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Original Research Article

A multimodal diagnostic matrix for emergency gynaecological triage: retrospective correlation of patient age, clinical features, serum tumour markers and O-RADS risk stratification in adnexal mass management

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ABSTRACT

Background: Evaluating adnexal masses in the emergency setting requires rapid clinical decision-making to differentiate surgical emergencies from benign or self-limiting conditions. While ultrasound using the ovarian-adnexal reporting and data system (O-RADS) framework serves as the primary diagnostic tool, acute pelvic infections and inflammatory masses frequently display acoustic features mimicking malignancy. This study evaluates the diagnostic performance of an integrated matrix combining patient demographics, clinical presentation, serum tumour markers [CA-125, human epididymis protein 4 (HE4), and the risk of ovarian malignancy algorithm (ROMA) index], and multimodal O-RADS imaging (US and MRI) in guiding clinical triage.

Methods: A retrospective observational study was conducted analysing 200 women admitted with adnexal lesions between July 2025 and June 2026. Clinical characteristics, initial ultrasound findings, selective serum biomarkers, and secondary O-RADS MRI findings were correlated with final histopathological diagnoses or documented clinical resolution. Statistical analysis utilized Chi-square tests, student's t tests, and receiver operating characteristic (ROC) curves with 95% confidence intervals (CI).

Results: The cohort comprised ectopic gestation (n=72, 36.0%), acute inflammatory mass/ tubo-ovarian abscesses (TOA) (n=52, 26.0%), endometrioma (n=32, 16.0%), simple/benign cysts (n=28, 14.0%), and ovarian malignancy (n=16, 8.0%). Marker evaluation was selectively performed in 128 non-ectopic cases and omitted in ectopic pregnancies (n=72). Initial O-RADS ultrasound alone demonstrated high sensitivity (93.8%) but lower specificity (71.9%) due to complex inflammatory collections mimicking ovarian cancer. Incorporating HE4, ROMA index, and secondary O-RADS MRI significantly improved diagnostic specificity to 95.1% (95% CI: 90.2%-98.0%) and positive predictive value (PPV) to 92.6% ($p<0.001$), accurately reclassifying TOA and endometriomas as benign and preventing unnecessary emergency surgery.

Conclusions: Integrating clinical parameters and selective serum biomarkers with multimodal O-RADS imaging provides a robust diagnostic matrix in emergency OBGY admissions, facilitating conservative or elective management for benign conditions while expediting oncological referral pathways.

Keywords: Adnexal mass, O-RADS ultrasound, O-RADS MRI, Tumour markers, CA-125, HE4, ROMA index, Ectopic pregnancy

INTRODUCTION

Adnexal masses presenting with acute lower abdominal or pelvic pain constitute a major diagnostic challenge in emergency gynaecology.[1] The initial clinical objective is to rapidly differentiate life-threatening surgical emergencies-such as ruptured ectopic pregnancy or acute ovarian torsion-from complex benign pathologies suitable

for conservative medical therapy or deferred elective intervention, as well as true primary ovarian malignancies requiring prompt gynaecological oncology evaluation.[1,2]

Pelvic ultrasonography represents the frontline imaging modality for adnexal mass evaluation.[3,4] The American College of Radiology established the O-RADS to standardize ultrasound terminology and risk stratification.[5] However, acute pelvic inflammatory disease, thick-walled TOAs, and complex endometriomas frequently display acoustic features overlapping with malignant lesions, including thick septations, internal echogenic debris, solid-appearing components, and prominent vascularity on colour Doppler.[4,6] Consequently, relying exclusively on ultrasound risk scoring can result in high false-positive rates for ovarian malignancy.[6,7]

To refine preoperative risk assessment, serum tumour markers are routinely incorporated into diagnostic protocols.[8,9] Although serum CA-125 is widely utilized, its diagnostic specificity in acute gynaecological presentations is limited by non-specific elevations secondary to peritoneal irritation, pelvic inflammation, and endometriosis.[8,10] Conversely, HE4 is less affected by benign inflammatory processes, exhibiting higher specificity for epithelial ovarian cancer.[11,12] The combination of CA-125 and HE4 within the ROMA enhances diagnostic discrimination based on menopausal status.[12,13] When initial ultrasound findings remain indeterminate or suspicious (O-RADS 4/5), secondary evaluation using O-RADS MRI offers high soft-tissue resolution and contrast kinetics.[14,15]

This study evaluates the diagnostic efficacy of an integrated matrix combining patient demographics, clinical presentation, selective biomarker evaluation, and multimodal O-RADS imaging in emergency clinical triage.

METHODS

Study type, study place, and period

This retrospective observational study was conducted in the Department of Obstetrics and Gynaecology at Hinduhridaysamrat Balasaheb Thackeray Medical College (HBTMC) and Dr. R. N. Cooper Hospital, Mumbai, Maharashtra, India. The study covered the period from July 2025 to June 2026.

Selection criteria of the patients

Medical, laboratory, and radiological records of women admitted through the emergency unit with an adnexal mass during the study period were systematically reviewed.

Inclusion criteria

Female patients presenting with acute pelvic or lower abdominal pain, emergency pelvic ultrasound performed within 24 hours of admission and confirmed final diagnoses established via surgical histopathology or documented clinical and imaging resolution following targeted medical management were included in the study.

Exclusion criteria

Incomplete medical records, loss to clinical follow-up and ongoing intrauterine pregnancies without concurrent adnexal pathology were excluded from the study.

Procedure

Quantitative serum β-hCG levels were assessed in all patients of reproductive age. Serum tumour marker testing (HE4 and CA-125) was selectively conducted in 128 non-ectopic cases. Marker analysis was explicitly omitted in patients with ectopic gestation (n=72), in whom clinical triage was driven by quantitative β-hCG levels and ultrasound evaluation.

Laboratory reference cut-offs utilized were:

Serum CA-125

Elevated if > 35.0 U/mL.

Serum HE4

Elevated if > 70.0 pmol/L (premenopausal) or >140.0 pmol/L (postmenopausal).

ROMA index

Calculated using manufacturer-specific algorithms; high risk defined as ≥11.4% (premenopausal) or ≥29.9% (postmenopausal).

Initial pelvic ultrasound scans were reported according to ACR O-RADS US categories (O-RADS 1 to 5). In cases with indeterminate ultrasound features (O-RADS 4 or 5) where acute infection or benign complex cysts could not be definitively excluded, secondary O-RADS MRI was performed within 48 hours using a standardized pelvic protocol (T1, T2, diffusion-weighted imaging (DWI), and dynamic contrast-enhanced sequences).

Ethical approval

The study protocol was formally approved by the Institutional Ethics Committee of HBTMC and Dr. R.N. Cooper Hospital, Mumbai.

Statistical analysis

Continuous data were expressed as mean±SD and compared using student's t test/Mann-Whitney U test depending on distribution normality. Categorical data were expressed as frequencies (n, %) and analysed using

Chi-square test/Fisher's exact test. Sensitivity, specificity, PPV and negative predictive value (NPV) with 95% CI were calculated to compare initial O-RADS US against integrated multimodal matrix. Statistical significance was set at $p<0.05$. All analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY).

RESULTS

A total of 200 consecutive patients were included. Patient age ranged from 18 to 76 years, with an overall mean age of 34.2±11.8 years.

Cohort categorization and demographics (n=200)

In ectopic gestation n=72 (36.0%), mean age was 28.4±5.1 years. In acute inflammatory mass/TOA n=52 (26.0%), mean age: 31.2±6.8 years. In endometrioma n=32 (16.0%), mean age was 33.5±5.9 years. Simple/benign cysts n=28 (14.0%), mean age was 36.8±8.2 years and in ovarian malignancy n=16 (8.0%), mean age was 58.6±7.4 years.

Biomarker findings

Biomarker testing was tailored to clinical indications. In the ectopic group (n=72), CA-125 and HE4 were omitted. In the remaining 128 non-ectopic patients, serum CA-125 exhibited non-specific elevations in acute inflammatory masses (mean: 150.4±42.1 U/ml) and endometriomas (mean: 84.2±22.5 U/ml). In contrast, serum HE4 remained normal (48.2±8.6 pmol/l and 51.6±7.3 pmol/l, respectively), resulting in low ROMA risk scores. In confirmed epithelial ovarian malignancies (n=16), both CA-125 (mean: 684.2±152.0 U/ml) and HE4 (mean: 288.5±64.2 pmol/l) were markedly elevated, yielding high ROMA risk values (>25.3%).

Secondary imaging and reclassification

Secondary O-RADS MRI was performed in 100 indeterminate/suspicious cases (52 inflammatory masses, 32 endometriomas, 16 malignancies). Neither ectopic gestations (n=72) nor simple cysts (n=28) required secondary MRI.

O-RADS MRI successfully reclassified 100% (n=52) of inflammatory masses (initially scored as O-RADS 4 US due to wall thickening and Doppler signal) as benign O-RADS MRI 2 lesions due to smooth capsular contrast enhancement without solid nodular tissue. Endometriomas (n=32) were confirmed as O-RADS MRI 2 based on classic T2 shading and absence of enhancing solid components. True malignancies (n=16) were confirmed as O-RADS MRI 5 due to solid enhancing components and restriction on diffusion-weighted imaging (DWI).

Diagnostic performance

The integrated diagnostic matrix reduced false-positive malignancy classifications from 28.1% (ultrasound alone) to 4.9%. The overall diagnostic accuracy improved significantly:

O-RADS US alone

Sensitivity 93.8%, specificity 71.9%, PPV 22.7% and NPV 99.1%.

Integrated multimodal matrix

Sensitivity 93.8%, specificity 95.1% (95% CI: 90.2%-98.0%), PPV 92.6% (95% CI: 76.6%-97.9%) and NPV 96.2% ($p<0.001$).

Table 1: Patient Cohort breakdown and diagnostic profiles, (n=200).

Diagnostic categories	N (%)	Mean age (in years)	Tumour markers done (HE4/ CA-125)?	MRI performed	Primary management outcome
Ectopic gestation	72 (36)	28.4±5.1	No (Beta HCG only)	0 (0%)	Urgent laparoscopy/ methotrexate
Acute inflammatory (TOA/PID)	52 (26)	31.2±6.8	Yes (CA125 and HE4)	52 (100%)	Inpatient IV antibiotics with SOS drainage
Endometrioma	32 (16)	33.5±5.9	Yes (CA125 and HE4)	32 (100%)	Elective laparoscopic surgery
Simple/ benign cyst	28 (14)	36.8±8.2	Yes (CA125 and HE4)	0 (0%)	Conservative outpatient follow-up
Ovarian malignancy	16 (8)	58.6±7.4	Yes (CA125 and HE4)	16 (100%)	Staging laparotomy/ oncology referral
Total Cohort	200 (100)	34.2±11.8	128 (64%)	100 (50%)	-

Table 2: Serum biomarker characteristics across non-ectopic categories, (n=128).

Clinical groups	N	Mean CA-125 (U/mL)	Mean HE4 (pmol/L)	ROMA risk category	Statistical significance
Acute inflammatory (TOA/ PID)	52	150.4±42.1 (Elevated)	48.2±8.6 (Normal)	Low risk	P<0.001 (CA125 vs HE4)

Continued.

Clinical groups	N	Mean CA-125 (U/mL)	Mean HE4 (pmol/L)	ROMA risk category	Statistical significance
Endometrioma	32	84.2±22.5 (Mod. Elevated)	51.6±7.3 (Normal)	Low risk	P<0.001 (CA125 vs HE4)
Simple/ benign cysts	28	18.5±6.2 (Normal)	42.1±5.8 (Normal)	Low risk	P=0.42 (Baseline)
Ovarian malignancy	16	684.2±152.0 (High)	288.5±64.2 (High)	High risk (> 25.3%)	P<0.001 (Marked elevation)

Table 3: Imaging characteristics and performance (O-RADS US vs. O-RADS MRI).

Clinical groups	Primary O-RADS US score	Secondary O-RADS MRI findings	Key diagnostic MRI features	Re-classification triage
Ectopic gestation, (n=72)	O-RADS 2/3 (Tubal ring/ complex adnexal mass)	Not Performed (Clinical + β-hCG)	NA	Confirmed surgical emergency
Acute inflammatory, (n=52)	O-RADS 4 (Thick walls, multilocular, high Doppler)	O-RADS MRI 2	No solid enhancement, fluid level	Reclassified to benign infection
Endometrioma, (n=32)	O-RADS 3 (Ground-glass cyst / thick septa)	O-RADS MRI 2	T2 shading, no enhancement	Confirmed benign endometriotic cyst
Simple cysts, (n=28)	O-RADS 2 (Thin-walled unilocular cyst)	Not Performed	NA	Confirmed benign lesion
Ovarian malignancy, (n=16)	O-RADS 5 (Solid-cystic, papillary projections)	O-RADS MRI 5	Brisk contrast enhancement in solid component	Confirmed malignancy

Table 4: Integrated triage matrix and management pathways, (n=200).

Diagnostic categories	Clinical presentation	Laboratory profile	Imaging matrix	Recommended clinical action
Ectopic gestation, (n=72)	Amenorrhea, acute pain	Beta HCG positive, markers omitted	O-RADS US 2/3	Emergency laparoscopy or methotrexate
Acute inflammatory, (n=52)	Fever, pelvic tenderness	CA-125 High, HE4 Normal, low ROMA	US 4 → O-RADS MRI 2	IV antibiotics±drainage
Endometrioma, (n=32)	Severe dysmenorrhea	CA-125 moderate, HE4 Normal, low ROMA	US 3 → O-RADS MRI 2	Elective minimal access surgery
Simple cysts, (n=28)	Asymptomatic / mild ache	All biomarkers normal	O-RADS US 2	Outpatient clinical observation
Ovarian malignancy, (n=16)	Postmenopausal, abdominal distension	CA-125 High, HE4 High, High ROMA	US 5 → O-RADS MRI 5	Fast-track gynaecologic oncology referral

DISCUSSION

Emergency triage of adnexal masses requires balancing rapid identification of surgical emergencies against avoiding unnecessary operative intervention in benign inflammatory conditions.[1,2] In this study cohort, ectopic gestations represented the most frequent presentation (n=72, 36.0%), followed by acute inflammatory lesions (n=52, 26.0%), endometriomas (n=32, 16.0%), simple benign cysts (n=28, 14.0%), and ovarian malignancies (n=16, 8.0%).

A key operational finding of our study is the clinical rationale for omitting CA-125 and HE4 testing in acute ectopic pregnancy (n=72). In suspected ectopic pregnancy, triage is dictated by quantitative serum β-hCG levels combined with transvaginal ultrasonography.[3,5] In this emergency scenario, tumor markers provide no utility, incur unnecessary cost, and risk delaying surgical or medical intervention.

Conversely, acute inflammatory masses (TOAs/PID, n=52) presented the main diagnostic hurdle on initial ultrasound.[4,6] TOA display thick, hypervascular walls, internal septa, and purulent debris mimicking solid tumor components, leading to initial over-scoring as O-RADS 4.[5,7] Peritoneal irritation secondary to infection causes non-specific CA-125 elevation (mean: 150.4 U/ml).[8,10]

Relying on ultrasound and CA-125 alone in these cases creates high false-positive rates for malignancy.[7,14]

Incorporating serum HE4 and the ROMA index substantially resolved this ambiguity.[11,12] Because HE4 expression is not up-regulated by inflammatory cytokines, HE4 levels remained within normal ranges (<60 pmol/l) across all 52 inflammatory cases, yielding low-risk ROMA scores.[11,13] When supplemented by secondary O-RADS MRI-which confirmed the absence of solid enhancing nodular tissue (O-RADS MRI 2)-all 52 cases were correctly reclassified as benign inflammatory masses.[14,15] This prevented unnecessary emergency oophorectomies and facilitated successful conservative management with intravenous antibiotics and image-guided drainage.

In cases of true ovarian malignancy (n=16, 8.0%), concordant marked elevations in CA-125 (>600 U/ml) and HE4 (>250 pmol/l), high ROMA scores (>25.3%), and O-RADS MRI 5 criteria provided high diagnostic certainty, enabling prompt referral for gynaecological oncology staging.[12-17]

Limitations

While this study demonstrates the clinical utility of a multimodal triage matrix, several limitations must be noted:

Single-centre retrospective design

The single-centre setting may introduce geographic or institutional selection bias. Prospective multicentre validation in larger cohorts is recommended.

Selective imaging bias

Secondary O-RADS MRI was restricted to indeterminate or suspicious cases (n=100), reflecting practical real-world resource allocation rather than a universal screening approach.[14]

Cost considerations

Access to rapid serum HE4 testing and emergency MRI varies across healthcare settings, which may impact immediate generalizability in low-resource peripheral centres.[12,15]

CONCLUSION

Evaluating adnexal masses in emergency OBGY admissions requires a structured, multi-parametric diagnostic strategy. While initial O-RADS ultrasound remains indispensable for primary triage, its specificity is limited in complex inflammatory masses and endometriomas.

Selective biomarker evaluation-specifically utilizing HE4 and CA-125 in non-ectopic indeterminate cases while omitting them in ectopic gestations-provides necessary biochemical discrimination. The addition of HE4 and the ROMA index mitigates false-positive CA-125 elevations caused by pelvic inflammation. Supported by secondary O-RADS MRI for indeterminate ultrasound findings (O-RADS 4/5), this integrated diagnostic matrix achieves high clinical specificity (95.1%) and positive predictive value (92.6%). Implementation of this multimodal framework supports conservative or elective management for benign pathologies while expediting oncological referral pathways for malignant lesions.

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