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THE SEVERITY OF ACUTE KIDNEY INJURY PREDICTS MORBIDITY AND MORTALITY IN SURGICAL PATIENTS AMONG EMERGENCY LAPAROTOMIES: OBSERVATIONAL COHORT STUDY

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ABSTRACT

Background: Acute Kidney Injury (AKI) patients undergoing emergency surgery have an increased risk of complications and mortality. We examined the incidence, mortality, hospital stay, and renal replacement therapy of patients who presented with AKI and underwent emergency laparotomies. **Methods:** This is an observational study done at Beaumont Hospital, Dublin. Patients who were included in the study had AKI and underwent laparotomies within 48 hours of admission. These patients were admitted to surgical care from the emergency department between 2012 and 2017. The main outcome analyzed was 30-day mortality. The other outcomes measured were length of stay, stage of AKI, and increased need for renal replacement therapy. **Results:** In our study, 641 patients underwent emergency laparotomies. 13.9% of patients (n=86) presented with AKI after excluding 3.9% of patients (n=24) with chronic kidney disease (CKD). Out of 86 AKI patients, 31.4% of patients (n=27) died after emergency laparotomy and 6.9% of patients (n=6) required renal replacement therapy. The relative risk of mortality was highest in stage 3 AKI (69%) and length of stay was also longest in stage 3 AKI 109(13-232) days. **Conclusion:** AKI is an important predictor of mortality for emergency laparotomies, and it is associated with an increased length of stay and renal replacement therapy requirement.

KEYWORDS: Acute kidney injury, Postoperative, Incidence, Prognosis, Risk factors, Emergency Laparotomy.

INTRODUCTION

Acute kidney injury (AKI) is a common and serious complication of emergency surgical admissions and the risk further increases in patients who undergo emergency laparotomy. Hospital-acquired acute kidney injury incidence in surgical patients is 4.9 percent with baseline serum creatinine known.[1] Furthermore, the type of emergency surgery influences the development of AKI. Exploratory laparotomy and small bowel resection are known to increase the risk of AKI as compared to appendectomy and gastric bypass procedures.[2] However, most literature focuses on cardiac and major vascular surgery. Even a mild degree of AKI has severe adverse physiological consequences and is associated with reduced survival. It has been confirmed by the UK's National Confidential Enquiry into Patient Outcome and Death (NCEPOD) that AKI recognition is sometimes delayed, and risk factors may expose these patients to an increased likelihood of developing AKI.[3] Even mild disease or a moderate increase in creatinine is associated with substantially reduced survival.[4]

Emergency surgical admission patients undergoing laparotomy are at risk of poor outcomes and a significant increase in risk of morbidity, mortality, and length of stay when compared with elective general surgical operations.[5] AKI associate Morbidity and Mortality were higher in the Emergency general surgery group when compared to non- Emergency general surgery group 12.5% and 2.66% respectively.[6] Patients in Emergency general surgery groups were five times more likely to die within 30 days of their operation.[7] In addition, the risk of development of AKI was 8 times higher as compared to non-Emergency General Surgery Group.[6] Chronic kidney diseases (CKD), End stage renal disease (ESRD) are long-term sequels of AKI. It has long-term effects on the cardiovascular system. Multiple risk factors are responsible for AKI, so it is important to identify risk factors, complications, and their outcomes.

AKI can frequently be avoided by preventing modifiable risk factors and a majority of surgical patients who have underlying renal disease, sepsis, volume depletion, and exposure to nephrotoxic agents are particularly at risk of AKI.[8] In recent literature, preoperative risk prediction models have been used for predicting postoperative acute kidney injury in patients undergoing orthopedic surgery. These predictors are male sex, age at operation, diabetes, GFR, use of ACE inhibitors, number of prescribed drugs, and ASA grade.

Research Question- What is the incidence of renal impairment in emergency surgical admissions amongst patients undergoing laparotomies and this is associated with an increase in incidence or morbidity, mortality, length of stay, and renal replacement therapy requirement?

Method

We included all surgical patients who presented to the Emergency Department (ED) and underwent laparotomy with AKI at the time of presentation in ED at Beaumont Hospital between January 1, 2012, to December 31, 2017. Beaumont Hospital, Dublin, Ireland, is a large academic teaching hospital and it provides emergency and acute care services to a local community of about 290,000 people.[10]

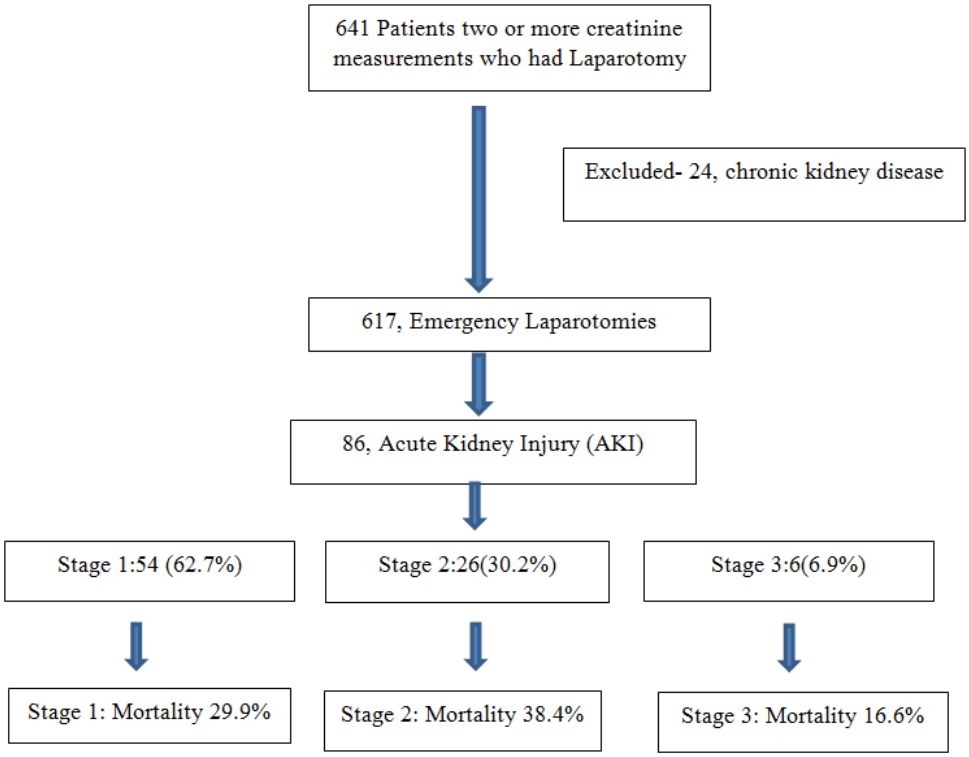
We retrieved administrative data from the Hospital Inpatient Enquiry System (HIPE) and laboratory data were extracted from the Patient Information Profile Explorer (PIPE) system. The RIFLE (Risk, Injury, Failure, Loss of kidney function, and End-stage kidney disease) classification was proposed to define and stratify AKI.[11] AKI as defined by Kidney Disease Improving Global Guidelines, KDIGO is an increase in serum creatinine or a decrease in urine output.[12] Furthermore, AKI should be staged based on the severity of the rise in creatinine level or decrease in urine output.

Patients who underwent emergency laparotomy procedure within 48 hours of emergency admission with AKI were included. The emergency laparotomies involve a large incision through the abdominal wall to gain access into the abdominal cavity under general anesthetics and the average post-operative length of stay is 16.3 days.[13,14,15] Chronic Kidney Disease (CKD) is determined by the Modification of Diet in Renal Disease (MARD) equation from baseline creatinine, age, race, and sex.[16] Patients with chronic kidney disease before laparotomy were identified by previous creatinine levels, renal replacement therapy, and renal dialysis data system.

The primary outcome was an acute kidney injury, defined by an abrupt rise in creatinine over hours to week.[17] Secondary outcomes were mortality, hospital stay, and renal replacement therapy (RRT). Acute kidney injury with renal replacement therapy (RRT) was defined as renal replacement therapy following AKI28.

We used serum creatinine to determine the RIFLE stage of AKI. Renal failure stages were defined as a fold change in creatinine level from baseline.[29] Stages of AKI were as stage 1(1.5 times of baseline), stage 2(>2 times of baseline), and stage 3 (>3 times of baseline).[18] Baseline preadmission creatinine levels were checked in all patients from prior hospital admission records on the PIPE system. If baseline creatinine levels were not available, then the first creatinine measurement in the emergency department was used as baseline creatinine. We collected the demographic data, serum creatinine level before admission, before the operation, post-operative, one week after the operation, two weeks, and at the time of discharge. Radiological investigations (CT/MRI) were recorded from the McKesson radiology viewer system.

Expecting an AKI incidence of 3.5 % in exploratory laparotomy[2] and 5.8% in emergency surgery30, 120 laparotomies performed each year in Beaumont hospital. So, we expected our study spreading over 6 years would yield more than an adequate number of AKI patients. All patients who were younger than 18, non-surgical admissions, and non-emergency laparotomies, discharged without spending a night in hospital, and those who were diagnosed with Chronic renal failure were excluded from the study.



RESULTS

We identified all patients with AKI who underwent laparotomies between January 1, 2012, and December 31, 2017. A total of 641 patients were included in this study.

There were 641 patients included in this study. All patients had baseline creatinine measured before or at the time of hospital admission and all patients underwent laparotomy within 48 hours of admission. 24 (3.9%) patients were excluded from the analysis as they presented with end-stage renal disease before or at the time of hospital admission. A total of 617 patients constituted the study cohort. A characteristic of the study population is in Table 1.

The overall incidence of AKI in emergency laparotomy patients was 86 (13.9 %). Furthermore, 68(87.2 %) patients had CT scans before surgery, and 11(12.7%) patients had investigations other than CT scans (Xray, MRI scans). Emergency Laparotomy patients in whom the index admission was associated with an episode AKI, 27(31%) died in 30 days [AKI stage 1, 54(62.7%), stage 2, 10(30.2%), stage 3, 1(6.9%)], compared to 3.2 % mortality in patients without AKI. Mortality was higher in stage 2 than in stage 3 because the majority of patients with stage 3 were on hemodialysis. Patients with AKI were old and had associated comorbidities. The majority of patients were male (55.8 %) and more than 60 years old (81.39%). The mean age at the time of admission was 69.24 years. A total of 24(3.9%) patients presented with chronic kidney disease. In this study, 6 (6.9%) developed AKI required renal replacement therapy and the rest of the patients 80(93%) were discharged at home 59 (68.6%) or died 27(31.3%).

There was a significant variation in the primary reasons of laparotomies with AKI, the commonest cause was small bowel resection 27(31.3%) and it was closely followed by subtotal colectomy 24(27.9%). Other common causes were right colectomy 24(27.9%) and Hartmann's procedure 12(13.9%). Overall, 78(90.6%) had bowel surgeries. In addition, other causes were Hernia repair 2(2.3%) and drainage of abscess 1(1.16%). 35(64%) patients from stage one AKI recovered due to the identification of causative factors. Only 4(4.6%) patients in stage 1 AKI required renal replacement therapy. However, 1(16.6%) from stage 3 returned to normal and one patient needed renal replacement therapy out of 6 patients in stage 3 AKI. (Table 7,8) The consequences of AKI were limited due to early and continued involvement of nephrologists. It has been shown in a UK based study that poor survival and long-term CKD is associated when no onsite nephrologist consultation is available.[18]

We reviewed the records of 27 patients who sustained AKI and died within 30 days. 9(33.3%) had small bowel resection; 6(22.2%) patients had right hemicolectomy as part of their laparotomy, and 5(18.5%) had documented subtotal colectomy.

Table 1: Characteristics of patients, laparotomies, AKI.

Year	Total number of patient	Total number of patient(excluding CKD)	Number of patients with AKI	Gender		Number of patient with CKD
				Female	Male	
2012	101	91	12	4	8	10
2013	87	87	19	12	7	0
2014	114	112	15	9	6	2
2015	114	111	13	6	7	3
2016	116	114	14	4	10	2
2017	109	102	13	3	10	7
Total	641	617	86(13.9%)	38(44.1%)	48(55.81%)	24 (3.9%)

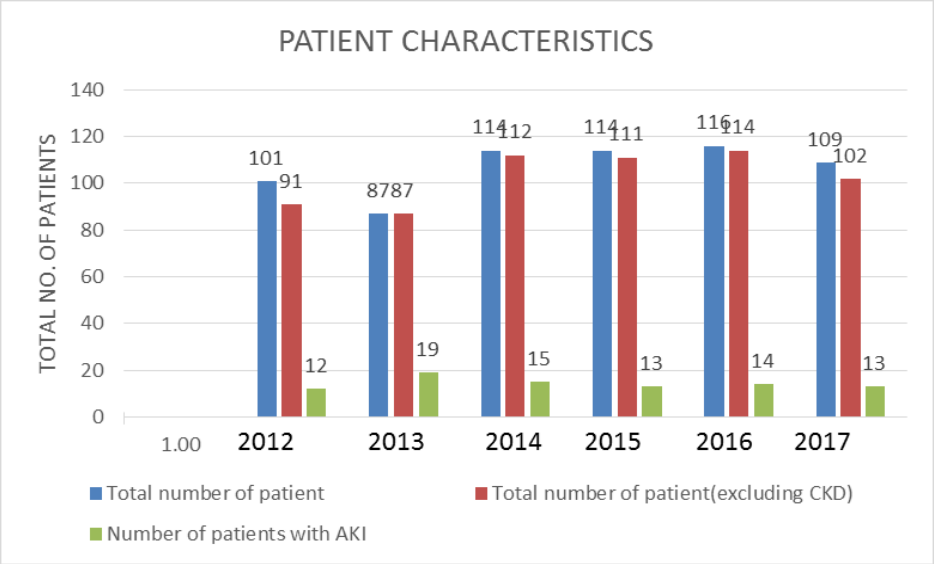


Table 2: Number of AKI, age ranges and gender.

Age ranges (when patients were admitted)	Female		Male		Total
	Death	Not	Death	Not	
1<20	0	0	0	0	0
21-40	2	0	0	3	5(5.8%)
41-60	0	4	1	6	11(12.8%)
>60	11	21	13	25	70(81.4%)
Total	13	25	14	34	86

Table 3: Number of AKI and Imaging.

IMAGING	WITH AKI
CT	68(79.0%)
MRI	
NO SCAN	19(21%)

Table 4: Thirty day mortality and stages of AKI.

STAGE OF AKI	Number of patients	MORTALITY
S1	54	16(62.7%)
S2	26	10(30.2)
S3	6	1(6.9)

Table 5: Stages of AKI and number days' hospitalization.

STAGE OF AKI	DAYS OF HOSPITALIZATION	MORTALITY
S1	27.5(2-212)	16
S2	20.6(1-87)	10
S3	109(13-232)	1

Table 6: Primary surgical procedure at emergency laparotomy.

Primary operative procedure	Number of patients	Mortality
Small-bowel resection	27 (31.3)	9(33.3%)
Colectomy-subtotal	24(27.9%)	5(18.5%)
Colectomy-right	14(16.2%)	6(22.2%)
Hartmann's procedure	12(13.9%)	3(11.1%)
Colectomy-left	01(1.16%)	1(3.7%)
Vascular procedures	03(3.4%)	2(7.4%)
Hernia	02(2.3%)	1(3.7%)
Drainage of abscess or collection	01(1.16%)	
Others	02(2.3%)	
Total	86	27

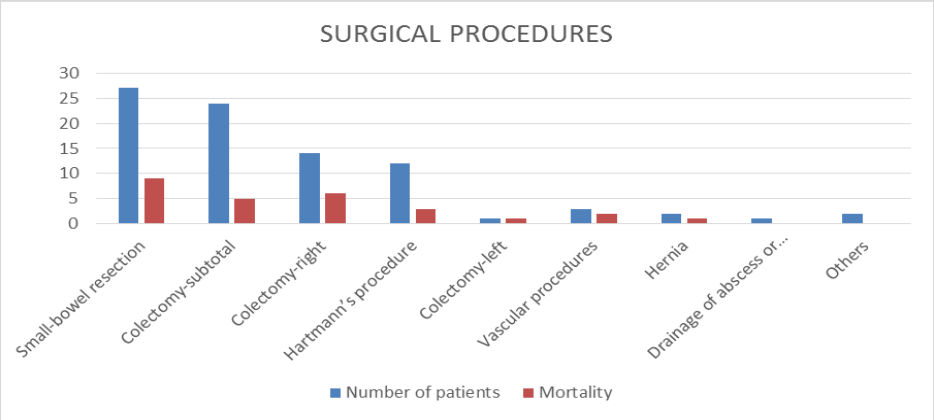


Table 7: Change in grade of AKI.

Stage of Aki	Total No. of Patients	Post Op Aki	No Change	Change in Grade To Normal	Increase in Grade	Decrease in Grade
S1	54	11	7	35(64.8%)	11	0
S2	26	1	7	10(38%)	7	1
S3	6		2	1(16.6%)	1	4
Total	86	12(13.9%)	16(18.6%)	46(53%)	19(22%)	5(5.8%)

Table 8: Requirement of renal replacement therapy.

STAGE OF AKI	Number of patients	Require renal replacement therapy (RR)
S1	54	4(4.6%)
S2	26	1(1.1)
S3	6	1(1.1)
Total	86	6(6.9%)

Stage	Serum creatinine	Urine output
1	1.5–1.9 times baseline or ≥0.3 mg/dl (≥26.5 µmol/l) increase	<0.5 ml/kg/h for 6–12 h
2	2.0–2.9 times baseline	<0.5 ml/kg/h for ≥12 h
3	3 times baseline or ≥4.0 mg/dl (≥353.6 µmol/l) increase or initiation of RRT or in patients <18 years a decrease in eGFR <35 ml/min/1.73 m^2	<0.3 ml/kg/h for ≥24 h or anuria ≥12 h

WHAT THIS STUDY ADDS

All emergency patients should undergo a risk assessment for AKI and all emergency admissions, regardless of the specialty, should have their electrolytes checked routinely on admission and appropriately thereafter. AKI should never occur in patients who have predictable and avoidable causes.

All patients who undergo laparotomy should have NELA and P-Possum Score assessment before laparotomy. It provided an estimated risk of mortality in 30 days. All acute admissions should receive adequate senior reviews as per NCEPOD recommendations and there should be sufficient critical care.

DISCUSSION

This study demonstrated that acute surgical emergency patients who required laparotomy within 48 hours of admission were associated with an increased risk of AKI. There is considerable concern about significantly high 30-day mortality in AKI patients who underwent laparotomy. Some studies focus on emergency surgery 32, ICU patients 17, and cardiac surgery and demonstrated high mortality.[4,17,19]

Few studies have shown the association between emergency surgery and AKI. In the present study, we found incidence of AKI in emergency laparotomies was 13.5%. This rate is higher as compared to exploratory laparotomy surgery 2 which has shown 3.5%. However, the incidence of AKI in cardiovascular surgery was reported 0.5 to 22.1 %.[33,34] The American College of Surgeons–National Surgical Quality Improvement Program (ACS–NSQIP) demonstrated 1% of non-cardiac surgery patients were complicated by AKI. Furthermore, all causes of 30-day mortality in patients who develop AKI and non-AKI were 42% and 8.6% respectively.[20] National Emergency Laparotomy Audit (NELA) showed 30-day emergency laparotomy mortality was 10.6 % but they did not do an analysis for AKI.[27] A recent study of hospital-acquired AKI in a UK acute hospital demonstrated an incidence of AKI was 2.2 % and it was associated with increased mortality but there was no increase in readmission rate.[21] It also showed that in-hospital-acquired AKI was associated with 34% mortality.

This study demonstrates the association of the worst prognosis in patients with AKI who present in the emergency department and underwent laparotomy as compared to non-emergency surgery without AKI. Association of duration of AKI, contrast study, dehydration, and sepsis in dose-response relationship of AKI. It also increases long-term outcomes including morbidity and mortality. Furthermore, the GIFTASUP guideline recommends the use of more balanced solutions like Ringer's lactate and Hartmann's solution.[22] Normal saline puts the AKI patient at risk of hyperchloremic metabolic acidosis and hypernatremia.[23] Accurate risk stratification of patients would enable the selection of optimal therapy and mitigate the effects of complications even before symptoms develop.[24] The first urinary biomarker for AKI which has been approved by U.S. Food and Drug Administration for risk stratification of AKI in critically ill patients is the product of the levels of tissue inhibitor of metalloproteinase 2 and insulin-like growth factor binding protein 7 (TIMP2*IGFBP7).[25]

One of the strengths of this study is we included all laparotomies, with and without AKI the results of the study could be generalized to varying populations and various clinical settings at tertiary hospitals. In this study, a Preoperative CT scan was performed and reported in 79% (68) cases and this helped in planning surgical management. However, contrast CT is associated with contrast dye-induced AKI and it has short and long-term mortality.[25] The proposed mechanism is a combination of hypoxia toxic damage and endothelial dysfunction.[26] However, Meta-analysis has shown that there is no difference in AKI, mortality in patients who receive contrast-enhanced CT or non-contrast CT.[30] In this study, we used RIFLE criteria to identify and stage acute kidney injury and it had been used and proven effective in other studies.[18,27,28,29]

There are some limitations to the current study. This study does not include Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and morbidity- (PPOSSUM), acute physiology, and chronic health evaluation (APACHE) II which are strong predictors of morbidity and mortality. The third patient report of the National Emergency Laparotomy Audit (NELA) was published in October 2017 which included P-POSSUM scoring for all patients who underwent laparotomies. NELA data had shown an emergency laparotomy-related mortality was 10.6% at 30 days.[32] Multiple possible co-founders were included in this study but there may be other factors that may lead to (observer) differences in results. Preoperative ASA physical status classification is an independent predictor of AKI even after adjusting GFR and other predictors of AKI.[33] The ASA physical status classification was not included in our study. It is a retrospective study. AKI is one of the complications after surgery, but it is associated with increased morbidity and mortality. Mild and moderate AKI are more common than severe AKI which is also shown in our series.[31]

CONCLUSION

AKI significantly affects overall outcome in surgical patients who presented to ED and underwent Laparotomies. All stages of AKI severity are associated with increased short and long-term morbidity and mortality. Clinical risk factors are not identical in different surgical populations. Current strategies should focus on better management of emergency patients with risk and susceptibilities for AKI.

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