Ultrasound in Med. & Biol., Vol. 48, No. 1, pp. 10–19, 2022

0301-5629/$ - see front matter

https://doi.org/10.1016/j.ultrasmedbio.2021.09.010

● *Review*

WORLD FEDERATION FOR ULTRASOUND IN MEDICINE REVIEW PAPER: INCIDENTAL FINDINGS DURING OBSTETRICAL ULTRASOUND

Stamatios Petousis,* Christos Chatzakis,* Susan Campbell Westerway,† Jacques S. Abramowicz,‡ Konstantinos Dinas,* Yi Dong,§ Christoph F. Dietrich,¶ and Alexandros Sotiriadis*

* Second Department of Obstetrics and Gynecology, Faculty of Medicine, Aristotle University of Thessaloniki, Greece; † School of Dentistry & Health Sciences, Charles Sturt University, New South Wales, Australia; ‡ Department of Obstetrics and Gynecology, University of Chicago, Chicago, Illinois, USA; § Department of Ultrasound, Zhongshan Hospital, Fudan University, Shanghai, China; and ¶ Department Allgemeine Innere Medizin (DAIM), Kliniken Hirslanden Beau Site, Salem und Permanence, Bern, Switzerland

(*Received* 8 *February* 2021; *revised* 7 *September* 2021; *in final form* 8 *September* 2021)

Abstract—Although the prevalence of incidental findings revealed during an obstetric ultrasound examination is low, the findings may include adnexal and cervical masses, uterine or urinary congenital malformations, free fluid in the pouch of Douglas or tortuous vessels (varices). Adnexal masses are the most common finding and vary in imaging characteristics. They are mainly unilateral, cystic masses with a low risk of malignancy that are treated conservatively. The International Ovarian Tumor Analysis scoring models may be helpful in differentiating benign from malignant masses. For those masses >5 cm, follow-up is recommended, and resection could be considered to avoid risk of torsion, rupture and hemorrhage, which may compromise pregnancy outcome. Uterine masses such as fibroids are commonly diagnosed early in the first trimester and should be followed up during pregnancy to evaluate any changes. Transabdominal and transvaginal ultrasound is the first-line test for the diagnosis of such incidentalomas; however, magnetic resonance ultrasound may have a useful role in excluding malignancy potential. As a result of their low frequency and the lack of good evidence, there are no specific guidelines on the management of incidentalomas detected at obstetric scans. Their management should follow the related general guidelines for ovarian, cervical and uterine masses, with individualized management depending on the pregnancy status. (E-mail: c.f.dietrich@googlemail.com) **© 2021 Published by Elsevier Inc. on behalf of World Federation for Ultrasound in Medicine & Biology.**

Key Words: **World Federation for Ultrasound in Medicine, Incidental findings, Obstetrical ultrasound.**

SUMMARY STATEMENTS

- Pelvic incidentalomas during obstetrical ultrasound are not common.
- The main incidentalomas are adnexal and uterine masses.
- Conservative management is the primary option.
- The management should be individualized and take into consideration maternal and fetal well-being.
- Magnetic resonance imaging may be helpful in differentiating the potential for malignancy.
- No specific guidelines exist regarding the optimal follow-up, timing and combinations of imaging modalities.

Address correspondence to: Christoph F. Dietrich, Department Allgemeine Innere Medizin (DAIM), Kliniken Hirslanden Beau Site, Salem und Permanence, Bern, Switzerland. E-mail: c.f.dietrich@googlemail.com

INTRODUCTION AND DEFINITION

Incidental findings, often called incidentalomas, are a relatively common event in medical imaging. Numerous studies have reported unexpected findings (Lumbreras et al. 2010), for example, in trauma patients undergoing various forms of imaging (Treskes et al. 2017) and healthy volunteers having scans for research purposes (Booth et al. 2010, 2012), or the impact of detecting potentially serious incidental findings (Gibson et al. 2018). Incidental findings can have clinical, ethical and financial implications, and there is an increasing interest in the evaluation of their incidence, the benefit and burden from their diagnosis and the management and communication of incidental findings in imaging studies (Pinato et al. 2012).

Diagnostic ultrasound is one of the safest, most cost-effective and accessible forms of medical imaging.

Use of ultrasound is increasing across a wide range of specialties from general practitioners, gynecologists and cardiologists to emergency physicians, who may perform an ultrasound scan to look for a specific diagnosis such as gallstones, endometrial thickening, pleural effusion or presence of a fetal heartbeat. With every focused scan comes the possibility of incidental findings. Particularly with respect to incidental findings during pregnancy, ultrasound seems to be the main imaging modality. In this context, special consideration should be given to optimizing technique as well as establishing quality criteria for both equipment and reporting.

The World Federation for Ultrasound in Medicine aims to address the clinical impact of an incidental finding in medical ultrasound with a series of publications on incidentalomas, which will look at their definition, prevalence, imaging features, combined imaging criteria, image-guided biopsy, if relevant, and the follow-up and recommendations.

Here we report on incidental findings diagnosed during obstetric ultrasound for pregnancy follow-up.

OVARIAN INCIDENTALOMAS

Prevalence and epidemiology

The prevalence of adnexal masses varies between 0.05% and 3.2% of live births (American College of Obstetricians and Gynecologists' Committee on Practice Bulletins 2016; Senarath et al. 2021). Their incidental detection has increased in recent years because of the technical advancements in ultrasound imaging (Yacobozzi et al. 2012). The frequency of ovarian tumors at prenatal scans is about 1 in 1000 pregnancies (Hermans et al. 2003), while the risk for malignancy is even lower, estimated at between 1/15,000 and 1/100,000 pregnancies (Goffinet 2011).

Clinical significance

The majority of uterine and adnexal masses in pregnancy are incidental findings and, for the most part, are not associated with symptoms at the time of diagnosis. Symptoms may be present in three main cases (Naqvi and Kaimal 2015): (i) rupture and hemorrhage, (ii) torsion and (iii) mass effect.

Cyst rupture and hemorrhage may manifest as acute abdominal pain. One option for treatment is expectant management with analgesia and hydration, waiting for the symptoms to resolve (Alalade and Maraj 2017). A deterioration in the hemodynamic status of the pregnant woman is the main indication for shifting to surgical intervention.

In contrast, torsion necessitates emergent surgery because of high maternal morbidity and fetal mortality without immediate treatment. It is estimated that about 10%−20% of ovarian torsion cases occur during pregnancy (Huang et al. 2017), most commonly during the first trimester and early second trimester. Torsion occurs more commonly on the right, likely because mobility of the left ovary is limited by the sigmoid colon. The possibility of torsion increases with adnexal mass size, and is highest in masses with a mean diameter >5 cm. Torsion symptoms during pregnancy are generally similar to those in non-pregnant women (Naqvi and Kaimal 2015); however, peritoneal signs are less common in pregnant than in non-pregnant women with torsion.

Another clinical situation to consider is the so-called “mass effect.” If an adnexal mass persists during pregnancy, while the uterus is continuously enlarging, the mass may be displaced in the pouch of Douglas or adnexa. This, in turn, may lead to clinical consequences such as symptoms from the urinary tract and lower digestive system because of pressure or obstruction of labor (Cavaco-Gomes et al. 2016). Therefore, the management choice should be individualized, based on symptoms and clinical evaluation for possible complications/labor obstruction, especially in nulliparous women.

The risk of malignancy during pregnancy is extremely low (Senarath et al. 2021). However, the identification of an ovarian mass as malignant is paramount because the clinical management will greatly depend on this categorization. The algorithm for evaluation of malignancy potential is identical to that used in non-pregnant women.

Finally, with respect to the time of diagnosis, the majority of ovarian incidentalomas are more frequently diagnosed in the first trimester of pregnancy. The main reason for early diagnosis is associated with the relatively smaller size of the uterus, permitting more accurate examination of adnexa as well during the first trimester. In addition, it is rather rare for complications such as torsion of ovarian cysts to occur in the third trimester, as potentially the increased size of the uterus and hosted fetus may indeed prevent such complications. In general, there is no definitive consensus on the exact time of diagnosis, but it seems that the majority of ovarian incidentalomas may be diagnosed at the end of the first trimester, while their complications may be apparent in both the first and second trimesters of pregnancy.

Ovaries and incidentalomas (too large, too small, atypical location)

Adnexal masses during pregnancy may present in a variety of sizes, shapes and imaging features, which may also be seen in other gynecological and non-gynecological conditions. The majority of ovarian masses are consistent with ovarian cysts, among which simple functional cysts are the most frequent (Fig. 1). Corpus luteum cysts may also be diagnosed, but they are expected to resolve by the 8th to 12th gestational weeks

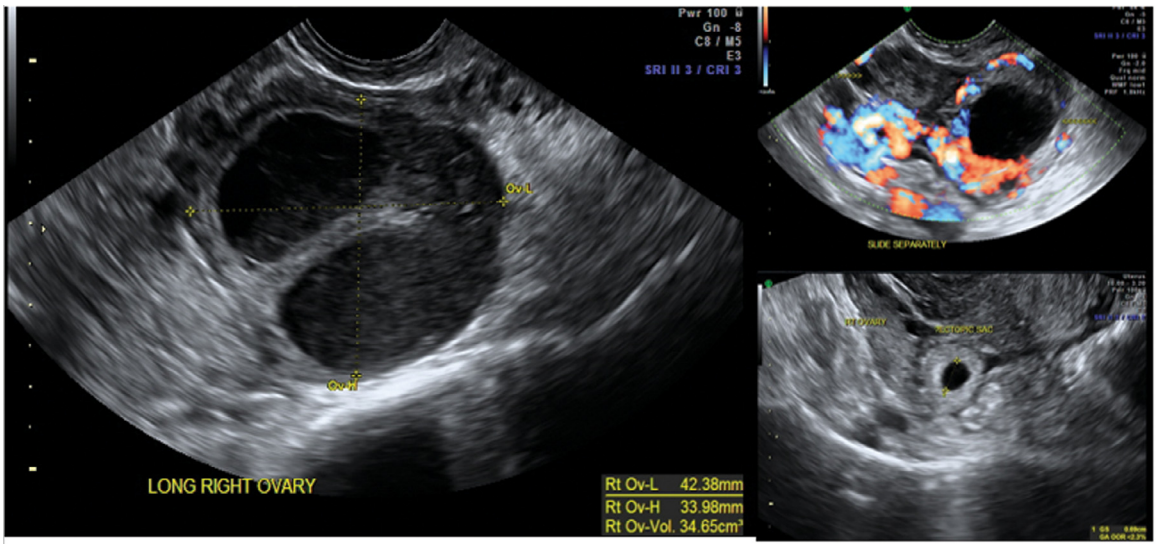

Fig. 1. Benign cyst of the ovary (left) versus non-ruptured ectopic pregnancy (right).

(Alalade and Maraj 2017). Ovarian functional cysts are usually unilateral and unifocal, less than 5 cm in size; a larger size may increase the possibility of clinical complications and may pose the question of surgical intervention (Agarwal et al. 2003; Condous et al. 2004; de Haan et al. 2015). Other types of ovarian benign cysts include serous cystadenomas, mucinous cystadenomas and endometriomas. Specifically, endometriomas are ovarian cysts with ground glass echogenicity of the cyst fluid, one to four locules and no papillary projections with detectable blood flow (Indrielle-Kelly et al. 2019).

Blood flow examination according to color Doppler ultrasound may be helpful in assessing the kind of ovarian incidentaloma through evaluation of the presence of blood flow in papillary projections. There have also been published studies that sought to customize blood flow patterns with risk for malignancy based on the pulsatility index (PI) of Doppler waves; however, no definitive results have yet been obtained.

Ovarian cysts must also be differentially diagnosed from para-ovarian cysts, paratubal cysts, pedunculated subserous uterine leiomyomas, hydrosalpinx and peritoneal pseudocysts, which may present with similar ultrasound features (Senarath et al. 2021). Mature cystic teratomas, also called dermoid cysts, are the most common adnexal cysts diagnosed after 16 wk of gestation (Fig. 2) (Agarwal et al. 2003; Hermans et al. 2003; Leiserowitz 2006; Pearl et al. 2017).

With respect to the ultrasound characteristics of ovarian torsion, Huang et al. (2017) precisely reported the ultrasound characteristics. An ovary in torsion may be rounded and enlarged compared with the contralateral ovary because of edema or vascular and lymph engorgement (Anthony et al. 2012; Wilkinson and Sanderson 2012). Color Doppler flow in the vessels of an ovary in torsion can be decreased or absent (Albayram and Hamper, 2001; Servaes et al. 2007). Color Doppler may not be the gold standard for diagnosis, but is a rather useful

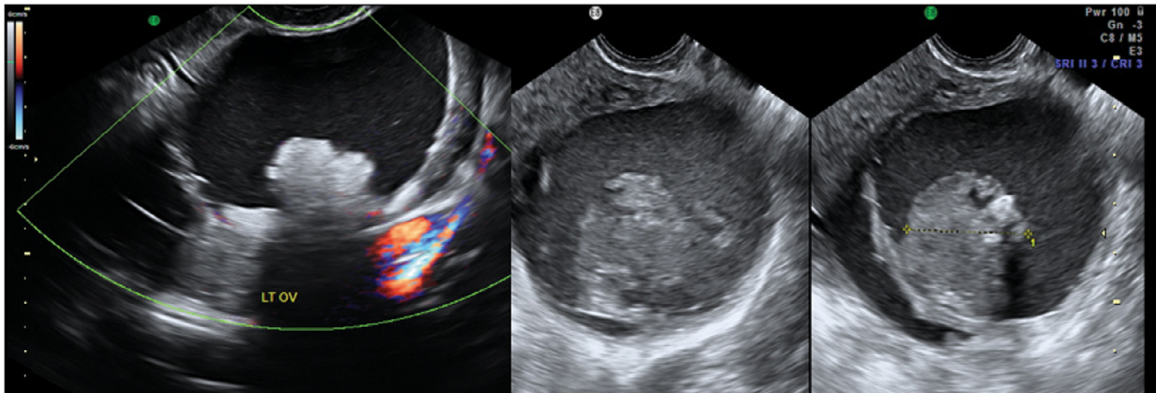

Fig. 2. Ovarian cystic teratoma (left) versus ovarian cancer (right).

imaging tool (Nizar et al. 2009). Finally, the so-called "whirlpool sign'' may be highly sensitive for ovarian torsion (Valsky et al. 2010). The whirlpool sign appears as a twisted vascular pedicle, and a color Doppler sonogram reveals circular vessels within the mass.

Is the incidental finding malignant or is it benign but malignant transformation is possible?

Only about 5% of ovarian tumors in pregnancy are malignant, estimated to range between 1/15,000 and 1/100,000 cases. The possibility of malignant transformation of previously benign lesions is disputed not only in pregnancy, but generally in ovarian tumors (Senarath et al. 2021).

Ultrasound features suggestive of malignancy include the presence of intracystic solid components, septations, papillary projections, increased vascularity and an increase in size by 20% on subsequent scan and ascites. On the contrary, a benign ovarian cyst will usually be unilocal and unifocal, without any of the aforementioned ultrasound characteristics.

The International Ovarian Tumor Analysis (IOTA) study developed a framework for differentiation between benign and malignant lesions. Simple rules from the IOTA study are based on the examination of five ultrasound features suggestive of malignancy and five suggestive of a benign mass. A mass is classified as malignant if at least one malignant feature and none of the benign features are present, and vice versa (Menon et al. 2009). If no benign or malignant features are present, or if both benign and malignant features are present, then the findings are considered inconclusive (unclassifiable mass), and a different diagnostic method should be used (Kaijser et al. 2013). Unilocular lesions, lesions with solid components and with intracavitary projections whose largest diameter is <7 mm, lesions presenting with an acoustic shadow, smooth multilocular tumors with the largest diameter <100 mm and lesions with no blood flow are characterized as lesions with benign features. On the other hand, irregular solid tumors, presence of ascites, presence of at least four papillary structures, irregular multifocal solid tumors with the largest diameter >100 mm and lesions with very strong blood flow are characterized as lesions with malignant features (Kaijser et al. 2013). In this context, we may also discuss the significant role of color Doppler ultrasound, as the presence or absence of blood flow is considered a decisive factor in malignancy potential assessment. The aforementioned approach has a sensitivity of 90% and specificity of 93% for detection of malignant ovarian masses (Timmerman et al. 2010). In the case of inconclusive findings (unclassifiable mass), magnetic resonance imaging (MRI) should be used to decide whether surgical evaluation is required and to guide the management plan.

Image-guided biopsy and fine-needle aspiration have been successfully used in the case of simple cysts to reduce the risk of torsion, rupture, obstructed labor and pain (Guariglia et al. 1999). The procedure is considered safe, without a significantly increased risk of recurrence, infection, hemorrhage and preterm labor (Graham 2007). However, the possibility of peritoneal spread of potential malignancy is a theoretical concern with these methods (Graham 2007). In the case of ovarian cancer, rupture of a malignant mass may change the stage of disease from IA to IC1 according to current FIGO staging, therefore compromising the prognosis of both the pregnancy and the patient.

It is very likely that ultrasound examination may not be able to provide a definitive diagnosis of an adnexal mass, especially in pregnancy. According to the ACOG guidelines, MRI is the preferred method in such cases. Indeed, MRI with intravenous (IV) contrast administration provides the highest post-test probability of ovarian cancer detection. However, their main contribution in the evaluation of an adnexal mass may actually lie in their high specificity as MRI permits reliable detection of many benign adnexal lesions (American College of Obstetricians and Gynecologists' Committee on Practice Bulletins 2016). However, the use of gadolinium is not recommended in pregnancy, unless a clear diagnostic benefit is expected (American College of Obstetricians and Gynecologists' Committee on Practice Bulletins 2016). Computed tomography (CT) should be performed with prudence during pregnancy only in certain indications such as the assessment of potential thoracic disease (*e.g.,* metastases), with appropriate use of abdominal shielding (American College of Obstetricians and Gynecologists' Committee on Practice Bulletins 2016).

Does the incidentaloma have hidden symptoms or endocrine activity?

This is unlikely during pregnancy.

Follow-up

There are no specific guidelines for the surveillance of adnexal masses during pregnancy. It is generally believed that the majority of functional cysts will resolve spontaneously before 16 wk (Agarwal et al. 2003). Follow-up ultrasound scans could be performed every 4−6 wk for cysts larger than 6 cm or with a complex appearance to evaluate potential differentiation in size along with the emergence of previously non-observed ultrasound characteristics, such as a change in vascularity.

Surgery and other treatment options

The management of adnexal masses during pregnancy depends on their malignancy potential and size and the manifestation of emergent clinical symptoms.

Surgery is indicated in cases in which malignancy is suspected according to IOTA scoring, as previously mentioned. Similarly, surgery may need to be performed in the case of emergent clinical symptoms, especially when these are correlated with hemodynamic instability and peritoneal symptoms (Alalade and Maraj 2017). Controversy exists regarding the optimal management of asymptomatic, non-malignant adnexal masses randomly diagnosed during obstetrical ultrasound. In such cases, the size of the lesion is the main determinant. It seems that for masses smaller than 5 cm that do not increase in size during pregnancy, the management should be expectant, while masses between 5 and 10 cm, and particularly those larger than 10 cm, should be resected because of the increased risk for torsion and rupture (Agarwal et al. 2003; Condous et al. 2004; Pearl et al. 2017).

As for the optimal gestational age at surgery, it was previously argued that non-urgent surgery should ideally be performed between the 16th and 23rd gestational weeks. On the other hand, secondary to the enlarged uterus, one runs the added risk of preterm labor (Agarwal et al. 2003; Condous et al. 2004; de Haan et al. 2015). With respect to the dilemma of laparotomy versus laparoscopy, it is becoming evident that the latter is preferred, although both methods have been proven to be safe (Alalade and Maraj 2017). A randomized controlled trial including 69 patients with ovarian cysts found that laparoscopy is associated with better visualization of the pelvic organs, as well as reduced risk of uterine irritability (Chen et al. 2014). There is no concern regarding the stability of uteroplacental perfusion during laparoscopic techniques. Laparoscopy is technically more challenging after the 16th gestational week because of the enlarging uterus; however, this is also dependent on the operator's experience and clinical skills (Pearl et al. 2017).

UTERINE INCIDENTALOMAS

Because of their prevalence and epidemiology, uterine myomas are the most common clinical entity that may be incidentally diagnosed during obstetrical ultrasound. Although rates around 1.6%–10.7% have been reported (Song et al. 2013), the exact prevalence of myomas in pregnancy cannot be easily estimated, and no consensus guidelines exist on their management during pregnancy. Diffuse uterine myomatosis in pregnancy is even rarer, with a prevalence of 0.1%–3.9% (Stratakis and Garnica 1995). Ethnicity seems to be an epidemiologic factor significantly affecting the risk of fibroids, as there appears to be a two- to threefold increased possibility of lifetime fibroid occurrence in black women.

Clinical significance

Depending on their location, myomas have been associated with increased risk for fetal malpresentation, cesarean birth, preterm delivery, premature rupture of membranes, pelvic pain, placental abruption, dysfunctional birth, dystocia and postpartum hemorrhage (Vergani et al. 2007; Vitale et al. 2013; Incebiyik et al. 2014; Michels et al. 2014). Furthermore, myomas are sometimes complicated by secondary changes during pregnancy, such as hemorrhage, necrosis and degeneration and, histologically, may represent a major diagnostic challenge versus the rare leiomyosarcoma. However, most myomas remain asymptomatic, and the development of symptoms depends on their number, size and location (Fig. 3).

Myomas diagnosed as incidental findings during pregnancy vary in size and location. Large myomas are usually diagnosed before pregnancy, and the majority of cases diagnosed during pregnancy are small (<4 cm) myomas that may be present in any of the potential

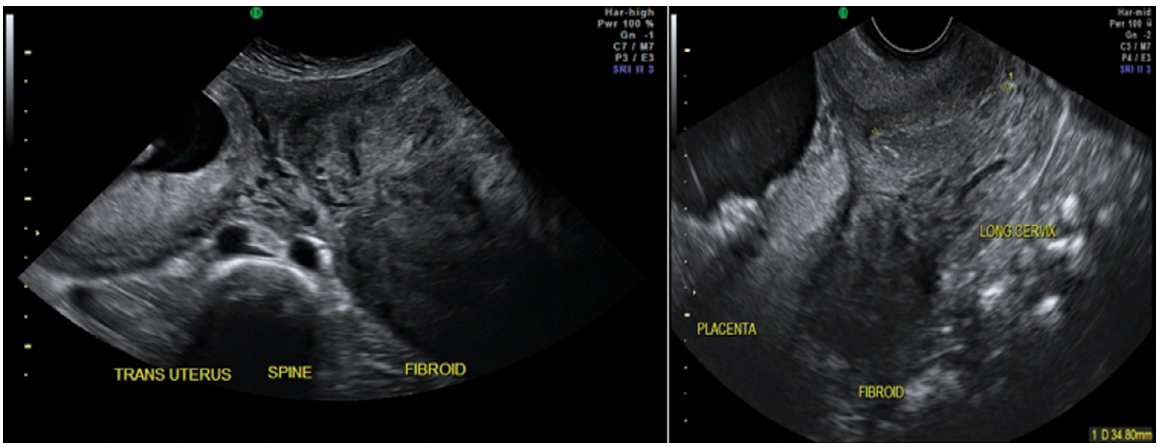

Fig. 3. Uterine fibroid and a concurrent *in utero* pregnancy.

locations according to FIGO classification (Vitale et al. 2013). Diffuse uterine leiomyomatosis in pregnancy is rare, with an estimated prevalence of 0.1%−3.9%.

Ultrasonography is the best tool for determining the size, number location and ultrasound features of myomas, their relationship with the placental location and their vascularization.

There is no definitive evidence regarding the potential time of uterine incidentaloma diagnosis during pregnancy. In general, it is more probable that their presence is diagnosed in the first trimester, apparently because of the smaller size of the uterus. However, we could highlight that complications may actually occur in all trimesters of pregnancy, predominantly after the second trimester as the aforementioned secondary changes in pregnancy occur as size and vascularization of the uterus increase after the second trimester. Color Doppler ultrasound may also assist significantly in evaluating vascularization pattern, which is a significant parameter in evaluation of malignancy potential.

Is the incidental finding malignant?

The differential diagnosis between a uterine myoma and a sarcoma may be very challenging and even more so in pregnancy.

Kim et al. (2019) recently published a study in which they retrospectively examined ultrasound characteristics of uterine masses previously misdiagnosed as benign and finally proven to be malignant. Ultrasound heterogeneity of the mass was the most frequent ultrasound characteristic, as this was present in all cases (100%). Furthermore, increased vascularity detected with color Doppler examination was also observed in 87.5% of patients. Moreover, the presence of a cystic portion with an irregular wall (87.5% of cases) was another common ultrasound characteristic. Margins of the mass could not be diagnostic as half of cases had clear margins and the other had irregular margins. Although validation of such characteristics has not yet been made for malignant tumors diagnosed during pregnancy, we should consider that ultrasound heterogeneity, increased vascularity with color Doppler examination and presence of a cystic portion with an irregular wall are the most frequent ultrasound characteristics in suspicious uterine masses.

Another useful imaging modality in the context of differential diagnosis between benign myomas and sarcomas may be MRI. There have been recent publications reporting the optimal diagnostic algorithm for differentiating atypical leiomyoma from malignant uterine sarcoma using diffusion-weighted MRI (Abdel Wahab et al. 2020). Predictive MRI criteria for malignancy were enlarged lymph nodes or peritoneal implants, a high diffusion-weighted imaging signal greater than that in the endometrium and an apparent diffusion coefficient $\leq 0.905 \times 10^{-3}$ mm^2/s. Conversely, a global or focal area of low T2 signal intensity and a low or intermediate diffusion-weighted imaging signal less than that in the endometrium or lymph nodes was significantly associated with the diagnosis of a benign uterine mass.

Finally, with respect to biochemical markers, their utility is rather limited, except for the relative contribution of lactate dehydrogenase isoenzymes (Di Cello et al. 2019). There are no descriptions in the literature of cases with malignant transformation of a fibroid during pregnancy. It is generally disputed whether sarcomas derive from malignant transformation or are *a priori* malignant uterine tumors.

Is the incidentaloma associated with hidden symptoms or endocrine activity?

Myomas are rather unlikely to present with hidden symptoms and endocrine activity.

Follow-up

Fibroids within the endometrial cavity that are not clearly delineated may require saline infusion sonography or hysteroscopy after pregnancy to further evaluate their relationship to the endometrial cavity. In the case of uncertain diagnosis, suspicion of uterine sarcoma or adenomyosis and inconclusive ultrasound findings, further investigation by MRI may be required (Omary et al. 2002).

Surgery and other treatment options

It still remains controversial whether growing myomas should be resected either during pregnancy or during cesarean section. In general, myomectomy is not recommended during pregnancy and is not a commonly performed procedure, although it may be considered an option for selected cases. Specifically, the torsion of a pedunculated myoma during pregnancy that could lead to a complete axial torsion of all pregnant tissues should be treated surgically (Deshpande et al. 2011; Currie et al. 2013; Sachan et al. 2014). Another indication is recurrent or severe pain after failure of expectant management. Absolute contraindications to myomectomy are uterine atony during labor, intramural nodules growing and expanding toward the uterine cavity or displacing large vessels. Although myomectomy during cesarean section remains controversial, it is a well-tolerated and feasible procedure despite the risk of bleeding, which may be very difficult to control (Ande et al. 2004; Song et al. 2013; Kumar et al. 2014; Kwon et al. 2014).

Another therapeutic strategy that may be used in certain cases of fibroids is uterine artery embolization (UAE). UAE is a therapeutic modality whose efficacy

has been indicated especially for large or multiple myomas. UAE may also be an efficient treatment approach to reduce the size of myomas, simplifying their surgical removal (Abrahami et al. 2021). However, to date, there are few published data regarding UAE during pregnancy; therefore, the decision to use such a therapeutic modality should be made with caution, in specific cases by centers with relative experience and in which a High-Risk Pregnancy Unit is available.

As for the risk of complications after myomectomy during pregnancy, it has been estimated that there is a twofold increase in the possibility of spontaneous miscarriage afterward, with an even higher rate for interventions during the first trimester (Benson et al. 2001).

OTHER INCIDENTAL FINDINGS

Fluid in the pouch of Douglas

Free fluid in the pouch of Douglas (cul-de-sac) is a common incidental finding and, if less than 10 mL, is usually owing to follicular or ovarian cyst rupture (Davis and Gosink 1986). It is usually detected in the first trimester by transvaginal ultrasound. Apart from free sonolucent fluid, blood or blood clots can also be found in the pouch of Douglas. These may arise from bleeding from an ectopic pregnancy or can be the result of a ruptured ovarian cyst. Management of free fluid in the pouch of Douglas is dictated by management of the initial cause. However, in case this is a solitary finding without underlying pathology, no certain guidelines exist for its management during pregnancy. Therefore, surveillance seems to be the most reasonable option.

Renal ectopic and fusion anomalies, pelvic kidney and horseshoe kidneys

Asymptomatic renal ectopic and fusion anomalies that were not diagnosed during childhood may be detected as incidental findings during transvaginal sonographic examination in the first trimester. An ectopic kidney located below the pelvic brim is commonly called a pelvic kidney (Guarino et al. 2004). The incidence of pelvic kidney is reported to be 1 in 2500 live births, and, if identified, it is important to confirm the presence or absence and the location of the contralateral kidney (Gencheva et al. 2019). Horseshoe kidneys (HSKs) are the most common fusion anomaly and have an incidence of 1 in 400−500 (Nahm and Ritz 1999; Rodriguez 2014). HSKs are typically found at the level of the fourth or fifth lumbar vertebra, and their blood supply varies widely (Bingham and Leslie 2021). HSKs often cause ureteral dilatation and lithiasis, which should be taken into account in their clinical management. However, urinary tract infections caused by HSKs in pregnancy are more common in children and are rather limited in pregnancy. CT imaging may be of help in assessing the related vasculature; however, its use is rather limited in pregnancy as previously described. MRI is potentially the best therapeutic modality in detecting such malformations. Finally, other urinary tract anomalies that can be detected during vaginal US include ureteral dilatation caused by malformations or lithiasis. Color Doppler helps to differentiate between hydro-ureter and vessels. Bladder anomalies such as tumors and utereoceles can also be detected during transabdominal US.

The clinical management of such findings during pregnancy has not yet been clarified, and no specific guidelines exist. However, it is already known that, because of their abnormal rotation, shape and vasculature, pelvic kidneys predispose to urinary tract infections in non-pregnant patients (Gulsun et al. 2000). As urinary tract infections may have clinical consequences in pregnancy, it would be reasonable to advise pregnant women to take preventive measures, such as adequate hydration. Furthermore, given that ectopic position makes the kidneys vulnerable to physical damage (Gulsun et al. 2000), acute abdominal pain and/or hemodynamic instability in patients with known urinary abnormalities should be always be dealt with in the light of possible trauma in the ectopic kidney. The risk for trauma and subsequent hemorrhage is also elevated by the complicated and highly variable vasculature of the pelvic kidney (Urban et al. 2001); therefore, the differential diagnosis of acute symptoms in cases with known congenital renal abnormalities should always take into account the possibility of traumatic damage. In any case, it should be highlighted that diagnosis of such clinical entities necessitates referral to specialized units with related experience in both treatment and follow-up.

Tortuous vessels (varices)

Tortuous pelvic vessels are characterized by regurgitation of blood from ovarian veins, leading to bulging of the veins and chronic pelvic pain (Venbrux and Lambert 1999). The uterus, ovaries or vulva may be affected because of the pooling of blood to these tissues. Fifteen percent of women have varicose veins in the pelvis, but many are symptomatic. Sonographic examination has a crucial role in the evaluation of pelvic tortuous veins, as it provides dynamic information on the visualized venous blood flow (Sharma et al. 2014). Sonographic criteria for the diagnosis of varices include dilated ovarian veins >4 mm in diameter, dilated tortuous arcuate veins in the myometrium that communicate with bilateral pelvic varicose veins, slow blood flow (<3 cm/s) on color Doppler examination and reversed caudal or retrograde venous blood flow particularly in the left ovarian vein (Coakley et al. 1999).

The sonographic finding of tortuous vessels during pregnancy is more commonly observed during early pregnancy at transvaginal scans (Sharma et al. 2014). Their exact significance in pregnancy remains unknown, and no evidence or guidelines exist on their optimal management and follow-up.

CLINICAL SCENARIOS AND ROLE OF ULTRASOUND

Detection of incidentaloma by transabdominal ultrasound

Transabdominal ultrasound is a valuable and widely available imaging tool throughout pregnancy, particularly during the second and third trimesters. Transabdominal ultrasound offers great advantages in the primary detection of both ovarian and uterine masses in the context of an obstetric scan. Despite the relatively low frequency of pelvic incidentalomas, it is difficult to miss the diagnosis of a large ovarian mass during a competently performed pregnancy scan (Senarath et al. 2021). Ultrasound is the best imaging method. No studies comparing ultrasound with other imaging modalities for incidentalomas in pregnancy have been reported. However, it is standard practice that ultrasound is the basis of follow-up for most incidentalomas during pregnancy. Ultrasound offers the advantages of safety, reproducibility, ease of access, low cost and availability of past images with which to compare the evolution of a known mass. Therefore, ultrasound is used for the follow-up of incidental findings during pregnancy, and additional imaging modalities can be considered in the case of suspicious masses.

Detection of incidental findings by cross-sectional imaging (CT, MRI)

MRI contributes to the overall imaging approach to incidentalomas during pregnancy, First, its can be invaluable in the differential diagnosis between benign and malignant ovarian masses (Malek et al. 2019). Indeed, MRI may be a completely reliable therapeutic modality with which to differentiate benign and malignant ovarian masses. However, accessibility and feasibility of ultrasound during pregnancy are the main reasons ultrasound is the first choice in detection of an incidentaloma, while MRI may be used in addition in certain cases. Furthermore, apart from ovarian masses, MRI may also help in discriminating between a myoma and a sarcoma as mentioned earlier. However, certain ultrasound characteristics may also be indicative of complicated uterine masses; therefore, education and standardization of reporting are needed. Moreover, MRI is potentially the best complementary imaging modality for uterine tract malformations. There is no consensus on optimal timing or the number of MRI scans; however, it would be reasonable to perform MRI once, preferably close to the time of detection, to have an initial imaging diagnosis excluding malignancy.

In contrast, CT rarely contributes to the diagnosis of incidental findings in pregnancy. Use of pelvic CT is avoided primarily for safety concerns, and therefore, there have not been many publications on its use in imaging incidental findings. Furthermore, with respect to its diagnostic accuracy, it seems that depending on the kind of major incidental findings, CT is rather inferior to ultrasound and MRI and offers no added diagnostic value in the majority of cases. Moreover, abdominal shielding, previously considered to decrease the amount of irradiation to which the fetus is exposed, increases; therefore, its use during pregnancy should be avoided (Begano et al. 2020).

To conclude, use of CT, in contrast to MRI, is limited during pregnancy as a diagnostic approach to incidental findings.

SUMMARY

Incidental findings in obstetric ultrasound are uncommon but may pose challenging diagnostic and therapeutic dilemmas. They are usually adnexal masses or uterine masses and, less commonly, genitourinary abnormalities. There are no consensus guidelines regarding the management of incidental findings during obstetric ultrasound; therefore, their management is commonly based on guidelines for non-pregnant women, taking into consideration the particular circumstances of pregnancy. The risk of malignancy is relatively low. The role of complementary imaging modalities is rather restricted to the use of MRI for suspicious masses. Further high-quality research is required to clarify optimal treatment and follow-up strategies. Referral of demanding and rare cases to experienced centers and physicians is recommended to achieve the optimum diagnostic approach and treatment.

Institutional review board gave approval and that subjects granted permission for the use of their data/images.

Conflict of interest disclosure—The authors declare no competing interests.

REFERENCES

Abdel Wahab C, Jannot AS, Bonaffini PA, Bourillon C, Cornou C, Lefrère-Belda MA, Bats AS, Thomassin-Naggara I, Bellucci A, Reinhold C, Fournier LS. Diagnostic algorithm to differentiate benign atypical leiomyomas from malignant uterine sarcomas with diffusion-weighted MRI. Radiology 2020;297:361–371.

Abrahami Y, Najid S, Petit A, Sauvanet E, Novelli L. Reducing the risk of bleeding after myomectomy: Is preemptive embolization a valuable tool?. CVIR Endovasc 2021;4:42.
Agarwal N, Parul Kriplani A, Bhatla N, Gupta A. Management and outcome of pregnancies complicated with adnexal masses. Arch Gynecol Obstet 2003;267:148–152.
Alalade AO, Maraj H. Management of adnexal masses in pregnancy. Obstetrician Gynaecologist 2017;19:317–325.
Albayram F, Hamper UM. Ovarian and adnexal torsion: Spectrum of sonographic findings with pathologic correlation. J Ultrasound Med 2001;20:1083–1089.
American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Gynecology. Practice Bulletin No. 174: Evaluation and management of adnexal masses. Obstet Gynecol 2016;128:e210–e226.
Ande AB, Ehigiegba AE, Umeora OU. Repeat myomectomy at caesarean section. Arch Gynecol Obstet 2004;270:296–298.
Anthony EY, Caserta MP, Singh J, Chen MY. Adnexal masses in female pediatric patients. AJR Am J Roentgenol 2012;198:W426–W431.
Begano D, Söderberg M, Bolejko A. To use or not use patient shielding on pregnant women undergoing CT pulmonary angiography: A phantom study. Radiat Prot Dosimetry 2020;189:458–465.
Benson CB, Chow JS, Chang-Lee W, Hill JA, III, Doubilet PM. Outcome of pregnancies in women with uterine leiomyomas identified by sonography in the first trimester. J Clin Ultrasound 2001;29:261–264.
Bingham G, Leslie SW. Pelvic kidney. StatPearls. Treasure Island, FL: StatPearls; 2021 January. [Internet]Available at: https://www.ncbi.nlm.nih.gov/books/NBK563239/.
Booth TC, Jackson A, Wardlaw JM, Taylor SA, Waldman AD. Incidental findings found in "healthy" volunteers during imaging performed for research: Current legal and ethical implications. Br J Radiol 2010;83:456–465.
Booth TC, Waldman AD, Wardlaw JM, Taylor SA, Jackson A. Management of incidental findings during imaging research in "healthy" volunteers: Current UK practice. Br J Radiol 2012;85:11–21.
Cavaco-Gomes J, Jorge Moreira C, Rocha A, Mota R, Paiva V, Costa A. Investigation and management of adnexal masses in pregnancy. Scientifica (Cairo) 2016;2016 3012802.
Chen L, Ding J, Hua K. Comparative analysis of laparoscopy versus laparotomy in the management of ovarian cyst during pregnancy. J Obstet Gynaecol Res 2014;40:763–769.
Coakley FV, Varghese SL, Hricak H. CT and MRI of pelvic varices in women. J Comput Assist Tomogr 1999;23:429–434.
Condous G, Khalid A, Okaro E, Bourne T. Should we be examining the ovaries in pregnancy? Prevalence and natural history of adnexal pathology detected at first-trimester sonography. Ultrasound Obstet Gynecol 2004;24:62–66.
Currie A, Bradley E, McEwen M, Al-Shabibi N, Willson PD. Laparoscopic approach to fibroid torsion presenting as an acute abdomen in pregnancy. JSLS 2013;17:665–667.
Davis JA, Gosink BB. Fluid in the female pelvis: Cyclic patterns. J Ultrasound Med 1986;5:75–79.
de Haan J, Verheecke M, Amant F. Management of ovarian cysts and cancer in pregnancy. Facts Views Vis Obgyn 2015;7:25–31.
Deshpande G, Kaul R, Manjudalevi P. A case of torsion of gravid uterus caused by leiomyoma. Case Rep Obstet Gynecol 2011;2011 206418.
Di Cello A, Borelli M, Marra ML, Franzon M, D'Alessandro P, Di Carlo C, Venturella R, Zullo F. A more accurate method to interpret lactate dehydrogenase (LDH) isoenzymes' results in patients with uterine masses. Eur J Obstet Gynecol Reprod Biol 2019;236:143–147.
Gencheva R, Gibson B, Garugu S, Forrest A, Sakthi-Velavan S. A unilateral pelvic kidney with variant vasculature: Clinical significance. J Surg Case Rep 2019;2019:rjz333.
Gibson LM, Paul L, Chappell FM, Macleod M, Whiteley WN, Al-Shahi Salman R, Wardlaw JM, Sudlow CLM. Potentially serious incidental findings on brain and body magnetic resonance imaging of apparently asymptomatic adults: systematic review and meta-analysis. BMJ 2018;363:k4577.
Goffinet F. Ovarian cysts and pregnancy. J Gynecol Obstet Biol Reprod 2011;30:S100–S108.
Graham I. Adnexal masses in pregnancy: Diagnosis and management. Donald School J Ultrasound Obstet Gynecol 2007;1:66–74.
Guariglia L, Conte M, Are P, Rosati P. Ultrasound-guided fine needle aspiration of ovarian cysts during pregnancy. Eur J Obstet Gynecol Reprod Biol 1999;82:5–9.
Guarino N, Tadini B, Camardi P, Silvestro L, Lace R, Bianchi M. The incidence of associated urological abnormalities in children with renal ectopia. J Urol 2004;172:1757–1759 discussion 1759.
Gulsun M, Balkanci F, Cekirge S, Deger A. Pelvic kidney with an unusual blood supply: Angiographic findings. Surg Radiol Anat 2000;22:59–61.
Hermans RHM, Fischer DC, van der Putten HWHM, van de Putte G, Einzmann T, Vos MC, Kieback DG. Adnexal masses in pregnancy. Onkologie 2003;167–172.
Huang C, Hong MK, Ding DC. A review of ovary torsion. Tzu Chi Med J 2017;29:143–147.
Incebiyik A, Hilali NG, Camuzcuoglu A, Vural M, Camuzcuoglu H. Myomectomy during caesarean: A retrospective evaluation of 16 cases. Arch Gynecol Obstet 2014;289:569–573.
Indrielle-Kelly T, Frühauf F, Burgetová A, Fanta M, Fischerová D. Diagnosis of endometriosis 2nd part—Ultrasound diagnosis of endometriosis (adenomyosis, endometriomas, adhesions) in the community. Ceska Gynekol 2019;84:260–268.
Kaijser J, Bourne T, Valentin L, Sayasneh A, Van Holsbeke C, Vergote I, Testa AC, Franchi D, Van Calster B, Timmerman D. Improving strategies for diagnosing ovarian cancer: A summary of the International Ovarian Tumor Analysis (IOTA) studies. Ultrasound Obstet Gynecol 2013;41:9–20.
Kim JH, Kim HJ, Kim SH, Shin SA, Park SY, Kim DY, Lee SR, Chae HD, Kang BM. Sonographic and clinical characteristics of uterine sarcoma initially misdiagnosed as uterine fibroid in women in the late reproductive age. J Menopausal Med 2019;25:164–171.
Kumar RR, Patil M, Sa S. The utility of caesarean myomectomy as a safe procedure: A retrospective analysis of 21 cases with review of literature. J Clin Diagn Res 2014;8:OC05–OC08.
Kwon DH, Song JE, Yoon KR, Lee KY. The safety of cesarean myomectomy in women with large myomas. Obstet Gynecol Sci 2014;57:367–372.
Leiserowitz GS. Managing ovarian masses during pregnancy. Obstet Gynecol Surv 2006;61:463–470.
Lumbreras B, Gonzalez-Alvarez I, Lorente MF, Calbo J, Aranaz J, Hernandez-Aguado I. Unexpected findings at imaging: Predicting frequency in various types of studies. Eur J Radiol 2010;74:269–274.
Malek M, Rahmani M, Seyyed Ebrahimi SM, Tabibian E, Alidoosti A, Rahimifar P, Akhavan S, Gandomkar Z. Investigating the diagnostic value of quantitative parameters based on T2-weighted and contrast-enhanced MRI with psoas muscle and outer myometrium as internal references for differentiating uterine sarcomas from leiomyomas at 3T MRI. Cancer Imaging 2019;19:20.
Menon U, Gentry-Maharaj A, Hallett R, Ryan A, Burnell M, Sharma A, Lewis S, Davies S, Philpott S, Lopes A, Godfrey K, Oram D, Herod J, Williamson K, Seif MW, Scott I, Mould T, Woolas R, Murdoch J, Dobbs S, Amso NN, Leeson S, Cruickshank D, McGuire A, Campbell S, Fallowfield L, Singh N, Dawnay A, Skates SJ, Parmar M, Jacobs I. Sensitivity and specificity of multimodal and ultrasound screening for ovarian cancer, and stage distribution of detected cancers: Results of the prevalence screen of the UK Collaborative Trial of Ovarian Cancer Screening (UKCTOCS). Lancet Oncol 2009;10:327–340.
Michels KA, Velez Edwards DR, Baird DD, Savitz DA, Hartmann KE. Uterine leiomyomata and cesarean birth risk: A prospective cohort with standardized imaging. Ann Epidemiol 2014;24:122–126.
Nahm AM, Ritz E. Horseshoe kidney. Nephrol Dial Transplant 1999;14:2740–2741.
Naqvi M, Kaimal A. Adnexal masses in pregnancy. Clin Obstet Gynecol 2015;58:93–101.

Nizar K, Deutsch M, Filmer S, Weizman B, Beloosesky R, Weiner Z. Doppler studies of the ovarian venous blood flow in the diagnosis of adnexal torsion. J Clin Ultrasound 2009;37:436–439.

Omary RA, Vasireddy S, Chrisman HB, Ryu RK, Pereles FS, Carr JC, Resnick SA, Nemcek AA, Jr., Vogelzang RL. The effect of pelvic MR imaging on the diagnosis and treatment of women with presumed symptomatic uterine fibroids. J Vasc Interv Radiol 2002;13:1149–1153.

Pearl JP, Price RR, Tonkin AE, Richardson WS, Stefanidis D. SAGES guidelines for the use of laparoscopy during pregnancy. Surg Endosc 2017;31:3767–3782.

Pinato DJ, Stavraka C, Tanner M, Esson A, Jacobson EW, Wilkins MR, Libri V. Clinical, ethical and financial implications of incidental imaging findings: Experience from a phase I trial in healthy elderly volunteers. PLoS One 2012;7:e49814.

Rodriguez MM. Congenital anomalies of the kidney and the urinary tract (CAKUT). Fetal Pediatr Pathol 2014;33:293–320.

Sachan R, Patel ML, Sachan P, Arora A. Complete axial torsion of pregnant uterus with leiomyoma. BMJ Case Rep 2014;2014 bcr2014205558.

Senarath S, Ades A, Nanayakkara P. Ovarian cysts in pregnancy: A narrative review. J Obstet Gynaecol 2021;41:169–175.

Servaes S, Zurakowski D, Laufer MR, Feins N, Chow JS. Sonographic findings of ovarian torsion in children. Pediatr Radiol 2007;37:446–451.

Sharma K, Bora MK, Varghese J, Malik G, Kuruvilla R. Role of transvaginal ultrasound and Doppler in diagnosis of pelvic congestion syndrome. J Clin Diagn Res 2014;8:OD05–OD07.

Song D, Zhang W, Chames MC, Guo J. Myomectomy during cesarean delivery. Int J Gynaecol Obstet 2013;121:208–213.

Stratakis CA, Garnica A. Premature infant with Wiedemann–Beckwith syndrome: Postnatal changes in facial appearance and somatic phenotype. Am J Med Genet 1995;57:635–636.

Timmerman D, Ameye L, Fischerova D, Epstein E, Melis GB, Guerriero S, Van Holsbeke C, Savelli L, Fruscio R, Lissoni AA, Testa AC, Veldman J, Vergote I, Van Huffel S, Bourne T, Valentin L. Simple ultrasound rules to distinguish between benign and malignant adnexal masses before surgery: Prospective validation by IOTA group. BMJ 2010;341:c6839.

Treskes K, Bos SA, Beenen LFM, Sierink JC, Edwards MJR, Beuker BJA, Muradin GSR, Hohmann J, Luitse JSK, Hollmann MW, Dijkgraaf MGW, Goslings JC. REACT-2 study group. High rates of clinically relevant incidental findings by total-body CT scanning in trauma patients: Results of the REACT-2 trial. Eur Radiol 2017;27:2451–2462.

Urban BA, Ratner LE, Fishman EK. Three-dimensional volume-rendered CT angiography of the renal arteries and veins: Normal anatomy, variants, and clinical applications. Radiographics 2001;21:373–386 questionnaire 549–555.

Valsky DV, EshBroder E, Cohen SM, Lipschuetz M, Yagel S. Added value of the gray-scale whirlpool sign in the diagnosis of adnexal torsion. Ultrasound Obstet Gynecol 2010;36:630–634.

Venbrux AC, Lambert DL. Embolization of the ovarian veins as a treatment for patients with chronic pelvic pain caused by pelvic venous incompetence (pelvic congestion syndrome). Curr Opin Obstet Gynecol 1999;11:395–399.

Vergani P, Locatelli A, Ghidini A, Andreani M, Sala F, Pezzullo JC. Large uterine leiomyomata and risk of cesarean delivery. Obstet Gynecol 2007;109:410–414.

Vitale SG, Tropea A, Rossetti D, Carnelli M, Cianci A. Management of uterine leiomyomas in pregnancy: Review of literature. Updates Surg 2013;65:179–182.

Wilkinson C, Sanderson A. Adnexal torsion—A multimodality imaging review. Clin Radiol 2012;67:476–483.

Yacobozzi M, Nguyen D, Rakita D. Adnexal masses in pregnancy. Semin Ultrasound CT MR 2012;33:55–64.