26 (18.4)	108 (76.6)
Sex, n (%)							
Male	209 (52%)	24 (11.5)	182 (87.1)	13 (6.2)	194 (92.8)	55 (26.3)	149 (71.3)
Female	193 (48%)	16 (8.3)	176 (91.2)	9 (4.7)	184 (95.3)	40 (20.7)	153 (79.3)
Age (%)							
65–74	183 (45.5)	15 (8.2)	166 (90.7)	7 (3.8)	175 (95.6)	44 (24)	136 (74.3)
75–84	150 (37.3)	16 (10.7)	132 (88.0)	8 (5.3)	141 (94.0)	36 (24)	36 (24.0)
>85	69 (17.2)	9 (13)	60 (87.0)	7 (10.1)	62 (89.9)	15 (21.7)	52 (75.4)
eGFR, n (%)							
≥60	265 (65.9)	18 (6.8)	245 (92.5)	9 (3.4)	255 (96.2)	61 (23)	202 (76.2)
<60	137 (34.1)	22 (16.1)	113 (82.5)	13 (9.5)	123 (89.8)	34 (24.8)	100 (73.0)
CKD 3a	64 (15.9)	11 (17.2)	52 (81.3)	8 (12.5)	55 (85.9)	18 (28.1)	43 (67.2)
CKD 3b	44 (10.9)	6 (13.6)	38 (86.4)	3 (6.8)	41 (93.2)	12 (27.3)	32 (72.7)
CKD 4+5	29 (7.2)	5 (17.2)	23 (79.3)	2 (6.9)	27 (93.1)	4 (13.8)	25 (86.2)
Albumin, n (%)							
≤35	216 (53.7)	30 (13.9)	184 (85.2)	18 (8.3)	197 (91.2)	57 (26.4)	155 (71.8)
>35	141 (35.1)	8 (5.7)	133 (94.3)	3 (2.1)	138 (97.8)	27 (19.1)	114 (80.9)
Haemoglobin, n (%)							
≥130	185 (46)	14 (7.6)	172 (93.0)	14 (7.6)	177 (95.7)	57 (30.8)	147 (79.5)
<130	216 (53.7)	8 (3.7)	186 (86.1)	3 (1.4)	200 (92.6)	27 (12.5)	153 (70.8)
Polypharmacy, n (%)							
≥5 Drugs	256 (63.7)	27 (10.5)	227 (88.7)	13 (5.1)	242 (94.5)	73 (28.5)	176 (68.8)
<5 Drugs	139 (34.3)	11 (8.0)	128 (92.1)	7 (5.1)	132 (95.0)	22 (15.9)	117 (84.2)
Co-morbidities, n (%)							
Diabetes mellitus	74 (6.7)	5 (6.8)	69 (92.0)	1 (1.4)	74 (98.7)	18 (24.3)	55 (73.3)
CCF	12 (3)	3 (25)	9 (75)	1 (8.3)	11 (91.7)	4 (33.3)	8 (66.7)
Dementia	15 (4)	2 (13.3)	13 (86.7)	2 (13.3)	13 (86.7)	4 (26.7)	10 (66.7)
Multimorbidity (≥2)	244	31 (12.1)	211 (86.5)	17 (7)	226 (92.6)	65 (26.6)	171 (70.1)

**Table 3**  
The effects of the additional covariates after adjustment of the base model (age group, albumin and eGFR).

	Mort 90			Mort 30			Readmission 30		
	OR	95% CI OR	P-value	OR	95% CI OR	P-value	OR	95% CI OR	P-value
Sex	1.33	0.76–2.32	0.31	1.52	0.76–3.03	0.24	1.1	0.79–1.52	0.57
Operation	0.72	0.37–1.38	0.32	0.81	0.37–1.78	0.6	0.65	0.44–0.96	0.03
Poly pharmacy (5 drugs)	1.98	1.03–3.77	0.039	1.5	0.67–3.32	0.32	1.97	1.37–2.82	<0.001
Multimorbidity (≥2)	2.32	1.13–4.75	0.021	1.96	0.79–4.86	0.15	1.39	0.93–2.07	0.1
Haem (<130 g/L)	1.1	0.61–2.00	0.75	0.77	0.37–1.59	0.47	1.46	1.02–2.09	0.04

The above have been adjusted for, age groups (65–74, 75–84, above 85), albumin and eGFR (>60, <60).

**Table 2**  
The base model, adjusted for age group, eGFR and albumin.

	Mort 90			Mort 30			Readmission 30		
	OR	95% CI OR	P-value	OR	95% CI OR	P-value	OR	95% CI OR	P-value
Age group									
65–74									
75–84	1.56	0.78–3.11	0.21	1.04	0.42–2.62	0.93	1.34	0.84–2.14	0.22
≥85	2.02	0.86–4.76	0.11	2.39	0.90–6.33	0.08	1.23	0.64–2.37	0.53
eGFR									
<60 ml/min/1.73 m <sup>2</sup>	3.37	1.82–6.27	<0.001	2.98	1.38–6.43	0.006	1.21	0.76–1.91	0.42
Albumin									
≤35	2.57	1.38–4.79	0.003	3.1	1.39–6.89	0.006	1.35	0.96–1.90	0.08

**Supplementary Table 1** summarises the multivariable analysis of stratified eGFR on outcomes.

Preoperative hypoalbuminaemia was found to predictive of 90 day mortality, with adjusted OR = 2.57 (95%CI 1.38–4.79,  $P = 0.003$ ).

### 3.2. Outcome 2: mortality within 30 days

The adjusted odds ratio of death were again higher in patients with an admission eGFR corresponding <60 ml/min/1.73 m<sup>2</sup> (OR = 2.98, 95%CI 1.38–6.43,  $P = 0.006$ ) when compared to patients with normal renal function. Similarly, on stratification of eGFR into

the CKD groupings, there was a trend towards an increasing odds ratio of mortality with increasing renal impairment; this is shown in **Supplementary Table 1**. However, only patients with an eGFR corresponding to CKD 3a showed a significant increase in mortality (OR = 3.39, 95%CI 1.35–8.55,  $P = 0.01$ ).

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in [Supplementary Table 1](#). However, only patients with an eGFR corresponding to CKD 3a showed a significant increase in mortality (OR = 3.39, 95%CI 1.35–8.55,  $P = 0.01$ ).

Hypoalbuminaemia again also significant in predicting 30 day mortality when compared patients with an albumin of  $>35$  g/L with an adjusted OR = 3.1 (95% 1.39–6.89,  $P = 0.006$ ).

### 3.3. Outcome 3: readmission within 30 days

Multivariable analysis did not demonstrate any significant increase in readmission rates for patients with an admission eGFR of  $<60$  ml/min/1.73 m<sup>2</sup> (OR = 1.21, 95%CI 0.76–1.91,  $P = 0.42$ ) when compared to patients with normal renal function or when stratified by CKD grouping. [Supplementary Table 1](#) and [Table 2](#) illustrate these findings.

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## 4. Discussion

This international multicentre study on emergency general surgical patients aged 65 years or older demonstrated that admission eGFR is a predictor for the clinically relevant outcomes of 30- and 90-day mortality. Patients with an admission eGFR of  $<60$  ml/min were three times more likely to die at 30 days or 90 days when compared to patients with normal eGFR. Previous studies have demonstrated impaired renal function preoperatively is a predictor of 30 day mortality in an elective surgical setting [8,11–13,15]. However, these studies did not investigate 90 day mortality, nor did they specifically look at older surgical emergency patients. No significant relationship between admission eGFR and readmission within 30 days of discharge was demonstrated in our study. To our knowledge, this is the first report of the impact of admission eGFR on outcomes in older people in an acute surgical setting.

Although these results indicate a progressive increased trend in the odds of death with increasing renal impairment from CKD stage 3–5, they did not reach statistical significance, which may be due to fewer patients with renal function of  $<60$  ml/min/1.73 m<sup>2</sup>, a weakness of this paper that underpowered the study. However a study in elective cardiac surgery demonstrated that when compared to a preoperative eGFR corresponding to CKD 1, progressive renal impairment up to CKD 4 increased the likelihood of mortality within 30 days [11]. Another large study on preoperative eGFR and surgical outcomes in an elective general surgical population also demonstrated increased likelihood of mortality within 30 days of admission with progressive CKD [8]. In contrast to this report, neither of these two studies [8,11] found impaired renal function as a predictor of 90 day mortality.

Although our study did not find admission eGFR to be a predictor of readmission within 30 days of discharge, one study on patients undergoing lower limb vascular procedures found that CKD was associated with increased odds of readmission 30 days after discharge [16]. However, they only found this association in those with stage 4 or 5 CKD. This discrepancy may again be due to a lack of power.

Another finding of this study is admission hypoalbuminaemia, defined as  $\leq 35$  g/L, being predictive of 30 and 90 day mortality. We were unable to find a directly comparable study to our own demonstrating albumin being predictive of 30 day mortality in a general surgical population. A previous study has shown

preoperative hypoalbuminaemia to be a risk factor for death within 90 days of surgery in patients undergoing elective radical cystectomy for bladder cancer, which is keeping with our results [17]. Hypoalbuminaemia has also found to be predictive of mortality in patients undergoing elective colectomies for colorectal cancer [18].

It is postulated that hypoalbuminaemia reflects not only nutritional deficiencies, but a systemic inflammatory response that compromises immune function prior to surgery and impairs recovery postoperatively [19]. However, even after adjustment for this confounding variable, eGFR still predicted mortality on our study population.

A notable weakness of this study was the lack of data relating to acute kidney injury (AKI), pre-existing CKD or acute-on-chronic renal injury at admission. This lack of information is a possible confounder, as studies in predominantly intensive care populations, have shown that patients with acute-on-chronic renal injury have a lower mortality when compared to patients with AKI and no background of CKD [20–22]. Though the findings in this study show an increased risk of poor outcomes as eGFR deteriorated when compared to normal eGFR, the risk in clinical stages of mild and moderately decreased eGFR appeared approximately the same. While the analysis did adjust for several common confounding variables, such as age and albumin, it was not possible to adjust for all potential confounding variables, for example, nephrotoxic medications, as these data were not collected to that degree of granularity. Also a priori analysis plan was in place to prevent multiplicity during our analysis.

Serum creatinine based eGFR calculation may over-estimate kidney function and this might have resulted in some severely ill patients, with low muscle mass, being included in the  $\geq 60$  ml/min/1.73 m<sup>2</sup> category. Thus, patients creatinine based eGFR category of  $\geq 60$  ml/min/1.73 m<sup>2</sup> may actually be at increased risk of poor clinical outcomes, attenuating the relationships observed.

This study was conducted at multiple sites across the UK and a single site in Belgium, with only minor differences in surgical practice between them. Sites varied in their location, with urban and rural populations and both academic and non-academic centres. Therefore, this sample would appear to be representative of a Northern European older emergency surgical population.

## 5. Conclusion

Admission eGFR provides useful prognostic information to clinicians and their patients. Our results suggest that preoperative eGFR should be checked in every emergency surgical admission. Those patients with CKD stage 3–5 should be considered for High Dependency monitoring, especially if emergency surgery is being considered. Indeed this is a proposal supported by the recent National Emergency laparotomy Audit ([www.nela.org](http://www.nela.org)). Prospective research should be performed to identify all interventions on kidney function that reduce the risk of complications and mortality. Whether closer monitoring and focused management at improving kidney function improves outcome in this patient population warrants further investigation.

## Disclosure of interest

The authors declare that they have no competing interest.

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.eurger.2017.03.001>.

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