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JMIG The Journal of Minimally Invasive Gynecology

Special Article

AAGL Practice Report: Practice Guidelines for the Management of Hysteroscopic Distending Media (Replaces Hysteroscopic Fluid Monitoring Guidelines. *J Am Assoc Gynecol Laparosc*. 2000;7:167–168.)

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ABSTRACT The objective of this guideline is to provide clinicians with evidence-based information about commonly used and available hysteroscopic distending media to guide them in their performance of both diagnostic and operative hysteroscopy. While necessary for the performance of hysteroscopy and hysteroscopically-directed procedures, distending media, if absorbed systemically in sufficient amounts, can have associated adverse events, including life-threatening complications. Consequently, understanding the physical properties and the potential risks associated with the use of the various distending media is critical for the safe performance of hysteroscopic procedures. This report was developed under the direction of the Practice Committee of the AAGL as a service to their members and other practicing clinicians. Journal of Minimally Invasive Gynecology (2013) 20, 137–148 © 2013 AAGL. All rights reserved.

Keywords: Distending media; Electrolyte-free media; Fluid management system; Hypertonic; Hyponatremia; Hysteroscopy; Intravasation; Mannitol; Ringer's lactate; Sorbitol; Uterine distention; Viscosity

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Definitions Used in this Guideline

Osmolality: The concentration of osmotically active particles in a solution

Hypertonic: Higher osmolality (concentration of particles) than what is found in normal cells

Hyponatremia: Lower concentration of sodium than is normally found in plasma

Hypotonic (or hypo-osmolar): Lower osmolality (concentration of particles) than what is found in normal cells

Resectoscope: An endoluminal surgical device comprising an endoscope (hysteroscope or cystoscope), sheaths for inflow and outflow, and an "element" that interfaces a specially designed electrode (or pair of electrodes) with a radiofrequency electrosurgical generator

Purpose and Scope

The objective of this guideline is to provide clinicians with evidence-based information about commonly used and available hysteroscopic distending media to guide them in their performance of both diagnostic and operative hysteroscopy.

Background

Hysteroscopy is invaluable for diagnosing and treating intrauterine pathology. Hysteroscopic procedures are performed using an endoscope, with or without an attached or integrated video imaging system, with intrauterine

The purpose of this guideline is to provide clinicians with evidence-based information about management of hysteroscopic distending media.

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Submitted December 4, 2012. Accepted for publication December 5, 2012. Available at www.sciencedirect.com and www.jmig.org

1553-4650/$ - see front matter © 2013 AAGL. All rights reserved.
http://dx.doi.org/10.1016/j.jmig.2012.12.002

distention accomplished with either gas (CO_2) or fluid distending media. Because of the risk of embolism, most experts consider that CO_2 should be used exclusively for diagnostic purposes, whereas fluid media can be used for both diagnostic and operative procedures. Fluid media can be of low or high viscosity and of low or high molecular weight and can be either electrically conductive or nonconductive based upon the presence or absence of electrolytes in the fluid. While necessary for the performance of hysteroscopy and hysteroscopically directed procedures, distending media, if absorbed systemically in sufficient amounts, can have associated adverse events including life-threatening complications. Consequently, understanding the physical properties and the potential risks associated with the use of the various distending media is critical for the safe performance of hysteroscopic procedures.

Identification and Assessment of Evidence

This AAGL Practice Guideline was produced after a systematic review of the literature was performed through a search of the following electronic sources: Medline, PubMed, OVID, EMBASE, and the Cochrane Database of Systematic Reviews. MeSH keywords included "hysteroscopy," "hysteroscopic risks," "hysteroscopy complications," "hysteroscopy distending medium," "hysteroscopy distending medium/media," "uterine distension," "distending media/low viscosity," "distending media/high viscosity," "distending media/gas" and encompassed articles published from July 31, 1985, through July 31, 2011. In total, 3196 papers were identified, with 3137 determined not to be relevant to the development of this guideline, leaving a total of 59 that were utilized.

The full text of all publications deemed potentially relevant was retrieved, abstracted and tabulated, and distributed for review by both the AAGL Distending Media Guideline Development Committee and the members of the AAGL Practice Committee. Relevant publications were then reviewed, and additional references were hand searched and added if appropriate and as necessary. All studies were assessed for methodologic rigor and graded according to the US Preventive Services Task Force classification system. outlined at the end of this document. Recommendations were based on the best available evidence, where possible, and where such evidence was not available, upon consensus of the expert panel.

Media Types

Distending media can be categorized as being either gaseous or fluid, but the only gaseous medium in use is CO_2. Fluid distending media can be classified according to their osmolality, their electrolyte content, and their viscosity. Traditionally, viscosity has been used to group media types, but this categorization is becoming less useful with the declining use of high-viscosity fluids.

Carbon Dioxide

It is generally accepted that CO_2 should be used as a distending medium for diagnostic hysteroscopy only, as it is not suitable for operative hysteroscopy or diagnostic procedures, in part because the concomitant blood and endometrial debris collect and obscure the optical field [1,2]. CO_2 is highly soluble in blood, and consequently, if modest volumes of the gas reach the systemic circulation, the gas is quickly absorbed and there is no relevant clinical impact [3]. However, if large volumes of CO_2 reach the systemic circulation and the heart, catastrophic cardiorespiratory collapse can occur [4]. Consequently, CO_2 should be delivered to the endometrial cavity through the sheath of the hysteroscopic system from an insufflator designed specifically for hysteroscopy, which regulates pressure and gas flow. The insufflator can be a separate unit or a small cartridge attached via a handle of the hysteroscopic system. It is essential that a low-pressure hysteroscopic insufflator be used and not a laparoscopic or other type of endoscopic insufflator, which typically inflate with much higher pressures. The use of such instruments for hysteroscopy could be associated with death secondary to CO_2 embolism [4].

CO_2 may also have some disadvantages when compared with fluid media, even in diagnostic procedures. Two separate randomized controlled trials (RCTs) were designed to measure, among other outcomes, the patient's report of pain during and after the examination, the use of local anesthesia, observation of vasovagal reactions, patient satisfaction, and procedure time among women randomized to receive distention with normal saline or with CO_2 [1,2]. In the study by Brusco et al [1] ($n = 74$), use of local anesthesia was greater, and the group assigned CO_2 reported higher procedure-related pain scores. Procedure times for the CO_2 and the normal saline groups were 5.96 ± 1.55 minutes and 3.12 ± 0.96 minutes, respectively [1]. Pellicano et al [2] found similar results in their multicenter study of 189 infertile patients. The normal saline group was observed to have a lower incidence of vasovagal reactions, had overall shorter operative times, required less analgesics after the procedure, and were more satisfied with the procedure. These findings suggest that any advantages of CO_2 are limited, but do not preclude its use in selected clinical situations with appropriate equipment.

High-Viscosity Distending Media

High-viscosity media have the advantage of being immiscible with blood, thereby facilitating evaluation of the endometrial cavity in the presence of bleeding. The most commonly used high-viscosity fluid for uterine distention is a hyperosmolar solution of 32% dextran 70 in 10% glucose (Hyskon, Coopersurgical Inc., Trumbull, CT). The osmolality of Hyskon is such that 100 mL of the solution administered intravenously can expand plasma volume by 870 mL [5], a circumstance that can result in vascular

overload and subsequent heart failure and pulmonary edema [6,7]. Although the manufacturer has suggested that the maximum volume of infused dextran should be 500 mL, the osmolality and impact on plasma volume suggest that this should be considered a maximum and that volumes as little as 300 mL may be associated with adverse outcomes [8,9].

Dextran 70 has also been associated with anaphylaxis, possibly related to prior sensitization to dextran from other sources. The incidence was determined to be 1:821 in a large study of 5745 patients who were given the agent intravenously [10], and a number of case series have been reported in association with use at hysteroscopy [11–13].

Another issue related to the use of Hyskon is that it tends to caramelize quickly on instruments, a feature that can lead to severe damage. Consequently, after using Hyskon or similar solutions for uterine distention for hysteroscopy, instrumentation should be thoroughly cleaned in warm water after each use. Furthermore, this issue precludes the use of Hyskon with flexible hysteroscopes.

Collectively, these issues, in addition to the availability of other suitable fluid media, bring into question the utility of 32% dextran 70 in 10% dextrose in contemporary hysteroscopy and hysteroscopic surgery. Clearly, when used, the clinician must be prepared for the rare case of anaphylaxis, limit the volume of infused solution, and have detailed and compulsive protocols for the appropriate cleaning of instruments following the procedure.

Low-Viscosity Distending Media

Background

Low-viscosity media can vary in their osmolality and electrolyte content. An original driver of the composition of distending media for urologic endoscopic surgery was the near ubiquitous use of monopolar electrosurgical instruments, notably the resectoscope. Such instruments require a nonconductive medium to facilitate completion of the radiofrequency (RF) electrical circuit between the active and remotely located dispersive electrode. If such instruments are used in saline, the media disperses the current from the active electrode, thereby preventing the creation of a surgical effect. Because of this innate property, sterile water was the original distending medium for resectoscopic urologic surgery; however, if absorbed in volume systemically, one of the risks was that of hemolysis. Consequently, the addition of solutes such as glucose, sorbitol, and glycine increased the medium's osmolality to a degree that hemolysis was largely prevented. Occasionally the systemic absorption of large volumes of these (usually) hypotonic and electrolyte-free solutions led to TURP (transurethral resection of the prostate) syndrome, characterized by hyponatremia, hypoosmolality, nausea, vomiting, and neurologic symptoms including muscular twitching, grand-mal seizures, and coma [14].

When the urologic resectoscope was adapted for intrauterine use, gynecologists initially assumed that the physiology of absorption of distending solution in women, including those of reproductive age, would be the same as that for males. However, whereas hyponatremia occurs with equal frequency in men and women, it became apparent that in such cases, premenopausal women are 25 times more likely to die or have permanent brain damage than men or postmenopausal women [15]. Collectively, these issues led to the need for careful evaluation of the mechanisms and impact of excess fluid absorption and the development of means by which these risks could be mitigated and managed.

Types of Low-Viscosity Media

The *electrolyte-free* low-viscosity media include 3% sorbitol, 1.5% glycine, 5% mannitol, and combined solutions of sorbitol and mannitol, typically a mixture of 3% sorbitol and 0.5% mannitol. Each of these solutions provides excellent visibility for the endoscopic surgeon but possess properties that have a potential impact on patient safety. Sorbitol is a reduced form of dextrose (D-glucitol) and an isomer of mannitol that when absorbed systemically is either excreted intact by the kidney or rapidly metabolized by the fructose pathway to CO_2 and water. Glycine is a nonconductive amino acid with a plasma half-life of 85 minutes that is uniquely metabolized in the liver to ammonia and free water, which can result in further reductions of serum osmolality. Ammonia may add to the consequences of excess absorption, as, in such instances, coma has been described despite the correction of electrolyte disturbances [16]. As a result, while 2.2% glycine solutions are isotonic (290 mOsm/L), concerns about hyperammonemia resulted in the development of a hypotonic 1.5% solution for cystoscopic and hysteroscopic procedures. Mannitol (D-mannitol) is a 6-carbon polyol that occurs in nature, is often called a sugar alcohol because of its derivation, and is an isomer of sorbitol. Solutions of mannitol are isotonic when mixed with water at a concentration of 5%, and because it is not absorbed by the renal tubules, it functions as an osmotic diuretic by increasing both sodium and extracellular water excretion.

Normal saline (NS) and other isotonic electrolyte-rich solutions are useful and safer media, for even if there is absorption of a substantial volume of solution, normal saline does not cause electrolyte imbalance and consequently is a good choice for minor procedures performed in the office. While electrolyte-containing solutions are not suitable for RF surgery with monopolar RF systems, the development of bipolar RF instrumentation for hysteroscopic surgery has allowed the application of saline as a distending medium in even more advanced and complex procedures [17,18]. Ringer's lactate, while infrequently reported as a medium used for hysteroscopy, possesses similar properties as normal saline but is even more "physiologic," and consequently would be expected to have a similar risk profile. However, no studies were identified that specifically evaluated the use of Ringer's lactate for hysteroscopic applications.

Mechanisms, Consequences, and Incidence of Excess Intravasation

Distention of the uterus is necessary for hysteroscopic visualization, and continuous turnover of the medium is important to maintain adequate imaging in the face of the debris and blood that accumulate during surgical procedures. Although CO_2 and high-molecular-weight dextran have been widely used for diagnostic hysteroscopy, the advantages of low-molecular-weight media have led to their near universal use for both diagnostic and operative procedures. Consequently, this section will be limited to discussion of the mechanisms and consequences of excess absorption—or excess fluid deficit—in the context of use of these media for hysteroscopic surgery.

Mechanisms of Systemic Absorption

The principal mechanism of systemic absorption of distention media appears to be directly related to surgical disruption of the integrity of venous sinuses in the deep endometrium and, more important, the myometrium. When these vessels or sinuses are transected, the media is provided the opportunity of access to the systemic circulation if the intrauterine pressure is greater than the pressure in the sinus or blood vessel. Consequently, it can be anticipated that the risks and extent of systemic absorption will be low in diagnostic hysteroscopy and other hysteroscopic interventions that do not have a risk of vessel transection and higher in procedures such as myomectomy, metroplasty, or endometrial resection that require dissection of or in the myometrium.

There are other factors that contribute to the volume of systemically absorbed media. The degree of uterine distention depends in large part on the pressure created by the intrauterine media: the higher the pressure, the greater the degree of systemic absorption. In a well-designed study of distending media, absorption was shown to increase considerably when intrauterine pressure exceeded mean arterial pressure [19]. Logically, the duration of the procedure will also impact the volume of "fluid deficit" experienced in a hysteroscopic procedure [20–22].

Fluid Overload, Hyponatremia, and Their Consequences

As suggested previously, the principal reason for the use of electrolyte-free solutions is their suitability for the performance of RF electrosurgery with monopolar instrumentation. However, hypotonic and electrolyte-free media can create fluid and electrolyte disturbances if absorbed in excess amounts [23]. Included in the sequelae are hyponatremia and related issues as well as heart failure (which can also be caused by absorption of conductive media such as normal saline) and pulmonary and cerebral edema. Absorption of hypotonic fluid causes an osmotic imbalance between extracellular fluid and cells including those in the brain. Under healthy conditions [24], the brain compensates with the sodium-potassium adenosine triphosphatase (NA+/K+-ATPase) "pump," which removes osmotically active cations out of the cells, thereby reducing swelling. However, under conditions of hyponatremia, water moves into brain cells, causing cerebral edema, which can lead to pressure necrosis and progression to brain stem herniation and rarely death [23,25].

Indeed, the issue may be even more important for premenopausal women because the Na+/K+-ATPase pump is inhibited by female sex steroids, most likely estrogens. This unique impact may explain why, in the context of hyponatremic encephalopathy, premenopausal women are 25 times more likely to die or have permanent brain damage than men or postmenopausal women [15]. It is also apparent that the sex steroid–related impact on the Na+/K+-ATPase pump can be preempted by the preoperative administration of GnRH agonists [26].

These circumstances make low osmolality a more risky proposition in premenopausal women, at least in those who undergo resectoscopic surgery absent the use of GnRH agonists [16]. Indeed, a number of deaths have been reported associated with the use of hypotonic glycine or sorbitol at the time of operative hysteroscopic surgery [27]. Hyperammonemia has been reported to be an independent cause of death associated with resectoscopic surgery of the prostate, but the incidence of this complication is extremely low. Furthermore, animal studies suggest that hyperammonemia likely plays a minor role in morbidity and mortality in cases of fluid overload [28]. Hypo-osmolarity and hyponatremia are more likely to induce the greatest degree of morbidity, but neurologic morbidity from hyponatremia in the absence of hypo-osmolality has not been described associated with resectoscopic intrauterine surgery. Theoretically, 5% mannitol (osmolality, 274 mOsm/L), by virtue of its near isotonic composition (normal osmolality, 280 mOsm/L), is a safer choice than either 1.5% glycine (200 mOsm/L) or 3% sorbitol (179 mOsm/L).

The impact of fluid imbalance also varies according to the patient's age and comorbid conditions including cardiovascular and renal function [29]. While low or even modest volumes of absorbed fluid can be accommodated by most healthy individuals, excessive absorption can result in fluid overload, and if nonphysiologic fluids are used, electrolyte disturbances typically result [9]. Severe hypocalcemia after hysteroscopy using sorbitol-mannitol solution has also been reported [30].

These issues have important practical considerations as electrolyte-free distending media for hysteroscopy are available in both hypotonic and isotonic solutions. Furthermore, the evolving availability of bipolar resectoscopic systems that function in electrolyte-containing solutions provides the opportunity to reduce the risk of hyponatremia as a consequence of excess absorption of distending media. Liquid distending media are characterized according to their relative conductivities and viscosities in Table 1.

Table 1

Liquid distending media (osmolality)

	Tonicity			Contains physiologic electrolytes		Viscosity	
Liquid Media	Iso	Hypo	Hyper	Yes	No	Low	High
Normal saline (NaCl 9%)	✓			✓		✓	
5% Glucose		✓			✓	✓	
1.5% Glycine		✓			✓	✓	
5% Dextrose (D5W)		✓			✓	✓	
5% Mannitol	✓				✓	✓	
3% Sorbitol		✓			✓	✓	
Mannitol/sorbitol (Purisol)		✓			✓	✓	
32% Dextran 70 (Hyskon)			✓		✓		✓

Incidence

The incidence of fluid overload associated with operative hysteroscopy has been estimated to be about 0.1% to 0.2% [29,31]. It is useful to evaluate this incidence based on specific procedures. For example, in an evaluation of 750 women who underwent resectoscopic endometrial ablation, Magos et al [32] reported left ventricular failure in 5, and Garry et al [33] described pulmonary edema in 4 of 859 patients. In a retrospective evaluation of 21 676 hysteroscopic surgeries, Aydeniz et al [29] identified 13 patients with fluid overload (0.06%), 10 of whom were associated with resectoscopic myomectomy and 3 with endometrial ablation. Isotonic saline or Ringer's lactate, if absorbed in sufficient volume, has also been associated with fluid overload leading to right-sided heart failure and pulmonary edema [34,35].

Managing Fluid Media

The goals of fluid management include (1) choosing the distending medium least likely to cause complications in the event of excess absorption; (2) minimizing systemic absorption during surgery; and (3) early recognition of excess absorption.

Selection of Distending Media

When selecting distention media for hysteroscopy, a number of factors should be considered including the procedure to be performed and the instruments to be used, particularly those that require RF electricity. If monopolar electrosurgical instruments are to be used, the distending medium cannot contain electrolytes. On the other hand, if mechanical or bipolar electrosurgical instruments are to be used, then normal saline should be employed.

If it is necessary to use fluids that do not contain physiologic electrolytes, the characteristics of the medium should be considered. Excess absorption of hypotonic agents can cause cerebral edema, which appears to result in the most severe complications of excess absorption, including death [16]. Five percent mannitol is isotonic, and although excess absorption of this nonelectrolytic fluid can cause hyponatremia, hypo-osmolality has not been reported [36].

When bipolar RF instruments are being utilized, then it is necessary to use electrolyte-containing solutions; normal saline has, by far, been the solution reported in the literature. Normal saline is associated with fewer unfavorable changes in serum sodium and osmolality than is the case when electrolyte-free media are used with monopolar systems [18,37–39]. The use of normal saline, however, does not eliminate the need to prevent excess absorption or to closely monitor fluid balance, as overload can cause pulmonary edema and has even caused death [34,35,40,41].

Techniques and Equipment for Uterine Distention

Media delivery systems refer to the method whereby the fluid is delivered to the endometrial cavity. There exist a number of media delivery systems, ranging from those based on the physics of simple gravity to automated pumps that are designed to maintain a preset intrauterine pressure.

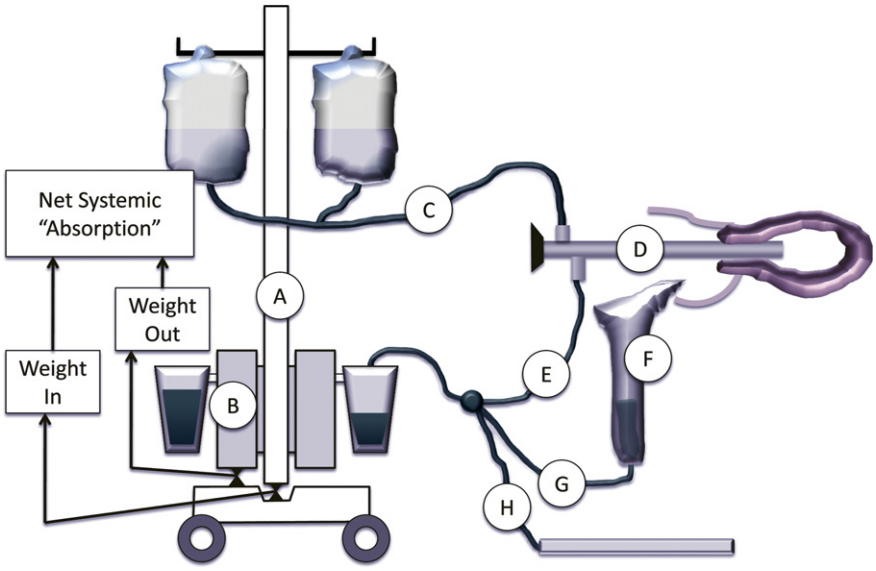
Gravity is the simplest method of instilling fluid under constant hydrostatic pressure. The container of fluid is generally hung from an intravenous (IV) pole, and should be initially placed at a height above the patient's uterus that creates an intrauterine pressure that is just below the patient's mean arterial pressure. The pressure delivered to the inflow port of the hysteroscope's outer sheath is the product of the inner diameter plane of the connective tubing and the elevation. The pressure is approximately 70 to 100 mm Hg when the bag is 1 to 1.5 m above the uterus [42]. The height should be kept at the minimum elevation to allow sufficient distention.

An extension of the gravity system is the simple pressurized delivery system that is created by positioning a pressure cuff around the bag filled with the distending media. Unfortunately, this approach does not allow precise control of the pressure, so that in long cases or those associated with violation of the integrity of the myometrium, excessive extravasation could occur, especially if intrauterine pressure is sustained above the mean arterial pressure.

A variety of infusion pumps is available, ranging from simple devices with constant flow and pressure (at the inflow

Fig. 1

Automated fluid management systems. This schematic shows the mechanism of action of the fluid balance component of an automated fluid management system. The infusion media is placed on the pole **(A)**, while canisters for collecting evacuated fluid are attached to a separately mounted collection platform **(B)**. The fluid is infused through tubing **(C)** to the resectoscope **(D)**, which is depicted passing through the vagina and the cervix into the endometrial cavity. Fluid within the endometrial cavity is evacuated via tubing **(E)** into the collecting canisters. Fluid that leaks around the resectoscope into the vagina is captured either in a specially designed pouch **(F)** or, if it falls on the floor, by a floor mat, each of which are connected to the collecting canister with tubing **(G** and **H)**. The pole and the collection platform are independently mounted on devices (generally based on Wheatstone bridges) designed to weigh the fluid electronically. The microprocessor subtracts the collected fluid (Weight Out) from the infused fluid (Weight In) to calculate the fluid balance—the net systemic absorption. Reproduced with permission from Munro [9] (Fig. 1).



port) to instruments that purport to monitor and maintain a preset intrauterine pressure. Simple pump devices continue to press fluid into the uterine cavity regardless of resistance, whereas the pressure-sensitive pumps reduce the flow rate when the preset level is reached [43]. While there is little value to using these systems for diagnostic hysteroscopy or even for simple procedures, maintenance of a standard intrauterine pressure is essential for prolonged operative interventions.

Unfortunately, measurement and control of true intrauterine pressure is problematic. In a static state, where there is no flow, the pressure of fluid at the inflow port of the hysteroscope's sheath will accurately reflect intrauterine pressure. Once fluid is flowing, leakage at the junction of instrument components, the resistance at the inflow and outflow ports, and the amount of suction (if any) applied to the outflow port cause the pressure measured at the inflow of the hysteroscope to be higher than intrauterine pressure [42]. At least one new fluid management system calibrates pressure vs flow in the hysteroscope being utilized, and theoretically should provide more accurate control of true intrauterine pressure. Nevertheless, relatively high-quality evidence suggests that maintenance of the intrauterine pressure, so measured, below the intrauterine pressure will minimize the amount of systemic absorption of distending media [19,44].

Monitoring Absorption

The detection of excess absorption requires accurate measurement of both media infused into the endometrial cavity and that removed or otherwise returned from the uterus, including all sources. Calculation of systemic absorption is complicated by 4 factors: (1) It may be difficult to collect all of the media that passes out of the uterus, including that which falls on the procedure or operating room floor; (2) the actual volume of media solution in 3-L bags is typically more than the labeled volume [45,46]; (3) difficulties in estimating the volume of media left in a used or "emptied" infusion bag [45]; and (4) systemic absorption that in some instances may occur extremely rapidly.

The simplest method of monitoring comprises manually subtracting the volume collected from the volume infused considering all sources including the hysteroscope/resectoscope outflow; the "perineal" collection drape, which includes a pouch to capture fluid spilled from the cervix but around the hysteroscope sheath; and the media spilled that collects on the floor. However, while conceptually simple, there are a number of difficulties encountered when attempting to collect media from all sources in the operating room environment. Prospective studies have shown that 3-L bags of the commonly used media are overfilled by about 2.8% to 6.0% [45,46], a factor that confounds

manual measurement and provides the opportunity for "undetected" fluid overload to occur. In addition, operating room staff are inconsistent in estimating the amount of fluid remaining in used distending media bags [45]. Another source of inaccuracy occurs because the media lost onto the drapes and the floor can confound the issue, making it difficult to evaluate the intake and output accurately [45]. These issues are compounded if the person monitoring fluid balance has other duties in the operating room, a circumstance that increases the risk of errors.

The limitations of manual measurement make it preferable to use an automated fluid measurement system that takes into account an exact measurement of infused volume as well as all of the potential sources of returned media. Such systems provide continuous measurement of the amount of distending media absorbed into the systemic circulation by using the weight of the infused volume [47]. Provided there are methods for collection from all sources, the device then calculates the total weight of all the media collected by the system, which is then subtracted from the total weight of the infused volume to provide a continuous measure of systemically absorbed volume (Fig. 1). An alarm can be set to sound a warning when a preset volume deficit is reached. The actual measurement of the infused volume prevents underestimating the fluid deficit but does not prevent overestimating the deficit because of fluid not recovered.

Reducing the Volume of Systemic Absorption

The process of reducing the risk of distention media–related complications commences well before the procedure starts. The clinician should recognize the types of procedures that are prone to excess media absorption so that any of a number of preoperative measures can be taken to reduce risk. On one hand, it is apparent that diagnostic hysteroscopy and simple intrauterine procedures that do not violate the integrity of the myometrium are at low risk for media-related complications. On the other, there are a number of procedures at higher risk including those that are anticipated to take longer, particularly if they involve dissection in the myometrium such as resection of type 1 or type 2 leiomyomas. Indeed, there is evidence that the risk of fluid overload in resectoscopic myomectomy is directly related to the duration of the procedure, the diameter of the leiomyoma(s), and the proportion of the leiomyoma that is in the myometrium [20]. A media management protocol should be in place, and it is preferable that such protocols include the use of automated fluid management systems previously described. The operative team should also predetermine the threshold for the intraoperative measurement of electrolytes, for the use of diuretics, and for the expeditious termination of the procedure should excess fluid absorption be detected.

Preoperative

There is generally consistent evidence regarding the value of preoperative administration of GnRH agonists, to reduce both the degree of systemic absorption of distending media (Table 2) and potentially the impact of hyponatremic hypotonic encephalopathy. The evaluation of the use of these agents for these purposes has to be performed independent of their value in creation of amenorrhea, thereby facilitating restoration of iron stores and hemoglobin levels, and their utility in preparing the uterus for endometrial ablation by reducing the thickness of the endometrium.

Preoperative use of GnRH agonists has generally been associated with reduced fluid deficit among premenopausal women [26,48–51] and may decrease the morbidity associated with fluid overload of nonionic hypotonic media [26]. In the RCT by Mavrelos et al [51], the mean systemic loss with GnRH agonists was less than for controls, but the difference was not significant. Nevertheless, all of the other comparative studies have shown a significant difference in this outcome.

Intraoperative

Intracervical Vasopressin. Two well-designed randomized trials have demonstrated that injecting dilute vasopressin into the cervix immediately before dilation can decrease fluid absorption. The odds ratio for excessive intravasation

Table 2

Comparative studies on systemic absorption (fluid deficit) and GnRH agonist

Source	Year	Type of study	Procedure	No. of patients	Median or mean fluid deficit (mL)		p Value
					GnRH agonist	Control	
Taskin et al [48]	1996	RCT	Endometrial ablation	13	490 ± 82*	660 ± 48*	<.05
Donnez et al [49]	1997	RCT	Endometrial ablation	346	150	225	.03†
Taskin et al [26]	1998	RCT	Endometrial ablation	17	540 ± 60*	760 ± 60*	<.05
Muzii et al [50]	2010	RCT	Myomectomy	39	378 ± 137*	566 ± 199*	<.005
Mavrelos et al [51]	2010	RCT	Myomectomy	47	300 (range, 0–1300)	500 (range, 0–975)	.84

GnRH = gonadotropin-releasing hormone; RCT = randomized controlled trial.
* Mean ± SD.
† Because of marked differences in reported mean values between centers, it was necessary to adjust for the effect of the centers. It was determined after adjustment that goserelin-treated patients absorbed on average a median of 40 mL less fluid than placebo-treated patients.

(>500 mL) of 3% sorbitol was 0.15 (95% confidence interval [CI], 0.03–0.94) in the vasopressin group compared with placebo controls in a double-blind RCT [52]. In the other randomized double-blind study, which included 106 women undergoing resectoscopic myomectomy, transcervical resection of the endometrium, or both, there was a marked reduction in intravasation when very dilute vasopressin (8 mL of 0.05 U/mL) was injected into the cervical stroma (448.5 ± 47.0 mL vs 819.1 ± 47.0 mL) [53]. Although Corson et al [52] obtained a significant result, a comparative result was obtained with about one-tenth the concentration and dose in the study by Phillips et al [53]. In each study, the impact was more significant with myoma resection. It is possible that even further reductions in systemic absorption could be realized by repeat injections at about 20-minute intervals [52], but this approach has not been subjected to structured evaluation. Care must be taken with the use of systemic vasopressin as large systemic doses have resulted in cardiovascular collapse, myocardial infarction, and death [54]. Consequently, the concentration of vasopressin should not exceed 0.4 U/mL [52], and preferably, given the study by Phillips et al [53], it should be much less than that.

Selection of Distending Media

Compared with hypotonic and electrolyte-free media, isotonic solutions like normal saline are associated with a reduced risk of hyponatremia [17]. As a result, wherever possible, isotonic media should be used when performing operative hysteroscopic procedures. Electrolyte-containing media are incompatible with operation of conventional monopolar resectoscopic instruments, but electrolyte-free isotonic solutions such as 5% mannitol, 1.5% glycine, and 3% sorbitol are available. The development of bipolar hysteroscopic instrumentation that require electrolyte-rich media have created the opportunity to perform resectoscopic surgery without the issues unique to electrolyte-free hypotonic fluid [17,18]. However, there is some evidence that some of these systems are not as efficient as monopolar instruments, a circumstance that has been associated with increased total absorption [17]. Another type of "resectoscope" that has been introduced is one that uses mechanical morcellation of leiomyomas or polyps and therefore can be used with saline, discussed below [55].

Infusion and Evacuation Techniques

There is evidence, previously discussed, that has demonstrated systemic absorption to be greater with increasing intrauterine pressure, especially if it exceeds mean arterial pressure. In addition, maintenance of intrauterine pressure at or below 75 mm Hg will reduce the volume of media spilling into the peritoneal cavity via the fallopian tubes [44]. Consequently, one could conclude that it is reasonable to operate at the lowest intrauterine pressure consistent with good visualization and, to the extent possible, below the mean arterial pressure.

There is high-quality evidence from one study that demonstrated that 80 to 100 mm Hg wall suction is superior to simple gravity for the evacuation of media from the endometrial cavity [56]. In the randomized trial of patients undergoing resectoscopic surgery, the median fluid deficit was 0 mL in those with suction, compared with 450 mL for the group where only gravity was employed. When using suction, the operator must manually control the outflow port diameter to prevent cavity evacuation to the extent that visualization is impaired.

A set of investigators has demonstrated that ceasing the procedure temporarily (10 minutes) was associated with overall reduction in the rate of distending media systemic absorption by a mean of 67.09% ± 14.45% [22]. They hypothesized that temporary cessation of the procedure allowed intravascular clotting, thereby reducing the ongoing rate of systemic absorption. No other studies using this technique were identified.

Resection Technique

The technique used for the resection or ablation of tissue may have an impact on the systemic absorption of hysteroscopic distending media. Use of RF vaporizing electrodes, capable of rapid conversion of large tissue volumes to gas, have been shown to lower fluid absorption in comparison with the cutting loop [57]. In a randomized trial that included women undergoing endometrial ablation, the mean systemic absorption was109 ± 126 mL in the vaporization arm and 367 ± 257 mL in the resection group (mean difference, 258 mL; 95% CI, 175–341 mL; p <. 001). Histopathologic results from *in vivo* studies showed that the mean depth of coagulation at the ablation zones was significantly greater (1.8 mm vs 0.4 mm) for the vaporizing electrode than for the cutting loop, suggesting that the explanation for the difference may be that the vaporizing electrode preemptively coagulates rather than transects the tissue [21].

The mechanical morcellator was introduced previously, a device that can be used to remove intrauterine masses—essentially polyps and selected submucous myomas—without the requirement for RF electrical energy. Only one trial was found comparing this technique to standard resectoscopic surgery with a loop electrode [58]. This randomized trial showed that residents performing myomectomy or polypectomy successfully completed the procedures more rapidly with the mechanical device (10.6 minutes; range, 7.3–14.0 minutes) than with a standard resectoscope (17 minutes; range, 14.1–17.9 minutes). These devices appear not to be useful in removing the intramural portion of type 1 and type 2 myomas.

Management of Excess Absorption of Distending Media

It is apparent that the best "management" of fluid overload is to prevent its occurrence by constantly and

accurately monitoring the distending medium input and output. Prevention requires that the team have a protocol for responding to escalating absorbed volume that stipulates thresholds for action. These thresholds may necessarily vary somewhat, depending on a number of factors that include the nature of the media (isotonic or hypotonic) and the patient's baseline and intraoperative medical condition. It has been shown with routine postoperative CT imaging of the brain that cerebral edema can occur with as little as 500 mL of hypotonic solutions [23], but no such data were available for other outcomes such as heart failure and pulmonary edema. Such low thresholds may be appropriate for those who are older and/or medically compromised, but for healthy individuals, absorption of up to 1000 mL can generally be tolerated. A decrease in serum sodium of 10 mmol corresponds to an absorbed volume of around 1000 mL [23]. Although most healthy individuals should tolerate larger absorbed volumes of normal saline or Ringer's lactate, data supporting a specific volume are not available. Consequently, if a threshold of 1000 mL is reached in healthy women free of cardiovascular disease, the patient should be carefully evaluated for signs of pulmonary edema before continuing the procedure. In addition, if absorption of electrolyte-free media is a concern, an indwelling catheter should be placed, and intraoperative measurement of serum electrolytes and osmolality is suggested. If overload has occurred while using electrolyte-containing solutions such as normal saline or hypotonic fluids such as glycine or 3% sorbitol, the use of intravenous furosemide is appropriate. The onset of action of intravenous furosemide is 5 minutes, and clinical improvement occurs in 15 to 20 minutes. It is important to insert an indwelling Foley catheter to monitor urinary output. More detail regarding dosing of furosemide as well as detailed management of fluid-related complications is not in the scope of this guideline. Significant fluid overload not quickly corrected by a diuretic should be managed by a team approach of experts including the gynecologist, anesthesiologist, nephrologist, cardiologist, and specialist in intensive care.

Recommendations

Evidence Level A

1. Intracervical injection of 8 mL of a dilute vasopressin solution (0.05 U/mL) immediately prior to the procedure reduces distending media absorption during resectoscopic surgery. Such administration may also reduce the force required for cervical dilation. (Discussed in section: Intracervical Vasopressin)
2. The uterine cavity distention pressure should be the lowest pressure necessary to distend the uterine cavity and ideally should be maintained below the mean arterial pressure (MAP). (Discussed in section: Infusion and Evacuation Techniques)

Evidence Level B

3. Excessive absorption of hypotonic fluids such as glycine 1.5% or sorbitol 3% can result in fluid overload and hypotonic hyponatremia, causing permanent neurologic complications or death. (Discussed in section: Mechanisms, Consequences and Incidence of Excess Fluid Extravasation: Low viscosity distention media)
4. The risk of hypotonic encephalopathy is greater in reproductive-aged women than in postmenopausal women. (Discussed in section: Mechanisms, Consequences and Incidence of Excess Fluid Extravasation: Low viscosity distention media)
5. When compared with electrolyte-free media, saline appears to have a safer profile. (Discussed in section: Managing Fluid Media: Selection of distending media)
6. Excessive absorption of isotonic fluids such as normal saline can cause severe complications. Although isotonic fluids do not cause cerebral edema, there is still a mandate for continuous and accurate measurement of input and output for the calculation of fluid absorption. (Discussed in section: Managing Fluid Media: Selection of distending media)
7. The risk of systemic absorption varies with the procedure and increases when myometrial integrity is breached with procedures such as myomectomy. In such instances, patients should be counseled that more than one procedure may be required. (Discussed in section: Reducing the Volume of Systemic Absorption–Preoperative)
8. Due to the conflicting evidence regarding their impact on the volume of fluid deficit during resectoscopic surgery, the decision to use a gonadotropin-releasing hormone (GnRH) agonist in premenopausal patients to reduce extent of fluid deficit should be made at the discretion of the provider. (Discussed in section: Reducing the Volume of Systemic Absorption–Preoperative)

Evidence Level C

9. CO_2 is a suitable medium for the performance of diagnostic hysteroscopy but should not be used for operative hysteroscopy because of its impact on hysteroscopic visualization and the risk of CO_2 embolus. (Discussed in section: Medial types: Carbon Dioxite)
10. Before performing operative hysteroscopy with liquid distending medium, it is important to purge the air out of the system and during the procedure to change the liquid-containing bag before it is completely emptied. (Discussed in section: Media types: Carbon Dioxide)
11. The risks associated with distending media overload may be reduced by limiting the degree of preoperative hydration with oral or intravenous fluids. (No published evidence: committee recommendation)
12. Shortly prior to performing resectoscopic surgery, it is advisable to obtain baseline levels of serum electrolytes including sodium, chloride, and potassium in women on diuretics or with medical conditions that may predispose to electrolyte disorders. (No published evidence: committee recommendation)

13. The following statements on maximum fluid deficits are based on expert opinion. The patient should be carefully evaluated, with consideration to terminating the procedure expeditiously if intravasation is known or thought to reach the volume in these clinical contexts. For elderly patients and others with comorbid conditions including compromised cardiovascular systems, a maximum fluid deficit of 750 mL is recommended. (Discussed in section: Management of Excess Absorption of Distending Media)

a. For healthy patients, the maximum fluid deficit of 1000 mL is suggested when using hypotonic solutions. This is based on a decrease in serum sodium of 10 mmol, with absorbed volume of around 1000 mL. The maximum limit for isotonic solution is unclear, but 2500 mL has been advocated in the previous AAGL Guidelines. Individualization and the anesthesiologist's opinion should be obtained.

b. When high-viscosity distending media are used, the maximum infused volume should not exceed 500 mL, and in the elderly and those with cardiopulmonary compromise should not exceed 300 mL.

14. When maximum absorption occurs with electrolyte-free distending media, immediate measurement of plasma electrolytes and osmolality is recommended. (Discussed in section: Management of Excess Absorption of Distending Media)

15. Normal saline should be used wherever possible for operative hysteroscopic surgery to reduce the risk of hyponatremia and hypo-osmolarity. Normal saline should be used for distention during operative hysteroscopic procedures not requiring the use of monopolar electrosurgical instruments. (Discussed in section: Managing Fluid Media: Selection of distending media)

16. The surgical team should be prepared to accurately monitor distending fluid medium input and output, including all 3 potential sources: return from the hysteroscope, spill from the vagina, and loss to the floor. An automated system for continuous calculation of fluid deficit is recommended. (Discussed in section: Monitoring Absorption)

17. The use of an automated fluid management system is recommended. Such systems should ideally comprise an infusion pump that allows determination and continuous monitoring of true intrauterine distention pressure and a system for accurate measurement of fluid deficit. (Discussed in section: Reducing the Volume of Systemic Absorption; and Monitoring Absorption)

18. The surgical team should, prior to the start of the case, predetermine the maximum acceptable volume of systemically absorbed distending media considering both the medical condition of the patient, and the osmolality and electrolyte content of the media to be used. (Discussed in section: Reducing the Volume of Systemic Absorption)

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Appendix

Studies were reviewed and evaluated for quality according to a modified method outlined by the US Preventive Services Task Force:

I Evidence obtained from at least one properly designed randomized controlled trial.

II Evidence obtained from nonrandomized clinical evaluation.

II-1 Evidence obtained from well-designed, controlled trials without randomization.

II-2 Evidence obtained from well-designed cohort or case-control analytic studies, preferably from more than one center or research center.

II-3 Evidence obtained from multiple time series with or without the intervention. Dramatic results in uncontrolled experiments also could be regarded as this type of evidence.

III Opinions of respected authorities, based on clinical experience, descriptive studies, or reports of expert committees.

Based on the highest level of evidence found in the data, recommendations are provided and graded according to the following categories:

Level A: Recommendations are based on good and consistent scientific evidence.

Level B: Recommendations are based on limited or inconsistent scientific evidence.

Level C: Recommendations are based primarily on consensus and expert opinion.

Publications that do not fit the AAGL evidence classification are classified as SR5, Systematic review; R5, Review; P5, Prevalence or Incidence Study; L5, Laboratory study; N/A if not otherwise classified.

This report was developed under the direction of the Practice Committee of the AAGL as a service to their members and other practicing clinicians. The members of the AAGL Practice Committee have reported the following financial interest or affiliation with corporations: Malcolm G. Munro, MD, FRCS(C), FACOG—Consultant: Karl Storz Endoscopy-America, Inc., Conceptus, Inc., Ethicon Women's Health & Urology, Boston Scientific, Ethicon Endo-Surgery, Inc., Bayer Healthcare, Gynesonics, Aegea Medical, Idoman; Jason A. Abbott, PhD, FRANZCOG, MRCOG—Speaker's Bureau: Hologic, Baxter, Bayer-Sherring; Tommaso Falcone, MD—nothing to disclose; Volker R. Jacobs, MD—Consultant: Top Expertise, Germering, Germany; Ludovico Muzii, MD—nothing to disclose; Togas Tulandi, MD, MHCM—nothing to disclose.

The members of the AAGL Guideline Development Committee for the Management of Distending Media have reported the following financial interest or affiliation with corporations: Paul Indman, MD—nothing to disclose; Olav Istre, MD—nothing to disclose; Volker R. Jacobs, MD—Consultant: Top Expertise, Germering, Germany; Franklin D. Loffer, MD—nothing to disclose; Ceana H. Nezhat, MD—Consultant: Ethicon Endo-Surgery, Lumenis, Intuitive Surgical, Karl Storz Endoscopy. Advisor: Plasma Surgical, SurgiQuest; Togas Tulandi, MD, MHCM—nothing to disclose.