Diagnostic Performance of Multidetector Computed Tomography in the Evaluation of Esophageal Varices: A Meta-Analysis Study

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Abstract- Multidetector Computed Tomography (MDCT) imaging is a noninvasive tool that does not necessitate sedation and allows accurate assessment of the variceal site and size. Patients experience better tolerance when using MDCT than upper GI endoscopy (EGD). The present study aimed to assess the efficacy of MDCT in evaluating esophageal varices. We conducted a thorough search of international databases (Web of Science, PubMed, Embase, and Scopus) and extracted studies using the appropriate keywords to investigate the efficacy of MDCT in evaluating esophageal varices. The collected data were analyzed using the random and fixed-effects model and STATA (version 15). 17 articles aligned with the inclusion criteria, published between 2008 and 2022, were included in the study. The pooled data of 15 articles on MDCT sensitivity and specificity were 0.87 and 0.82, with 95% CI of 0.85-0.89 and 0.81-0.84, respectively. The meta-analysis of the data from fourteen articles showed a pooled PPV of 0.85 and a pooled NPV of 0.84, with 95% CI of 0.83-0.87 and 0.82-0.85, respectively. Also, our meta-analysis of eight surveys that reported accuracy revealed a high pooled accuracy of 0.92 (95% CI: 0.90-0.93), underscoring the reliability of MDCT in evaluating esophageal varices. These findings strongly suggest that MDCT holds considerable potential as a valuable diagnostic tool for clinicians managing patients with liver cirrhosis and suspected esophageal varices, paving the way for more effective patient care.

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Introduction

Esophageal varices are dilated submucosal veins in the lower esophagus due to increased portal pressure secondary to liver disease. They pose a significant risk of bleeding, which can be life-threatening (1). Early detection and accurate grading of esophageal varices are crucial for risk stratification, treatment planning, and prognosis assessment (1). Imaging is essential in diagnosing and assessing esophageal varices, guiding treatment decisions, and estimating prognosis (2). Endoscopic techniques, such as esophagogastroduodenoscopy (EGD), have traditionally been the gold standard for diagnosing esophageal varices due to their high sensitivity and specificity. However, EGD is an invasive procedure with associated risks and limitations, including patient discomfort, the need for sedation, and operator dependence (3). Non-invasive imaging modalities, such as Multidetector Computed Tomography (MDCT), offer an alternative approach to evaluating esophageal varices, providing detailed anatomical information without requiring invasive procedures (4). MDCT, with its ability to provide detailed anatomical information and assess vascular structures, has emerged as a promising imaging modality for evaluating esophageal varices (5).

Several studies have investigated the diagnostic performance of MDCT in detecting and grading esophageal varices compared to EGD, the reference standard (5,6). Overall, MDCT has demonstrated good

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sensitivity and specificity in detecting esophageal varices, with reported sensitivities ranging from 70% to 90% and specificities ranging from 80% to 95%. MDCT can accurately identify the presence of esophageal varices, characterize their size and location, and assess associated complications such as variceal hemorrhage and portal vein thrombosis (7).

Advancements in MDCT technology, including multi-planar reconstruction, dual-energy CT, and perfusion imaging, have further improved its diagnostic accuracy, and enabled comprehensive evaluation of esophageal varices (8). Dual-energy CT, for example, allows for the differentiation of varices from surrounding tissues based on their material composition, providing additional diagnostic information and enhancing tissue characterization (9).

The primary objective of this study is to establish the diagnostic effectiveness of MDCT in detecting and grading esophageal varices in cirrhotic patients and compare its efficacy with conventional EGD. MDCT is expected to be highly sensitive and specific, thus making it a reliable, non-invasive test rather than a routine endoscopy to assess esophageal varices.

Materials and Methods

The present study was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (10).

A comprehensive search was performed to extract published studies reporting the role of dynamic contrast-enhanced and diffusion-weighted magnetic resonance imaging in evaluating endometrial lesions. Keywords used included "multidetector computed tomography", "esophagus", "esophageal varices", "esophagus varices", "X-ray computed", "sensitivity", "specificity", and "varic". These keywords were also combined using Boolean operators ("OR" and "AND") to search international databases, including ISI, PubMed, Embase, and Scopus. Google Scholar was searched for studies not included in the mentioned databases. After that, references of the extracted studies were checked to find potentially relevant studies. All records were then imported into the EndNote, and duplicates were deleted.

Study selection

After eliminating the duplicate studies, the titles and abstracts of the remaining articles were checked to find eligible studies based on the following inclusion and exclusion criteria.

Inclusion criteria included only original research studies involving human subjects of any age, gender, or ethnicity. Participants must have suspected or confirmed esophageal varices diagnosed by any reference standard (e.g., endoscopy).

Studies that utilize MDCT as the index test for evaluating esophageal varices were included. Studies reporting data on MDCT's diagnostic performance parameters for the detection and characterization of esophageal varices were also included. These parameters may consist of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and area under the receiver operating characteristic curve (AUC). No language restrictions were imposed, and studies published in languages other than English were included if translation resources were available.

Reviews, case reports, editorials, letters, conference abstracts, or studies with inappropriate or insufficient data were excluded. In vitro and animal studies, non-esophageal varice, and non-MDCT imaging modalities-based studies were excluded. In addition, studies that did not present complete diagnostic performance data (i.e., sensitivity, specificity, PPV, NPV) for MDCT in esophageal varices assessment were excluded.

Data extraction and quality assessment

Data was extracted from the selected studies by two authors. They included the authors' names, locations, publication date, sample size, ages, study design, and positive predictive value (PPV) and negative predictive value (NPV) of MDCT methods. All the data were reviewed for potential bias by other authors and confirmed by all. The Newcastle-Ottawa scale was used to assess the methodology and quality of the studies (11). Articles with scores 0-3, 4-6, and 7-9 were considered low, medium, and high quality; none of the studies scored <4 (Table 1).

Characteristic data

This meta-analysis includes seven prospective, four retrospective, and four cross-sectional articles. A total of 1443 people were examined. The Mean±SD age of the investigated subjects was 61±11.02 years, and the age range was 42 to 83 years (Table 2).

Evaluation of MDCT diagnostic performance

Meta-analysis of 17 studies that assessed the diagnostic yield of MDCT in the evaluation of esophageal varices was promising. Pooled sensitivity of MDCT was 0.87 (95% CI: 0.85-0.89), indicating that

MDCT is highly sensitive for detecting esophageal varices with very few chances of false negatives (Figure 2.). Pooled specificity was 0.82 (95% CI: 0.81-0.84), which means that MDCT has moderate accuracy to discriminate between patients with and without esophageal varices (Figure 3). PPV was 0.85 (95% CI: 0.83-0.87) and NPV was 0.84 (95% CI: 0.82–0.85), illustrating that MDCT is a precise method for both the confirmation and exclusion of the presence of esophageal varices in clinical practice.

The high pooled accuracy of 0.92 (95% CI: 0.90-0.93) illustrates the overall diagnostic accuracy of MDCT, making it a valuable alternative to traditional invasive examinations like EGD (Figure 4.). Clinically, these results suggest that MDCT can be helpful in the non-invasive screening and grading of esophageal varices, particularly in resource settings where EGD is not available or appropriate, or in patients who are intolerant of invasive procedures. However, while MDCT has high sensitivity, its moderate specificity should encourage clinicians to seek confirmatory testing, when necessary, particularly in individuals with high clinical suspicion of varices but negative MDCT findings.

Publication bias

After the evaluation, according to Begg's test, there was no publication bias. The results of Begg's test and funnel plot are presented in Figure 5.

Table 1. Quality assessment table

First author's name	Type of Study	Selection				Comparability	Outcome			Total
		1	2	3	4	1	1	2	3	
Cansu (12)	Prospective	*	*			*	*	*		5
Karatzas (13)	Prospective	*			**	*	**			6
Perri (14)	Prospective	*	*	*	*	*	*	*	*	8
Kim (15)	Retrospective	*	*			*	**			5
Zhu (16)	Retrospective	*	*	*		*	**			6
Yu (17)	Retrospective	*	*		**	*	**	*		8
Lipp (18)	Retrospective	*	*	*	*	*	*	*		7
Shah (19)	Cross-sectional	*	*	*		*	**	*	*	8
Abdelmawgoud (20)	Cross-sectional	*	*	*	*	*	*	*		7
Mohamed (4)	Prospective	*	*	*		*	*	*	*	7
ELKammash (5)	Prospective	*	*		**	*	**	*	*	8
BASHIR (21)	Cross-sectional	*	*			*	*	*		5
Dessouky (22)	Prospective	*		*	*		**	*	*	7
Ali (23)	Prospective	*	*	*	*		*	*		6
Wan (24)	Cross-sectional	*	*		**		**	*		7

Risk of bias between studies

Begg's funnel plots and Egger's test were selected to evaluate the data's publication bias, and *P* less than 0.05 were considered significant.

Statistical analysis

The effect size and the 95% CI were calculated using Stata version 15. Also, the publication bias was assessed using Begg's test. We measured the heterogeneity of each group using the inconsistency index (I^2). An I^2 greater than 50% or a *P* lower than 0.05 is recognized as significant heterogeneity. If the heterogeneity was high, a random-effect model was used to calculate the pooling effect and 95% CI. Otherwise, the fixed effect was used. The diagnostic value of dynamic contrast-enhanced and diffusion-weighted magnetic resonance imaging in evaluating endometrial lesions was determined by calculating the pooled positive predictive value (PPV), negative predictive value (NPV), and accuracy, with 95% confidence intervals (CI).

Results

Study selection

A total of 17 studies were included in this meta-analysis, as illustrated in the PRISMA flow diagram. Initially, 161 records were identified through database searching across PubMed (26), Scopus (78), Embase (13), and ISI (44). After removing duplicates, 85 records remained. Of these, 47 studies were excluded after screening titles and abstracts due to irrelevant data or not meeting the inclusion criteria. A further 9 studies were excluded after full-text assessment for being review articles, case reports, or having insufficient data. Ultimately, 17 studies were included, with a total of 1,443 patients across prospective (7), retrospective (4),

and cross-sectional (6) designs. The steps of selecting the studies are shown in Figure 1.

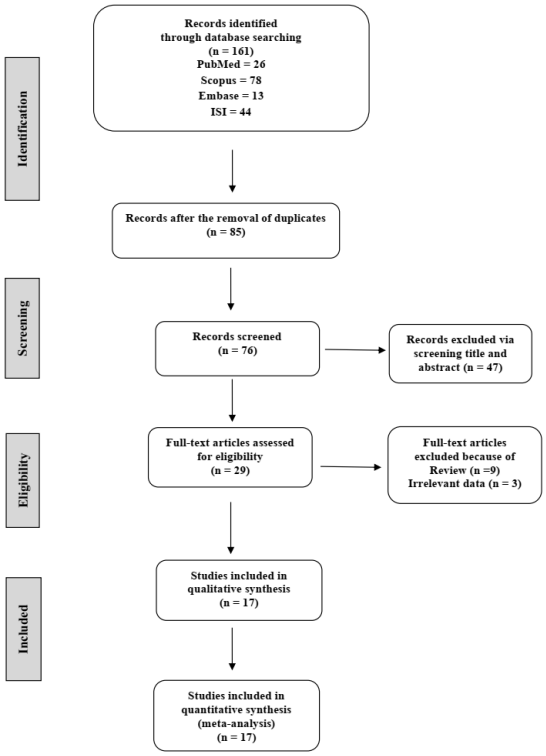

Figure 1. PRISMA flow diagram illustrating selection of articles

Table 2. Characteristics of the studies reviewed in the present study

AUTHOR (Ref)	Year	Country	Sample Size	Age (Mean±SD)	Study design	Technique	Minimum slice thickness (mm)
Cansu (12)	2014	Turkey	42	56.2±13	Prospective	N/A	
Karatzas (13)	2016	Greece	38	63±12	Prospective	GE Lightspeed 16x	0.625-1.2
Perri (14)	2008	USA	101	59.2±10.5	Prospective	N/A	0.5-1.5
Kim (15)	2009	Republic of Korea	110	-	Retrospective	N/A	5
Zhu (16)	2010	China	127	-	Retrospective	N/A	2.5
Yu (17)	2011	USA	109	55.9±11.8	Retrospective	Systems, Milwaukee, Wisconsin"	1
Lipp (18)	2011	USA	165	-	Retrospective	N/A	1
Shah (19)	2020	Pakistan	180	47.57±10.56	Cross-sectional	N/A	N/A
Abdelmawgoud (20)	2021	Egypt	35	55.23±8.46	Cross-sectional	N/A	N/A
Mohamed (4)	2020	Egypt	50	49.9	Prospective	N/A	0.7
ELKammash (5)	2016	Egypt	112	51.14±8.4	Prospective	"128 multidetector	5
BASHIR (21)	2017	Pakistan	145	-	Cross-sectional	CT scanner (GE Optima CT model 660)"	5
Dessouky (22)	2013	Egypt	137	58.7	Prospective	N/A	1
Ali (23)	2022	Egypt	39	-	Prospective	"16 slice scanner, Activation	1.5
Wan (24)	2020	China	53	57	Cross-sectional	16 model TSX-031A-2012"	1-2

Table 3. Diagnostic performance according to sensitivity, specificity, PPV, NPV, and accuracy

AUTHOR	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)
Cansu	75.8	66.7	89.3	42.9	73.8
Karatzas	86.1	57.1	77.5	70.6	
Perri	56	87	77	75	
Kim	92	92	86	96	
Zhu	81	96	82	96	78.7
Yu	76	49	67	64	
Lipp	89	68	69	72	
Shah	93.33	94.67	96.08	91.03	93.89
Abdelmawgoud	93.75	100	100	95	97.14
Mohamed	99.5	99.6	99.4	99.5	99.5
ELKammash	94.8	98.5	94.8	98.5	97.8
BASHIR	94.4	89.2	84.6	96.2	93.1
Dessouky	99	98	99	98	99
Ali	92.8	100	100	72.7	
Wan	80	75			

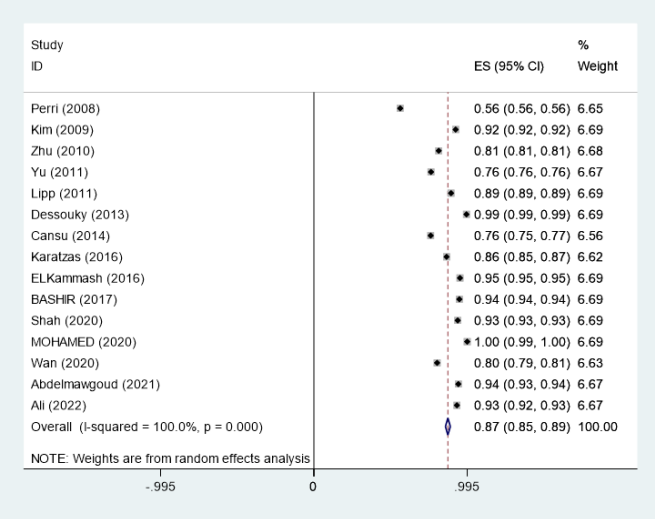

Figure 2. Forest plot of the sensitivity of the MDCT for identifying esophageal varices

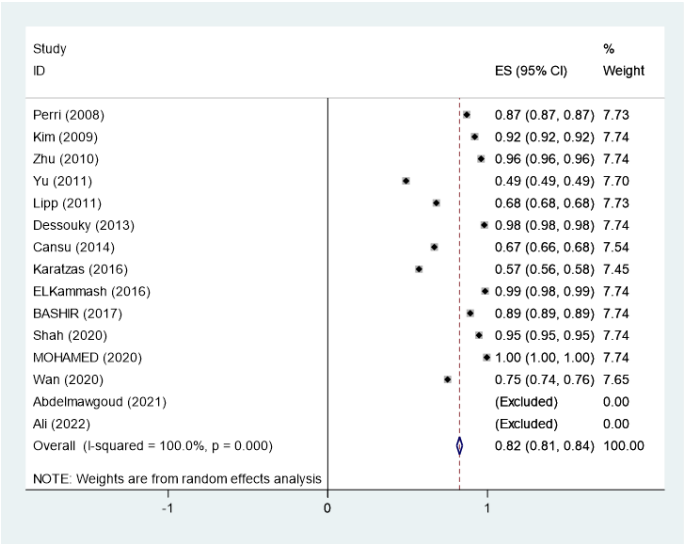

Figure 3. Forest plot of the specificity of the MDCT for identifying esophageal varices

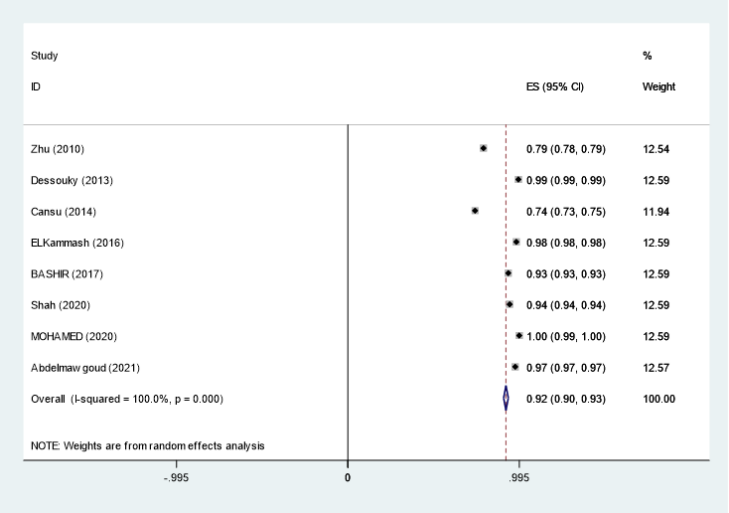

Figure 4. Forest plot of the accuracy of the MDCT for identifying esophageal varices

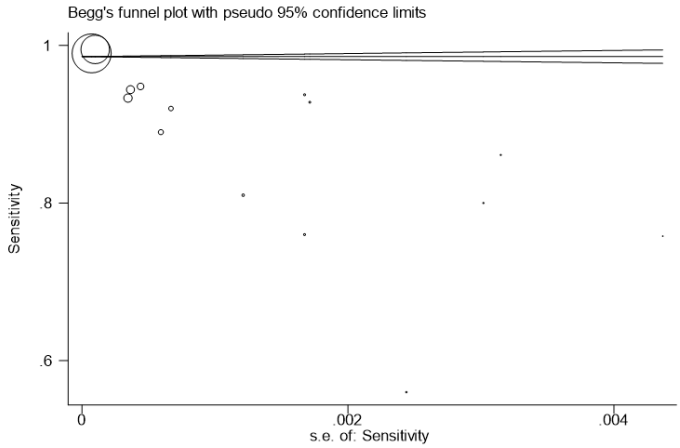

Figure 5. Publication bias test using Begg's funnel plot test

Discussion

MDCT's noninvasive nature, high sensitivity, and specificity make it a valuable alternative to invasive procedures like endoscopy. It offers a well-tolerated and effective imaging modality for diagnosing and grading esophageal varices in cirrhotic patients (23).

The present study evaluated MDCT's diagnostic performance in assessing esophageal varices. Our meta-analysis revealed MDCT's promising diagnostic performance in evaluating esophageal varices. The pooled sensitivity and specificity were found to be 0.87 and 0.82, respectively, indicating a relatively high sensitivity in detecting esophageal varices while maintaining acceptable specificity.

However, our study also highlights several important considerations regarding the utility of MDCT in this context. Firstly, while MDCT demonstrates good sensitivity, its specificity remains moderate. While MDCT may effectively identify patients with esophageal varices, it may also yield false-positive results, potentially leading to unnecessary interventions or increased healthcare costs. Hence, clinicians should interpret MDCT findings cautiously and consider additional confirmatory tests in cases of diagnostic uncertainty (25).

Several studies have reported high sensitivity, specificity, PPV, NPV, and accuracy for MDCT in detecting and grading EVs (25-27). In these studies, MDCT has been found to have a sensitivity ranging from 92.8% to 100%, specificity ranging from 97.6% to 100%, PPV ranging from 99.0% to 100%, NPV ranging from 72.7% to 96.4%, and accuracy ranging from 87% to 98.1%. MDCT has also been shown to accurately

assess the site and size of varices and detect other portosystemic collaterals and extra-luminal pathology.

MDCT can be used as a screening test for varices and as an excellent alternative to invasive procedures like endoscopy. It can potentially change how chronic liver disease is managed and can be a valuable tool in the early detection and care of patients with varices (28).

A meta-analysis study by Tseng *et al*., to evaluate gastroesophageal varices in patients with portal hypertension showed that MDCT sensitivity for identifying esophageal varices was 0.896, and specificity for identifying esophageal varices was 0.723 (9).

In their 2024 meta-analysis, Li et al. assessed the effectiveness of computed tomography (CT) in diagnosing gastroesophageal varices (GEVs) and detecting high-risk GEVs in cirrhotic patients. The study found that CT shows significant diagnostic accuracy for identifying GEVs and differentiating high-risk GEVs in these patients (29).

Even though MDCT is sensitive to detecting esophageal varices, its specificity is problematic when false positives are possible, and patients get wrongly diagnosed with esophageal varices. The clinical consequences of such false-positive diagnoses are significant. False positives can lead to unjustified treatment, e.g., variceal banding or drug treatment with agents like beta-blockers, which pose risks such as bleeding, infection, and intolerance to medication (18,21). Furthermore, patients may be subjected to further diagnostic procedures, such as repeat endoscopy or other imaging studies, resulting in increased healthcare costs, patient discomfort, and unnecessary exposure to potential procedural complications (17). Thus, MDCT findings must be interpreted cautiously and in conjunction with clinical evaluation and other imaging studies to prevent overtreatment and ensure appropriate patient management (9).

Limitations

This meta-analysis has faced some limitations. Initially, publication bias is not entirely considered a concern since it is biased towards positive studies, and they may overestimate MDCT's diagnostic accuracy. Although publication bias has been checked by Begg's funnel plot and Egger's test, this cannot be entirely ruled out.

Second, heterogeneity across studies occurs due to variations in study design, sample size, patient population, and diagnostic criteria. Even though random-effects models were used to control this, such heterogeneity can impact the pooled estimates.

Lastly, MDCT's flaws as an imaging tool, including its comparatively mediocre specificity, carry the potential for false positives and unnecessary interventions. The variability of the MDCT protocol between studies, including the use of various scanners and scanning techniques, can be presented as diagnostic discrepancies.

In conclusion, the present study demonstrates that MDCT holds potential as a valuable tool for the detection of esophageal varices, offering a non-invasive alternative to traditional diagnostic methods. However, the findings also highlight the need for caution in relying solely on computed tomography due to its limitations, including moderate specificity. Future research efforts should address these limitations and further optimize the diagnostic performance of computed tomography in evaluating esophageal varices, ultimately contributing to improved patient outcomes and clinical management.

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