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Review

Comparing Contrast Enhanced Spectral Mammography (CESM) and Magnetic Resonance Imaging (MRI) Sensibility and Specificity: A Systematic Review

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Abstract: Introduction: Contrast-enhanced spectral mammography (CESM) is a novel technique employed in breast cancer screening and detection. In this systematic review, we aim to compare the diagnostic performance of CESM with magnetic resonance imaging (MRI) in the context of breast cancer diagnosis. **Material and Method:** We have searched for paper in Pubmed and Scopus from July 2023 to February 2024, finding 256 suitable papers according to our selection criteria (perspective or retrospective studies, women diagnosed with breast cancer, comparison of Contrast-enhanced Spectral Mammography and Magnetic Resonance Imaging, sensitivity and specificity metrics provided). Every paper was then checked for quality using the QUADAS 2 assesement score. Sensibility, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and accuracy were recorded. **Results:** 15 studies were selected for analysis. CESM demonstrated comparable sensitivity to MRI, with values ranging from 36.4% to 100% for CESM and 0% to 100% for MRI. Specificity varied between the modalities, with CESM showing specificity ranges of 17% to 100% compared to 23% to 92.31% for MRI. **Discussion and Conclusion:** CESM has comparable diagnostic validity to MRI, and is a valuable tool in detecting breast cancer.

Keywords: CESM; MRI; breast cancer; mammography screening

Introduction

Breast cancer stands as the most prevalent malignancy among women [1]. Given its substantial impact and mortality rates, there has been a progressive development of sophisticated screening programs aimed at early lesion detection, contributing significantly to reduced mortality by identifying lesions before clinical manifestation [2]. Radiodiagnostic techniques play a pivotal role in achieving this goal [2]. Indeed, mammography stands as the most extensively utilized method in screening programs across numerous countries [3]. Other radiological imaging techniques can also

be used, such as ultrasound (a very cost-effective and reproducible technique, but with low specificity [4]) or magnetic resonance imaging (MRI, especially effective in identifying new lesions with very high sensitivity and used in screening women with risk factors [5]). Over time, techniques utilizing contrast medium have been developed, such as Contrast-Enhanced Spectral Mammography (CESM). CESM employs an iodinated contrast medium to enhance the visualization of vascular patterns in lesions, thereby improving diagnostic accuracy while maintaining the ease of use associated with conventional mammography [6], with some authors even speculated it might be a better diagnostic tool than MRI [7]. In this systematic review (conducted in accordance with the PRISMA statement [8]) we evaluate the sensitivity and specificity performance of Contrast-Enhanced Spectral Mammography (CESM) compared to Magnetic Resonance Imaging (MRI).

Material and Method

The search for papers was conducted between July 2023 and February 2024 on PubMed and Scopus. Various search terms were utilized, including “Contrast-enhanced mammography AND magnetic resonance,” “CESM AND MRI,” “Contrast-enhanced spectral mammography AND magnetic resonance,” “Contrast-enhanced spectral mammography AND magnetic resonance AND Breast,” and “Contrast-enhanced spectral mammography OR magnetic resonance AND Breast” on Pubmed and Scopus. Initially, 19,589 results were identified, out of which 19,603 were excluded based on title and abstract screening and duplicates. Subsequently, 256 papers were analyzed, with 212 being excluded after full-text reading. Of the remaining 44 eligible papers, 29 were excluded based on study quality assessment. Finally, 15 papers were deemed eligible for review [9–23] (Figure 1). The selection criteria for the papers included: perspective or retrospective studies, women diagnosed with breast cancer, comparison of Contrast-enhanced Spectral Mammography (CESM) and Magnetic Resonance Imaging (MRI), sensitivity and specificity metrics provided, focus on initial diagnosis.

Each selected paper underwent evaluation using the QUADAS-2 assessment tool [24], and those demonstrating a risk of bias were excluded from the review (Table 1).

Table 1. QUADAS 2 quality assessment.

Study	Risk of Bias				Applicability Concerns		
	Patient Selection	Index Test	Reference Standard	Flow and Timing	Patient Selection	Index Test	Reference Standard
Łuczyńska E. et al (2015) [9]	Low	Low	Low	Low	Low	Low	Low
Wang Q. et al. (2016) [10]	Unclear	Low	Low	Unclear	Unclear	Low	Low
Li L. et al (2017) [11]	Low	Low	Low	Low	Low	Low	Low
Iotti V. et al. (2017) [12]	Low	Low	Low	Low	Low	Low	Low

Lee Felker SA et al. (2017) [13]	Low	Low	Low	Unclear	Low	Low	Low
Kim EY et al (2018) [14]	Unclear	Low	Low	Unclear	Unclear	Low	Low
Patel BK et al. (2018) [15]	Low	Low	Unclear	Unclear	Low	Low	Low
Barra FR et al (2018) [16]	Low	Low	Low	Unclear	Low	Low	Low
Xing D. et al (2019) [17]	Low	Low	Low	Unclear	Low	Low	Low
Clauser P. et al. (2020) [18]	Low	Low	Low	Unclear	Low	Low	Low
Rudnicki W. et al (2021) [19]	Unclear	Low	Low	Unclear	Unclear	Low	Low
Steinhof-Radwanska K. et al (2021) [20]	Low	Low	Low	Low	Low	Low	Low
Lee SC et al. (2021) [21]	Low	Low	Low	Unclear	Low	Low	Low
Ferranti FR. et al (2022) [22]	Low	Low	Low	Low	Low	Low	Low
Feng L. et al. (2022) [23]	Low	Low	Low	Unclear	Low	Low	Low

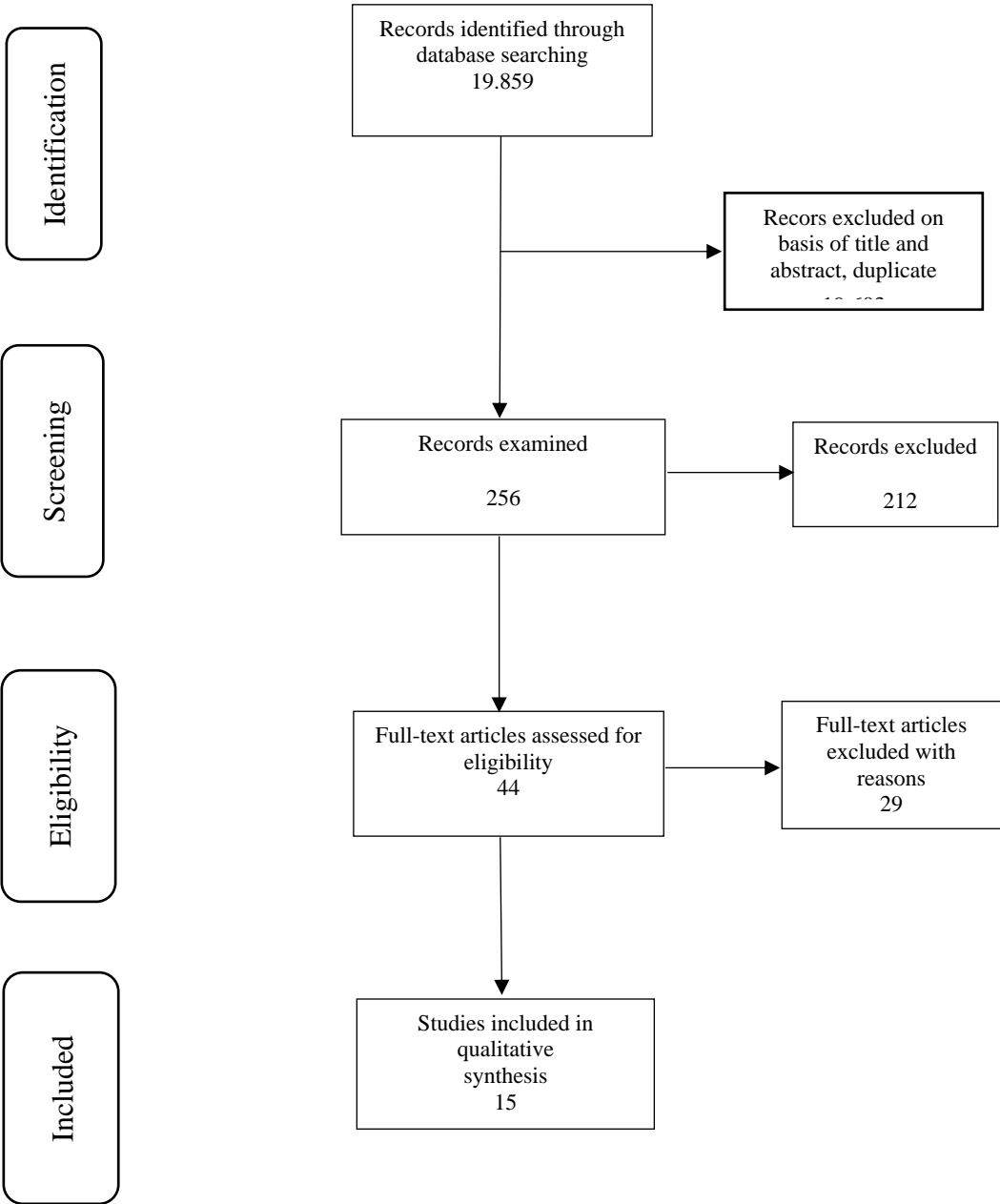


Figure 1. PRISMA Flow diagram.

Results

A total of 15 studies were included in the systematic review, examining the diagnostic performance of Contrast-Enhanced Spectral Mammography (CESM) compared to Magnetic Resonance Imaging (MRI) in detecting breast lesions. Across the studies, CESM demonstrated comparable sensitivity to MRI, with values ranging from 36.4% to 100% for CESM and 0% to 100% for MRI. Specificity varied between the modalities, with CESM showing specificity ranges of 17% to 100% compared to 23% to 92.31% for MRI. In terms of positive predictive values (PPV), CESM showed a range from 55.56% to 100%, while MRI exhibited PPV ranges of 0% to 96.9%. Negative predictive values (NPV) were generally high for both CESM and MRI, with CESM ranging from 0% to 96.9% and MRI from 32% to 96.15%.

Overall, the accuracy of CESM and MRI in detecting breast lesions was comparable, with CESM achieving accuracy ranges of 60% to 97.75% and MRI ranging from 78% to 96.3% (Table 2, Figure 2).

Table 2. Characteristics and diagnostic accuracy of CESM and MRI.

Study	Study type	CESM Contrast	Patients (n)	Detected Lesions	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Accuracy
Łuczyńska E. et al (2015) [9]	Prospective	1.5 ml/kg of body mass of non-ionic contrast agent (Iopromide 370)	102	118 total (81 malignant, 37 benign) MRI: 107 (75 malignant, 32 benign) CESM: 106 (81 malignant, 25 benign)	MRI: 93% CESM: 100%	MRI: 69% CESM: 68%	MRI: 74% CESM: 77%	MRI: 5% CESM: 100%	MRI: 73% CESM: 79%
Wang Q. et al. (2016) [10]	Prospective	Omnipaque, 350 mgI/mL; GE Healthcare, Dublin, Ireland) at a 1.5 mL/kg	68	77 (48 malignant, 29 benign)	MRI: 93.8% CESM: 95.8%	MRI: 2.8% CESM: 65.5%	MRI: 88.2% CESM: 82.1%	MRI: 2.3% CESM: 90.5%	MRI: 89.6% CESM: 84.4%
Li L. et al (2017) [11]	Retrospective	Sieve®370 (Iopamidol injection 76%)	48	MRI: 66 (62 malignant, 4 benign) CESM: 64 (62 malignant, 2 benign)	MRI: 100% CESM: 100%	Not estimable	MRI: 93.9% CESM: 96.9%	Not estimable	MRI: 93.9% CESM: 96.9%
Iotti V. et al.	Prospective	ioversolo 350 mg/	46	46	MRI: 87%	MRI: 60%	MRI: 32%	MRI: 96%	MRI: 65%

(2017) [12]		ml at 1.5 ml/kg			CES M: 100%	CESM: 84%	CESM: 57%	CESM : 100%	CESM :87%
Lee Felker SA et al. (2017) [13]	Retrospec tive	90 mL of iodinated contrast material (Omnipaque 350, GE Healthcare)	52	120	MRI: 99% CES M: 94%	MRI: 4% CESM: 17%	MRI: 60% CESM: 93%	MRI:6 7% CESM : 20%	MRI: 60.17 % CESM :87.1%
Kim EY et al (2018) [14]	Prospect ive	Omnipaque 350 (GE Healthcare, Shanghai, China; 1.5 mL/kg of body weight	84	121	MRI: 83.9% CES M:83. 9%	MRI: 73.6% CESM: 81.1%	MRI:6 5% CESM: 72.2%	MRI:8 8.6% CESM :89.6%	MRI:7 7.4% CESM :82.1%
Patel BK et al. (2018) [15]	Propsec tive	1.5 mL/kg of iohexol (Omnipaque 350; GE Healthcare)	65	65	MRI: 95% CES M:95 %	MRI:6 8.9% CESM: 66.7%	MRI:5 7.6% CESM: 55.9%	MRI:9 6.9% CESM :96.7%	MRI:8 5.9% CESM :85.1%
Barra FR et al (2018) [16]	Porspec tive	1.5 ml/kg of non-ionic contrast medium (Iohexol, 300 mg/ml)	33	33	MRI: 92% CES M: 76%	MRI:7 5% CESM: 87.5%	MRI: 92% CESM: 95%	MRI:7 5% CESM :86.4%	MRI: 80.61 % CESM : 83.7%
Xing D. et al (2019) [17]	Prospect ive	iohexol at 1.5 mL/kg body	235	MRI:258 CESM: 259	MRI: 91.5% CES M: 91.5%	MRI: 80.2% CESM: 89.5%	MRI: 90.5% CESM: 94.7%	MRI:8 2.1% CESM :83.7%	MRI:7 1.7% CESM :81%
Clause r P. et al.	Prospect ive	2 mL/kg body weight of nonionic iodine	80	93	MRI: 83.6% - 93.4%	MRI: 37.5%- 53.1%	MRI: 73.3%- 77%	MRI:6 3%- 76.5%	MRI:7 2%- 75.3%

(2020) [18]		contrast agent (Iobitridol/Xenetix 350, Guerbet, Villepinte, France)			CESM: 65.6% - 90.2%	CESM: 46.9%-96.9%	CESM: 76.4%-97.6%	CESM: 59.6% -71.4%	CESM: 75.3% -76.3%
Rudnicki W. et al (2021) [19]	Retrospective	Iopromide (1.5 ml/kg of body weight)	121	MRI: 121 CESM:108	MRI 100% CESM: 100%	MRI:2 3% CESM: 33%	MRI:7 2% CESM: 75%	MRI: 100% CESM: 100%	MRI:7 8% CESM: 68%
Steinhof-Radwan'ska K. et al (2021) [20]	Retrospective	1.5 mL/kg of body mass of non-ionic contrast agent	60	MRI:33 CESM:30	MRI: 91.18% CESM: 85.29%	MRI:9 2.31% CESM: 96.15%	MRI:9 4% CESM: 97%	MRI:8 9% CESM: 84%	MRI: 91% CESM: 90%
Lee SC et al. (2021) [21]	Prospective	1.5 ml/kg of iodine contrast	41 CESM 32 MRI	41 malignant	MRI: 94.74% CESM: 92%	MRI: 0 CESM: 74.43%	MRI:8 5.71% CESM: 95-83%	MRI:0 CESM: 55.56%	Not reported
Ferranti FR. et al (2022) [22]	Prospective Cohort Study	Visipaque 320	118	MRI: 108 CESM:110	MRI 99% CESM: 100%	MRI:4 7% CESM: 50%	MRI:8 8% CESM: 92%	MRI: 90% CESM: 100%	MRI:8 8% CESM: 93%
Feng L. et al. (2022) [23]	Prospective	ioversol injection (1.5 ml/kg)	54	188 malignant 11 benign	MRI: 99.4% CESM: 98.3%	MRI:3 6.4% CESM: 98.3%	MRI: 96.17% CESM: 97.75%	MRI: 80% CESM: 70%	MRI:9 5.7% CESM: 96.3%

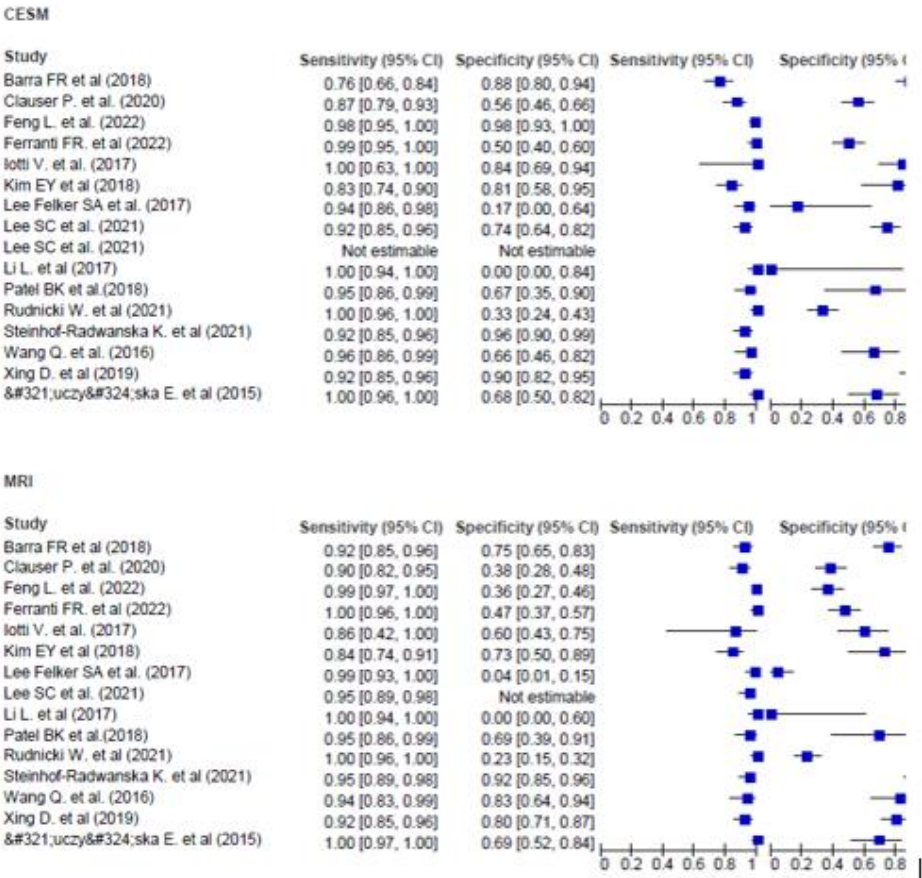


Figure 2. Forrest plot of CESM and MRI sensitivity and specificity.

Discussion and Conclusions

The diagnostic performance between Contrast-Enhanced Spectral Mammography (CESM) and Magnetic Resonance Imaging (MRI) emerges as comparable, particularly regarding sensitivity. However, CESM exhibits a more favorable specificity profile, potentially leading to a reduced incidence of false positives in lesion detection. This advantage could translate into fewer unnecessary invasive interventions in individuals without the disease, enhancing patient care and reducing healthcare costs.

One potential critical issue in our findings is the wide variability observed in the results across the selected studies. However, it's worth noting that similar considerations and results have been reported by other authors in the literature. This variability could stem from differences in imaging protocols, patient populations, and study methodologies, highlighting the need for further standardization and validation of diagnostic criteria in future research. Despite this variability, the overall trends and conclusions drawn from our systematic review align with existing evidence in the field [25,26]. Despite demonstrating equivalent diagnostic performance, CESM also appears to offer economic advantages over MRI. Some authors have estimated that the cost to health systems for CESM is nearly half that of MRI [27]. This economic consideration underscores the potential value of CESM as a cost-effective alternative for breast lesion detection, particularly in resource-constrained settings where cost-effectiveness is a critical factor in decision-making processes regarding healthcare resource allocation. In addition to the economic advantages, there are also advantages in patient compliance: in fact, CESM is found to be tolerated more to MRI in cancer patients, both in the context of screening and follow-up [28,29]. This improved tolerance may be attributed to factors such as shorter examination times and reduced claustrophobia associated with CESM compared to MRI.

In conclusion, CESM turns out to be an effective radiodiagnostic method in the prevention and monitoring of breast cancer, flanking performance comparable to the gold standard with better economic manageability and greater tolerability by patients.

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Conflicts of Interest : We have no Conflict of Interest to declare.

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