Endometrial ablation: Indications, Contraindications, Techniques

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Article History: Received: 22.06.2023 **Revised:**07.07.2023 **Accepted:** 23.07.2023

Abstract:

The destruction of the endometrium in women with heavy menstrual bleeding has been used for well over a century, and the various techniques of delivering forms of thermal energy have been modified over the years to ensure a safe and effective treatment approach. Today, 6 nonresectoscopic devices are approved for use in the United States in addition to resectoscopic techniques that rely on the skillful use of the operative hysteroscope. Regardless of the technique used, endometrial ablation uniformly reduces menstrual blood loss, improves general and menstrual-related quality of life, and prevents hysterectomy in 4 of 5 women who undergo the procedure. When patients are appropriately selected, outcomes are optimized, and risks of serious complications are minimized. This article reviews the literature with singular reference to nonresectoscopic endometrial ablation procedures including historical background, appropriate patient selection, clinical outcomes data, complications, and special or unique considerations.

Keywords: Endometrial ablation, heavy menstrual bleeding, techniques.

DOI: 10.53555/ecb/2023.12.1110

Introduction:

Endometrial ablation is an outpatient procedure that removes or destroys the endometrial layers. The opposing walls of the myometrium collapse onto each other, and the damaged tissue contracts and develops into a scar. Any endometrium remaining after the ablation is trapped beneath the scar, preventing further bleeding. Estimation of the number of endometrial ablations performed each year is difficult, because many are performed in the office setting **(1).**

Endometrial ablation is performed to reduce menstrual bleeding, such as menorrhagia. Menorrhagia is menstrual bleeding that is heavy in amount or duration and that occurs at regular intervals. Loss of more than 80 mL of blood per menstrual cycle is considered abnormal. Menorrhagia affects approximately 10-30% of premenopausal women and up to 50% of perimenopausal women. Abnormal bleeding is a common reason for outpatient gynecologic visits and is one of the most common causes for surgery among women **(2).**

In the past, hysterectomy was the most common surgical treatment for menorrhagia; 10% of hysterectomies are performed for menstrual disorders. Although endometrial ablation is not a pure substitute for hysterectomy, it offers patients a fast, outpatient procedure, with little to no postoperative downtime; It also affords a reasonable surgical option for those patients who have failed, declined, or are ineligible for medical therapy, and who also desire to avoid hysterectomy **(3).**

The etiology of menorrhagia may not always be known, but endometrial hyperplasia or carcinoma must be excluded as the cause of bleeding before proceeding to the endometrial ablation **(4).**

Although the first medical literature reports of endometrial destructive procedures are older than 100 years, widespread adoption of this modality did not occur until the advent of hysteroscopically guided techniques. Until the mid-1990s, hysteroscopically guided ablation (resectoscopic endometrial ablation [REA]) using laser, fulguration, or vaporization techniques was the most common approach **(5).**

Since then, global endometrial ablation (GEA) devices, developed to treat all areas of the endometrial cavity simultaneously or with minimal manipulation of the device, have simplified the application of endometrial ablation and extended the location of the procedure to the office setting. These devices require less operator time and training to achieve excellent results. To date, 5 GEA devices have been approved by the US Food and Drug Administration (FDA) for minimally invasive treatment of idiopathic menorrhagia **(6).**

GEA techniques have improved the ease with which gynecologic surgeons can effectively treat abnormal uterine bleeding of benign origin. Improvements in these devices have come quickly, including the ability to treat submucosal fibroids and irregularly shaped endometrial cavities. The high overall success and patient satisfaction rates reported with GEA techniques make them a viable option for conservative surgical management **(7).**

I. Indications

Endometrial ablation is indicated for the treatment of menorrhagia in premenopausal or perimenopausal women with normal endometrial cavities. It may also be indicated for the

treatment of postmenopausal bleeding of benign origin. Premenopausal patients should be advised that whereas endometrial ablation generally decreases menstrual bleeding, a small percentage of patients will experience no change **(8).**

Patients with anovulatory bleeding and bleeding secondary to fibroids are potential candidates for the procedure, but they should be aware that endometrial ablation does not specifically address ovulatory dysfunction and, by itself, does not remove fibroids. Thus, these patients may be at higher risk of unsatisfactory results and may be better served by other treatments, either medical or surgical **(9).**

The GEA devices currently available are approved for the treatment of abnormal uterine bleeding and intramural or submucosal fibroids smaller than 2 cm. Only the microwave endometrial ablation device is approved for use in the presence of submucosal fibroids of up to 3 cm **(10).**

Some of the previous contraindications to endometrial ablations, including irregular cavity shape and larger-than-average cavity size, have been addressed by some of the global endometrial ablation devices. The microwave endometrial ablation device is FDA-approved for uteri measuring up to 14 cm, and the hydrothermal ablation device is FDA-approved for irregularly shaped cavities **(11).**

The basic preoperative criteria for any patient opting for endometrial ablation are, at a minimum, the following:

- Abnormal uterine bleeding of benign etiology (as evidenced by preoperative endometrial sampling and histologically benign findings).
- No desire for future fertility.
- Desire to retain the uterus or to avoid hysterectomy.

Although failure of medical therapy is not a prerequisite for the procedure, it is an important consideration **(12).**

II. Contraindications

Absolute contraindications for endometrial ablation include the following:

- Pregnancy or a desire for future pregnancy.
- Active urogenital or pelvic infection (eg, cystitis, vaginitis, cervicitis, endometritis, salpingitis, pelvic inflammatory disease [PID], or tubo-ovarian abscess [TOA]).
- Suspected or documented premalignant or malignant conditions of the endometrium or uterus **(13).**

Additional contraindications may include the following:

- Recent uterine infection.
- A cavity that exceeds the device's functional length and uterine diameter.
- Hydrosalpinx.
- History of classical cesarean section.
- History of a transmural myomectomy.
- Uterine anomalies **(14).**

Infections should be treated preoperatively. When possible, repeat testing to document resolution should be completed preoperatively **(15).**

Premalignant abnormalities of the endometrium should be treated with high-dose progestins or surgery, depending on the abnormality. Malignant conditions of the endometrium are treated by means of hysterectomy, with or without adjuvant radiation or chemotherapy. Endometrial ablation should not be performed in patients who have or are suspected of having either of these disease processes **(16).**

Therapy with the levonorgestrel-releasing intrauterine system (LNG-IUS) should be given particular consideration in patients with comorbid conditions predisposing to a higher risk of endometrial hyperplasia or carcinoma (eg, obesity, diabetes, family history, or anovulation). Endometrial carcinoma has been reported in patients who previously underwent endometrial ablation; thus, definitive surgical therapy with hysterectomy should be considered in high-risk patients, unless they are poor surgical candidates **(17).**

The bipolar energy ablation device and the microwave ablation device should not be used in patients with previous classical cesarean delivery or transmural myomectomy out of concern for possible transmural thermal injury to the abdominal and pelvic organs. In addition, preoperative ultrasonographic evaluation must verify that transmural thickness is at least 1 cm in all areas of the uterus before microwave ablation is done, and intraoperative hysteroscopy is recommended to ensure uterine wall integrity **(18).**

Finally, reablation with a GEA device should be avoided because of the theoretical increased likelihood of transmural energy transmission. Repeat GEA is not approved by the FDA **(19).**

Periprocedural Care

✓ Patient Education and Consent

Informed consent must be obtained. Patients should be counseled that endometrial ablation is not considered a form of sterilization and that subsequent pregnancies, though atypical, have been reported and are associated with a wide range of complications, including spontaneous

abortion, abnormal placentation, preterm labor, preterm delivery, uterine rupture, and antepartum hemorrhage **(20).**

✓ **Preprocedural Planning**

Obtain a careful history, and perform a physical examination. Remove any indwelling intrauterine device (IUD) that may be present (this can be done at the same time as the procedure) **(21).**

Preoperative endometrial preparation

Endometrial ablation is most effective when the endometrium is resected to the level of the basalis, which is approximately 4-6 mm deep. Endometrial thinning before ablation has been shown to improve both the operating conditions and the initial postoperative outcome. The bipolar ablation device is the only global endometrial ablation (GEA) device that has been shown to work with equal effectiveness with or without pretreatment **(22).**

Danazol, medroxyprogesterone, and gonadotropin-releasing hormone (GnRH) agonists have been used to pretreat the endometrium and obtain atrophy. Best results are seen after 6 weeks of drug therapy. GnRH analogues produce more consistent endometrial thinning. Notably, pretreatment with GnRH agonists or danazol before resectoscopic endometrial ablation (REA) results in higher amenorrhea rates at 12 months, shorter procedures, greater reported ease of surgery, and lower postoperative dysmenorrhea rates **(23).**

Dilation and curettage can be performed immediately before ablation to thin the endometrial lining by mechanical means. This is particularly recommended with the thermal balloon device **(24).**

Preoperative cervical preparation

Preoperative cervical preparation regimens include both intraoperative cervical dilation and the use of preoperative oral or vaginal regimens aimed at cervical softening or dilation. These outpatient regimens typically involve the use of misoprostol either the evening before the procedure, the morning of the procedure, or both. Because of the minimally invasive nature of endometrial ablation procedures, aggressive dilation regimens are generally not required **(25).**

Antibiotic prophylaxis

At present, no randomized controlled data support routine use of prophylactic antibiotics for REA and GEA procedures. Furthermore, observational data reveal an extremely low risk of infection. Accordingly, the American Congress of Obstetricians and Gynecologists (ACOG) does not recommend the routine use of prophylactic antibiotics for endometrial ablation. However, the use of preoperative antibiotics, especially in the office setting, is not uncommon **(26).**

Sterilization at time of ablation

Because endometrial ablation is not itself a method of permanent sterilization, patients sometimes elect to undergo concomitant elective tubal sterilization when undergoing endometrial ablation. The sterilization procedure may be performed laparoscopically either before or after the ablation. In addition, some GEA techniques have been successfully performed in conjunction with hysteroscopically guided intratubal placement of microinserts (Essure; Conceptus, Inc, Mountain View, CA) for sterilization **(27).**

Because these microinserts may transmit heat through the tubes, the operator should strongly consider delaying their placement until after completion of the ablation. It is worth noting that Conceptus has issued a warning against concomitant performance of ablation and Essure placement, on the grounds that postoperative development of uterine synechiae may compromise subsequent tubal occlusion testing (hysterosalpingography) **(28).**

In view of the lack of long-term data involving these concomitant hysteroscopic procedures, caution is advised in the implementation of such techniques **(29).**

- ***Office-based ablation***

Many regimens for analgesia are available in this setting, including pain medications ranging from preoperative nonsteroidal anti-inflammatory drugs (NSAIDs) to oral or intramuscular narcotics and adjunct medications ranging from oral anxiolytics to intravenous (IV) sedatives. Anesthesia may range from local anesthesia to monitored anesthesia care by an anesthesiologist **(30).**

Even in settings outside the operating room, physicians must maintain the appropriate emergency and operative equipment and protocols for handling rare complications such as anaphylaxis or allergic reactions, significant vagal reactions, hemorrhage, uterine perforation, and pelvic organ injury **(31).**

- ✓ **Preprocedural Evaluation**

- ***Laboratory testing***

Urine human chorionic gonadotropin (hCG) testing can detect hCG levels as low as 20 mIU/mL (International Reference Preparation). The test becomes positive approximately 1 week after conception. Perform the test preoperatively on the day of surgery **(32).**

Endometrial ablation should not be performed in the presence of active pelvic infection; accordingly, gonorrhea and chlamydia testing is necessary **(33).**

- ***Ultrasonography and hysteroscopy***

Either pelvic ultrasonography or hysteroscopy is recommended to evaluate the uterine anatomy and measure uterine length before or at the time of the ablation. Ultrasonography may be used to assess for and measure intracavitary or submucosal myomas **(34).**

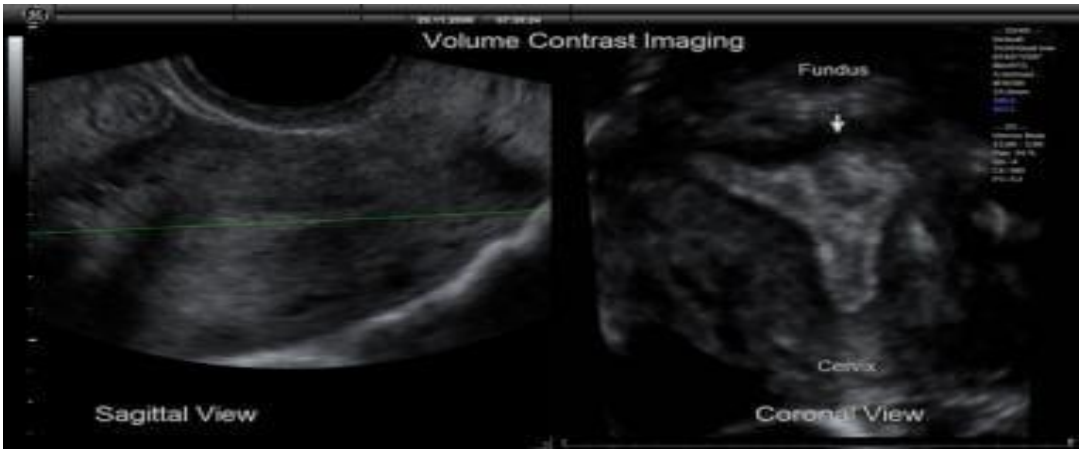

Fig (1): Volume contrast imaging showing sagittal view of the uterus and endometrium (left) and coronal view of the endometrium with an endometrial polyp in the fundal region (arrow) **(35).**

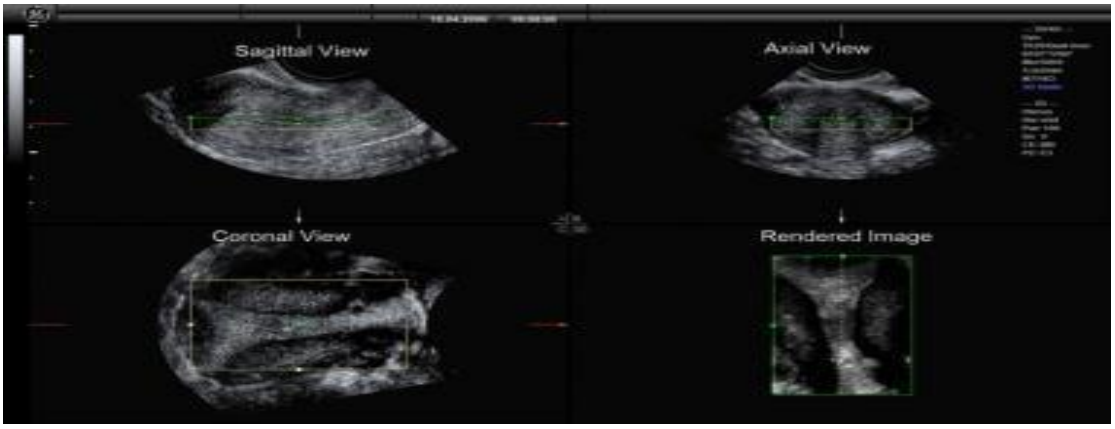

Fig (2): The orthogonal views (sagittal, axial and coronal), as well as the rendered 3D image of the endometrium, taken by vaginal 3-D ultrasound transducer **(36).**

Hysteroscopy is more commonly used before endometrial ablation to assess the length of the uterine cavity and to evaluate the internal architecture of the uterus. It can also visualize polyps, abnormally shaped cavities, and leiomyomas. The presence of these may be limitations to certain ablation techniques **(37).**

When no other abnormalities are present, preoperative imaging with transvaginal ultrasonography may be sufficient for achieving an accurate assessment of overall uterine size and shape. In cases of suspected uterine abnormalities, saline-infusion sonohysterography or office hysteroscopy may be used to characterize the uterine cavity and aid in proper selection of the ablation device **(38).**

For many patients, medical therapy often controls abnormal uterine bleeding. However, failure of such therapy or inability to tolerate it is not an absolute prerequisite for endometrial

ablation. Patients with abnormal uterine bleeding secondary to systemic disease should be managed medically; the use of endometrial ablation in these patients requires further study **(5).**

Endometrial biopsy

Endometrial biopsy is used to exclude endometrial hyperplasia and malignancy. For premenopausal patients in particular, endometrial biopsy can easily be accomplished in the office setting in most cases, and the results can be reviewed before ablation is scheduled. However, in patients unable to tolerate office biopsy or in clinical scenarios not amenable to sampling in the office, dilation and curettage with possible hysteroscopy is warranted to rule out premalignant and malignant conditions of the endometrium **(5).**

Proper selection of a device for endometrial ablation should take into account the following factors:

- Cavity size and shape
- Previous uterine surgery
- Location of procedure
- Results of the preoperative evaluation **(9).**

Equipment for resectoscopic procedures

REA procedures include rollerball fulguration, laser fulguration, vaporization, and endomyometrial resection. All are performed under direct visualization and require a modified urologic resectoscope that uses radiofrequency (RF) alternating current (AC). Resection via a loop electrode, fulguration or desiccation via a barrel or ball-shaped electrode, and vaporization via a pointed-tip electrode have been commonly performed through the resectoscope **(39).**

Equipment for global (nonresectoscopic) procedures

Devices that have been approved for use in GEA procedures include the following:

- Thermal balloon ablation device (ThermaChoice; Ethicon, Somerville, NJ)
- Hydrothermal ablation (HTA) device (Hydro ThermAblator and Genesys HTA; Boston Scientific, San Diego, CA)
- Bipolar energy ablation device (NovaSure; Hologic, Bedford, MA)
- Cryotherapy ablation device (Her Option; Cooper Surgical, Trumbull, CT)
- Microwave endometrial ablation device (Hologic, Bedford, MA) **(18).**

Thermal balloon ablation

With the ThermaChoice, a single-use silicon balloon-tipped catheter probe-handpiece measuring 4-5 mm is connected via a cable to a dedicated control unit. The heating element is contained within the balloon, and a separate port attached to the handpiece allows instillation of 5% dextrose in water (D5W) into the balloon. The control unit aborts the procedure if the temperature of the fluid in the balloon does not reach the appropriate level during the preheating phase **(40).**

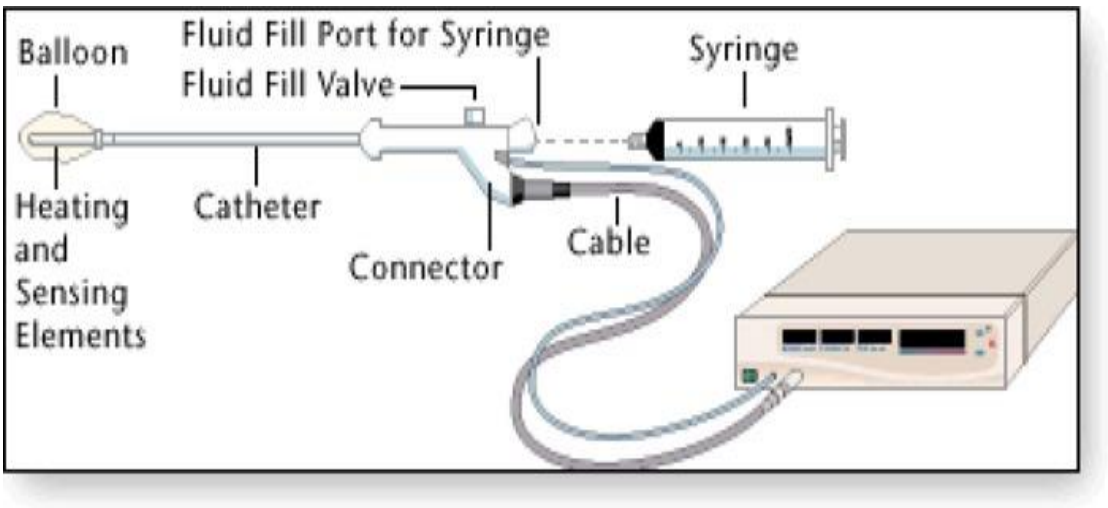

Fig (3): Example of thermal endometrial ablation therapy. The procedure works by ablating the endometrial lining of the uterus, in three phases: 1) insertion and balloon inflation; 2) heating, ablation, and monitoring; 3) deflation and removal **(41).**

Hydrothermal ablation

The Hydro ThermAblator includes a single-use 7.8-mm outer-diameter (OD) sheath that attaches to a variety of standard 3-mm OD hysteroscopes, which, in turn, provide intraoperative direct visualization of the procedure. Attached to the hysteroscope is a closed fluid circuit that uses normal saline; this is managed by the control unit. The control unit automatically aborts the procedure if more than 10 mL of fluid is lost, regardless of route **(30).**

Bipolar energy ablation

The NovaSure includes a single-use 7.2-mm OD probe-handpiece that is attached to a microprocessor-based control unit. A bipolar gold mesh electrode array is located on the end of the probe, wrapped around 2 extendable curved arms that deploy through retraction of the sheath. The probe is equipped with standardized deployment lengths (eg, depth of cavity), which the operator manually sets before inserting the probe on the basis of an initial sounding of the uterus **(42).**

In addition, the NovaSure insufflates carbon dioxide into the cavity, in fixed volume, to determine the integrity of the cavity. The current generation of the device does not allow activation of the ablation phase if the cavity does not pass this integrity test **(43).**

The NovaSure also employs a closed circuit to apply suction to the endometrial cavity for the evacuation of steam, debris, and blood during the ablation phase **(44).**

Cryoablation

Her Option includes a single-use 4.5-mm OD probe-handpiece that is attached via a cable to a control unit. The probe is inserted into the endometrial cavity, and 2-4 "freeze" locations are typically employed. The probe creates an elliptical ice ball measuring approximately 3.5 cm by 5 cm. The procedure is performed under abdominal ultrasonographic guidance; although this may require extra personnel, it gives the operator valuable visual feedback for proper treatment of the entire cavity **(45).**

Microwave endometrialablation

The microwave endometrial ablation device includes an 8-mm OD single-use probe as well as a reusable probe, either of which can be attached to a 9.2-GHz, 30-W control unit via a reusable cable. The probe is manually moved about the entire endometrium while the operator receives temperature monitoring data via the control unit. A marker located 4 cm from the tip of the probe helps the operator identify the cervicouterine junction and thus avoid inadvertent ablation of the cervix **(46).**

✓ **Patient Preparation**

- ***Anesthesia***

Several different anesthetic regimens may be used for endometrial ablation; the choice should be individualized on the basis of the patient's characteristics and condition and the location of the procedure. Possibilities for anesthesia include the following:

- No anesthesia
- Paracervical block, with or without sedation
- Spinal anesthesia
- General anesthesia **(47).**

- ***Positioning***

The patient can be placed in either the low or the high dorsal lithotomy position. Proper positioning techniques should be observed to minimize the risk of femoral or peroneal nerve injury; however, because these procedures are generally of short duration, they are already associated with a lower risk than longer procedures such as hysterectomy. Multipositional stirrups (eg, Yellowfin or Allen) generally support the legs better than traditional "candy cane" stirrups do, especially for patients with an increased body mass index **(48).**

III. Technique

✓ Approach Considerations

Endometrial sampling before ablation can help rule out current malignancy. However, malignancy can be masked after an ablation. Accordingly, one should consider alternatives to ablation for patients who are at very high risk for endometrial cancer. There is no known increased risk for endometrial malignancy after endometrial ablation **(49).**

Postoperatively, patients who have had endometrial ablation are able to go home on the day of the procedure. Postoperative pain is typically controlled with ibuprofen. The recommended follow-up is 2 weeks after the procedure **(50).**

Concomitant microinsert placement

Essure devices are small microinserts containing a stainless steel inner coil with polyester fibers and a superelastic nitinol outer anchoring coil. This device is inserted hysteroscopically into the fallopian tubes for contraception **(51).**

No data suggest that these procedures cannot be done at the same time as an endometrial ablation. There has been concern that uterine synechiae would interfere with the ability to perform and interpret the hysterosalpingogram that is normally performed 3 months postoperatively, but data have shown that uterine synechiae did not interfere with the ability to document proper location of the Essure device or the ability to grade the degree of tubal occlusion **(52).**

Because the Essure microinserts are made of nickel-titanium, there is the potential for energy conduction when bipolar energy ablation is used. When endometrial ablation is being done concomitantly with hysteroscopic tubal occlusion, performing the ablation before placing microinsert placement should prevent such complications **(53).**

Essure has also been shown to be safe for use in conjunction with thermal balloon ablation for accomplishing endometrial ablation and permanent sterilization. The ThermaChoice is approved by the US Food and Drug Administration (FDA) for this indication, but the NovaSure has not been and thus would be an off-label choice **(30).**

✓ Resectoscopic Endometrial Ablation

Resectoscopic endometrial ablation (REA) procedures include rollerball (roller barrel) desiccation, laser vaporization, and wire-loop resection. All of these procedures are performed through the resectoscope under direct visualization with laser energy or with monopolar or bipolar RF energy sources. In general, REA procedures are less costly than global endometrial ablation (GEA) procedures **(40).**

For standard monopolar electrosurgical techniques, distention media typically consist of low-viscosity, electrolyte-free solutions (eg, 1.5% glycine, 3% sorbitol, 5% mannitol, or combined sorbitol-mannitol). The potential for systemic intravasation of these solutions and subsequent adverse sequelae necessitates use of a strict fluid measurement and management system, preferably automated, to monitor differences between fluid instilled and fluid returned. To further reduce intravasation risk, the lowest effective intracavitary pressure should be used **(17).**

Newer bipolar devices are also available; however, the small gauge of the device (typically < 5 mm) results in increased operating times. Electrolyte-free distention media are not required, allowing the operator to use normal saline instead. Consequently, there is not the same risk of fluid intravasation, and this advantage may outweigh the risks of increased operating time for an experienced operator **(54).**

- ***Rollerball (roller barrel) desiccation***

The distention medium is introduced, the power is set to 50-150 W on the generator, and monopolar energy is used to desiccate the endometrium. The rollerball is initially placed at the fundus, then moved to the anterior and lateral walls, and finally moved to the posterior wall. The goal is to destroy the visible endometrium to a depth of 1-2 mm; this prevents regeneration because the basal and spiral arterioles do not survive the exposure. The procedure is approximately 30 minutes in duration **(55).**

Laser vaporization

A neodymium:yttrium-aluminum-garnet (Nd:YAG) laser is placed through the instrument channel of the hysteroscope. The laser fibers touch and then photocoagulate the endometrial tissue. Because of the high cost of the equipment and the considerable training required, this procedure is not commonly used **(56).**

- ***Wire-loop resection***

A wire loop is used with the operative hysteroscope to manually resect the endometrium to a depth of 5-6 mm. The loop is connected to either a monopolar or a bipolar electric current **(57).**

- ✓ **Global Endometrial Ablation**

Each GEA technique requires thorough knowledge of the equipment, the procedure, and intraoperative response of the uterus and endometrium. The newer tools for GEA require less operator time and training to achieve excellent results than the earlier devices did **(58).**

Table (1): Global Endometrial Ablation Techniques **(43).**

Method	**Sounded Uterine Length**		**Cervical Dilation**	**Time**	**Pretreatment**
	Min	Max	(cm)	(min)	
Thermal balloon	4	10	5	8	Suction curettage
Cryotherapy	n/a	10	5	14	Yes
Hydrothermablation	4	10.5	8	10	Yes
Microwave	6	14	8	3.5	Yes
Bipolar energy	6	10	8.5	1.5	No

Almost all GEA devices are designed with fail-safe mechanisms to detect procedural abnormalities (eg, uterine cavity defects, fluid loss, and pressure loss). Some are also designed to automatically detect procedure completion, as in the case of the NovaSure, which measures tissue impedance to determine depth of ablation in an attempt to ensure proper treatment **(59).**

Thermal balloon ablation

ThermaChoice consisted of a latex balloon. This was replaced with a silicone balloon in ThermaChoice II. The third generation of the device, ThermaChoice III, uses a stronger and more flexible Silastic balloon, thereby improving coverage throughout the cavity and, potentially, over small submucosal myomas smaller than 2 cm **(60).**

Thermal balloon ablation is performed via a cannula. Advance the balloon-tipped probe into the cavity and inflate it with 5% dextrose in water (D5W) to a pressure of 160-180 mm Hg, up to a total of 30 mL of fluid **(61)**

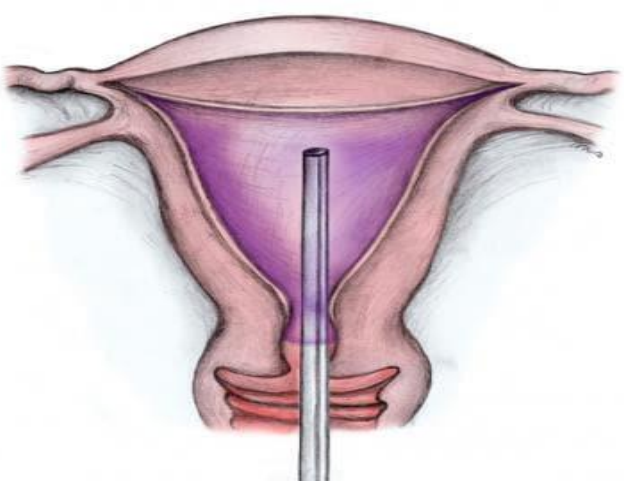

Fig (4): ThermaChoice uterine balloon device **(62).**

Activate the device (this requires a minimum pressure of 150 mm Hg). It automatically passes through a 2-minute warm-up phase, then an 8-minute ablation phase, and finally a 2-minute cooldown phase. During the ablation phase, the fluid is maintained at 87°C. Tissue is destroyed to a depth of 3.3-5 mm **(63).**

The system automatically shuts down under the following conditions:

- Rapid decrease in pressure
- Pressure >210 mm Hg
- Pressure < 45 mm Hg, temperature >37°C
- Temperature < 37°C for > 15 seconds **(64).**

The procedure is performed blindly, and total procedure time is approximately 30 minutes **(42).**

It is important to keep in mind that the ThermaChoice requires a pressure of 160-180 mm Hg for proper application of the balloon to the endometrial cavity. During the initial filling of the balloon, the operator may notice a rapid increase in uterine pressure as a result of a uterine contraction, which is typically self-limited. After completion of the initial filling of the balloon, the uterus may relax, resulting in a slight loss of pressure. This can be addressed by continued slow filling if the pressure has stabilized to a less-than-optimal level **(65).**

Occasionally, a uterine contraction may be encountered during the ablation phase, resulting in intracavitary pressures exceeding the predetermined device limit and possible automatic cessation of the procedure. This can be remedied by releasing a small amount of fluid from the balloon intraoperatively to maintain the appropriate pressure **(66).**

Alternatively, uterine relaxation may be encountered during the ablation phase. However, additional fluid injection is not recommended, because the introduction of cool fluid would compromise endometrial cavitary temperature. It is reasonable to continue the procedure; the device will continue ablation as long as the pressure remains above 45 mm Hg (though it should ideally be at least 100 mm Hg to ensure minimally adequate pressure within the cavity) **(67).**

- ***Cryoablation***

In endometrial cryoablation with Her Option, a cryoprobe is placed into the uterus and cooled with pressurized carbon dioxide to create temperatures of –100° to –120°C **(66).**

Advance the cryoprobe into the endometrial cavity, typically starting with the tip of the probe at one cornu. Activate the device. This cools the probe to –90°C, which results in the formation of an elliptical ice ball that measures approximately 3.5-5 cm. Each of these freeze cycles is followed by a thaw cycle. The process takes 4-6 minutes and is repeated at the contralateral cornu. It may be repeated in the lower uterine segment **(69).**

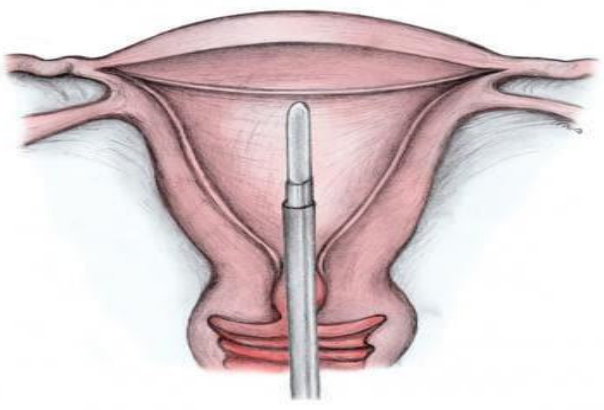

Fig (5): HerOption cryoablation device **(70).**

As a rule, 2 to 3 ice balls are adequate for complete treatment, but the number of ice balls can be increased, depending on the total size of the endometrial cavity. A temperature of –20°C is required for permanent destruction, and this is achieved at 3-5 mm from the edge of the ice ball, where the temperature increases to a nondestructive 0°C **(71).**

Monitor the procedure via transabdominal ultrasonography. Monitor the edge of the ice ball to ensure that it does not traverse the uterine serosa. Total procedure time is up to 20 minutes **(72).**

Option confers the deepest tissue penetration (up to 9-12 mm) with probably the least discomfort; freezing techniques generally result in less pain than heat-employing techniques. A significant advantage of this device includes the ability to observe tissue destruction ultrasonographically, though such observation can be compromised in obese patients. Performing the procedure with a full bladder can help with visualization, as can intrauterine saline instillation **(73).**

Placement of the initial freeze at the fundus prevents the operator from having to attempt to move the probe through an ice ball. Increasing the cornual freeze times may be necessary to achieve the proper depth of tissue destruction. Like hydrothermablation, endometrial cryoablation is not limited by the size of the uterus **(74).**

- ***Hydrothermal ablation***

Hydrothermal ablation is the only second-generation ablation technique that uses hysteroscopy during treatment. The device is a closed-loop system in which heated saline circulates freely in the uterine cavity and is monitored hysteroscopically. A sheath is placed over a standard 3 mm hysteroscope to provide fluid recirculation. A computerized system controls the cycles, which consist of a priming cycle and a treatment cycle **(75).**

Advance the hysteroscope with sheath into the lower uterine segment (see the image below), and instill room-temperature saline into the cavity using gravity to create a low distending pressure (ie, well below 70 mm Hg, which is the approximate opening pressure of the fallopian tubes). During the priming cycle, the fluid is circulated in the uterine cavity for 2 minutes **(76).**

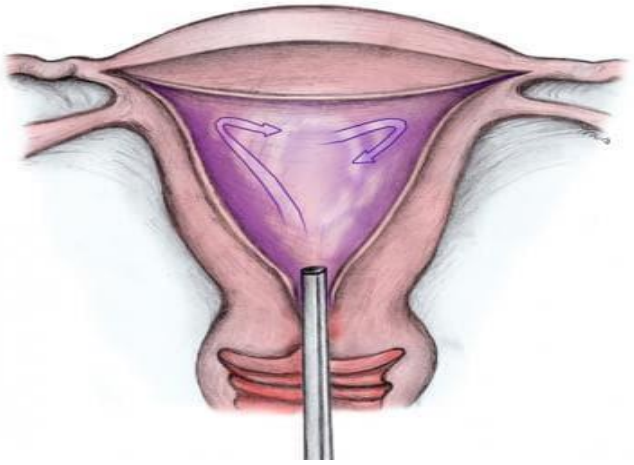

Fig (6): Hydrothermal endometrial ablation (HTA) device **(77).**

Once activated, the device preheats the circulating fluid to 80-90°C, which takes approximately 3 minutes. Again, the pressure should be maintained at 40-50 mm Hg to prevent fluid exiting through the fallopian tubes. A 10-minute treatment phase follows, during which the system shuts down if a deficit larger than 10 mL or a gain larger than 20 mL is measured **(78).**

The entire procedure is performed under direct hysteroscopic visualization; it is the only GEA device that allows such visualization during the ablation phase. Total operating time is approximately 20 minutes. One advantage of hydrothermal ablation is that it is effective in irregularly shaped uterine cavities, because the water will contact all surfaces. At present, this

device is the only one approved by the US Food and Drug Administration (FDA) for ablation of abnormally shaped endometrial cavities **(79).**

The procedural success of hydrothermal ablation is partially dependent on achieving a proper watertight seal at the level of the cervix. The manufacturer produces an extra ridged sheath attachment that is designed to ensure a proper seal. Another method of ensuring a proper seal is to apply a single-toothed tenaculum at the 3 o'clock or 9 o'clock position (or both) for further cervical compression. If automatic shutoff of the device should occur (for the reasons cited above), repeating the procedure is generally not recommended **(80).**

- ***Bipolar energy ablation***

The NovaSure system consists of a disposable handpiece and a computerized electrosurgical generator. First, sound the uterine cavity, paying particular attention to the length of the cervix (from external os to internal os) and the total length of the uterus. Calculate the cavity length by subtraction, and enter this number into the controller. A slide lock on the handpiece allows the operator to preset the mesh deployment depth (ie, cavity length). The maximum cavity length possible is 6.5 cm **(24).**

Using the measured depth of the uterine cavity, advance the device to the uterine fundus, retract it 1 cm, and deploy the bipolar mesh (a metallic, gold-plated grid) by squeezing the main handle of the handpiece until the handle locks into the open position of Laparoscopic **(81)**.

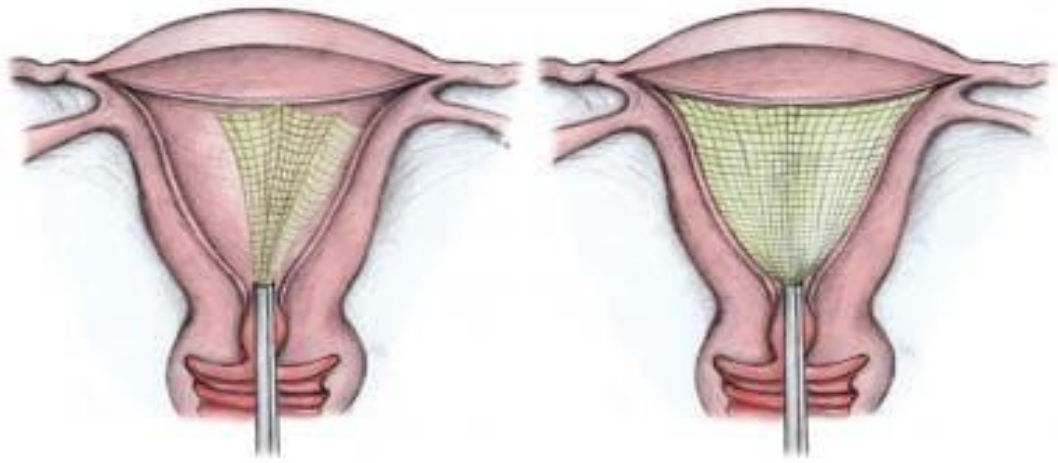

Fig (7): NovaSure bipolar radio frequency device **(81).**

Manipulate the handpiece as necessary until the most distal portion of the mesh is at its widest possible measurement within the cavity (as measured by the rotary dial at the back end of the handpiece). Manipulations that may be used to achieve full deployment of the radiofrequency (RF) array may include gentle back-and-forth movements of the operator's end of the device in any of the following directions: from one side to the other, from anterior to posterior, from clockwise to counterclockwise, and, with caution, in and out **(82).**

Submucosal myomas, even if smaller than 2 cm, can significantly impair the deployment of the array. Consequently, it is the author's practice first to partially or fully resect these myomas hysteroscopically **(83).**

Enter the cavity width into the controller. Advance the cervical collar to the external os, and lock it in place to create a seal. Use the controller to perform a cavity assessment by initially insufflating a small amount of carbon dioxide into the cavity, ensuring that pressure can be maintained for 4 seconds (to rule out uterine perforation). The current version of this device includes a safety feature that prevents the overriding of the cavity assessment function, thus precluding ablation if the uterus does not pass the cavity assessment **(84).**

Apply suction to the cavity, drawing it into contact with the mesh. This allows the removal of blood, charred endometrium, and vapor at the same time. These 3 factors can increase impedance and potentially reduce the depth of energy penetration **(85).**

During the ablation phase, the generator applies up to 180 W of bipolar power (automatically calculated by the controller on the basis of the previously entered parameters). This phase generally lasts 1-2 minutes. The device ablates to a resistance of 50 ohms or a total of 2 minutes, whichever comes first. This results in desiccation to a depth of 4-5 mm **(86).**

The procedure is performed blindly, and total operating time is approximately 10-15 minutes. An advantage of bipolar energy ablation is that it has equal efficacy whether pretreatment of the endometrium is undertaken or not, which makes it ideal for patients who are unable or unwilling to undergo preoperative hormonal treatment **(65).**

- ***Microwave ablation***

In microwave endometrial ablation, microwave energy (30 W at a frequency of 9.2 GHz) is applied to the endometrium with a transcervical probe that moves through the endometrial cavity. The microwave endometrial ablation device is the only GEA device approved by the FDA for use in the presence of submucosal leiomyomas up to 3 cm and cavity lengths up to 12 cm **(87).**

Advance the probe to the fundus, typically starting at one cornu. Activate the system, creating a temperature of 75-85°C that penetrates to a depth of 6 mm. Move the probe from side to side while slowly treating the entire cavity from fundus to the lower uterine segment. Safety mechanisms prevent ablation if the probe has not yet been placed into the uterus, if the probe is advanced further than the original sounding, or if an abnormal rise in temperature (possibly due to perforation) is detected. Total treatment time is 2-5 minutes **(88).**

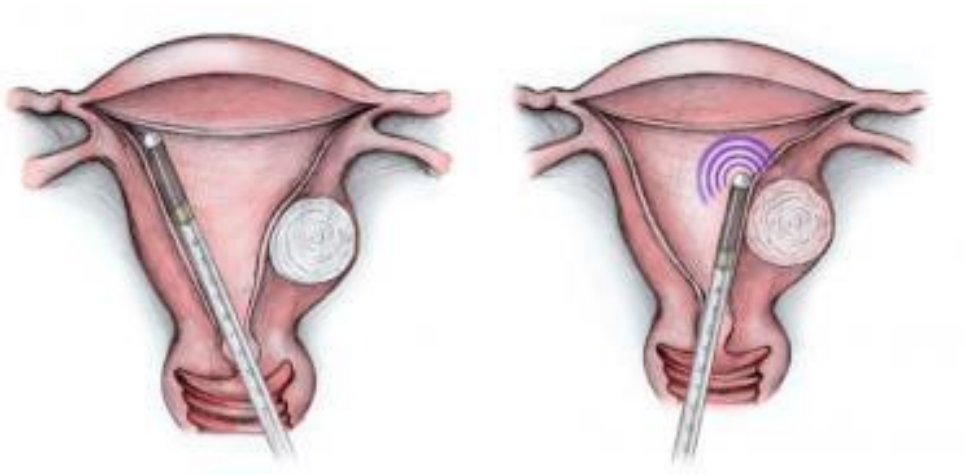

Fig (8): Microsulis Endometrial Ablation (MEA) microwave device **(18).**

With this procedure, it is recommended that the patient not undergo mechanical dilation and curettage beforehand. However, ultrasonography (to document a transmural thickness of at least 1 cm) and hysteroscopy are recommended before the procedure **(89).**

Unique to the microwave endometrial ablation device is the thermocoupler, which gives the operator ongoing feedback regarding the temperature at the point of ablation. This is particularly useful in targeted treatment of submucosal myomas, the thorough ablation of which is monitored through both tactile and thermal feedback **(90).**

References:

1. Naor-Revel, S., Goldstone, R., & Revel, A. (2021). Hysteroscopy, the Window into the Uterine Cavity. In Advances in Minimally Invasive Surgery. IntechOpen.
2. Marnach, M. L., & Laughlin-Tommaso, S. K. (2019, February). Evaluation and management of abnormal uterine bleeding. In Mayo Clinic Proceedings (Vol. 94, No. 2, pp. 326-335). Elsevier.
3. Whitworth, H., Sartain, S. E., Kumar, R., et al. (2021). Rate of thrombosis in children and adolescents hospitalized with COVID-19 or MIS-C. Blood, The Journal of the American Society of Hematology, 138(2), 190-198.
4. Bergeron, C., Laberge, P. Y., Boutin, A., Thériault, M. A., Valcourt, F., Lemyre, M., & Maheux-Lacroix, S. (2020). Endometrial ablation or resection versus levonorgestrel intra-uterine system for the treatment of women with heavy menstrual bleeding and a normal uterine cavity: a systematic review with meta-analysis. Human Reproduction Update, 26(2), 302-311.

5. Singh, R., Upadhyay, A. K., Chandra, P., & Singh, D. P. (2018). Sodium chloride incites reactive oxygen species in green algae Chlorococcum humicola and Chlorella vulgaris: implication on lipid synthesis, mineral nutrients and antioxidant system. Bioresource technology, 270, 489-497.
6. Benetti-Pinto, C. L., Rosa-e-Silva, A. C. J. D. S., Yela, D. A., et al. (2017). Abnormal uterine bleeding. Revista Brasileira de Ginecologia e Obstetrícia, 39, 358-368.
7. Vitale, S. G., Riemma, G., Mikuš, M., et al. (2022). Quality of Life, Anxiety and Depression in Women Treated with Hysteroscopic Endometrial Resection or Ablation for Heavy Menstrual Bleeding: Systematic Review and Meta-Analysis of Randomized Controlled Trials. Medicina, 58(11), 1664.
8. MacGregor, B., Munro, M. G., & Lumsden, M. A. (2023). Therapeutic options for the management of abnormal uterine bleeding. International Journal of Gynecology & Obstetrics, 162, 43-57.
9. Goldstein, S. R., & Lumsden, M. A. (2017). Abnormal uterine bleeding in perimenopause. Climacteric, 20(5), 414-420.
10. Rodriguez-Triana, V. M., & Parker, W. H. (2023). Management of Fibroids. In Handbook of Gynecology (pp. 495-511). Cham: Springer International Publishing.
11. Dong, A. C., & Sasaki, K. J. (2021). A Surgical History of Endometrial Ablation: Past, Present and Future Perspectives. Journal of Gynecologic Surgery, 37(5), 387-391
12. Loring, M., Chen, T. Y., & Isaacson, K. B. (2021). A systematic review of adenomyosis: it is time to reassess what we thought we knew about the disease. Journal of minimally invasive gynecology, 28(3), 644-655.
13. Giuliani, A., Greco, S., Pacilè, S., Zannotti, A., Delli Carpini, G., Tromba, G., ... & Ciarmela, P. (2019). Advanced 3D imaging of uterine leiomyoma's morphology by propagation-based phase-contrast microtomography. Scientific Reports, 9(1), 10580.
14. Gould, S. W., Calle Toro, J. S., Back, S. J., Podberesky, D. J., & Epelman, M. (2020). Female genital tract. Pediatric body MRI: a comprehensive, multidisciplinary guide, 387-424.
15. Mayne, A. I., Davies, P. S., & Simpson, J. M. (2018). Antibiotic treatment of asymptomatic bacteriuria prior to hip and knee arthroplasty; a systematic review of the literature. The Surgeon, 16(3), 176-182.

16. St. Amant, H. G., Schrager, S. M., Peña-Ricardo, C., Williams, M. E., & Vanderbilt, D. L. (2018). Language barriers impact access to services for children with autism spectrum disorders. Journal of autism and developmental disorders, 48, 333-340.
17. Patseadou, M., & Michala, L. (2017). Usage of the levonorgestrel-releasing intrauterine system (LNG-IUS) in adolescence: what is the evidence so far?. Archives of gynecology and obstetrics, 295, 529-541.
18. Carugno, J., & Andrade, F. (2018). Is There a Role for Hysteroscopic Endometrial Ablation in Modern Gynecology?. Hysteroscopy, 625-634.
19. Mastrocola, L. E., Amorim, B. J., Vitola, J. V., Brandão, S. C. S., Grossman, G. B., Lima, R. D. S. L., ... & Meneghetti, J. C. (2020). Update of the Brazilian guideline on nuclear cardiology-2020. Arquivos Brasileiros de Cardiologia, 114, 325-429.
20. Burnett, M., & Lemyre, M. (2017). No. 345-primary dysmenorrhea consensus guideline. Journal of Obstetrics and Gynaecology Canada, 39(7), 585-595.
21. Smith, A. L., & Yeguez, A. C. (2022). Rare Conditions Causing Incontinence and Their Treatment. In Female Urinary Incontinence (pp. 407-426). Cham: Springer International Publishing.
22. Belfort, M. A., Whitehead, W. E., Shamshirsaz, A. A., Espinoza, J., Nassr, A. A., Lee, T. C., ... & Sanz Cortes, M. (2020). Comparison of two fetoscopic open neural tube defect repair techniques: single-vs three-layer closure. Ultrasound in Obstetrics & Gynecology, 56(4), 532-540.
23. Bedaiwy, M. A., Allaire, C., & Alfaraj, S. (2017). Long-term medical management of endometriosis with dienogest and with a gonadotropin-releasing hormone agonist and add-back hormone therapy. Fertility and sterility, 107(3), 537-548.
24. Leathersich, S. J., & McGurgan, P. M. (2018). Endometrial resection and global ablation in the normal uterus. Best Practice & Research Clinical Obstetrics & Gynaecology, 46, 84-98.
25. Allen, R. H., & Singh, R. (2018). Society of Family Planning clinical guidelines pain control in surgical abortion part 1—local anesthesia and minimal sedation. Contraception, 97(6), 471-477.
26. Kaye, K., Paprottka, F., Escudero, R., Casabona, G., Montes, J., Fakin, R., ... & Benito-Ruiz, J. (2020). Elective, non-urgent procedures and aesthetic surgery in the wake of

SARS–COVID-19: considerations regarding safety, feasibility and impact on clinical management. Aesthetic plastic surgery, 44, 1014-1042.

27. Munro, M. G. (2018). Endometrial ablation. Best Practice & Research Clinical Obstetrics & Gynaecology, 46, 120-139.
28. Mazur, M., Dang, M., & Vega, M. (2021). COVID-19 and the march 2020 stock market crash. Evidence from S&P1500. Finance research letters, 38, 101690.
29. Alvi, F. A., Glaser, L. M., Chaudhari, A., Tsai, S., & Milad, M. P. (2017). New paradigms in the conservative surgical and interventional management of adenomyosis. Current Opinion in Obstetrics and Gynecology, 29(4), 240-248.
30. Levie, M. D., & Chudnoff, S. G. (2019). A prospective, multicenter, pivotal trial to evaluate the safety and effectiveness of the AEGEA vapor endometrial ablation system. Journal of minimally invasive gynecology, 26(4), 679-687.
31. Dolma, K. G., & MD, W. M. (2022). Acinetobacter baumannii: An overview of emerging multidrug-resistant pathogen. Med J Malaysia, 77(3), 357.
32. del Valle García, R., Mora, J. M. C., San Martín, N. L. C., Rodríguez, O. Z., Rodríguez, A. M., Pérez, L. H., ... & Rodeiro, R. C. (2021). An enzyme immunoassay to determine human chorionic gonadotropin (HCG) in serum and urine samples using an ultra-microanalytical system. Journal of Pharmaceutical and Biomedical Analysis, 204, 114239.
33. Kawaguchi, R., Matsumoto, K., Ishikawa, T., Ishitani, K., Okagaki, R., Ogawa, M., ... & Kobayashi, H. (2021). Guideline for gynecological practice in Japan: Japan Society of Obstetrics and Gynecology and Japan Association of Obstetricians and Gynecologists 2020 edition. Journal of Obstetrics and Gynaecology Research, 47(1), 5-25.
34. Arya, S., & Kupesic Plavsic, S. (2017). Preimplantation 3D ultrasound: current uses and challenges. Journal of perinatal medicine, 45(6), 745-758.
35. Foti, P. V., Tonolini, M., Costanzo, V., Mammino, L., Palmucci, S., Cianci, A., ... & Basile, A. (2019). Cross-sectional imaging of acute gynaecologic disorders: CT and MRI findings with differential diagnosis—part II: uterine emergencies and pelvic inflammatory disease. Insights into Imaging, 10, 1-19.

36. Bahrami, S., Khatri, G., Sheridan, A. D., Palmer, S. L., Lockhart, M. E., Arif-Tiwari, H., & Glanc, P. (2021). Pelvic floor ultrasound: when, why, and how?. Abdominal Radiology, 46, 1395-1413.
37. Park, M. G., & Isaacson, K. B. (2022). Hysteroscopic Management of Intrauterine Disorders: Polypectomy, Myomectomy, Endometrial Ablation, Adhesiolysis, and Removal of Uterine Septum. In Clinical Reproductive Medicine and Surgery: A Practical Guide (pp. 429-458). Cham: Springer International Publishing.
38. Dueholm, M., & Hjorth, I. M. D. (2017). Structured imaging technique in the gynecologic office for the diagnosis of abnormal uterine bleeding. Best Practice & Research Clinical Obstetrics & Gynaecology, 40, 23-43.
39. Donnez, O. (2020). Cesarean scar defects: management of an iatrogenic pathology whose prevalence has dramatically increased. Fertility and Sterility, 113(4), 704-716.
40. Munro, M. G., Critchley, H. O., Fraser, I. S., FIGO Menstrual Disorders Committee, Haththotuwa, R., Kriplani, A., ... & Warner, P. (2018). The two FIGO systems for normal and abnormal uterine bleeding symptoms and classification of causes of abnormal uterine bleeding in the reproductive years: 2018 revisions. International Journal of Gynecology & Obstetrics, 143(3), 393-408.
41. Thai, M. T., Phan, P. T., Hoang, T. T., Wong, S., Lovell, N. H., & Do, T. N. (2020). Advanced intelligent systems for surgical robotics. Advanced Intelligent Systems, 2(8), 1900138.
42. Lee, W., Oh, W., Ko, H. S., Lee, S. Y., Kim, K. W., & Yang, E. J. (2019). Effectiveness of retrobulbar hyaluronidase injection in an iatrogenic blindness rabbit model using hyaluronic acid filler injection. Plastic and reconstructive surgery, 144(1), 137-143.
43. Fallahi, H., & Prakash, P. (2018). Antenna designs for microwave tissue ablation. Critical Reviews™ in Biomedical Engineering, 46(6).
44. Munro, M. G., & Gomel, V. (Eds.). (2018). Reconstructive and Reproductive Surgery in Gynecology: Two Volume Set. CRC Press.
45. Scotland, R. W., Muñoz-Rodríguez, P., Carruthers, T., Wood, J. R., Williams, B. R., Weitemier, K., Kronmiller, B., ... & (2019). A taxonomic monograph of Ipomoea integrated across phylogenetic scales. Nature plants, 5(11), 1136-1144.

46. Dogan, E. & Inglesi-Lotz, R., (2018). The role of renewable versus non-renewable energy to the level of CO2 emissions a panel analysis of sub-Saharan Africa's Big 10 electricity generators. Renewable Energy, 123, 36-43.
47. Einerson, B. D., & Weiniger, C. F. (2021). Placenta accreta spectrum disorder: updates on anesthetic and surgical management strategies. International Journal of Obstetric Anesthesia, 46, 102975.
48. Abd-Almageed, W., & Wu, Y., Natarajan, P. (2017, October). Deep matching and validation network: An end-to-end solution to constrained image splicing localization and detection. In Proceedings of the 25th ACM international conference on Multimedia (pp. 1480-1502).
49. Tanos, V., Berry, K. E., Frist, M., Campo, R., & DeWilde, R. L. (2018). Prevention and management of complications in laparoscopic myomectomy. BioMed research international, 2018.
50. Cooper, H., Hedges, L. V., & Valentine, J. C. (Eds.). (2019). The handbook of research synthesis and meta-analysis. Russell Sage Foundation.
51. Lazorwitz, A., & Tocce, K. (2017). A case series of removal of nickel–titanium sterilization microinserts from the uterine cornua using laparoscopic electrocautery for salpingectomy. Contraception, 96(2), 96-98.
52. Belinga, E., Tompeen, I., Ndoua, C. C. N., et al. (2018). Diagnostic, therapeutic and prognostic aspects of uterine synechiae managed by hysteroscopy in the gyanecological endoscopic surgery and human reproductive teaching hospital. International Journal of Reproduction, Contraception, Obstetrics and Gynecology, 7(1), 57.
53. Sheffield, J., Yuan, X., Wang, L., Wu, P., Ji, P., Zhang, M. (2019). Anthropogenic shift towards higher risk of flash drought over China. Nature communications, 10(1), 4661.
54. Clark, A., Jit, M., Warren-Gash, C., et al. (2020). Global, regional, and national estimates of the population at increased risk of severe COVID-19 due to underlying health conditions in 2020: a modelling study. The Lancet Global Health, 8(8), e1003-e1017.
55. Yang, L., Zhang, Y., Kang, S., Wang, Z., & Wu, C. (2021). Microplastics in soil: A review on methods, occurrence, sources, and potential risk. Science of the Total Environment, 780, 146546.

56. Gachabayov, Lee, H., M., Rojas, A., Felsenreich, D. M., Tsarkov, P., & Bergamaschi, R. (2020). Systematic review of failure of nonoperative management in complicated sigmoid diverticulitis with abscess. Langenbeck's Archives of Surgery, 405, 277-281.
57. Friedman, S. L., Neuschwander-Tetri, B. A., Rinella, M., & Sanyal, A. J. (2018). Mechanisms of NAFLD development and therapeutic strategies. Nature medicine, 24(7), 908-922.
58. Wahlström, Molinaro, A., A., & Marschall, H. U. (2018). Role of bile acids in metabolic control. Trends in Endocrinology & Metabolism, 29(1), 31-41.
59. Areias, I. O. R., Vieira, C. M. F., Colorado, H. A., Delaqua, G. C. G., Monteiro, S. N., & Azevedo, A. R. G. (2020). Could city sewage sludge be directly used into clay bricks for building construction? A comprehensive case study from Brazil. Journal of Building Engineering, 31, 101374.
60. Miller, R. (2018). Transforming the future: Anticipation in the 21st century (p. 300). Taylor & Francis.
61. Meena, K. V., & Sankar, A. R. (2021). Biomedical catheters with integrated miniature piezoresistive pressure sensors: A review. IEEE Sensors Journal, 21(9), 10241-10290.
62. Aminimoghaddam, S., Nezhadisalami, F., Anjidani, S., & Tond, S. B. (2018). Outcome of treatment with EMA/EP (etoposide methotrexate and actinomycin-D/etoposide and cisplatin) regimen in gestational trophoblastic neoplasia. Medical Journal of the Islamic Republic of Iran, 32, 36.
63. Curran, Oliver, S. E., Gargano, J. W., Marin, M., Wallace, M., K. G., Chamberland, M., ... & Dooling, K. (2020). The advisory committee on immunization practices' interim recommendation for use of Pfizer-BioNTech COVID-19 vaccine—United States, December 2020. Morbidity and mortality weekly report, 69(50), 1922.
64. Hughes, T. P., Anderson, K. D., Connolly, S. R., Heron, S. F., Kerry, J. T., Lough, J. M., ... & Wilson, S. K. (2018). Spatial and temporal patterns of mass bleaching of corals in the Anthropocene. Science, 359(6371), 80-83.
65. Riese, C. S., & Yandell, R. B. (2018). Light/Laser Applications in Gynecology. Lasers in Dermatology and Medicine: Dental and Medical Applications, 115-134.
66. Porter, Lenihan, D., Carver, J., C., Liu, J. E., Dent, S., Thavendiranathan, P., ... & Herrmann, J. (2020). Cardio-oncology care in the era of the coronavirus disease 2019

(COVID-19) pandemic: an International Cardio-Oncology Society (ICOS) statement. CA: a cancer journal for clinicians, 70(6), 480-504.

67. Olutoye, O. A., Rosen, M., & Rollins, M. D. (2020). Anesthesia for Fetal Intervention and Surgery. Gregory's Pediatric Anesthesia, 475-504.
68. Sharp,Chaplin-Kramer, R., R. P., Weil, C., Bennett, E. M., Pascual, U., Arkema, K. K., ... & Daily, G. C. (2019). Global modeling of nature's contributions to people. Science, 366(6462), 255-258.
69. Cholkeri-Singh, A. (2018). Predictors of endometrial ablation failure. Hysteroscopy, 521-530.
70. Skye, H. M., & Pfotenhauer, J. M. (2020). Joule Thomson Cryocoolers and Cryoablation. Cryocoolers: Theory and Applications, 47-63.
71. Zheng, Lin, YL., Zheng, Z., Wu, Y., Hu, Z., Yan, C., & Yang, Y. (2019). Improving person re-identification by attribute and identity learning. Pattern recognition, 95, 151-161.
72. Sprayberry, Lu, K. G., & K. A. (2021). Managing Reproduction Emergencies in the Field: Part 2: Parturient and Periparturient Conditions. Veterinary Clinics: Equine Practice, 37(2), 367-405.
73. Mayordomo-Martínez, D., Sánchez-Aarnoutse, J. C., Carrillo-de-Gea, J. M., García-Berná, J. A., Fernández-Alemán, J. L., & García-Mateos, G. (2019). Design and development of a mobile app for accessible beach tourism information for people with disabilities. International journal of environmental research and public health, 16(12), 2131.
74. Chudzik, P., Majumdar, S., Calivá, F., Al-Diri, B., & Hunter, A. (2018). Microaneurysm detection using fully convolutional neural networks. Computer methods and programs in biomedicine, 158, 185-192.
75. Beelen,Sobral-Leite, M., Salomon, I., Opdam, M., Kruger, D. T., K. J., van der Noort, V., ... & Kok, M. (2019). Cancer-immune interactions in ER-positive breast cancers: PI3K pathway alterations and tumor-infiltrating lymphocytes. Breast Cancer Research, 21(1), 1-12.

76. Tsuji, Ishiura, H., Doi, K., Mitsui, J., Yoshimura, J., Matsukawa, M. K., Fujiyama, A., ... & S. (2018). Expansions of intronic TTTCA and TTTTA repeats in benign adult familial myoclonic epilepsy. Nature genetics, 50(4), 581-590.
77. Klebanoff, J., Makai, G. E., Patel, N. R., & Hoffman, M. K. (2017). Incidence and predictors of failed second-generation endometrial ablation. Gynecological Surgery, 14(1), 1-6.
78. Khoo, M. C. (2018). Physiological control systems: analysis, simulation, and estimation. John Wiley & Sons.
79. Curlin, Bates, T. A., Leier, H. C., Lyski, Z. L., Goodman, J. R., M. E., Messer, W. B., & Tafesse, F. G. (2021). Age-dependent neutralization of SARS-CoV-2 and P. 1 variant by vaccine immune serum samples. Jama, 326(9), 868-869.
80. Khalifehzadeh, R., & Arami, H. (2020). Biodegradable calcium phosphate nanoparticles for cancer therapy. Advances in colloid and interface science, 279, 102157.
81. Zhao, S., Lin, Q., Ran, J., Musa, S. S., Yang, G., Wang, W., ... & Wang, M. H. (2020). Preliminary estimation of the basic reproduction number of novel coronavirus (2019-nCoV) in China, from 2019 to 2020: A data-driven analysis in the early phase of the outbreak. International journal of infectious diseases, 92, 214-217.
82. Malekshoar, M., Malekshoar, M., & Javanshir, B. (2021). Challenges, limitations, and solutions for orthodontists during the coronavirus pandemic: A review. American Journal of Orthodontics and Dentofacial Orthopedics, 159(1), e59-e71.
83. El-Nashar, S. A., Hopkins, M. R., Creedon, D. J., Sauver, J. L. S., Weaver, A. L., McGree, M. E., ... & Famuyide, A. O. (2009). Prediction of treatment outcomes after global endometrial ablation. Obstetrics and gynecology, 113(1), 97.
84. Pereiro, I., Khartchenko, A. F., Petrini, L., & Kaigala, G. V. (2019). Nip the bubble in the bud: a guide to avoid gas nucleation in microfluidics. Lab on a Chip, 19(14), 2296-2314.
85. Hojjat, M. (2020). Nanofluids as coolant in a shell and tube heat exchanger: ANN modeling and multi-objective optimization. Applied Mathematics and Computation, 365, 124710.

86. Chen, J., & Packard, C. E. (2021). Controlled spalling-based mechanical substrate exfoliation for III-V solar cells: A review. Solar Energy Materials and Solar Cells, 225, 111018.
87. Fallahi, H. R., Keyhan, S. O., Zandian, D., Kim, S. G., & Cheshmi, B. (2020). Being a front-line dentist during the Covid-19 pandemic: a literature review. Maxillofacial plastic and reconstructive surgery, 42(1), 1-9.
88. Green, R. W., & Epstein, E. (2020). Dynamic contrast-enhanced ultrasound improves diagnostic performance in endometrial cancer staging. Ultrasound in Obstetrics & Gynecology, 56(1), 96-105.
89. Mettler, Alkatout, I., Mechler, UL., Pape, J., Maass, N., Biebl, M., ... & Freytag, D. (2021). The development of laparoscopy—a historical overview. Frontiers in surgery, 8, 799442.
90. Bongiovanni, S., Brambillasca, P. M., & Fumarola, E. M. (2022). Vascular, Interventional Radiology, and Interventional Oncology. In The Radiology Survival Kit: What You Need to Know for USMLE and the Clinics (pp. 261-283). Cham: Springer International Publishing.