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Review article

Ultrasound for assessing tumor spread in ovarian cancer. A systematic review of the literature and *meta*-analysis

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ABSTRACT

In this review, we aimed to assess the diagnostic performance of ultrasound for assessing the tumor spread in the abdomen in women with ovarian cancer. A search for studies evaluating the role of ultrasound for assessing intrabdominal tumor spread in women with ovarian cancer compared to surgery from January 2011 to March 2023 was performed in PubMed/MEDLINE, Web of Science, and Scopus databases. The Quality Assessment of Diagnostic Accuracy Studies 2 evaluated the quality of the studies (QUADAS-2). All analyses were performed using MIDAS and METANDI commands in STATA 12.0 software. We identified 1552 citations. After exclusions, five studies comprising 822 women were included. Quality of studies were considered as good, except for patient selection as all studies were considered as having high risk of bias. The pooled sensitivity and specificity could be calculated for three anatomical areas (recto-sigma, major omentum and root of mesentery) and the presence of ascites. The pooled sensitivity and specificity for detecting disease in the recto-sigma, major omentum and root of mesentery were 0.83 and 0.95, 0.87 and 0.87, and 0.29 and 0.99, respectively. The pooled sensitivity and specificity for detecting ascites was 0.95 and 0.91, respectively. There is evidence that ultrasound offers good diagnostic performance for evaluating the intra-abdominal extent of disease in women with suspected ovarian cancer.

Introduction

Ovarian cancer is the seventh most common cancer among women and the most common cause of death among all gynecological cancers in developed countries with a 30–45 % 5-year overall survival. At the time of diagnosis, about 70–80 % are in an advanced-stage [1,2], defined by the spread of the disease outside the pelvis (International Federation of Obstetrics and Gynecology (FIGO) stages III and IV) [3].

Current treatment for advanced ovarian cancer includes exploratory staging surgery with primary tumor debulking surgery, followed by a taxane/platinum-based chemotherapy [2,4]. Optimal cytoreduction is consistently associated with improved response to chemotherapy and prolonged survival. In contrast, suboptimal cytoreduction has no beneficial effect on survival and may be associated with significant morbidity and mortality [5]. The optimal reduction success rate reported in centers with adequate resources, volume and experience varies between 60 and 90 % [6]. An alternative therapeutic strategy for patients judged as not suitable for optimal surgery is neoadjuvant chemotherapy followed by interval debulking surgery [2,7].

The presence of extensive parenchymal liver disease, mesenteric root involvement, lymph node involvement cranial to renal vessels and large volume diaphragmatic involvement with disease penetrating into the thoracic cavity are acceptable criteria for considering the patient as a non-candidate for optimal primary cytoreduction [8]. Therefore, preoperative assessment of extent of disease using imaging techniques in order to predict the cytoreducibility of the disease and planning the surgery is important to proper patient management [9].

Currently, guidelines suggest preoperative imaging evaluation. Computed tomography (CT) scan is considered the first-line imaging modality for staging, selecting treatment choice and assessing disease response in patients with ovarian cancer [9–12]. However, some *meta*-analyses reported in the last years have shown that the performance of CT scan for detecting tumor spread and predicting surgical outcome is limited [13–15]. In fact, Rutten et al. showed in a *meta*-analysis

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published in 2015 that several models developed for predicting suboptimal cytoreduction had a sensitivity ranging from 15 % to 79 %, whereas specificity ranged from 32 % to 64 % [13]. More recently, a *meta*-analysis reported by Hu et al, showed that sensitivity of CT scan to detect disease in several anatomical areas was rather poor, ranging from 21 % to 64 % [14].

Ultrasound has traditionally been considered a poor technique for assessing tumor extension in ovarian cancer [16]. However, a series of studies emerged analyzing the ability of ultrasound to detect the presence of tumor in the major omentum, peritoneal carcinomatosis and rectosigmoid infiltration [17–20].

Since the publication of the seminal paper from Fischerova, describing the examination technique in the ultrasound assessment of intra-abdominal extension in patients with ovarian cancer [21], several prospective studies using this technique have been published. The aim of the present systematic review was to evaluate the current state of art of the role of ultrasound for assessing intra-abdominal and pelvic tumor extension in ovarian cancer.

Methods

Literature search

The study protocol was established prior to starting citations search and data collection. The protocol was not registered. Given the design and nature of this article, there was no need for an ethics committee approval. The systematic review and *meta*-analysis was performed according to preferred reporting items for systematic reviews and *meta*-analyses (PRISMA).

Three of the authors reviewed three electronic databases (PubMed, SCOPUS and Web of Science) in order to identify eligible papers published. We used the following terms: “ultrasound”, “ovarian”, “cancer” and “staging” in all three databases. The publication period restriction was set from January 2011 (year of the publication of the standardized technique for assessing tumor spread in ovarian cancer using ultrasound [21]) to March 2023. Language restriction was set to English. Cross-references were checked. A librarian was not involved in the search.

Studies selection

Two authors working together combined the searches in different databases and excluded duplicate citations and papers reported in non-English language. Then, all three authors filtered all citations by the titles and abstract in order to exclude articles not related to this topic as well as those that were not primary studies (letter to the Editors, case reports, reviews or systematic reviews). Then, full-text articles of the remaining citations were read to identify potentially eligible studies. Three reviewers applied the following inclusion criteria: prospective cohort studies including patients who underwent ultrasound assessment for evaluating ovarian cancer spreading into the pelvis and abdominal cavity and surgical assessment as reference standard. In case of disagreement, a consensus was achieved among the three authors.

From the ultimately selected studies, the following variables were extracted: author, year of publication, country of precedence and study design, recruitment period, inclusion and exclusion criteria, consecutive patients selection or not, total number of patients, median age of the patients, body mass index (BMI), number of patients included in each FIGO stage (I-IV) and tumor histology. Concerning the index test (ultrasound), we assessed the type of ultrasound machine, the number of sonographers, the ultrasonographic exploratory technique described in the study, the pelvic and abdominal anatomic areas evaluated, the definition and/or criteria for positive disease on each anatomic area. We also extracted data about sensitivity, specificity, positive predictive value and negative predictive value of ultrasound for detecting disease in each anatomical area assessed in each individual study. As reference standard (surgical and/or histological findings), we extracted from the studies the number of surgeons, if they were blinded or not to ultrasound findings, if they were oncological surgeons or not, if the surgical approach was laparotomy or laparoscopy and time elapsed between ultrasound and surgery. We decided to use surgical/histological findings because of we wanted to assess diagnostic performance of ultrasound. Studies comparing ultrasound to CT were analyzed, but we did not use CT as reference standard because this would be an agreement assessment rather than a diagnostic performance assessment.

Qualitative synthesis

The Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) was used for quality assessment of the included studies in this systematic review [22]. The QUADAS-2 format includes four domains: patient selection, index test, reference standard, and flow and timing. For each domain, the risk of bias and concerns about applicability (not applying to the domain of flow and timing) were analyzed and rated as high, low or unclear risk. The results of quality assessment were used for descriptive purposes to evaluate the overall quality of the studies included and to investigate potential sources of heterogeneity. Three authors independently evaluated the methodological quality, using a standard form with quality assessment criteria. Disagreements were solved by discussion between these authors.

In order to assess the quality of the included studies, the authors relied on the design of the study, description of inclusion and exclusion criteria, description of the technique and interpretation of the index text, description of reference standard which was used and whether surgeons were blinded or not to index test for reference standard domain. Surgical findings were defined as the reference of standard. For the evaluation of the flow-and-timing domain, a description of the time elapsed from the index test assessment to the reference standard result was evaluated.

Quantitative synthesis

We evaluated each article and the reported diagnostic performance of ultrasound for detecting disease for each specific anatomical area. When the same anatomical area, for example, involvement of major omentum, was analyzed in at least four studies, we decided to perform a quantitative synthesis according to Synthesizing Evidence from Diagnostic Accuracy Tests (SEDATE) guidelines [23]. For this, we extracted the number of true positives (TP), false positive (FP), true negative (TN) and false negative (FN) of ultrasound from each individual study. Disagreements generated in the process of study selection and data collection were resolved by consensus among all the authors. Using these data, we estimated pooled sensitivity, specificity, positive likelihood ratio (LR +) and negative likelihood ratio (LR −), using the random-effects model. Forest plots for sensitivity and specificity were plotted and the presence of heterogeneity for sensitivity and specificity was estimated using Cochran’s Q statistic and the I^2 index [24]. Summary receiver-operating characteristics (sROC) curves were also plotted. Publication bias was assessed using Deek’s method [25]. Using the mean prevalence of ovarian cancer spreading (pretest probability) for each anatomical area in which we could perform quantitative synthesis, depending upon the technique assessed and LRs, post-test probabilities were calculated and plotted on Fagan’s nomograms. All these analyses were performed using the METANDI command in STATA v12.0 (Stata Corporation, College Station, TX, USA). A p-value < 0.05 was considered as statistically significant.

Results

Search in the three electronic databases mentioned above provided 2162 citations (PubMed: 1221 citations, SCOPUS: 422 citations and Web of Science: 530 citations). After excluding 513 duplicate records and 137 papers published in languages other than English, 1512 citations remained. After reading titles, 1459 citations were ruled out (paper not

related to the topic, letter to Editor, commentary, pictorial essay, *meta*-analysis and/or review). Two authors read the abstracts of the remaining papers, and 21 more citations were dropped out. After that, we examined the full text of the remaining 27 articles and finally papers were discarded due to not meeting inclusion criteria (lack of data needed to build the 2x2 table). Thus, five studies were ultimately included in the review [26–30]. No additional relevant studies were found from references cited in the papers included in the review. A flowchart summarizing the literature search is shown in Fig. 1.

Characteristics of included studies

A general overview of the characteristics of all five included in this review is shown in Table 1.

Testa and colleagues reported the first study in 2012 [26]. They reported a prospective study including 147 patients with advanced ovarian cancer (FIGO stage III and IV). Patients were enrolled in a consecutive series between January 2005 and October 2008. They included 7 patients stage IIIB, 195 patients stage IIIC and 28 patients stage IV. No specific data of the histological type of the included malignant tumors were provided in this article. A single sonographer with transvaginal and transabdominal ultrasound evaluated all included patients prior to surgery. The ultrasound machine was high-brand ultrasound (Esaote Technos, Esaote, Genoa, Italy. Equipped with a 5–9 MHz endovaginal probe and a 3–5 MHz transabdominal probe) and the scanning protocol was standardized. They evaluated the following items: peritoneal carcinomatosis, bowel mesentery involvement, omental involvement, massive pelvic involvement, parenchymal liver metastases, parenchymal spleen metastases, splenic hilum involvement and ascites. These authors found that ultrasound is able to detect intra-abdominal spread of disease with acceptable accuracy and a good correlation with surgical findings. Diagnostic performance of ultrasound for each area evaluated is given in Table 2.

In 2017, Fischerova et al. reported a prospective series of 394 patients with ovarian cancer, including FIGO stage I to IV [27]. Patients were consecutively enrolled between March 2008 and January 2013. They included 78 stage I, 23 stage II, 266 stage III and 27 stage IV. The authors included 303 serous carcinomas, 31 endometrioid carcinomas, 30 clear cell carcinomas, 22 mucinous carcinoma and 8 described as other histological types. Borderline and metastatic ovarian tumors were excluded. Like in the study by Testa et al, all patients were evaluated by transvaginal and transabdominal route prior to surgery (primary or interval cytoreduction). Three sonographers performed all examinations. The ultrasound machine was high-brand (Voluson E8, GE Healthcare, Zipf, Austria. Equipped with a 5–9 MHz endovaginal probe and a 3.5–7 MHz transabdominal probe) and the scanning protocol was standardized [21]. They evaluated the predictive value of ultrasound for intra-abdominal spreading in pelvic carcinomatosis, rectosigmoid wall infiltration, upper abdomen carcinomatosis, diaphragm, liver or splenic surfaces, middle abdomen carcinomatosis, omental infiltration, intestine and/or colon surface, any peritoneal carcinomatosis and metastatic lymph nodes. The authors concluded that ultrasound offers good diagnostic performance for detecting disease in many anatomical areas of the abdomen and pelvis, but is limited in terms of sensitivity in others, such as the mesentery root or retroperitoneal lymph nodes, as shown in Table 3.

Alcazar et al. reported in 2019 the first prospective study comparing ultrasound with computed tomography in the assessment of the extent of abdominal disease in epithelial ovarian cancer [28]. Between January 2012 and December 2017, 93 patients with stage I to IV epithelial ovarian cancer were prospectively and consecutively evaluated by ultrasound and computed tomography and subsequently underwent surgery. According to FIGO staging, 26 patients had stage I; eleven, had stage II; 47, had stage III and nine had stage IV. A single sonographer using a high-brand ultrasound machine (Voluson E8 and Voluson E10, GE Healthcare, Zipf, Austria. Equipped with a 5–9 MHz endovaginal probe and a 3.5–7 MHz transabdominal probe) and a standardized scanning protocol [21] performed the ultrasonography examination. They evaluated the following anatomic areas: pelvic peritoneum, rectosigmoid, pelvic lymph nodes, small bowel major omentum, upper abdomen peritoneum, mesogastrium, hepatic hilum, liver and spleen parenchyma, root of mesentery and *para*-aortic and inferior cava vein lymph nodes. These authors found that ultrasound is able to detect with acceptable accuracy and good correlation with surgical findings, the

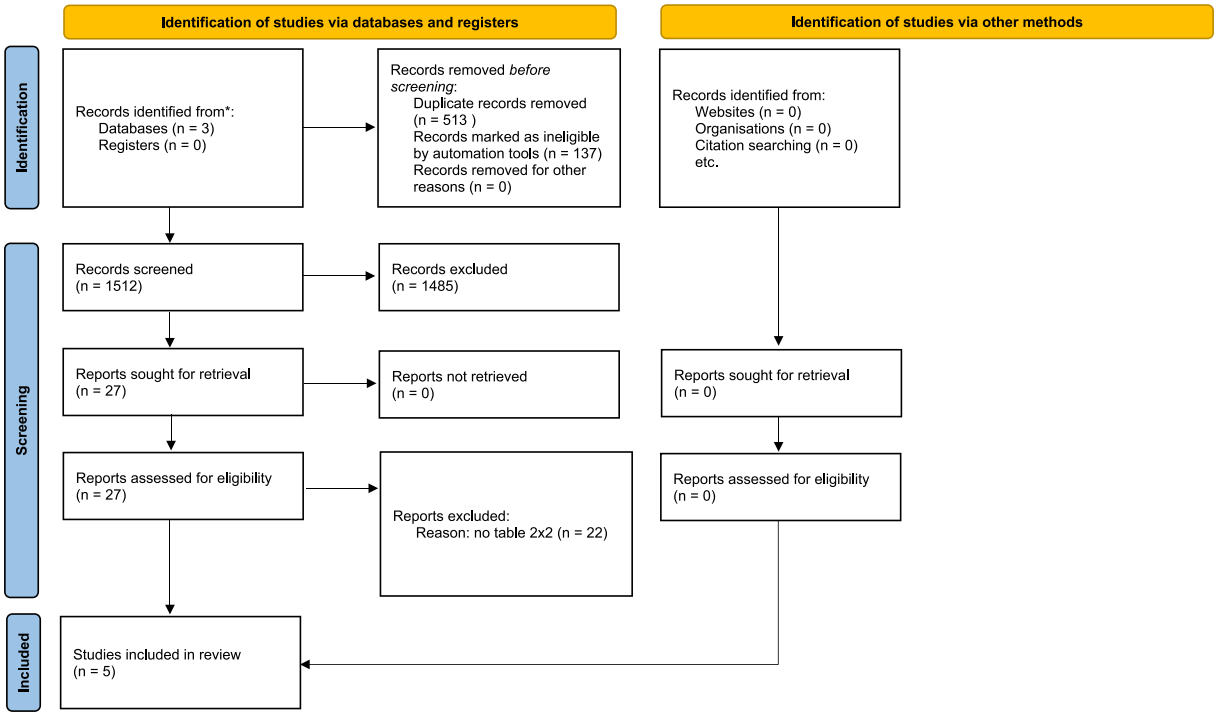

Fig. 1. Flowchart of studies' search and selection.

Table 1
Main characteristics of the studies included in this review.

Author	Year	Study design	Consecutive Series	N	TVS/TAS scan	Observers ultrasound	Oncologic Center	Blind surgeon	Flow and timing
Testa [26]	2012	Prospective	Yes	147	Yes	NA	Yes	NA	4 days
Fischerova [27]	2017	Prospective	Yes	394	Yes	Three experts examiners	Yes	NA	< 4 weeks
Alcázar [28]	2019	Prospective	No	93	Yes	Single expert examiner	Yes	Yes	< 7 days
Tomasisnka [29]	2021	Prospective	Yes	132	Yes	One non-expert examiner and two expert examiners	Yes	NA	< 4 weeks
Fischerova [30]	2022	Prospective	Yes	67	Yes	Three experts examiners	Yes	NA	< 4 weeks

Table 2
Diagnostic performance of ultrasound according to Testa's study (adapted from reference [23]).

Area evaluated	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Massive pelvic involvement	94.0	96.7	97.5	92.1
Peritoneal carcinomatosis	91.5	88.2	98.3	57.7
Major omentum	94.4	90.0	98.3	72.0
Root of mesentery	66.7	87.8	74.3	83.3
Liver parenchyma	92.9	98.5	86.7	99.2
Spleen parenchyma	75.0	98.5	75.0	98.5
Ascites	98.3	96.9	99.1	93.9

Table 3
Diagnostic performance of ultrasound according to Fischerova's study (adapted from reference [24]).

Area evaluated	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Recto-sigmoid	83.1	96.6	94.3	89.3
Pelvic peritoneum	81.4	97.0	97.4	79.5
Major omentum	67.3	93.6	93.2	68.7
Diaphragmatic peritoneum	30.8	98.9	93.2	73.3
Surface Bowel	44.9	98.2	83.9	89.4
Root of mesentery	23.5	99.7	95.9	83.4
Hepatic hilum	30.0	100.0	100	92.2
Pelvic lymph nodes	32.1	99.2	85.7	89.8
Para-aortic lymph nodes	31.3	99.7	95.5	87.6
Ascites	94.6	94.1	62.5	99.4

intra-abdominal spread of the disease depending on the anatomical area evaluated. The diagnostic performance of ultrasound for each area is shown in Table 4.

Table 4
Diagnostic performance of ultrasound according to Alcazar's study (adapted from reference [25]).

Area evaluated	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Recto-sigmoid	59.3	97.0	88.9	85.3
Pelvic peritoneum	74.6	94.1	95.7	68.1
Major omentum	82.6	97.9	97.4	85.2
Abdominal peritoneum	76.7	94.0	91.7	82.5
Bowel	41.7	95.1	55.6	91.7
Root of mesentery	25.0	100.0	100	96.7
Mesogastrium	50.0	93.8	54.5	92.7
Hepatic hilum	30.0	100.0	100	92.2
Liver parenchyma	100.0	100.0	100	100
Spleen parenchyma	40.0	100	100	96.7
Pelvic lymph nodes	46.2	98.8	85.7	91.9
Para-aortic lymph nodes	44.4	98.7	88.9	88.1
Ascites	97.8	97.9	97.8	97.8

Tomasinska et al. also studied the strength of ultrasound in the assessment of ovarian cancer [29]. They included prospectively and consecutively 132 patients diagnosed with ovarian cancer who underwent an oncological surgery prior to a standardized ultrasound assessment. Recruitment period elapsed from June 2018 to February 2021. 125 patients suffered from an epithelial cancer whereas seven of them had a non-epithelial ovarian cancer. Moreover, regarding FIGO staging, 13 patients had stage I; 11 stage II; 84 stage III and 24 stage IV. Ultrasonography examination was performed by three observers who followed a specific training in oncologic ultrasound. They used a high-brand ultrasound machine (Philips HD15, Philips Healthcare, Best, The Netherlands. Equipped with a 5–9 MHz endovaginal probe and a 2.4–5 MHz transabdominal probe) and a standardized scanning technique [21]. They evaluated the following anatomic areas: omentum, small bowel mesentery root, abdomen peritoneum, pelvis peritoneum, ascites, parenchymal lesions of liver and spleen, hilum lesions of liver and spleen, right and left diaphragm and recto-sigmoid. They also evaluated if there was a frozen pelvis and they predicted the cancer stage, surgical complexity and residual disease during the ultrasound assessment. All surgeries were performed in the first month after the sonographic assessment. These authors found that ultrasound is able to detect with acceptable accuracy and a good correlation with surgical findings, the intra-abdominal spread of the disease depending on the anatomical area evaluated. The diagnostic performance of ultrasound for each evaluated area are given in Table 5.

In 2022, Fischerova et al. reported a study comparing the performance of sonography with contrast-enhanced computed tomography and whole-body magnetic resonance imaging with diffusion-weighted sequence in patients with suspected ovarian cancer [30]. Between March 2016 and October 2017, 67 patients with stage I to IV ovarian cancer were prospectively and consecutively evaluated and subsequently underwent surgery. According to FIGO staging, fourteen patients enrolled had stage I: two, stage II; 44, stage III and seven, stage IV. Ultrasonography was performed by three expert examiners. They used

Table 5
Diagnostic performance of ultrasound according to Tomazinska's study (adapted from reference [26]).

Area evaluated	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Omentum, gross involvement	96.9	89.4	89.9	96.7
Omentum, small nodules	17.4	97.2	57.1	84.6
Small bowel mesentery root	80.0	97.4	70.4	97.4
Peritoneum, abdomen	87.7	53.4	59.5	84.8
Peritoneum, pelvis	80.0	81.2	55.8	93.2
Ascites	95.5	96.9	97.0	95.4
Liver, parenchymal	99.2	100	100	75.0
Liver hilum	99.1	42.1	91.1	88.9
Spleen, hilum	90.3	76.9	90.3	76.9
Spleen, parenchymal	100	100	100	100
Diaphragm, right	90.0	59.5	58.4	90.4
Diaphragm, left	94.8	20.6	77.1	58.3
Rectum	84.0	89.0	91.9	81.4

high-brand ultrasound scanners ((Voluson E8 and Voluson E10, GE Healthcare, Zipf, Austria. Equipped with a 5–9 MHz endovaginal probe and a 3.5–7 MHz transabdominal probe) and used the same methodology and a standardized scanning protocol [21]. They evaluated the following anatomical areas: pelvic peritoneum involvement, rectosigmoid carcinomatosis, upper abdominal involvement (diaphragm, spleen, liver and lesser omentum), supracolic omentum, infracolic omentum, colon infiltration by omentum, paracolic gutter, anterior abdominal wall, small bowel serosa and bowel involvement. These authors observed that ultrasound performed good in the detection of carcinomatosis and deep rectosigmoid wall infiltration. Results are presented in Table 6.

Qualitative synthesis

Table 7 graphically presents the assessment of risk of bias and applicability concerns for the selected studies. We did consider that all studies had low risk of bias and concerns of applicability for index and reference test domains, as well as a low risk of bias for flow and timing domain. In all studies, the scanning technique as well as the definitions for considering the disease present or absent in the respective anatomical areas evaluated in each study were clearly stated. Furthermore, in all studies expert examiners performed the ultrasound scans. Certainly, reproducibility has not been assessed in any of the studies analyzed, but we did not consider this fact as a risk of bias, but rather a limitation.

In addition, in all studies expert surgeons performed surgery. Therefore, we did consider as low risk of bias for the reference test. Furthermore, mean time elapsed from ultrasound scan to surgery was less than 4 weeks in all five studies, meaning that the risk of bias for this dominion can be considered as low.

However, we did consider that all studies had a high risk of bias for the patient selection dominion. Testa el al only included stages III and IV [26]. As they did not include early stage cases, the specificity of ultrasound could be overestimated, since false positive cases in some anatomical areas (for example, major omentum) could be present in cases ultimately proven as stage I or II. On the other hand, the other four studies were considered as having inadequate exclusions. Fischerova et al. excluded cases that had subjective assessment of ovarian tumor not consistent with primary ovarian cancer, cases with incomplete ultrasound evaluation and cases with final histology of metastatic tumor to the ovary [27]. Alcazar et al. excluded patients whose final histology was non-epithelial ovarian cancer or metastatic tumor to the ovary [28]. Tomazinska et al. also excluded cases of metastatic tumor to the ovary [29]. Finally, Fischerova et al excluded non-epithelial ovarian cancer or metastatic tumor to the ovary [30]. We did consider these exclusions as inadequate because of these cases are also cases were preoperative evaluation of tumor spread is needed from the clinical point of view.

Table 6
Diagnostic performance of ultrasound according to Fischerova's study (adapted from reference [27]).

Area evaluated	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Pelvic peritoneum	94.0	95.0	98.0	86.0
Recto-sigmoid	94.0	93.0	94.0	93.0
Left diaphragmatic peritoneum	24.0	98.0	83.0	73.0
Spleen surface	33.0	96.0	67.0	86.0
Right diaphragmatic peritoneum	50.0	97.0	95.0	63.0
Liver surface	54.0	96.0	78.0	89.0
Lesser omentum	38.0	100.0	100.0	92.0
Major omentum	86.0	88.0	92.0	79.0
Small bowel serosa	35.0	100.0	100.0	78.0
Small bowel	32.0	96.0	75.0	78.0
Bowel mesentery	26.0	96.0	83.0	64.0
Retroperitoneal lymph nodes	52.0	100.0	79.0	83.0

Quantitative synthesis

Involvement of recto-sigma, major omentum, root of mesentery, as well as the presence of ascites were assessed in at least four studies. We did perform a quantitative synthesis for the diagnostic performance of ultrasound for detecting disease in these areas.

Major omentum was assessed in all five studies. Pooled sensitivity, specificity, positive likelihood ratio and negative likelihood ratio of ultrasound for detecting disease in this area was 0.88 (95 % confidence interval (CI): 0.76–0.94), 0.92 (95 % CI: 0.88–0.95), 11.3 (95 % CI: 7.5–16.9) and 0.13 (95 % CI: 0.06–0.27), respectively. Heterogeneity was high for sensitivity and moderate for specificity (Fig. S1).

Recto-sigma involvement was assess in four studies [27–30]. Pooled sensitivity, specificity, positive likelihood ratio and negative likelihood ratio of ultrasound for detecting disease in this area was 0.83 (95 % CI: 0.70–0.91), 0.95 (95 % CI: 0.91–0.97), 17.2 (95 % CI: 9.5–31.1) and 0.18 (95 % CI: 0.10–0.32), respectively. Heterogeneity was moderate for both sensitivity and specificity (Fig. S2).

Root of mesentery involvement was assess in all five studies. Pooled sensitivity, specificity, positive likelihood ratio and negative likelihood ratio of ultrasound for detecting disease in this area was 0.43 (95 % CI: 0.24–0.64), 0.98 (95 % CI: 0.93–1.00), 23.8 (95 % CI: 8.0–71.2) and 0.58 (95 % CI: 0.41–0.82), respectively. Heterogeneity was low for both sensitivity and specificity (Fig. S3).

The presence of ascites was assessed in four studies [26–29]. Pooled sensitivity, specificity, positive likelihood ratio and negative likelihood ratio of ultrasound for detecting ascites was 0.97 (95 % CI: 0.94–0.98), 0.95 (95 % CI: 0.93–0.97), 19.6 (95 % CI: 13.4–28.7) and 0.03 (95 % CI: 0.02–0.06), respectively. Heterogeneity was high for both sensitivity and specificity (Fig. S4).

Areas under the curve of sROC for detecting disease involving the major omentum, recto-sigma, root of mesentery and ascites were 0.95 (95 % CI: 0.92–0.96), 0.97 (95 % CI: 0.95–0.98), 0.85 (95 % CI: 0.82–0.88) and 0.99 (95 % CI: 0.98–1.0), respectively (Figs. S5 to S8).

We did not observe publication bias (Figs. S9 to S12).

Discussion

Summary of findings

Our review found that there is a paucity of studies assessing the role of ultrasound in staging ovarian cancer. Overall, the quality of studies reported is good. We observed that ultrasound shows a good diagnostic performance to detect disease in some anatomical areas, such as rectosigmoid and major omentum, but it is low in others, such as root of mesentery. We could not assess the pooled diagnostic performance for other areas such as retroperitoneal lymph nodes, abdominal carcinomatosis, liver or spleen due to the limited data available.

Implications for clinical practice

Although early reports indicated that ultrasound was inferior to CT scan or MRI [12,31], our results indicate that ultrasound staging of ovarian cancer might have a role in clinical practice. This fact could be relevant, since ultrasound is more widely available and cheaper than other imaging techniques routinely used in the preoperative assessment of women with ovarian cancer, such as CT scan or MRI [9,32]. We agree with Pinto et al. [33], that ultrasound offers other advantages such as examination time (usually less than 20 min), that it is a dynamic examination (this allows assessing the infiltration of structures such as bowel, colon or peritoneum by evaluating the sliding and movement of these structures), there is no radiation exposure, there are no contraindications and there is no specific need for patient preparation.

However, it should be borne in mind that ultrasound may have some

Table 7
Quality assessment of the studies included in this sytematic review.

	Risk of bias				Concerns applicability		
Author	Patient selection	Index test	Reference test	Flow and timing	Patient selection	Index test	Reference test
Testa [23]	High*	Low	Low	Low	Low	Low	Low
Fischerova [24]	High	Low	Low	Low	Low	Low	Low
Alcázar [25]	High	Low	Low	Low	Low	Low	Low
Tomasisnka [26]	High	Low	Low	Low	Low	Low	Low
Fischerova [27]	High *	Low	Low	Low	Low	Low	Low

"technical" limitations for assessing the whole abdomen in case of scanty or absent ascites, presence of intestinal gas and patient habitus (for example, the retroperitoneal space in obese patients).

In addition, ultrasound has been considered as a limited technique for assessing the lungs and mediastinal areas. However, efforts is being made for describing the technique for ultrasound examination of these areas [34,35].

Another potential limitation is the examiner expertise. No doubt, this type of ultrasound examination needs training and expertise. There are no data about the learning curve for this examination. Furthermore, there is no information available regarding the reproducibility of this examination. All these factors might affect the generalizability of the use of ultrasound as imaging technique for preoperative staging of ovarian cancer.

Strengths and limitations

The main strength of our study is that, to the best of our knowledge, this is the first review about this topic using a *meta*-analytic approach. A recent narrative review by Pinto et al has been published [33]. However, these authors did not perform a qualitative nor quantitative synthesis.

We are aware that our study has limitations. We do report pooled data from a limited number of studies comprising a limited number of patients. However, it should be borne in mind that the number of studies reported is certainly scanty. We did not compare ultrasound with other imaging techniques, such as CT scan, MRI or PET-CT scan. Thus, we cannot assess whether ultrasound is actually comparable in terms of diagnostic performance to these other techniques. Furthermore, we did not assess the capacity of ultrasound to predict non-cytoreduction in women with ovarian cancer.

Future research agenda

Future research should focus on prospective studies comparing diagnostic performance of ultrasound and other imaging techniques. In this sense, results from the ISAAC trial [36], a multicenter prospective European study comparing the diagnostic performance of ultrasound, CT scan and MRI for preoperative assessment of non-resectability in ovarian cancer, are eagerly expected. Furthermore, studies on reproducibility and learning curve are needed in order to properly asses the generalizability of this approach.

Conclusions

We can conclude that current evidence shows that ultrasound offer a good diagnostic performance for evaluating the intra-abdominal extent of disease in women with suspected ovarian cancer. However, it should be borne in mind the limitations of this imaging technique.

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Institutional review board statement

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Informed consent statement

Not applicable.

CRediT authorship contribution statement

Juan Luis Alcázar: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Juan Ramón Pérez-Vidal:** Methodology, Formal analysis, Investigation. **Sarah Tameish:** Methodology, Formal analysis, Investigation. **Enrique Chacón:** Conceptualization, Validation. **Nabil Manzour:** Conceptualization, Validation. **José Ángel Mínguez:** Conceptualization, Validation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejogrb.2023.11.017.

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