Original Article

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Radiology Section

Diagnostic Accuracy of Transabdominal Ultrasonography in Evaluation of Gastric Malignancies: A Cross-sectional Study

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ABSTRACT

Introduction: Gastric Cancer (GC) is the fifth most common malignancy worldwide. Transabdominal Ultrasonography (TA-USG) is a non invasive and inexpensive imaging modality that is widely available. However, there is a lack of knowledge regarding the utility of USG among radiologists in the diagnosis of GC.

Aim: To evaluate the accuracy of TA-USG in the detection of gastric malignancy.

Materials and Methods: This was a cross-sectional study conducted in the Department of Radiodiagnosis at Father Muller Hospital, Mangaluru, Karnataka, India from October 2021 to February 2023. Patients with Upper Gastrointestinal (UGI) symptoms and suspected Gastric Carcinoma, who underwent UGI scopy (n=107) referred from the Departments of Gastrosurgery, Medical Gastroenterology, and Oncosurgery, were included. The sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) of TA-USG in the diagnosis of GC were determined.

Results: The TA-USG could diagnose 94 out of 107 cases of malignancy, with the best results in detecting antropyloric malignancy. TA-USG performed worst in early GC. The authors had four cases of early GC, all of which were not diagnosed with TA-USG. The sensitivity, specificity, PPV, NPV, Positive Likelihood Ratio (PLR), Negative Likelihood Ratio (NLR), and accuracy were calculated to be 87.85%, 93.83%, 86.24%, 94.61%, 14.23, 0.13, and 92%, respectively, with a p-value of <0.001.

Conclusion: The TA-USG is a valuable tool for detecting gastric malignancy, especially in patients with gastric outlet obstruction, a non distensible stomach, or other risk factors that preclude endoscopy. It can also play a role in regions where UGI endoscopy is not available.

Keywords: Endoscopy, Gastric cancer, Gastroenterology, Radiology

INTRODUCTION

Gastric Cancer (GC) is the fifth most common malignancy in the world, with approximately 70% of cases occurring in developing countries [1,2]. It is the fourth leading cause of death worldwide, with a higher incidence in men [3]. The incidence of GC is highest in East Asia, where it accounts for 40% of all new cases worldwide [4,5]. UGI endoscopy is the gold standard for diagnosing GC, but it is an invasive procedure that requires sedation or anaesthesia and may not be well-tolerated by all patients. Additionally, UGI endoscopy may not be available or accessible in some areas [6]. TA-USG is a non invasive and inexpensive imaging modality that is widely available. TA-USG has been shown to be effective in detecting various abdominal pathologies, including GC. However, TA-USG is not routinely used for GC imaging, and there is a lack of knowledge among radiologists regarding TA-USG imaging of the stomach [7].

The present study aimed to evaluate the utility and accuracy of TA-USG in the diagnosis of GC by comparing TA-USG findings with UGI endoscopy findings in patients diagnosed with GC. The study also examined the spectrum of TA-USG findings with fluid-filled techniques to assess the stomach.

MATERIALS AND METHODS

The present study was a cross-sectional study conducted at the Department of Radiodiagnosis at Father Muller Hospital, Mangaluru, Karnataka, India, from October 2021 to February 2023. Ethical approval was obtained from the Institutional Ethics Committee, with a letter numbered FMIEC/901/2021. Informed consent was obtained from all patients.

The study population consisted of patients with upper Gastrointestinal (GI) symptoms suspected to have gastric carcinoma who underwent UGI endoscopy. These patients were referred from the Departments of Gastrosurgery, Medical Gastroenterology, and Oncosurgery.

The sample size of 107 was determined based on the prevalence of gastric malignancy, which is 16.5 per 100,000 (GLOBOCAN 2020) [8].

Inclusion and Exclusion criteria: The inclusion criteria included patients aged between 18 and 90 years with UGI symptoms suspected to have gastric malignancy. The patients below 18 years or above 90 years of age, those with prior surgery or bypass involving the distal esophagus, stomach, or duodenum, patients with chronic liver disease or portal hypertension, those with acute haematemesis, known cases of gastric malignancy, patients unfit for UGI endoscopy, and patients not consenting to the study were excluded.

Study Procedure

The TA-USG was performed on the same day as the UGI endoscopy. Patients arrived in the morning for the UGI endoscopy, followed by conventional and high-resolution USG of the non distended stomach after 5-6 hours. This was done to screen for obvious lesions. Subsequently, conventional and high-resolution USG of the fluid-filled stomach was performed using a Philips IU22 machine. The fluid-filled technique that was followed included administering 500 mL-1000 mL of filtered water to the patient prior to the USG scan in order to displace the intraluminal gas. The patient was examined in the supine position, primarily focusing on the epigastrium, left and right hypochondrium regions, and in the right lateral position for a general screening of the stomach in both longitudinal and transverse planes. This was done to detect any obvious mass lesions.

After fluid distention of the stomach, the patient was examined using multiple manoeuvres. Firstly, the Esophageal-gastric (OG) junction was examined by placing the probe in the superior aspect of the epigastrium in both axial and sagittal views to visualise the OG junction. In the axial view, the probe was angulated approximately 30-40 degrees cranially to screen the lower esophagus. Secondly, the cardia and fundus were examined by moving towards the left hypochondrium. Following this, the body of the stomach was examined in the epigastrium, and then moving further right laterally into the right hypochondrium to examine the antropyloric region. The patient was also examined in the right lateral and left lateral positions to optimally imaging of different parts of the stomach and to displace residual air in the stomach.

The IU22 Philips Machine was used in the study, with the C5-1 curvilinear low-frequency probe and the L9-3 linear, flat panel, high-frequency probe. In instances where the IU22 machine was unavailable due to maintenance or unforeseen reasons, the authors used the HD-7 Phillips machine with the C5-2 curvilinear low-frequency probe and the L12-3 linear, flat panel, high-frequency probe.

The diagnosis of malignant gastric lesions was based on the criteria used in a study by Singh S and Chowdhury V [7]. These criteria include:

1. Wall thickness of more than 5 mm in all regions of the stomach and more than 8 mm in the distal antrum.
2. Loss of normal wall stratification.
3. Hypoechoic/heteroechoic echogenicity and irregularity of the wall.
4. Luminal narrowing.
5. Abnormalities of the surrounding connective tissues.

In equivocal cases where the USG findings did not meet the above criteria, the cases were labelled as negative for malignancy.

Blinding: The performing radiologist was not aware of the findings of the UGI endoscopy in terms of the location and extent of gastric thickening. All TA-USG scans were performed by the same radiologist. At the end of the study, the USG findings were compared with the UGI endoscopy findings.

STATISTICAL ANALYSIS

The data were analysed using Statistical Package for Social Sciences (SPSS) software version 22.0. The sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) of TA-USG in the diagnosis of GC were calculated.

RESULTS

A total of 107 patients were diagnosed with gastric carcinoma on UGI endoscopy. The most common symptoms reported were loss of appetite (n=50, 46.7%), weight loss (n=40, 37.3%), and nausea and vomiting (n=45, 42%) [Table/Fig-1]. The age distribution ranged between 28-88 years, with the majority in the 41-50 and 51-60 age groups, with a mean age of 57.2±13.1 years [Table/Fig-2]. The gender distribution consisted of 79.7% male (n=76) and 20.3% female (n=31) patients.

Symptoms	Frequency (n)
Pain abdomen	33
Nausea/vomiting	45
Indigestion	30
Dysphagia	24
Retrosternal pain	10
Loss of appetite	50
Weight loss	40
Haematemesis	28
Melena	4
Palpable mass	7
Gastric outlet obstruction	15

[Table/Fig-1]: Frequency distribution of symptoms.

Age distribution (years)	Frequency (n)	Percentage (%)
21-30	3	2.8
31-40	7	14.5
41-50	25	23.3
51-60	44	41.1
61-70	19	17.7
71-80	5	4.6
81-90	4	3.7
Total	107	100

[Table/Fig-2]: Age distribution frequency table.

In the present study of 107 cases of UGI endoscopy-proven GC, 27 (25.2%) consisted of antropyloric malignancy, 20 (18.7%) consisted of carcinoma at the GE-Junction, and 10 (9.3%) had lesser curvature malignancy [Table/Fig-3]. Out of these cases, four were early GC.

Cases	Frequency (n)	Percentage
AP malignancy	27	25.2%
Carcinoma GE junction	20	18.7%
Lesser curvature malignancy	10	9.3%
Greater curvature malignancy	19	17.7%
Carcinoma fundus/cardia	10	9.3%
Linitis plastica	9	8.4%
Malignant gastrointestinal stromal tumour	4	3.7%
Carcinoma body of stomach	6	5.6%
Gastric lymphoma	2	1.8%

[Table/Fig-3]: Case-wise frequency distribution of malignant lesions.

Using the fluid-filled technique of the stomach, the authors diagnosed 94 cases (87.8%) of GC, including all cases of Antropyloric (AP) malignancy, linitis plastica, and carcinoma of the body. The authors could not diagnose 13 cases (12.2%) of GC, including all four cases of early GC, three cases of gastric cardia cancer, two cases of cancer of the gastroesophageal junction, and two cases each of lesser curvature cancer and greater curvature cancer [Table/Fig-4].

Cases	Missed cases by USG
Carcinoma GE junction	2
Carcinoma fundal/cardia	3
Greater curvature carcinoma	2
Early gastric CA	4
Lesser curvature	2

[Table/Fig-4]: Number of cases missed on transabdominal USG.

The sensitivity, specificity, PPV, NPV, PLR, NLR, and accuracy of TA-USG in diagnosing GC were calculated to be 87.85%, 93.83%, 86.24%, 94.61%, 14.23, 0.13, and 92% respectively, with a p-value of <0.001 [Table/Fig-5].

Variables	Values
Sensitivity	87.85%
Specificity	93.83%
Positive Likelihood Ratio (PLR)	14.23
Negative Likelihood Ratio (NLR)	0.13
Positive Predictive Value (PPV) (*)	86.24%
Negative Predictive Value (NPV) (*)	94.61%
Accuracy (*)	92.00%
p-value	<0.001

[Table/Fig-5]: USG in comparison to UGI endoscopy.

Wall stratification was lost in all 94 detected cases of gastric malignancy detected by USG, which turned out to be true positives. Among the false positive cases, four cases showed loss of wall stratification. All 94 cases diagnosed by TA-USG showed hypoechoic echotexture. It was noticed that gastric lymphoma tended to have a more homogenously hypoechoic echotexture compared to other malignancies. Among the 10 false positive cases, eight cases showed hypoechoic echotexture.

Luminal narrowing was noted in all cases of antropyloric malignancies and linitis plastica. The rest of the gastric malignancies presented with focal wall thickening without luminal narrowing.

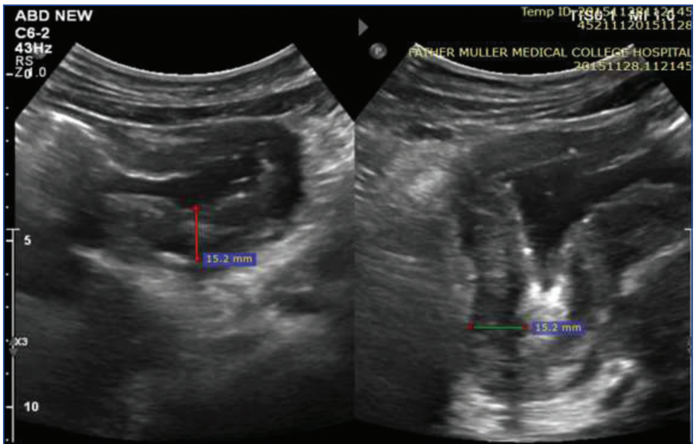
Out of the 27 malignant cases, evidence of local infiltration was seen, including five cases of transverse colon infiltration, two cases of pancreatic infiltration, eight cases of hepatic infiltration, and 12 cases of perigastric fat involvement. Distant metastasis was detected in nine patients, with eight cases showing hepatic metastasis and one case showing periumbilical deposit. The cut-off for malignant wall thickening was 10.25 mm, with a mean thickness of 13.41±4.95 mm.

DISCUSSION

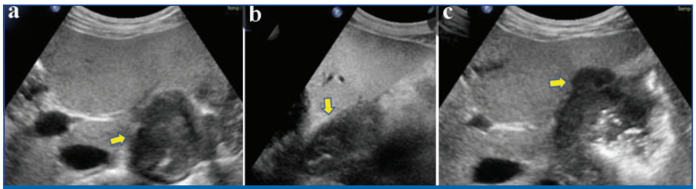
The most common symptoms in the present study were loss of appetite, weight loss, and nausea and vomiting. These symptoms are also commonly reported in patients with GC in other studies [7,9]. It is important to note that these symptoms are non specific and can make early diagnosis of GC challenging.

The TA-USG has been shown to be capable of diagnosing gastric malignancies with the factors mentioned above, which is consistent with findings from Wong M et al., Tomizawa M et al., and O'Malley ME, Wilson SR [9-11]. Wong M et al., demonstrated in a case report that TA-USG can identify gastric wall thickening with loss of mural stratification, and the use of fluid-filled techniques can enhance visualisation of the stomach [9]. Tomizawa M et al., stated in their study that stomach wall thickening detected on TA-USG is likely indicative of submucosal and deeper infiltration [10]. O'Malley ME and Wilson SR highlighted in their study that hypoechoic gastric wall thickening with loss of wall stratification can be detected on TA-USG [11]. The accuracy of TA-USG in detecting GC depends on various factors, including tumour size, location, and the experience of the radiologist.

In the present study, TA-USG was able to diagnose 94 out of 107 cases of malignancy, with the best results seen in detecting Antropyloric malignancy [Table/Fig-6]. The most common site of malignancy in the present study was the Antropyloric region, accounting for 27 cases (25.2%). TA-USG successfully detected all 27 cases of Antropyloric malignancy. The second most common site was carcinoma at the Gastroesophageal (GE) Junction [Table/Fig-7a-c], which included 20 cases (18.7%). These findings align with those reported by Singh S and Chowdhury V [7]. In their study, Singh S and Chowdhury V noted that tumours in the distal stomach are more easily accessible and therefore more frequently diagnosed than tumours in the proximal stomach [7].

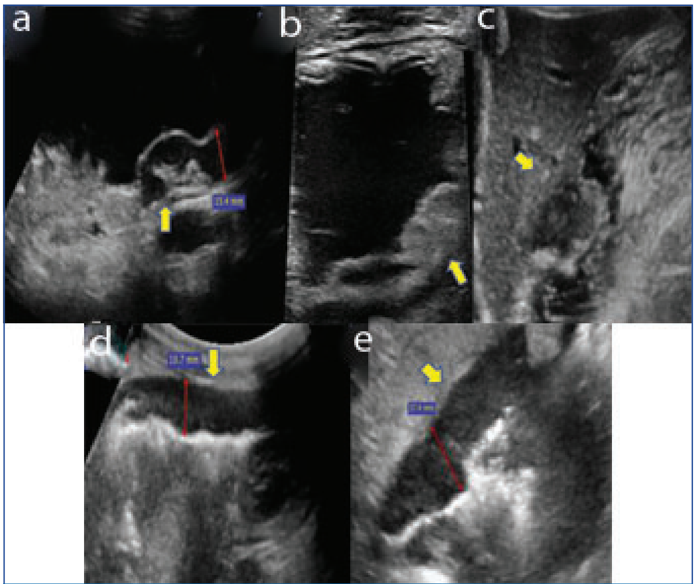


[Table/Fig-6]: Malignant gastric Antropyloric wall thickening with extension into (measuring a maximum thickness of 15.2 mm).



[Table/Fig-7]: GE junction malignancy. (a) and (c) Transverse USG sections; (b) longitudinal USG sections, showing e/o hypoechoic asymmetrical wall thickening involving the GEJ (maximum thickness 18 mm) with e/o hepatic infiltration; (c) (arrows).

In the present study, the authors were able to detect all cases of Antropyloric malignancy as this region is easily visualised on TA-USG, especially with the use of fluid-filled techniques. However, the authors encountered challenges in imaging lesions of the posterior wall of the stomach, GE junction, fundus, and cardia [Table/Fig-8a-e]. These findings are consistent with those reported by Wong M et al., and Perlas A et al., [9,12]. Wong M et al., and Perlas A et al., both state that the gastric fundus is the least amenable to image due to its location and the presence of air that is difficult to displace. Goudarzi M et al., emphasise the importance of careful evaluation of the stomach to detect lesions [13]. The presence of air can obscure the posterior wall, while over-distention of the stomach can make imaging of the posterior wall challenging. Additionally, imaging the fundus is difficult due to its location. Even with manoeuvres such as positioning the patient in the right lateral position, imaging the fundus remains challenging due to its location and the difficulty in displacing air, as supported by Miyamoto Y et al., Deslandes A, and Worlicek H et al., [14-16].



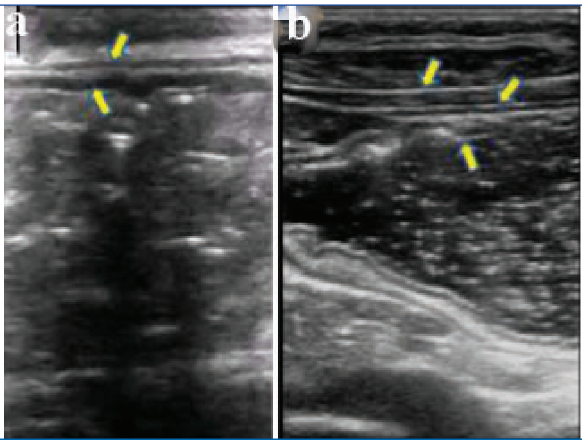
[Table/Fig-8]: USG images depicting malignancy involving the posterior body (a), greater and lesser curvature (b and c), anterior body (d) and fundus (e) (arrows).

In the Tumour, Node, Metastasis (TNM) classification used for staging GC, involvement of the submucosa is classified as T1, involvement of the muscularis propria as T2, involvement of subserosal connective tissue as T3, and involvement of the visceral peritoneum and adjacent structures as T4. Most of the cases in the present study were classified as T3 (n=68) and T4 stages (n=22), and no T1 stage tumours could be detected. We found it challenging to image T1 and T2 tumours unless careful observation and sufficient time were devoted to their detection. This finding is consistent with the study by Liao SR et al., [17].

The cut-off values for malignant wall thickening mentioned by Singh S and Chowdhury V were 10 mm, Wong M et al., reported a mean thickness of 12.2±3.45 mm, and Goudarzi M et al., used a cut-off of 7 mm [7,9,13]. The values we obtained in our study were lower compared to these previous studies. This could be attributed to better access to healthcare and improvements in TA-USG, leading to improved detection of gastric lesions in their early stages.

As discussed in detail above, wall thickening is a common criterion for diagnosing gastric malignancies. However, it is important to note that gastric ulcers and gastritis can also present with gastric wall thickening, as explained earlier. The cause of gastric wall thickening can be both neoplastic and non neoplastic, as supported by Goudarzi M et al., [13]. However, in the present study, gastric wall thickening was more commonly found in malignant cases.

The normal appearance of the gastric wall [Table/Fig-9a,b] is similar to that of other bowel segments, with a target appearance and distinct layers. The layers consist of the muscle layer, which appears hypoechoic, and the other layers appear hyperechoic [7,8,11,17]. This is known as wall stratification and is due to the differences in acoustic impedance between the layers. The layers include the hyperechoic mucosa, hypoechoic muscularis mucosa, hyperechoic muscularis mucosa, hypoechoic muscularis propria, and hyperechoic serosa. However, some articles describe only three layers of the stomach, including the hyperechoic mucosa and submucosa, hypoechoic muscularis propria, and hyperechoic subserosa [9].



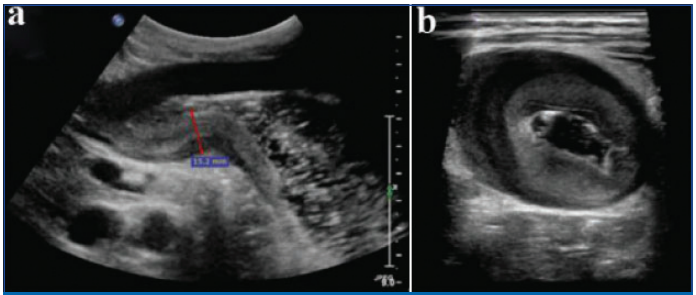
[Table/Fig-9]: (a) and (b) Normal wall stratification. High frequency transverse sections (USG) of the stomach showing the 5-layers of the stomach, the hypoechoic layers are the muscle containing layers (muscularis mucosa and propria) (arrows in (a) and the hyperechoic layers, mucosal air interface, the submucosa and the serosa (arrows in b).

In the present study, we observed that when we zoomed into the gastric wall using a high-frequency probe and fluid-filled techniques, the authors were able to appreciate all five layers of the gastric wall [16]. However, when zoomed out at normal magnification, only the three layers as described earlier were visible. Loss of mural stratification is a sign of gastric wall disease and can be attributed to wall oedema or an infiltrative process. This is known to be a sign of malignancy, which is supported by multiple studies [7,9-15,17,18].

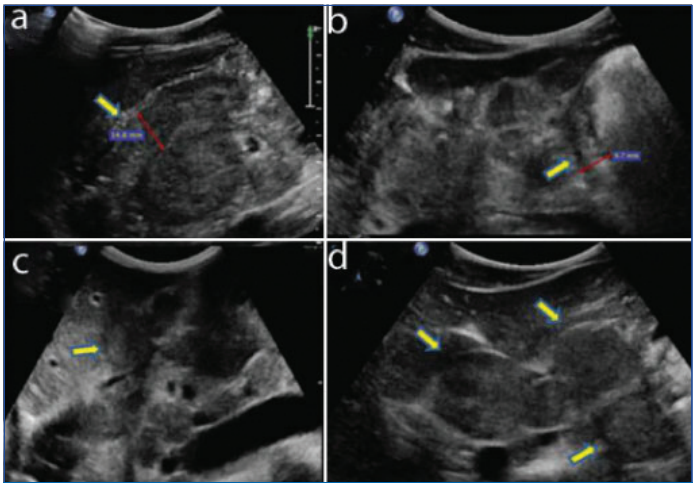
There are two situations that can arise: wall thickening with loss of wall stratification, and wall thickening without loss of wall stratification. The former is an indicator of malignancy and an infiltrative sign of the disease, while the latter is typically found in non neoplastic cases such as gastric ulcers, gastritis, and Menetrier's disease, as described by Wong M et al., [9]. However, it is important to note that non neoplastic cases with gastric wall thickening and loss of mural stratification can also be present. This can be explained by the presence of deep ulcers or severe gastritis, both of which can cause gastric wall oedema.

In the present study, the authors encountered 10 cases of false positives, which occurred earlier in the study and can be attributed to the operator's inexperience. In these cases, inadequate stomach distention led to a false impression of wall thickening. The authors also encountered cases of portal gastropathy and Menetrier's disease, which can mimic gastric carcinoma. In portal gastropathy, other features of liver failure are typically present. Additionally, in severe gastritis, wall thickening and loss of mural stratification can occur, although this is rare in the era of proton pump inhibitors.

In the present study, the authors found that Transabdominal Ultrasound (TAUS) had advantages over UGI endoscopy in patients with gastric outlet obstruction and non distensible stomach, such as in cases of linitis plastica [Table/Fig-10a,b]. TAUS also aided in the evaluation of disease spread, including lymph nodes [Table/Fig-11a-d] and hepatic metastasis.



[Table/Fig-10]: Linitis Plastica. USG, a) (transverse) and b (longitudinal) diffuse gastric hypoechoic wall thickening with relative sparing of the mucosa.



[Table/Fig-11]: Antropyloric malignancy with multiple lymph nodes and body involvement. (a,b,d) Transverse low frequency USG sections and (c) low frequency longitudinal USG section: Antropyloric malignancy. (a) and (b) Asymmetrical wall thickening with loss of mural stratification involving the antropyloric region (arrows) (maximum thickness (18 mm)) with extension into posterior body (b) (arrow); (c) and (d) Multiple lymph node involvement (periportal/paraaortic/coeliac/perigastric stations) (arrows).

A systematic review and meta-analysis conducted by Zhang Y et al., involving seven papers found that the accuracy of TAUS in detecting Gastric Cancer (GC) is higher for larger tumours and tumours located in the antrum and body of the stomach [19]. This is consistent with the findings of the present study. The diagnostic accuracy odds ratio was higher for advanced GC compared to early GC, with an odds ratio of 5.74 (95% confidence interval: 4.27-7.17). The pooled accuracy for advanced GC was 79.7% and for early GC was 38.7% [19].

Another study by Sato K et al., states that TAUS can be used to assess the depth of tumour invasion in GC and potentially avoid more invasive modalities like Endoscopic Ultrasound (EUS) [20]. TAUS is also valuable in evaluating treatment efficacy and monitoring patients with GC [20]. However, TAUS is more accurate in detecting late-stage gastric carcinomas and may have limitations in detecting early-stage gastric carcinomas, which aligns with the findings of the present study.

The findings of the present study have several potential clinical implications. Firstly, TAUS could be used as a screening tool for gastric malignancies in high-risk populations, such as patients with chronic gastritis or a family history of GC. Secondly, TAUS could serve as a follow-up tool for patients with known gastric malignancies to monitor disease progression and treatment response. Lastly, TAUS could be employed to guide biopsies or other interventional procedures in patients with suspected or known gastric malignancies.

Limitation(s)

This was a single-centre study, and larger multicentre studies are needed to validate the present study findings. The authors did not evaluate the doppler and vascularity of wall thickening, so future studies should investigate the role of doppler USG in the diagnosis of gastric malignancies. Imaging the stomach in its entirety was challenging in obese patients. Further studies are needed to evaluate the use of different impedance agents, such as contrast agents, to improve stomach imaging in obese patients. The authors did not utilise contrast and elastography in the present study. Contrast agents may improve the visualisation of the stomach in obese patients, but more research is required to evaluate their effectiveness and safety. Elastography may be helpful in distinguishing between benign and malignant wall thickening, as malignant wall thickening is often stiffer than benign wall thickening. The limitations of the present study may restrict the generalisability of the present findings and may limit authors ability to detect certain types of gastric malignancies, particularly early gastric cancer.

CONCLUSION(S)

Transabdominal Ultrasound (TAUS) is a highly accurate method for diagnosing GC, particularly in advanced cases. Based on the present study findings, the authors propose that TAUS could be used as a first-line imaging modality for the diagnosis of GC. TAUS is a valuable technique that does not involve radiation and can effectively detect GC. Future studies should focus on evaluating the role of TAUS in specific clinical settings, such as screening high-risk populations or the follow-up of patients with known gastric malignancies. Additionally, further research should investigate the potential benefits of combining TAUS with other imaging modalities, such as computed tomography or magnetic resonance imaging, to enhance diagnostic accuracy and staging.

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