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REVIEW ARTICLE

Single-site port robotic-assisted hysterectomy: an update

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Abstract
Single-incision approach in robotic gynecology is a relatively new concept. The role of single-port systems in robotic hysterectomy, their advantages and disadvantages, as well as the technical challenges, are still under investigation. A systematic review was performed by searching in PubMed and Scopus databases. In 810 out of 1225 patients, hysterectomy was performed for non-neoplastic disease. Single-Site® was the most common port system. Duration of the procedure and relative blood loss ranged from 60 to 311 min and 7 to 750 ml, respectively. The weight of the removed uteri ranged from 39 to 520 g. 4.9% of the included patients presented complications, among which bleeding, vaginal haematoma, laceration and dehiscence, umbilical hernia, and visceral injuries. Conversion rate to laparotomy reached 2.8%. Although some technical difficulties are still described in the literature, the single-port approach is becoming more standardized nowadays and performed by more surgeons. The initial phase of the learning curve can be achieved after five cases, while a proficiency in intracorporeal cuff suturing after 14 cases. Uterus weight and previous abdominal surgical history can still be limitations of the technique. Compared to our previous study, we can see that the technique has been used in more elderly or obese patients. The complication rate can reach 4.9% while the conversion rate can reach 2.8%. However, we consider that complication and conversion rates as well as surgical time could be improved with experience. Regarding post-operative pain and cosmetic outcomes, the lack of information do not allow us to draw any safe conclusions.

Keywords Single port · Laparoendoscopic single site · Single incision · Robotics · Hysterectomy · Update

Introduction

The single-incision approach in robotic gynaecology is a relatively new concept. Langebrekke et al., in 2009, was the first to perform a single-port laparoscopic hysterectomy [1], while Fader et al. were the first to perform a single-port robotic hysterectomy in 2009 [2]. Three years ago, our team published a systematic review presenting the role of single-port systems in robotic hysterectomy, their advantages and disadvantages, as well as the technical challenges [3]. With this updated systematic review, we are trying to further clarify the role of single-port approach as the technique became more standardized and used by more surgical teams worldwide. We presented the suggested technique of hysterectomy, bilateral salpingooophorectomy and pelvic lymph node dissection in our previous review.

The purpose of this article is to present an update of the clinical evidence regarding the use of single-port robotic-assisted hysterectomy in the treatment of gynaecological pathologies.

Methods

Data sources

A systematic electronic search was performed in PubMed (31 October 2017) and Scopus (31 October 2017). Both in PubMed and in Scopus databases, the search strategy which was applied included the combination of the key words: (LESS OR single port OR laparoendoscopic single site) AND (robot OR robotic OR telesurgery) AND hysterectomy. A hand search of the references of both potentially relevant

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articles and articles qualifying for inclusion was also performed. The literature search was performed in accordance with the preferred reporting items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [4].

Study selection criteria

Studies reporting data on the single-port robotic-assisted hysterectomy were considered includable for this review. Abstracts in scientific conferences, editorials, letters to the editor, animal studies as well as studies published in languages other than English, German, French, Italian, Greek and Spanish were not included in this review.

Results

A systematic search performed in electronic databases of PubMed and Scopus retrieved a total of 202 and 598 studies, respectively, among which 26 studies (18 case series and 8 case reports) were meeting the inclusion criteria of our review [2, 5–29]. A hand search of references present in the included studies was also performed without successful additional studies identified. The included studies were represented graphically in Fig. 1 (flow diagram).

In Table 1, the principal characteristics of the included studies are represented in our review (number of patients included in each study, age of the patients, body mass index and diagnosis of the patients, port system utilized, duration of the procedure, blood loss due to the operation, weight of the removed uterus, conversion rate to three-port robotic or open procedures, need for post-operative transfusion, post-operative hospital stay, post-operative complications and duration of follow-up). In Table 2, the overall operative data of the included patients are represented.

In the study, 1225 patients in total were included (720 patients as control group), of whom 1211 patients were included in case series studies. Their age ranged from 21 to 88 years. The body mass index of the included patients ranged from 15.9 to 55 kg/m^2. Hysterectomy was performed in 810 out of 1225 patients due to non-neoplastic diagnosis (such as uterine fibroids, endometriosis). The most common port system utilized in the included studies was the Single-Site® port (13 out of 26 studies). Regarding the duration of the procedure and the relative blood loss, they ranged from 60 to 311 min and 7–750 ml, respectively. The weight of the removed uteri ranged from 39 to 520 g. Twenty-five of the 505 included patients (4.9%) presented complications, among which the most common were the post-operative ones (21 out of 25 patients). Conversion to multi-port robotic/laparoscopy/laparotomy surgery was necessary in 14 out of 505

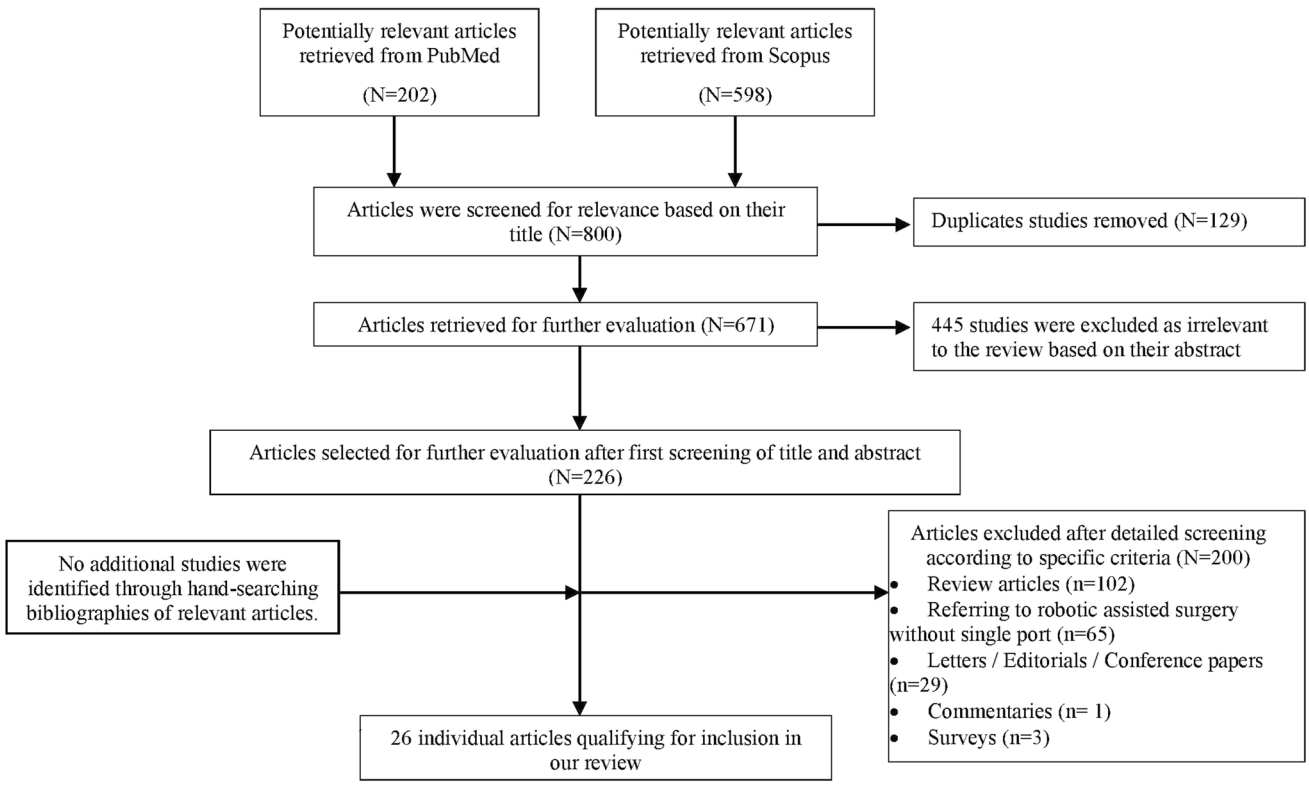

Fig. 1 Flow diagram of the detailed process of selection of articles for inclusion in the review

Table 1 Studies referring to robotic single-port hysterectomy

First author, year, country (Ref)	Nr. of patients	Age of patient (in years)	BMI (kg/m^2)	Diagnosis (%)	Port system applied	Duration of the procedure (in min)	Estimated blood loss (in ml)	Uterus weight (in gr)	Conversions (%)	Transfusion needed	Hospital stay (in days)	Complications (%)	Follow-up (in mo)
Case series													
Buckley de Meritens, 2017, USA [5]	41	Median (range): 50.8 (33–74)	Median (range): 27.2 (18–42)	Fibroids: 7/41 (17), malignancy: 8/41 (19.5), adnexal disease: 3/41 (7.3), BRCA/HBOC: 8/41 (19.5), complex atypical hyperplasia: 10/41 (24.4), others: 4/41 (9.75)	Single-Site® port: 40/41 Gelport®: 1/40	Median (range): 128 (60–275)	Median (range): 69 (10–200)	Median (range): 164 (30–460)	1/41[e] (2.4)	–	Median: 0.5	Umbilical hernia: 2/41 (4.8)	NR
Gungor, 2017, Turkey [6]	20	Mean (SD): 54.4 (7.8)	Mean (SD): 28.7 (3.6)	Benign pathologies: 13/20 (65) Early endometrial cancer: 7/20 (35)	Single-Site® port	Median (range): 90 (70–165)	Median (range): 40 (20–200)	NR	0/20	0/20	Median (range): 1 (1–2)	0/20	Median (range): 12 (5–24)
	25[f]	Mean (SD): 52.4 (7), $p = 0.38$	Mean (SD): 26.8 (3.6), $p = 0.14$	Benign pathologies: 25/25 (100)	SILS Port®	Median (range): 90 (60–200), $p = 0.74$	Median (range): 50 (20–250), $p = 0.77$	NR	0/25	0/25	Median (range): 1 (1–3), $p = 0.17$	0/25	
Moukarzel, 2017, USA [7]	30	Median (range): 52 (35–77)	Median (range): 26 (19–34)	Uterine cancer: 13/30 (43.3) preinvasive cervical/uterine disease: 9/30 (30) Cervical cancer: 3/30 (10) BRCA carrier: 5/30 (16.6)	Single-Site® port	Median (range): 172 (115–451)	Median (range): 86 (10–300)	Median (range): 117 (35–275)	1/30[e] (3.3)	0/30	Mean: 1	0/30	Range: 4–6 weeks

Table 1 (continued)

First author, year, country (Ref)	Nr. of patients	Age of patient (in years)	BMI (kg/m^2)	Diagnosis (%)	Port system applied	Duration of the procedure (in min)	Estimated blood loss (in ml)	Uterus weight (in gr)	Conversions (%)	Transfusion needed	Hospital stay (in days)	Complications (%)	Follow-up (in mo)
Corrado, 2016, Italy [8]	125	Median (range): 59 (35–84)	Median (range): 27 (19–52)	Adenocarcinoma: 124/125 (99.2) Adenosquamous: 1/125 (0.8)	Single-Site® port	Median (range): 122 (35–282)	Median (range): 50 (10–250)	NR	0/125	1/125 (0.8)	Median (range): 2 (1–16)	Haemoperitoneum: 2/125 (1.6) Wound infection: 2/125 (1.6) Cystitis: 2/125 (1.6) fever: 1/125 (0.8) Deep vein thrombosis: 1/125 (0.8) Vaginal vault haematoma: 1/125 (0.8) Lower limbs neuropathy: 1/125 (0.8)	Median (range): 24 (8–46)
Corrado, 2016, Italy [9]	23	Median (range):64 (35–85)	Median (range): 26.6 (17.8–33.6)	Adenocarcinoma: 23/23 (100)	Single-Site® port	Median (range): 110 (60–160)	Median (range): 50 (10–150)	NR	0/23	0/23	Median (range): 2 (2–5)	Postoperative bleeding: 1/23 (4.3)	Median (range): 41.4 weeks (27.2–50.1)

Table 1 (continued)

First author, year, country (Ref)	Nr. of patients	Age of patient (in years)	BMI (kg/m^2)	Diagnosis (%)	Port system applied	Duration of the procedure (in min)	Estimated blood loss (in ml)	Uterus weight (in gr)	Conversions (%)	Transfusion needed	Hospital stay (in days)	Complications (%)	Follow-up (in mo)
	46[g]	Median (range): 59 (38–88), $p = 0.401$	Median (range): 28.5 (20–34.6), $p = 0.071$	Adenocarcinoma: 45/46 (97.8) Adenosquamous: 1/46 (2.2)	–	Median (range): 102.5 (70–175.5), $p = 0.881$	Median (range): 100 (10–250), $p = 0.001$	NR	0/46	2/46 (4.4)	Median (range): 3 (2–6), $p = 0.001$	Fever: 1/46 (2.2)	Median (range): 56.4 weeks (8–66.9)
Bogliolo, 2016, Italy [10]	45	Mean (SD): 46 (10.9)	Mean (SD): 25 (5)	Fibroids: 33/45 (73.3), adenomyosis: 5/45 (11.1), genetic risk of cancer: 4/45 (8.9)	Single-Site® port	Mean (SD): 144 (41)	Mean (SD): 46 (52)	Mean (SD): 137 (39)	0/45	–	Mean (SD): 1.5 (1)	1/45 (2.2)	12
	59[g]	Mean (SD): 48 (8.4), $p = 0.96$	Mean (SD): 24 (4), $p = 0.86$	Fibroids: 41/59 (69.5), $p = 0.67$ Adenomyosis: 6/59 (10.2), $p = 0.87$ Genetic risk of cancer: 5/59 (8.5), $p = 0.94$	–	Mean (SD): 146 (47), $p = 0.84$	Mean (SD): 150 (151), $p < 0.001$	Mean (SD): 245 (182), $p = 0.15$	0/59	–	Mean (SD): 2.5 (2), $p = 0.009$	3/59 (5.1)	12
El Hachem, 2016, USA [11]	13	Mean: 43	Mean: 27.4	Endometrial carcinoma: 7/13 (53.8), ovarian cancer: 1/13 (7.7)	NR	Mean: 101.6	Mean: 96.2	Mean: 104.5	0/13	1/13 (7.7)	< 24 h: 13/13	Vaginal laceration: 1/13 (7.7) Vaginal leaking: 1/13 (7.7)	6 weeks
	26[f]	Mean: 60.4, $p = 0.61$	Mean: 27.9, $p = 0.66$	Endometrial carcinoma: 12/26 (46.1), ovarian cancer: 8/26 (30.7)	–	Mean: 88.8, $p = 0.02$	Mean: 107, $p = 0.21$	Mean: 152.6, $p = 0.09$	0/26	0/26	> 24 h: 1/26	Vaginal laceration: 1/26 (3.8)	6 weeks

Table 1 (continued)

First author, year, country (Ref)	Nr. of patients	Age of patient (in years)	BMI (kg/m^2)	Diagnosis (%)	Port system applied	Duration of the procedure (in min)	Estimated blood loss (in ml)	Uterus weight (in gr)	Conversions (%)	Transfusion needed	Hospital stay (in days)	Complications (%)	Follow-up (in mo)
Akdemir, 2015, Turkey [12]	24	Median (range): 49.5 (40–61)	Median (range): 28.5 (21.7–34.2)	Non-neoplastic disease	TriPort®	Median (range): 98.5 (71–183)	Median (range): 22.5 (40–61)	Median (range): 192.5 (65–520)	0/24	–	Median (range): 1.6 (1–3)	–	Mean: 9
	34[f]	Median (range): 51.5 (44–67), $p = 0.38$	Median (range): 27.45 (22.5–34.5), $p = 0.93$			Median (range): 86 (59–140), $p = 0.013$	Median (range): 25 (44–67), $p = 0.38$	Median (range): 117.5 (50–535), $p = 0.026$	0/34		Median (range): 1.8 (1–4), $p = 0.92$	–	Mean: 12
Bogliolo, 2015, Italy [13]	45	Mean (SD): 49.5 (12.9)	Mean (SD): 25 (4)	Endometrial carcinoma: 15/45, uterine fibroids: 13/45, endometriosis: 4/45, uterine adenomyosis: 3/45, endometrial hyperplasia: 3/45, in situ cervical carcinoma: 4/45, female to male transsexualism: 3/45	Single-Site® port	Mean (SD): 134 (36)	Mean (SD): 40 (38)	Median (SD): 161.4 (130)	1/45 (2.2)	–	Mean (SD): 2.7 (2)	Perumbilical vascular injury: 1/42 (2.2) Vaginal cuff haematoma: 1/42 (2.2)	NR
Chong, 2015, Korea [14]	16	Mean (SD): 45.3 (3.5)	Mean (SD): 23.1 (2.9)	Non-neoplastic disease	OctoPort®	Mean (SD): 130.2 (32.6)	Mean (SD): 32.2 (27.6)	Mean (SD): 335.1 (203.6)	0/16	–	Mean (SD): 4.6 (1.9)	Rectal serosa injury: 1/16 (6.3)	NR
Lopez, 2015, USA [15]	50	Mean (SD): 46 (9.4)	Mean (SD): 25.9 (6.1)	Non-neoplastic disease	NR	Mean (SD): 139.3 (45.8)	Mean (SD): 37.2 (30.7)	Mean (SD): 125.6 (68.5)	8/50 (16)[e]	NR	Mean (SD): 23.3 (9.1) hr	Vaginal dehiscence: 1/50 (2)	NR

Table 1 (continued)

First author, year, country (Ref)	Nr. of patients	Age of patient (in years)	BMI (kg/m^2)	Diagnosis (%)	Port system applied	Duration of the procedure (in min)	Estimated blood loss (in ml)	Uterus weight (in gr)	Conversions (%)	Transfusion needed	Hospital stay (in days)	Complications (%)	Follow-up (in mo)
	50[f]	Mean (SD): 45.4 (8.9), $p = 0.75$	Mean (SD): 28.8 (5.5), $p = 0.02$			Mean (SD): 121 (31.7), $p = 0.02$	Mean (SD): 42 (37.9), $p = 0.49$	Mean (SD): 117.9 (56.8), $p = 0.54$	5/50 (10)[e], $p = 0.54$		Mean (SD): 31.9 (14.8) hr, $p = 0.001$	Cystotomy: 1/50 (2) vaginal dehiscence: 1/50 (2)	
Paek, 2015, Korea [16]	25	Mean (SD): 48 (4.1)	Mean (SD): 24.3 (2.5)	Non-neoplastic disease	Single multichannel port system	Mean (SD): 170.9 (65.5)	Median: 20	Mean (SD): 271 (119)	0/25	–	Mean (SD): 3.5 (0.7)	0/25	NR
	442[f]	Mean (SD): 48.9 (8.7), $p = 0.382$	Mean (SD): 24 (3.3), $p = 0.608$			Mean (SD): 88.3 (38.4), $p < 0.0001$	Median: 50, $p = 0.04$	Mean (SD): 249 (190), $p = 0.386$	0/442	3/440 (0.68)	Mean (SD): 3.8 (1.4), $p = 0.111$	Abdominal pain/fever: 5/442 (1.1) Ureter injury: 2/442 (0.5) Vaginal dehiscence: 2/442 (0.5) Haemoperitoneum: 2/442 (0.5)	

Table 1 (continued)

First author, year, country (Ref)	Nr. of patients	Age of patient (in years)	BMI (kg/m^2)	Diagnosis (%)	Port system applied	Duration of the procedure (in min)	Estimated blood loss (in ml)	Uterus weight (in gr)	Conversions (%)	Transfusion needed	Hospital stay (in days)	Complications (%)	Follow-up (in mo)
Scheib, 2015, USA [17]	40	Median (range): 42 (21–68)	Median (range): 28.2 (15.9–55)	Fibroids, bleeding, pain, malignancy, ovarian cysts	Gelport®	Median (range): 134 (84–311)	Median (range): 50 (25–300)	Median (range): 146.5 (39–439)	1/40 (2.5)	–	Mean (SD): 0.5 (0.5)	Major: clostridium difficile colitis: 1/40 (2.5) Minor: vaginal cuff cellulites: 1/40 (2.5) Vaginal cuff defect: 1/40 (2.5)	Median (range): 7.6 (2–8.5)
Fagotti, 2013, Italy [18]	19	NR	Median (range): 26 (18–35)	Early endometrial cancer	Single-Site® port	Median (range): 90 (60–147)	Median (range): 75 (50–250)	NR	0/19	0/19	NR	Haemoperitoneum: 1/19 (5.9)	NR
	38[f]		Median (range): 23 (17–41), $p = 0.132$			Median (range): 107 (47–140), $p = 0.354$	Median (range): 30 (10–300), $p = 0.005$		0/38	0/38		–	
Sendag, 2014, Turkey [19]	24	Median (range): 49.5 (40–61)	Median (range): 28.5 (21–34)	Non-neoplastic disease	Single-Site® port	Median (range): 98.5 (71–183)	Median (range): 22.5 (7–120)	Median (range): 192.5 (65–520)	0/24	–	1	–	Median (range): 2.5 (1–11)
Cela, 2013, Italy [20]	12	Median (SD): 61 (9)	Median (SD): 26 (3)	Non-neoplastic disease	Single-Site® port	Mean (SD): 85 (33)	Mean (SD): 80 (18)	Mean (SD): 220 (45)	0/12	–	Median: 2	–	NR
Vizza, 2013, Italy [21]	17	Median (range): 64 (42–84)	Median (range): 26.6 (18–52)	Endometrial cancer	Single-Site® port	Median (range): 90 (70–147)	Median (range): 75 (50–150)	NR	0/17	–	Median (range): 2 (1–3)	–	Median (range): 7.5 (5–12)

Table 1 (continued)

First author, year, country (Ref)	Nr. of patients	Age of patient (in years)	BMI (kg/m^2)	Diagnosis (%)	Port system applied	Duration of the procedure (in min)	Estimated blood loss (in ml)	Uterus weight (in gr)	Conversions (%)	Transfusion needed	Hospital stay (in days)	Complications (%)	Follow-up (in mo)
Nam, 2011, Korea [22]	7	Median (range): 48 (34–70)	Median (range): 21.9 (15.8 to 35.8)	Fibroids: 5/7 cervical cancer: 1/7 In situ cervical carcinoma: 1/7	ALEXIS Wound Retractor®	Median (range): 109 (105–311)	Median (range): 100 (10–750)	Median (range): 200 (40–310)	1/7 (14.3)[a]	–	Median (range): 4 (3–6)	–	NR
Case reports													
Ding, 2017, Taiwan [23]	3	44	22.5	Adenomyosis	Single-Site® port	200	100	NR	0/3	–	4	–	NR
		43	23.6			233	300				4		
		48	26.6			300	250				4		
Silva, 2017, Brazil [24]	1	42	21.3	Cervical adenosquamous cell carcinoma	Single-Site® port	NR	NR	85	0/1	–	1	–	NR
Pluchino, 2014, Switzerland [25]	1	43	29.2	Multiple leiomyomas	NR	240[c]	NR	142	0/1	–	1.5	–	NR
Lue, 2012, USA [26]	1	46	NR	Menorrhagia, multiple leiomyomas	SILS Port®	180	25	NR	0/1	–	NR	–	NR
Mereu, 2012, Italy [27]	4	NR	Median (range): 25.65 (22–29.3)	Endometrial adenocarcinoma	Gelport®	Median (range): 183 (160–250)	Median: 50	NR	0/4	–	2	–	NR
Kane, 2010, USA [28]	1	37	NR	Recurrent endometriosis	SILS Port®	172	50	180	0/1	–	NR	–	NR
Escobar, 2009, USA [29]	1	60	26	Prophylactic hysterectomy[b]	Gelport®	168	80	NR	0/1	–	NR	–	NR
Fader, 2009, USA [2]	2	59	27	Prophylactic hysterectomy[d]	NR	178	NR	NR	0/2	NR	1	–	NR

Table 1 (continued)

First author, year, country (Ref)	Nr. of patients	Age of patient (in years)	BMI (kg/m^2)	Diagnosis (%)	Port system applied	Duration of the procedure (in min)	Estimated blood loss (in ml)	Uterus weight (in gr)	Conversions (%)	Transfusion needed	Hospital stay (in days)	Complications (%)	Follow-up (in mo)
		49	20		NR	145	NR	NR		NR	1	–	NR

USA United States of America, *nr* number, *NR* not referred, *BMI* body mass index, *yrs* years, *mo* months, *SD* standard deviation, *weeks* weeks, *hr* hours, *BRCA* breast cancer, *HBOC* hereditary breast and ovarian cancer

[a]To 3-port robotic surgery due to severe pelvic adhesions

[b]Patient with BRCA(+) breast cancer

[c]Hysterectomy was combined with single-port cholecystectomy

[d]Breast cancer, BRCA1(+), on tamoxifen: risk-reducing extrafascial hysterectomy combined with bilateral salpingoophorectomy

[e]Conversion to multi-port arrangement

[f]Laparoscopic group

[g]Multi-port robotic group

Table 2 Overall operative data of the included patients treated with robotic single-port hysterectomy

Surgical outcome	Values* (%)
Port placement time (in min)	4.75 (1–11)
Docking time (in min)	8.1 (2–40)
Console time (in min)	104.5 (17–312)
Cuff closure time (in min)	23.9 (9–77)
Total operative time (in min)	122 (60–311)
Estimated blood loss (in ml)	50 (7–750)
Decrease in haemoglobin concentration (in g/dl)	1.04 (0.1–3)
Uterine weight (in g)	164 (30–520)
Intra-operative complications	4/505 [0.8]
Post-operative complications	21/505 [4.15]
Blood transfusions	2/505 [0.4]
Conversion to multi-port robotic/laparoscopy/vaginal/laparotomy	14/505 [2.8]
Hospital stay (in days)	1.5 (1–6)

*Median (range) was evaluated, where was possible

patients (2.8%), while there were two cases, where blood transfusion was needed. The median post-operative hospital stay was 1.5 (range 1–6) days. The post-operative follow-up ranged between 1 and 46 months. Only two studies reported data on scar cosmesis of the included patients.

Fourteen patients were included in eight case reports. Their age ranged from 37 to 60 years. The body mass index of the included patients ranged from 20 to 29.3 kg/m^2. In 9 out of 14 patients, a hysterectomy was performed due to benign diagnosis (such as endometriosis, prophylactic hysterectomy). Regarding the duration of the procedure and the relative blood loss, they ranged from 147 to 300 min and 25–300 ml, respectively. The mean weight of the removed uteri was 123 g. None of the included patients presented any post-operative complications. No conversion to multi-port robotic surgery was reported while there were no cases where blood transfusion was necessary. The mean post-operative hospital stay was 2.8 days. The post-operative follow-up was not reported in the included studies. There was no information on the scar cosmesis in any of the included studies.

From the included studies, the main issue is the heterogeneity of the included diagnoses which reflects to variety of operations. In 7 out of 26 studies, were exclusively included 202 patients with neoplastic disease [8, 9, 11, 18, 21, 24, 27]. Regarding the duration of the procedure and the relative blood loss, they ranged from 60 to 282 min and 10–250 ml, respectively. Fourteen of the included patients presented post-operative complications. No conversion to multi-port robotic surgery was reported while there were 2 cases where blood transfusion was necessary. The median post-operative hospital stay was 2 days. The post-operative follow-up

ranged between 1 and 48 months. On the other hand, in 13 out of 26 studies, were only included 202 patients with non-neoplastic disease [2, 10, 12, 14–16, 19, 20, 23, 25, 26, 28, 29]. As far as the duration of the procedure and the relative blood loss, they ranged from 71 to 300 min and 22.5–300 ml, respectively. Three of the included patients presented post-operative complications. Eight cases of conversion to multi-port robotic surgery were reported while there were no cases where blood transfusion was necessary. The mean post-operative hospital stay was 2.2 days. The post-operative follow-up ranged between 1 and 12 months.

Discussion

The main advantages of a single-port hysterectomy include approach through a single transumbilical entry point, a fact which can improve cosmetic results and possibly minimize port-associated complications. However, some technical difficulties are described in the literature including instrument crowding and clashing, absence of triangulation, and reduced operative working place. The various movements of the robotic arms can cause gas leaking reducing the necessary pneumoperitoneum, while a query could also be raised regarding the increased possibility of port site metastasis in such patients in the future. Regarding the learning curve of such a challenging technique not sufficient information could be found in the literature due to the absence of large cohort studies. Nevertheless, the till now evidence reveals that the initial phase of the learning curve for single-port robotic hysterectomy can be achieved after five cases [20, 30], while a proficiency in intracorporeal cuff suturing for the procedure can be reached after 14 cases [31]. Intuitive Surgical Inc. received FDA approval for da Vinci Sp™ single-port robot-assisted surgical system which is fully compatible with da Vinci Xi robot [32]. This improvement may increase the number of gynaecologists who are going to perform a single-site robotic hysterectomy in the near future.

Our update of the literature revealed 26 relevant studies (18 case series and 8 case reports) compared to 2 case series and 4 case reports in our first systematic review. Five hundred and five patients (compared to 16 patients in our previous study) underwent single robotic hysterectomy with age ranging between 21 and 88 years and a BMI between 15.9 and 55 kg/m^2 which can show that age and BMI are not limitations for such a technique. Compared to our previous study, we can see that the technique has been used in more elderly or obese patients. In our current review, the duration of procedure was ranging between 60 and 311 min. However, longer duration was found in cases which included lymph node dissection or difficult cases of endometriosis. If we exclude such cases, the duration of simple hysterectomy could range between 60 and less than 180 min. As it is shown in Table 2, the majority of the surgical time is spent as expected in the console while docking time is similar to the multi-port approach and port placement ranges from 1 to 11 min. However, longer time could be spent on vaginal vault closure ranging from 9 to 77 min compared to the multi-port approach. This can be explained because of the instrument crowding and clashing, absence of triangulation, and lack of operative working place. However, the use of barbed suture could further reduce the vaginal vault closure time in single-port technique [33]. Furthermore, the blood loss was ranging between 7 and 750 ml. The relevant literature revealed that only one of the initial cases had a blood loss of 750 ml, due to important intra-operative bleeding after symphysiolysis of severe pelvic adhesions [22]. If we exclude such a case then the blood loss is ranging between 7 and 300 ml similar to the multiple-port approach. The complication rate was 4.9% and included bleeding, vaginal haematoma, laceration and dehiscence, umbilical hernia, visceral injuries (one ureteric, one bladder and one rectal serosa injury). The only post-associated complication found in our review included one periumbilical vascular injury which is the only type of complication that could be related to the single-port approach. More specifically, in that case, at the 2nd post-operative day, the patient developed haemoperitoneum that required a laparoscopic evaluation of the abdomen to control the bleeding, without the need of blood transfusion [13]. The conversion rate in our systematic review was 2.8%, although the patients could be converted either to multi-port robotic/laparoscopic or open/vaginal approach. The main reason of conversion was mainly the intra-operative bleeding. Based on the above findings, although more surgical teams are using nowadays the single-port approach, the technique is still not standardized while our results should be considered as the initial learning curve outcomes of each surgical team and it is expected that complication and conversion rates as well as duration of the procedure would get improved with higher experience. The suggested advantages of single-port hysterectomy including reduced post-operative pain with a single-site incision, and improved cosmesis were frequently criticized due to the large incision that the procedure requires [36]. Regarding post-operative pain and cosmetic outcomes, the lack of information does not allow us to draw any safe conclusion on the superiority of the single-port technique. Long-term complication such as port site metastasis in cancer patients is not reported yet; however, we have shown that even though it is a rare event, there is always the probability of port site metastasis, especially when the rules of correct specimen evacuation are not respected [34]. Regarding the additional cost of single-site port, this could be reduced with the utilization of simple gloves as single port and the increase of competition in the market to reduce the price of the robotic single-port equipment [22, 35].

Several limitations should be taken into consideration in the analysis of the clinical findings of this study. The number of the included studies in addition to the total number of the patients included in these studies is restricted showing that the use of single port in robotic-assisted hysterectomy is still a relatively new technique in evolution. Although, careful selection of the included studies was performed, it could not be further clarified whether Corrado et al. study—which is a multi-institutional study evaluating 125 patients performed from 1/2012 to 2/2015—might include 45 patients from Bogliolo et al. study (period 5/2012–6/2013) or 19 patients from Fagotti et al. study (12/2011–1/2013) or 17 patients from Vizza et al. study (12/2011–6/2012) [8, 10, 18, 21]. Last but not least, case series or even better randomized control trials are fundamental not only to standardize this technique but also to compare the complication rates between the multichannel and single-site port technique. As far as our literature search, even though it is relatively extensive at its range, it could be considered as limited initially due to the language restrictions of the included studies and also due to the exclusion of review articles, conference papers, letters to the editor, short surveys and commentaries.

Conclusion

Such a technically challenging operation is nowadays performed by more surgeons and it is becoming a more standardized technique. Experienced laparoscopic skills are essential for the safe and effective completion of surgery. The initial phase of the learning curve can be achieved after five cases, while a proficiency in intracorporeal cuff suturing after 14 cases. Successful procedure requires accurate selection of patients taking into account main limitations such as uterus weight and abdominal surgical history. Age and BMI are not a limitation for such a technique. Compared to our previous study, we can see that the technique has been used in more elderly or obese patients. Our systematic review revealed a complication rate of 4.9% including bleeding, vaginal haematoma, laceration and dehiscence, umbilical hernia, visceral injuries while the conversion rate reached 2.8%, although the patients could be converted either to multi-port robotic/laparoscopic or open/vaginal approach. Although, the wide variability leads to few conclusions being able to be drawn, we consider that complication and conversion rates as well as surgical time could be improved with experience. Regarding post-operative pain and cosmetic outcomes, the lack of information does not allow us to draw any safe conclusions.

Compliance with ethical standards

Conflict of interest Christos Iavazzo has no conflicts of interest or financial ties to disclose. Evelyn Eleni Minis has no conflicts of interest or financial ties to disclose. Ioannis D. Gkegkes has no conflicts of interest or financial ties to disclose.

Ethical standards All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Not applicable.

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