Original Report

Preoperative Risk Stratification of Adnexal Masses in the Pediatric and Adolescent Population: Evaluating the Decision Tree System

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A B S T R A C T

Study Objective: To evaluate the diagnostic performance of the Decision Tree System (DTS) rules 2 and 3 for surgically managed adnexal masses in the North American population and to compare it with the risk stratification criteria used at The Hospital for Sick Children (≥8 cm and complex/solid).
Design: A retrospective cohort study of patients who presented with adnexal masses and were surgically treated between April 2011 and March 2016.
Setting: The Hospital for Sick Children (Toronto, Ontario, Canada).
Participants: Patients 1-18 years of age with adnexal masses who underwent surgical treatment.
Interventions and Main Outcome Measures: Main outcome measures included diagnostic performance (preoperative sensitivity, specificity, positive predictive value [PPV], and negative predictive value [NPV] for malignancy) of the DTS rules 2 and 3 and ≥8 cm and complex/solid criteria.
Results: The malignancy rate was 10.4%. The DTS rules 2 and 3 had a sensitivity of 84% (95% confidence interval [CI], 79-90), specificity of 77% (95% CI, 71-83), PPV of 30% (95% CI, 17-42), and NPV of 98% (95% CI, 94-100). The 8 cm or larger and complex/solid criteria had a sensitivity of 89% (95% CI, 85-94), specificity of 71% (95% CI, 64-77), PPV of 27% (95% CI, 16-38), and NPV of 98% (95% CI, 96-100).
Conclusion: Our study showed that DTS rules 2 and 3 had similar diagnostic performance as the 8 cm or larger and complex/solid criteria in the same population, with a very high NPV and a low PPV. Future prospective investigations should be conducted to further assess how DTS components can be incorporated into future algorithms for the management of adnexal masses in the pediatric population.
Key Words: Adnexal mass, Algorithm, Oophorectomy, Ovarian cystectomy, Risk stratification, Malignancy, Benign

Introduction

Neoplastic adnexal masses in the pediatric population are uncommon with an annual incidence of 2.6 per 100,000.[1–3] Most adnexal masses that undergo surgery in this age group are benign, whereas 10%-20% are malignant.[4] It is recommended that benign adnexal masses undergo conservative management with ovarian cystectomy.[5,6] A minimally invasive approach is preferred if surgically feasible.[5,6] In contrast, malignant masses should be managed with oophorectomy, without interruption of the ovarian capsule, and appropriate surgical staging.[7] The difficulty in distinguishing benign from malignant masses preoperatively can result in incorrect surgical management. This might involve unnecessary loss of an ovary, or if cystectomy is applied to a malignancy, a change in the need for chemotherapy as part of treatment protocols.[8] Optimal preoperative risk stratification criteria for adnexal masses in children and adolescents has not been established.

We previously showed that using ultrasound criteria of 8 cm or larger and complex features yielded a preoperative negative predictive value (NPV) of 100% and positive predictive value (PPV) of 37.1% for malignancy in the pediatric and adolescent population.[7] Although they can have high accuracy in identifying malignant masses, these criteria have potential to incorrectly identify benign masses as malignant, which might lead to a decreased rate of ovarian conservation. We hypothesize that applying more refined imaging criteria might improve the PPV.

Stankovic et al[9] published an algorithm for the management of adnexal masses in children and adolescents termed the Decision Tree System (DTS; Fig. 1). The DTS uses ultrasound criteria almost exclusively and consists of 3 rules, dependent on the clinical situation, that incorporate a morphology index (MI) score and the ovarian crescent sign (OCS) for risk stratification. For their surgically managed adnexal masses, the DTS had an NPV of 99% and a PPV of

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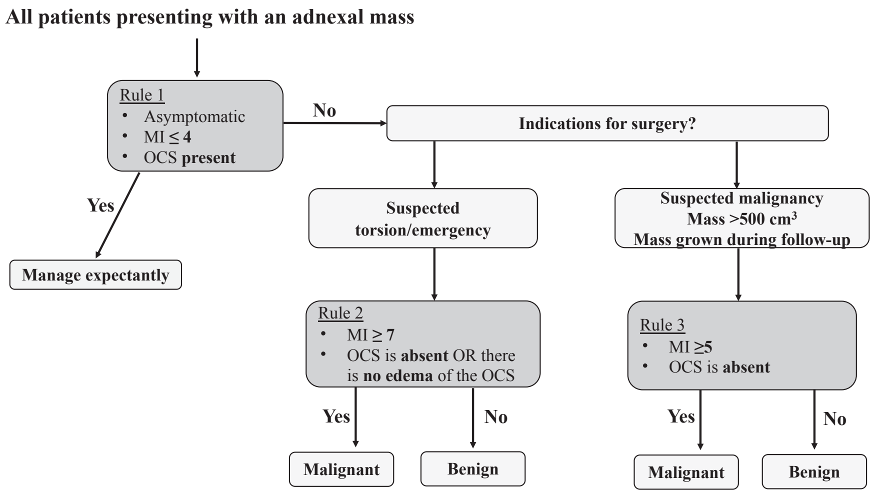

Fig. 1. Summary of the Decision Tree System. MI, morphology index; OCS, ovarian crescent sign. Adapted from Stankovic et al.[9]

86%, which is superior to the 8 cm or larger and complex criteria in our previous publication.

The purpose of this study was to investigate if the DTS rules have similar performance for preoperative risk stratification for surgically managed adnexal masses in a North American population and to compare the DTS rules with the current risk stratification used in the evidence-based algorithm at our institution (≥8 cm and complex or solid of any size).

Materials and Methods

Patient Population

A retrospective study of all female patients aged 1-18 years old who presented with an adnexal mass to The Hospital for Sick Children between April 2011 and March 2016 was conducted with research ethics board approval. Patients were excluded if the mass was not managed surgically or if there was no ultrasound available.

Study Design

Medical charts were reviewed to obtain data on patient demographic characteristics, adnexal mass characteristics, tumor marker evaluation, management, and pathological diagnosis. Bilateral masses were each analyzed separately. A single radiologist blinded to final diagnosis and previous ultrasound assessment evaluated presenting ultrasound exams by assigning the mass a MI score, composed of a structural score and volume score, and determining whether the OCS was absent or present (Table 1). Figure 2 shows examples of structural scoring and Figure 3 shows examples of assessment of the OCS. The DTS rules 2 and 3 (applicable to surgically managed masses) were then retrospectively applied to each mass to determine if the mass was malignant or benign (Fig. 1). DTS rule 2 states that for masses undergoing emergent surgical management (torsion), an MI score of 7 or higher and the absence of the OCS or no edema of the OCS indicates that the mass should be classified as malignant. DTS rule 3 states that for masses undergoing nonemergent surgical management, an MI score of 5 or higher and the absence of the OCS indicates that the mass should be classified as malignant. DTS rule 1 was not investigated because nonsurgically managed adnexal masses without pathology were excluded for this study. The diagnostic performance of DTS rules 2 and 3 was determined using the pathologic diagnosis as the reference standard. A second radiologist also blinded to final diagnosis and previous ultrasound assessment reviewed a representative subset of 30 masses to assess inter-rater reliability on the DTS rules.

The cm or larger and complex or solid of any size criteria were also applied retrospectively to the study cohort. Complexity on ultrasound examination was defined as a mass encompassing solid and cystic components and/or septations. The diagnostic performance of the 8 cm or larger and complex/solid criteria was determined using the pathologic diagnosis as the reference standard and was compared with the diagnostic performance of DTS rules 2 and 3.

Statistical Analyses

Statistical analyses were performed using SPSS (version 25; IBM Corp) and GraphPad Prism (version 8).[10] PPV, NPV, sensitivity, and specificity were calculated for all diagnostic parameters including the DTS rules. The difference in diagnostic performance of each diagnostic parameter was determined using the 2-sample proportion test. Inter-rater

Table 1
Morphology Index Scoring Criteria

Score Type	Description
Structural Score	
0	Smooth wall, sonolucent
1	Smooth wall, diffuse echogenicity
2	Wall thickening (<3 mm), fine septa
3	Papillary projection (≥3 mm)
4	Complex, predominantly solid
5	Complex, solid, and cystic areas with extratumoral fluid
Volume Score (length × height × width × 0.523)	
0	<10 cm^3
1	>10-50 cm^3
2	>50-100 cm^3
3	>100-200 cm^3
4	>200-500 cm^3
5	>500 cm^3

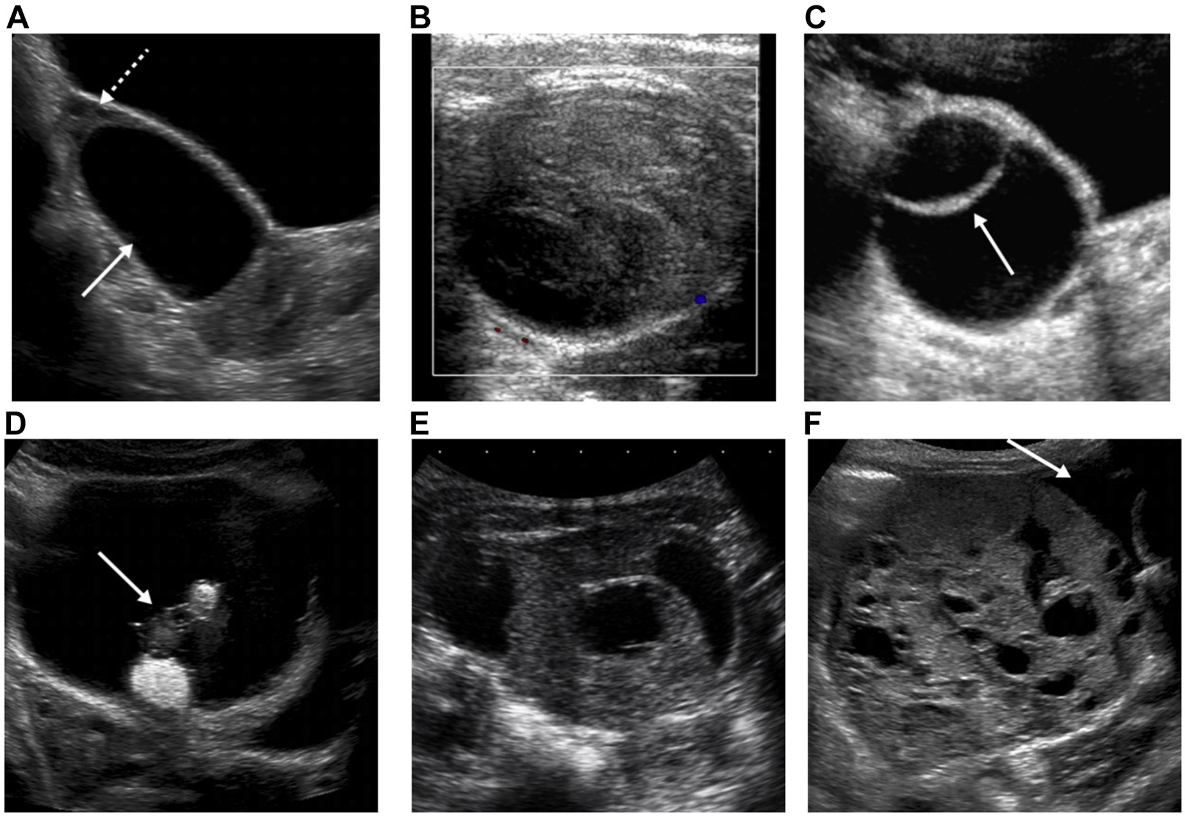

Fig. 2. Examples of structural score (SS). (A) SS 0. Longitudinal sonogram shows a smooth-walled unilocular cyst (arrow) arising from the left ovary (dashed arrow). (B) SS 1. Longitudinal color Doppler sonogram shows a complex cyst arising from the left ovary (not shown), with diffuse heterogeneous internal echogenicity and absent internal vascularity. (C) SS 2. Longitudinal sonogram shows a right ovarian cyst containing a single septation with <3 mm wall thickening (arrow). (D) SS 3. Transverse sonogram shows a multilocular cystic adnexal mass with a heterogeneous papillary projection (arrow). (E) SS 4. Transverse sonogram shows a complex mixed solid-cystic adnexal mass, which is predominantly solid. (F) SS 5. Longitudinal sonogram shows a complex solid-cystic adnexal mass, which is predominantly solid, associated with moderate adjacent extra-tumoral fluid (arrow).

reliability was assessed using κ statistics with quadratic weighting. The κ value was interpreted according to Landis and Koch[11] using the following guidelines: A κ value below 0.20 represented slight agreement, 0.21-0.40 represented fair agreement, 0.41-0.6 represented moderate agreement, 0.61-0.80 represented good agreement, and 0.81-1.00 represented very good agreement.[11]

Results

The study population included 172 patients with 183 masses. The nonemergent cohort included 120 masses and the emergent cohort included 63 masses. The average age (±SD) was 13.0 (±3.4) years old. Seventy-three percent of the study population were postmenarchal.

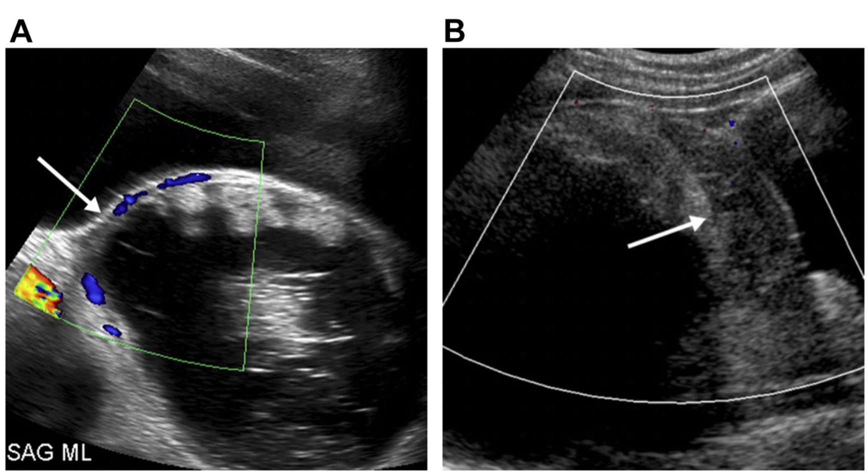

Fig. 3. Examples of the ovarian crescent sign (OCS). (A) Longitudinal color Doppler sonogram shows a thin crescent of vascular ovarian tissue (arrow) stretched around a 12.0-cm mature cystic teratoma, consistent with a positive OCS. (B) Longitudinal color Doppler sonogram shows a crescent of enlarged edematous ovarian tissue without internal vascularity (arrow), representing acute ovarian torsion due to a 13.3-cm mature cystic teratoma lead point, and consistent with a positive OCS with edema.

Table 2
Pathology of Adnexal Masses (n = 183)

Pathology	n (%)
Non-neoplastic	
Simple/follicular	4 (2.2)
Corpus luteum	2 (1.1)
Hemorrhagic	9 (4.9)
Paratubal	19 (10.4)
Normal ovarian tissue	1 (0.6)
Ovarian edema	1 (0.6)
Neoplastic (benign)	
Mature teratoma	74 (40.4)
Cystadenoma	50 (27.3)
Sex cord stromal (benign)	4 (2.2)
Neoplastic (malignant)	
Borderline	4 (2.2)
Immature teratoma	3 (1.6)
Mixed germ cell	3 (1.6)
Juvenile granulosa cell	2 (1.1)
Dysgerminoma	2 (1.1)
Sertoli Leydig	2 (1.1)
Mucinous carcinoma	1 (0.6)
Neuroendocrine	1 (0.6)
Yolk sack	1 (0.6)

Adnexal mass pathology is shown in Table 2. Mature teratomas were the most common type of mass in the study population (74/183, 40.4%). Overall, there were 19 malignancies of 183 masses (10.4%). The most common malignant masses were borderline epithelial tumor (4/183, 2.2%), immature teratoma (3/183, 1.6%), and mixed germ cell tumor (3/183, 1.6%).

The preoperative sensitivity, specificity, PPV, and NPV of each diagnostic parameter investigated are shown in Table 3.

With the application of DTS rules 2 and 3, there were 41 discrepancies from pathology. In the emergent group, 11/11 (100%) discrepancies were false positive for malignancy; 7/11 (64%) false positive results had a volume score of 5 compared with 19/63 (30%) total cases in the emergent cohort (P = .04). In the nonemergent group, 27/30 (90%) discrepancies were false positive; 20/27 (74%) false positive results had a volume score of 5 compared with 46/120 (38%) total cases in the nonemergent cohort ($P < .01$).

The remaining 3/41 (7.3%) discrepancies were false negative in the nonemergent cohort. The 3 false negative results all had MI scores of 7 or 8, however, failed to meet DTS criteria for malignancy because they were assessed to have an OCS present.

Inter-rater reliability via weighted κ statistics was very good for structural score ($\kappa = 0.839$; $P < .001$), volume score ($\kappa = 0.988$; $P < .001$), and MI score ($\kappa = 0.934$; $P < .001$). Inter-rater reliability was not good and potentially in the fair range for OCS ($\kappa = 0.267$; $P = .140$; $\kappa < 0.6$; $P = .035$). Inter-rater reliability was moderate for DTS rules 2 and 3 ($\kappa = 0.598$; $P = .001$). In all cases for which there was a difference in diagnosis between raters according to DTS rules 2 and 3, there was a difference in OCS assessment.

Discussion

Our study showed that the diagnostic performance of DTS rules 2 and 3 was similar to the 8 cm or larger and complex/solid criteria when retrospectively applied to adnexal masses in a North American pediatric and adolescent population. The PPV of DTS rules 2 and 3 in this study was lower (30%) compared with the initial DTS study conducted by Stankovic et al (86%).[9] Most of the discrepancies from pathology with the application of DTS rules were false positive results. Large masses with a volume score of 5 were more commonly represented in the discrepant cases, likely miscategorized because of difficulty in assessing the OCS. Inter-rater reliability was very good for MI score, fair for OCS, and moderate for DTS rules 2 and 3.

In the study conducted by Stankovic et al,[9] the DTS rules 2 and 3 had a PPV of 86% (95% confidence interval [CI], 72.8-94), which is, to our knowledge, the highest PPV reported in the literature thus far. This was not replicated in our study population despite a similar prevalence of malignant tumors (10.4% vs 14%). In our study, DTS rules 2 and 3 showed an NPV of 97% (95% CI, 94%-100%), however, a PPV of only 30% (95% CI, 17%-42%). The criteria of 8 cm or larger and complex on ultrasound examination showed an NPV of 98% (95% CI, 96%-100%) and a PPV of 29% (95% CI, 17%-40%), which was not statistically different from the DTS rules 2 and 3. Thus, whereas both algorithms had a high NPV, they were lacking in PPV.

Other studies in the literature have suggested ways to risk-stratify adnexal masses in the pediatric and adolescent population. Similar to the current study, they describe risk stratification on the basis of the size and heterogeneity of the mass, with some including tumor marker analysis. Oltmann et al[12] suggested that the best predictors of malignancy include a mass greater than 8 cm (odds ratio [OR], 19.0, 95% CI, 4.42-81.69) with solid components (OR, 10.13, 95% CI, 1.83-56.05). Other predictors of malignancy in their study included age between 1 and 8 years (OR, 3.02, 95% CI, 1.33-6.86), and a presenting complaint of precocious puberty (OR, 5.67, 95% CI, 1.60-20.03) or a mass (OR, 4.84, OR 2.48-9.45). Madenci et al[13] created a decision strategy on the basis of size of the mass, heterogeneity on ultrasound, and tumor markers. Their study showed that the categories

Table 3
Preoperative Sensitivity, Specificity, PPV, and NPV for Malignancy

Diagnostic Parameter	Sensitivity (95% CI)	P*	Specificity (95% CI)	P*	PPV (95% CI)	P*	NPV (95% CI)	P*
≥8 cm complex/solid	89 (85-94)		71 (64-77)		27 (16-38)		98 (96-100)	
DTS rules 2 + 3	84 (79-90)	.63	77 (71-83)	.21	30 (17-42)	.75	98 (94-100)	.76
MI ≥ 7	100 (100)	.15	74 (67-80)	.54	31 (19-42)	.65	100 (100)	.14
Absent OCS	84 (79-90)	.63	75 (69-82)	.32	29 (17-40)	.85	98 (95-100)	.75
Tumor markers	61 (53-69)	**.04**	85 (79-91)	**.01**	37 (19-54)	.34	94 (89-98)	.09

CI, confidence interval; DTS, Decision Tree System; MI, morphology index; OCS, ovarian crescent sign; PPV, positive predictive value; NPV, negative predictive value.
Data are presented as percentages.
P values <.05 are in bold.
* Comparison of diagnostic parameter with ≥8 cm complex/solid.

with the highest malignancy rates were tumor marker-positive heterogeneous masses (malignancy rate of 66.7% (6/9); 95% CI, 35.4%-87.9%) and solid tumors of 9 cm or larger (malignancy rate of 69.2% (9/13); 95% CI, 16.2%-40.3%).[13] However, only 15/44 malignancies were in those categories; the remainder were stratified into categories with lower risks of malignancy. Recently, Depoers et al[14] created a malignancy scoring system for masses with normal tumor markers, encompassing 3 risk groups on the basis of size of lesion (<65 mm, 65-130 mm, >130 mm) and unilocularity. Their scoring system showed a PPV of 37% and NPV of 100%.[14] Thus, most of the literature consistently shows that large masses with solid components are at higher risk for malignancy. The difficulty with each existing algorithm is the ability to correctly differentiate the benign from malignant among the subset of masses that are large and complex.

In our study, there were 41 discrepancies from pathology when the DTS rules 2 and 3 were applied to the nonemergent and emergent cohorts. Most of these discrepancies were false positive results, meaning that they were incorrectly categorized as malignant. Most of these false positive results had an absent OCS, as expected, because OCS is required to be absent for a classification of malignancy in the nonemergent cohort. Furthermore, most of these false positive results had a volume score of 5 (>500 cm^3).We hypothesize that one reason for reduced PPV of the DTS in our study population is the poor ability to accurately assess the OCS retrospectively, particularly because the OCS might not have been a point of emphasis when the ultrasound examinations were performed. This holds true particularly for large masses. According to the adult literature, comprehensive assessment of the periphery of large ovarian masses can be difficult because of the size.[15] Although we do not have similar literature in children, it is possible that in our study, the periphery of large masses was not completely visualized and therefore the OCS was incorrectly described as absent. Future research will involve assessing the DTS rules prospectively so that the presence or absence of the OCS can be more accurately determined, with special attention being paid to assessing the periphery of large masses.

In our study cohort, application of the DTS rules 2 and 3 resulted with 3 false negative results, meaning that 3 malignancies were incorrectly categorized as benign. Similarly, in the study of Stankovic et al,[9] 3 false negative results were also reported in the surgically managed group. All false negative results in our study were in the nonemergent cohort. In all cases, the MI score was 7 or higher, however, the OCS was assessed to be present. A present OCS excludes the mass from being categorized as malignant according to the DTS. Although it is possible that prospective evaluation of the OCS could improve the false negative rate, these findings support that a small false negative rate should be expected using the DTS, because the presence or absence of the OCS might not be a definitive sign of benignity or malignancy, respectively.[16]

The inter-rater reliability for DTS rules 2 and 3 was moderate, which was reduced because of only fair inter-rater reliability of the OCS. Indeed, all differences between raters in diagnosis according to the DTS rules involved differences in OCS assessment, which we attribute to the difficulty in retrospectively assessing the OCS as discussed previously. These results emphasize the strong influence that the OCS has on the DTS rules. Inter-rater reliability was very good for the structural score, volume score, and MI. Nevertheless, there were a few instances in which one rater assigned a lesion a structural score of 1 whereas the other rater assigned a structural score of 4, typically related to interpretation of solid tissue. Refinement of the structural score criteria might possibly improve reproducibility.

In addition to the DTS and its components, in our study we examined the utility of measuring the following tumor markers and hormones: Alphafetoprotein (AFP), beta human chorionic gonadotropin (HCG), carcinoma antigen 125, inhibin, estradiol, and testosterone. Results showed that abnormal tumor markers have an NPV of 94% (95% CI, 89%-98%) and a PPV of 40% (95% CI, 22%-58%). Whether tumor markers can be helpful in preoperative risk stratification of adnexal masses is unclear.[7] In a previous study in our institution, Rogers et al[7] reported that tumor markers had a NPV of 94.4% and PPV of 17%. Oltmann et al[12] reported that abnormal tumor markers were present in 54% (19/35) of malignant masses and 6.5% (8/122) of benign masses ($P < .001$). Madenci et al[13] reported that heterogeneous lesions with positive tumor markers showed a 66.7% (6/9) malignancy rate compared with heterogeneous lesions with negative tumor markers, which showed a 14.7% (11/75) malignancy rate. Therefore, most of the literature consistently shows that malignant masses will often be associated with abnormal tumor markers. The difficulty is in the ability to correctly differentiate benign from malignant masses among the subset of masses that are associated with abnormal tumor markers. The utility of tumor markers in preoperative risk stratification of adnexal masses should be investigated further.

One of the strengths of our study is that it is, to our knowledge, the first to evaluate the DTS in another population. Second, it encompassed a sizeable sample of surgically managed masses. Last, because the diagnostic performance of the DTS rules 2 and 3 and the 8 cm or larger and complex/solid criteria were both assessed in the same cohort of patients, the diagnostic performance of each strategy could be directly compared.

Our study is limited because of the retrospective design. As mentioned, this makes it more difficult to accurately assess the OCS and therefore validate the DTS. Nevertheless, the data from this study provide additional information on the DTS and its components, which might affect design of future algorithms. A second limitation is that only surgically managed masses were assessed, and therefore only DTS rules 2 and 3 were evaluated.

Conclusion

The diagnostic performance of the DTS rules 2 and 3 shown previously was not replicated in this retrospective cohort. Our study showed that DTS rules 2 and 3 had diagnostic performance similar to the simpler criteria of 8 cm or larger and complex/solid in the same population, with a very high NPV and a low PPV. Because of the inadequate inter-rater reliability of the OCS, which was possibly limited by retrospective assessment, the true applicability of the technique requires further investigation. Future prospective research should be conducted to further assess how DTS components could be incorporated into future modified algorithms for optimal management of adnexal masses in the pediatric and adolescent population.

References

1. Kirkham YA, Lacy JA, Kives S, et al: Characteristics and management of adnexal masses in a Canadian pediatric and adolescent population. J Obstet Gynaecol Can 2011; 33:935
2. Hermans AJ, Kluivers KB, Wijnen MH, et al: Diagnosis and treatment of adnexal masses in children and adolescents. Obstet Gynecol 2015; 125:611
3. Spinelli C, Buti I, Pucci V, et al: Adnexal torsion in children and adolescents: new trends to conservative surgical approach – our experience and review of literature. Gynecol Endocrinol 2013; 29:54
4. Eskander RN, Bristow RE, Saenz NC, et al: A retrospective review of the effect of surgeon specialty on the management of 190 benign and malignant pediatric and adolescent adnexal masses. J Pediatr Adolesc Gynecol 2011; 24:282
5. Kirkham YA, Kives S: Ovarian cysts in adolescents: medical and surgical management. Adolesc Med State Art Rev 2012; 23:178. xii.
6. Litz C, Danielson P, Chandler NM: Single incision laparoscopic surgery for pediatric adnexal pathology. J Pediatr Surg 2014; 49:1156
7. Rogers EM, Cubides GC, Lacy J, et al: Preoperative risk stratification of adnexal masses: can we predict the optimal surgical management? J Pediatr Adolesc Gynecol 2014; 27:125
8. Billmire D: Surveillance after initial surgery for pediatric and adolescent girls with stage 1 ovarian germ cell tumors: report from the Children's Oncology Group. J Clin Oncol 2014; 32:456
9. Stankovic ZB, Sedlecky K, Savic D, et al: Ovarian preservation from tumors and torsions in girls: prospective diagnostic study. J Pediatr Adolesc Gynecol 2017; 30:405
10. IBM Corp: IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY, IBM Corp, 2017
11. Landis JR, Koch GG: An application of hierarchical kappa-type statistics in the assessment of majority agreement among multiple observers. Biometrics 1977; 33:363
12. Oltmann SC, Garcia N, Barber R, et al: Can we preoperatively risk stratify ovarian masses for malignancy? J Pediatr Surg 2010; 45:130
13. Madenci AL, Levine BS, Laufer MR, et al: Preoperative risk stratification of children with ovarian tumors. J Pediatr Surg 2016; 51:1507
14. Depoers C, Martin FA, Timoh KN, et al: A preoperative scoring system for adnexal mass in children and adolescents to preserve their future fertility. J Pediatr Adolesc Gynecol 2019; 32:57
15. Ekerhovd E, Wienerroith H, Staudach A, et al: Preoperative assessment of unilocular adnexla cysts by transvaginal ultrasonography: a comparison between ultrasonographic morphologic imaging and histopathologic diagnosis. Am J Obstet Gynecol 2001; 184:48
16. Holsbeke CV, Belle VV, Leone FPG, et al: Prospective external validation of the 'ovarian crescent sign' as a single ultrasound parameter to distinguish between benign and malignant adnexal pathology. Ultrasound Obstet Gynecol 2010; 36:81