Feasibility of office CO_2 laser surgery in patients affected by benign pathologies and congenital malformations of female lower genital tract

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Abstract. – OBJECTIVE: Traditional surgery presents some disadvantages, such as the necessity for general anesthesia, hemorrhage, recurrence of pathology, and the possible onset of dyspareunia due to an excessive scarring. CO_2 laser surgery might resolve these problems and might be employed in a wider range of clinical indications than usual. We examined the results of CO_2 laser surgery in patients affected by benign pathologies and congenital malformations of the female lower genital tract.

PATIENTS AND METHODS: In this observational study, we enrolled 49 women who underwent CO_2 laser surgery for the following indications: Bartholin's gland cyst, imperforate hymen, vaginal septum, Nabothian cyst, and vaginal polyps. Feasibility, cost-effectiveness, complication rate, recurrence rate, short- and long-term outcomes were assessed.

RESULTS: All procedures were carried out in a short operative time, without any intraoperative complications. Only 1 (2.0%) out of 49 patients required a hemostatic suture for bleeding. Postoperative period was uneventful in all patients, except 6 (12.2%) out of 49 patients who reported pain one day after surgery, successfully treated with paracetamol. Healing was rapid and excellent in all cases; no wound infection, scarring or stenosis were noticed. Preoperative symptoms reduced or disappeared in all cases. No recurrence was observed and no re-intervention was needed.

CONCLUSIONS: CO_2 laser surgery provides several advantages over traditional surgery, as its systematic use in treating pre-invasive, benign, and congenital pathologies of the female lower genital tract reduces patient discomfort, improves short- and long-term outcomes, and optimizes cost-effectiveness.

Key Words:
 CO_2 laser, Lower genital tract, Benign pathologies, Congenital malformations.

Introduction

The term LASER is an acronym for "Light Amplification by Stimulated Emission of Radiation", a concept formulated by Einstein in 1917[1,2] who theorized that electrons could be stimulated to emit light of a particular wave length. The first laser was produced by Theodore H. Maiman in 1960[3], using ruby as a lasing medium. However, the first medical treatment on a human patient was performed in 1961 by Campbell and Koester[4] who used a prototype ruby laser photocoagulator to destroy a retinal tumor. They were followed in 1962 by Goldman et al[5] who introduced laser in dermatologic setting. When Patel[6] invented in 1963 the carbon dioxide laser (CO_2 laser), it quickly became popular among the medical community, and in 1967 Jako[7] and Polanyi et al[8] used the first CO_2 laser on cadaveric larynges. In gynecology, it was used for the first time in 1973 by Kaplan et al[9] to treat cervical erosions, and later by Bellina[10] for treatment of cervical intraepithelial neoplasia (CIN), as well as for microsurgery of the fallopian tubes.

Laser light has got some particular properties:

1. Monochromaticity: all the emitted waves have the same wavelength and energy, allowing precise targeting within tissues;
2. Brilliancy: the beam brightness is extremely intense and may also be enhanced by techniques like pulsing and Q-switching;
3. Unidirectionality: all the emitted photons travel in a single direction, so that the laser beam is very concentrated and can be focused on a very small spot size. Conversely, other forms of light are diffuse and consequently less intense.

4. Coherence: all the emitted photons vibrate in phase both in space and in time, allowing the laser beam to be more precisely focused[11].

While the use of CO_2 laser surgery in treating benign and pre-neoplastic HPV-related lesions of the vagina, cervix, and vulva is well studied and yet standardized, there are currently very few studies in literature about the effectiveness of CO_2 laser surgery in some congenital malformations and benign pathologies of the female lower genital tract, and their results are also often discordant. According to our case series, CO_2 laser surgery represents an interesting technique mainly for the increasing range of clinical indications, its cost-effectiveness, and the execution in an outpatient setting.

Among patients referred to our Department and submitted to CO_2 laser surgery from 2007 to 2012, we enrolled 49 patients treated for the following congenital malformations and benign pathologies of the female lower genital tract: Bartholin's gland cyst, imperforate hymen, vaginal septum, Nabothian cyst, and vaginal polyps. We evaluated our results in terms of feasibility, cost-effectiveness, complication rate, recurrence rate, short- and long-term outcomes.

Patients and Methods

Among patients referred to our Department from September 2007 to December 2012, we enrolled 49 patients who underwent CO_2 laser surgery at Surgical and Medical Department of Translational Medicine, Sant'Andrea Hospital, Faculty of Medicine and Psychology, Sapienza University of Rome for the following gynecological congenital malformations and benign pathologies: Bartholin's gland cyst, imperforate hymen, vaginal septum, Nabothian cyst, vaginal polyps.

All patients enrolled in this observational study signed an informed consent. The study was conducted in accordance to the Helsinki Declaration. Exclusion criteria were: pregnancy, previous vulvar surgery (except episiotomy), gynecological malignancies, hypersensitivity to local anesthesia.

Preoperative Assessment

All our study patients were asked to complete a form created in our Department about their sexual activity, in order to detect the existence of dyspareunia and its severity using a score from 0 (= no pain) to 10 (high dyspareunia). In women affected by Bartholin's gland cyst and imperforate hymen, pain intensity was also assessed by asking women to answer a validated standardized questionnaire by a 10-point visual analog scale (VAS score; 0 = no stress, 10 = very stressful).

All patients were submitted to a gynecological evaluation, by inspection and bimanual examination. In absence of a recent one, a Pap smear was performed. The cytological findings were formulated in agreement with the 2001 Bethesda System[12].

Women were also submitted to vulvoscopy, according to current guidelines, and colposcopy by a standard OM50 Zeiss colposcope (Carl Zeiss, Inc., Jena, Germany). The colposcopic examination was performed after the application of a 5% acetic acid solution, followed by a Schiller test. If the squamous-columnar junction (SCJ) was entirely detectable, colposcopy was considered satisfactory. The colposcopic findings were reported in agreement with the International Nomenclature IFCPC 2012[13].

A transvaginal ultrasound was also performed to detect any other gynecologic disease, using the Voluson 730 Expert ultrasound system (GE Healthcare, Little Chalfont, Buckinghamshire, UK) equipped with a 7.5-MHz transvaginal probe.

As regard to women diagnosed with imperforate hymen, preoperative assessment included only gynecological inspection, transabdominal ultrasonography, and VAS score to evaluate dysmenorrhea and chronic pelvic pain.

Surgical Techniques

CO_2 laser surgery was performed in an outpatient setting after the injection of 2% lidocaine for local anesthesia. All procedures were carried out by a CO_2 Laser (733A; ESC Sharplan, Yokneam, Israel) with a maximum power output of 25 W used in continuous mode, connected to a colposcope (Carl Zeiss, Oberkochen, Germany). The laser beam was guided by a manipulator to focus it on the lesion.

The surgical techniques used for each condition are described below:

1. Batholin's gland cyst: all patients were administered antibiotic prophylaxis with 2 g of cephalosporins intramuscularly, 1 hour before surgery and for 7 days after the procedure. The CO_2 laser excision was performed using a spot size varying from 0.5 to 1 mm and a power

density ranging from 600 to 1200 W/cm², in continue mode. We administered a 5 mL solution of 2% lidocaine through multiple injections in the skin overlying the cyst. After digitally examined the internal face of the affected labium, we performed a 1.5 cm longitudinal incision by the laser beam near the place where the cyst wall was closer to the vulvar epithelium. This incision allowed us to visualize the cyst capsule easily thanks to its white-pearl color. We grasped the lateral edges of the incision and held them in tension by Ellis forceps to help the voiding of the internal content during the opening of the cyst capsule. Thus, we proceeded to an irrigation of the inner cyst surface with sterile saline solution. Afterwards, we performed a complete eversion of the inner surface of the cyst capsule, which was then vaporized with a depth of destruction of 2 to 3 mm. The procedure was completed by a CO_2 laser vaporization of the edges of the mucosal incision to avoid external bleeding. In case of multiloculated cysts, we repeated the same procedure for each cyst, using the same skin orifice.

2. Imperforate hymen: after administration of local anesthesia and disinfection of the external genitalia, we created a new orifice measuring approximately 2-2.5 cm of diameter, by a circular incision. The mean spot size was 1 mm and the power density ranged from 450 to 600 W/cm², in continue mode. No antibiotic prophylaxis was needed.

3. Vaginal septum: all patients were examined carefully in order to delimit the septum, using a 4-valves speculum to preserve vaginal tissues. The CO_2 laser excision consisted of two phases: first of all we divided the septum into 2 parts, anterior and posterior by a transversal incision; then, we vaporized the excess vaginal tissue. The laser spot size was 0.5-1 mm for transversal incision and 3-4 mm for the vaporization. We used a power density of 800-1000 W/cm² for each time of the procedure. No antibiotic prophylaxis was needed.

4. Nabothian cyst: a circular section was performed at the center of the cyst by a laser mean spot size of 0.8 mm and a power density of 300-1000 W/cm². When the evacuation was complete and the cyst wall collapsed, we carried out a CO_2 laser vaporization of the entire cyst bed by a 4 mm mean spot size.

5. Vaginal polyps: the polyp was grasped with a surgical clamp in order to visualize its peduncle; then, we performed the excision starting from the polyp base, using a 0.7 mm mean spot size and a 900 W/cm² power density. We completed the procedure vaporizing the polyp base by a mean spot size of 4 mm.

Post-Treatment Follow-Up

All patients were advised to immediately return to our Department in cases of significant pain or considerable vaginal bleeding. During the follow-up period, patients were evaluated at 7, 15, 30 days after surgery and annually thereafter. At every follow-up check, we performed a colposcopic examination; the presence of pain, dyspareunia, any complications, return to daily activity, recurrence, VAS score and sexual activity questionnaire score were also evaluated.

Results

Bartholin's Gland Cyst

We examined 21 patients with a median age of 27 years (range: 21-39 years) and a median parity of 1 (range: 0-3) (Table I). Eight (38.1%) out of 21 patients had previously undergone right mediolateral episiotomy. The cysts were right-sided in 9

Table I. Study patients characteristics.

	Bartholin's gland cyst (n = 21 pts)	Imperforate hymen (n = 13 pts)	Vaginal septum (n = 7 pts)	Nabothian cyst (n = 5 pts)	Vaginal polyps (n = 3 pts)
Median age (years)	27	15	16	32	27
Median parity	1	0	0	2	2
Median sexual activity questionnaire score (0-10)	8	–	9	7	6
Smoking habits (%)	42.9%	15.4%	28.6%	20%	–

(42.9%) out of 21 cases and left-sided in 12 (57.1%) cases. Median cyst diameter measured 3 cm (range: 2-5 cm). Cysts were unilocular in 16 (76.2%) patients and multilocular in 5 (23.8%) patients. No bilateral cysts were observed. The most common symptoms were burning, vulvar pain, and dyspareunia. Four (19.0%) patients reported 1 episode of cyst infection with fever in the last 12 months. All patients had previously attempted a medical therapy with antibiotics (amoxicillin or ciprofloxacin), with no benefit. Nine (42.9%) women reported current or past tobacco use. Median preoperative VAS score was 7 (range: 5-10) (Table II) and the sexual questionnaire median score was 8 (range: 6-10).

All procedures lasted an average of 12 minutes (range: 6-19 minutes). No intraoperative complications were reported, except one (4.8%) patient who needed a hemostatic suture for bleeding (Table III). No packing was required.

As regard to follow-up checks, 6 (28.6%) out of 21 patients reported pain one day after surgery, successfully treated with paracetamol. No wound infection occurred. Healing was complete within 5 weeks (median: 24 days; range: 3-5 weeks) in all patients, without any tissue fibrosis or scarring.

Return to daily living required a median time of 2 days (range: 1-5 days). Sixteen (76.2%) out of 21 patients returned to their sexual activity after a median time of 17 days (range: 14-22 days), while 5 (23.8%) patients did not return to sexual activity for all the follow-up period (Table III). Preoperative symptoms significantly reduced or disappeared in all cases. The sexual activity form administered at 30 days after surgery showed no dyspareunia. VAS score was assessed at 7, 15, 30 days after surgery with a crescent improvement (median scores were 3, 1, 0, respectively) (Table II). There was no case of recurrence.

Imperforate Hymen

We examined 13 patients with a median age of 15 years (range: 12-16 years) (Table I). All patients had primary amenorrhea and were referred to our Department because of acute pelvic pain. Ten (76.9%) out of 13 patients reported no dysuria, acute urinary retention, nausea, or vomiting. Instead, 3 (23.1%) patients presented with acute urinary retention and needed a catheterization, evacuating 600 cc of urine. During gynecologic examination, we observed a pelvic mass in 3 (23.1%) patients causing urinary retention, whereas in 10 (76.9%) patients the examination was normal. Secondary sexual characteristics were normally developed in all patients. We found in all cases an imperforate hymen, with a bluish aspect due to the retained blood. Transabdominal ultrasonography confirmed the presence of hematocolpos and hematometra in all patients. Two (15.4%) patients reported current cigarette smoking. Median preoperative VAS score was 9 (range: 7-10) (Table II).

All procedures required a median time of 3 minutes (range: 1-5 minutes). No bleeding was observed and no suturing was required (Table III). Antibiotics were not prescribed.

At the first follow-up check, no patients reported fever, pain or vaginal bleeding. Moreover, no wound infection, scarring or hymeneal stenosis were noticed. Healing was satisfactory and complete within 2 weeks (median: 7 days; range: 1-2 weeks) in all cases. Although all patients had a regular menstrual cycle, 4 (30.8%) out of 13 women presented a significant dysmenorrhea, successfully treated with FANS. At 1-year follow-up, no re-intervention was required.

Return to normal lifestyle occurred in a median time of 1 day (range: 1-3 days). Six (46.2) out of 13 patients became sexually active after a median time of 18 months (range: 13-22 months), experiencing no dyspareunia. The remaining 7 (53.8%) patients did not become sexually active for all the follow-up period (Table III). VAS score was assessed at 7, 15, 30 days after surgery with a crescent improvement (median scores were 2, 1, 0, respectively) (Table II).

Table II. Preoperative and postoperative VAS score evaluated in patients with Bartholin's gland cyst and imperforate hymen.

	Median preoperative VAS score	Median VAS score at 7 days	Median VAS score at 15 days	Median VAS score at 30 days
Bartholin's gland cyst	7	3	1	0
Imperforate hymen	9	2	1	0

Table III. Median surgical time for each CO_2 laser procedure, intraoperative and postoperative complication rate, main postoperative outcomes.

	Bartholin's gland cyst (n = 21 pts)	Imperforate hymen (n = 13 pts)	Vaginal septum (n = 7 pts)	Nabothian cyst (n = 5 pts)	Vaginal polyps (n = 3 pts)
Median surgical time (minutes)	12	3	4	4	3
Intraoperative complication rate (%)	4.8%[a]	–	–	–	–
Postoperative complication rate (%)	28.6%[b]	–	–	–	–
Wound healing median time (days)	24	7	19	10	12
Return to normal lifestyle (days)	2	1	1	1	1
Return to sexual activity	17 days[c]	18 months[d]	38 days	15 days	28 days
Recurrence rate (%)	–	–	–	–	–

[a]One (4.8%) patient needed a hemostatic suture for bleeding. [b]Six (28.6%) out of 21 patients reported pain one day after surgery, successfully treated with paracetamol. [c]Sixteen (76.2%) out of 21 patients returned to their sexual activity after a median time of 17 days (range: 14-22 days), while 5 (23.8%) patients did not return to sexual activity for all the follow-up period. [d]Six (46.2) out of 13 patients became sexually active after a median time of 18 months (range: 13-22 months), experiencing no dyspareunia. The remaining 7 (53.8%) patients did not become sexually active for all the follow-up period.

Vaginal Septum

Seven patients with a median age of 16 years (range: 13-17 years), nulliparous were enrolled (Table I). All patients had regular menstrual cycle with normally developed secondary sexual characteristics, and were referred to our Department with a diagnosis of vaginal septum. After a careful examination, we confirmed the diagnosis of longitudinal vaginal septum in all cases: 6 (85.7%) out of 7 patients showed a complete septum, whereas 1 (14.3%) patient had a median incomplete vaginal septum. Transvaginal ultrasound excluded any other gynecologic malformations in all patients. Two (28.6%) patients reported current tobacco use. Sexual activity questionnaire revealed a considerable dyspareunia in all patients, with a median score of 9 (range: 6-10).

Surgical procedures required a median time of 4 minutes (range: 3-5 minutes), without any intraoperative complications (Table III).

At the first follow-up check, no postoperative complications were noticed. Healing was complete within 4 weeks (median: 19 days; range: 1-4 weeks) in all patients. At 1-year follow-up, no re-intervention was required.

All patients returned to daily activity within 3 days (median: 1 day; range: 1-3 days), while return to sexual activity required a median time of 38 days (range: 4-8 weeks). The sexual activity form administered at 30 days after surgery showed a median score of 0 (range: 0-2) (Table III).

Nabothian Cysts

We examined 5 patients, with a median age of 32 years (range:26-39 years) and a median parity of 2 (range: 0-4) (Table I). One (20%) patient had previously undergone episiotomy on the right side. One (20%) woman reported former tobacco use. Three cysts (60%) arose from the anterior cervical wall, whereas the other 2 (40%) cysts from the posterior cervical wall. Median cyst size was 3 cm (range: 2-5 cm). All patients were asymptomatic and Nabothian cysts were diagnosed during a routine gynecologic examination. No patient reported a history of cytological abnormalities. The sexual activity form showed a median score of 7 (range: 5-9).

All surgical procedures were carried out in a median time of 4 minutes (range: 3-7), without any bleeding or vaginal damage (Table III).

At the first follow-up check, no postoperative complications were registered. Healing was complete within 2 weeks (median: 10 days; range 1-2 weeks) in all cases. Return to daily activity was estimated in 1 day (range: 1-3 days), while return to sexual activity required a median time of 15 days (range: 9-17 days) (Table III). The sexual activity form administered at 30 days after surgery showed a significant improvement. No recurrence was observed.

Vaginal Polyps

Three patients with a median age of 27 years (range: 25-28 years) and a median parity of 2 (range: 1-3) were enrolled (Table I). They were

all asymptomatic and vaginal polyps were detected during a routine gynecological examination. No patient had previously undergone episiotomy. No patient reported either a history of cytological abnormalities or tobacco smoking. At the sexual activity questionnaire, we found a median score of 6 (range: 5-7).

Surgical procedures were completed in a median time of 3 minutes (range: 3-5 minutes), without any bleeding (Table III).

At the first follow-up check, no postoperative complications were observed. Healing was complete within 2 weeks (median: 12 days; range: 1-2 weeks) in all patients. Return to normal lifestyle was estimated in 1 day (range: 1-2 days), while return to sexual activity required a median time of 4 weeks (range: 3-6 weeks). The sexual activity form administered at 30 days after surgery showed a 1 median (range: 0-2) score. No recurrence occurred (Table III).

Discussion

Traditional surgery shows some disadvantages such as the necessity for general anesthesia, hemorrhage, recurrence, and the possible onset of dyspareunia due to an excessive scarring[14,15]. As a consequence, it is very important to find some alternative therapeutic methods, which could permit to resolve these problems and reduce patient discomfort. CO_2 laser is an interesting therapeutic tool, thus the aim of our study was just to prove the efficacy of CO_2 laser surgery in treating some benign pathologies and congenital anomalies of the female lower genital tract, for which only a few studies are currently present in literature.

The Bartholin's gland cyst is a benign pathology caused by the obstruction and consequent dilation of the cyst duct[16]. It affects approximately 2% of women, mainly in the age range 20-29 years, and is associated with significant patient discomfort[17]. The main treatments include surgical removal of the entire cyst and marsupialization. However, these techniques show some limitations: surgical excision may be associated to significant bleeding, hematomas formation, prolonged healing process[15], and permanent compromise of vaginal lubrication[17]. Furthermore, it must be performed under general anesthesia, and a high recurrence rate (until 24%) has been recorded[16]. On the other hand, marsupialization causes less discomfort and blood loss risk, but is associated with a prolonged healing process,

constant external drainage, significant scarring[15,18] and probably a higher recurrence rate[16]. Marsupialization is also not useful in treating abscesses[17]. Moreover, surgical gland excision and marsupialization may be associated to surgical infections[17] and may lead to dyspareunia due to scar tissue formation[15]. A less-invasive and effective alternative is the Word catheter; however, it must be left in place for 4 to 6 weeks and requires that patients return at least twice (the first time for remove or substitute the catheter, and the second time for reassessment)[16,17,19-21]. Some Authors[22,23] also advocate alcohol sclerotherapy and silver nitrate insertion as outpatient treatments, but they seem to be associated with high failure rates.

In the last years, an increasing number of Authors[15-17,19,24-27] have focused their attention on the use of CO_2 laser surgery in treating Bartholin's gland cyst. In our study, CO_2 laser surgery showed important advantages over traditional surgical strategies: it was performed under local anesthesia in an outpatient setting, required a short operative time (median: 12 minutes), was bloodless, and did not cause any postoperative scarring or stenosis. Among our 21 patients, no recurrence occurred at a median follow-up of 28 months, confirming that CO_2 laser excision/vaporization should be preferred to conservative surgical treatments, because a complete destruction of cyst lining avoids recurrences[15]. In contrast, Benedetti Panici et al[16] performed a conservative CO_2 laser surgery, creating a new stoma on the original duct orifice and preserving the gland function. Using such a conservative technique, this group reported a 10.5% recurrence rate at a median follow-up of 32 months[16], which is approximately 2-fold higher than that reported by Fambrini et al[19] using a destructive method (4.3% recurrence rate at a median follow-up of 42 months). This may be due to 2 main reasons, as explained by Fambrini et al[19]: first, Benedetti Panici et al[16] included abscesses, which are themselves characterized by a higher recurrence rate; second, they might have not identified some multiloculated cysts for the lack of incision and drainage. Moreover, preserving the Bartholin's gland original function seems not to be useful, as no patient experienced dyspareunia after the gland removal either in our study or in Fambrini et al's[19].

As to imperforate hymen, this condition is usually asymptomatic and undiagnosed until the onset of menstruation. After menarche, blood be-

gins to accumulate behind the imperforate hymen, developing hematocolpos, hematometra, and hematosalpinx and so causing cyclic symptoms. Hematocolpos can also associate to obstruction of urethra and urinary retention[28]. Several surgical techniques[28-32] (including hymenectomy and virginity sparing hymenotomy), followed or not by the application of Foley catheter to prevent restenosis, have been proposed in the correction of this defect. CO_2 laser surgery can be successfully used in the treatment of this rare congenital anomaly, as previously demonstrated by Friedman et al[14]. Our 13 patients were submitted to CO_2 laser surgery in an outpatient setting under local anesthesia to create a new orifice. As no patient required to preserve hymeneal integrity, we decided to perform a quite large incision (approximately 2.5 cm) in order to reduce restenosis risk: indeed, a smaller hymeneal incision has been reported to be associated to the onset of restenosis[33]. All procedures required an average of 3 minutes (range: 1-5 minutes) and no intraoperative complications were recorded. The wound was completely healed within 2 weeks in all cases, without any scarring or stenosis. One year after CO_2 laser surgery, no patient required re-intervention.

Müllerian duct anomalies, including congenital malformations of cervix, vagina and uterus, occur in 1-3% of women[34]. The cause of these anomalies remains unclear, however they may be due to a failed fusion of müllerian ducts and/or reabsorption of the septum[34]. Two classifications of müllerian duct anomalies have been suggested: the first one was proposed in 1979 by Buttram and Gibbons, and the second one by the American Fertility Society in 1988, categorizing these abnormalities in seven classes[34,35]. Longitudinal vaginal septum is often associated with other uterine anomalies, such as complete or partial high septum and dydelphis uterus[35-42], whereas isolated vaginal septa are rarely described in literature[34,43]. Nonetheless, in all our 7 patients transvaginal ultrasonography provided a diagnosis of isolated longitudinal septum, excluding any other müllerian abnormalities. Longitudinal vaginal septum is usually resected using the classical surgical procedure: excision by scissors after the application of 2 Kelly or Kocher forceps to prevent any blood loss, and suturing of the edges with absorbable sutures[35]. Traditional surgery may present some complications, such as damage of the bladder or rectum, with subsequent bleeding and scarring[35]; furthermore, it requires

general anesthesia and hymenotomy in presence of an intact hymen[34]. Hence, alternative methods are strongly required to simplify the procedure and to minimize the risk of complications. Hysteroscopic treatment has been demonstrated to be an easy, effective, and safe alternative method to conventional surgery in young women as it preserves hymen integrity[34,35,39-42]. However, to the best of our knowledge only Di Spiezio Sardo et al[34] performed hysteroscopic resection with no analgesia or anesthesia in an outpatient setting, requiring an operative time of 10 minutes, whereas other Authors performed this procedure under general anesthesia[35,39-42]. CO_2 laser surgery may offer some advantages also in this clinical setting, as it does not damage adjacent tissue and may be performed in an out patient setting, under local anesthesia. In our case load, all procedures lasted an average of 4 minutes (range: 3-5 minutes), without any intraoperative complications. At follow-up checks, we found no postoperative complications, a rapid healing (within 3 weeks) and a significant reduction of dyspareunia in all cases. One year after CO_2 laser surgery, no re-intervention was required.

Similarly, satisfactory short- and long-term results were registered for both Nabothian cysts and vaginal polyps, reporting no intraoperative complications and an uneventful postoperative period. Nevertheless, CO_2 laser vaporization has got a significant limitation as it does not provide any sample for histological analysis and this could be a problem, mainly in some cases of deep Nabothian cysts which could mimic other malignant pathologies[44-46].

As demonstrated in this study, CO_2 laser surgery yields considerable advantages over conventional surgery, such as its precision thanks to the connection to colposcope, the minimal thermal reaction to adjacent tissue, an immediate hemostasis during the vaporization of tissues without any bleeding. It also guarantees a rapid and excellent healing, without any postoperative scarring or stenosis[14,15]. Currently, the use of CO_2 laser surgery is not widespread, mainly in the above mentioned benign pathologies and congenital malformations. This may be due to several reasons, such as the general complexity of techniques requiring a long training from physicians, the initial elevated investment, and the costly maintenance of the instrument. Overall, the techniques utilized in our study are very simple, so they would require only a minimum learning curve from clinicians to be applied.

Even if the costs of the instrument and its technical servicing are remarkable, we could recuperate a significant amount of the cost by its wide scale use to treat the widest possible range of pre-invasive, benign and congenital pathologies of the female lower genital tract[19,25]. The lower rate of intra- and post-operative complications and the minimum recurrence rate also make CO$_2$ laser surgery more cost-effective than traditional surgery. Moreover, it is performed under local anesthesia without the presence of a dedicated anesthesiologist, requires a short operative time, and is carried out in an outpatient setting, thus reducing the hospital costs[25,26]. Conversely, traditional treatments needing general anesthesia and hospitalization are not so cost-effective, causing a significant increase in health-care costs.

Conclusions

The effectiveness of CO$_2$ laser surgery should be verified in a larger series, in order to validate its indication in the above-mentioned benign pathologies and congenital malformations, thus reducing patient discomfort, improving short- and long-term outcomes, and optimizing cost-effectiveness.

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Conflict of Interest

The Authors declare that there are no conflicts of interest.

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