Chapter 4

Sonographic Assessment of Uterine Fibroids and Adenomyosis

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Introduction

Uterine fibroids (or leiomyomas) are the most common benign gynaecological tumours, formed by smooth muscle and connective tissue. Most are asymptomatic, but sometimes may cause pain, pressure symptoms, metrorrhagia, infertility due to implantation failure, miscarriage, preterm delivery, and puerperal haemorrhage. Fibroids can be single or multiple. Their size and location vary and they may undergo benign degenerative changes: atrophic and hyaline degeneration, calcification, infection, and infarction. Malignant degeneration towards leiomyosarcoma is extremely rare, occurring in less than 0.2 per cent of cases [1].

Adenomyosis is defined as the presence of endometrial tissue with its glands and stroma, implanted in the myometrium. Dysmenorrhoea and abnormal uterine bleeding in nulliparous women are the usual presenting symptoms associated with this condition. Adenomyosis is reportedly linked to infertility; however, the exact mechanism of this negative effect is unknown [2–8]. In addition, an association between this condition and various obstetric diseases (preterm delivery, growth retardation, recurrent bleeding, etc.) has also been found [9]. Ultrasound scans – two-dimensional (2D), power Doppler (PD) angiography and three-dimensional (3D) – are often adequate to make a definitive diagnosis and plan subsequent management. These investigations are the preferred diagnostic tools due to lower cost, accessibility, patient tolerability and minimal invasiveness of the procedure compared to other modalities [10].

The aim of this chapter is to provide an overview of the ultrasound diagnosis of uterine fibroids and adenomyosis and their sonographic appearance in typical and atypical cases, and to provide guidance when pitfalls are encountered.

Uterine Fibroids

Transvaginal ultrasound with high-frequency endocavitary transducers and wide angles of acquisition constitute the best diagnostic tool for describing uterine leiomyomas. On occasion, transabdominal ultrasound may provide better details, particularly in cases of large fibroids. The lower frequency of abdominal ultrasound transducers allows assessment of structures at a greater distance, and therefore, both routes can be combined for detailed analysis (Figure 4.1). Occasionally, application of abdominal pressure with the non-scanning hand may move the fibroid closer to the transvaginal transducer, allowing better visualization of the fibroid and surrounding structures.

Modern ultrasound equipment is delivered with predefined technical settings for a gynaecological examination recommended by the manufacturer. In general, the preset parameters are very suitable and usually do not need to be modified. In 2D mode these parameters include frequency, power, gain, dynamic range and greyscale; in PD mode they include wall filter and the pulse repeated frequency (PRF); and in 3D/4D mode they include acquisition mode, volume angle, quality and various image display modalities including sectional planes and render modes. Nevertheless, in some cases these settings need to be modified depending on the patient's characteristics (body mass index, uterine position, uterine size), the particular type of examination and the preferences of the examiner. Attenuation of ultrasound waves through fibroid is common and therefore assessment in 'penetration mode' (low frequency and better depth, but at the cost of resolution) may often be needed, especially in cases of an enlarged uterus with multiple fibroids.

Myomas appear on the ultrasound as rounded or oval structures, well defined and circumscribed nodular masses, usually hypoechogenic and homogeneous with respect to the surrounding myometrium. Occasionally, these fibroids are minimally echogenic, appearing as small cystic masses in the myometrial layer (Figure 4.2). The echogenicity depends on the amount of fibrous tissue present in the smooth

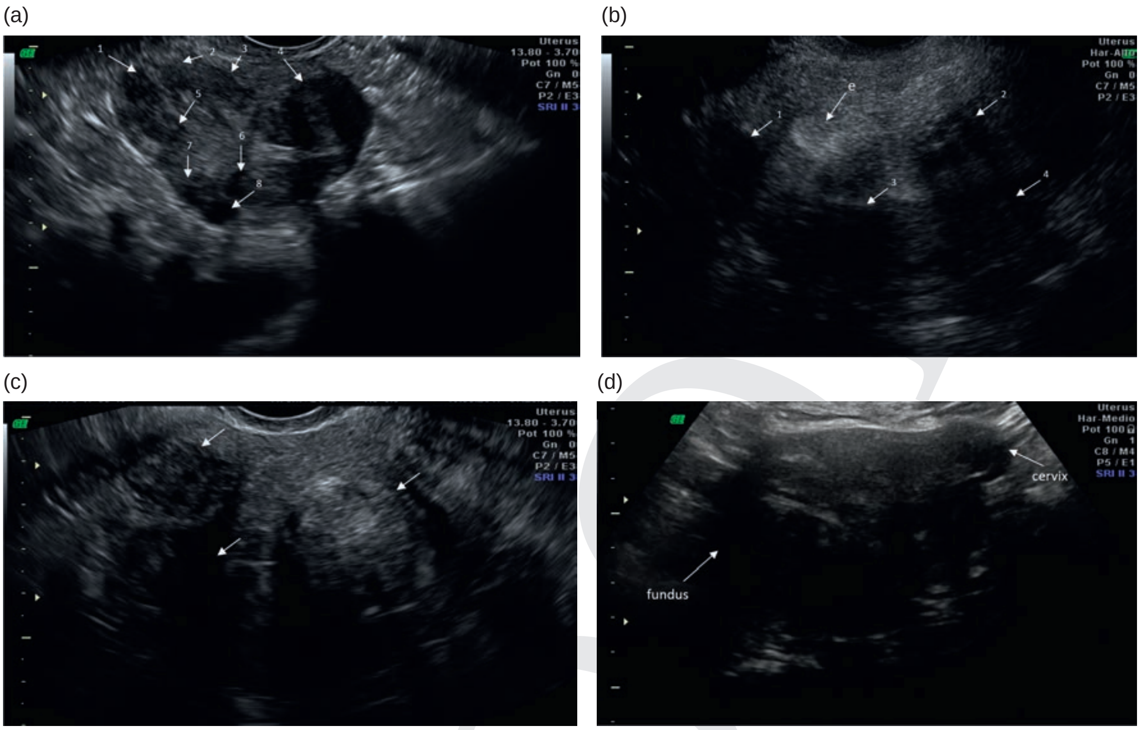

Figure 4.1 Transvaginal ultrasound showing two examples of a uterus with multiple myomas (arrows): (a) Uterus with eight fibroids. (b) Uterus with four fibroids showing endometrium (e). (c) Transvaginal ultrasound showing a large uterus with multiple myomas, partially visible. (d) Abdominal ultrasound showing the same uterus allows for complete visualization and the measurement of all its diameters.

muscle, in addition to vascular contribution and the presence of degenerative changes. Even the inner fibrous spiral architecture can sometimes be seen, since the fibres of the smooth muscle and connective tissue are arranged in a concentric pattern. It is essential to visualize the interface between the normal myometrium and the pseudocapsule surrounding the myoma, as this allows the examiner to differentiate fibroids from true adenomyosis.

Establishing the location and size of myomas [11] is necessary for a full assessment. This should be carried out in the longitudinal and transverse planes of the uterus and the fibroid location should be noted in relation to the anterior, posterior, right or left uterine walls, as well as to the endometrial cavity. This approach allows for measurement of the fibroids in three orthogonal planes. In cases of multiple fibroids and enlarged uterus, fibroid mapping can be difficult by ultrasound. Systematic scanning and identification of relevant landmarks (i.e. the bladder and cervical canal) is very helpful, especially when planning any surgical interventions. The assessment should follow the endometrial cavity from the cervical canal to the fundus (and *vice versa*), and systematically, the mapping of fibroid location is done. Assessment should be completed by scanning the uterus from one side to the other (operator preference dictates whether the start is on the right or the left side of the uterus). When multiple fibroids are mapped, a typed report should be supplemented by a graphic representation of the exact location of the myomas.

According to the location of the myomas with respect to the uterine layers, they are classified as intramural (confined within the myometrium), subserosal (greater than 50 per cent of the fibroid protrudes through the serosal surface) and submucosal (distorting the endometrial cavity). Multiple types of fibroids can co-exist at any time (Figures 4.3–4.9), and intramural types, when continuing to grow, may change and indent the endometrial or serosal surfaces, thus becoming submucosal or subserosal types, respectively. Fibroids may also be intraligamentous (e.g. within the broad ligament), pedunculated, cervical or within the uterine horn (Figures 4.3–4.9).

(a)

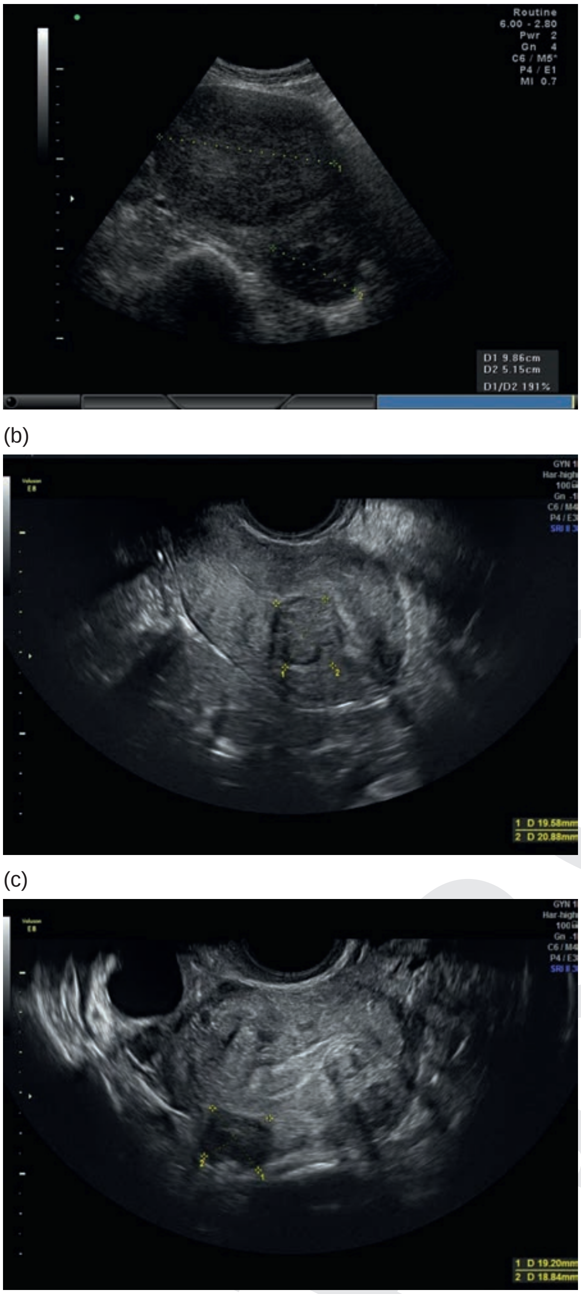

Figure 4.2 Different sonographic appearances of fibroids: (a) circumscribed nodular masses; (b) fibroid isoechogenic with respect to the surrounding myometrium; (c) small hypoechogenic masses in the thickness of the myometrium.

Subserous myomas deform the uterine contour. In the case of intraligamentous and pedunculated fibroids, locating the vascular connection with the uterus ('bridge sign') is very useful to accurately determine its uterine origin and avoid confusion with adnexal masses. Another way to determine the origin of the adnexal mass is to apply a slight pressure on the fibroid with the vaginal transducer; if the mass moves with the uterus, its uterine origin is confirmed. As for intramural myomas, during a scan the normal myometrium can be clearly demonstrated surrounding the fibroid and separates them from the endometrium or the external surface of the uterus. The large leiomyomas can, however, deform the cavity or alter the uterine contour.

Submucous myomas can be confused with endometrial polyps, although polyps are usually more echogenic and most often contain one feeding vessel when visualized using Doppler sonography. It is very important, especially from the reproductive point of view, to delineate the exact relationship to the uterine cavity and to assess the degree of protrusion into it. There are several classifications, although the classical one belongs to Wamsteker and Blok and has been adopted by the European Society for Gynaecological Endoscopy (ESGE) [12], which defines them as follows: type 0 (100 per cent inside the cavity), type 1 (more than 50 per cent inside the cavity) and type 2 (less than 50 per cent inside the cavity). Other authors recently modified this classification for better management in subsequent hysteroscopy using the STEPW parameters, which include size, topography, extension of the base of the myoma, penetration of the fibroid into the myometrium, and wall [13]. Each factor is scored on a scale 0–1–2 according to predefined criteria, and in the multicenter study of 465 submucous myomas, fibroids with a score of ≤4 were resected completely and had a better sensitivity of 100 per cent (95 per cent CI 89.4–100.0 per cent) and specificity 74.1 per cent (95 per cent CI 69.7–78.1 per cent), compared to the ESGE system when using the type 1 fibroids as a cutoff (sensitivity 36.4 per cent (95 per cent CI 20.4–54.9 per cent) and specificity 84.0 per cent (95 per cent CI 80.2–87.3 per cent)) [13]. Hysterosonography or saline infusion sonography (SIS) may sometimes be very useful for reaching a definitive diagnosis of submucous myomas and to determine the extent of protrusion of fibroid into the endometrial cavity [14] (Figure 4.10). For all types of myomas, it is essential to measure its diameter in three perpendicular planes, and for the large ones to measure at least two major perpendicular diameters (Figures 4.11–4.13).

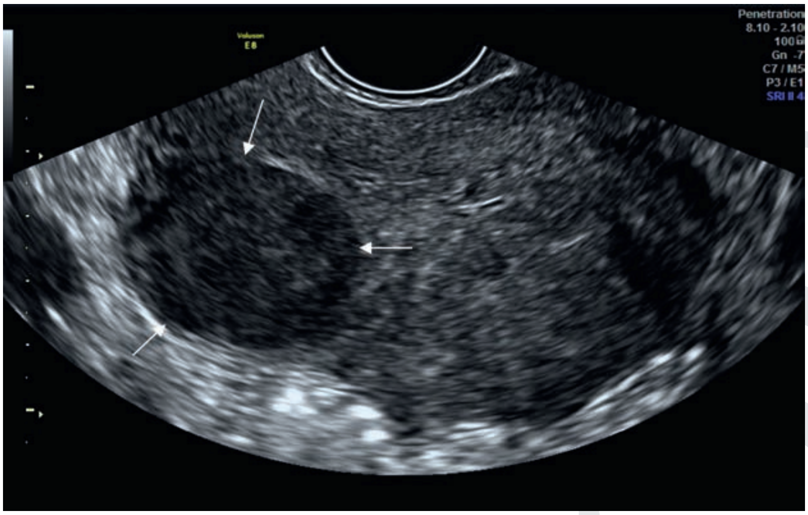

Figure 4.3 Uterus with a subserous myoma (arrows) located on the posterior wall.

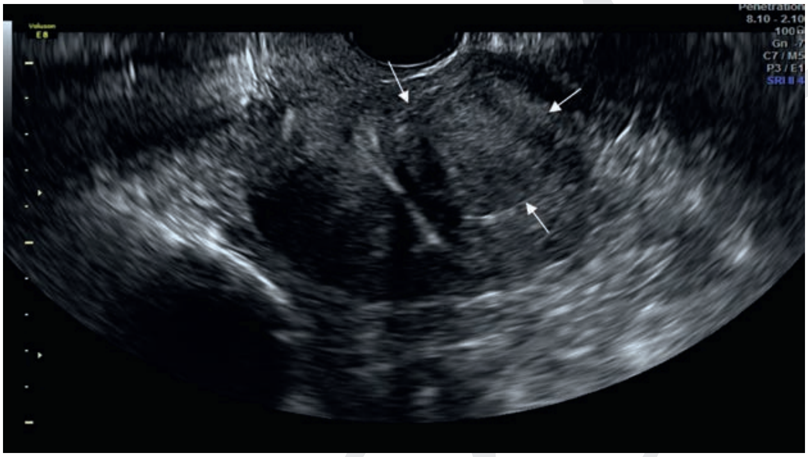

Figure 4.4 Intramural myoma (arrows) located within the myometrium, without reaching the endometrial cavity or deforming it (bright stripe below and to the left of the fibroid).

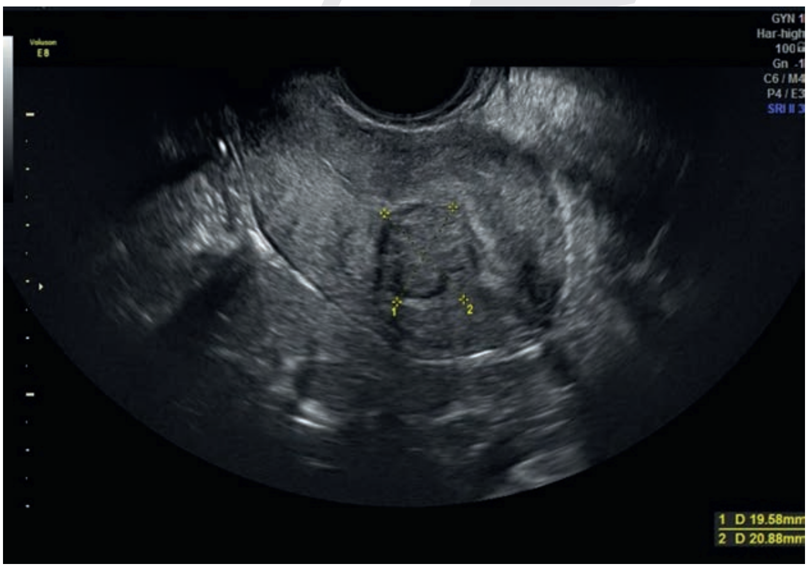

Figure 4.5 Submucous myoma easily visible and measured in two dimensions.

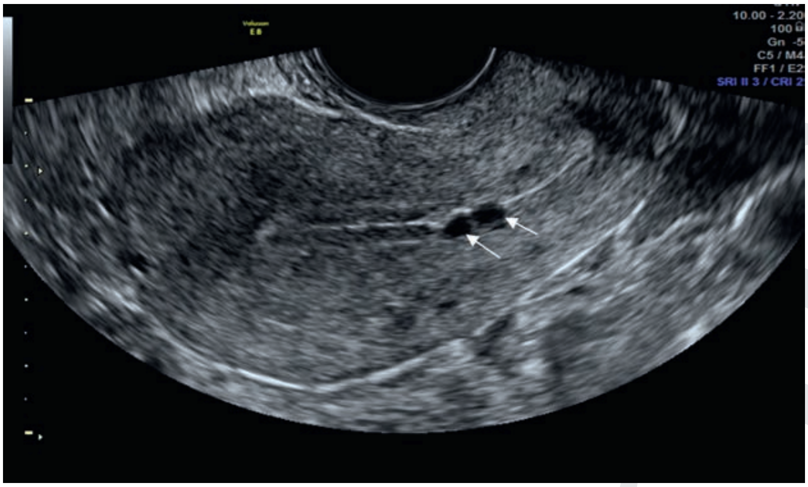

Figure 4.6 Two small submucous fibroids located near the internal cervical orifice.

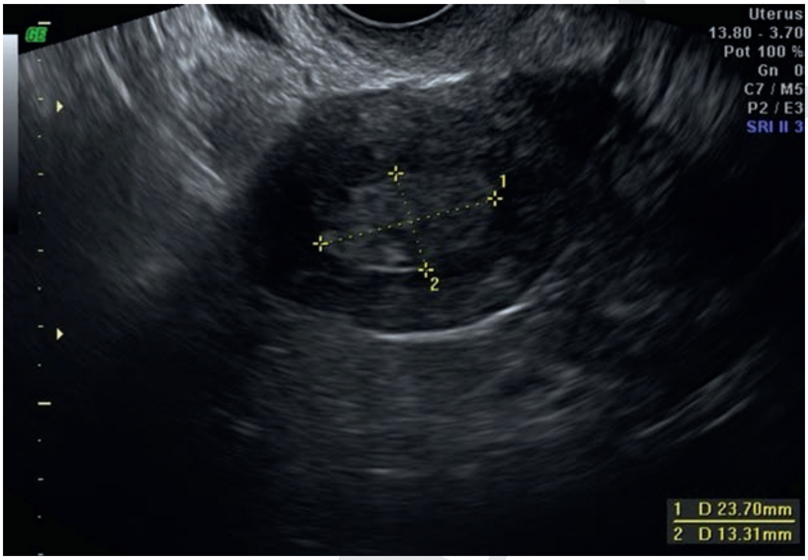

Figure 4.7 Large submucous myoma that occupies the entire endometrial cavity.

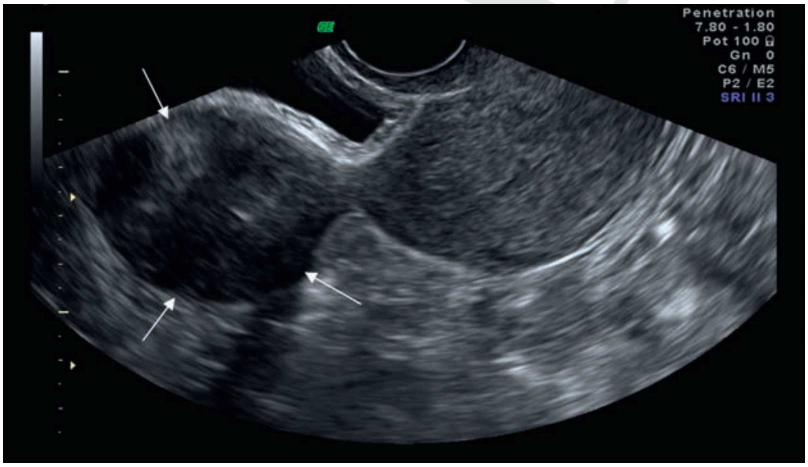

Figure 4.8 Pedunculated myoma (arrows) on the right side of the uterus.

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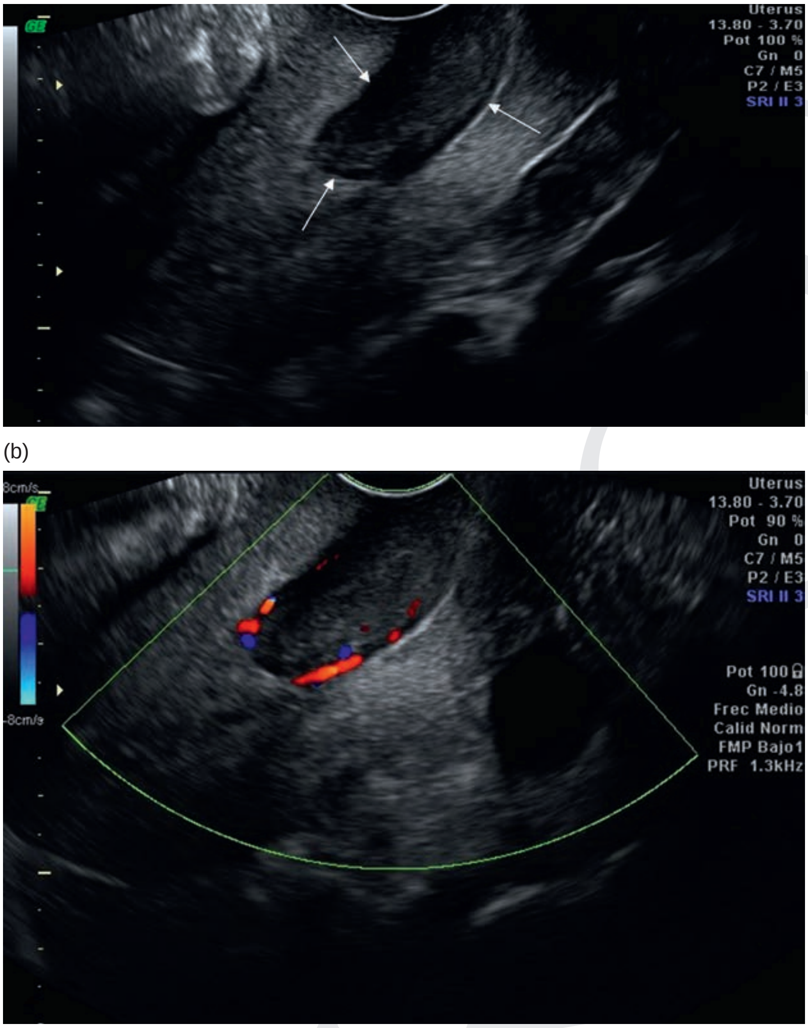

Figure 4.9 (a) A prolapsing cervica myoma (arrows) by transvaginal ultrasound; (b) colour Doppler allows for differentiation from a polyp or cervical mucus.

It should be noted that myomas can undergo degenerative phenomena so their echogenicity may change over time depending on the type of degeneration that they are undergoing. The longstanding ones may become hyperechogenic, with intense circumferential acoustic shadowing suggesting calcifications, and may be in the form of small isolated foci or a complete border surrounding the entire fibroid, with other patterns in between also being common (Figures 4.14 and 4.15).

The vascular blood supply may become insufficient to supply the entire fibroid, hence leading to vascular, ischaemic necrosis. In the beginning of pregnancy, myomas can rapidly increase in size, leading to extensive necrosis affecting the entire fibroid, with sudden and intense pain; this situation is called red degeneration. Red degeneration on ultrasound scan may appear as hypoechogenic structures that may be confused with blood vessels or adenomyotic cyst. Prior knowledge of presence and location of fibroids may be of help when making the diagnosis. Using power Doppler modality or elastography is also useful to clarify the nature of the observed structure. Presence of Doppler signal indicates a blood vessel, whereas a red contour on elastography indicates a high-density structure (i.e. fibroid). Doppler imaging in early pregnancy should only be used if absolutely necessary.

In cases when the blood supply to the fibroid is reduced gradually, its degeneration may be in the

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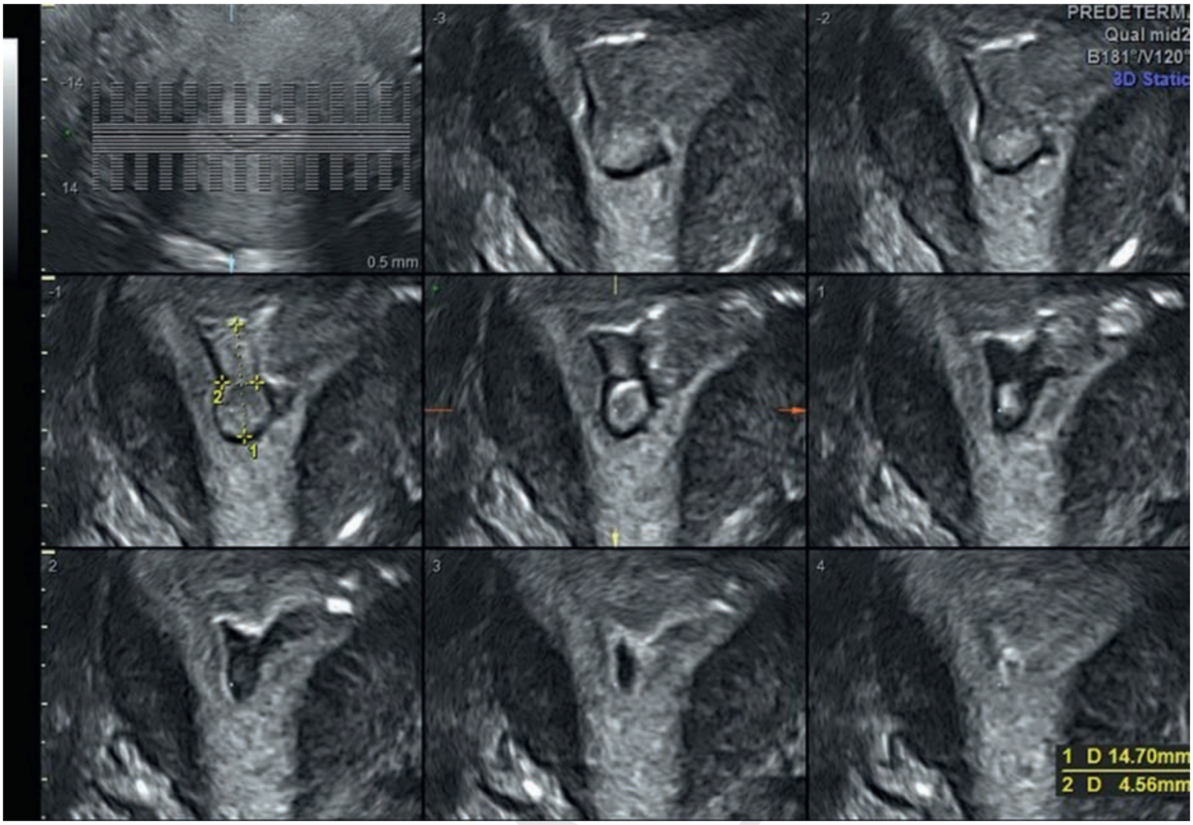

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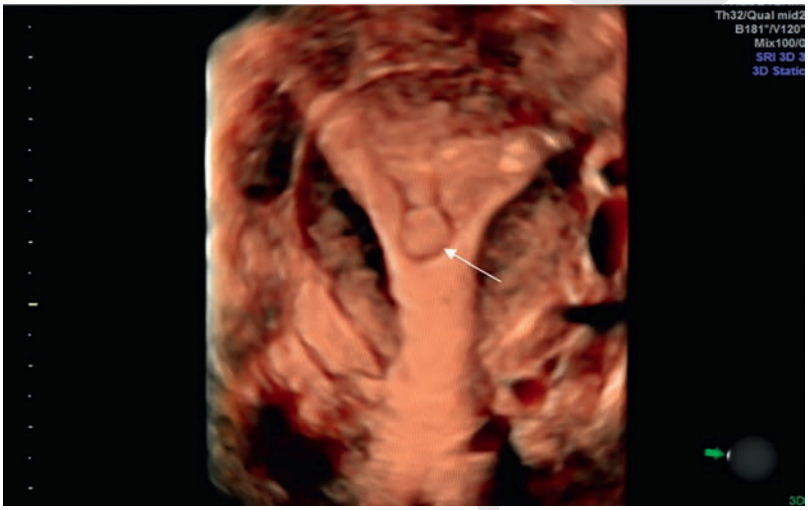

Figure 4.10 Hysterosonography for visualization of submucous myoma. 3D ultrasound is used to improve the delineation of the fibroid in two modalities: (a) with tomographic ultrasound imaging and (b) reconstruction in the coronal plane.

form of hyaline, cystic, fat or myxomatous. This will present with a complex ultrasound appearance of a homogeneous hyperechogenic lesion without acoustic shadowing or occasionally with posterior reinforcement, irregular hyperechoic or anechoic areas inside the fibroid, representing fat or myxoid degeneration

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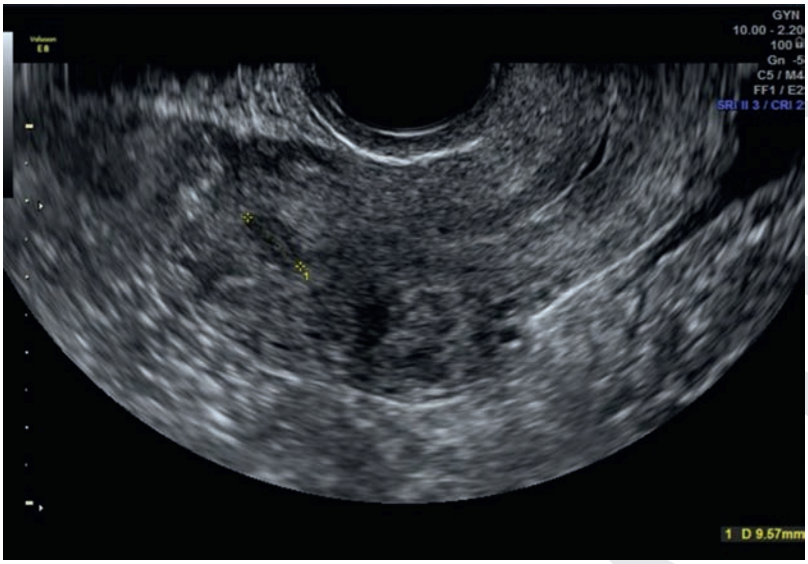

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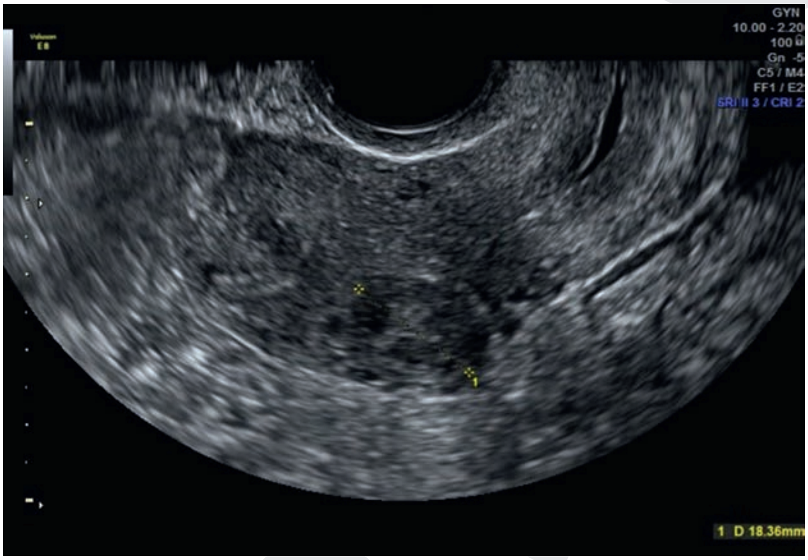

Figure 4.11 (a) Measurement of a small intramural myoma. In the cases of small, regular/globular fibroids, a single diameter measurement is sufficient. (b) Measurement of a subserous fibroid.

respectively. Hyaline degeneration is the most common and appears on ultrasound as anechoic foci within the myoma (Figure 4.16).

Fibroids should be distinguished from two conditions associated with the myometrium: adenomyosis, which will be described later in the chapter, and uterine sarcomas. The latter usually appear in menopausal women, the former can be present in any age group. Sonographic appearance should raise suspicion when a mass is visualized within the myometrium or distorts the uterine layers, has mixed echo density, a central necrosis and blood vessels with irregular distribution with low resistance as measured by pulse wave Doppler sonography (Figure 4.17). A rapidly growing fibroid should also raise suspicion of malignant transformation, and it is always useful to compare findings with prior imaging, if possible.

The histological structure of fibroids, with their concentric muscle fibre arrangement, drives the specific vascular pattern, which on Doppler imaging is mainly present on the periphery of the fibroid, with minimal observable vascularity within. This pattern allows us to differentiate fibroids from adenomyomas. Adenomyomas are composed of localized

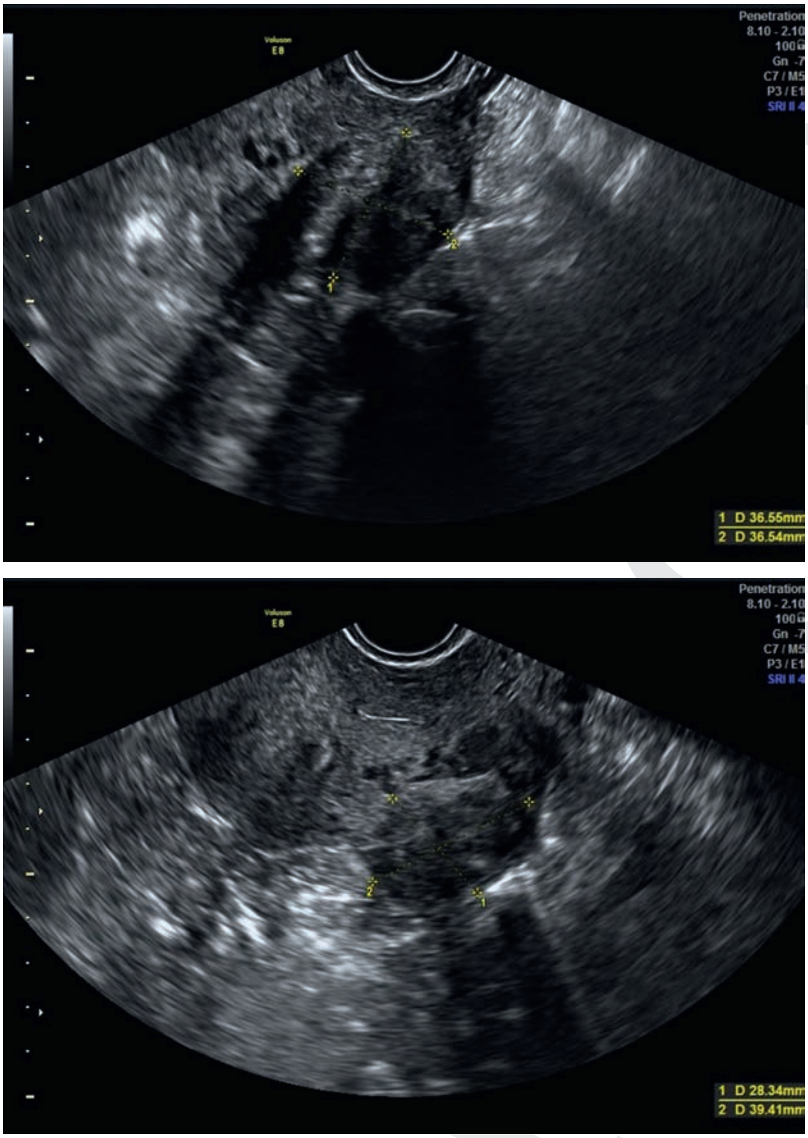

Figure 4.12 Measurement of larger fibroids should be carried out in at least two dimensions.

adenomyosis characterized by islands of ectopic endometrium interspersed by intense vascularization that crosses the structure in a disordered way; however, it often maintains its perpendicular course to the endometrium. Significant central vascularity in a fibroid may indicate sarcomatous change.

The application of 3D ultrasound imaging during transvaginal scanning allows for visualization of the coronal plane of the uterus. This plane has been especially useful as it allows definitive clarification of the exact position of the myoma in relation to the endometrial cavity, and the degree of cavity distortion can be determined. Fibroids may often cause uterine rotation along their axes, especially when they reach a considerable size, causing difficulties with endometrial assessment, but in some cases 3D analysis may be helpful as image manipulation may allow for some degree of cavity assessment (Figures 4.18 and 4.19). Colour or power Doppler ultrasound aids in difficult cases and helps to localize the myoma and its vascular supply, which may be useful for assessing the response to non-surgical treatments [15] (Figures 4.20 and 4.21), as well as monitoring the completeness of surgical resection and possible recurrence.

VOCAL (virtual organ computer-aided analysis) allows for accurate measurement of the volume of

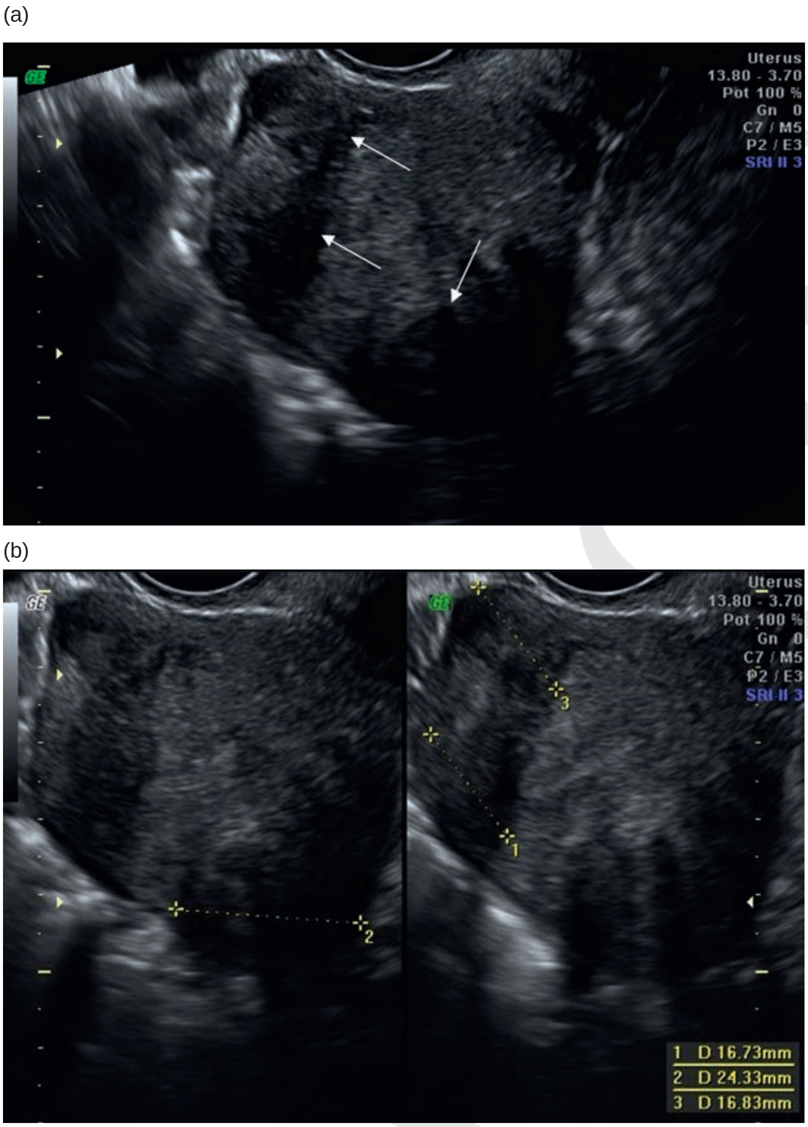

Figure 4.13 (a) Polymyomatous uterus. (b) Location and accurate measurement of each of the fibroids is indicated and helps with monitoring or response to treatment assessment.

each myoma, which may be used for monitoring the size of the fibroids (Figure 4.22); however, this is not used in routine practice. Tomographic ultrasound imaging (TUI) integrated within the 3D software provides a single screen with multiple tomographic sections of the uterus of the multiplanar representation chosen for the exact delineation of the myoma (Figures 4.23 and 4.24). Applying various thickness settings to the sections and numbers of sections allows for accurate assessment of the fibroid in relation to anatomical landmarks, in a way not too dissimilar to how computer tomography (CT) allows for slicing through anatomical structures in a sequential manner.

It is important to monitor myomas in pregnancy, with accurate description of measurements and locations [16]. Large fibroids may contribute to the following obstetric complications: red degeneration due to the rapid growth of the fibroid with intense pain, foetal malpresentation at term, the possibility of obstruction of the birth canal, and postpartum haemorrhage. All these conditions may be related to the distortion of the endometrial cavity produced by the myoma or by the alteration in the vascularization of the placenta when it is implanted over the fibroid. As mentioned earlier, during pregnancy the size of the fibroids may increase, especially in the first trimester, but may also be maintained or even decrease during

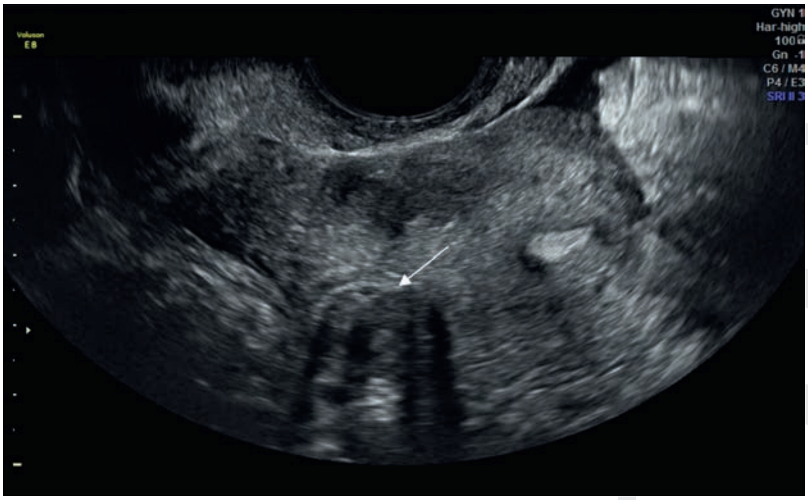

Figure 4.14 Myoma slightly calcified (arrow) on the posterior aspect of the uterus. An acoustic shadow is already noted.

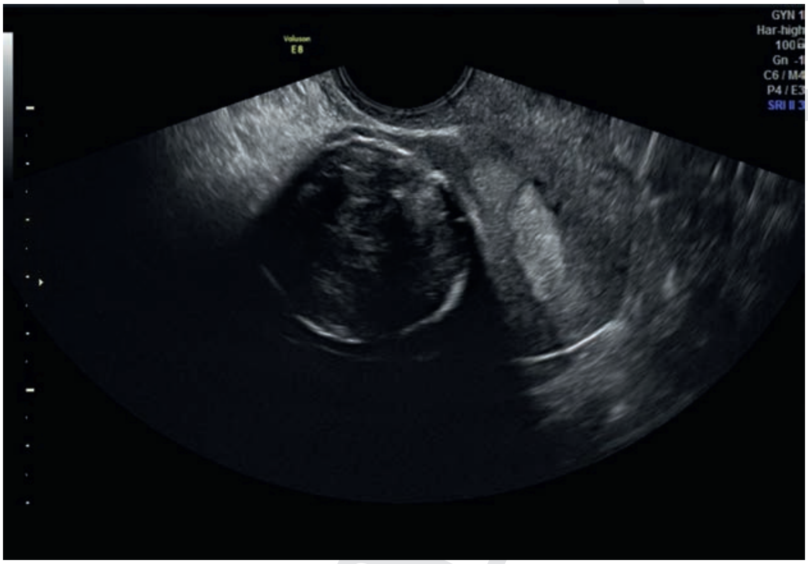

Figure 4.15 Large myoma on the right side of the uterus with a fully calcified surface and significant acoustic shadowing.

the second half, and particularly in the immediate puerperium [17] (Figures 4.25–4.27).

Adenomyosis

Adenomyosis is a uterine condition where heterotopic endometrial glands are located within the myometrium, with hyperplasia of the adjacent smooth muscles [18]. Diagnosis of this condition is based on clinical data corroborated with imaging findings, although the definitive confirmatory test remains histological analysis of the uterus. MRI has traditionally been considered as the gold standard non-invasive diagnostic test; however, ultrasound – with its improved resolution and 3D capability – has now become the diagnostic modality of choice, as it is well tolerated, less expensive and widely available. While adenomyosis remains a diagnostic challenge, the finding of endo-myometrial junctional zone (JZ) thickening has been considered pathognomonic. Other described and recognized ultrasound findings suggestive of adenomyosis include an irregular JZ diffusely or asymmetrically thickened with no relation for fibroids, distorted myometrium with heterogeneous hyperechogenicity, myometrial inclusion cysts in the form of anechoic lagoons, subendometrial linear striations with radial pattern, parallel shadowing or an adenomyoma (ill-defined, nodular and heterogeneous myometrial mass) [19,20] (Figure 4.28).

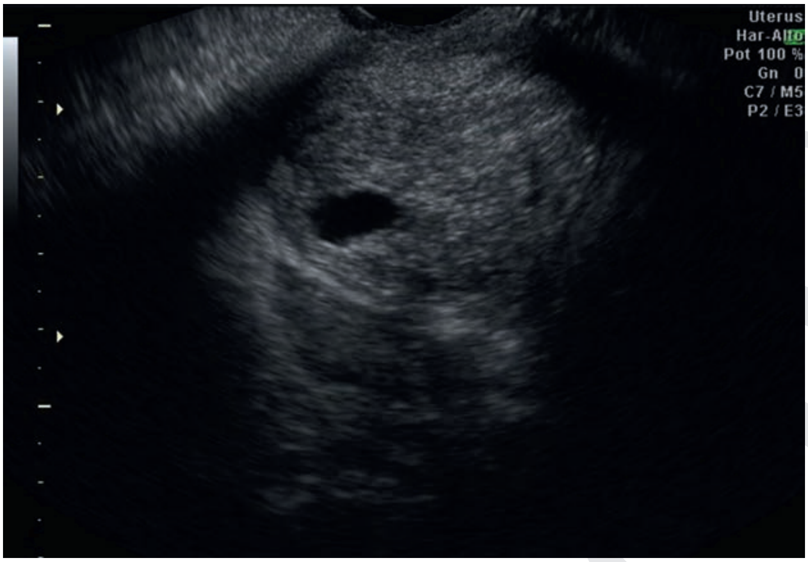

Figure 4.16 Hyaline degeneration within myoma (hypoechoic oval shape).

Some of the above ultrasound features, especially the hyperechogenic islands in the myometrial tissue, are more pronounced in the second half of the menstrual cycle owing to the secretory changes the tissue undergoes. The use of power Doppler allows for visualization of the straight blood vessels crossing the adenomyotic lesion, which follow a course completely perpendicular to the endometrium (Figure 4.29), thus differentiating it from the circumferential pattern of vascularity observed in fibroids. In the case of focal adenomyosis, or adenomyoma, the mass is contained within the myometrium, asymmetrically distorting the uterus, it is poorly delineated and has mixed echogenicity, with hyperechoic foci in the luteal phase representing ectopic endometrium. Blood vessels as seen on Doppler imaging traverse the mass freely (Figures 4.30 and 4.31).

The diagnosis of adenomyosis can be improved by using 3D ultrasound, as it allows for offline analysis with reconstruction of various anatomical lanes, especially the coronal plane of the uterus. This particular view allows for subjective and objective assessment of the endo-myometrial JZ. A thickened JZ (≥8 mm) with lack of defined boundaries and bridging of the JZ by echogenic endometrial foci are typical characteristics of adenomyosis on a 3D ultrasound multiplanar view or reconstruction [21–23] (Figure 4.32).

The authors propose a novel sonographic marker for diagnosis of adenomyosis using technology introduced by General Electric (Zipf, Austria) on their newest ultrasound machines – the HDLive mode (High Definition Live). The volume for analysis is obtained in a similar fashion as for any 3D volume and the image is manipulated to create a coronal view of the endometrial cavity (a detailed description of how to obtain 3D images is presented in Chapter 5).

Once the coronal plane is constructed, the ‘Edit Light’ functionality is activated, which allows directed trans-illumination of the object from different angles. In severe cases of adenomyosis, the authors observed the ‘tree sign’, with the cervical canal and the lower endometrial cavity simulating the trunk and the irregularities of the JZ with perpendicular blood vessels, and hypoechoic lagoons completing the image of the tree (see Figures 4.33 and 4.34). The study evaluating the reproducibility and reliability of this sign, as well as its association with reproductive outcomes, is ongoing.

Tips and Tricks

- Transvaginal ultrasound is the diagnostic modality of choice for fibroids and adenomyosis.
- Transabdominal ultrasound may complement transvaginal ultrasound in cases of large fibroids or multifibroid uterus.
- Location of fibroids, especially in relation to the endometrium, may be best assessed with 3D ultrasound scan or TUI.
- Fibroids may change appearance over time due to various histological (physiological and pathological) changes and may develop anechoic spaces, acoustic shadowing or posterior reinforcement.

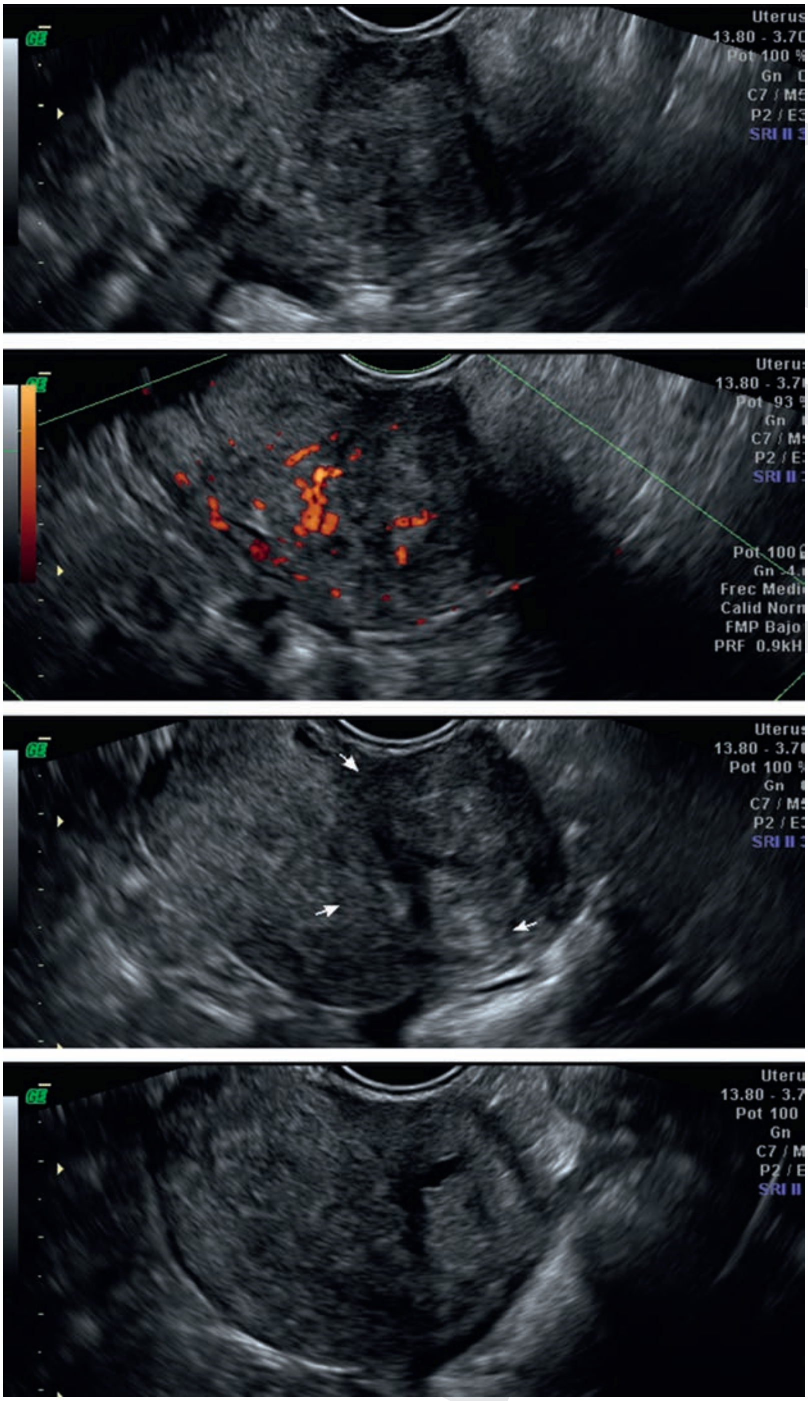

Figure 4.17 Case of a uterus with sarcoma: the entire uterine thickness is encompassed by a poorly defined lesion with central necrosis and abundant, irregular blood vessels.

- Rapid increase in size should raise suspicion of sarcomatous transformation, especially if coupled with increased vascularity.
- Fibroid vascularity is mainly on the periphery, creating a ‘ring of fire’ appearance on Doppler imaging.

- Differentiation between type 0 fibroid and endometrial polyp may be achieved with Doppler imaging – feeding vessels will be present in both cases, but circular or semicircular patterns will be seen in the case of fibroids and a branching pattern (or just a feeding vessel) will be seen in polyps.

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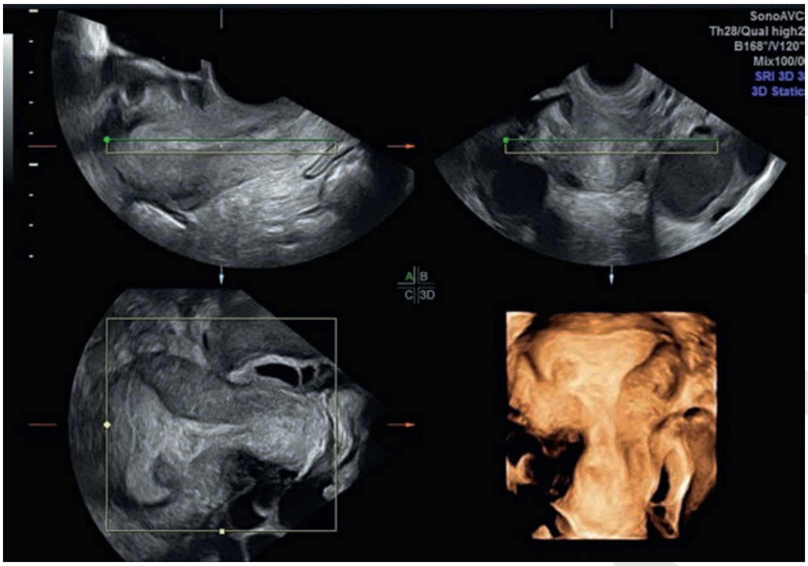

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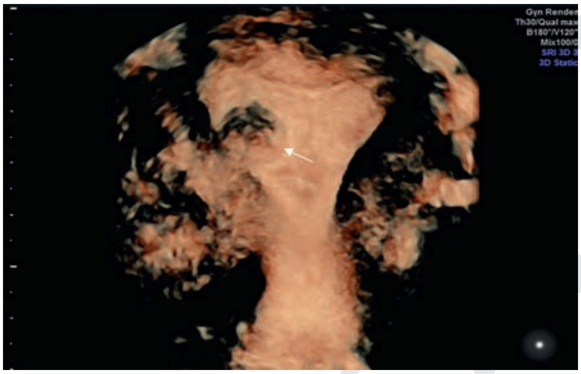

Figure 4.18 (a) Study of a submucous myoma (arrow) using 3D ultrasound with multiplanar representation. (b) Coronal plane of the uterus in the HDLive modality, with clear delineation of the myoma (arrow) in the cavity.

- Adenomyosis is best assessed in the luteal phase of the menstrual cycle.
- Asymmetrically enlarged uterus with inclusion cysts and parallel shadowing is a typical 2D sonographic appearance of adenomyosis.
- 3D imaging is very useful when assessing the endo-myometrial junction zone to help diagnose adenomyosis.
- Vascularity in adenomyosis is uninterrupted and transverses the lesion running perpendicular to the endometrium.
- Adenomyomas differ from fibroids in lack of a clear capsule and uninterrupted vascular pattern.

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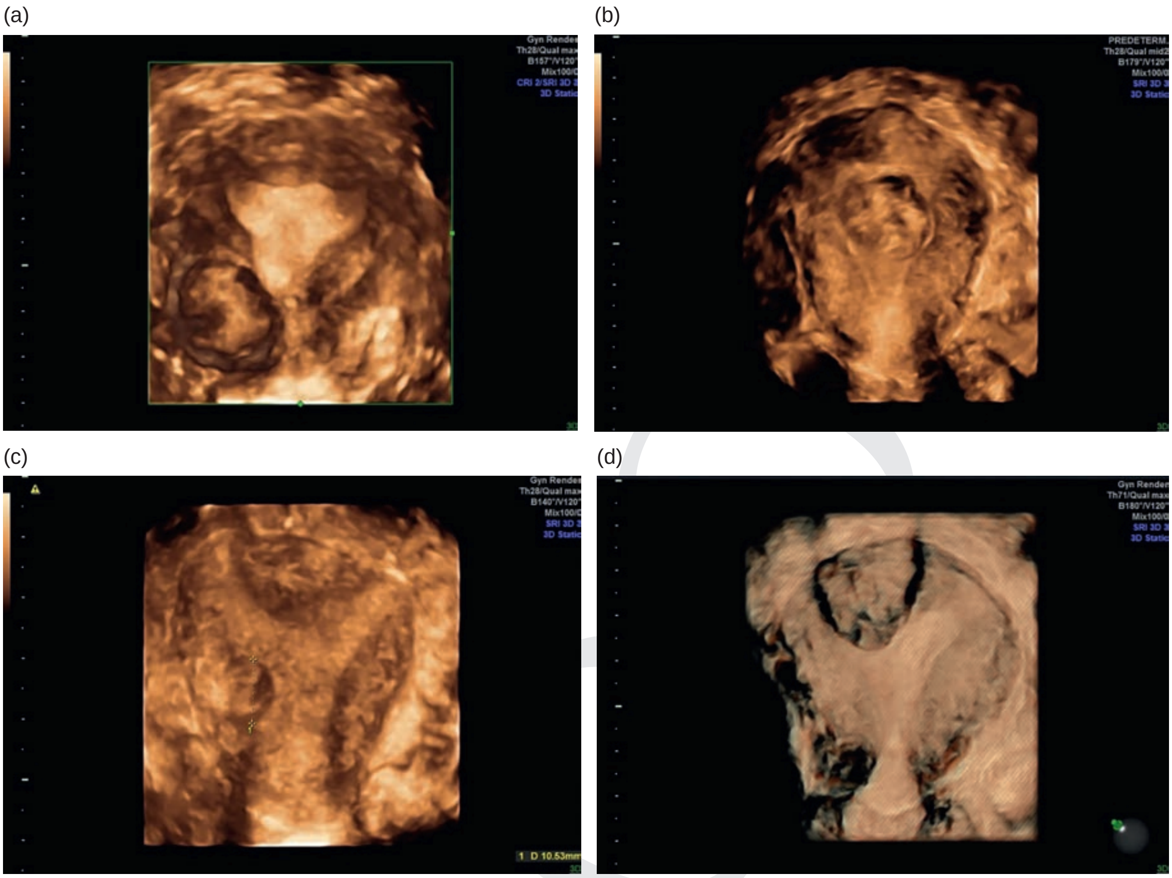

Figure 4.19 Several fibroids in 3D. (a) Intramural myoma, near the cervix. (b) Submucous myoma occupying much of the endometrial cavity. (c) Intramural myoma partially deforming the cavity. (d) Intramural myoma in the uterine fundus.

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(a)

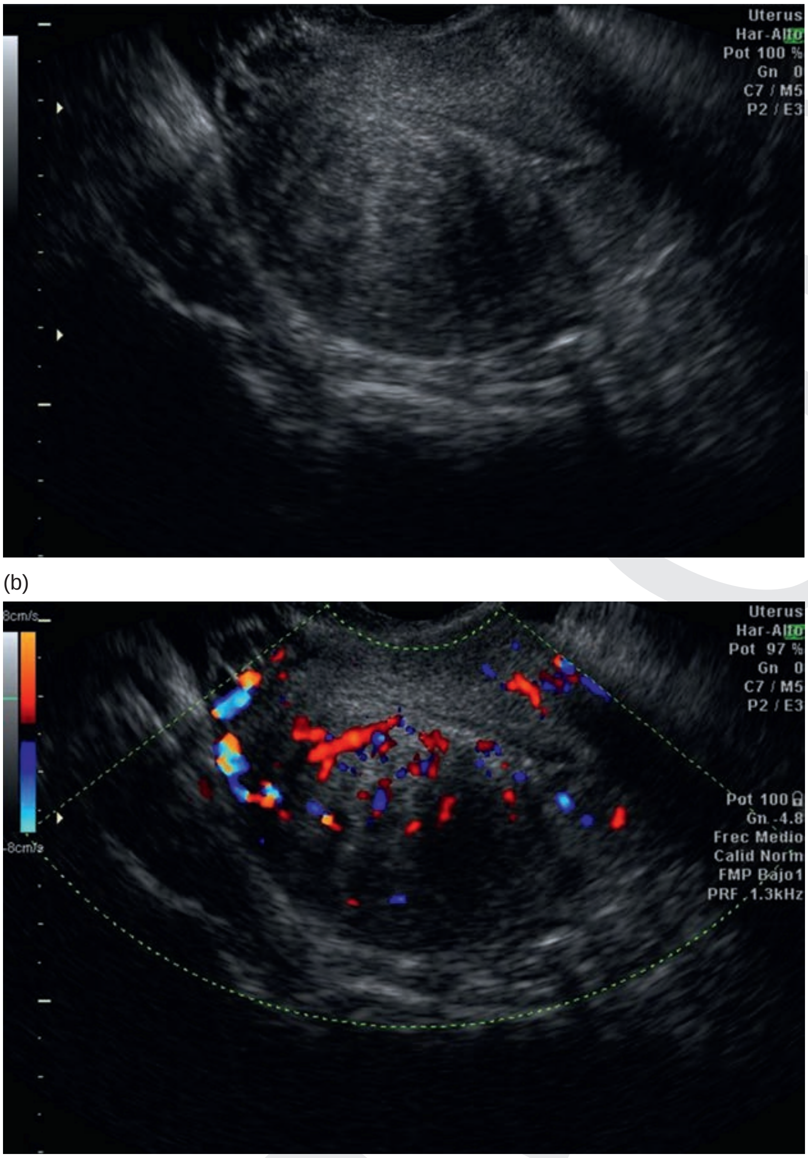

Figure 4.20 (a) Intramural myoma with poor delineation. (b) application of colour Doppler allows for a more accurate assessment of location and differentiation from adenomyosis, as the blood vessels show a peripheral distribution.

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(a)

(b)

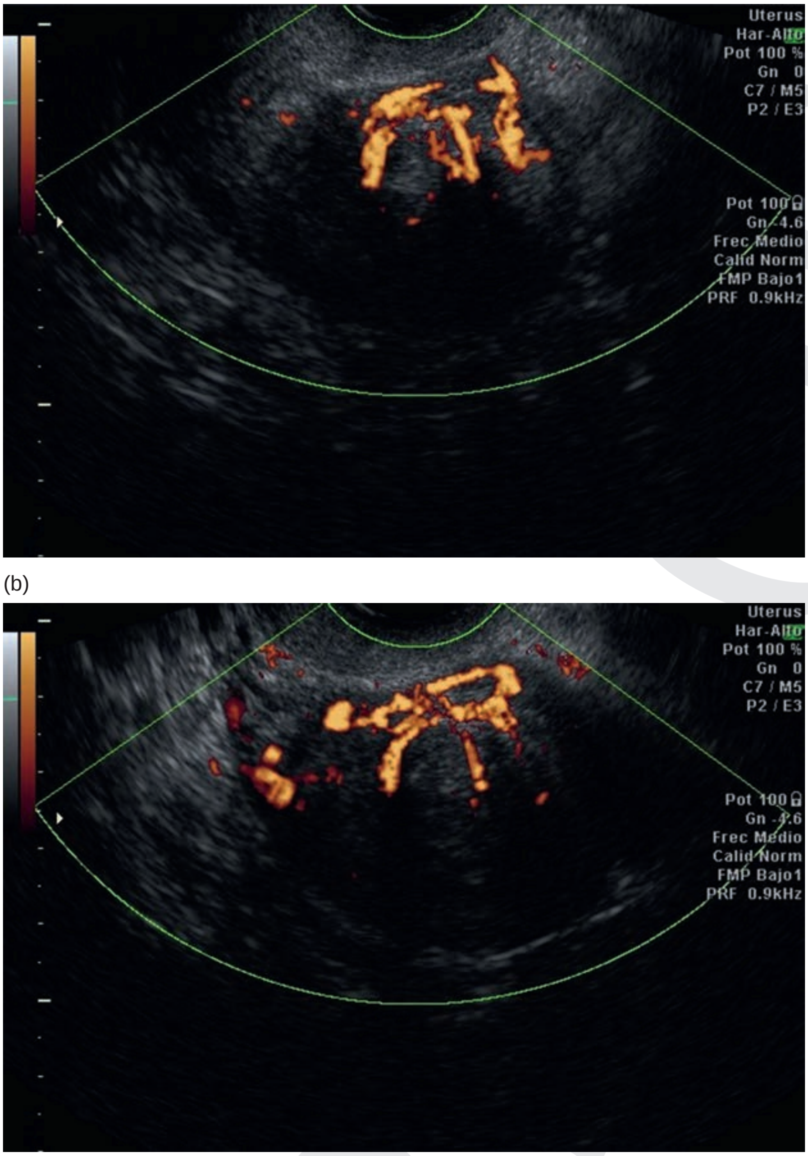

Figure 4.21 Power Doppler imaging of the same myoma as in Figure 4.20 in different planes.

22. Exacoustos C, Brienza L, Di Giovanni A, et al. Adenomyosis: three dimensional sonographic findings of the junction zone and correlation with histology. *Ultrasound Obstet Gynecol* 2011;**37**(4):471–9.

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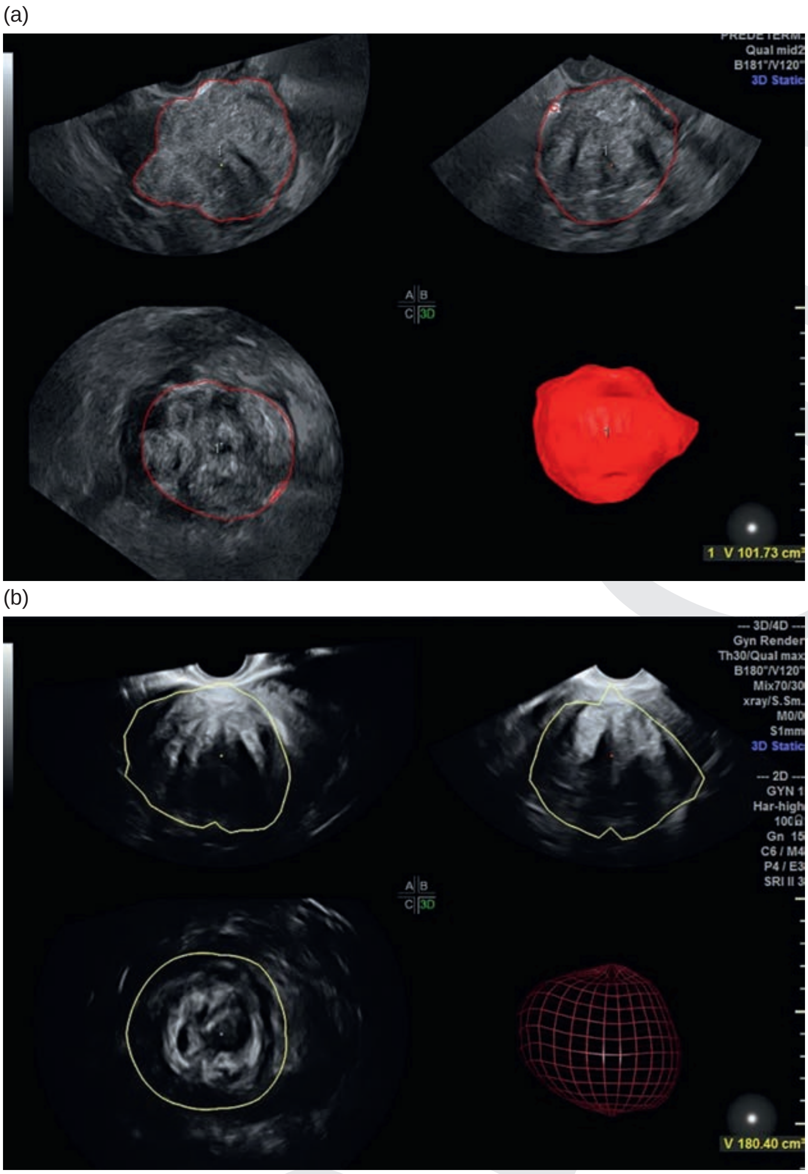


Figure 4.22 The VOCAL modality allows obtaining the volume of the myoma under study, as shown in the multiplanar representation of fibroids.

(a)

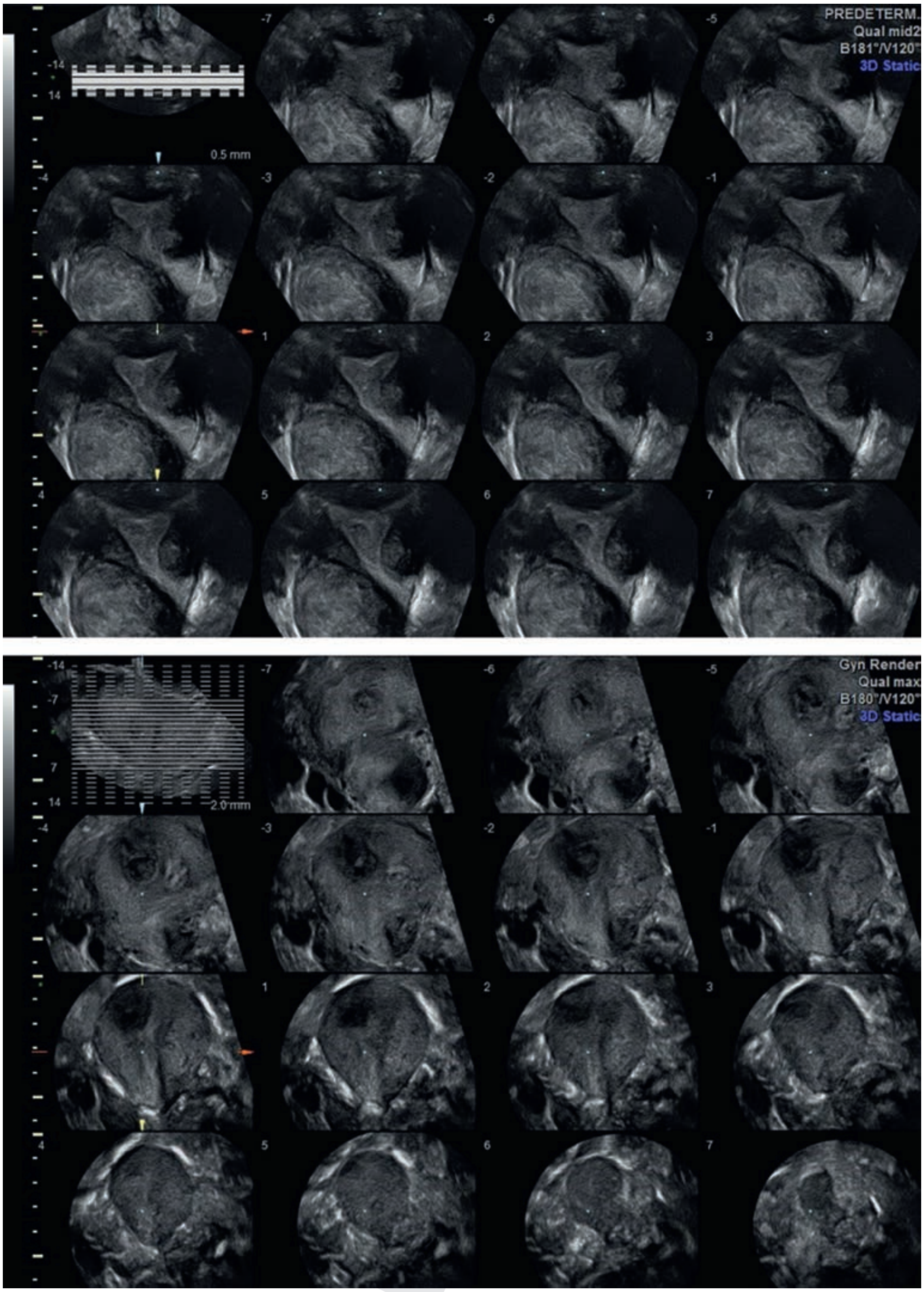


Figure 4.23 The TUI modality provides multiple tomographic sections of the uterus, allowing the exact delineation of the myoma within the myometrial wall and in relation to the endometrial cavity. Four examples are shown.

(b)

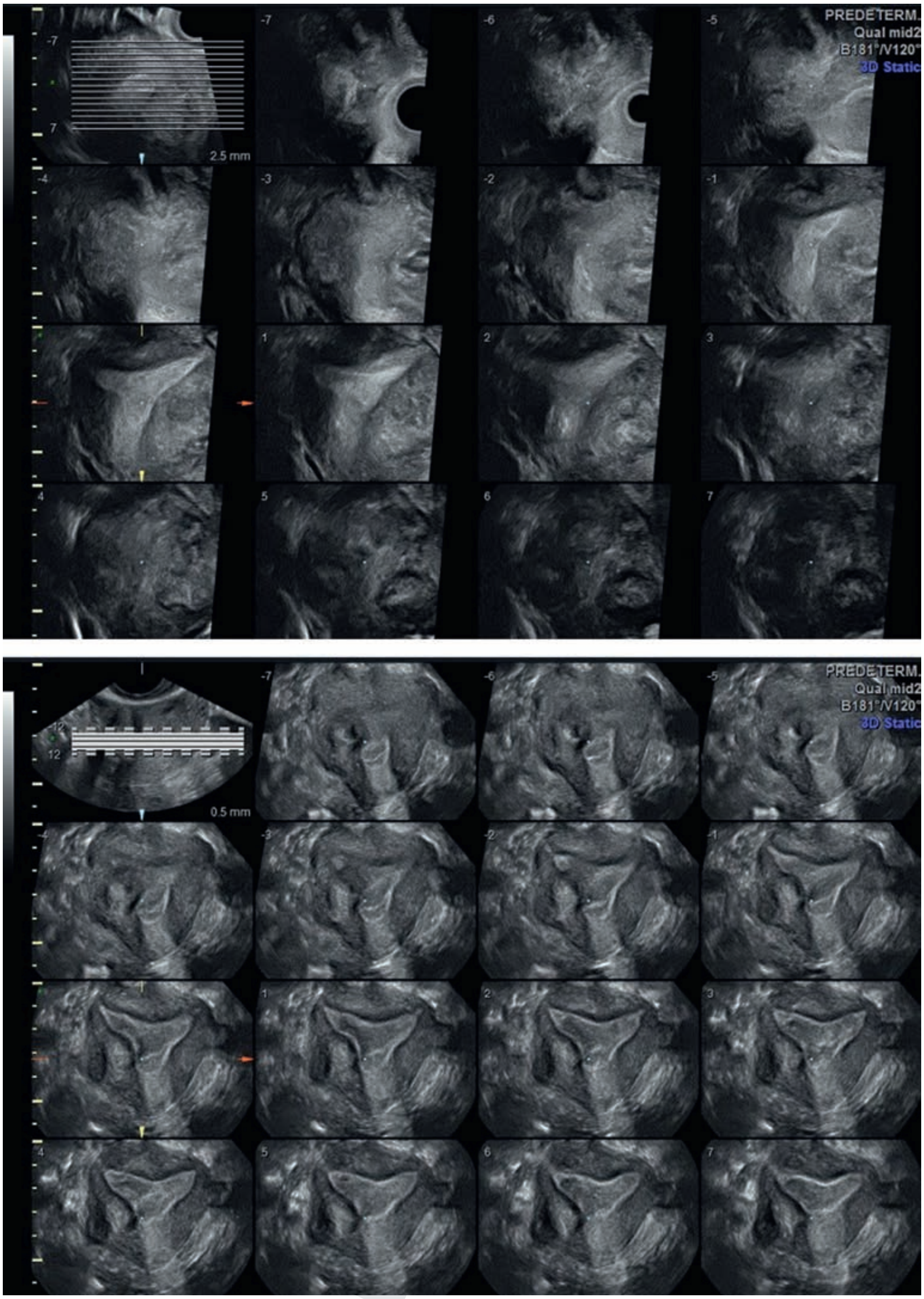


Figure 4.23 (cont.)

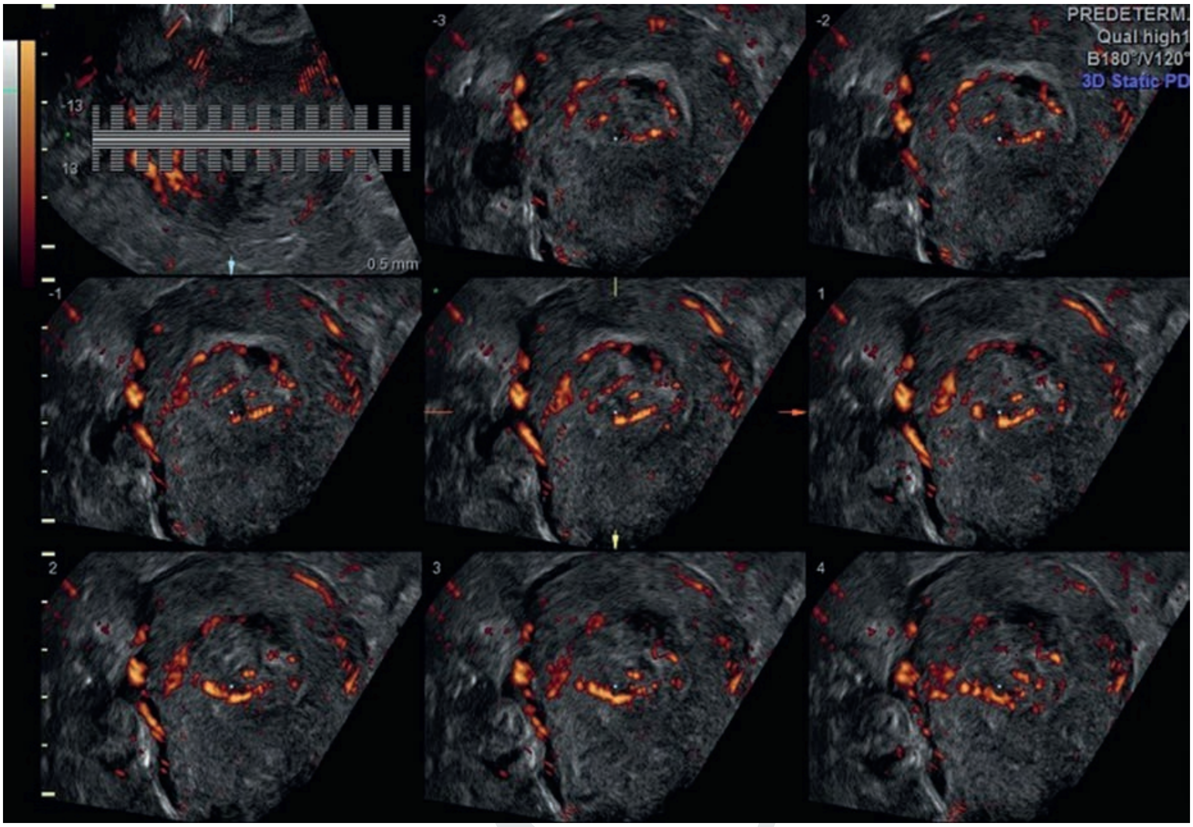


Figure 4.24 Several 3D modalities can be combined; for example, the 3D power Doppler and the TUI demonstrating a submucosal fibroid with peripheral vascularity.

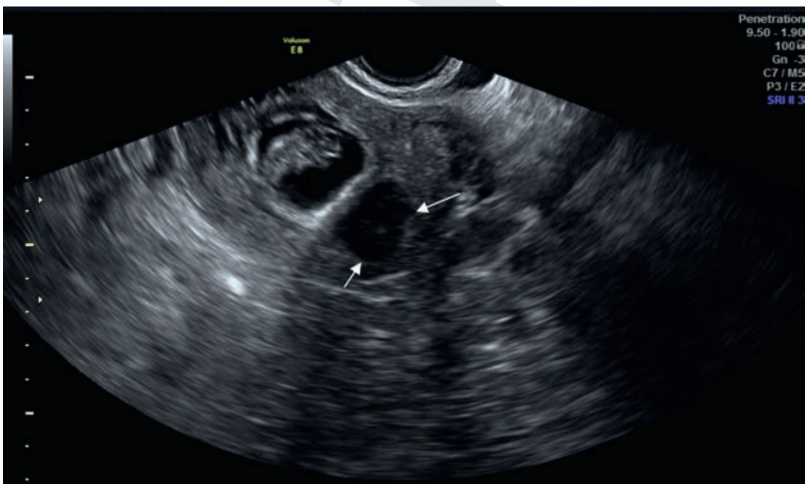


Figure 4.25 A uterus containing a pregnancy of nine weeks' gestation with a single intramural myoma (arrows).

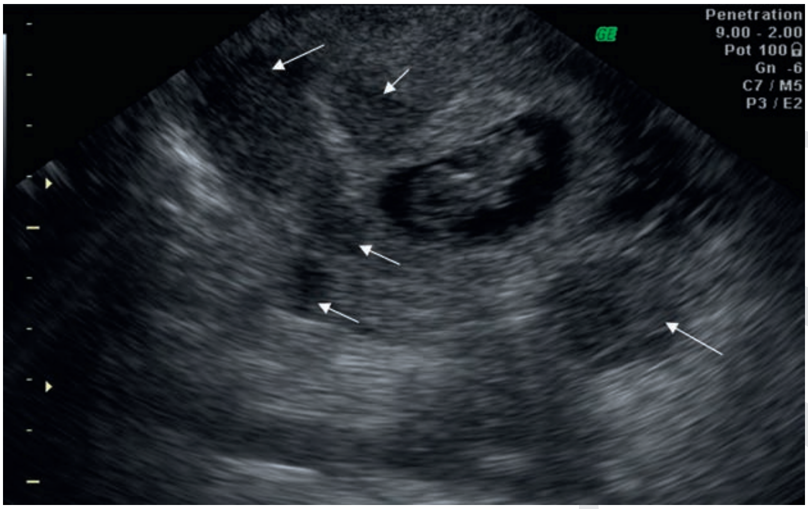


Figure 4.26 Gestation of nine weeks implanted in a polymyomatous uterus.

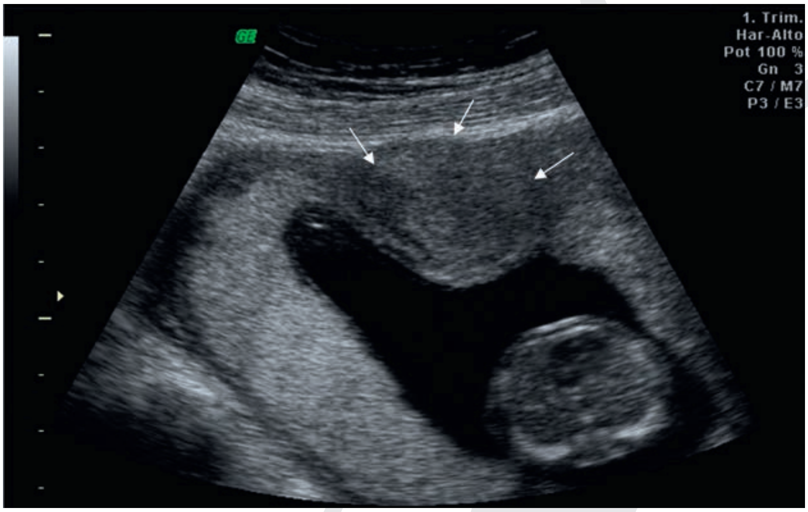


Figure 4.27 Gestation of 14 weeks, with myoma (arrows) deforming the amniotic cavity.

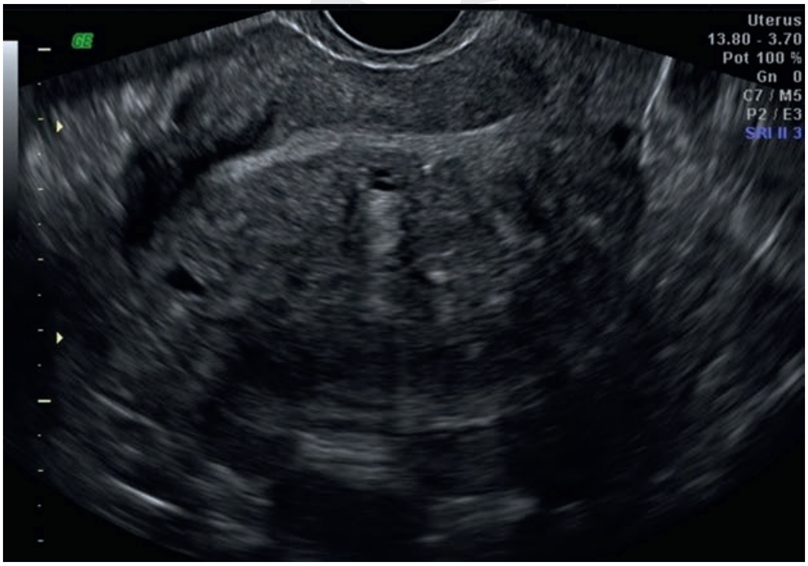


Figure 4.28 Classic signs of adenomyosis on 2D ultrasound scan: loss of endometrium–myometrium interface, thickening of the myometrium, differences in thickness of myometrial walls, heterogeneous hyperechogenicity, subendometrial cysts in the form of anechoic lagoons, and subendometrial striations.

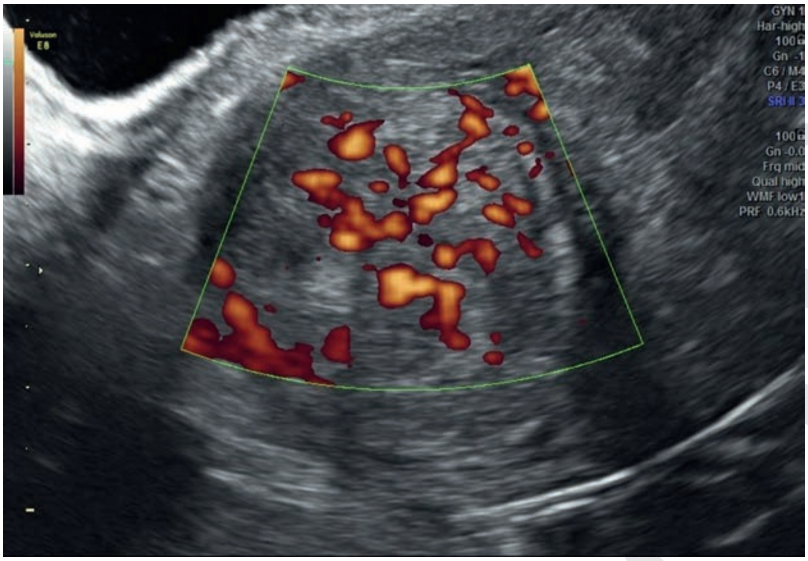


Figure 4.29 Power Doppler analysis demonstrates an uninterrupted vascular pattern in this case of adenomyosis, though the paths are irregular and not perpendicular to the endometrium as typically seen.

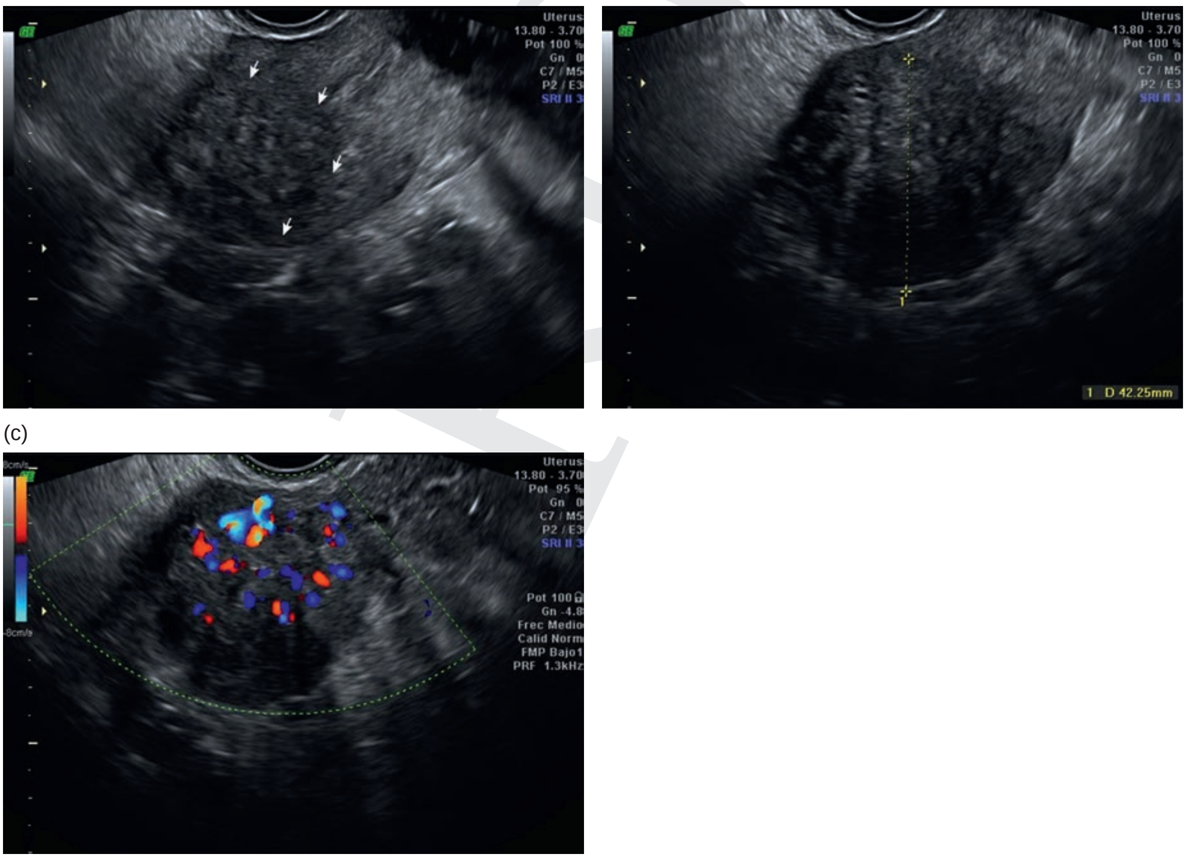


Figure 4.30 (a) Adenomyoma; arrows demonstrate a poorly defined border. (b) It is usually located within the uterine fundus. (c) Doppler modality helps to differentiate from fibroids.

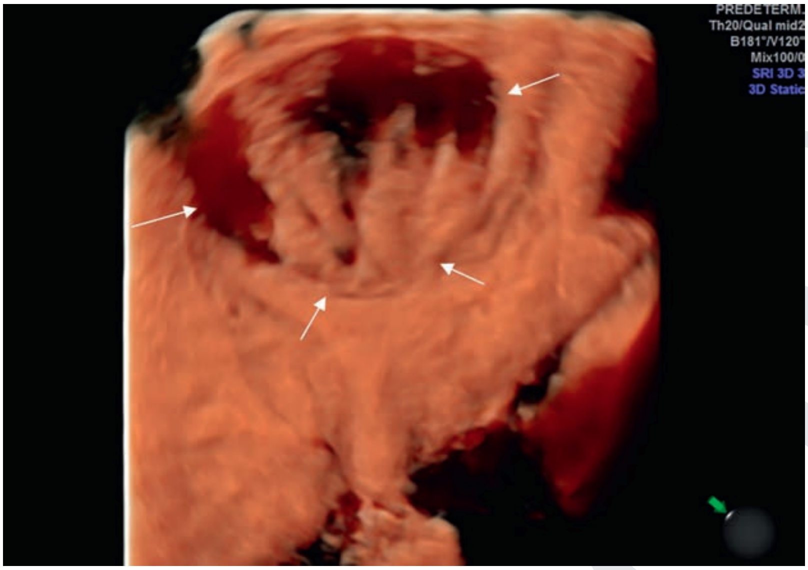


Figure 4.31 Adenomyoma (arrows) of the uterine fundus demonstrated with HDLive.

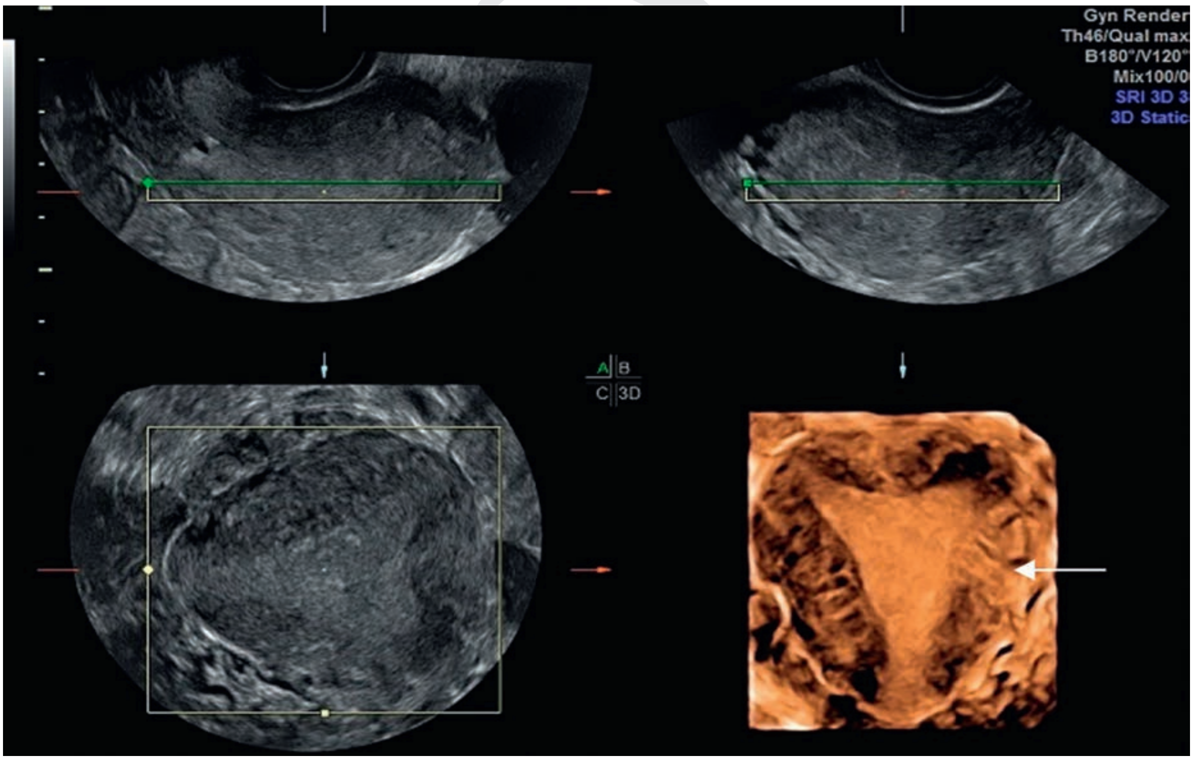


Figure 4.32 3D multiplanar view of a uterus with an area of adenomyosis located in the left lateral wall: effacement and lack of definition of the limits of the JZ, with infiltration towards the myometrium (arrow).

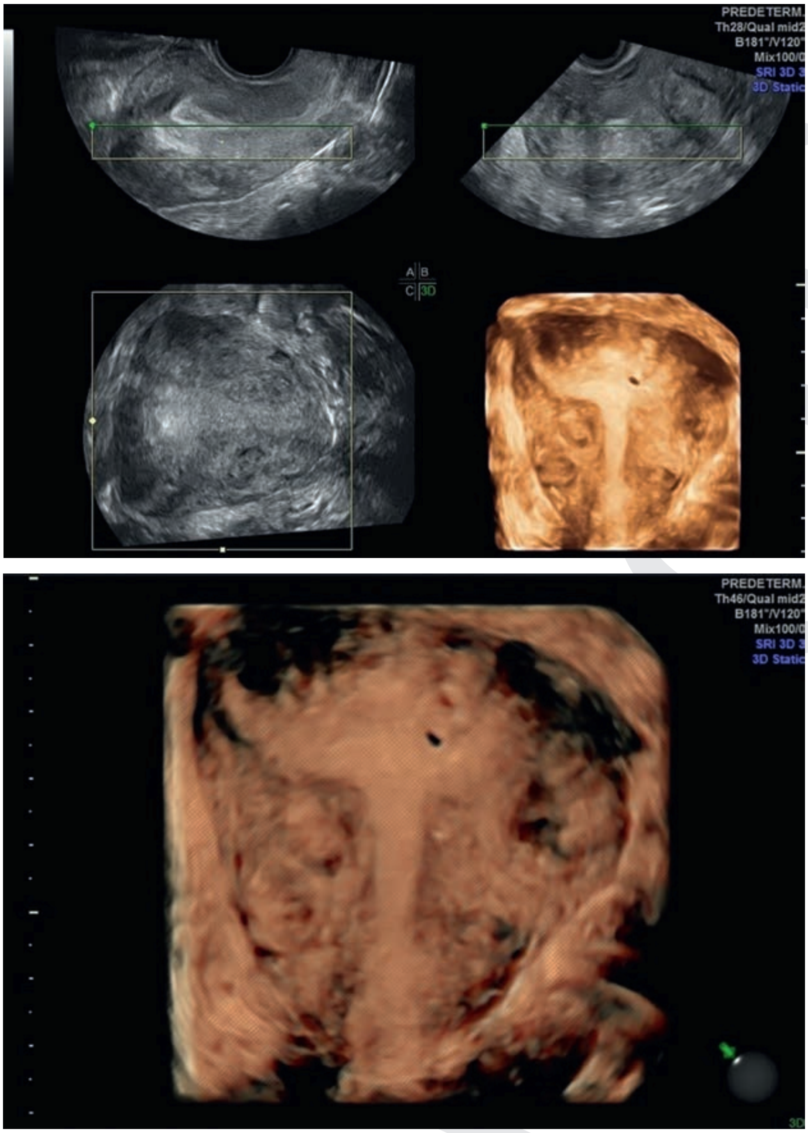
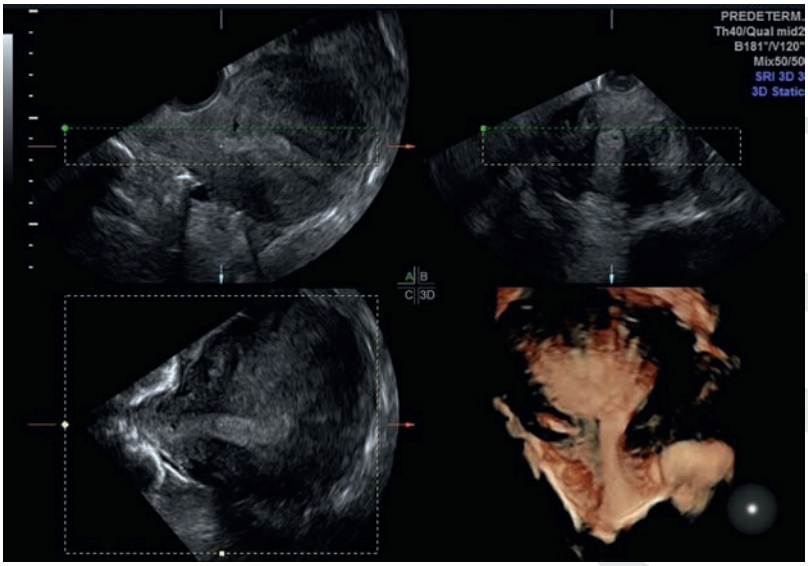


Figure 4.33 3D ultrasound multiplanar mode and reconstruction of images with the HDLive mode. Three cases of diffuse adenomyosis and 'tree sign' are shown. The right lower corner of the image demonstrates the direction of light. The trunk of the tree is formed by the cervical canal and the lower part of the endometrial cavity. Completing the image of this tree is the rest of the endometrial cavity and adenomyotic implants with feeding blood vessels.



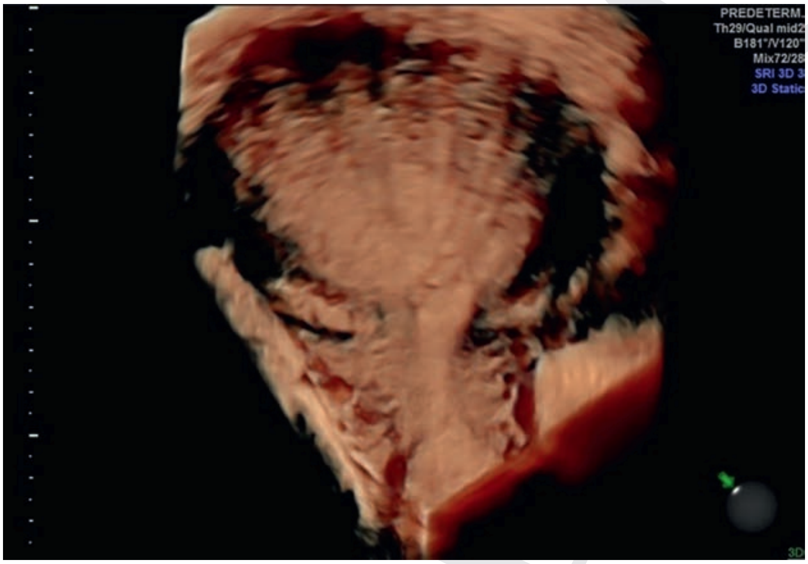


Figure 4.33 (cont.)

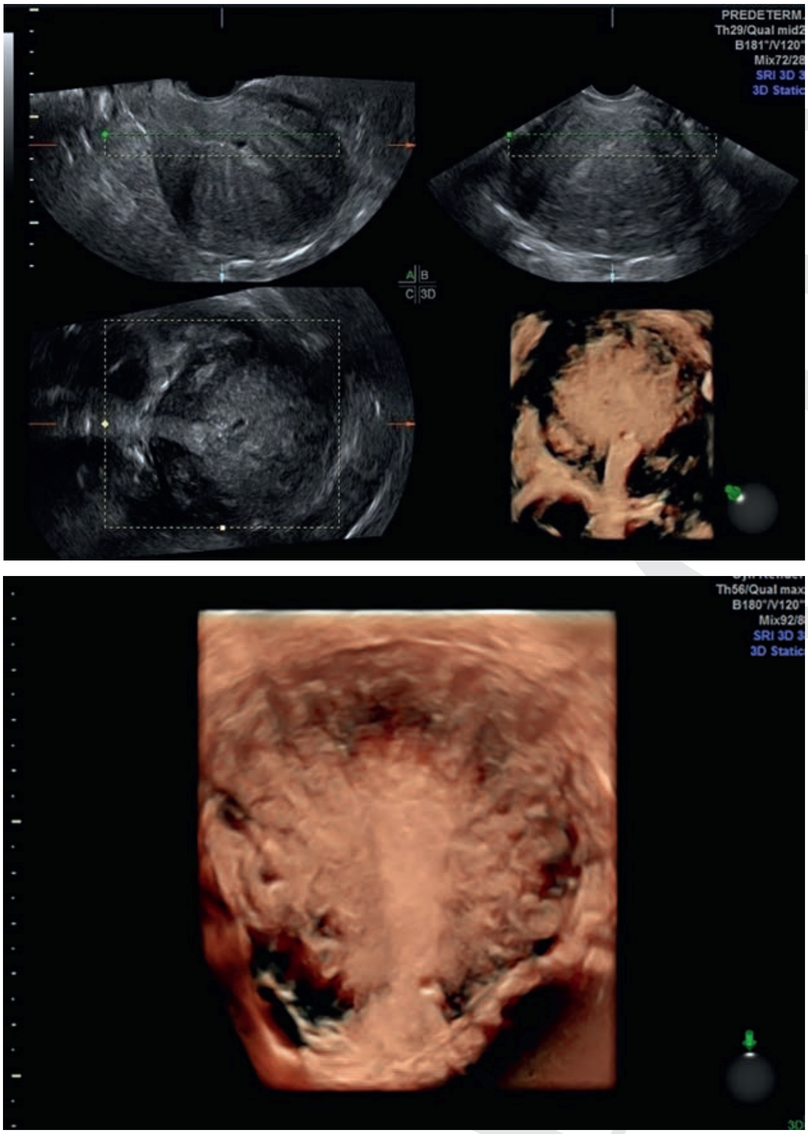


Figure 4.33 (cont.)

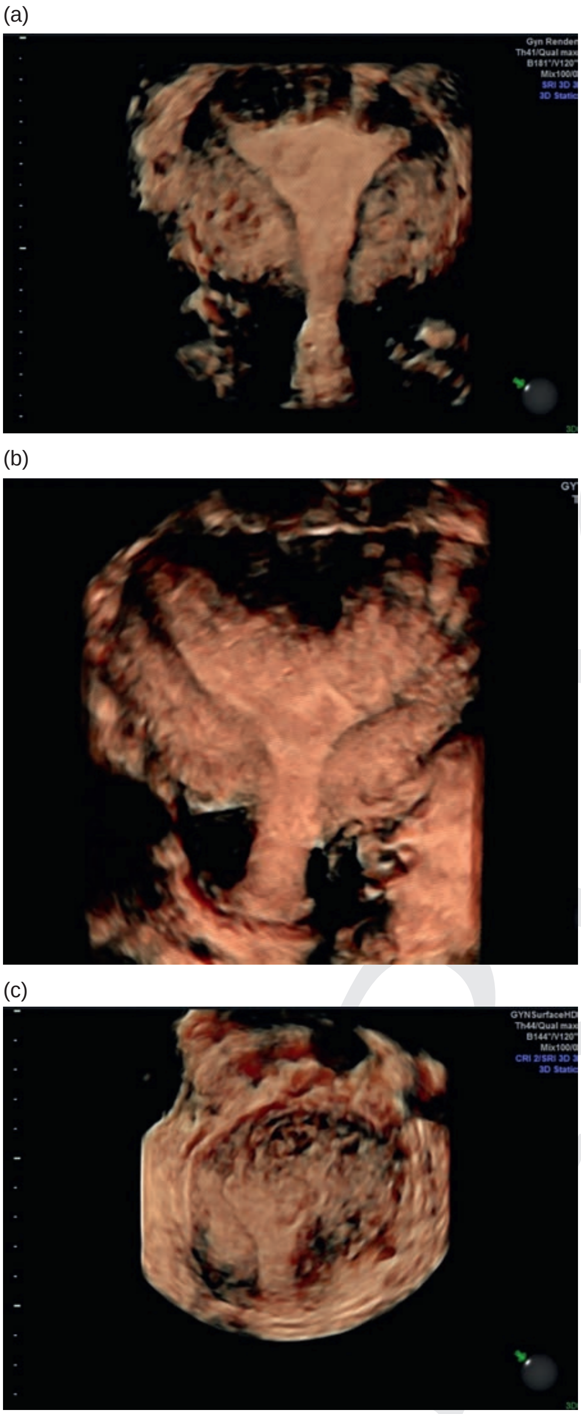


Figure 4.34 Proposed classification of adenomyosis with the help of HDLive imaging: (a) mild (globulous uterus, linear striations, local disruptions and heterogeneous myometrium); (b) moderate (myometrial cysts and adenomyotic implants, or adenomyoma); (c) severe, with the described ‘tree sign’.