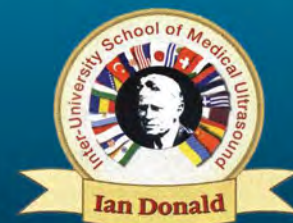
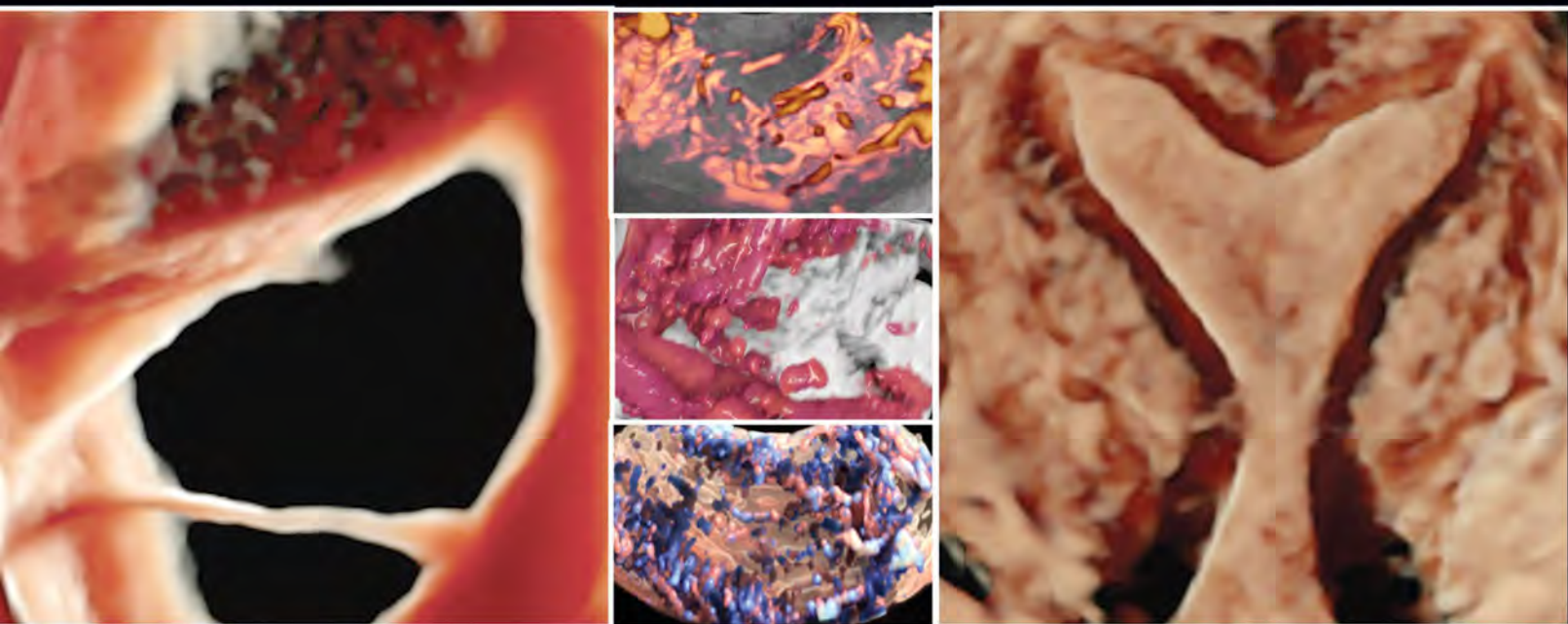


*Get Full Access
with added features at*

emedicine360.com



Donald School 3D-4D ULTRASOUND IN GYNECOLOGY



Editors

**Zorancha Petanovski
Asim Kurjak**

Foreword

Frank A Chervenak



JAYPEE

Contents

SECTION 1: General Principles of 3D Ultrasound in Gynecology

1. Development of 3D Ultrasound	3
<i>Kazunori Baba, Asim Kurjak</i>	
▪ What can 3D Ultrasound Do?	3
▪ Technical Aspects of 3D Ultrasound	3
▪ Practical Tips	12

SECTION 2: 3D Ultrasound Examination of the Uterine Lesion

2. Uterine Fibroids (Leiomyoma and Myoma)	21
<i>Zorrancho Petanovski, Asim Kurjak</i>	
▪ Ultrasound Characteristics of Uterine Fibroids	21
▪ Localization of Fibroids	24
▪ Classifications of the Leiomyoma	26
3. Adenomyosis.....	37
<i>Zorrancho Petanovski, Asim Kurjak, Sonal Panchal</i>	
▪ Ultrasound Criteria of Adenomyosis	37
▪ Differential Diagnosis between Adenomyosis and Uterine Fibroids	39
▪ 3D Vaginal Ultrasonography in Infertility Related to Adenomyosis	39
4. Uterine Polyp	44
<i>Zorrancho Petanovski</i>	
▪ Ultrasound Characteristics of Endometrial Polyp	44
▪ 3D Ultrasonography: Location of the Endometrial Polyp	45
▪ 2D/3D Saline Infusion Sonohysterography	45
▪ Differential Diagnosis between Endometrial Hyperplasia and Endometrial Polyp	45
5. Imaging of Malignant Uterine Lesions	49
<i>Zorrancho Petanovski</i>	
▪ Vascularization of Uterine Tumors	49
▪ Uterine Leiomyosarcoma	51
▪ Endometrial Carcinoma	53
▪ Cervical Carcinoma	56
6. Imaging of Acquired Uterine Lesions.....	58
<i>Zorrancho Petanovski, Asim Kurjak, Emilija Petanovska Kostova</i>	
▪ Enhanced Myometrial Vascularity/Arteriovenous Malformation	58
▪ Isthmocele	59
▪ Intrauterine Adhesions: Asherman's Syndrome	61
▪ Nabothian Cysts	62
7. Uterine Anomaly	64
<i>Zorrancho Petanovski</i>	
▪ Ultrasound Assessment of Uterine Anomalies	64
▪ Didelphys Uterus	65
▪ Unicornuate Uterus (ESHRE—Class U4; ASRM—Class II)	65
▪ Uterine Septum (ASRM—Class V; ESHRE/ESGE—Class U2)	66
▪ Arcuate Uterus	68
▪ Bicornuate Uterus	69
▪ T-shaped Uterus (ASRM—Class VII); Dysmorphic Uterus (ESHRE/ESGE—Class U1)	69

SECTION 3: 3D Ultrasound Examination of Adnexal Masses

8. Ovarian Cystic Formation	79
<i>Zorrancho Petanovski, Asim Kurjak</i>	
▪ Hemorrhagic Corpus Luteum Cyst	79
▪ Polycystic Ovaries	80
▪ Endometrioma	82
9. Ovarian Tumors.....	86
<i>Zorrancho Petanovski, Asim Kurjak</i>	
▪ Cystic Ovarian Tumors	86
▪ Solid-cystic Ovarian Tumor	94
▪ Solid Ovarian Tumors	94
10. Adnexal Masses.....	97
<i>Zorrancho Petanovski, Asim Kurjak, Emilija Petanovska Kostova</i>	
▪ Chronic Inflammation of the Fallopian Tubes	97
▪ Ectopic Pregnancy	97
11. 3D Ultrasound and Ovarian Cancer	105
<i>Asim Kurjak, Sonal Panchal</i>	
▪ Ovarian Tumors	105
▪ Role of Ultrasound in Diagnosis of Ovarian Lesions	105
▪ Three-dimensional Ultrasound	107
▪ Three-dimensional Power Doppler	109
▪ Contrast-enhanced 3D Power Doppler	112
12. Screening for Ovarian Cancer: What does 3D Power Doppler Add?	114
<i>Asim Kurjak, Sonal Panchal</i>	
▪ Difficulties in Ovarian Cancer Screening	114
▪ Attempts to Screen: Some Lessons Learned	114
▪ Screening Tests	114
▪ Target Populations	116
▪ Ovarian Cancer Screening Trials	117
▪ Ovarian Cancer: The Role of 3D Ultrasound and 3D Power Doppler Imaging	118
▪ Zagreb Ovarian Cancer Screening Trial	119

SECTION 4: 3D Ultrasound Examination in Infertility

13. Volume Ultrasound in Infertility.....	129
<i>Sonal Panchal</i>	
▪ Diagnosis of Uterine Pathologies that Affect Implantation	129
▪ Diagnosis of Ovarian Lesions that Affect Fertility	136
▪ Diagnosis of Tubal Pathologies	138
▪ Tubal Patency Assessment	138
▪ Polycystic Ovaries	139
▪ Assessment of Ovarian Reserve and Response	141
▪ Assessment of Follicular Maturity	142
▪ Assessing Endometrial Receptivity	143
▪ Prediction of Ovarian Hyperstimulation Syndrome	145
▪ For Diagnosis and Differentiation of Ectopic Pregnancies in Uterus	145

<i>Index.....</i>	<i>147</i>
-------------------	------------

SECTION

3D Ultrasound Examination of the Uterine Lesion

2

- ⦿ **Uterine Fibroids (Leiomyoma and Myoma)**
Zorancho Petanovski, Asim Kurjak
- ⦿ **Adenomyosis**
Zorancho Petanovski, Asim Kurjak, Sonal Panchal
- ⦿ **Uterine Polyp**
Zorancho Petanovski
- ⦿ **Imaging of Malignant Uterine Lesions**
Zorancho Petanovski
- ⦿ **Imaging of Acquired Uterine Lesions**
Zorancho Petanovski, Asim Kurjak, Emilija Petanovska Kostova
- ⦿ **Uterine Anomaly**
Zorancho Petanovski

Uterine Fibroids (Leiomyoma and Myoma)

Zoranko Petanovski, Asim Kurjak

◇ INTRODUCTION

Uterine fibroids (leiomyomas, myomas) are the most common tumor formations of the uterus. Leiomyomas are the result of the growth of fibrovascular cells from the myometrium. Histologically, fibroids contain muscle and connective tissue. These have a pseudocapsule that is richly vascularized.¹ Certain factors from that vascularized pseudocapsule raise the level of estrogen which in turn increase the level of certain growth factors resulting in the growth of the tumor itself.^{2,3} The peak prevalence of uterine fibroids is the fourth decade of a woman's life, due to the cumulative effect of estrogen, progesterone, and fibroid growth factors during the female reproductive period,⁴ with a presence of over 70% in women over 50 years of age. These are tumors with benign potential and the occurrence of malignancy or finding of leiomyosarcoma is rare with about 0.2%.⁵

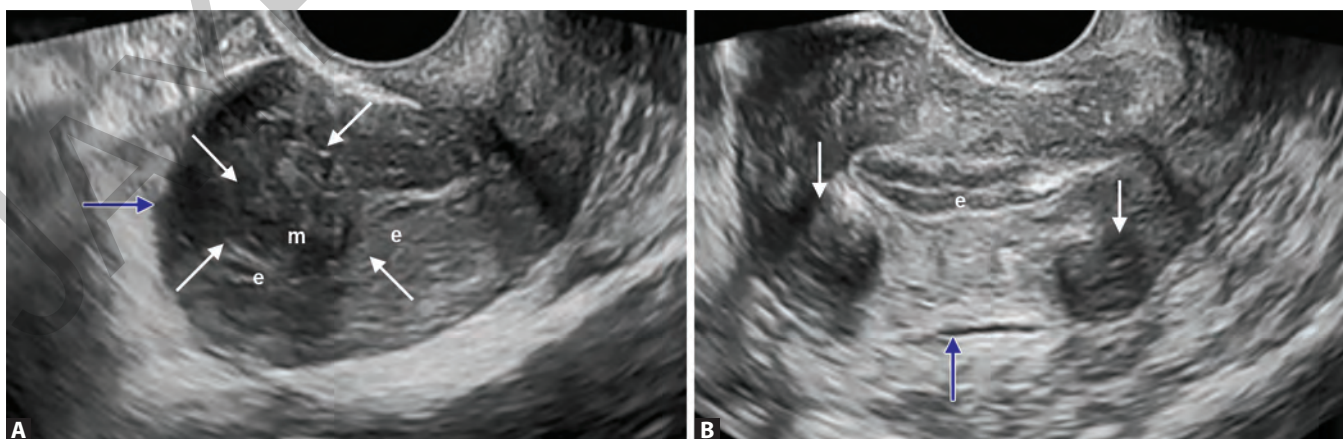
◇ ULTRASOUND CHARACTERISTICS OF UTERINE FIBROIDS

The appearance of uterine fibroids on ultrasound is determined by the structure of the tumor itself. The muscle tissue from which the uterine fibroid is made gives echogenicity to the tumor similar to that of the myometrium. Leiomyomas generally have whorled appearance of solid

masses, with a clear edge of demarcation of the tumor to the surrounding tissue due to displacement of myometrial fibers resulting into pseudocapsule. Vascularity may vary in abundance but peripheral circular pattern is consistent in all leiomyomas.

From an ultrasound point of view, according to Morphological Uterus Sonographic Assessment (MUSA)—consensus statement on terms, definitions, and measurements that may be used to describe and report the sonographic features of the myometrium using grayscale sonography, color/power Doppler, and three-dimensional (3D) ultrasound imaging, uterine fibroids have the following characteristics:⁶

- A well-defined lesion, the serosal contour of uterus lobulated or regular and asymmetry of uterine walls in presence of a well-defined lesion (**Figs. 1 to 4**).
- Round, oval, lobulated shape of the lesion, a contour is smooth and hypo- or hyperechogenic rim (**Figs. 5A and B**).
- *Shadowing*: Edge shadows, internal shadows (often fan-shaped shadowing) (**Figs. 6 to 8**).
- *Echogenicity*: Uniform hypoechogenic usually; non-uniform: hyper-, hypo- or mixed echogenicity or even calcified or anechoic if degenerated (**Figs. 9 to 12**).
- *Vascularity*: Circumferential flow (**Figs. 13 to 15**).



Figs. 1A and B: Two-dimensional ultrasonography of myoma. Well-defined lesion—intramural myoma: (A) Serosal contour of uterus is regular (blue arrow); (B) Smooth serosal contour of uterus. (m: myoma; e: endometrium; white arrows: border of the myoma)

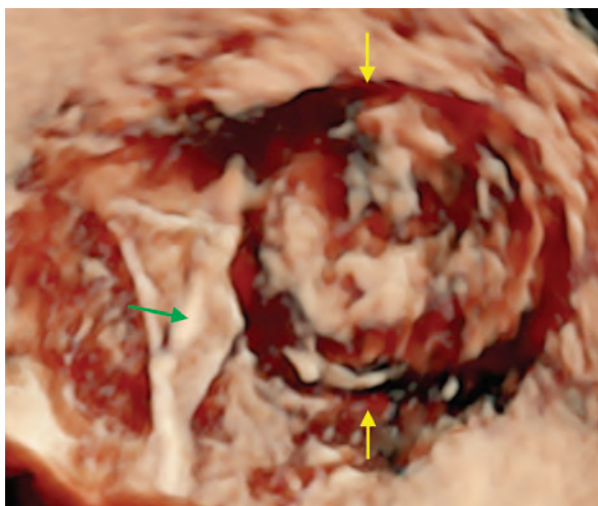


Fig. 2: Three-dimensional ultrasonography of uterine fibroid: Distorted serosal margin (yellow arrows) due to large fibroid extending from mucosa to serosa; green arrow—intrauterine device.

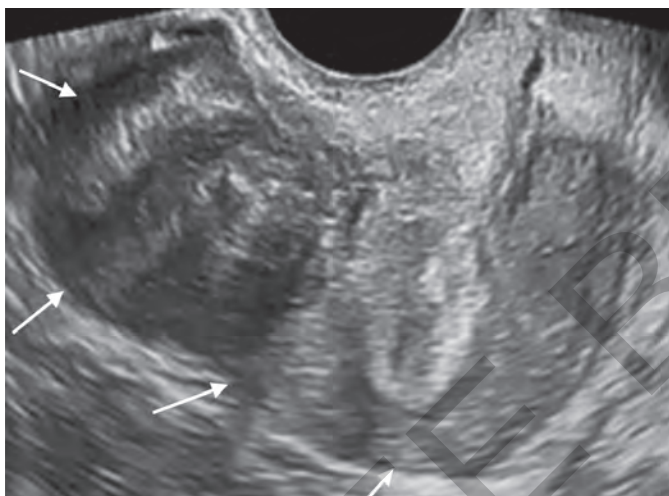


Fig. 3: 2D ultrasonography distorted serosal margin of the uterine wall due to subserosal fibroid (white arrows).

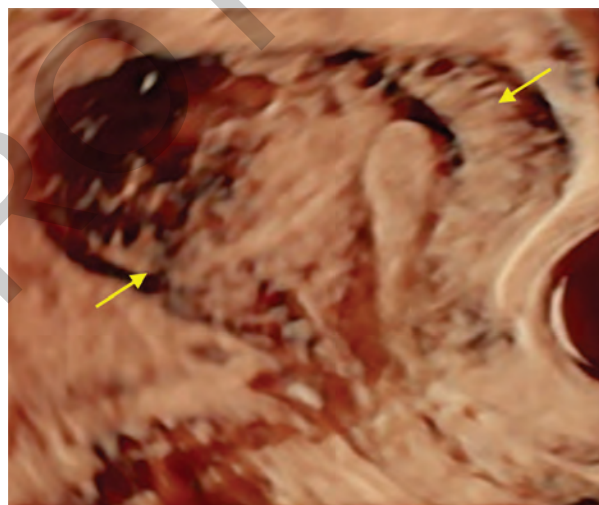
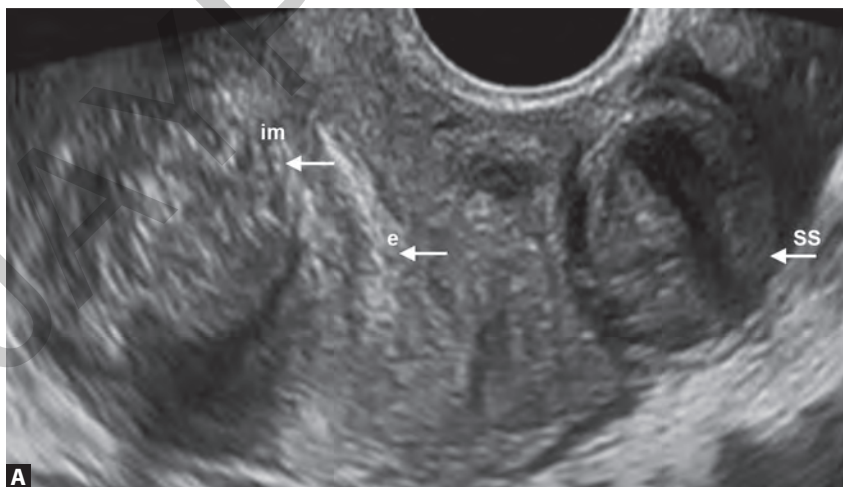
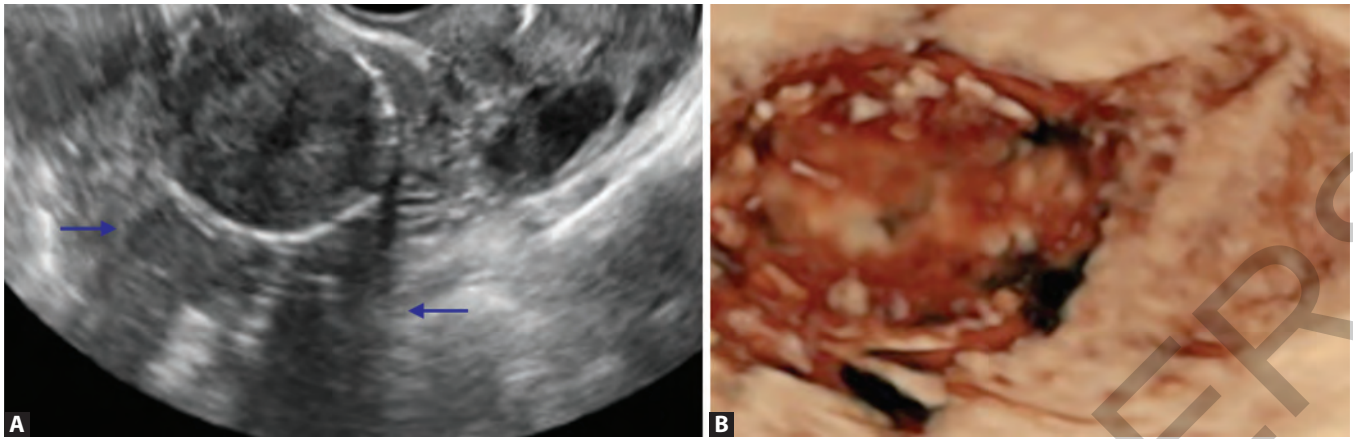


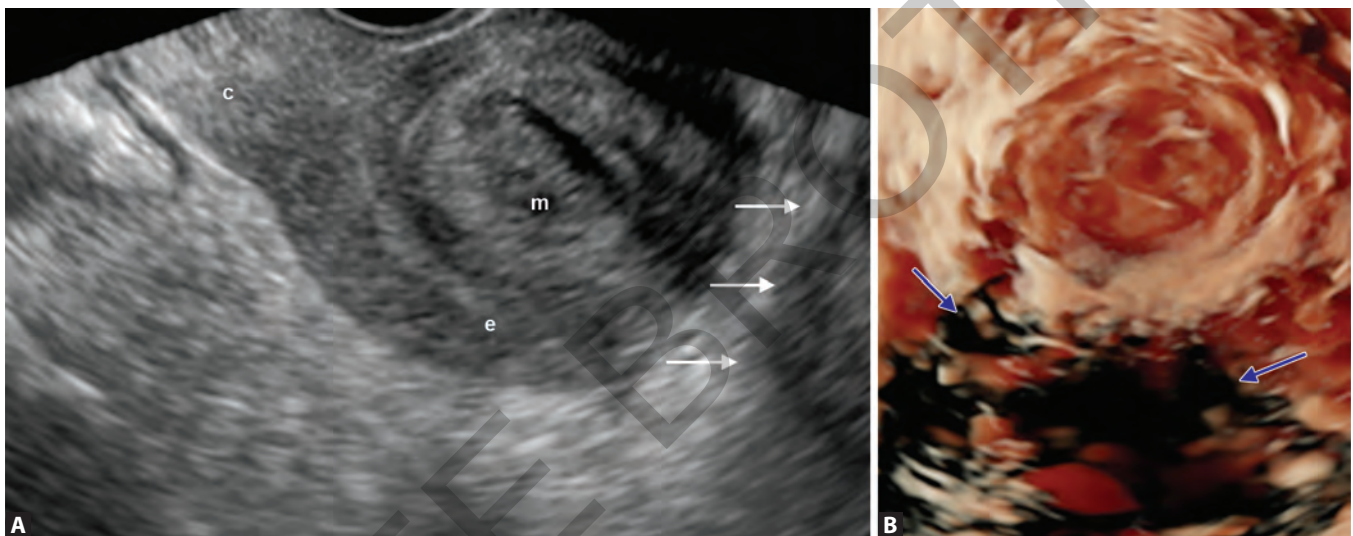
Fig. 4: Three-dimensional ultrasonography: Asymmetry of uterine walls with large fibroid on posterior wall (yellow arrows).



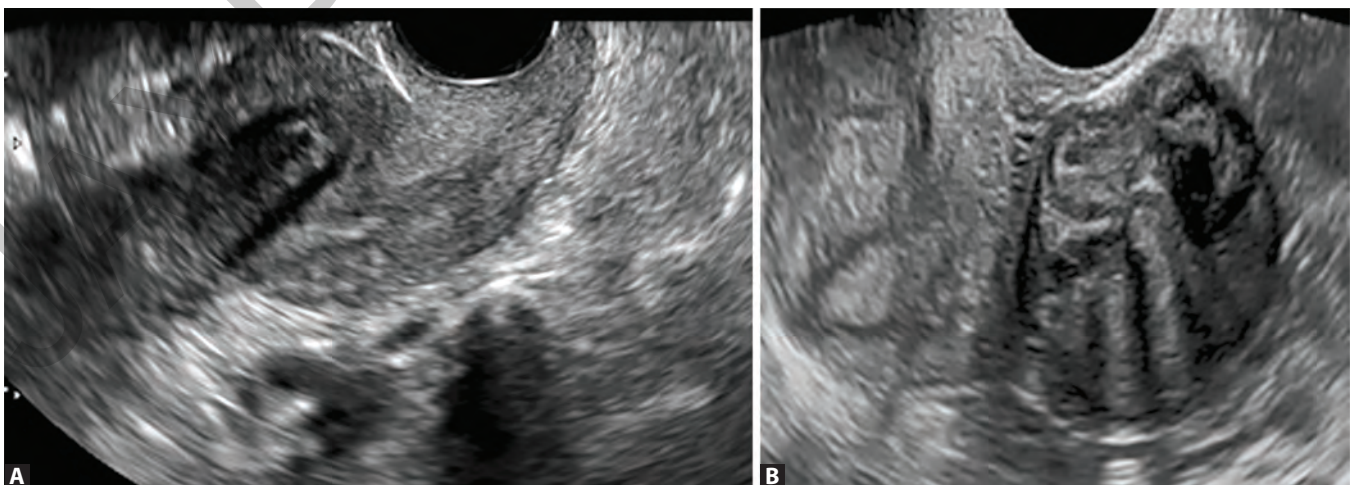
Figs. 5A and B: Multiple fibroids on B-mode ultrasound with lobulated uterine margins. (e: endometrium; im: intramural myoma; SS: subserosal myoma).



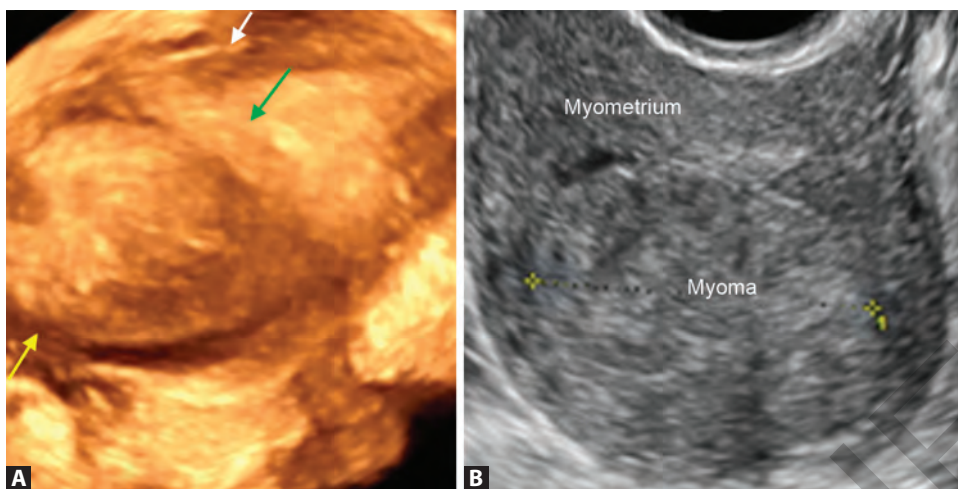
Figs. 6A and B: Two-dimensional (2D)/3D ultrasound image showing fibroid with calcification, large subserosal fibroid with fan and edge shadows in the fibroid (blue arrows).



Figs. 7A and B: Two-dimensional ultrasound of leiomyoma "shadowing sign": Intramural fibroid with edge shadows white arrows (A); blue arrows (B). (m: myoma; e: endometrium)



Figs. 8A and B: Two-dimensional ultrasound of leiomyoma "shadowing sign": (A) Internal shadows—intramural calcified leiomyoma; (B) Fan-shaped shadowing with edge shadows—subserosal leiomyoma.



Figs. 9A and B: Echogenicity of the leiomyoma: Uniform roundish lesion and is echogenic as myometrium on two-dimensional (2D) and 3D ultrasound. (A) and (B) Leiomyoma (yellow arrow), endometrium (green arrow), myometrium (white arrow).



Fig. 10: Echogenicity of the leiomyoma: Uniform roundish lesion and mixed echogenicity on two-dimensional ultrasound. (m: myoma; e: endometrium).

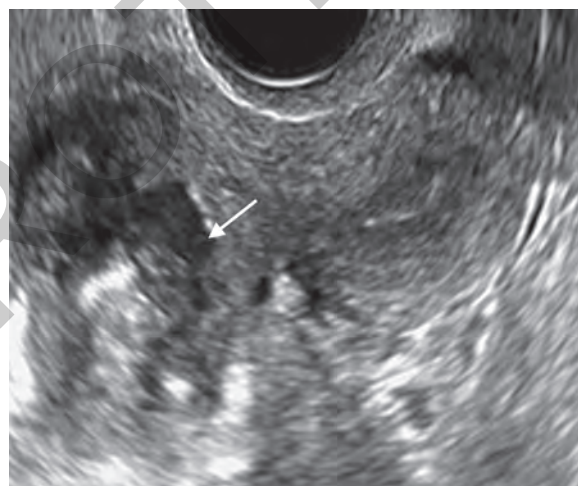


Fig. 11: Echogenicity of the leiomyoma: Nonuniform—mixed echogenicity as a result of degeneration of the tumor, hypoechogenic area with hyperechogenic shadows (white arrow).

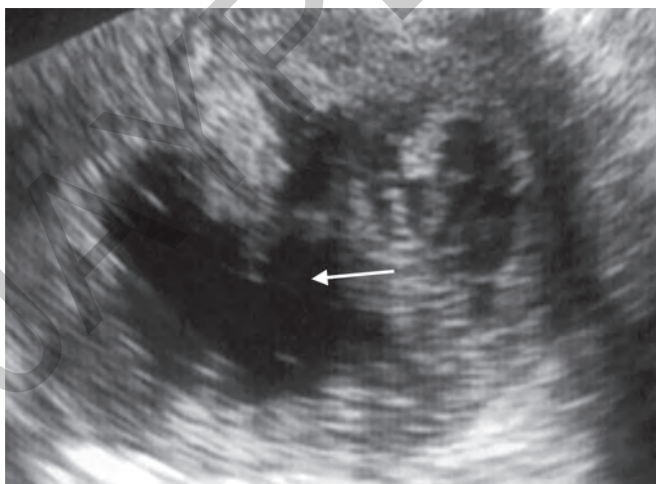
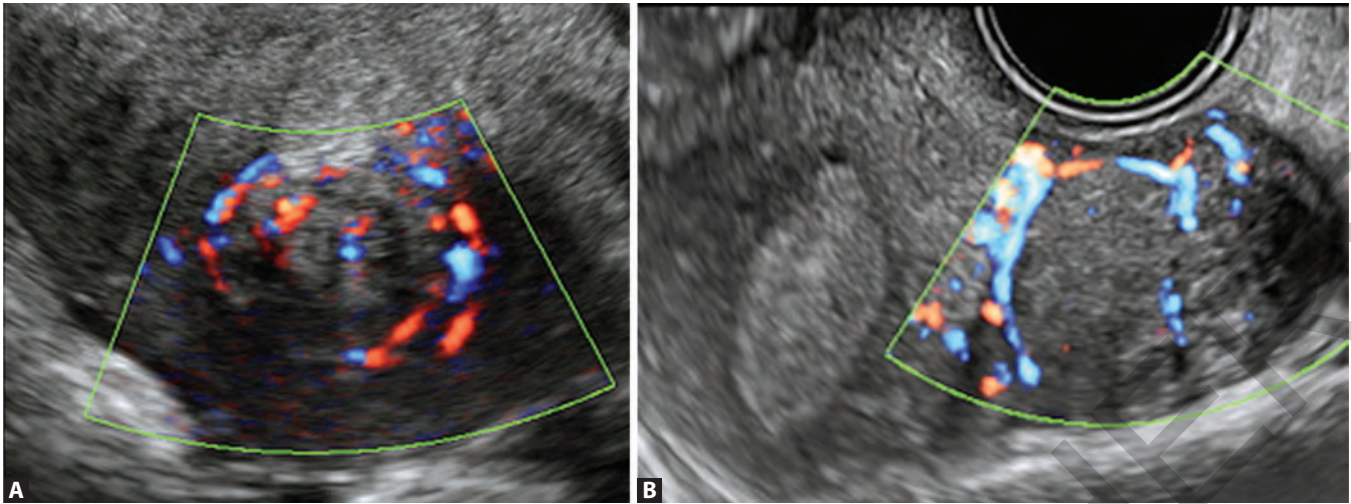


Fig. 12: Echogenicity of the leiomyoma: Nonuniform—hypoechogenic area with hyperechogenic shadows in the side of central hypoechogenic area as a result of central tumor degeneration.

- *Junctional zone (JZ) thickness, regularity:* Not thickened; regular or not visible.
- *JZ interruption:* Interrupted or overstretched JZ in areas with lesions of the International Federation of Gynecology and Obstetrics (FIGO) types 1–3 (**Figs. 16 and 17**).

◇ LOCALIZATION OF FIBROIDS

Fibroids can occur in any part of the uterus. They can appear on the cervix, the corpus in broad ligament. The general classification of fibroids is based on their localization and is divided into intramural, submucosal, and subserosal fibroids. Intramural myomas are located in the muscle part or myometrium of the uterus. If the tumor progresses in the uterine cavity, it is called submucosal myoma (**Figs. 18 and 19**), and if it is just under the serosa, it is called subserosal myoma (**Fig. 20**).



Figs. 13A and B: Two-dimensional (2D)/3D color Doppler, vascularity leiomyomas: Circumferential flow of fibroid on high-definition Doppler flow.



Fig. 14: Two-dimensional (2D)/3D color Doppler, vascularity leiomyomas: Rich vascularized pseudocapsule of leiomyoma.

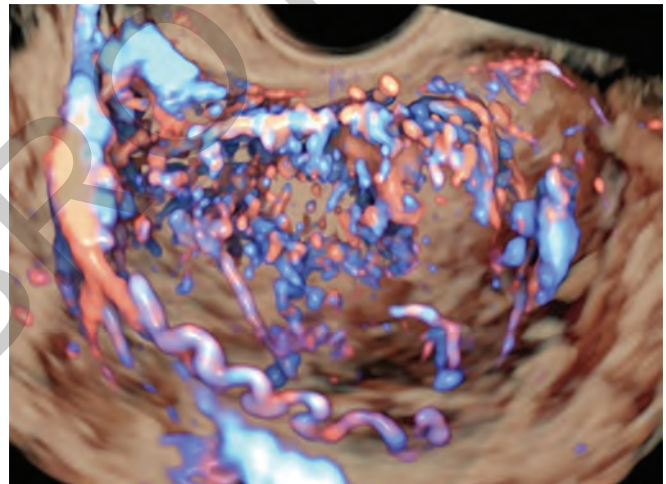


Fig. 15: 4D ultrasonography and color Doppler—mapping the vessels of leiomyoma.

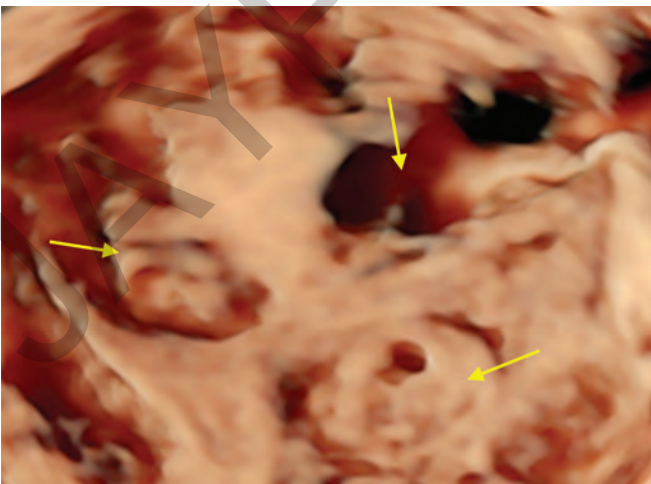


Fig. 16: Three-dimensional ultrasonography of junctional zone (JZ): Distorted JZ by several leiomyomas (yellow arrows).

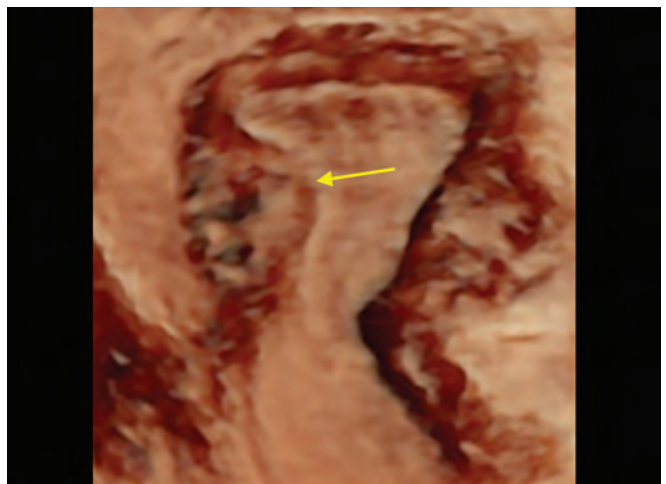
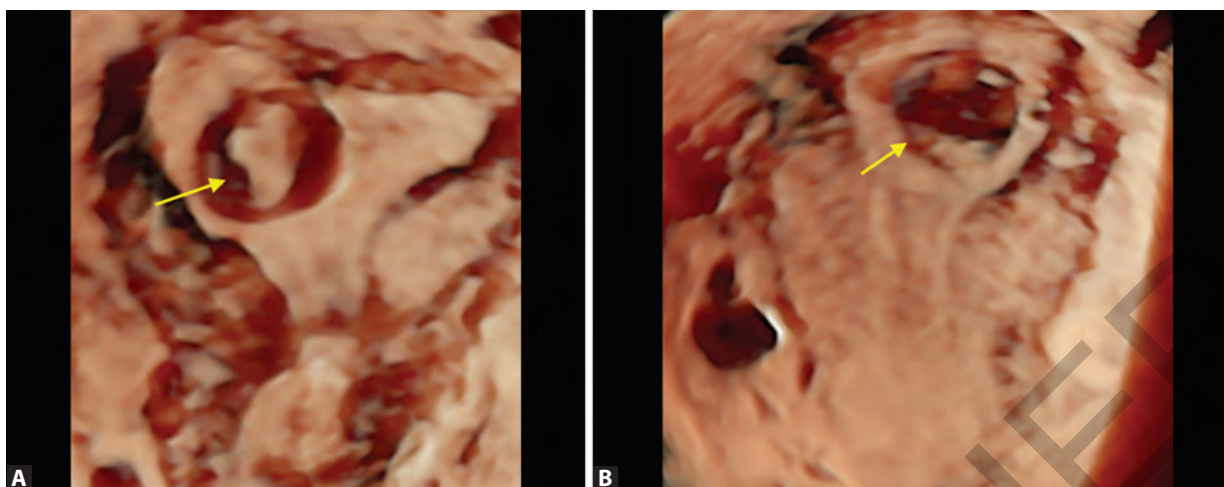


Fig. 17: Three-dimensional ultrasonography of junctional zone (JZ): Overstretched JZ by intramural leiomyoma (yellow arrow).



Figs. 18A and B: Submucosal fibroid on three-dimensional ultrasound (yellow arrows).

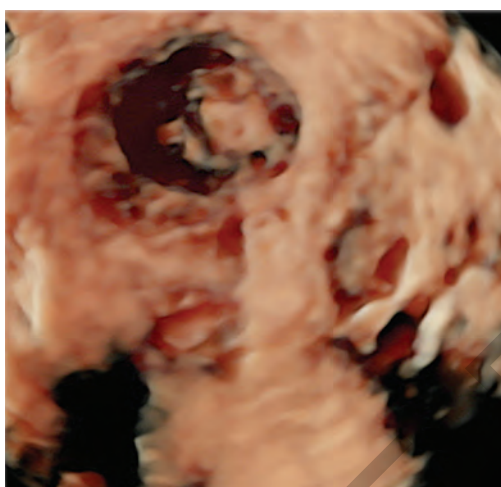


Fig. 19: Submucosal fibroid extending into intramural layer.

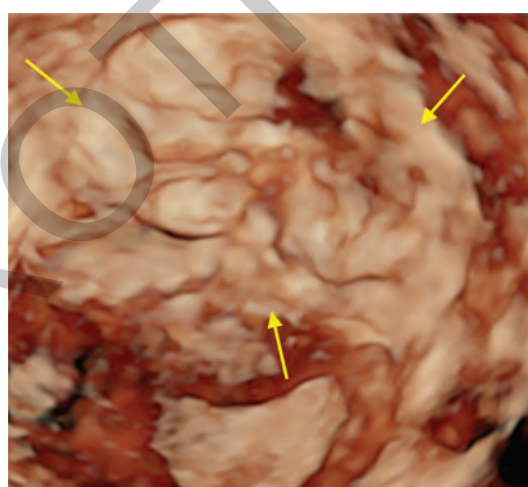


Fig. 20: Subserosal fibroid on uterine fundus with heterogeneous echogenicity (yellow arrows).

The symptoms associated with fibroids depend on the location and size of the tumor mass. Myomas are often asymptomatic and are detected on routine examination. The most common symptom caused by fibroids is uterine bleeding, which is usually in the form of either menorrhagia or hypermenorrhea. Larger fibroids are associated with pain and bloating in the abdomen. In myomas, infarction can be severe and may cause severe pain like in acute abdomen of any cause. Depending on their localization, urinary incontinence, constipation, and dyspareunia may occur. Interesting is the fact that submucosal fibroids are the least frequent (only 5%), but are accompanied by the greatest consequences in terms of symptoms such as uterine bleeding, as well as its negative impact on reproduction in women.

◇ CLASSIFICATIONS OF THE LEIOMYOMA

Therefore, there are several types of classifications that aim to localize the tumor itself preoperatively. The most commonly

used one now is by FIGO's PALM-COEIN (polyp, adenomyosis, leiomyoma, malignancy and hyperplasia, coagulopathy, ovulatory dysfunction, endometrial, iatrogenic, and not yet classified) classification.⁷

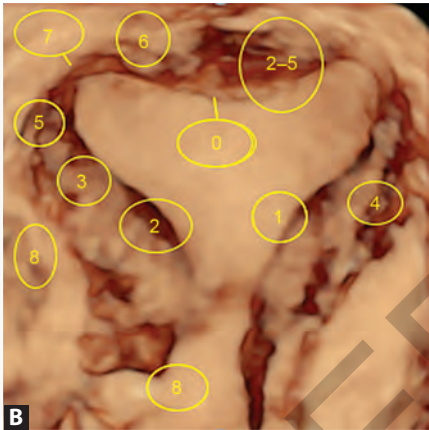
FIGO Leiomyoma Subclassification System

This classification of fibroids is based on the localization of the tumor in relation to the uterine cavity or endometrium on the one hand and the localization of the fibroid in relation to the serosa of the uterus⁷ (**Figs. 21A and B**).

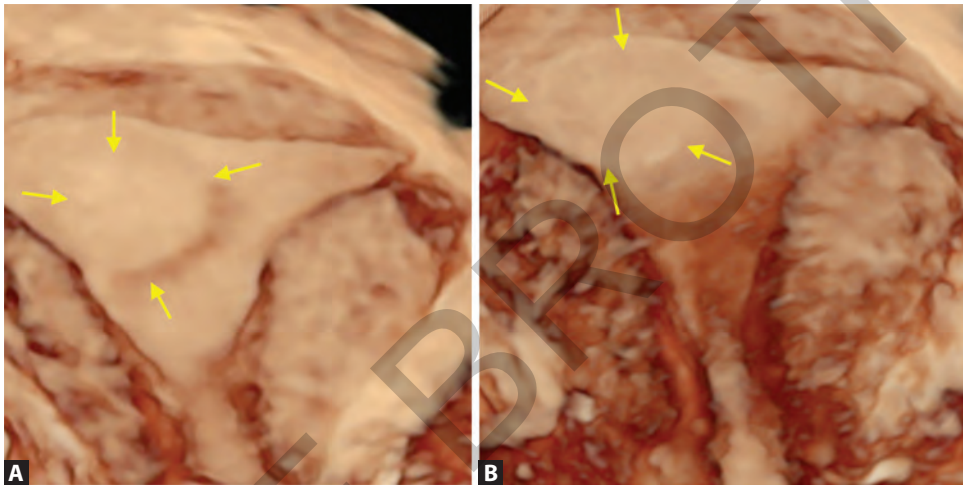
Submucous Myoma Fibroids

Submucous fibroids are subdivided into type 0 (completely intracavitary) (**Figs. 22A and B**), type 1 (being <50% of the mean diameter intramural) (**Fig. 23**), and type 2 (at least 50% intramural)⁷ (**Fig. 24**). There are two options for diagnosis of submucosal leiomyomas: (1) two-dimensional (2D) ultrasound and (2) 3D ultrasound. The 2D ultrasound detects

SM—submucous	0	Pedunculated intracavitary
	1	<50% intramural
	2	>50% intramural
	3	Contact endometrium, 100% intramural
O—other	4	Intramural
	5	Subserosal at least 50% intramural
	6	Subserosal <50% intramural
	7	Subserosal pedunculated
	8	Other; cervical, parasitic
A Hybrid	2–5	Contact both endometrium and serosa



Figs. 21A and B: FIGO classification of uterine fibroids⁷ (the numbers are defined in Fig. 21A).



Figs. 22A and B: Three-dimensional ultrasonography: Submucosal leiomyoma within endometrial cavity, no myometrial extension—submucosal leiomyomas (FIGO and ESGE—type 0) (yellow arrows).

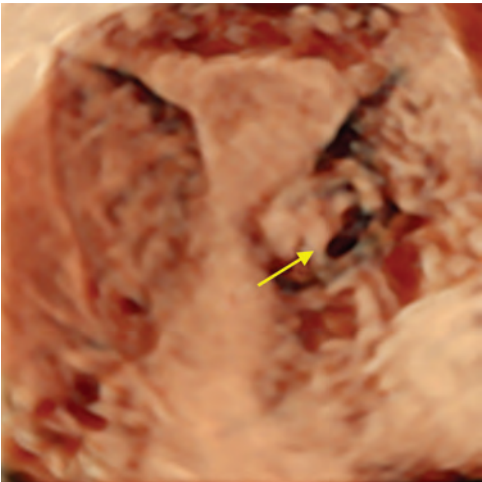
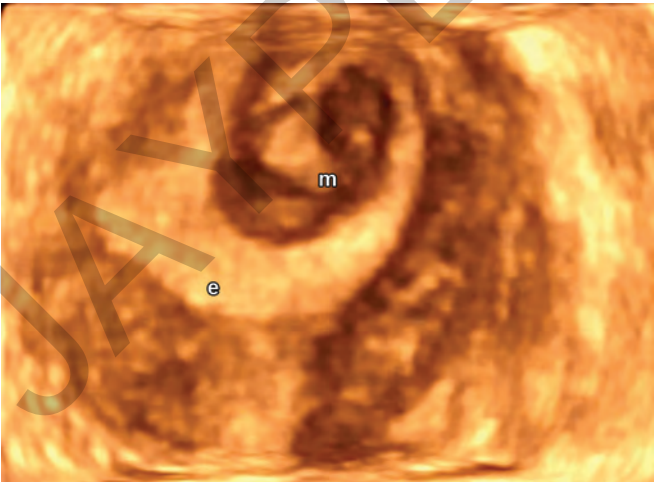
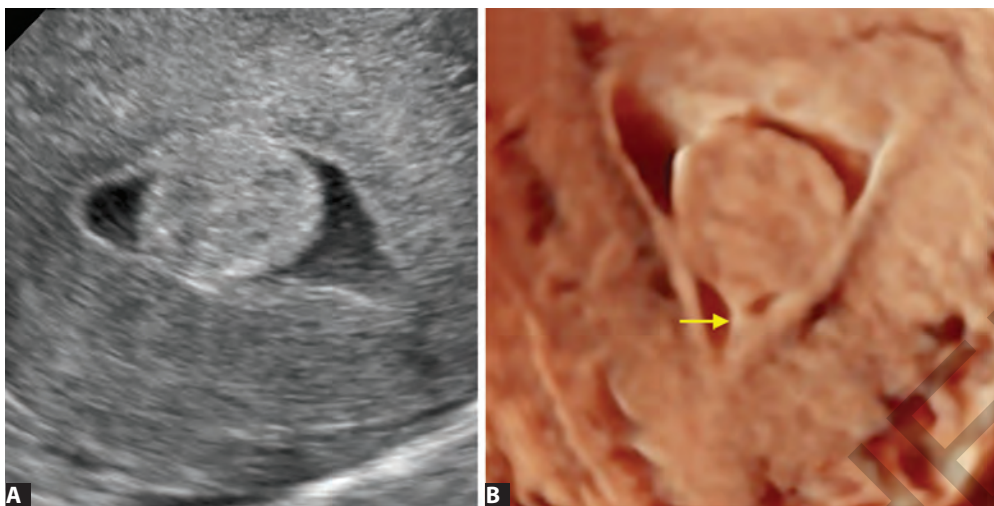


Fig. 23: Three-dimensional ultrasound of distortion of uterine cavity by submucosal myomas: FIGO/ESGE classification—type 1: <50% intramural/<50% myometrial extension. (m: submucosal myoma; e: endometrium)

Fig. 24: Three-dimensional ultrasound of distortion of uterine cavity by submucosal myomas: FIGO/ESGE classification—type 2: >50% intramural/>50% myometrial extension.



Figs. 25A and B: Two-dimensional and 3D saline infusion sonohysterography: Single peduncle (yellow arrow) submucosal leiomyoma.

an initial pathological change and an image of leiomyoma protrusion into the uterine cavity is easily obtained, but it can be underestimated or overestimated if the image is not in the right projection. 3D gives a much better image and can correct this lack of 2D ultrasonography,⁸ noting that analyses in recent studies have shown that 3D ultrasonography does not give an ideal clear picture of protrusion into the intracavitary space (protrusion of <50% was generally overestimated, and fibroid protrusion of >50% was generally underestimated compared to hysteroscopy).⁹ On the other hand, a study comparing the preoperative hysteroscopic Lasmar score with the 3D ultrasonographic Lasmar score can be obtained 3D ultrasound. 3D ultrasound is best done in luteal phase.¹⁰

Saline Infusion Sonography and Submucous Leiomyoma

One method that can give a clearer picture especially in small intramural myomas is saline infusion sonography (SIS). The technique of this method is based on injecting contrast into the uterine cavity during the examination with vaginal ultrasonography. This shows the whole interior better and the one determined by subtle pathology. It is better to perform it in the first phase of the cycle, i.e., immediately after the end of the menstrual bleeding.

Both 2D and 3D transvaginal sonography can be combined with SIS to improve the contrast between the myometrium, fibroid, and uterine cavity. Regarding the 3D SIS studies, they prove that 3D SIS is associated with more successful resection of submucosal leiomyomas because preoperative ultrasound findings are very precise in terms of location, the ratio of endometrium to the myometrium of the leiomyoma itself^{11,12} (Figs. 25 to 27).

Intramural Leiomyoma

International Federation of Gynecology and Obstetrics (FIGO) type 3 leiomyomas are totally intramural but also contact the

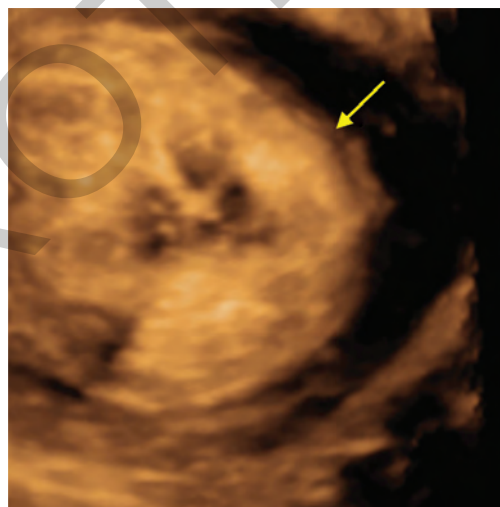


Fig. 26: Three-dimensional saline infusion sonohysterography: Large submucosal myoma (yellow arrow).

endometrium. Type 3 leiomyomas are formally distinguished from type 2 with hysteroscopy using the lowest possible intrauterine pressure necessary to allow visualization (Figs. 28A and B). Type 4 lesions are intramural leiomyomas that are entirely within the myometrium, with no extension to the endometrial surface or to the serosa⁷ (Figs. 29A and B). Intramural myomas are the most prevalent of all the leiomyomas (58–79%) occurrence, a median growth rate of 35.2% by volume per year, and have a higher yearly volumetric increase of intramural myomas compared to either subserosal or submucous myomas. There is no significant evidence of a negative impact of fibroids on female reproduction, but there are studies that indicate that reproduction is compromised when there exist intramural leiomyomas (especially >4 cm in diameter), primarily due to the presence of uterine contractions in fibroids,¹³ the size of the fibroid,¹⁴ and the distance from the edge of the fibroid to the endometrium¹⁵

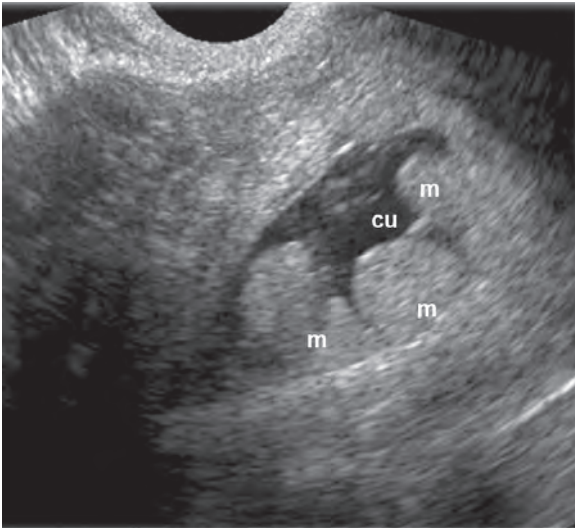
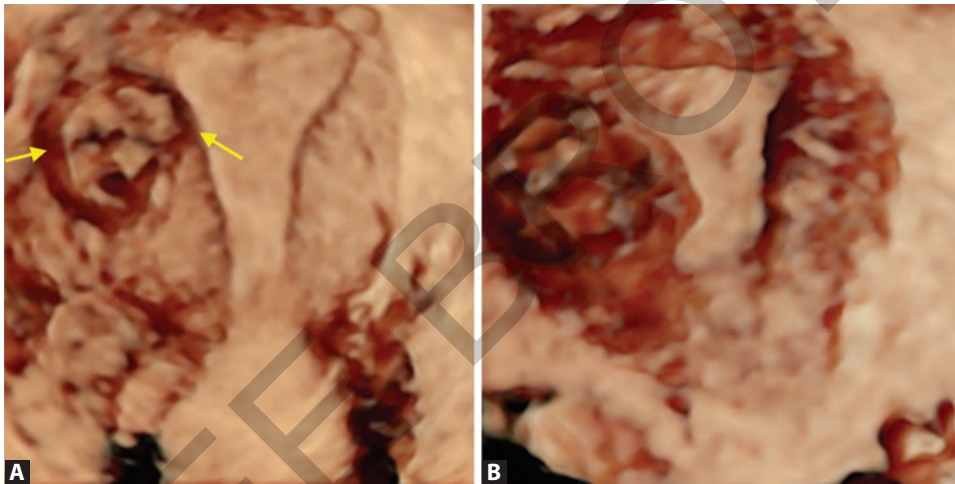


Fig. 27: Two-dimensional saline infusion sonohysterography: Several submucosal myomas. (m: myoma; cu: uterine cavity)

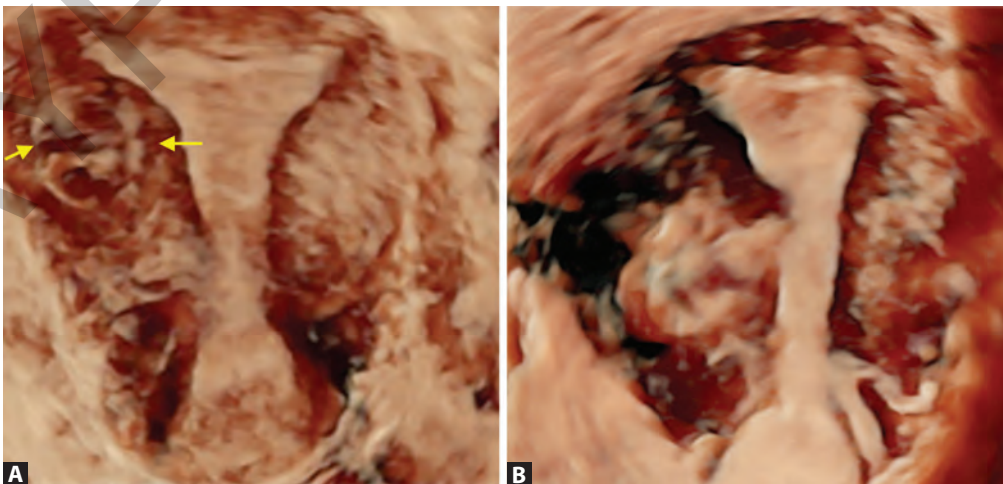
have a negative impact on embryo implantation and live birth rate. In type 4 fibroids, it is essential to mention, minimum inner and outer free margin to decide the route of surgery.

Subserosal Leiomyoma

Subserosal (types 5, 6, and 7) leiomyomas represent the mirror image of the submucous leiomyomas—with type 5 is at least 50% intramural (**Fig. 30**), type 6 is <50% intramural (**Figs. 31 and 32**), and type 7 being attached to the serosa (**Fig. 33**). Type 8 is reserved for leiomyomas that do not relate to the myometrium at all and would include cervical lesions (demonstrated), those that exist in the round or broad ligaments without direct attachment to the uterus, and other so-called “parasitic” lesions⁷ (**Fig. 34**). The existing data on the effects of subserosal fibroids on fertility support concluded that subserosal leiomyomas do not have any adverse effects on fertility potential of women and no adverse effect on assisted reproductive technology (ART) outcome.¹⁶



Figs. 28A and B: International Federation of Gynecology and Obstetrics (FIGO) classification of intramural myomas: Intramural myomas with no distortion of uterine cavity even though the tumor is near to endometrial/myometrial junction zone (FIGO type 3).



Figs. 29A and B: International Federation of Gynecology and Obstetrics (FIGO) classification of intramural myomas: FIGO type 4: 100% intramural myoma with no distortion of the uterine cavity.

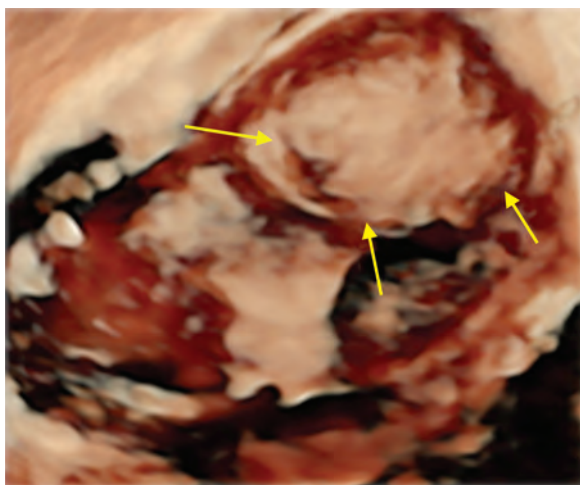


Fig. 30: Subserosal leiomyoma: International Federation of Gynecology and Obstetrics (FIGO) type 5: Subserosal leiomyomas with 50% or more contact with the myometrium (yellow arrows).

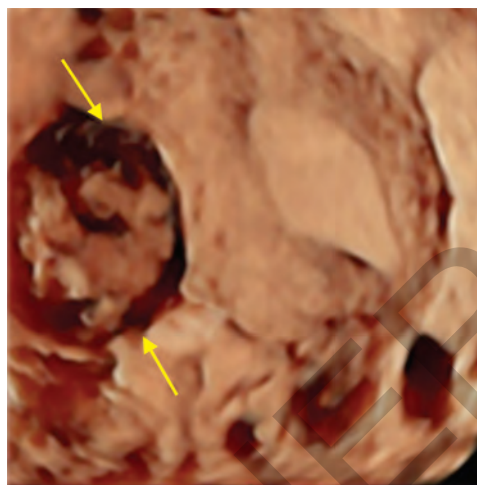
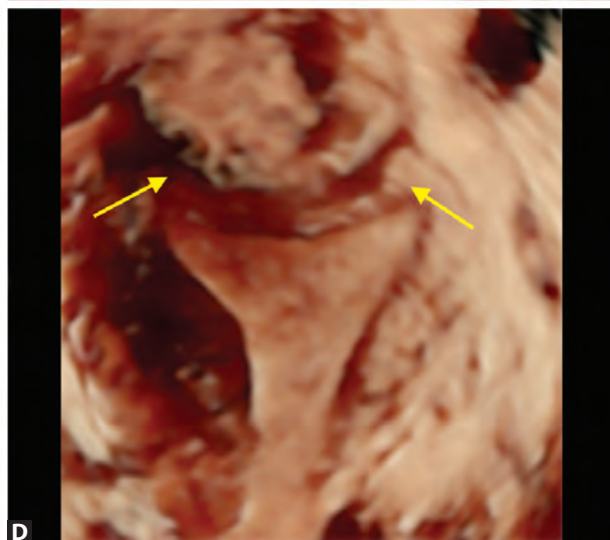
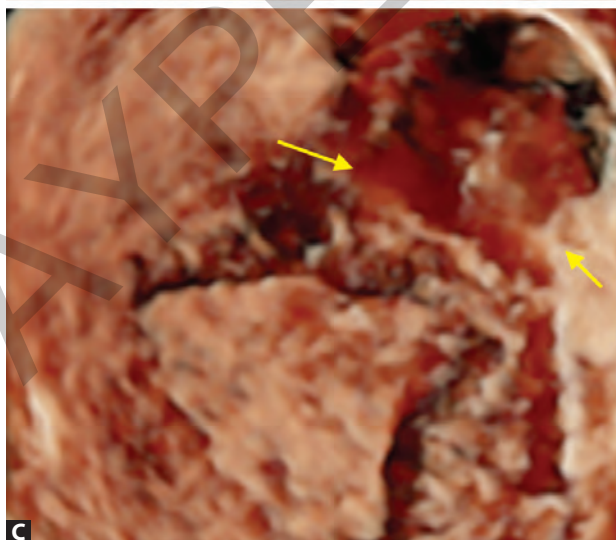
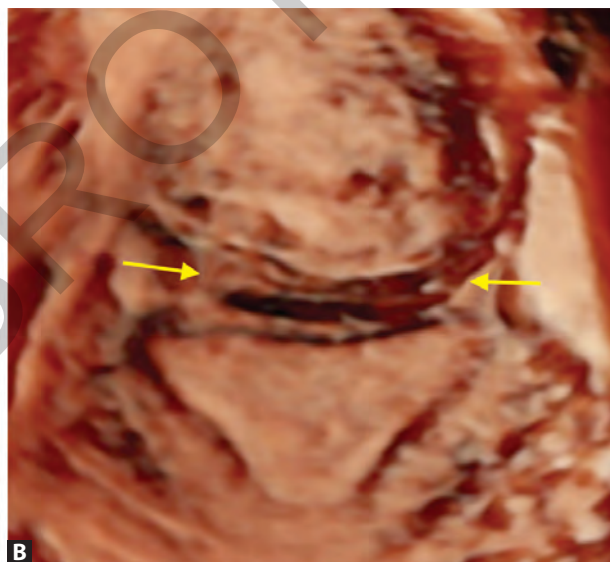
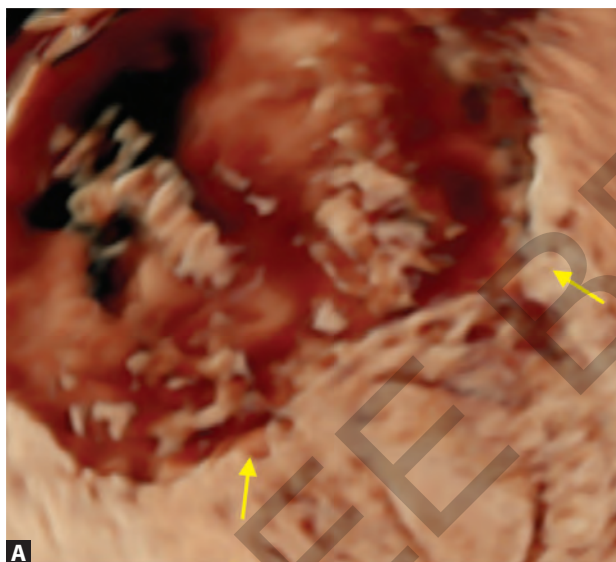


Fig. 31: Subserosal leiomyoma: International Federation of Gynecology and Obstetrics (FIGO) type 6: Subserosal leiomyomas with less than 50% contact with the myometrium (yellow arrows).



Figs. 32A to D: Subserosal leiomyoma: International Federation of Gynecology and Obstetrics (FIGO) type 6: Subserosal leiomyomas with very low percentage of contact with the myometrium (yellow arrows).

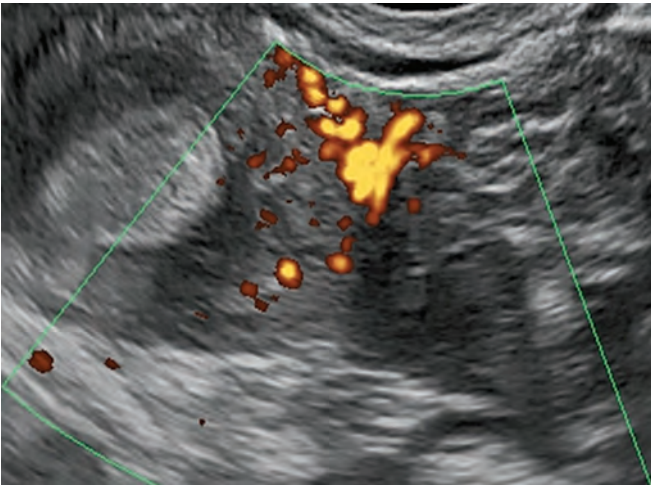


Fig. 33: Subserosal leiomyoma: International Federation of Gynecology and Obstetrics (FIGO) type 7: Serosal pedunculated, vascularization of the pedicle.

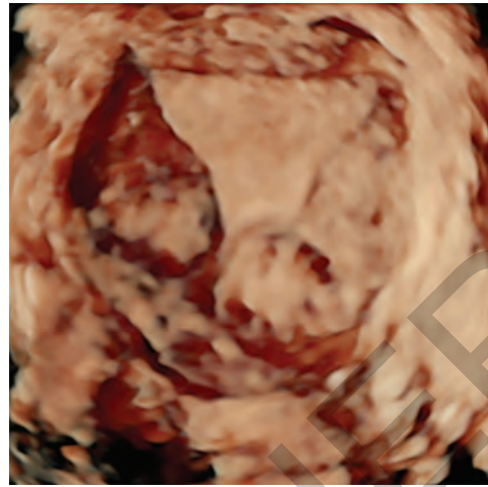
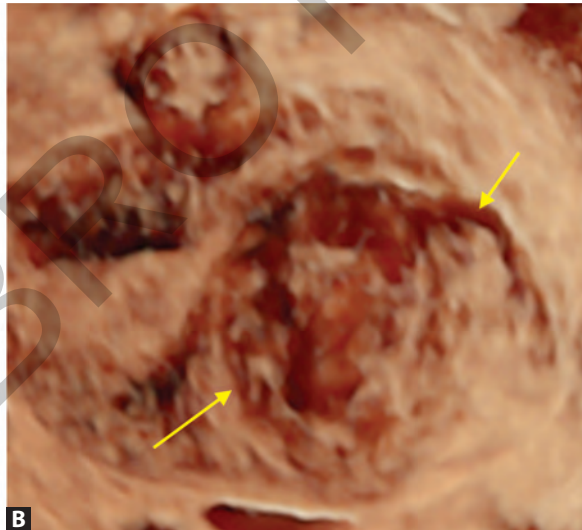
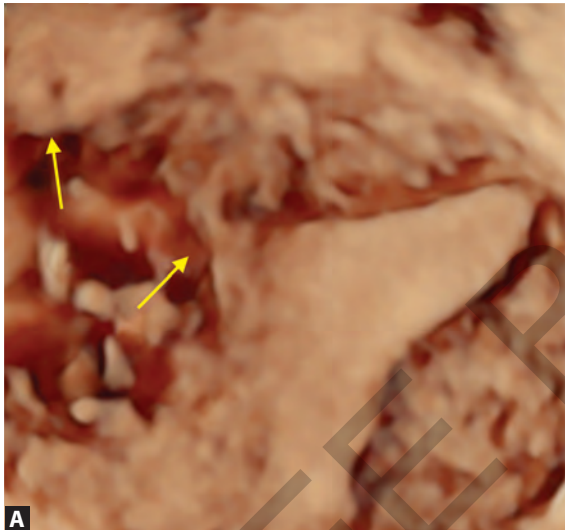


Fig. 34: Three-dimensional ultrasound: International Federation of Gynecology and Obstetrics (FIGO) type 8: Cervical leiomyoma.



Figs. 35A and B: Three-dimensional ultrasonography of International Federation of Gynecology and Obstetrics (FIGO) hybrid leiomyoma: Transmural leiomyomas are categorized by their relationship to both the endometrial and the serosal surfaces (yellow arrows).

This conclusion is further supported by the fact that no beneficial effect on fertility is noted when myomectomy is performed for subserosal leiomyomas.¹⁷

Hybrid Leiomyomas

Classification of lesions that are transmural are categorized by their relationship to both the endometrial and the serosal surfaces. The endometrial relationship is noted first, with the serosal relationship second⁷ (**Figs. 35 and 36**).

Unlike previous classifications such as the European Society for Gynaecological Endoscopy (ESGE), the group 3 where the intramural myoma touches the area of the endometrium, cavitation distortion, also in the group of subserosal fibroids introducing new subgroups.⁷ This is important because this system provides a basic framework for deciding on surgical treatment of fibroids, i.e., which lesions

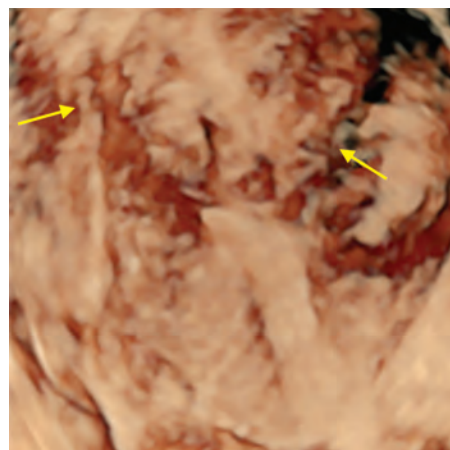


Fig. 36: Three-dimensional ultrasonography of large myoma on fundal region distorting endometrium and serosa (hybrid myoma by International Federation of Gynecology and Obstetrics).

Donald School 3D-4D ULTRASOUND IN GYNECOLOGY

Salient Features

- Reflects the current state of 3D/4D ultrasound in gynecology
- Thirteen richly illustrated chapters will provide readers with an excellent overview of the possible application of this technology.

Zoranko Petanovski MD PhD is a Professor, Department of Obstetrics and Gynecology, University "Goce Delcev" Shtip, North Macedonia and Medical Chief, Center for Assisted Reproduction, First Private General Hospital, Re Medika, Skopje, North Macedonia.

Asim Kurjak MD PhD is a Professor, Department of Obstetrics and Gynecology, Medical School Universities of Zagreb, Zagreb, Croatia and Professor Emeritus, University Sarajevo School of Science and Technology, Sarajevo, Bosnia and Herzegovina. He published 1,175 papers which have been cited more than 13,400 times (Google Scholar bases) and authored, co-authored or co-edited 121 books. He is the President of International Academy of Perinatal Medicine, President of International Academy of Science and Art in Bosnia and Herzegovina, and the Director of Ian Donald Inter-University School of Medical Ultrasound. He received doctorum honoris causa from Universities in Banja Luka, Budapest, Barcelona, Bucharest, Athens, Montevideo, Tomsk, Buenos Aires, St Petersburg, Moscow, Tirana, and Khartoum.

Printed in India

**Available at all medical bookstores
or buy online at www.jaypeebrothers.com**



JAYPEE BROTHERS
Medical Publishers (P) Ltd.
EMCA House, 23/23-B, Ansari Road,
Daryaganj, New Delhi - 110 002, INDIA
www.jaypeebrothers.com

Join us on [f facebook.com/JaypeeMedicalPublishers](https://www.facebook.com/JaypeeMedicalPublishers)

Shelving Recommendation
OBSTETRICS & GYNECOLOGY

ISBN 978-93-5465-004-8



9 789354 650048