Hysteroscopy Simplified by Masters

Sunita Tandulwadkar
Bhaskar Pal
Editors

Hysteroscopy Simplified by Masters

Sunita Tandulwadkar • Bhaskar Pal
Editors

Hysteroscopy Simplified by Masters

Springer

Editors
Sunita Tandulwadkar
Department of Obstetrics and Gynaecology
Ruby Hall Clinic
Pune
India

Bhaskar Pal
Department of Obstetrics and Gynecology
Apollo Gleneagles Hospitals
Kolkata
India

ISBN 978-981-15-2504-9 ISBN 978-981-15-2505-6 (eBook)
https://doi.org/10.1007/978-981-15-2505-6

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

This book is dedicated to all those who have passion for endoscopy and craving for updating oneself and to those who do not want to stop learning at any stage of professional life!

Foreword

As the Chair of Global Community of Hysteroscopy (GCH) I had the opportunity to meet Dr. Sunita Tandulwadkar years ago. During the last few years we have been collaborating in many scientific projects, collaboration that developed also into a friendship, and when she asked me to write a foreword for her book, I felt very honored.

Sunita is a prominent endoscopist with a focus on reproductive surgery. Her skills are known in her country, India, but also internationally. Her curiosity and interest for the uterine cavity and the effect on fertility is the fuel of her passion, a passion that we share together.

As president of the IAGE during 2019–2020 she gave hysteroscopy the place it deserves by creating important CME programs for the gynecologists in her country, helping to improve skills but at the same time focused on research. The seed she planted on this surgical procedure will flourish for years to come. It was only a matter of time for her to come with this idea as the culmination of her great work, a book.

This book is not just another book on hysteroscopy, but a step forward compared to other publications in the same field—a fact not only based on the excellent contributors she has chosen, both national and international, but based mainly on the topics included.

This book is focused on giving an answer to all those questions a surgeon of the uterine cavity may have, before the procedure, during the procedure, and even after it is finished. Topics are chosen in a very pragmatic way, directed to the most important issues related to hysteroscopy surgery, both for professionals that wish to start performing their first steps and for those who just would like to improve their skills.

I know that as a reflection of the personal success, this book quickly will become a reference in the hands of all the hysteron lovers.

Barcelona, Spain
Hadera, Israel
Haifa, Israel

Sergio Haimovich

Preface

The future belongs to those who believe in the beauty of their dreams
—Eleanor Roosevelt

Only those who practice perseverance achieve the dream! I saw an academic dream and probably have succeeded with the help of so many colleagues who believed in my dream! Being adventurous in nature, I had developed the habit of learning and introducing new advancements into my practice.

Hysteroscopy has been a part of routine gynecological practice and a main diagnostic tool for intrauterine pathology in the modern era. Being it "office" or in the operating room, hysteroscopy has the advantage of diagnostic as well as therapeutic knifeless day care procedure with minimal complications even in the most complex cases in one sitting by "see and treat" way.

The idea behind this comprehensive book on hysteroscopy is to share myriad clinical pearls by expert contributors to improve patient care and to minimize complications of hysteroscopy. This book can be a guide to gynecologists for case management efficiently on a daily basis. This book is also conceived with beginners in mind to help them become masters in hysteroscopy.

The book covers the most up-to-date and detailed possible though precise, consisting of 20 experts across the globe as contributors. It consists of more than 20 chapters, and illustrated by over 20 images to make it a kind of Hysteroscopic Atlas that you would love to have at your desk. We are more focused on practical aspects of each procedure along with common questions, tricks and tips to prevent complications.

I believe hysteroscopy is an art! To make beautiful cavity out of completely obliterated one in Asherman syndrome and to achieve successful implantation demands something more than just a skill! The excellent outcomes from operative hysteroscopic and minimally invasive surgical procedures keep us inspired!

We would like to thank all the contributors, our patients who entrusted us for their care, publisher, sponsor…

Finally, to our families and friends who supported us outside of our work place, we thank you!

Pune, Maharashtra, India — Sunita Tandulwadkar
Kolkata, India — Bhaskar Pal

Contents

About the Editors

Sunita Tandulwadkar, MD, FICS, FICOG presently works as the Head of Department of Obstetrics & Gynaecology, Ruby Hall Clinic, Pune, India and Chief of Ruby Hall IVF and Endoscopy Center, Pune, India. She is also the Director of Solo Clinic, Centre of Excellence Infertility & Endoscopy and Founder & Medical Advisor of Solo Stem Cells, Stem Cells Research & Application Centre, Pune, India and Co-Founder of Solo Research Foundation (SPONSOR A BIRTH).

She is the president of the Indian Association of Gynecological Endoscopists (IAGE) (2019–2020); chairperson and founder secretary of Maharashtra State Chapter of the Indian Society for Assisted Reproduction (ISAR) (2019–2020); and 2nd Vice President of Indian Society of Assisted Reproductive Medicine; Founder Secretary of Maharashtra Chapter ISAR; Vice-President of West Zone FOGSI (2017). She was an elected board member of the International Society of Gynecologic Endoscopy (ISGE) (2013–2017). She was chairperson of the Infertility Committee of the Federation of Obstetrics and Gynecology of India (FOGSI) (2011–2013) and the west zone vice-president of FOGSI. She is also the Reviewer of Fertility and Sterility and Advisor & Reviewer of Journal of Human Reproductive Sciences. She has published several books and contributed many book chapters. She is an active member of various national and international societies and committees. Dr. Tandulwadkar also conducts workshops and trainings to help educate promising future doctors.

Bhaskar Pal, MD, DGO, DNBE, MRCOG, FICOG has been a Senior Consultant in Obstetrics and Gynaecology at Apollo Gleneagles Hospital, Kolkata, for the past 17 years. His area of interest is minimal access surgery. He has authored over 30 publications and book chapters and has co-edited four books.

Dr. Pal was vice-president of the Federation of Obstetric and Gynaecological Societies of India (FOGSI) in 2017. He is currently the general secretary of the Indian Association of Gynaecological Endoscopists (IAGE) and chair of the India East International Representative Committee of the Royal College of Obstetricians and Gynaecologists, London. He is the president elect of the Bengal Obstetric and Gynaecological Society and was the Biostatistician for the *Journal of Obstetrics and Gynaecology of India (2007–09)*. He was a member of the Governing Council of the Indian College of Obstetrics & Gynaecology (ICOG) (2015–17) and Chairperson of the Young Talent Promotion Committee of FOGSI (2011–13).

1 History and Evolution of Hysteroscopy

Sejal Naik and Sweta Patel

The telescope to view the uterine cavity, the hysteroscope, has evolved over the last two centuries. In 1805, a long-standing desire of physicians to see into the interior of body cavities was fulfilled. Hysteroscopy is a technique by which we can peep into the cavity of the uterus through the cervix. Before the advent of hysteroscope, the standard procedure of blind dilatation and curettage was used along with hysterosalpingography (HSG) for the evaluation of the uterus [1, 2].

Bozzini in 1805 first peered into the urethra of living subject and this was the beginning of endoscopy which has now advanced into a modern endoscopic surgery. Bozzini described the device and its use for the illumination of "inner cavities and interstices of the living animal body." In the preface of this article, he wrote, "Every invention owes its origin to a happy combination of various circumstances; it is always born like a child, and like a child keeps becoming nearly perfect in a step-wise fashion [1]." The device consisted of a tubular speculum. A candle was put into the square-windowed, hollow tube, while light was directed by a concave mirror through the tube into the cavity which was to be examined. The results, however, were unsatisfactory (Figs. 1.1 and 1.2).

Fig. 1.1 Philipp Bozzini

Fig. 1.2 First endoscope 1805–1807

S. Naik (✉)
Belly & Love, Women's Care, Surat, India

S. Patel
Female First hospital, Surat, India

S. Tandulwadkar, B. Pal (eds.), *Hysteroscopy Simplified by Masters*,
https://doi.org/10.1007/978-981-15-2505-6_1

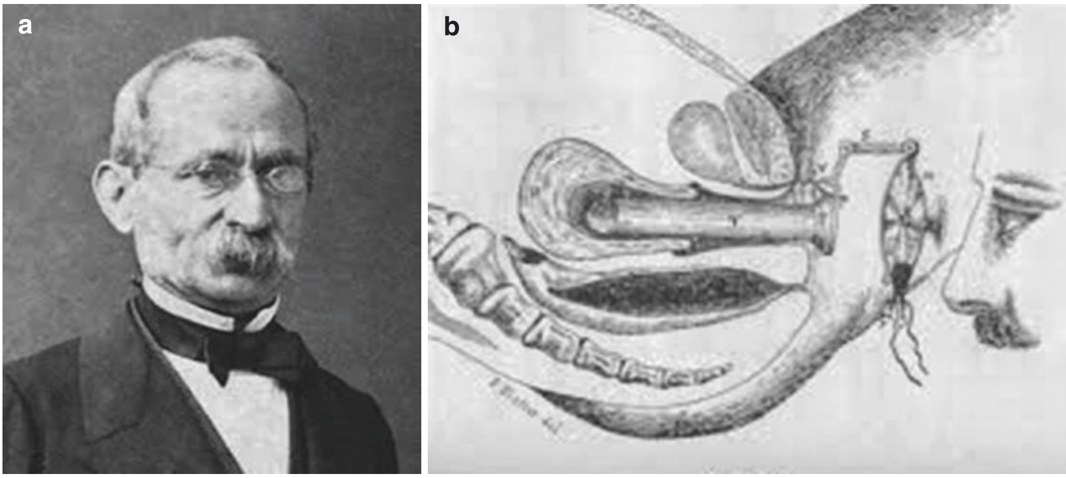


Fig. 1.3 (**a**) Pantaleoni (1810–1885) (**b**). Hysteroscopy as describe by S. Duplay and S. Clado, 1898

The credit of performing the first successful hysteroscopy goes to Pantaleoni in 1869. He evaluated a 60-year-old lady with therapy-resistant bleeding and detected a polypoid growth in the uterus on hysteroscopy, which was cauterized with silver nitrate [3] (Fig. 1.3).

Ernst Bumm [4] reported his first experiments and experiences with hysteroscopy in Vienna congress. He used endoscope that is commonly used for the male urethra. A head lamp with an incandescent light reflector served as an illuminator. This instrument enabled him to discover changes in the mucosa of the uterus, such as hyperaemia, granulation, uterus and polypoidal growth, but he also mentioned the disadvantages and difficulties such as bleeding which disturbed visualization.

Uterine cavity is not easy to explore, given the difficulty of distending its walls, in addition to its physiological fragility as well as tendency towards endometrial mucosal bleeding.

David [5] was first to use a workable hysteroscope in which the illuminating device modelled as Nitze's cystoscope was mounted near the viewing end and had a magnifying effect by way of a built-in lens. The viewing end of the inserted instrument was inserted into the fundus of the uterus. He demonstrated that endoscopy of the uterus was not only possible, but it considerably enriched gynaecologic diagnosis. In 1914 Heineberg [6] of Philadelphia described an endoscope equipped with a light source similar to Nitze's cystoscope but with an additional inner water sprinkler. The purpose of this was to rinse off the blood which covered the lens and hindered the view. In most cases, the result of the observation was satisfactory. His reason for endoscopic inspection of the uterine cavity was recognition of endometritis and exertainment of the presence of retained placenta after abortion (Fig. 1.4).

The uterus, a small cleft-shaped hollow cavity, is surrounded by tough, easily expanding muscle walls and its mucous membrane has the characteristic of bleeding even when slightly touched. Rubin [7] developed further methods to overcome this difficulty. His attempt to insufflate with carbon dioxide instead of water brought better result. He treated bleeding with an application of adrenaline. Out of 42 women, only 6 were disturbed by bleeding during his study. In some cases, patients were slightly affected by the insufflation. No infections were observed. Seymour [8] introduced a hysteroscope in 1926 which had a suction tube which drained away the mucus and blood.

After having carried out over 350 trouble-free examinations, Schroeder [9] felt that hysteroscopy was an excellent diagnostic tool for the recognition of certain intrauterine diseases. Exactly like these procedures, he could recognize the various cycles of the endometrium and patho-

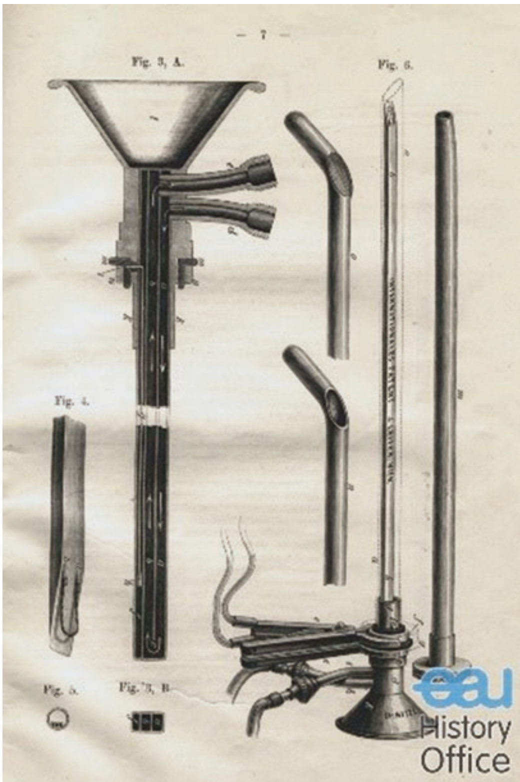


Fig. 1.4 Nitz's cystoscope

logic and anatomic changes, especially polyps and submucous fibroids. He emphasized the value of hysteroscopy for the radiologist who could located a corpus carcinoma and through this establish a targeted radium application. It was also possible to study the endometrium in vivo in the case of primary and secondary amenorrhoea. Von Midulicz, Radecka and Frand used saline as a rinsing system with separate channels for inlet and outlet [10].

Maleschki [11] published his observations on the blood circulation of the human endometrium according to the different cyclical phases and the colour of the mucous membrane changes. The fluctuations were unknown. Edstrom and Fernstrom [12] in 1970 used about 50–100 mL of a highly viscous 32% dextran-70 as a solution for the inspection of the uterus. The solution flows slowly under pressure through the tubes into the uterus. In order to keep the cavity at a constant level of expansion the cavity is constantly reflected from outside. Their hysteroscope was equipped with two separate canals. One is used to insert the dextran solution for expansion of the uterine cavity, whereas through the other one, a flexible biopsy forceps could be guided. Examination was done under barbiturate anaesthesia or paracervical block. They found dextran superior to other distension media because of its property of high viscosity and immiscibility with blood.

Various workers used a different distending medium to improve the visibility and ensure safety, especially in operative procedures. The credit of using 1.5% glycine instead of dextran for operative endoscopy goes to none other than Jagnes Hamon, a French surgeon. An ideal distension medium which is totally physiological and which will not cause fluid overload or electrolyte disturbances is yet to be found.

Lindemann [13] for 2 years practised hysteroscopy with a newly developed method, wherein the uterine cavity is filled with carbon dioxide gas. The best visibility was achieved when 80–100 mL/min of carbon dioxide gas with a pressure of about 200 mmHg is insufflated into the cavity and both tubes are penetrated with a viewing period of 5 min which is sufficient for the examination of the cavity. About 500 mL of carbon dioxide gas is insulated into the peritoneum. This gas quantity affects the patient only slightly if at all with diaphragmatic irritation and subsequent shoulder pain.

The improvement in optics, video system, safe and effective distension media and reduced telescope size has led to increased acceptance of hysteroscopy by both physicians and patients when symptoms require direct intrauterine examination.

References

1. Brooks PJ, Serden SP. Hysteroscopic findings after unsuccessful dilatation and curettage for abnormal uterine bleeding. Am J Obstet Gynaecol. 1985;158:1354–7.
2. Vallie E, Zupi E, Marconi D. Outpatient diagnostic hysteroscopy. J Am Assoc Gynaecol Laparosc. 1998;5:397–402.

3. Palaleoni DC. On endoscopic examination of the cavity of the womb. Med Press Circ. 1869;8:26–7.
4. Bumm E. Experimente and Erfahrungen mitder Hysteroskopie. Wiener Congress, 1895.
5. David Ch. L'endoscopie uterine (hysteroscopy) applications au diagnostic et au traitement des affection intrauterines. Par. G.Jaques. p.1 pl. 8, 1908. p. 132.
6. Heineberg A. Uterine endoscopy; an aid to precision in the diagnosis of intrauterine disease, a preliminary report, with the presentation of a new uteroscope. Surg Gynec Obstet. 1914;18:513.
7. Rubin JC. Uterine endoscopy, endometroscopy with the aid of uterine insufflations. Am J Obstet Gynecol. 1925;10:313.
8. Seymour HFJ. Endoscopy of uterus; with a description of hysteroscopy. BMJ. 1925;2:1220.
9. Schroeder C. Uber den Ausbau and die Leistung der Hysteroscopie. Arch Gynak. 1934;156:407.
10. Von M, Radecki F, Freund A. Ein neues hysteroskop and Sein praktische Anwendung in der Gynakalogie. Zeitschriff fur Geburstshilfe and Gynakalogie, 1927.
11. Maleschki V. Die modern Zervikoskopie and Hysteroskopie. Abl Gynaek. 1966;88:20.
12. Edstrom K, Fernstrom J. The diagnostic possibilities of a modified hysteroscopic technique. Acta Obstet Gynecol Scand. 1970;49:327.
13. Lindemann HJ. Eine neue Methode fur die Hysteroskopie. In: Fifth Kongre Deutsche Gesellschaft fur Endoskopie, Erlangen, 1972.

2 Instrumentation in Hysteroscopy

Sujata Kar and Kirty Nanda

2.1 Introduction

Hysteroscopy is derived from the two Greek words 'hystera' meaning uterus and 'skopeo' meaning to view. *Hysteroscopy* is the procedure of inspection of the uterine cavity by endoscopy through the cervix. It is used as a diagnostic tool for intrauterine pathology as well as a method for surgical intervention (operative hysteroscopy).

The diameter of the modern hysteroscope is generally small enough to conveniently pass the cervix directly. For a proportion of women, cervical dilation may need to be performed prior to insertion. Cervical dilation can be performed by pretreatment with misoprostol prior to the procedure or by serial dilation with the help of dilators.

2.1.1 History

It was first performed on a live human subject in 1869 by Diomede Pantaleone, who used a tube with external light source to detect 'polyp' within the uterine cavity in a 60-year-old female who was complaining of abnormal uterine bleeding. He successfully treated her with repeated cycle of silver nitrite. Later David performed hysteroscopic examination using a cystoscope with an internal light and lens system.

While Von Midulicz, Radecka and Freund used saline as a rinsing system, Edstrom and Ternstrom used 32% Dextran 70 as a distension medium and claimed it to be superior to other distension media because of its property of high viscosity and immiscibility with blood. Various workers used different distending media to improve the visibility and ensure safety, especially, in operative procedures. It was only in 1967 that Fritz Menken made a first step towards an atraumatic ambulatory approach using a paediatric cystoscope to perform a hysteroscopy. The distension of the uterine cavity was done with a high colloidal liquid, called luviscol, and an elastic cone was used to seal the cervical channel and prevent leakage of the liquid [1].

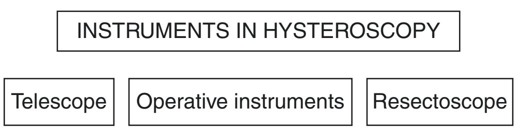
In the 1970s, Lindemann et al. [2, 3] published their experimental findings regarding the influence of CO_2 gas during hysteroscopy. Here, for the first time, not only the advantages of this new method but also the possible dangers and complications of gas insufflation were analysed. Cornier [4], and Lin et al. [5] tried to find a new way by using a flexible hysteroscope, a small flexible bored instrument with a channel for instrument application, through which, for example, laser wires could be applied. The use of the Nd-YAG laser for the destruction of the endometrium in patients with idiopathic uterine bleeding disorders, as published by Goldrath [6], was certainly

S. Kar (✉) · K. Nanda
KCHPL, Bhubaneswar, India

S. Tandulwadkar, B. Pal (eds.), *Hysteroscopy Simplified by Masters*,
https://doi.org/10.1007/978-981-15-2505-6_2

the start for renewed interest in this method by the public, mainly because the transcervical approach offered a safe and valid alternative with extremely high patient compliance in comparison to the transabdominal approaches [7]. At the end of the 1980s, CO_2 was replaced by watery or low-viscosity solutions as a distension medium and the introduction of a continuous flow system enabled the surgeon to restore view in nearly every situation. Hamou, in 1979, idealized the microhysteroscope with panoramic vision and of contact. The introduction of the atraumatic technique, the new mini-hysteroscopes and the technically superior video documentation now raises the chances that hysteroscopy, both diagnostic and operative, may become established as a routine procedure by every gynaecologist. The new generation of mini-endoscopes, both rigid and microfibre systems, have excellent to acceptable optical qualities with a large image diameter, sufficient brightness, good resolution and a field of view which allows panoramic sight. These instruments are suitable for both laparoscopy and hysteroscopy [8, 9].

In the last 150 years with the advancement of technology, developments in optics and fibreoptics, instruments and distension media help gynaecologist all over the world to diagnosis and treat many intrauterine pathologies.



2.1.2 Telescopes/Hysteroscopy

The telescopes have three parts:

1. The eyepieces: the end on the observer side which gets attached to the camera.
2. The barrel: containing the optical fibres and lens systems; light source is attached to it. It can be rigid or flexible, unicompartmental or multi-compartment.
3. The objective lens: it is the main optics of the scope placed at different angles for different viewing purposes.

In general, hysteroscopes are classified as rigid or flexible. It is designed for both diagnostic or operative use and possessing fixed or variable focussing. The key specification of a hysteroscope are telescope diameter, lens offset, sheath diameter and its ability to be used with a variety of distention media.

2.1.3 Rigid Telescope

There are most commonly used and most preferable for operative procedures. Usually they vary in size according to function and requirement. Size as small as 3 mm when coupled with endoscopic video system with zoom lenses are highly satisfactory for both office hysteroscopy as well as operative procedures. The 4 mm gives the sharpest and clearest image:

(a) 3 mm—rarely cervical dilation required
(b) >5 mm—specific surgical instrument through separate parts
(c) 8–10 mm—continuous flow of media.

Optics: The lens system is basically derived into three types:

(a) Classical optics.
(b) Hopkins.
(c) Graded index lens system (GRIN).

In Classical optics the width of the lens is far less than that of a telescope and also distance between lenses is large. On the other hand, in Hopkins the lens has a larger diameter with smaller separation between the lenses, thus providing a larger angle of view and brighter image. In the GRIN system, the entire telescope is occupied by a slender red of glass. This lens system is mostly used in contact hysteroscopy.

The picture through the hysteroscopy is affected by the angle of lenses to the central axis of the telescope. The telescope has a viewing angle of 0° straight on and 30° for oblique view. The advantage with 0° lenses is that it centred along the axis of the endoscope so that a 360° rotation of the telescope will not change the view. Again the 0° lens allows the operator to see operative devices on a relatively distant panorama; on the other hand, with fore-oblique lens, when the telescope is rotated 360°, an expanded field of view is seen. The 180°, 0°, 15° and 25° angles may be more beneficial for the resectoscope. The depth of visual field of these telescopes is about 2 to 3 cm with 4× to 5× magnification with liquid distending medium. Most hysteroscopes posses an outer lens that will provide a 60° to 90° field of view depending on the distending medium. In gaseous medium, the view is wider compared to the aqueous media due to more optimal refractive index.

2.1.4 Sheath

There are basically two types of sheath: (a) diagnostic and (b) operative.

(a) *Diagnostic*: It is required to deliver the distending media into the uterine cavity. The sheath is 4–5 mm in diameter, depending upon the outer diameter of the telescope leaving 1 mm space in between to deliver the distending media. The telescope and the sheath are secured by a watertight seal that locks them in place and the medium instillation is controlled by an external stopcock.
(b) *Operative sheaths*: These have a layer diameter ranging from 7 to 10 mm with an average of 8 mm as these have space for instillation of the medium, for telescope and for operative devices. These are again of two types: one with single cavity for all three and the other with isolated cavity for each. The major disadvantage of single cavity is its inability to flush the uterine cavity with distending media and difficulty in manipulating the operating tools inside the cavity. The popular model of isolated channel sheath that consists of a double-flushing sheath permits media instillation by way of inner sheath and media reliever by outer perforated sheath. The constant flow of liquid medium in and out of the cavity creates a very clear operative field.

2.1.5 Flexible Telescope

The flexible telescope was initially described by Brueseke and Wilbanks in 1974. It also comes in various sizes ranging from outer diameter of 8.5–3.6 mm. A standard 4.8-mm-diameter fibre-optic hysteroscope with an operating channel of 2 mm consists of three sections:

(a) A soft flexible front section.
(b) A rigid-rotating middle section.
(c) A semirigid rear section.

The major advantage of these is they offer steerability and flexion inside the uterus for better viewing of the uterotubal openings, for aligning the catheter for tubal canalization and for viewing lateral aspects of the uterine wall. Nowadays, these are available as single-use sterile sheaths which eliminate the need to sterilize the equipment in between cases.

Drawbacks of flexible hysteroscopes include the fact that only a gaseous distending medium is recommended, diminution in the image and its resolution due to light transmission by fibres and its high cost.

2.2 Operative Instruments

The ancillary instrument for use through rigid hysteroscope are of three types: (a) flexible, (b) semirigid, and (c) rigid.

The flexible instruments like biopsy forceps, grasping forceps, and scissors are fragile and cumbersome and need frequent replacement. Development of the large isolated channel sheath has made the use of totally flexible 3 mm operative instrument feasible. Semirigid instruments provide easier manipulation and durability. They bent slightly but cannot be bent to 90° without breaking. The rigid instruments are fixed at the end of the operating bridge attached to the dorsal aspect of the distal end of the sleeve in such a way that the instrument tip is in full endoscope view. These are cumbersome to use, require the whole instrument to be moved towards targets reducing the viewing field. Again, the entire hysteroscope has to be removed while changing the instrument. Great care should be taken to avoid perforation. Other operative devices include monopolar balls, needles, shaving loops, bipolar balls and cutting loops electrodes, bipolar scissor and needles.

2.2.1 Resectoscope

This is a specialized electrosurgical endoscope that consists of inner and outer sheaths for providing a continuous flow system. It includes straight forward 0° or 30° telescope with a 3.5–4 mm outer diameter; the outer sheath is 8–9 mm (29 F) in diameter. The double-armed electrode is fitted to a trigger device that pushes the electrode out beyond the sheath and then pulls it back within the sheath. By activating the spring mechanism, the electrode can be moved about 4 cm into the visual field, providing a clear unobstructed view of the uterine cavity. Other operating tools consist of four basic electrodes: a cutting loop, ball, button and angulated needle. Contemporary small-diameter resectoscopes use a 3 mm telescope and a 7–7.5 mm sheath.

2.2.2 Some Special Hysteroscopic Instruments

2.2.2.1 Versa Point

This is a type of bipolar instrument that can be used with normal saline solution as distension media. Thus it combines the two conventional output modalities of bipolar and monopolar electrosurgery in a specific system configuration. Unlike conventional bipolar electrodes, this system utilizes the fact that the irrigating solution is conductive to stagger the electrode arrangement at the tip so that the “return” electrode is mounted on the shaft of the instrument and thus remote from the tissue. Firstly, the proximity of the return electrode to the working tip and the fact that no tissue other than that contacting the active electrode is involved in the electrical circuit preserve the recognized safety features of bipolar electrosurgery. Secondly, this arrangement may avoid problems commonly encountered when using bipolar electrosurgery: orientation of the electrode to tissue visualization of the working tip, tissue sticking and limited power delivery.

2.2.2.2 Contact Hysteroscopy

This, mentioned earlier, rely on GRIN lens and do not require a distension media or fibre-optic light. Rather a light-collecting chamber is there located near the eyepiece. For viewing, the endoscope must touch the object. Because of rigid glass guide, there is no distortions from transmitted images. Also, it provides a magnification of 1.6 times without any lens. Greater magnification depends on the eyepiece. Its major advantage is excellent visualization even in the presence of bleeding. The major drawback is lack of panoramic view and inability to operate through the scope.

2.2.2.3 Microhysteroscopy

Hamon described it as instruments that can provide a panoramic view of the distended uterine cavity along with providing contact and 150x magnified views as well.

Key Points

1. Instruments used in hysteroscopy are divided as telescope and optics, operative instruments and resectoscope.
2. Telescope can be rigid or flexible.
3. Three types of lens systems are present: classical, Hopkins and GRIN.
4. Sheaths are of two types: diagnostic and operatives.
5. Special hysteroscope consists of resectoscope, Versapoint, microhysteroscopy and contact hysteroscopy.

References

1. Menken FC. Fortschritte der gynäkologischen Endoskopie. In: Demling L, Ottenfann R, editors. Fortschritte der Endoskopie, Bild. I. Stuttgart: Schattauer; 1967.
2. Lindemann HJ, Mohr J, Gallinat A, Buros M. Der Einfluß von CO2 Gas während der Hysteroskopie. Geburtshilfe Frauenheilk. 1976;36:153–62.
3. Lindemann HJ, Gallinat A, Lueken RR. Metromat—a new instrument for producing pneumometra. J Reprod Med. 1979;23:73–5.

4. Cornier E. Ambulatory hysterofibroscopic treatment of persistent metrorrhagias using the Nd:YAG laser. J Gynecol Obstet Biol Reprod (Paris). 1986;15:661–4.
5. Lin BL, Miyamoto N, Tomomatsu M, et al. The development of a new flexible hysterofiberscope and its clinical applications. Nippon Sanka Fujinka Gakkai Zasshi. 1987;39:649–54.
6. Goldrath MH, Fuller TA, Segal S. Laser photovaporisation of the endometrium for the treatment of menorrhagia. Am J Obstet Gynecol. 1981;140:14–21.
7. Fayez JA. Comparison between abdominal and hysteroscopic metroplasty. Obstet Gynecol. 1986;68:399–403.
8. Karabacak O, Tiras MB, Taner MZ, et al. Gazi small diameter versus conventional laparoscopy: a prospective, self-controlled study. Hum Reprod. 1997;12:2399–401.
9. Risquez F, Pennehoaut G, McCorvey R, et al. Diagnostic and operative microlaparoscopy: a preliminary multicentre report. Hum Reprod. 1997;12:1645–8.

3 Energy Sources in Hysteroscopy

Omer Moore and Sergio Haimovich

The use of electricity is an integral part of hysteroscopy. Some of the hysteroscopic instruments being used routinely for diverse kinds of procedures demand different power setting. The surgeon has to be familiar with the electrosurgery physical principles, in order to use confidently the instruments, making the least possible accidents.

The hand instrument connected to an electric generator may bring to bear the electricity capabilities, giving it the operative ability in the uterus.

There are different types of energy in use, among them we may find bipolar and monopolar energy, both being used today as the main energy in the operative hysteroscopy. Laser energy which lately gains momentum in the operative hysteroscopy or microwave energy which is being used today in ablation therapy. In order to bring those energy types to usage, a hand instrument will transform them to heat.

O. Moore (✉)
Department of Obstetrics and Gynecology, Yitzhak Shamir Mecical Center (Formerly Assaf Harofeh), Zerifin, Israel

The Sackler Faculty Of Medicine, Tel Aviv University, Tel Aviv, Israel

S. Haimovich
Del Mar University Hospital, Barcelona, Spain

Hillel Yaffe Medical Center, Hadera, Israel

Technion – Israel Institute of Technology, Haifa, Israel

The versatility of procedures in the field of operative hysteroscopy is large. In a variety of ways, the surgeon may use one of the hysteroscopic hand instruments in order to solve the pathology or he may choose one of the other instruments in hand.

It is expected from any hysteroscopy surgeon to be deeply familiar with the pathology, knowing the different surgical technological options and the differences between the hand instruments and their usage.

It is important that the surgeon will be familiar with the electrosurgery physical principles, in order to use confidently the instruments, making the least possible accidents.

The ability of the electrosurgical instruments to achieve minimal blood loss and to reduce the operation time has a great medico-economic significance. With the hand instruments that we have in use now and the ones that we will have in the future, along with the surgeon's familiarity with the equipment, we will be able to face new pathologies in a better and safer way.

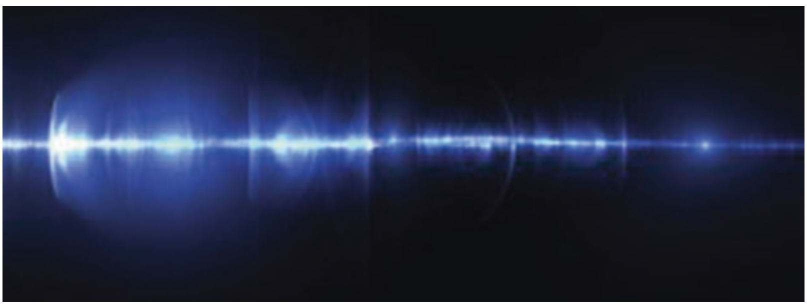
The electricity in endoscopy, whether it is hysteroscopy or laparoscopy, is based on the same principles.

Hundreds of years ago, heat was used to stop bleeding. The use of electrical devices, to heat tissue and control bleeding, was used as technology advanced. Modern-day electrosurgery is a result of these advancements (Table 3.1).

S. Tandulwadkar, B. Pal (eds.), *Hysteroscopy Simplified by Masters*,
https://doi.org/10.1007/978-981-15-2505-6_3

Table 3.1 shows the evolution of electricity used in surgery

Time of advancement	Researcher	Advancement
Early nineteenth century	Henri **Becquerel** (French physicist)	Heating a wire by passing a direct current (D.C.) through it, effectively cauterizing the tissue upon contact.
1881	Jacques-Arsène **d'Arsonval** (french biophysicist)	Was the first to use an alternating electrical current (A.C.) in a human body. *Proving that at a frequency of 200 kHz or higher alternating electrical current could pass through the human body without causing muscle stimulation, but instead generates heat in tissue.*
1890–1910	Karl Franz **Nagelschmidt** (German physician)	By understanding that cellular ions collide and release energy, he was able to develop a machine that is capable of producing the following therapeutic tissue effects: Fulguration, desiccation and cutting.
Late 1920's	William T. **Bovie** (American scientist) Harvey **Cushing** (American neurosurgeon)	Electrosurgical units we use today are a direct result of their research. Bovie used the knowledge to create his electrosurgical device and he first employed it in neurosurgical cases with Harvey Cushing. Dealing with bleeding.



3.1 Electrosurgery Principles and Types of Energy Used in Hysteroscopy

3.1.1 Electrosurgery Basic Principles

To better understand the mechanism of electrosurgery in hysteroscopy, one must know the basics of electricity.

- *Electrical current* flows when electrons from one atom move to an adjacent atom through a circuit.
- *Voltage* (V) is the necessary force that mediates or drives this electron movement. This power is measured by volts.
- *Current* (I) is the movement of electrons in the same direction, measured by amperes.
- *Resistance* (R) is the difficulty in driving the electrons through the tissue or other materials, measured by ohms.
- *Heat* is produced when electrons encounter resistance.

The flow of electricity in living tissue being governed by Ohm's law:

$$\text{Voltage } (V) = \text{Current } (i) * \text{Resistance } (R).$$

The circuit in the operating room consists of the patient, electrosurgical generator, and the active and return electrodes.

- *The circuit* has to be continuous in order for current to flow.
- *The electrosurgical unit* is the source of the voltage.
- *The active electrode* conducts electrons to the patient.
- *The patient's tissue* provides resistance to current flow, thereby producing heat and the resulting tissue effect.
- *The return electrode* is responsible of returning the current flow to the electrosurgical unit through either the conducting instrument itself or a patient return electrode.

All of this leads to basic *principles of electrosurgery*, found in Box 3.1.

The factors appearing in Box 3.2 have a major impact on tissue effect: current density, time, electrode size, tissue conductivity, current waveform, and manipulation of the electrode.

Box 3.1 Basic Principles to Remember

1. Alternating electric current enters the patient where it seeks the path of least resistance.
2. Electricity always needs to be grounded.
3. Electrical energy made by the flow of electrons will create heating of the tissue, yielding a range of different effects.
4. In order for electricity to work it has to have a complete circuit.

Notice!

- Electrosurgery—using alternating current (A.C.) including the patient in the circuit.
- Electrocautery—using direct current (D.C.) where only the heated wire comes in contact with the tissue. (This term cannot describe electrosurgery.)

Box 3.2 Electrosurgery Factors with Impact on Tissue Effect

1. *Current density*
   (a) The greater the current that passes through an area, the greater the effect will be on the tissue.
   (b) The greater the amount of heat that is produced by the current, the greater the thermal damage on tissue.
2. *Time*
   (a) The amount of time an active electrode is in use will determine the effect on the tissue. Too much time will produce wider and deeper tissue damage (thermal spread).
   (b) The speed with which an electrode is moved will result in either less or more coagulation and thermal spread.
3. *Tissue conductivity*
   - Electrical resistance is different with the various tissue types and this affects the rate of conductivity. The adipose tissue and bone are poor conductors of electricity, having high resistance, whereas muscle and skin are good conductors but have low resistance.
4. *Electrode size*
   (a) To achieve a higher current density one needs to use a smaller electrode, resulting in a concentrated heating effect at the site of tissue contact.
   (b) The return electrodes used in monopolar electrosurgery are large relative to the active electrode in order to disperse the current that is returning to the electrosurgical unit and minimize heat production at this return electrode site.
5. *Current (energy) waveforms*
   - There is a different tissue effect created by different current types. Electrosurgical generators produce three different waveforms—cut, blend, and coagulation. See below.
6. *Manipulation of the electrode*
   - This will determine whether vaporization or coagulation occurs. While sparking to the tissue from distance versus holding the electrode in direct contact with tissue.

3.1.1.1 Current (Energy) Waveforms

- *Cutting waveform* (higher current, lower voltage)
- – Local and intense heating effect that will vaporize tissue with minimal coagulation effect.
  - – To be effective, a cutting current power setting needs to be between 50 and 80 W. Holding the electrode slightly away from the tissue, for achieving the best cutting results, will create a **spark gap** by which the current reaches the tissue. This spark gap results from heating up the atmosphere between the electrode and the tissue.
  - – In comparing a cutting current to a coagulation current, the former produces less charring and tissue damage (Figs. 3.1 and 3.2a).
- *Coagulation waveform* (lower current, higher voltage)
  - – Intermittent waveform, where the generator modifies the waveform so that the duty cycle is reduced to about 5% of time.
  - – When the waveform spikes, the tissue is heated. The tissue cools between spikes, producing the coagulation effect. In order for the current to pass through the highly resistant and desiccated tissue, one needs to use higher voltage. It is possible to cut tissue using coagulation currents at high power; however, this will result in greater charring and tissue damage (Fig. 3.1).
  - – When a discrete bleeder cannot be identified in the surgical field, it is common to use coagulation current in a fulguration way.
  - – *Fulguration* is noncontact coagulation. **A spark gap** is used to mediate the tissue effect resulting in heating, necrosis, and a greater thermal spread (Fig. 3.2b).
  - – *Desiccation* is another form of coagulation, where **direct contact** with the tissue is made, resulting in a total electrical energy conversion to heat within the tissue as opposed to both cutting and fulguration currents which lose a significant amount of electrical energy, when the spark gap is created (Fig. 3.2c).
- *Blend waveform*
  - – A modification of the duty cycle. When changing the type of the wave from cutting to coagulation, the generator reduces the time of duty cycle ("on" time), producing less heat on the tissue. Blend waves are used less often in hysteroscopy (Fig. 3.1).

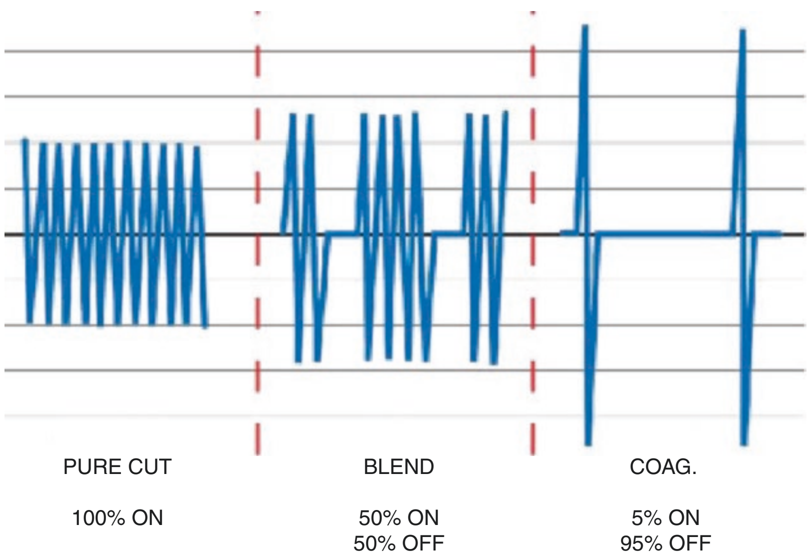


Fig. 3.1 Current waveforms

Fig. 3.2 (**a**) Cutting/Vaporization. (**b**) Fulguration. (**c**) Coagulation/desiccation are the main effects achieved by electrode manipulation. Watch the differences in the distance of the electrode from the tissue

3.1.2 Types of Energy Used in Hysteroscopy

3.1.2.1 Monopolar and Bipolar Electrosurgery

Historically the electrical current passed through the patient, completing the circuit either by the operating room floor via a grounded object or returning to a solid-state generator. As great concern arouse over accidental burns, the isolated generator system was developed in the 1970s, avoiding an alternating pathway to the ground.

Activation of the electrosurgical unit in both monopolar and bipolar is usually made by foot.

The *monopolar* device, being the most commonly used device in electrosurgery, becoming less frequently used in hysteroscopy, due to its need for a non-electrolytic solutions, such as glycine 1.5%, to distend the uterine cavity, with the potential of nonphysiological fluid absorption complications (such as hyponatremic encephalopathy, hypercapnia, and postoperative hyperammonemia).

The monopolar device conducts the current of electricity through the patient while using a return electrode on the patient's body, usually on the thigh (Fig. 3.3).

The patient's return electrode should contact a well-vascularized muscle tissue with a large-enough pad to prevent a high-density current producing an unintended burn.

The monopolar waveform can be modified into three clinical effects: cutting, fulguration, and desiccation.

Three main complications exist with the use of monopolar energy: direct coupling, insulation failure, and capacitive coupling. They will be discussed further on in the chapter.

The *bipolar* device conducts the energy and returns it by the instrument itself, whether by the conducting (active) electrode tip or by the second blade of the hand instrument, without the requirement for a grounding pad (Fig. 3.4).

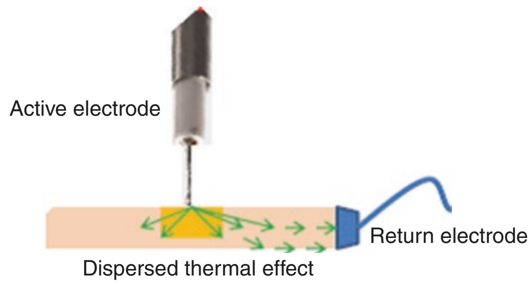


Fig. 3.3 Monopolar electrode

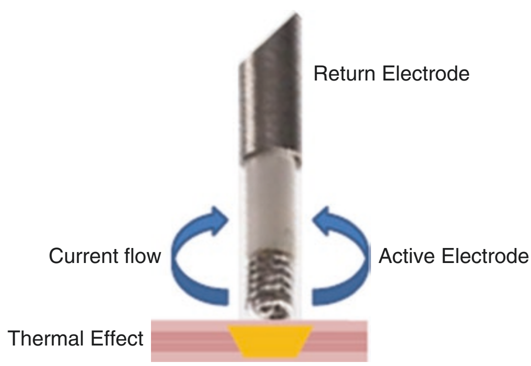


Fig. 3.4 Bipolar electrode. The tissue effect is taking place only between the active and the return electrodes. No dispersive electrode is needed

When compared to monopolar energy, while using a bipolar energy only the tissue held between the instrument's blades is included in the electrical circuit, becoming a tissue that is under effect, thereby reducing to minimum the damage on the surrounding tissue.

Using the bipolar device to focus the energy between the two electrodes along with lower voltage waveform results in a refined area of coagulation with less char formation.

Disadvantages for bipolar device:

1. Using a low power setting demands increased time for coagulation.
2. Incidental tearing of adjacent blood vessels since tissues can sometimes become adherent to the electrodes.

The proximity of the return electrode to the working tip manifest as a lack of versatility of tissue effects, as neither tissue vaporization nor fulguration is possible with bipolar electrosurgery.

One must remember that bipolar electrosurgery does not eliminate the risk of stray current injury from insulation failure (with or without direct coupling to other instruments) (Table 3.2 and Box 3.3).

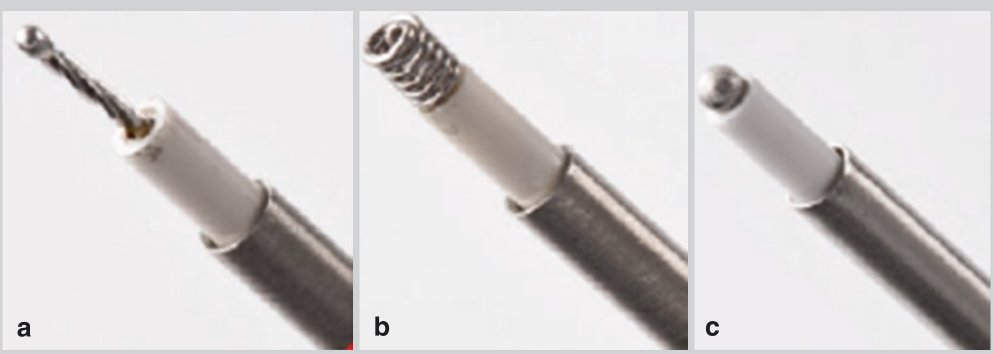
Table 3.2 Comparison of energy modalities

	Monopolar	Bipolar	Laser
Tissue effect	Cutting, coagulation	Cutting, coagulation	Cutting, coagulation
Power setting	50–80 W	30–50 W	15 W
Thermal spread	Not well assessed (multiple variables)	2–6 mm	<1 mm
Maximum temperature	>100 °C	>100 °C	>100 °C

Box 3.3 Bipolar Instruments

Bipolar instruments can be used with electrolyte solutions (normal saline solution 0.9%). Using a generator that works in combination with 3 main types of 5 Fr (1.6 mm) electrodes:

(a) *The Twizzle*, widely used for fine-regulated and precise tissue vaporization.
(b) *The Spring*, useful for the vaporization of larger portion of tissue.
(c) *The Ball*, extremely useful for coagulation.



3.1.2.2 Resectoscope

The modern resectoscope typically consists of a working element, two sheaths (inner and outer), and the loop (active or cold). The most used are of 22 Fr (~7.3 mm), 26 Fr (~8.7 mm), and 27 Fr (~9 mm) and can equip *unipolar or bipolar* energy.

The introduction of smaller devices ranging from 3 to 6 mm caliber such as the mini-resectoscope (Box 3.4) has allowed the possibility of displacing many indications from the operating room to office procedure settings, that is, on a "see and treat" basis.

When using a unipolar energy with a resectoscope, one can find cutting loops (angled or straight) with a great number of electrodes (pointed or Collins electrode, ball-end coagulating electrodes, spike electrode, roller electrode, and VaporCut).

The bipolar resectoscopic instruments may be cutting loop, ball-end coagulating, and pointed electrodes (Fig. 3.5).

Box 3.4 Mini Resectoscope

Bipolar/monopolar energy coupled with small-diameter hysteroscopes that have a continuous flow system

A mini-resectoscope was first demonstrated in 2009 when 26 patients underwent an office polypectomy and all lesions were resected. From then on, proving its advantages, the miniresectoscope Reducing medical costs, improving patient tolerability and reducing complications associated with traditional resectoscope. The miniresectoscope has its own promise in Hysteroscopy.

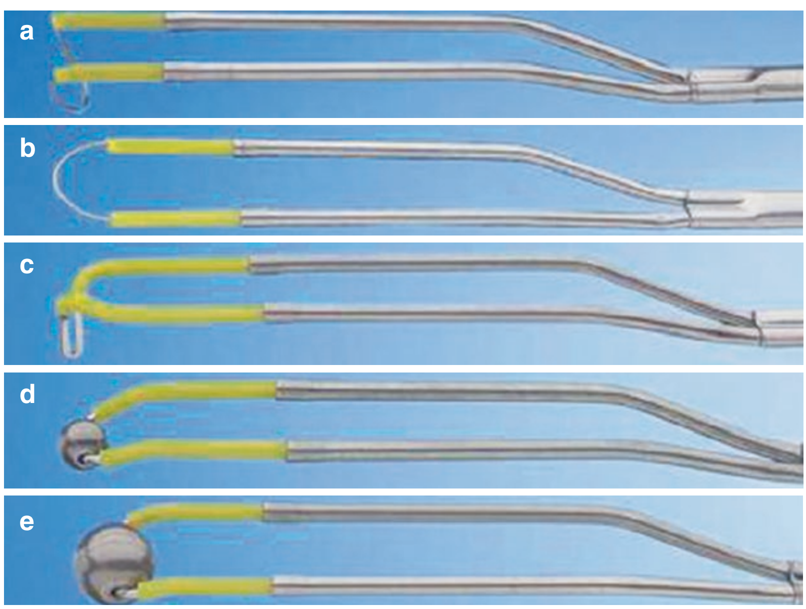
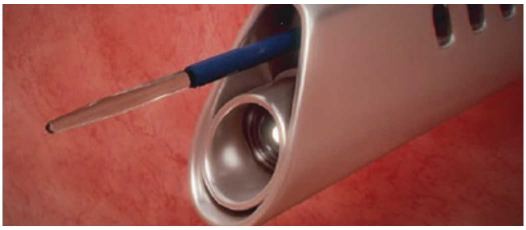


Fig. 3.5 Unipolar loops and electrodes. (**a**) Angled cutting loop; (**b**) Straight 5-mm cutting loop; (**c**) Collins pointed electrode; (**d**) 3-mm ball-end coagulating electrode; (**e**) 5-mm ball-end coagulating electrode

3.1.2.3 Laser



The diode laser was introduced to hysteroscopy in the 1970s and 1980s in the USA. The typical laser device is amplifying light to be reflected between parallel mirrors. The laser comes out as a parallel beam light, monochromatic and coherent with highly concentrated energy. Due to these features, the high-energy light beam is able to section tissue or even to vapor it. The beam might have high tissue penetration or low.

The main advantages using laser energy are avoidance of most of pain, low relapse rate, and high patient satisfaction compared with the electrical bipolar procedure. The results do not seem to be related to size or number of pathologies, and a 12-month follow-up shows both the lowest recurrence and complications rates (Fig. 3.6 and Box 3.5).

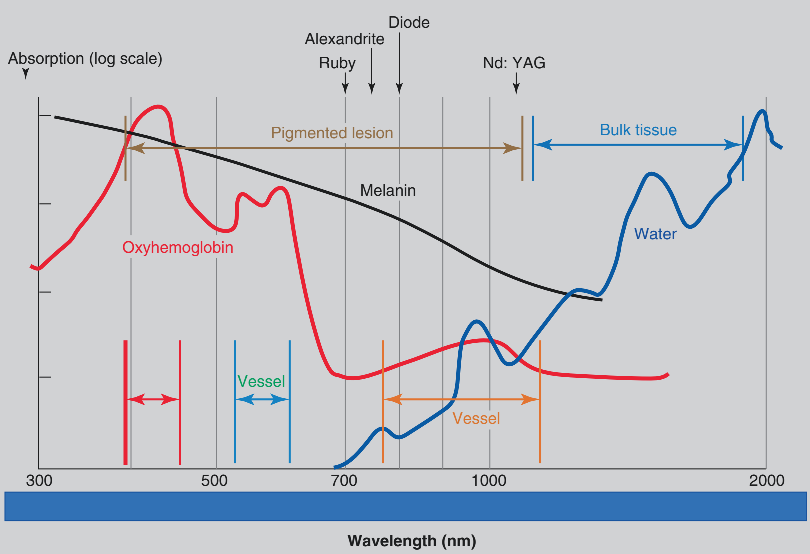
3.1.2.4 Ablation

Endometrial ablation is done mainly to manage abnormal uterine bleeding.

The basic method of endometrial ablation is to place an electrode over the target tissue to transmit high-frequency alternating current to the tissue in the range of 350 to 500 kHz. It can increase the temperature of the target tissue to greater than 100 ° C and cause protein denaturation, desiccation, and coagulation necrosis; it has a built-in sensor for automatically terminating transmission of the current at a particular set point to prevent overheating and unwanted collateral damage (Box 3.6).

Box 3.5 Parameters for Laser Surgery

1. Power in watts (Watt): relatively low energy (15 W) may be used for tissue sectioning, While energy over 100 W is needed to vapor tissue.
2. Wavelength: depending on the wavelength, the energy emitted will behave different. A 980 nm wave will be absorbed by hemoglobin having a coagulation effect, while the 1470 nm wave being absorbed by water will have a vaporization effect.



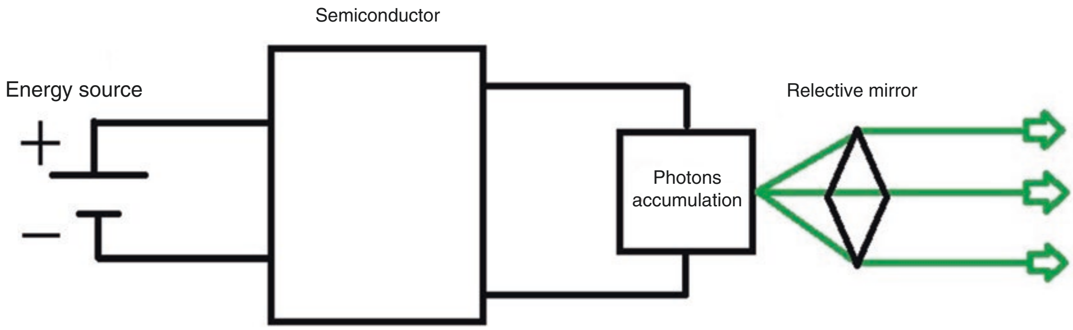


Fig. 3.6 Laser technology Scheme. (1) Energy source. (2) Semiconductor. (3) Photon accumulation. (4) Reflective mirror

Box 3.6 Options for Endometrial Ablation
Options for endometrial ablation include:

- *Electrosurgery*. Heating of the endometrium.
- *Cryoablation*. Extreme cold is used to create two or three ice balls that freeze and destroy the endometrium.
- *Free-flowing hot fluid*. Heated saline fluid is circulated within the uterus.
- *Heated balloon*. A balloon device is inserted through the cervix and then inflated with heated fluid.
- *Microwave*. A slender wand is inserted through the cervix. The wand emits microwaves, which heat the endometrium.
- *Radiofrequency*. A special instrument unfurls a flexible ablation device inside the uterus. The device transmits radiofrequency energy that vaporizes the endometrium (Fig. 3.7).

3.1.3 Electrosurgical Hysteroscopic Hazards

Operating room fires might be the result of inappropriate use of electrosurgical devices. Where in laparoscopic procedures it is mainly due to limited surgeon's field of view, in hysteroscopy, though very rare, it is due to inappropriate use of the equipment.

Some of the most frequently encountered complications related mainly to monopolar device are direct coupling, insulation failure, and capacitive coupling.

$$\text{Burn} = \frac{\text{Current} \times \text{Time}}{\text{Area}}$$

(a) Direct coupling—When the active electrode is near another metal instrument during electrical activity. The energy will seek a different route to the return electrode.
(b) Insulation failure—Happens mainly during coagulation, using high voltage energy. Where the energy "leaks" via a break in the active electrode device, seeking a different route to the return electrode.
(c) Capacitive coupling—When energy from an active electrode is transferred across the insulator surrounding it to another conductor.
(d) Dangerous return electrode contact—If the surface area of the return electrode is reduced or if the impedance of the contact is increased, a burn might ensue.

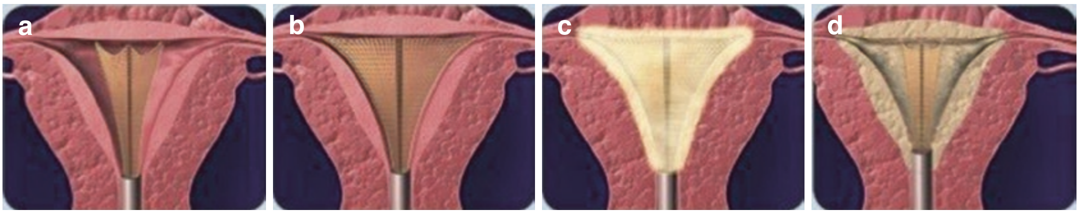


Fig. 3.7 Radiofrequency (Novasure) ablation: (**a**) Triangular mesh device is extended in the uterus. (**b**) Fitting to the size of the uterus. (**c**) RF energy is delivered through the mesh. (**d**) The mesh device is pulled back

Check for updates

4 Distension Media and Fluid Management in Hysteroscopy

Aswath Kumar and Megha Jayaprakash

Since the uterine walls are closely apposed to each other, hysteroscopic visualization of any intrauterine pathology requires adequate distension of uterine cavity by overcoming the myometrial resistance. Knowledge of the characteristics of each distension medium, its interactions with energy sources and its potential complications is an essential prerequisite for all gynaecologists.

4.1 History

Selection and use of distension media has evolved over the years. Lindermann introduced CO_2 as a distending medium through automatic pressure insufflator in 1972 [1]. This was followed by the usage of dextrose (5% and 10%) as well as high-molecular-weight dextran (32%) in the 1980s, both of which have become unpopular due to adverse effects and difficulties associated with use.

Currently low-molecular-weight liquid media which includes electrolyte solutions like normal saline and non-electrolyte solutions like sorbitol and glycine are mostly in use.

A. Kumar (✉)
Jubilee Mission Medical College, Thrissur, India

M. Jayaprakash
Govt Medical College, Thrissur, India

4.2 Classification of Distension Media

1. Based on physical state into
   - (a) Gaseous—CO_2.
   - (b) Liquid—Normal saline, mannitol, sorbitol, glycine, dextran.
2. Based on molecular weight and viscosity into
   - (a) High viscosity, high molecular weight—32% Dextran 70 (Hyskon).
   - (b) Low viscosity, low molecular weight
     - Electrolyte-rich
       - Normal saline (0.9%)
       - Ringer lactate
     - Electrolyte-free
       - 5% Mannitol
       - 3% Sorbitol
       - 1.5% Glycine
       - 3% Sorbitol + 0.5% mannitol (Purisol)

An ideal distending medium should allow clear visualization and at the same time be inexpensive, a nonconductor, nonallergenic, isoosmolar, nontoxic, nonhaemolytic and rapidly cleared from the body. Such a perfect medium is yet to be discovered!

The choice of medium will depend mainly on the type of procedure (diagnostic/operative) and the choice of the energy source used by the surgeon.

Let us examine each commonly used medium in detail.

S. Tandulwadkar, B. Pal (eds.), *Hysteroscopy Simplified by Masters*,
https://doi.org/10.1007/978-981-15-2505-6_4

4.2.1 Gaseous Media

4.2.1.1 Carbon Dioxide

It is the only gaseous medium used in hysteroscopy now. Since it has a refractive index of 1, it allows maximal angle of view and clear viewing. As it is highly soluble and diffusible in blood, it is easily eliminated through the lungs. But if there is intrauterine bleeding, it can form gas bubbles and impair vision.

A specialized hysteroscopic insufflator is needed to calibrate gas flow rate and intrauterine pressure when using CO_2 and a laparoscopic insufflator should never be used as it can cause gas embolism. This is because the flow rates in laparoscopic insufflator are very high in the range of 1 L/min when compared to 100 mL/min or less with hysteroscopic insufflator to achieve intrauterine pressures of around 100 mmHg. Gas embolism can also occur if very high intrauterine pressures are used for a long time.

Other problems with CO_2 include shoulder pain due to diaphragmatic irritation by CO_2. This usually resolves by itself without treatment.

CO_2 is used only for simple diagnostic procedures if at all. As randomized trials have shown that pain scores and operating times are lesser and visualization and satisfaction scores are better with normal saline, it is preferred over CO_2 for diagnostic procedures too [2]. BSGE/ESGE Guidelines advise not to use CO_2 for operative hysteroscopy.

4.2.2 Electrolyte-Rich, Low-Viscosity Media

4.2.2.1 Normal Saline

It is a freely available, inexpensive, isoosmolar (285 mEq/L) and metabolically inert electrolyte-rich fluid of low viscosity containing Na+ (153 mEq/L) and Cl− ions in physiological concentration. Being isotonic, it does not disturb the osmolar balance between intracellular and extracellular fluid compartments.

Hyponatraemia is also not a problem with this fluid and it is the preferred medium for diagnostic hysteroscopy. It is also used in operative procedures using bipolar electrosurgery, laser and microwave energy as well as mechanical tissue morcellation and removal.

It is contraindicated with monopolar resectoscopic surgery as the electrolytes conduct and disperse the electric current and impede the electrosurgical effect.

In cases of intravasation of excessive amounts of normal saline (in excess of 2.5 L), the patient can develop fluid overload with pulmonary oedema and congestive heart failure. Guidelines from AAGL, BSGE and ESGE recommend using automated fluid pumps and fluid-monitoring systems to strictly monitor input and deficit.

When automated monitors are not available, a designated person should manually monitor both input and deficit. Longer operating times and use of higher pressures to distend the uterus are associated with higher risk of intravasation.

A cutoff of 2500 mL is suggested as criterion to terminate the procedure for electrolyte-containing media like normal saline in healthy women. This cutoff is kept at 1500 mL for women with comorbidities. These cutoffs are arbitrary and good practice points [2, 3].

Gas embolism can also occur with fluid media through production of gas bubbles during electrosurgery or with entry of air through an open cervix or during removal and reinsertion of instruments. Dyspnoea with fall in end tidal CO_2 should alert the monitoring personnel on the possibility of gas embolism. Fluid deficit more than 1000 mL, high intrauterine pressures above 150 mmHg and longer operating times are also found to increase the risk of gas embolism.

4.2.2.2 Ringer Lactate Solution

It is an isoosmolar(279 mEq/L) electrolyte-rich fluid containing water and sodium chloride, potassium, lactate and calcium. So electrolyte imbalance is not a problem but excessive fluid intravasation leading to volume overload and heart failure is a distinct possibility, warranting the use of automated fluid infusion pumps and automated deficit monitoring systems. The deficit cutoff recommended is 2500 mL which is the same as for normal saline.

It can be used for diagnostic hysteroscopy as well as operative procedures using bipolar and laser energy as well as for mechanical morcellation and removal.

4.2.3 Nonelectrolyte Low-Viscosity Media

4.2.3.1 Sorbitol 3%

It is an inexpensive, electrolyte-poor 6-carbon sugar (reduced form of glucose) solution which is metabolized in the liver into fructose, glucose, CO_2 and water in the body. It has an elimination half-life of approximately 33 min. It is a hypoosmolar solution (165 mosmol/L) and can cause fluid overload with hypoosmolar hyponatraemia, hyperglycaemia, hypocalcaemia, cerebral oedema, skeletal muscle and nerve dysfunction if large volumes are absorbed.

Hence, strict monitoring of fluid deficit is essential. It is preferred for all procedures using monopolar electrocautery.

4.2.3.2 Glycine 1.5%

It is an amino acid solution that is metabolized into serine, ammonia and free water in the liver and has an elimination half-life of more than 40 min but the half-life is dose dependent as glycine is absorbed intracellularly and metabolized.

It is a hypoosmolar solution (200 mosmol/L), and intravasation of large volumes can cause volume overload, hypoosmolar dilutional hyponatraemia, hyperammonaemia, neurological symptoms like seizures, temporary blindness and coma due to cerebral oedema. Hence, strict monitoring of fluid deficit is essential.

There is good evidence recommending the use of intracervical injection of dilute vasopressin (1 unit in 20 mL normal saline at two sites around the cervix) at the start of the procedure to minimize intravasation of electrolyte-poor distending media. It is preferred for operative procedures using monopolar electrosurgical instruments.

Traditionally a fluid deficit of >1000 mL is considered a cutoff for stopping the procedure when using all nonelectrolyte solutions. This is because a drop in serum sodium level by 10 mEq/L corresponds to an absorbed volume of 1000 mL. In elderly patients with comorbidities, it is advisable to stop the procedure at a fluid deficit of around 750 mL [2, 3].

4.2.3.3 Mannitol 5%

It is a 6-carbon sugar alcohol (polyol) and is an isoosmolar solution (275 mosmol/L). It is an osmotic diuretic with only minimal amounts being metabolized. Its elimination half-life is more than 100 min. It can produce hyponatraemia due to increased sodium excretion. Volume overload can also occur and strict monitoring is required. It is used for operative procedures using monopolar electrosurgery.

4.2.4 High-Viscosity Fluids

4.2.4.1 32% Dextran 70 (Hyskon)

It is a high-molecular-weight substance (70,000 kDa) in dextrose solution. Being highly viscous, only a small quantity is needed. Being immiscible with blood and with a high refractive index, it gives clear views even in the presence of bleeding.

But it has fallen into disrepute because of serious side effects like anaphylaxis, electrolyte imbalances, coagulopathies and disseminated intravascular coagulation. It is also known to cause crusting on instruments, making it very difficult to clean and reducing the lifespan of these expensive instruments. Hence it is no longer used [3].

4.2.4.2 Methods for Fluid Inflow

Gravity

The fluid bag is suspended at a height of about 80–100 cm from the perineum and the fluid is allowed to flow by gravity to get an irrigation pressure of about 70–80 mmHg. It can only be used in diagnostic and simple office hysteroscopic procedures that can be completed in a short time.

Pressure Cuffs

These cuffs are applied over the fluid bag and inflated manually by an assistant to get a pressure of around 80 mmHg. The pressure needs adjustment with the emptying of the bag. Precise calibration of pressures may not be possible, leading to increased fluid absorption.

This is useful only in diagnostic and short office procedures.

Electronic Fluid Infusion Pumps

These automated systems allow control of flow rate, setting of a desired pressure cutoff and titration of intrauterine pressure. Ideally, titration of pressure within the uterus rather than a constant pressure throughout the procedure is required.

Some advanced systems also allow precise calculation of fluid deficit and these are invaluable in operative hysteroscopy involving deep resection, opening up vascular channels and needing longer operating times.

When using manual methods to infuse fluid and to measure fluid deficit, it is advisable to have drapes with reservoir bags [3].

4.3 Major Complications Associated with Distension Media

4.3.1 Gas/Air Embolism

It can occur not only with CO_2 but also with fluid media. With the use of dedicated hysteroinsufflator which controls the flow rate and pressure, the incidence of gas embolism with CO_2 has decreased. It is more common in lengthy operative procedures undertaken using large volumes of fluid distension media at high intrauterine pressure with multiple reinsertion of the scope, air getting in through open cervix or by the presence of air bubbles in the tubings. Gas embolism significant enough to cause cardiovascular collapse is rare but can be fatal.

Symptoms of gas embolism include dyspnoea (most common), gasping, "sucking sound" of air entering vessels, substernal chest pain, dizziness and blurring of vision. These can only be appreciated with regional anaesthesia.

Signs include tachypnoea, tachycardia, hypotension, wheeze, rales, Mill-wheel murmur, elevated JVP with signs of right heart failure, sharp fall in end tidal CO_2 and respiratory failure. There may be altered mentation with focal neurological deficits. If it is, a massive air embolism crepitus may be elicited over superficial vessels and livedo reticularis on skin.

Once there is a suspicion of air embolism, the procedure should be stopped and the uterus deflated. Supportive resuscitation is the main mode of management and includes ventilation, volume expansion and vasopressors.

Preventive measures include:

- Ensuring there are no gas bubbles in all tubings.
- Clamping the open cervix around the hysteroscope.
- Limiting removal and reinsertion of hysteroscope.
- Titration of intrauterine pressure to keep it not too high compared to mean arterial pressure (not more than 125–150 mmHg).
- Limiting fluid deficit to less than 1000 mL.
- Use of hysteroinsufflators for CO_2.
- Using flat or reverse Trendelenburg position.
- Avoiding nitrous oxide for anaesthesia.

4.3.2 Excess Fluid Intravasation with Electrolyte Imbalance

This is more common in hysteroscopy than TURP procedure in urology as the distension pressures used are much higher than the mean arterial pressure in hysteroscopy. The incidence is less than 0.5% and is dependent on the patient's age, comorbidities, type of distension medium used, length and complexity of procedure, size and intramyometrial depth of lesion to be excised.

4.4 Factors Influencing Fluid Absorption

- The higher the intrauterine pressure is above the mean arterial pressure, the more the chance of intravasation into the blood. Pressures above 75 mmHg drives fluid through the tubal ostia into the peritoneal cavity. Fluid absorption is also higher in elderly and in those with cardiovascular conditions with low mean arterial pressure.
- In procedures like myomectomy, endometrial resection and metroplasty where there is deep dissection that opens up larger diameter blood vessels, there is danger of rapid intravasation of fluid under high pressure.
- In larger uteri with greater surface area, the chance of absorption is more.
- It is also higher with longer operating times.
- Complications from fluid overload tend to be more severe and occur at lower fluid deficits in women with cardiovascular and renal diseases.
- Neurological complications are higher in premenopausal women as oestrogen suppresses the ATPase pump that regulates the flow of electrolytes across the blood-brain barrier [3].
- Though it is a threat with all types of fluid media, hypoosmolar electrolyte-poor media are more likely to cause fluid overload with electrolyte and metabolic abnormalities at relatively lesser fluid deficits when compared to electrolyte-rich media.

It can manifest as headache, dyspnoea, chest pain, facial oedema (parotid area sign), bradycardia, acute pulmonary oedema, hyponatraemia, visual disturbances, seizures and coma.

Measures to decrease fluid absorption include:

- Avoiding excess preloading with intravenous fluids.
- Injecting intracervical diluted vasopressin at the start of the procedure.
- Using isoosmolar, electrolyte-rich media whenever possible.
- Using regional anaesthesia to limit intraoperative fluids.
- Opting for regional anaesthesia to elicit symptoms in the awake patient.
- Using automated systems that control flow rate, titrate intrauterine pressure and monitor fluid deficit accurately with safety alerts and alarms for high pressure and fluid deficit.
- Limiting removal and reintroduction of hysteroscope [4] and surgical time to less than an hour if possible.
- Limiting fluid deficit to less than 1000 mL for electrolyte-poor media and to less than 2500 mL for electrolyte-rich media.
- There is conflicting evidence regarding the use of preoperative GnRHa in reducing fluid absorption [2, 3]. Its use can be considered in premenopausal women [3].

It is advisable to measure fluid deficit at 10-min intervals [3] and to reassess the cardiovascular, mental and respiratory status of the patient after a deficit of 500 mL with evaluation of laboratory parameters and to terminate the procedure if the cutoffs for fluid deficit or blood levels are attained. Evaluation of haematocrit, platelets, blood urea nitrogen, creatinine, sodium, potassium, chloride, bicarbonates, glucose, ammonia and plasma osmolality are done depending on the medium used. It is important to know that some patients may not show any symptoms but since fluid and electrolyte shifts continue for several hours, it is mandatory to continue monitoring them postoperatively.

Management should be multidisciplinary in an intensive care setting and includes terminating the procedure with the use of intrauterine balloon tamponade if there is excessive bleeding, fluid restriction, diuresis with intravenous frusemide, correction of hyponatraemia with hypertonic saline and if required positive pressure ventilation and haemodialysis.

Too rapid and too late correction of hyponatraemia both can produce central pontine myelinolysis. Hypertonic saline (1 L = 513 mEq/L) is usually reserved for severe cases with correction at the rate of 1–2 mEq/L per 2 h until serum level of 120 mEq/L is attained, followed by less concentrated saline until the goal of 135 mEq/L is reached [1].

Other complications associated with distension media include vasovagal syncope due to pain during distension and theoretical risk of spilling neoplastic cells into peritoneal cavity [1].

Key Points

1. Use electrolyte solutions or CO_2 for distension in simple diagnostic procedures.
2. Use monopolar electrosurgery only with electrolyte-poor fluid media like glycine and sorbitol.
3. Use electrolyte-rich media with other energy sources as well as for mechanical morcellation.
4. Use automated fluid infusion and monitoring systems for operative hysteroscopy.
5. Use intracervical dilute vasopressin before cervical dilatation to minimize fluid absorption.
6. Terminate the procedure at a fluid deficit of 1000 mL for electrolyte-poor media and at 2500 mL for electrolyte-rich media. Use lesser level cutoffs for patients with advanced age and comorbidities.
7. Use dedicated hysteroscopic insufflators while using carbon dioxide.
8. Maintain the lowest intrauterine pressures that provide adequate visualization.
9. Ensure operating team has efficient management plans in place to prevent, recognize and treat complications associated with distension media.

References

1. Mencaglia L, Cavalcanti L, Alvarez AA. Manual of hysteroscopy. 1st ed. Tuttlingen: EndoPress, Straub Druck+Medien AG; 2015. p. 8–10,46,82-85.
2. AAGL Advancing Minimally Invasive Gynecology Worldwide, Munro MG, Storz K, et al. AAGL practice report:practice guidelines for the management of hysteroscopic distending media. J Minim Invasive Gynecol. 2013;20:137.
3. Umranikar S, Clark TJ, Saridogan E, et al. BSGE/ESGE guideline on management of fluid distension media in operative hysteroscopy. Gynecol Surg. 2016;13:289.
4. Manual of operative hysteroscopy. AICOG, 2013. pp. 6–12.