Gynecol Surg (2009) 6:15–20
DOI 10.1007/s10397-008-0400-3

ORIGINAL ARTICLE

Bipolar resectoscope: the future perspective of hysteroscopic surgery

Luca Mencaglia · Emmanuel Lugo · Sabina Consigli · Cristiana Barbosa

Received: 30 January 2008 / Accepted: 15 April 2008 / Published online: 24 May 2008

Abstract The objective of this study is to prove the effectiveness and security of bipolar resectoscope in hysteroscopic surgery. A clinic-based, prospective, non-randomised trial was conducted in Centro Florence di Chirurgia Ambulatoriale, Florence, Italy. One hundred fifty-seven women with endocavitary uterine pathologies, such as myoma, polyp, uterine septum and endometrial hyperplasia, were included in the study. Myomectomy, polypectomy, metroplasty and endometrial ablation have been done through the use of Karls Storz 26 Fr bipolar resectoscope and Autocon II 400 high-frequency unit with parameters standard selected 180 (in effect 4) for cut and 120 (in effect 4). The main outcome measures are the current flow, distension media, tissue alteration, bleeding during resection, visibility and cost. Cutting power and coagulations appears sensibly better in comparison with monopolar resection, thanks to plasma effect. The vision during resection is not disturbed by the presence of the technical characteristics of the instruments. Results in terms of time of surgery, intra-operatory bleeding and complete removal of the pathology were better compared with traditional monopolar resection. There were no complications with bipolar resection thanks to use of saline solution as distention media. The bipolar resectoscope presents some advantages in comparison with the monopolar such as: better cut and coagulation by plasma effect of bipolar current, minor risks with the use of saline solution, lower alterations of the tissue, less bleeding during resection, better visibility and reduced cost.

Keywords Hysteroscopy · Bipolar resectoscope · Hysteroscopic surgery

L. Mencaglia · E. Lugo (✉) · S. Consigli · C. Barbosa
via di Careggi 38,
Florence 50139, Italy
e-mail: emmanuel.lugo@centroflorence.it

L. Mencaglia
e-mail: luca.mencaglia@centroflorence.it

S. Consigli
e-mail: sabina.consigli@centroflorence.it

C. Barbosa
e-mail: cristiana.barbosa@centroflorence.it

Introduction

The gynaecological resectoscope, born from its urological equivalent, is commonly used in gynaecological practice to resect or remove intra-cavitary pathology and also to perform endometrial ablation. The resectoscope consists of a telescope (2.9 and 4 mm, preferably with a 12° angle of view to always keep the loop within the viewing field), an electrical loop to perform passive cuts and two sheaths for continuous flow suction and irrigation of liquid distension medium. Besides the cutting loop, other instruments such as micro-knives or series of coagulation or vaporisation electrodes of various shapes can be connected to the resectoscope.

There are essentially two types of resectoscopes which differ in outer diameter: 7.5 and 9.2 mm. The 7.5-mm resectoscope should be used in case of narrow cervical canal or difficult dilatation; the 9.2 mm resectoscope allows to perform major surgery [1].

Electrosurgery in hysteroscopy

Biological tissue contains a more or less high concentration of electrolytes, making it sufficiently conductive to be

treated electrosurgically. The thermal effect of high-frequency current is used for separating (cutting) and coagulating tissue (desiccation of tissue). The high-frequency currents must be used on the patient since low-frequency currents can stimulate nerve and muscle cells in the currents flow due to electrochemical processes (electrolysis). These effects are small enough to be disregarded with frequencies above 100 kHz [2].

Monopolar or bipolar current system can be adopted

Monopolar resectoscope Conventional hysteroscopic surgery uses a monopolar electrocautery system in which the current passes from the active electrode through the patient's body towards the return plate. The distension media used is glycine 1.5% sorbitol–mannitol (non-electrolyte irrigation fluid). The monopolar resectoscope is connected to monopolar electrosurgery generator of high frequency and automatically controlled by an acoustic alarm system. In a monopolar system, the electrons flows from a electrosurgery generator to active electrode (electrode of the loop). From the electrode, the current flow is transmitted to tissue then to the plate (neutral electrode) and returns to generator. This system is potentially dangerous since the electrons flows through the body, outside the surgeon visual control, before it can return to the generator. The new generators, however, decreased the incidence of electric damage. In these generators, the cut current flow is automatically regulated based on tissue resistance. The unipolar loop can be used as coagulation, cut and combined (coag–cut) current. The coagulation current flow is characterised by intermittent current flow periods, which cause cellular dehydration, resulting in tissue haemostasis. The non-modulated cut flow is a continuous flow, with high intracellular temperature, causing cellular explosion. Non-modulated flow can be used also for coagulation and it should be preferred because the voltage is lower and continuous [1].

Fig. 1 Endometrial ablation with bipolar resectoscope

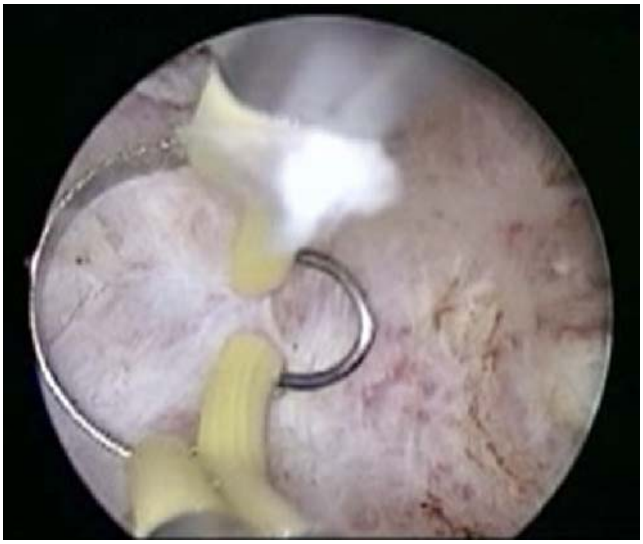

Fig. 2 Metroplasty with bipolar resectoscope

Bipolar resectoscope In bipolar electrosurgery, the current flow through the tissue is restricted to the area between the two electrode's loops that are under visual control of the surgeon (Figs. 1 and 2). In this case, saline solution can be used as distension media because it has no risk of current dispersion. The generator produces a high initial voltage spike that establishes a voltage gradient in a gap between the bipolar electrodes. When the activated bipolar electrode is not in contact with the tissue, the electrolyte solution in the uterus dissipates it. When the loop is sufficiently close to tissue, the high bipolar voltage spike arc between the electrodes converts the conductive sodium chloride solution into a non-equilibrium vapour layer or "plasma effect" containing energy-charged sodium particles. Once formed, this plasma effect can be maintained at lower voltages (100–350 root mean square voltage) [3]. With tissue contact, there is disintegration of tissue via molecular dissociation. Energetic species of the charged ions from the plasma effect result in disruption of carbon–carbon and carbon–nitrogen bonds. There is also electron impact dissociation of water molecules into exited fragments of H^+ and OH^- ions. The bottom line is rupture of cell membranes which translates into visible cutting. Clinically, there is a precise tissue effect with minimal collateral damage, as the charged ions have an estimated penetration depth in tissue of only 50 to 100 μm (0.5–1 mm) [4, 5]. The depth of coagulation is determined principally by the electrode configuration and by the system design, as well as by the technique used by the operator (time and pressure of contact) [6].

Subjects

A series of 157 patients with endocavitary pathologies, previously diagnosed, have been selected in the Centro Florence di Chirurgia Ambulatoriale. This study was performed between September 2005 and February 2006. The pathologies included: uterine myomas G0, G1, G2 (European Society of Gynaecologic Endoscopic classification), endometrial polyps, endometrial hyperplasia without cytological atypia and uterine septums.

Materials and methods

For all hysteroscopic surgeries, the new working element developed by Karl Storz System, the Autocon II 400 (Fig. 3), in bipolar and hysteroscopic function have been used. The parameters' socket used were cutting and coagulation activation type. By using bipolar system in the saline Time-C-Cut mode as the saline coagulation mode, the HF voltage form is un-modulated sinusoidal; the rated frequency is 350 kHz (at RL=500 Ω) ±10%, the crest factor is 1.4, the rated load resistance is 50 Ω, the maxim HF peak voltage is 190 Vp, the maxim power output 370 W ±20%. The parameter standard used is effect setting 4 for cut and also effect setting 4 for coagulation. The average applied HF power is approximately 130 W for resection. The bipolar components are compatible with existing resectoscope (optics, sheath). The sheath designed by Karl Storz-Endoskope is electrically completely isolated, the current returns directly via the return electrode and prevents a current flow via the sheath, guarantying a high level of safety. The cutting loops used were GP, GPV, GD, GDV in 24 F. The parameter's electronic irrigation and suction pump were 110 mmHg per 250 ml/min of flow rate and 75 mmHg/0.25 bar of suction pressure. Maximum fluid volume used for patient was 3 l. The surgery techniques for each intervention are the same as the one used with the monopolar resectoscope.

Fig. 3 Autocon II 400

Table 1 Bipolar resection in 157 patients

	Number	>4 cm
Myomas G0	19	4
Myomas G1	35	7
Myomas G2	20	4
Endometrial ablation	32	
Polyps	28	
Uterine septum	23	
Total	157	

cm centimeters

Results

Our preliminary experience in gynaecology consists of 157 patients (Tables 1 and 2) treated by Karls Storz 26 F bipolar resectoscope and Autocon II 400 high-frequency unit with parameters standard selected 180 (in effect 4) for cut and 120 (in effect 4) for coagulation. The resection loops are completely insulated from the sheath of the resectoscope and are reusable loops. Saline solution (NaCl 0,9%) was used as distension medium with no complications. Cutting power and coagulation appears sensibly better in comparison with monopolar resection. In particular, the first cut in case of fibroid tissue does not give any problem, thanks to the plasma effect. Furthermore, the vision during resection is not disturbed by the presence of air bubbles. We included in our series complex cases to evaluate the technical characteristics of the instruments, including an important number of uterine fibroids that in some cases were more than 4 cm in size and G1 and G2 (partially or totally intramural localisation). Results in terms of time of surgery, intra-operatory bleeding, and complete removal of the pathology were better compared with traditional monopolar resection (Table 3).

Table 2 Patient characteristic

	Myomectomy	Polypectomy	Metroplasty	Endometrial ablation
Number of patients	74	28	23	32
Age	35.5+3.1	33.2+4.7	32.1+5.3	51.4+8.3

Values are presented as mean±SD

Table 3 Peri-operative data

	Myomectomy group	Polypectomy group	Metroplasty group	Endometrial ablation group
Operative time (min)	10.6±1.4	4.8±2.2	9.5±2.5	13.2±3.3
Complications (intra-operatory–post-operatory–control hysteroscopy)	0	0	0	0

Values are presented as mean±SD

Discussion

The introduction of bipolar energy in the field of hysteroscopic surgery has meant the beginning of a new age of technology in which the best levels of security and effectiveness will be guaranteed . In 2007, Makris et al. [7] recently reported an experience of 5 years with Gynecare Ethicon bipolar resectoscope in gynaecology, which was used in 59 patients who underwent fibroid resection, evidencing the usefulness of bipolar current to remove small myomas. No complications were reported. In 2000, Loffer FD [8] reported a preliminary experience with the Versa Point bipolar resectoscope in gynaecology, used in 15 patients, vaporising electrode in saline solution distending medium and showing its effectiveness in the removal of submucous myomas. Golan et al. [9] in 2001 reviewed outcomes of operative hysteroscopy, using bipolar electrical energy (Versa Point) in saline solution in 116 women with intrauterine pathology and they proposed this new technique to potential replacement of the monopolar resection. Furthermore, many studies had demonstrated their benefits in urology. Recently, Singh H et al. [10] reported the utility of bipolar system in the transurethral prostate resection (TURP underlined in 2004) and the advantage of the bipolar system in TURP, with the Vista System, and stressed the theoretical benefit of avoiding the risk of TUR syndrome. In our experience and also in the analysis of the published data, it appears very clear that the bipolar resectoscope presents some advantages in comparison with the monopolar.

The current flow through tissue with less post-operative dysuria Wendt-Nordahl [11] et al. is restricted to the area between the two electrode's loops that are under direct vision of the surgeon. Current can be regulated at all times and set to the lowest possible optimal flow of current for minimally invasive treatment. The plasma effect of bipolar current allows better cut and coagulation. In the monopolar technique, the current passes through many tissues outside the surgeon's visual control before it can return to the generator [5, 12]. The risk of thermal injuries at distant organs or tissues, by direct contact of instruments, imperfection of insulation or diffusion of the electric current, is reduced in the bipolar technique [13, 14]. It has minor risk of interference on other electronic equipments (electrocardiogram, pace makers and others) simultaneously connected to the patient [5, 15]. Furthermore, there is reduced stimulation of peripheral nerves including the obturator nerve because there is no current flow through the body of the patient.

Distension media According to Kolmer and Norlen [16] and Koshiba et al. [17], incidence of overflow syndrome in gynaecology and TUR syndrome in urology varies considerably in the literature, ranging from 0.18% to 10.9%. Mebust et al. [18] reported in 3,885 patients an incidence of 2% of TUR syndrome. Kudela et al. [19], in 1996, reported the risk of fluid overload syndrome during hysteroscopy monopolar procedure and underlined the necessity to adhere to safety measures which includes selection of a suitable medium (hypotonic electrolyte-free solutions—glycine or sorbitol–mannitol solution), control duration of surgery, respecting correct surgical indications and procedure and specially perform continuous control of balance of the distension medium. Estes and Maye [20] in 2003 stand out the danger of hypotonic, electrolyte-free distension media and their potentiality to be absorbed in volumes large enough to cause hyponatraemia and hypervolaemia. Main concerns in urological and gynaecological conventional monopolar resection is fluid absorption with hyponatraemia, hypervolaemia and glycine toxicity. This syndrome is very dangerous for the patient, leading to neurotoxic coma and death in the worst cases. Most of the morbidities of the overflow syndrome are related to the use of hypotonic non-electrolyte irrigation fluid. For this reason, close and continuous peri-operative monitoring of the balance of distension medium by a nurse and frequent laboratory investigations are required. Bipolar resection system permits resection using saline solution. The use of saline solution for distension media of the uterine cavity is the principal advantage of this technology so avoid use of hypotonic non-electrolyte solution that can cause fluid overload during the surgical procedure. Saline solutions is easily metabolised, is not toxic and can be used with higher quantity and it is also less expensive than conventional hypotonic non-electrolyte solutions. Singh et al. [10] in a bipolar versus

monopolar TURP randomised controlled study reported a significant difference in serum sodium concentration post-operatively. In bipolar TURP, the change in serum sodium was −1.2 mEq/l (not different from pre-operative serum Na concentration), whereas in the monopolar group the mean decrease was 4.6 mEq/l. In three patients, serum Na was >125 mEq/L, at risk of TUR syndrome. However, balance of distension medium using saline solution should also be under control. Starkman and Santucci [21] retrospectively reviewed 43 undergoing TURP, 18 consecutive patients treated with the monopolar TURP and 25 with bipolar TURPs. These investigators found an unexpected case of hyponatraemia and pulmonary oedema in a bipolar TURP patient. Patel et al. also expressed concern for potential problems with hypervolaemia and hyponatraemia. They suggest warming the saline solution and emptying the bladder from time to time during surgery. In our experience, no overflow syndrome occurs.

Tissue alterations In traditional monopolar resection, the tissue's electrical resistance creates temperature as high as 400°C which leads to desiccation with significant collateral and penetrative tissue damage [6]. High-frequency current generated by a bipolar instrument tends to remain superficial; Luciano et al. [4, 5] reported a 0.5–1-mm depth of penetration compared with the 3–5 mm seen in monopolar system allowing a better control of the cut and lower possibility of accidental injury. The technique allows to maintain the current between the active electrode and the adjacent return electrode. Plasma effect of the loop prevents sticking effect onto it. In this case, tissue damage is minimised and tissue temperature range from 40°C to 70°C. Improved tissue analysis secondary to reduction of carbonisation of tissue has been also reported with better histological interpretation. Improved visibility aiding the identification of surgical landmarks during procedure have been repeatedly reported.

Less bleeding during resection Optimised resection current provided by the Karl Storz Autocon II 400 allows a better coagulation during resection with reduced bleeding. Furthermore, the coagulation capacity by itself is extremely more powerful in the bipolar system in comparison with monopolar. This avoids time-consuming re-coagulation after resection for coagulation and contributes to close the superficial capillary vascularisation, also reducing intravasation.

Better visibility Minor air bubbles and less bleeding during resection allow a better vision during surgery reducing length of surgery and improving results.

Reduced costs Compatible components of existing monopolar Karl Storz resectoscopes (optics, sheaths). Resection loops are reusable and have a duration and a cost comparable with the traditional monopolar ones.

The outcomes of studies in gynaecology and urology with bipolar system demonstrate its versatility and the possibility of rapid replacement of "old" monopolar system. The bipolar system is technically superior, cost-effective and safer in comparison with the monopolar system. If we take in consideration also the medical–legal aspects, it will be very dangerous to maintain the old system, especially in case of complications. Preliminary findings of decreased morbidity using bipolar system using saline solution force us to consider others factors involved in possible complications such as duration of surgery as well as the experience of the surgeon. These variables must be included in our future investigations. However, the decrease of "theoretical risk" of overflow syndrome that give the bipolar system does not allow to avoid close peri-operative monitoring of distension medium balance and laboratory investigations.

Larger prospective randomised clinical trails examining cost-effectiveness and long-term outcome need to be performed, although it seems already very clear that this technology will replace in a near future the conventional monopolar electrosurgery.

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