SONOGRAPHIC EVALUATION OF UTERINE LEIOMYOMAS AND ADENOMYOSIS

INTRODUCTION

Leiomyomas are the most common type of uterine tumor with a prevalence of 30% in women over 30[1]. They are composed primarily of smooth muscle and a variable amount of connective tissue. Leiomyomas are surrounded by a pseudo-capsule. The size of leiomyomas is highly variable. As they increase in size, leiomyomas begin to distort the normal uterine contour (Fig. 1). If a leiomyoma undergoes cystic degeneration, it may mimic a number of different pelvic pathologic conditions (Table I)[2,3,4].

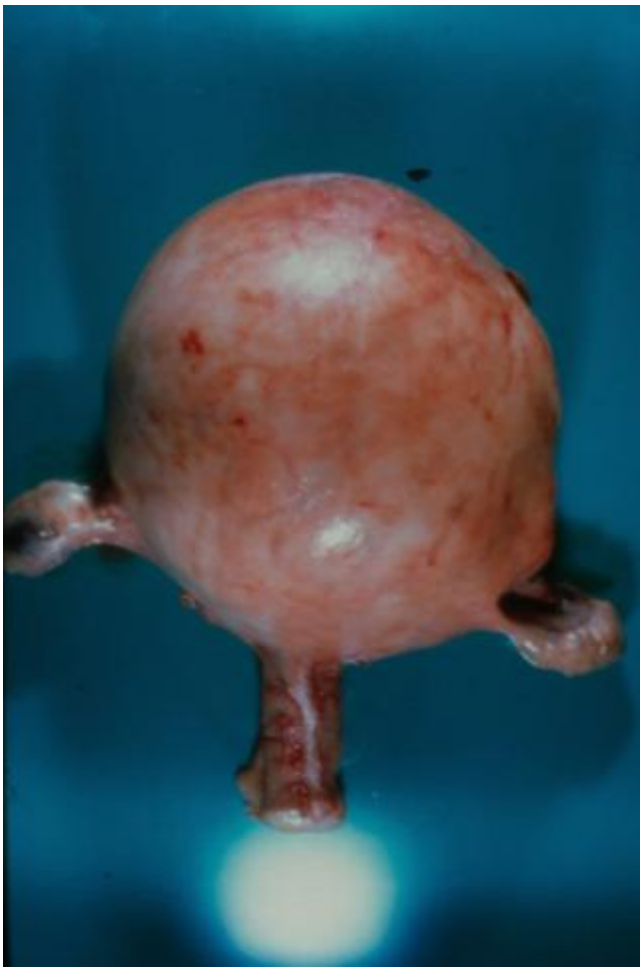

Figure 1 - Uterus distorted by leiomyomas

Table I. Cystic degeneration of a leiomyoma mimicking other diagnoses[2,3,4]

Ectopic Blighted ovum Ovarian cyst Endometrioma Endometrial hyperplasia Hydatidiform mole

The majority of women with uterine leiomyomas are asymptomatic; they become symptomatic in approximately 25% of cases[5]. Symptomatic leiomyomas are among the most common reasons for hysterectomy in the United States[6].

Leiomyomas are spherical or ovoid in shape and have a whirled appearance on cut surface. Large leiomyomas may outgrow their limited blood supply; resulting in hyaline or cystic degeneration. As the blood supply to a leiomyoma decreases, it may become calcified.

PATHOGENESIS

Estrogen and progesterone receptors are in higher concentrations in leiomyomas than in the normal surrounding myometrium[7]. The growth rate of leiomyomas is related to their number of estrogen and progesterone receptors[8]. Gonoadotrophic-releasing hormone agonists result in a temporary reduction in the size of leiomyomas by 45% at 24 weeks of treatment. However, once the medication is discontinued, the leiomyomas return to their former size in 6 months[9].

SIGNS AND SYMPTOMS

The location, number and size of leiomyomas determine when, and how, they become symptomatic. Abnormal uterine bleeding, pelvic pressure, and lower abdominal pain are the most common complaints of women with symptomatic leiomyomas. If the leiomyomas are large enough (Fig. 2), obstructive hydronephrosis may occur.

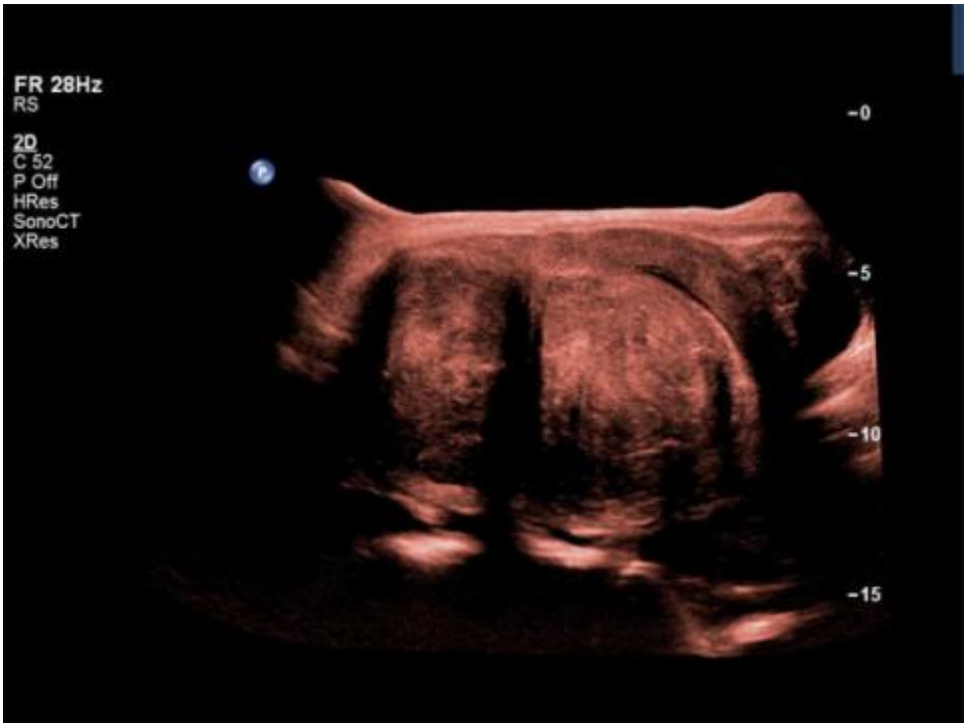

Figure 2 - A panoramic view of large leiomyomas.

Leiomyomas may occur in either the cervix or the main body of the uterus. Cervical leiomyomas more

commonly involve the posterior wall. Within the corpus of the uterus, a leiomyoma is either subserosal (Fig. 3), intramural, submucosal (Fig. 4) or intracavitary (Fig. 5). A pedunculated leiomyoma (Fig. 6) is connected to the uterus by a stalk containing its vascular supply. Intraligamentary tumors extend into the broad ligament. Occasionally, a pedunculated leiomyoma will become attached to the omentum. As the blood supply from the omentum increases, the blood supply from the uterus decreases. Eventually, the leiomyoma will become parasitic – deriving all if its blood flow from the omentum.

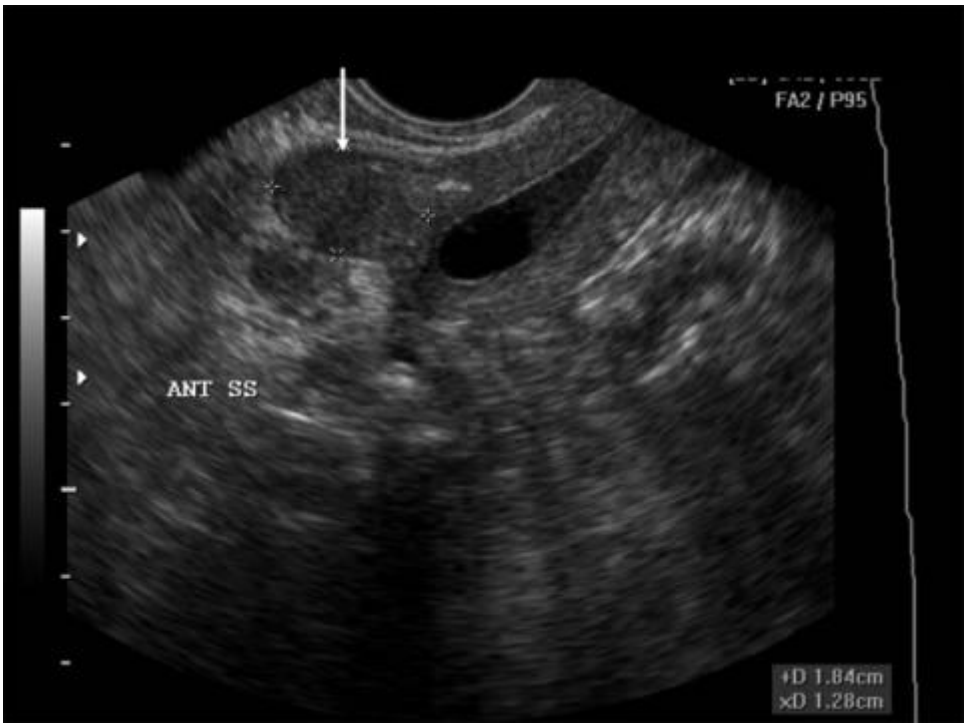

Figure 3 - Anterior subserosal leiomyoma (arrow) in a postmenopausal female. The endometrial lining is atrophic and fluid is present within the endometrial cavity.

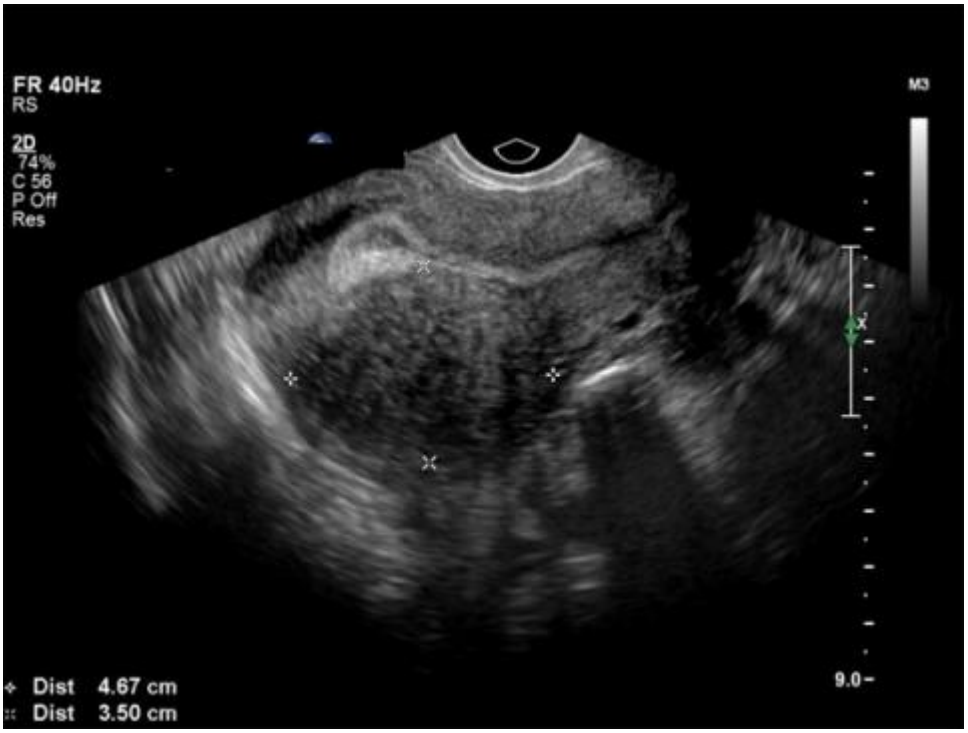

Figure 4 - A leiomyoma (between the markers) that extends from the serosa to the mucosa.

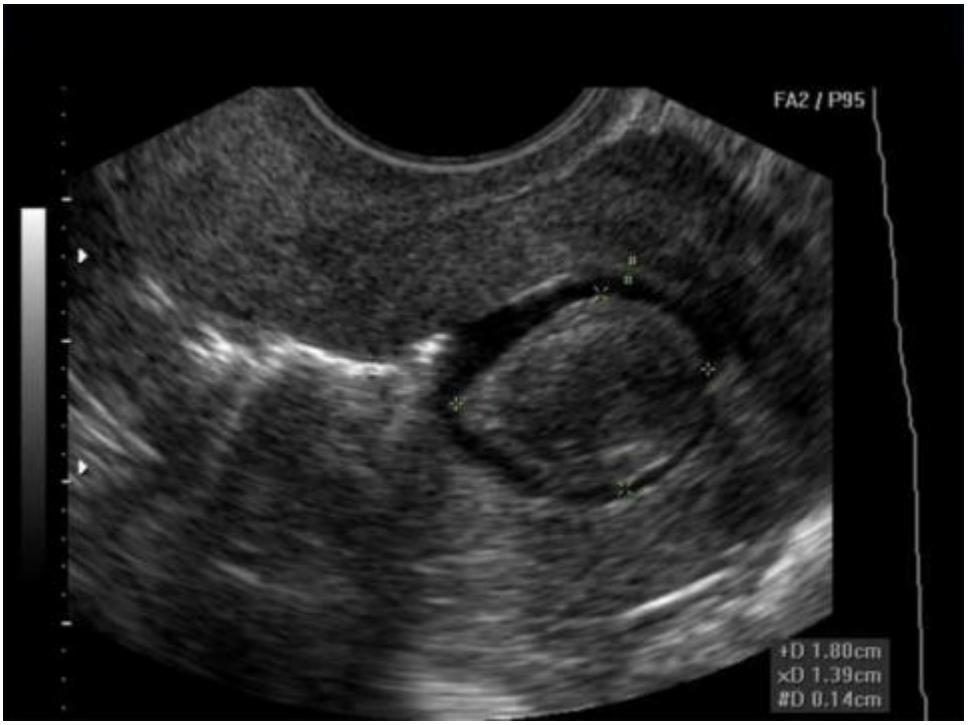

Figure 5 - Sonohysterogram of an intracavitary leiomyoma.

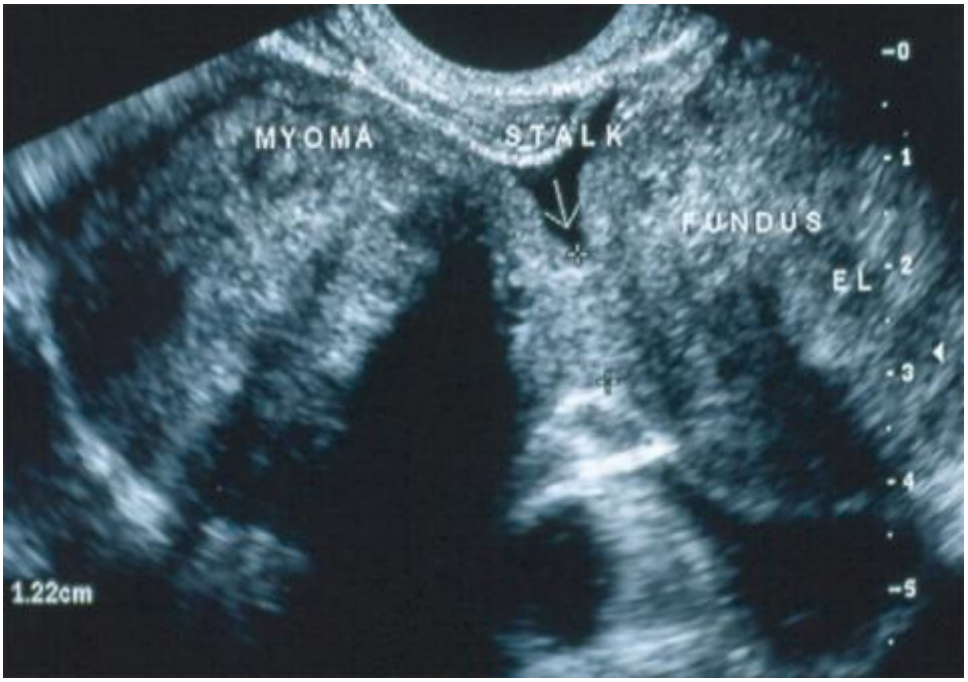

Figure 6 - Pedunculated leiomyoma. The adjoining stalk (arrow) measures 1.22 cm

Because of their location, submucous leiomyomas are the most symptomatic and, may result in significant vaginal bleeding. These leiomyomas may also become pedunculated, extending into the endometrial cavity and even through the cervix.
Leiomyomas only rarely appear to affect fertility[10].
The main vessel supplying a leiomyoma is on its periphery and can be visualized with color Doppler (Fig. 7). This vessel is detected in approximately half of uterine leiomyomas and has been associated with an increased likelihood of leiomyoma growth[11]. In contrast to the single feeding vessel of a polyp,

submucosal leiomyomas generally have several central vessels[12].

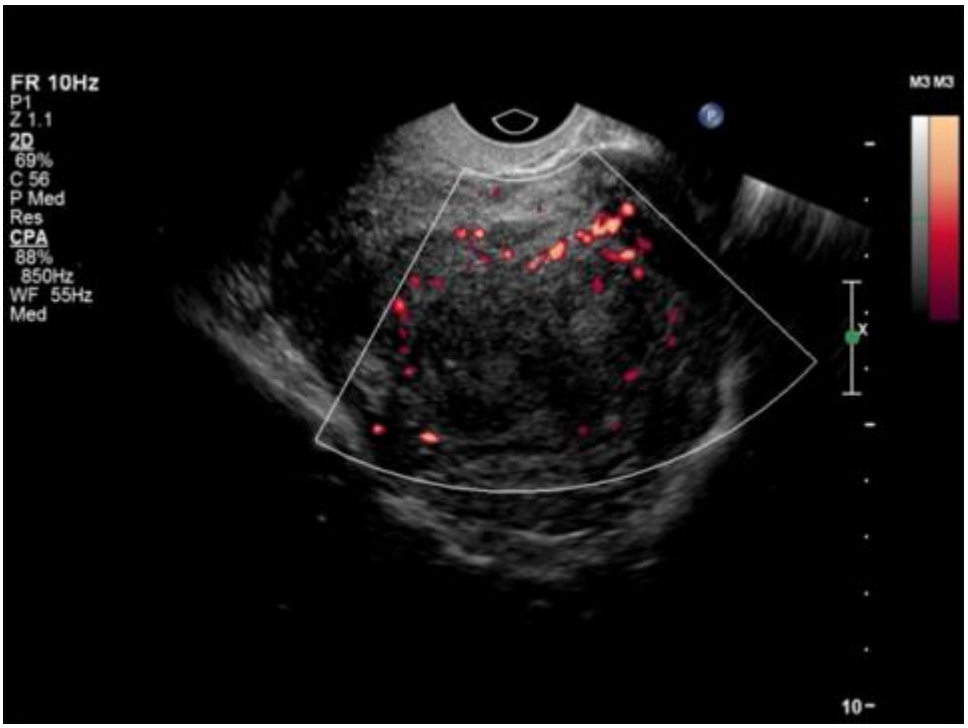

Figure 7 - Color Doppler illustrating minimal vascular flow to a leiomyoma.

13% of premenopausal women with leiomyomas will develop one or more additional leiomyomas over 2.6 years. Some leiomyomas with a mean diameter of 1.1 cm or less may completely resolve[13].
Multiple discrete shadows tend to originate from within larger leiomyomas (> 5 cm). This sonographic pattern is derived from the transition between muscular and fibrous tissue within the leiomyoma. Since this sonographic finding is dependent upon the muscular and fibrous components of the leiomyoma, it is not present with all leiomyomas. This pattern may also be present with ovarian fibromas and adenomyosis[14].
A lipoleiomyoma contains a high concentration of fat (Fig. 8), while a vascular leiomyoma has numerous large vessels.

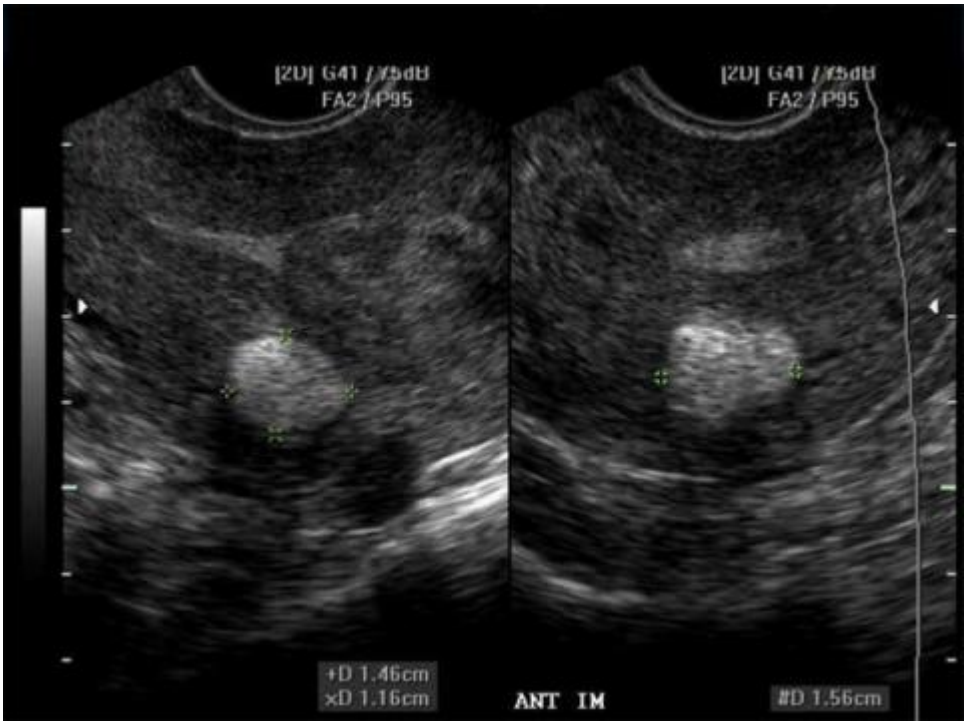

Figure 8 - A longitudinal (a) and transverse (b) image of a 1.46 x 1.16 x 1.56 anterior leiomyoma that has undergone fatty degeneration.

TREATMENT

Treatment options for women with symptomatic leiomyomas have expanded considerably. In the past, hysterectomy was the treatment of choice. Myomectomy and endometrial ablation are additional surgical options. Uterine volume continues to gradually decline over 6 months after myomectomy. The removal of the leiomyoma and its higher estrogen concentration results in a gradual reduction in the size of the hypertrophied surrounding myometrium. Regardless of the initial size of a myomatus uterus, the non-myoma volume ends up very close to the volume of a normal uterus[15,16].

Medical therapy has been limited to the temporizing utilization of GnRH agonists to reduce the size of leiomyomas prior to surgical intervention.

Over the past 10 years interventional therapy, i.e. uterine artery embolization has gained in popularity[17]. In one study the mean reduction in vascularity after uterine artery embolization was 44%. The size of leiomyomas may gradually decrease in size for up to 1 year after embolization[18]. Collateral blood flow from the ovarian artery will reduce the efficacy of uterine artery embolization[19].

The location of leiomymomas correlates with outcome – a submucosal location is a strong predictor of successful uterine fibroid embolization[20].

Pedunculated intracavitary or subserosal leiomyomas are removed by hysteroscopy and laparoscopy, respectively. Uterine artery embolization is reserved for those leiomyomas with a larger intramural component[16].

Although women who are considering pregnancy have been excluded from studies utilizing uterine artery embolization, successful pregnancies after this procedure have been reported[16].

The complications reported with uterine artery embolization are outlined in Table IV. Death has been reported in 4 of 50,000 reported procedures[21].

Table IV. Complications associated with uterine artery embolization[18]

• Postembolization syndrome
  ◦ Abdominal pain
  ◦ Nausea
  ◦ Vomiting
• Anorexia
• Leukocytosis
• Groin infection
• Arterial thrombosis
• Allergic reaction to contrast
• Sepsis
• Non-targeted ovarian embolization
  ◦ Amenorrhea
  ◦ Menopause
• Deep vein thrombosis
• Pulmonary embolism

Clinical failure rates after uterine artery embolization are between 6% and 19%[15].
Thermoablation of uterine leiomyomas utilizing MRI-guided focused ultrasound has recently been employed. Pre-treatment with a GnRH agonist not only decreases the size of leiomyomas, but also reduces their blood supply. The latter effect enhances thermoablation by reducing heat conduction[22].
As the treatment options for uterine leiomyomas has increased, so has the importance of pretreatment assessment. Sonohysterography (Fig. 9) has become an important addition to transvaginal sonography in the accurate delineation of submucous and intracavitary leiomyomas.[23]
Submucous leiomyomas have been classified based upon the extent of uterine wall invasion (Table II). Cohen and Valle[24] have proposed a similar classification for intramural and subserosal leiomyomas (Table III).

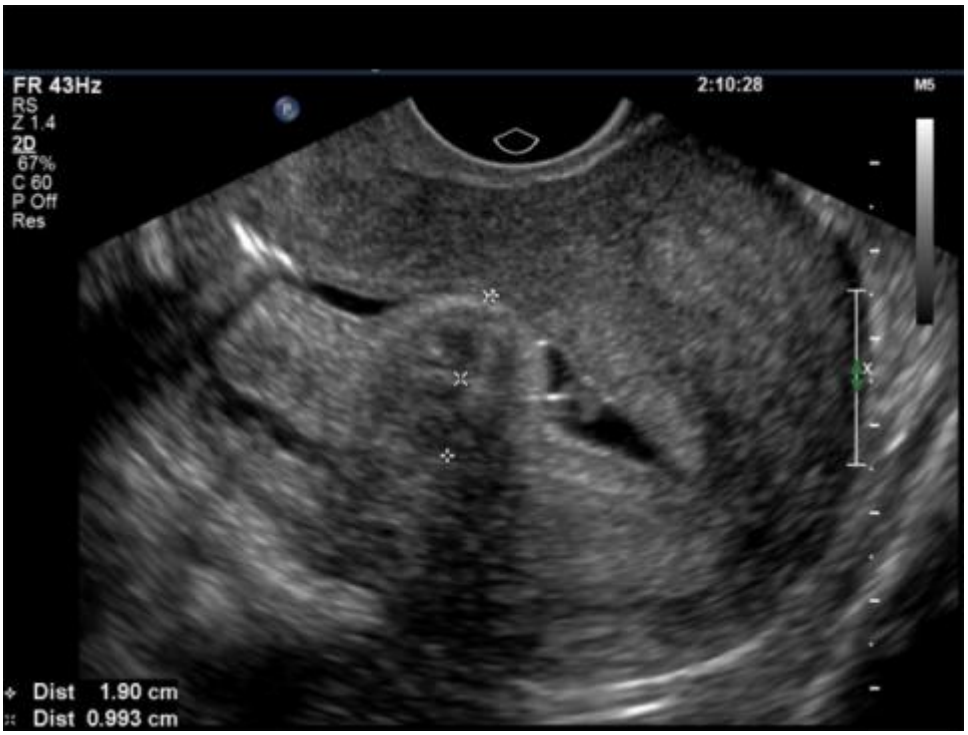

Figure 9 - Sonohysterogram of a submucosal leiomyoma that extends into the endometrial cavity 1 cm

Table II. Classification of submucous leiomyomas[25]
O: intracavitary, pedunculated leiomyomas I: submucous leiomyomas extending < 50% into the myometrium II: submucous leiomyomas extending > 50% into the myometrium

Table III. Classification of intramural and subserosal leiomyomas[23]
O: pedunculated subserosal leiomyoma I: involvement of < 50% of the outer uterine wall II: involvement of > 50% of the myometrial wall III: leiomyomas that extend from the mucosa to the serosa

The utilization of these classifications for pre-operative mapping of leiomyomas allows the selection of the most appropriate operative technique. As a submucosal leiomyoma extends further into the myometrium, the likelihood of complete resection is reduced and the number of repeat procedures to affect complete removal increases[25]. As the size of the uterus and the number of leiomyomas increases, transvaginal sonography even with sonohysterography is increasingly limited in its ability to accurately map all of the patient's leiomyomas. MRI18 and, more recently, 3D ultrasound (Fig. 10) has, therefore, been employed.

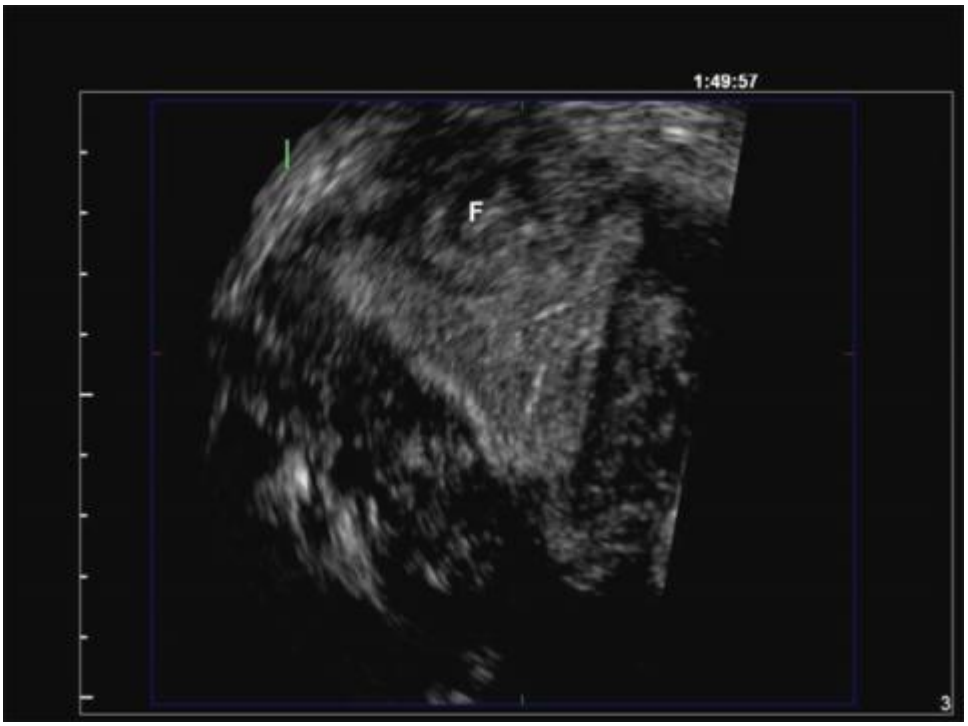

Figure 10 - 3-D ultrasound of a fundal submucosal leiomyoma (F).

ADENOMYOSIS

Adenomyosis is characterized by the endometrial invasion of the myometrium. In addition, there is a generalized hypertrophy and hyperplasia of the surrounding muscular elements of the myometrium[26,27].

Its prevalence in surgical series varies between 5% and 70%[28] with a mean of 20% - 30%[29]. The histologic criteria that are used, as well as the number of myometrial sites sampled, play a role in the discrepancies in the reported prevalence[29].

Adenomyosis has two distinct forms: nodular and diffuse. The nodular type is circumscribed and may be confused with a leiomyoma. An adenomyoma, in contrast to a leiomyoma, does not have distinct margins and contains one to several cystic spaces. In the diffuse form the islands of adenomyosis are dispersed throughout the myometrium. The presence of estrogen and progesterone receptors in adenomyotic lesions indicates that it is hormone dependent[27]. Bazot et al[27] have graded adenomyosis 1, 2 and 3 based on the involvement of the inner third of the myometrium, two-thirds of the myometrium, and the entire myometrium, respectively. There is not a consistent diagnosis of the depth of endometrial penetration that is required to diagnose adenomyosis. Most authors use a depth of endometrial penetration between 1-4 mm[30]. McCausland[31] has reported that 1 mm of endometrial penetration with smooth muscle hypertrophy is sufficient to cause menorrhagia.

Adenomyosis may result in menorrhagia and/or dysmenorrhea. There is a correlation between the depth of adenomyosis and the severity of menorrhagia[31]. It has been hypothesized that the dysfunctional generalized hypertrophy surrounding the endometrial glands prevents uterine contractions from tamponading bleeding myometrial arterioles[32]. The posterior uterine wall is more frequently involved with adenomyosis[31].

Since adenomyomas extend into the normal myometrium, excision is difficult. As with the diffuse form, hysterectomy remains the primary treatment.

Transvaginal ultrasound has been reported to diagnosis adenomyosis with a sensitivity, specificity, positive and negative predictive value of 87%, 98%, 74.1% and 98.6%, respectively[33]. Transabdominal sonography alone cannot be used to accurately diagnosis adenomyosis[27]. However, in women with large uteri, transvaginal sonography cannot adequately evaluate the entire uterus. In these cases combined transabdominal and transvaginal sonography are required to accurately diagnosis adenomyosis[27].

The sonographic criteria for adenomyosis are outlined in Table V[26]. The number and distribution of myometrial cysts (Fig. 11) correlates with the grade of adenomyosis[27]. Histologically these cysts are ectopic endometrial glands. Since adenomyosis may consist of a basal glandular component that is not responsive to hormones, cyclic hemorrhage rarely occurs in adenomyosis. Cystic degeneration of small leiomyomas may mimic the lacunae associated with adenomyosis[34]. Hypoechoic linear myometrial striations are due to the myometrial hypertrophy associated with the hormonal status of the ectopic myometrial glands[27]. The latter finding is, therefore, more prevalent in menstruating, in contrast to post-menopausal women. A poor definition of the endo-myometrial junction and the lack of a mass effect on the myometrium suggests the presence of diffuse adenomyosis[33]. Occasionally, hyperechoic myometrial nodules will be present (Fig. 12).

Table V. Sonographic criteria for adenomyosis[26,34,35]

- Globular shaped uterus
- Myometrial cysts (2-6 mm in diameter)
- Mottled inhomogeneous myometrium
- Indistinct borders to a myometrial mass
- Indistinct endometrial stripe
- Hyperechoic myometrial nodules
- Asymmetric thickening of the anterior or posterior uterine wall
- Mimimal mass effect on the endometrium or serosa

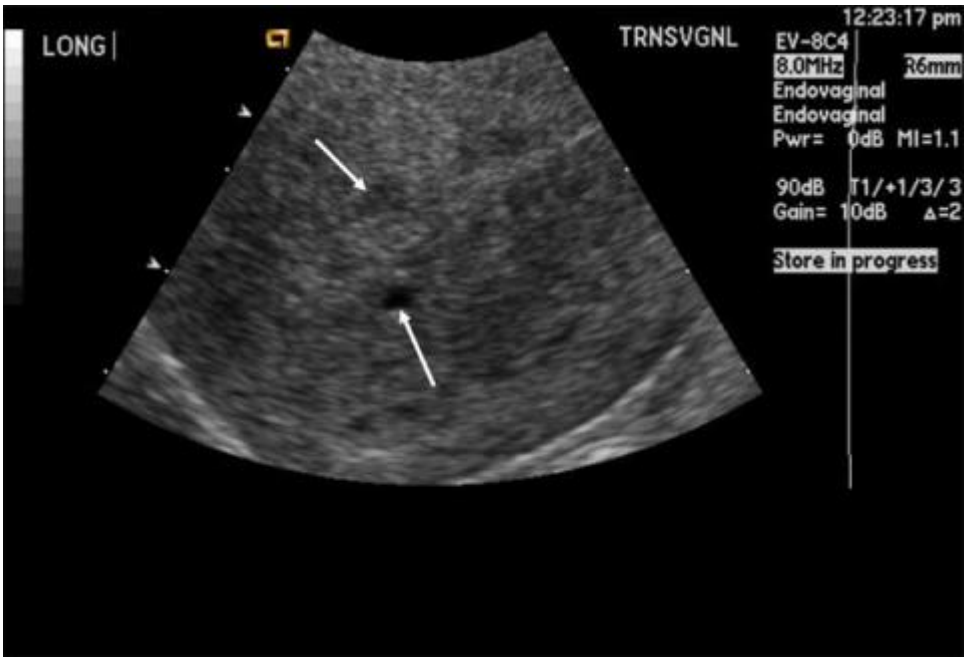

Figure 11 - Cystic spaces (arrows) associated with adenomyosis.

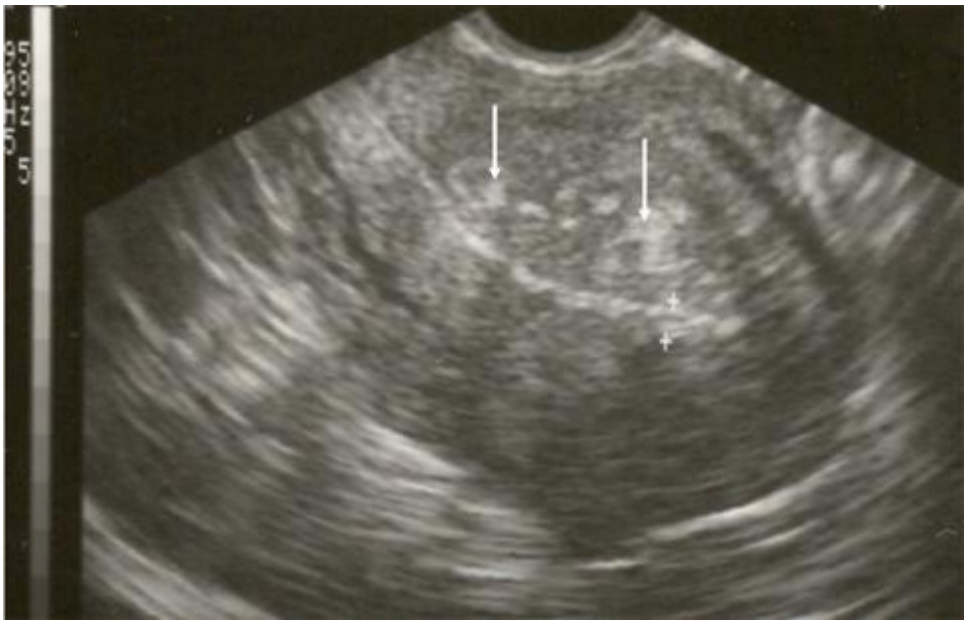
Figure 12 - The echogenic nodules within the anterior myometrium (arrows) suggest adenomyosis

With significant adenomyosis the uterus is globular and the diameter of the anterior and posterior

myometrium are asymmetric. Hypoechoic myometrial contractions can occasionally be mistaken for adenomyosis. Within 10 to 15 minutes the latter will resolve[35].
Color Doppler can be utilized to help distinguish between leiomyomas and adenomyosis. While larger leiomyomas tend to have a peripheral feeding vessel, adenomyosis has either no vascular flow or vessels transversing the hypertrophic myometrium between cystic spaces[27].
The accuracy of transvaginal ultrasound in the detection of adenomyosis is highly operator dependent. An increased awareness of adenomyosis as a possible diagnosis in conjunction with sufficient clinical experience are required in order to detect the relatively subtle sonographic signs of adenomyosis. In women without leiomyomas, transvaginal sonography is as reliable as MRI (Fig. 13) in the detection of adenomyosis. However, in the presence of multiple leiomyomas, MRI performs better in detecting concomitant adenomyosis[36].

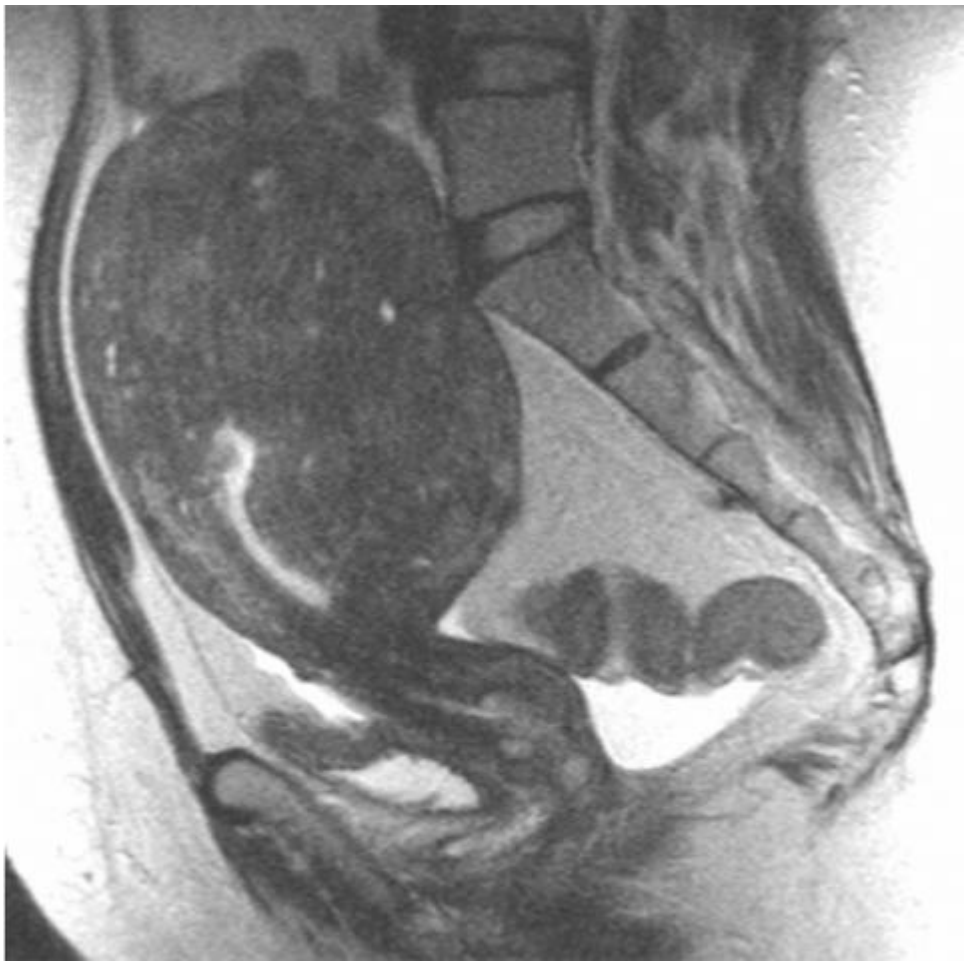
Figure 13 - MRI of a uterus with extensive adenomyosis.

A myometrial biopsy at the time of hysteroscopy has been suggested as another method to diagnosis adenomyosis[31]. However, this technique has not been found to improve the diagnostic accuracy of transvaginal sonography[37].
Conservative surgery consists of endomyometrial ablation for patients with disease limited to the endo-myometrial junction (i.e. a depth of 2-3 mm). This procedure results in a 55% relief of menstrual symptoms for at least 2 years[38]. For patients with deeper adenomyosis, endometrial ablation is not successful[32]. In fact, incomplete ablation of the endometrium may initiate the growth of the endometrium into the myometrium resulting in adenomyosis[32].

The primary treatment of adenomyosis remains hysterectomy. There have been limited attempts to utilize uterine artery embolization in cases of isolated adenomyosis without concomitant leiomyomas. Pelage et al[30] reported that after 6 months 15/16 (94%) of women with symptomatic adenomyosis reported improvement in menorrhagia after uterine artery embolizaton. However, improvement decreased over time with only 5/9 (56%) reporting resolution of menorrhagia at 2 years.
While anti-estrogen drug therapy has been attempted, there is a lack of controlled studies. As a result the efficacy of anti-estrogens (birth control pills, progestogens, GnRH agonists) has not yet been conclusively proven[38].

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