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REVIEW

HYSTEROSCOPY: CURRENT KNOWLEDGE AND FUTURE PERSPECTIVES

Modern operative hysteroscopy

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ABSTRACT

Hysteroscopy is an endoscopic surgical procedure that has become an i[illegible] evaluat[illegible]thology. It offers a direct visualization of the entire uterine cavity and provid[illegible] of perf[illegible]g b[illegible] suspected lesions that can be missed by dilatation and curettage (D&C). In mo[illegible]terine[illegible]es can be diagnosed and treated at the same setting as office hysteroscopy ("see and [illegible]"). For e[illegible]le, [illegible]etrial polyps can be diagnosed and removed; similarly, intrauterine adhesions [illegible] in the ou[illegible] setting without the need for an operating theatre. Today, many hysteroscopic procedures [illegible]formed i[illegible] outpatient setting. This is due to the feasibility of operative hysteroscopy using saline as [illegible]tending me[illegible]ne [illegible]ginoscopic approach of hysteroscopy and the availability of mini-hysteroscopi[illegible]doscopes. There is [illegible] to suggest that hysteroscopy in an ambulatory setting is preferable for the patient, [illegible]avoids comp[illegible] a quicker recovery time and lowers cost. Advances in technology have led to [illegible] of high-def[illegible]oscopes without compromising optical performance, thereby making hysterosc[illegible] s[illegible], safe and [illegible]ffice procedure. The new surgical technology such as bipolar electrosurgery, e[illegible]a[illegible]ion devices, [illegible]e[illegible]ic sterilization, and morcellators has revolutionized this surgical modality. The [illegible]lopment of [illegible] completely transformed the approach to the uterine intracavitary pathologies m[illegible] from [illegible]nd proc[illegible]ral anesthesia to an outpatient procedure performed under direct visualization [illegible]erapeutic an[illegible] possibilities of treatment that should belong to every modern gynecologist.

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Hysteros[illegible]an end[illegible]gical pr[illegible]ng to [illegible] visualization of t[illegible]cal canals [illegible]erine cavity that in the l[illegible] decades gain a more and more important role in gynecological practice. Diagnostic and operative hysteroscopy are nowadays the "gold standards" in the diagnosis and treatment of abnormal uterine bleeding as well as complementary exam in the study of infertility.

Initially hysteroscopy gained a well-established position as second line diagnostic tool after ultrasonographic suspicious of intracavitary abnormalities, but it has been recently proposed as a first line investigation tool with more and more consents.

Thanks to technological progress hysteroscopy can be proposed as a safe outpatient procedure introducing the concept of Office hysteroscopy and expanding the feasibility examination not only as minimally invasive diagnostic technique, but also enabling the surgeon to perform small interventions through an operative channel such as polipectomy, endometrial biopsy or facilitate subsequent operative hysteroscopy.

Furthermore the same technical progress applied to operative hysteroscopy enlarged the

field of applicability transforming most of the intracavitary abnormalities that just few years before were treated by conventional surgery, such as myomas and uterus septum, in something that belong exclusively to hysteroscopy.

Nowadays office hysteroscopy is a tool that should belong to every modern gynecologist, because it offers to most of the patient a painless and effective treatment that avoids local or general anesthesia, a faster return to normal activity reducing the costs and optimizing of the operating room for major procedures.

History of hysteroscopy

The first reported hysteroscopy was performed for the first time in 1869 by an Italian doctor, Diomedes Pantaleoni, who used the cystoscope of Desormeaux to remove an endometrial polyp in woman with postmenopausal bleeding.[1]

During the 50s hysteroscopy was mainly a diagnostic tool with the possibility to remove synechiae with the tip of the instrument and perform sterilization through the intratubal injection of sclerosing substances such as silver nitrate.

Cornier *et al.* developed in the '80s a flexible hysteroscope trying to reduce patient's discomfort,[2, 3] and Gold introduced for the first time a tool to perform endometrial ablation to treat metrorrhagia by Nd-YAG laser (neodymium-doped yttrium aluminium garnet).[4] The same author also used transtubal ostium cauterization with a success close to of 90% (sterilization was also obtained by introducing hysteroscopic coils or other forms to block the entrance in tube.[6]

During the second half of the twentieth century hysteroscopy underwent significant changes and technical improvements, both in terms of the size of the instruments and distension medium.

The size moved from 11 and 8 mm in diameter in 1934 with Segond, to 4 mm at the end of the 70s as well as CO2 was replaced by saline solution at the end of the '80s and the introduction of continuous flow allowed a clear vision of the cavity even in the presence of bleeding or secretions.

Finally the introduction of monopolar currant and the development of the first resectoscope enlarged the field of application enabling Neuwirth to perform the first hysteroscopic myomectomy in 1981 and Decherney the first resectoscopic ablation in 1983.

In 1995 Ivan Mazzon introduces the use of loops cold for enucleation of myomas G1 (submucosal with intramural component).

Modern outpatient hysteroscopy

The modern office hysteroscopy changed during the '90s with the miniaturization of the instrument that allowed surgeons to perform the procedure in an outpatients setting, the so called office hysteroscopy. The introduction of diagnostic approach or "no-touch" technique by Vercellini *et al.* in 1997 significantly reduced the patient's discomfort allowing to perform hysteroscopy even on virgin or post-menopausal women without anesthesia with a failure rate reported from 0% to 2.4%.[7]

Nowadays the most commonly used device employed in office hysteroscopy is a 5 mm operative hysteroscope with continuous flow provided with a 2.9 mm and 30° fore-oblique optic. Stefano Bettocchi changed the way to do hysteroscopy modifying the shape of an existing instrument of 6.5 mm from round to oval and introducing a 5 Fr operative channel.

The possibility to introduce operative semirigid instrument through a 5 Fr operative channel canceled the distinction between diagnostic and operative histeroscopy introducing the new concept of "see and treat". For more then a decade the only available instrument were mechanical represented essentially by grasping forceps and scissors that would be used to treat small endometrial polyps, intracavitary uterine synechiae and to make biopsies.[7, 12]

In 1997 it was also introduced into the market a versatile electrosurgical system dedicated for hysteroscopy (VersaPoint Bipolar Electrosurgical System, Ethicon, Somerville, NJ, USA) that is a high-frequency bipolar gen-

erator and coaxial bipolar electrodes allowing to cut, coagulate, and vaporize the tissues.[12, 13] This bipolar flexible electrode can be introduced through the working channel of modern hysteroscopes enlarging the types of feasible procedure in an outpatient setting.[14]

The introduction of bipolar electrodes involved a changing in the distension medium from the nonionic one (glycine, sorbitol, mannitol) to a simple saline solution and transforming hysteroscopy in safer procedure.[15] The saline solution has proved to be not only associated with a better vision in case of bleeding, a better patients compliance and cost-benefit ratio but it also allows the surgeon to work for a longer time because the patient can bear a large amount of fluid imbalance without the risk of developing hyponatremia and the removal of an endometrial polyps or myomas whose dimensions exceed the diameter of uterine orifice became reality just cutting it in smaller pieces with the bipolar electrode.[16]

To increase the size of polyps that may be removed without anesthesia a new hysteroscopic tool has been developed from a existing laparoscopic device, the mor The hysteroscopic morcellator is office setting and fragments the a rotating blade while a suction the tissue simultaneously operative time and patients di

To reduce patient gery hysteroscopy strument used important no or vagal st caused pelvic pain and the fundamental elements in the induction of both pelvic pain that vagal stimulation.

A flow of 200-350 ml/min with a pressure of 70 mmHg or lower is usually enough to have a good distension of the uterine cavity avoiding unnecessary channeling of the tube ("tubal spillage") with subsequent passage of distention medium in the abdominal cavity.

Even if the vaginoscopic approach, making examination well tolerated by almost all patients, has almost completely removed the need of premedication and/or analgesia to perform hysteroscopy in of cases cervical channel stenosis or operative procedure additional analgesic medicaments might be needed.

Anesthetic techniques for the outpatient procedure include topical lidocaine, intrauterine lidocaine and the traditional or deep paracervical block.[20] Analgesia, in the form of paracetamol or anti-inflammatory drugs may be used for outpatient hysteroscopy operations: Diclofenac sodium i one that has shown greater efficacy.

The use of laser tech gynecology has become widespre CO2 laser was initially used *et al.* in 1973 for treatment of erosions, then for the treatment of intraepithelial neoplasia and micro the fa tube.[21-23] Since t advanc ser technolo made, other types of la ow ava comm gers in gynecology are C gon, K YAG. Each instrument produ waves of specific wavelngth giv characteristic color (monochrom of these lasers use a flexible fiber th be passed easily through the operative channel of the hysteroscope. The fiber is protected by using an Albarrán's bridge that is attached to the operating hysteroscope. The use of laser energy for the treatment of menorrhagia was first reported in 1981and hysteroscopic procedures that can be accomplished with the laser include removal of fibroids and polyps, transection of uterine septa, lysis of adhesions, and endometrial ablation.[24]

Fields of application

Uterine myomas are the most common pelvic tumors of the female genital tract. Even if usually asymptomatic, these benign masses have been associated with a number of clinical issues such as abnormal uterine bleeding (AUB), heavy menstrual bleeding (HMB), infertility, recurrent pregnancy loss, especially when these masses are submucous.[25]

Golden standard treatments for symptomatic submucous fibroids have long been con-

sidered their laparotomic removal or a total hysterectomy,[26-30] according to the desire of preserving fertility. However, the laparotomic approach requires the opening of the uterine cavity causing often pelvic post-operative adhesions, altering the likelihood of subsequent conception [31] and increasing the complications of spontaneous delivery. The development of endoscopy has made these fibroids accessible and removable from the inner surface of uterus.[32] Hysteroscopic myomectomy is now the standard uterus-sparing surgical procedure for treating submucous fibroids. Whereas hysteroscopic myomectomy of lesions lying entirely or mostly in the uterine cavity has become a standard technique, there is no consensus regarding hysteroscopic excision of submucous fibroids with a major intramural component. Although some reported an increased need for repeated resections and reduced success rate, others found no effect of the intramural extension on long-term outcome.[28, 33]

The morcellation of the fibroid by IUM (intra uterine morcellator) represents a new alternative technique which is performed with heat, coagulation or vaporization. The main advantage is to leave tissue unharmed for histological examination. Recently Bonaldi *et al.* [19] have shown that morcellation by IUM was effective and faster than conventional resectoscopy for the treatment of FIGO G1 and G0.

The possibility to perform an outpatient setting introduced the opportunity to modify surgical steps to perform the subsequent operative hysteroscopy in the operating room, as the recently introduced OPI (Optimization of Partial Intramural Myomectomy - O.P.P.I.uM). The OPI technique aims essentially to facilitate the resettoscopic removal of submucosal myoma with an intramural component (G1-G2) where the pseudocapsul is transected facilitating the intracavitary herniation.[34]

Hysteroscopy has a primary role to increase fertility in most of the congenital and acquired problems affected women in fertility age, allow defining that diagnostic and operative hysteroscopy is a rapid and safety technology to improve fertility.

Uterine pathologies, including congenital or acquired lesions, have been reported in 21 to 47% of patients undergoing in vitro fertilization cycles. Hysteroscopy can diagnose and remove polyps, submucosal myomas distorting uterine cavity, reduce cervical stenosis, septa and adhesions, and finally diagnose chronic asymptomatic inflammation.

Some studies have started to evaluate the importance of subjecting the patient to an office hysteroscopy before ART, considering patient compliance, possible side effects and complications of the procedure. It is made that even office hysteroscopy should be part of the infertility workup before ART also in patients with normal HSG findings. This is especially relevant in patients with prior failed ART cycles.[35]

Hysteroscopy can be therefore used also to perform tubal sterilization in outpatient setting thanks to the risks associated with general anesthesia, the cost and the length of hospital

Essure [redacted] is the first device for hysteroscopic tubal sterilization authorized by FDA in [redacted] 2002.[36] It is a small flexible spiral [redacted] (length 40 mm-diameter 0.8 mm) [redacted] of nitinol, stainless steel and polyethylene terephtalate). The procedure is performed in vaginoscopy with [redacted] speculum and tenaculum using a rigid hysteroscope with the diameter smaller than 5 mm. The micro device is released and expands staring inside the tubes stimulating an inflammatory reaction that causes a permanent fibrotic occlusion of the lumen by three months.[37] It takes between 15-25 minutes to be performed and recent studies reported a success rate higher than 90%.[38-40]

Another therapeutic alternative that comes out form the recent development of hysteroscopy is to treat abnormal uterine bleeding. Dysfunctional bleeding is always a major gynecological problem, particularly in women over 40, and is not easy to resolve with medical treatment.[41] In fact, hormonal medication often has a transitory effect and cannot be administered for long periods of time.

The possibility to ablate the endometrium is a minimally invasive approach that found its

main application in those patients resistant to medical therapy and contraindication to surgery or for those who want to preserve their uterus.[42, 43]

The first generation techniques are implemented under direct vision of uterine cavity, for transcervical, with use of a loop electrical and/or rollerball. The outcomes of these techniques, difficult to learn, are strictly dependent from the experience of the surgeon.[44, 45] The second generation devices has been essentially developed to reduce the failure rate and transform the procedure in something more simple and much less dependent from the surgeon allowing in some cases to perform the procedure in an out-patients setting. Trying to improve the efficacy lot of different techniques has been employed such radio frequency, microwaves and hydrothermal ablation.[46, 47]

The radio frequency ablation tool uses a triangle mesh adaptable to the endometrial cavity a generator that transmits radio waves (500 kHz, 180 watts) through a probe of 8 mm.

A tissue impedance limit of 50 ohms, fined by the system and its tissue myomet determines the end of intervention, th tion of which is less than 2 minutes Sure system can be applied for r cavity with dimensions of b cm. The success rate at one orrhea rushes in 43% of

The microwave te Microwave Endom tem, Minitouch is based on th duced by m probe o ing to 6 the duration of minutes. Require cervical dilation and therefore local anesthesia; the success rate at one year is 97% and amenorrhea was reported in 33-53% of cases.[49, 50]

This device is the only approved in women with submucosal myomas of diameter >3 cm or with an endometrial thickness >14 mm; even patients with low C-section can be treated if the thickness of the scar, measured with TVUS, is >8 mm.

Hydrothermoablation (HTA) differs from the other second generation devices to be a hysteroscopic endometrial ablation procedure executes with vision, based on the use of a hysteroscope to 3 mm with the outer shirt of 7.8 mm. The technique consists in endometrial instillation closed-loop and continuous saline pre-heated to 80-90° C, for a period of 10 minutes, at pressures (40-50 mm/Hg) lower than those sufficient to force the tubal passage (60 -70 mm/Hg). The liquid circu freely in the uterine cavity, reaching also t tubal and thus acting on the metrial surface.

It requires local nd endometrial preparation; the avity should measure <12 cm, but f uterus can be treated. The succe year i ith amenorrhea r 0-60% .[49, 51]

De d effe ene hysteroscopy nosis impaired by an ndomet hinn ss that may hide s tracavi alities. This small disadvantage sily overtaken planning e proce early proliferative phase of the cle or controlling the endometrial ing with hormonal drugs.

studies, pretreatment of the en for three month with GnRH anaogu (GnRH-a) - prior to endometrial ablation has been reported to increase the success e, as well as to reduce the menstrual blood flow, accounting for a significantly higher postoperative amenorrhea rate. The advantages are also improved hysteroscopic view, reduced blood loss, absorption of uterine distending fluid. The aim of pretreatment is not only to obtain a thin endometrium but also to reduce the size and vascularization of myomas being treated, with advantages for operating time. Prior to hysteroscopic myoma resection, pretreatment with GnRH-a may be particularly indicated for all myomas with a diameter of more than 3 cm and/or with an intramural portion, or for patients suffering from secondary anemia.[52]

Hysteroscopic examination may also be preceded by a drug treatment involves the use of drugs such as progestins or danazol, which

have effects consistent with the treatment with GnRH, but fewer side effects. A short pretreatment with combined oral contraceptive containing dienogest (DNG) and estradiol valerate (E_2V) seems to have a favorable impact on endometrium, which can result in an improvement of the overall results of office hysteroscopy.[53]

Conclusions

Hysteroscopy arose as a diagnostic technique but then it also became an alternative surgical technique for many diseases, offering therapeutic and irreplaceable possibilities of treatment, avoiding major surgery on the one hand and allowing the correction of several pathologies on the other hand.

In conclusion, the modern development of hysteroscopy completely transformed the approach to the uterine intracavitary pathologies moving from a blind procedure under general anesthesia to an outpatient procedure performed under direct visualization. Th[illegible] changes improved dramatically the treat[illegible] effectiveness and reduced the costs and [illegible] not least enhanced patient's comp[illegible] satisfaction.

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Conflicts of interest.—The author[illegible]here is no [illegible]rest with any financial organization regarding the material discussed in the manuscript.

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