Intraoperative Laparoscopic Ultrasound Increases Fibroid Detection During Laparoscopic Myomectomy

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ABSTRACT

Objective: To assess the utility of intraoperative laparoscopic ultrasound in detecting additional fibroids during laparoscopic myomectomy (LM).

Methods: Forty-two patients were enrolled in this prospective cohort study. All cases were performed by the same surgeon at a university affiliated hospital between April 1, 2019 and February 29, 2020. Following routine laparoscopic myomectomy, the laparoscopic ultrasound was then introduced, and ultrasonography was performed directly on the uterus. Any additional fibroids discovered were enucleated.

Results: Using the laparoscopic ultrasound, an additional 54 fibroids among 27 (64%) of the 42 patients were found, with a median of 2 additional fibroids per patient (interquartile range [IQR] 1,3). Median fibroid size detected by laparoscopic ultrasound was 1.5 centimeters (IQR 1–3) and the most common types were FIGO grades 3 and 2 (43% and 33% respectively). The median surgical time was longer among patients in whom additional fibroids were found (170 minutes (IQR 137–219) vs 150 minutes (IQR 120–193), p = .044). When ≥ 2 fibroids were removed by usual methods, the laparoscopic ultrasound found additional fibroids 80% of the time, compared to 25% when < 2 fibroids were removed by usual methods (p < .001).

Conclusion: Intraoperative laparoscopic ultrasonography is a useful tool in detecting additional fibroids that would have otherwise been missed. It is particularly helpful in identifying smaller intramural fibroids and in patients with multiple fibroids. By detecting additional fibroids, laparoscopic ultrasonography can help maximize the effectiveness of laparoscopic myomectomy and help decrease the rates of residual fibroids.

Key Words: Fibroids, Gynecology, Minimally Invasive, Surgery, Ultrasound.

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INTRODUCTION

Uterine fibroids are a common cause of abnormal uterine bleeding, pain, and infertility, which often necessitate surgical intervention. Advances in minimally invasive surgery have made laparoscopic myomectomy (LM) an effective alternative to open abdominal surgery, particularly in patients desiring uterine conservation.

A cornerstone of LM is the detection of myomas using imaging techniques, such as transvaginal ultrasonography and magnetic resonance (MR) imaging, in addition to intraoperative visualization and tactile feedback. Of these, MR imaging has been shown to be the most sensitive and specific.[1–4] While pre-operative MR imaging has become standard of care for LM, it has limitations in the mapping of multiple myomas and translation of findings intraoperatively.[3,4] Intraoperative laparoscopic ultrasound (LUS) can provide real-time mapping of myomas, allowing for increased detection and removal.[5,6] Hao et al. reported an additional 140 myomas detected using the LUS among 78 women undergoing LM, though they did not employ preoperative MR imaging to aid in mapping of myomas.[7] Shimanuki et al. reported that among 42 patients undergoing LM with pre-operative MR imaging, the addition of intraoperative LUS detected a total of 25 additional myomas in 23 patients.[8]

Our study aimed to assess if and when the addition of LUS to pre-operative MR imaging aided in the detection of myomas. We hypothesized that the addition of LUS would enhance myoma detection and removal. Given the paucity of data in this area, we believe this information can be valuable in maximizing the effectiveness of LM, particularly since residual myoma rates are higher with LM compared to traditional abdominal myomectomy.[9–12]

METHODS

Subjects

A total of 42 patients were enrolled in the study and underwent LM at a university affiliated hospital between April 1, 2019 and February 29, 2020. All patients ≥18 years old who were scheduled for LM based on history, physical examination, and imaging findings were offered enrollment in the study during pre-operative consultation. There were no exclusions with regards to fibroid size, number, and uterine location when considering candidates for LM. All patients in the study received pre-operative MR imaging of the abdomen and pelvis to aid in mapping of fibroids. The MR imaging studies were all done at the same facility and read by the institution's radiologists. They were interpreted based on similar parameters utilized by the department of radiology. The study and its protocols were approved by the Institutional Review Board.

Instrument

Intraoperative ultrasonography was performed using the BK 3500 ultrasound system (B-K Medical, Inc.). The rigid 10 mm BK Laparoscopic 8636 transducer was used to perform ultrasonography directly on the surface of the uterus (**Figure 1**).

Figure 1. BK rigid Laparoscopic Transducer 8836.

Surgical Technique

All laparoscopic myomectomies were performed by the same surgeon. The primary trocar was introduced under direct visualization at the umbilicus or Palmer's point. An additional 12 mm port was placed in the right lower quadrant under direct visualization, followed by the remaining 5 mm ports. A total of three to four ports were used depending on habitus and anatomy. The uterine serosa overlying the target fibroid was injected with dilute vasopressin solution (20 u in 100 cc saline) to achieve hydrodissection of the fibroid pseudocapsule and minimize bleeding. The Harmonic Ace® (Ethicon Endo-Surgery, Inc.) scalpel was then used to dissect the myometrium down to the fibroid. The underlying fibroid was grasped with a tenaculum and dissected away from the myoma bed using traction and mechanical dissection with the Harmonic scalpel. After all detectable fibroids were removed from the incision based on visualization, haptic feedback, and pre-operative MR imaging findings, the laparoscopic ultrasound was introduced into a 12 mm trocar prior to myometrial repair (**Figure 2**). The entire pseudocapsule was scanned and any additional fibroids detected were removed in similar fashion. The uterine incision was then sutured in multiple layers using 2-0 V-loc suture with a CT-1 needle. The final serosal layer was repaired with a series of figure-of-eight stitches using 0-Monocryl. The above process was continued until all fibroids were removed. After repair of all uterine incisions, laparoscopic ultrasonography was performed again, but this time over the entire uterine serosa. Any additional fibroids identified were then removed in similar fashion as above.

All enucleated myomas that could not be directly removed through a 12 mm trocar were removed from the abdomen via uncontained power morcellation using the Karl Storz Rotocut 12 mm device (Karl Storz Endoscopy-America, Inc.). All visible fibroid fragments were removed, and the abdomen and pelvis were copiously irrigated. Our tissue

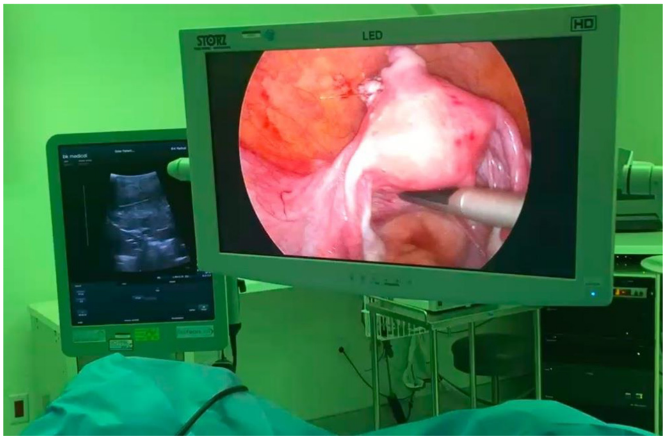

Figure 2. Intraoperative application of laparoscopic ultrasound.

extraction techniques and strategies to minimize dispersal of spindle cells are described elsewhere.[13]

Demographics, including age, body mass index (BMI), indication, and previous surgical history were abstracted for all participants based on chart review. Intraoperative findings were documented immediately after surgery including number, size, and location of all fibroids removed. Fibroids identified by the laparoscopic ultrasound were also noted. Participants were followed for four to six weeks postoperatively and discharged from the study after the postoperative clinic visit.

Statistics

The sample size calculation was based on a one-sample proportion test to detect an additional fibroid detection rate of 75%, with 50% as the null proportion. It was determined that 30 participants were needed to achieve 80% power with an α of 0.05. Participant characteristics were compared between those who had additional fibroids detected by LUS with those who did not using a t test (or Wilcoxon rank-sum, if necessary) and χ^2 test (or Fisher's exact, if necessary). Fibroid characteristics were summarized for those detected by usual methods and by LUS. All tests were 2-sided with an α set at 0.05 for statistical significance. All statistical analyses were performed using SAS 90.4 (Cary, NC).

RESULTS

A total of 42 participants were enrolled in the study. The mean age of study participants was 40.5 years old (range 21–62). The most common indication for surgical intervention was abnormal uterine bleeding (61%) and pelvic pain/bulk symptoms (61%) followed by infertility (15%), with 34% of all participants having a combination of indications.

Using the LUS, an additional 54 fibroids among 27 (64%) of the 42 participants were found. There was no statistical

Table 1.
Patient Data

	Detected Additional LUS Fibroids		
	Yes (n = 27)	No (n = 15)	p-Value
Age, mean (SD)	39.8 (7.9)	41.7 (8.1)	0.456
Body Mass Index, % (n)			0.513[1]
Underweight (< 18.5)	0 (0)	7 (1)	
Normal (18.5 – 24.9)	50 (13)	60 (9)	
Overweight (25 – 29.9)	23 (6)	20 (3)	
Obese (≥ 30)	27 (7)	13 (2)	
Estimated blood loss, % (n)			0.405[1]
0 – 100 ml	93 (25)	93 (14)	
101 – 200 ml	7 (2)	0 (0)	
201+ ml	0 (0)	7 (1)	
Surgical time, median (IQR)	170 (137, 219)	150 (120, 183)	0.044[2]

[1]Fisher's exact, [2]Wilcoxon rank-sum.
Abbreviations: LUS, laparoscopic ultrasonography; SD, standard deviation; IQR, interquartile range.

Table 2.
Description of All Fibroids Detected

	Fibroids Detected Prior to LUS (n = 177) (n) %	Fibroids Detected with Use of LUS (n = 54) (n) %
Fibroid location		
Anterior	34 (59)	38 (21)
Broad ligament	2 (4)	6 (3)
Cornual	2 (4)	6 (3)
Fundal	30 (53)	13 (7)
Posterior	32 (55)	37 (20)
Fibroids grade		
0	1 (2)	0 (0)
1	0.5 (1)	0 (0)
2	3 (6)	33 (18)
3	10 (18)	43 (23)
4	10 (18)	15 (8)
5 – 8	75 (132)	9 (5)
Fibroids size, % (n)		
0 – 2.99 cm	38 (68)	67 (36)
3 – 5.99 cm	24 (42)	27 (15)
6 – 10.99 cm	31 (55)	6 (3)
11 – 25 cm	7 (12)	0 (0)

Abbreviation: LUS, laparoscopic ultrasonography.

difference in additional myomas detected with respect to age, BMI, and estimated blood loss (**Table 1**). When additional fibroids were found, the median surgical time was longer by 20 minutes (170 minutes (interquartile range [IQR] 137–219) vs 150 minutes (IQR 120–193), p = .044) (**Table 1**). The endometrial cavity was entered in seven of the 42 participants to facilitate complete removal of fibroids. It should be noted that in two participants, the additionally detected fibroids were left in-situ due to complexity of surgery and intraoperative weighing of risks and benefits. All participants were discharged from the hospital either the same day or on postoperative day one. One participant had an estimated blood loss of 1 L. One participant was readmitted within 30 days for suspected syndrome of inappropriate antidiuretic hormone secretion. No other operative complications or readmissions within 30 days of surgery were noted.

Among the 27 participants in whom additional fibroids were detected, a median of 2 additional fibroids per participant was found (IQR 1–3). The median size of a fibroid detected by LUS was 1.5 cm (IQR 1–3) and the most common types were FIGO grades 3 and 2 (43% and 33% respectively)[14] (**Table 2**). Comparatively, fibroids removed prior to introduction of the LUS tended to be larger in size, with a median size of 4 centimeters (IQR 1–7), and predominantly FIGO grades 5–8 (75%) (**Table 2**).

When ≥ 2 fibroids were removed by usual methods, the LUS found additional fibroids 80% of the time, compared to 25% when < 2 fibroids were removed by usual methods (p < .001) (**Table 3**). When > 8 fibroids were removed by usual methods, additional myoma detection rate with the LUS was 100%.

DISCUSSION

Compared to traditional abdominal myomectomy, LM has higher rates of residual fibroids.[9–12] This is in part due to the loss of haptic feedback with a laparoscopic approach. Pre-operative MR imaging has been utilized to increase fibroid detection and removal during LM. However, this method has limitations in mapping of multiple myomas and application of findings intraoperatively.[3–5] MR images are typically obtained in 1 cm increments in three different planes and so smaller fibroids can evade detection. Conversely, intraoperative LUS can provide real-time mapping of myomas continuously and in infinite planes, while also identifying proximity to key structures such as the endometrial cavity. There is limited data regarding the use of LUS in LM. One study by Levine et al. (2013) compared myoma detection by LUS, contrast MR imaging and transvaginal ultrasound in 135 women and found LUS to be superior in the detection of myomas.[5] Another study by Hao et al. reported an additional 140 myomas detected

Table 3.
Number of Fibroids Removed by Usual Methods; Categorized

	Number of fibroids removed by usual methods		
	< 2 Fibroids Removed (n = 12)	≥ 2 Fibroids Removed (n = 30)	p-Value
Finding additional LUS fibroids, % (n)			0.001[1]
Yes	25 (3)	80 (24)	
No	75 (9)	20 (6)	

[1]Fisher's exact.
Abbreviation: LUS, laparoscopic ultrasonography.

using the LUS among 78 women undergoing LM. These studies, however, looked at individual modalities separately.[7] Few studies to date have compared pre-operative MR imaging to the combination of pre-operative MR imaging and intraoperative ultrasonography in detection and removal of myomas. A study by Mimura et al. reported decreased residual rate of myomas with the addition of LUS to pre-operative MR imaging but reported no statistically significant difference in the number of myomas removed.[6] Shimanuki et al. reported that among 42 patients undergoing LM with pre-operative MR imaging, the addition of intraoperative LUS detected a total of 25 additional myomas in 23 patients.[8] Our study sought to build upon this limited data and further evaluate the utility of LUS during LM.

Similar to Shimanuki et al., our study had an additional fibroid detection rate of 64% using the LUS. The LUS was particularly helpful in finding smaller and more intramural fibroids. While MR imaging can detect 1–3 cm fibroids, translation of these findings intraoperatively can be challenging, particularly with intramural fibroids that cannot be readily visualized or palpated. The LUS allows a way to locate these fibroids in real time. Though fibroids < 3cm may not be the cause of a patient's immediate symptoms, leaving them behind increases the risk that they may grow and become symptomatic in the future, necessitating re-intervention.[9,15]

When more than one fibroid was removed, the addition of the LUS found additional fibroids 80% of the time. This association seems to be strengthened as the number of fibroids removed by conventional methods increased. This, in part, may be due to the inherent increased number of fibroids in these cases. However, it is also reflective of the difficultly of translating MR images intraoperatively, particularly once anatomy is obscured after multiple uterine incisions and blood in the visual field. Thus, as demonstrated by our data, the addition of the LUS is most helpful with large multifibroid uteri.

The use of LUS in our study showed no significant increase in blood loss or rate of postoperative complications with its use. In cases where additional fibroids were found by LUS, the median operative time was increased by 20 minutes. This is largely due to the time involved in enucleating these additional fibroids, since performing the ultrasonography is rather quick. Additionally, the LUS was a useful tool in delineating the endometrial cavity during enucleation. Endometrium was entered in seven of the 42 cases. Though the study was not powered to detect a significant difference in rates of endometrial entry with or without the LUS, this can be an area for further exploration.

There are some limitations to our study. Firstly, all operations were performed by a single experienced surgeon, who was experienced with LUS prior to study initiation. Thus, there was no significant difference in fibroid detection rates over the duration of the study due to operator familiarity. However, this does make translation of these findings to the general laparoscopic surgeon limited. Additionally, there is a learning curve in the use of the LUS. The surgeon must toggle between the ultrasound image screen and the laparoscopic surgical view to deploy the device, scan the uterus and translate ultrasound findings to the surgical approach in real-time. This may be a limiting factor in the reproducibility of the study and in the widespread adaptation of the technique. Furthermore, the data as gathered from the operative notes were dictated by the performing surgeon, making it difficult to blind the researchers and limit any inherent bias. Though referenced studies were performed in similar manner, future studies can consider inclusion of multiple skilled surgeons across institutions to minimize bias. In the future, consideration can also be given to a blinded central reader to quantify fibroids based on MR images prior to surgery to increase the robustness of such a study.

In conclusion, our study provides compelling evidence for the use of LUS during LM. LUS is a useful tool in detecting additional, often clandestine, uterine fibroids that may be present at time of LM. LUS helps maximize the effectiveness of LM by decreasing the number of residual fibroids.

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