Original Article

Comparative preoperative sonological assessment of gastric contents in patients with chronic kidney disease versus those with normal renal function - A prospective observational study

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ABSTRACT

Background and Aims: Though the role of fasting preoperative gastric ultrasound has been validated in different patient populations, namely, obese, pregnant and diabetics, it has not been explored in patients with chronic kidney disease (CKD). This prospective, observational study compared the fasting sonological assessment of gastric contents in patients with CKD versus those with normal renal function scheduled for elective surgery. **Methods:** After ethical approval and trial registration were obtained, preoperative gastric ultrasound was done in 115 CKD patients and 115 with normal renal function. Qualitative and quantitative assessment of residual gastric volume was done. Also, the patients were administered the Porto Alegre Dyspeptic Symptoms Questionnaire (PADYQ) to evaluate gastroparesis objectively. The researcher was not blinded to the patient groups. Data analyses were done using the Statistical Package for Social Sciences (SPSS) for Windows software (version 22.0). **Results:** Gastric volumes exceeding 1.5 ml/kg or particulate or solid contents were found in 57 patients with CKD and 36 patients with normal renal function ($P = 0.004$). The PADYQ scores were 6.54 ± 8.49 for CKD and 2.15 ± 5.71 for normal renal function ($P < 0.0001$) groups. CKD patients had a higher age ($P < 0.001$), lower body mass index ($P = 0.005$) and higher incidence of diabetes mellitus ($P < 0.001$). There were no incidents of gastric aspiration. **Conclusion:** Renal dysfunction contributes to delayed gastric emptying. PADYQ can also help identify those at high risk of gastroparesis. Combining the questionnaire and preoperative gastric ultrasound must be considered in these patients to ensure optimum safety.

Key words: Chronic kidney disease, fasting, gastro-oesophageal reflux, gastroparesis, renal insufficiency, ultrasonography

INTRODUCTION

Pre-anaesthetic gastric ultrasound determines the safe limits of preoperative fluid consumption.[1,2] A previous audit has determined that body mass index (BMI), gastro-oesophageal reflux disease (GORD) and chronic kidney disease (CKD) have a more significant effect on residual volumes than hours of fasting.[3] Detailed studies of gastrointestinal magnetic resonance imaging in fasted and fed states revealed the association of CKD with dysmotility and delayed gastric emptying.[4] Impaired gastric emptying has been demonstrated in CKD patients on peritoneal dialysis (PD), irrespective of PD fluid in the peritoneal cavity.[5] Dyspepsia in patients on haemodialysis (HD) correlated with Porto Alegre Dyspeptic Symptoms Questionnaire (PADYQ) scores, and octanoic acid breath testing revealed that

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the score correlated positively in dyspeptics and was associated with longer gastric emptying times than non-dyspeptics.[4]

The primary objective of this study was to perform fasting preoperative ultrasound for residual gastric volume in patients with CKD and compare the findings in patients with normal renal function posted for elective procedures. The secondary objectives were to assess if PADYQ can be used to delineate patients into a group at high risk for increased residual gastric contents and to determine other factors that may influence gastric volume, such as coexisting comorbid illness and drug intake.

METHODS

This prospective observational study was conducted between 10 February 2020 and 20 August 2020. Approval was obtained from the Institutional Scientific Advisory Committee and the Institutional Ethics Committee (NU Hospitals Ethical Committee- No. EC-CT-2017-0006 dated 06.01.2020), after which 230 patients were enrolled. The trial was registered with the Clinical Trials Registry - India (vide registration number CTRI/2020/02/023518, ww.ctri.nic.in). The study was conducted following the ethical principles laid down for medical research by the Declaration of Helsinki, 2013. Written informed consent was obtained from all the patients for participation in the study and using the patient data for research and educational purposes.

Consenting adults aged between 18 and 80 years with a creatinine clearance less than or more than 60 ml/kg/min/1.73 m^2 according to the Chronic Kidney Disease Epidemiology Collaboration creatinine formula, with American Society of Anesthesiology (ASA) physical status of I-III, presenting for elective surgical procedures were included. Exclusion criteria were pregnancy, patients who had undergone surgical procedures for gastro-oesophageal reflux disease, parkinsonism, hypothyroidism, multiple sclerosis and patients unwilling to participate in the study. Patients were questioned about the severity of dyspeptic symptoms with the help of PADYQ. The questionnaire was developed and validated originally to study non-ulcer dyspepsia.[6]

Based on creatinine clearance, the recruited patients were divided into two groups – normal renal function (defined as creatinine clearance of more than 60 ml/kg/min/1.73 m^2) and CKD (defined as creatinine clearance of less than 60 ml/kg/min/1.73 m^2). A complete history and physical examination of the patients were conducted. Age, height, weight, BMI, PADYQ scores, presence or absence of diabetes mellitus (DM), preoperative glycosylated haemoglobin (HbA1c) values, if available, whether patients were on dialysis or not, dialysis vintage of each patient and medication list of each patient were also noted. The medications known to affect gastric emptying adversely were withheld on the day of surgery. The only exceptions were calcium channel blockers, which were used to control preoperative blood pressure. Time to first meal postoperatively, the reason for the delay and any incidents of vomiting or aspiration were noted. All patients were advised to fast preoperatively for 8 h for a solid meal and for 2 h for clear liquids.

A preoperative sonological assessment of gastric contents was done in the holding area before patients were wheeled into the operation theatre complex. All ultrasound examinations were done with a General Electric Venue 40 system (General Electric, Chicago, IL, USA) with a curvilinear array probe with a frequency of 4 Hz or a MindRay Mobile trolley Model UMT-300 (MindRay Medical International Ltd, Shenzen, China) curvilinear array probe with a frequency of 4 Hz. The ultrasound examinations were done by one of the three anaesthesiologists. All three authors have published a previous audit in which they were trained to perform ultrasound examinations by the radiology team. Therefore, the initial 40 examinations were a part of the learning curve, after which the authors were deemed competent.

Patients were scanned in the supine, and the right lateral decubitus (RLD) position and the gastric content were assessed both qualitatively and quantitatively. The antrum was identified in the epigastric region, with the liver at a cephalad position and the aortic pulsation visualised posteriorly. Qualitative assessment was done by classifying the antral contents into empty, clear, particulate and solid. If the gastric antrum was empty, it was visualised as an empty structure with gastric rugosities. If the gastric antrum had clear content, the same antrum was visualised as a distended structure with the disappearance of the rugosities. If the antrum contained particulate substances, it was visualised as a starry sky appearance within the stomach. An antrum with solid contents was visualised as round and distended with thin walls and hyperechoic heterogeneous contents. A quantitative assessment of the antral contents was done by measuring the

antral content sonologically and applying the RLD cross-sectional area (CSA) to the previously validated formula below to arrive at the estimated gastric volume.[7] An average of three readings was taken in both positions. Figure 1 shows a typical image on a gastric ultrasound showing particulate contents.

(volume (ml) = 27.0 + [14.6 × RLD CSA − 1.28 × age])

Patients with an estimated gastric volume greater than 1.5 ml/kg and qualitative assessment revealing particulate or solid content were at high risk for aspiration in both groups. Patients with a high gastric volume were anaesthetised using rapid sequence intubation with Sellick's manoeuvre, adequate preoxygenation and avoidance of mask ventilation.

Data analyses were done using the Statistical Package for Social Sciences (SPSS) for Windows software (version 22.0). Sample size estimation was done considering the 7% prevalence of CKD in India, with a power of the study set at 0.8 and an alpha of 5%.[8] Descriptive statistics such as mean and standard deviation (SD) for continuous variables and frequencies and percentages for categorical variables were calculated. The association between variables was analysed using the Chi-square test for categorical variables. The quantitative variables' mean was compared using an unpaired *t*-test. PADYQ score analysis in detail was done using the Mann–Whitney test.

RESULTS

The demographic data of the study subjects have been presented in detail in Table 1. The presence of CKD was associated with a higher fasting gastric volume. A gastric volume of >1.5 ml/kg and/or solid or particulate content was seen in 57 patients in the CKD group and 36 in the normal renal function group ($P = 0.004$). A graphic representation of the volumes is shown in Figure 2.

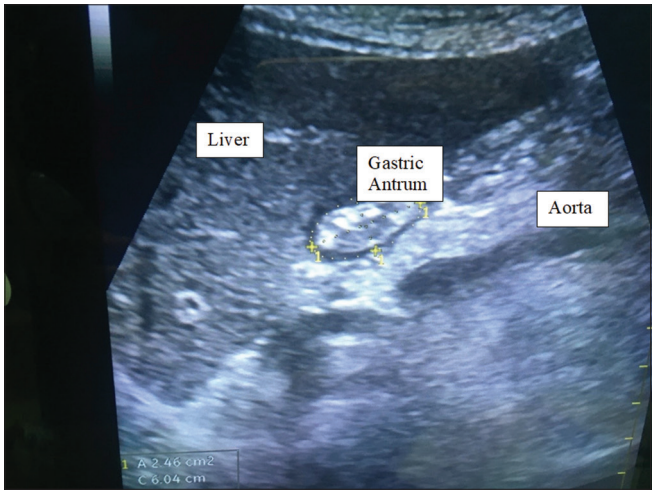

Figure 1: Gastric antrum visualised clearly between the liver and aortic pulsation, showing particulate content

Out of the 115 CKD patients, 14 received general anaesthesia (GA), 17 received intravenous (IV) sedation and/or regional anaesthetic (RA) and 84 received RA alone. Out of the 115 patients in the normal renal function group, 50 received GA, 27 received IV sedation and/or RA and 38 received RA alone. A total of four patients had delayed intake postoperatively due to bowel resection (one CKD patient and three normal renal function patients). All patients who had a delayed intake had received GA.

The PADYQ scores averaged 6.54 ± 8.49 for patients in the CKD group and 2.15 ± 5.71 among those in the normal renal function group ($P < 0.001$). PADYQ had a sensitivity of 34.4%, specificity of 73.7% and accuracy of 57.8% when measured against gastric ultrasound as the standard.

Age was significantly higher among those in the CKD group than those in the normal renal function group ($P < 0.001$). A separate correlation analysis between measured volumes and age revealed a small but significant negative correlation ($r = -0.40$). The patient's weight in the normal renal function group was significantly higher than those in the CKD group ($P = 0.001$). Among the CKD group patients, 41 who formed the greatest single group had a BMI range of 18.5–22.9. Among those in the normal renal function group, 71 were overweight, with a BMI range of 25–29.99 Kg/m^2 ($P = 0.005$). The incidence of DM was significantly higher in the CKD group ($P < 0.001$). Gastric volume, when compared between diabetics and non-diabetics in the two groups, was comparable ($P = 0.227$ and $P = 0.231$, respectively). Gastric volume was also comparable among patients on HD versus CKD patients not on HD ($P = 0.531$).

Analysis of time since the last meal proved clinically significant between the two groups, with an average preoperative nil per oral (NPO) duration of 13.42 h among those in the CKD group and 12.87 h among those in the normal renal function group ($P = 0.001$). Postoperatively, time to first meal consumption was significantly different between the two groups ($P < 0.001$).

Table 1: Demographic data

Variables	CKD group (*n*=115)	Normal renal function group (*n*=115)	*P*
Age (years)	58.2±15.21	48.70±17.80	-
Height (cm)	152.99±36.53	149.92±46.74	0.580
Weight (kg)	65.76±13.42	71.59±13.54	**0.001**
Body mass index (kg/m^2)	25.3±5.14	26.53±4.7	**0.049**
Sex			
Female	82	90	0.191
Male	33	25	
HbA1c	7.78±1.96	08.06±1.89	0.712
Nil per oral duration (h)	13.42±1.26	12.87±1.3	**0.001**
PADYQ	6.54±8.49	2.15±5.71	**<0.0001**
Diabetes mellitus (number of patients=*n*)			
Yes	78±67.8	43±37.4	0.0001
No	37±32.2	72±67.6	
Haemodialysis (number of patients=*n*)			
Yes	47±40.9	0	-
No	68±49.1		

CKD=chronic kidney disease, HbA1c=glycosylated haemoglobin, PADYQ=Porto Alegre Dyspeptic Symptoms Questionnaire, SD=standard deviation. Data are represented as mean±SD or number

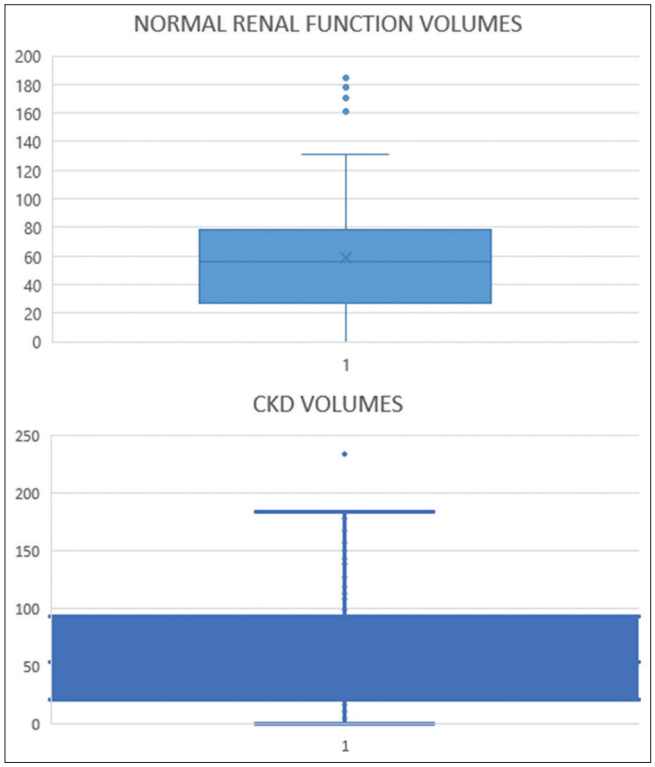

Figure 2: Box and whisker plot showing the average volumes in both groups CKD = chronic kidney disease

Table 2 describes the patient parameters for those with > 1.5 ml/kg gastric volume.

Drugs including proton pump inhibitors, H2 receptor blockers, calcium channel blockers, prokinetics, antiemetics, tricyclic antidepressants, iron supplements and steroid supplements did not contribute to higher gastric volumes. In addition, there were no incidents of gastric aspiration during the study period.

DISCUSSION

We observed in our study that CKD patients had a higher residual gastric volume than patients with normal renal function. Among those in the normal renal function group, only 16 had a PADYQ score higher than 6, compared to 52 in the CKD group. In our study, PADYQ had a sensitivity of 34.4%, specificity of 73.7% and accuracy of 57.8% when measured against gastric ultrasound.

A study to assess fasting preoperative gastric ultrasound between renal failure patients and normal healthy controls showed a 34% prevalence of delayed gastric emptying in patients with renal failure.[9] Although it has been extensively proven that CKD due to diabetes has delayed gastric emptying, it may be noted that non-diabetics with CKD also showed a significant delay.[10] Other studies also found that patients with CKD and DM had a statistically significant increase in unsafe gastric volumes.[11] CKD is also a clear indication for point-of-care ultrasound as these patients have delayed gastric emptying.[12] Cases had a statistically significantly higher age than controls. Increasing age causes various gastrointestinal motility disorders due to the combined effects of medications for comorbid conditions.[13] Age can be confounding because the validated formula for calculating gastric volume incorporates age. It needs to be studied if age alone is a significant factor to outweigh other comorbid illnesses such as DM and CKD.

BMI and body weight were significantly higher among controls than among cases. Raised BMI has

Table 2: Patients with gastric volume >1.5 ml/kg in both groups (high risk for aspiration)

Parameter	CKD group (*n*=57), Mean±SD	Normal renal function group (*n*=36), Mean±SD	*P*
Body mass index (kg/m^2)	25.21±5.14	27.40±4.15	0.049
Diabetes mellitus, *n*	38	18	CKD group – 0.227[1a] Normal renal function group – 0.531[1b]
EGFR (ml/kg/1.73 m^2)	14.68±13.87	96.56±16.76	-
Haemodialysis, *n*	22	NA	-
Preoperative fasting (h)	13.57	12.5	0.001
PADYQ			<0.01
>6	52	16	
>22	5	2	
Drug analysis			0.26
No drugs	4	28	
H2 receptor blockers	34	2	
PPI	9	0	
CCBs	30	2	
Domperidone	7	0	
Iron supplements	5	3	
Steroid	0	1	
Activated charcoal	0	1	
Acotiamide and Mebeverine	1	0	
USG parameters			0.15
Antral quality			
Clear	20	12	
Particulate	30	21	
Solid	7	3	
Volume >1.5 ml/kg	33	16	0.04
Anaesthesia plan change	2	0	0.253
Events			0.34
Nausea	0	1	
Vomiting	1	2	
Aspiration	0	0	
Postoperative meal			
Immediate	44	9	<0.001
<2 h	8	5	-
4–6 h	4	20	-
>24 h	1	3	-

CCB=calcium channel blockers, CKD=chronic kidney disease, DM=diabetes mellitus, EGFR=estimated glomerular filtration rate, H2 blockers=histamine receptor blockers, PADYQ=Porto Alegre Dyspeptic Symptoms Questionnaire, PPI=proton pump inhibitors, SD=standard deviation, USG=ultrasonography. [1a]Comparison of gastric volume between DM and non-DM among CKD group patients. [1b]Comparison of gastric volume between DM and non-DM among normal renal function group patients

been proven to be related to increased fasting gastric volume and antrum size.[14] Despite having lower BMI and longer fasting, cases had higher volumes than controls, which may suggest that CKD has a stronger association with increased gastric volume than BMI or hours of fasting.

Hours of fasting were significantly greater among cases as they had more extensive preoperative investigations and issues such as hyperkalaemia or hypertension that needed tackling, resulting in a delay in induction.

DM has been proven to cause gastroparesis despite fasting.[15] In our study, the incidence of diabetes was higher among cases than controls. However, gastric volume was not significantly different when patients were subanalysed between those with diabetes and those without among both subgroups.

Classically, erythromycin improves gastric motility in people with diabetes with gastroparesis.[16] None of our patients were on erythromycin. Calcium channel blockers delay gastrointestinal motility in animals; however, it has not been conclusively proven in normal subjects.[16] Metoclopramide has been proven to improve gastric liquid emptying when used acutely. However, it is ineffective when used chronically.[17] Patients with CKD are most commonly prescribed gastric acid–suppressive agents to combat their symptoms, and these drugs have also

been found to delay the emptying of solids more than liquids.[18,19] Gastroparesis in CKD patients does not improve on renal replacement therapy or even after a renal transplant.[20] Our data did not suggest a significant role for any drugs studied.

Our study has some obvious limitations. The patients in our control and case groups were not age-matched; we focused on other factors to include them in the study. The authors were not blinded to the patients.

CONCLUSION

CKD causes a sonologically demonstrable delay in gastric emptying, suggesting a routine pre-induction gastric ultrasound in all CKD patients. PADYQ can be used as a specific tool in categorising patients into risk groups.

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Conflicts of interest

There are no conflicts of interest.

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