Original Article Open Access

Preoperative magnetic resonance imaging findings of myoma as risk factors for bleeding during laparoscopic myomectomy

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Abstract

Objectives: The objective of this study was to identify the correlation between preoperative magnetic resonance imaging (MRI) findings of myoma and the incidence of bleeding during laparoscopic myomectomy (LM).

Methods: We investigated the preoperative MRI findings of 25 patients who underwent LM from January 2012 to December 2014, including patients who had undergone myoma resection. We evaluated the correlations between perioperative blood loss and the size of the myoma as well as between perioperative blood loss and the maximal minor axis of flow void (MMAFV) of the myoma margins.

Results: The mean diameters of the myomas were as follows: longest axis, 60.4 ± 20.6 mm; occipitofrontal diameter, 55.0 ± 15.7 mm; upper and lower diameters (ULDs), 53.7 ± 19.3 mm; and transverse diameter, 56.5 ± 21.7 mm. The mean MMAFV was 2.1 ± 0.9 mm. The estimated mean blood loss was 104.9 g (range, 5–450 g). All myoma diameters showed a significant linear positive correlation with the estimated perioperative blood loss. The correlation of the ULDs was the highest among all myoma diameters ($r = 0.59$, $P = 0.0021$). The MMAFV showed a significant linear positive correlation with the estimated perioperative blood loss ($r = 0.62$, $P = 0.0010$).

Conclusions: Our results suggest that the ULDs and MMAFV of the myoma margins are risk factors for bleeding during LM, as determined using preoperative MRI.

Keywords: Uterine myoma, Magnetic resonance imaging, Bleeding, Laparoscopic myomectomy

Introduction

Uterine myomas are the most common tumors of the genital tract. These tumors affect 20% to 50% of all women, with an increased frequency in the later years of a woman's reproductive cycle.[1] Laparoscopic myomectomy (LM), which involves the surgical removal of myomas, serves as an alternative treatment for symptomatic uterine myomas; furthermore, this treatment helps to avoid hysterectomy and preserve fertility.[2] Childbearing after LM has been reported.[3-7] Given the present trend toward marrying later in life, LM is being performed increasingly more often because it preserves fecundity. However, LM can be associated with life-threatening bleeding, and excessive bleeding can necessitate emergency blood transfusion.[8]

At present, the strategies for reducing blood loss during traditional myomectomy include injection of vasopressin into the myometrium[5,9,10] and preoperative administration of gonadotropin-releasing hormone (GnRH) agonists.[2,4] However, there is no method with which to predict the occurrence of perioperative blood loss during LM. Therefore, preoperative evaluation of the risk of bleeding is important in patients with uterine myomas. Moreover, preoperative magnetic resonance imaging (MRI) is more readily available for examining patients with uterine myomas. Hatta et al.[11] reported that because surgeons require preoperative information regarding uterine weight, the preoperative total length of myoma nodules measured using MRI is a useful parameter with which to select the optimal treatment.

The flow-void sign is defined as the presence of multiple dot-like or tubular structures with low signal intensity located within or around the lesion; these structures probably correspond to vessels on MRI.[12] Pathologically, dilated feeding arteries and draining veins are frequently observed within the surrounding myometrium in the presence of the flow-void sign.[13] Therefore, during enucleation of a uterine myoma, blood vessels within the myoma margins may be injured. The purpose of this study was to identify the correlation between preoperative MRI findings, including the size of the myoma and diameter of the flow-void myoma margins, and bleeding during LM.

Methods

Patient Population

This study was approved by the institutional review board of our university. From January 2012 to December 2014, 25 patients who underwent preoperative MRI followed by LM to treat infertility or other gynecological disorders associated with uterine leiomyomas and who were diagnosed with an intramural or subserous leiomyoma were included in this retrospective study. We excluded patients with cervical leiomyomas, ovarian tumors, and endometrioses who underwent single-port laparoscopy. The patients ranged in age from 27 to 44 years (median, 34 years). We recorded the patients' demographic characteristics, including their mean age (± standard deviation) and body mass index (kg/m^2). Eligible patients were included regardless of whether they were using GnRH agonists.

Received 11 May, 2016, **Accepted** 20 July, 2016

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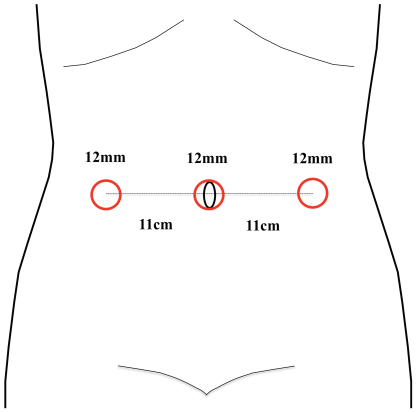
Surgical Procedure

All LMs were performed using three entry ports (Figure 1). The operating team included three operators (A, B, and C) who had each performed >100 major and advanced laparoscopic procedures. Each operator had 15 to 20 years of experience in surgery. All LMs were performed by one operator and one or two assistants (total of two or three surgeons). All patients were perioperatively treated with a myometrial injection of vasopressin.

Figure 1.



Port placement system for laparoscopic myomectomy. A 20-mm camera port is placed at the umbilicus. Two other 12-mm ports are placed 11 cm bilaterally at the level of the umbilicus.

MRI Protocol

MRI was performed using either a 1.5-T whole-body instrument (Achieva; Philips, the Netherlands or Signa Excite; GE Healthcare, Milwaukee, WI) or a 3.0-T whole-body unit (Ingenia; Philips or Vantage Titan; Toshiba Medical Systems Corporation, Tokyo, Japan). A phased-array coil was used to perform the body scans. All patients were examined in the supine position. T2-weighted images (axial, sagittal, and coronal planes) were obtained for each patient. The parameters for the Achieva 1.5-T whole-body unit were as follows: repetition time/time to echo ratio (TR/TE), 2000/90 ms; field of view, 250 mm; matrix size, 512 × 512; section thickness, 6 mm; intersection gap, 1 mm; and signals acquired, 4. The parameters for the Signa Excite 1.5-T whole-body unit were as follows: TR/TE, 4500/100 ms; field of view, 250 mm; matrix size, 512 × 512; section thickness, 6 mm; intersection gap, 1 mm; and signals acquired, 1. The parameters for the Ingenia 3.0-T whole-body unit were as follows: TR/TE, 4000/90 ms; field of view, 250 mm; matrix size, 640 × 640; section thickness, 5 mm; intersection gap, 1 mm; and signals acquired, 1. The parameters for the Vantage Titan 3.0-T whole-body unit were as follows: TR/TE, 6133/120 ms; field of view, 250 mm; matrix size, 640 × 640; section thickness, 5 mm; intersection gap, 1 mm; and signals acquired, 1.

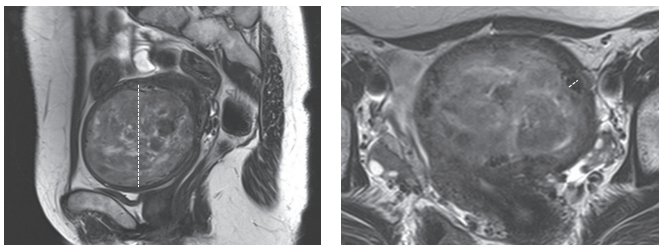
Image Analysis

We retrospectively evaluated all MRI findings acquired to aid the preoperative diagnosis. The size of the myoma and maximal minor axis of flow void (MMAFV) of the myoma margins on T2-weighted images were measured using an image analysis system (Rapideye Core; Toshiba Medical Systems Corporation). The size of the myoma was evaluated by dividing the myoma into the longest axis, occipitofrontal diameter, upper and lower diameters (ULDs), and transverse diameter. The MMAFV of the myoma margins was assessed by measuring the largest diameter in the axial, sagittal, and coronal planes of T2-weighted images (Figure 2) as well as by determining the location of the myoma. The MMAFV was measured three times, and a mean value was then calculated for the final statistical analysis.

Statistical Analysis

The correlations between perioperative blood loss and the size of the myoma as well as between perioperative blood loss and the MMAFV of the myoma margins were evaluated by calculating the Pearson correlation coefficients and *P* values. Smaller and larger groups, defined according to the MMAFV of the myoma margins and the value of each diameter of the myomas showing the strongest correlation with the estimated perioperative blood loss, were compared using the Student's *t*-test. Comparison between perioperative blood loss and the differences among the three operators (A, B, and C) was performed using one-way analysis of variance. We compared the correlations between the number of surgeons and perioperative blood loss using Student's *t*-test. We also evaluated the correlations between the operation time and perioperative blood loss using Pearson's correlation coefficient. All statistical analyses were performed using GraphPad Prism v.6 for Mac (GraphPad Software, San Diego, CA, USA). A *P* value of <0.05 was considered to indicate statistical significance.

Figure 2.



(A) (B)

Measurement of the myoma size and flow-void diameters. The size of the myoma and the maximal minor axis of flow void (MMAFV) of the myoma margins on T2-weighted images were measured using an image analysis system. (A) The upper and lower diameters of myoma are shown. (B) The MMAFV was assessed using the largest diameters of the axial, sagittal, and coronal planes of T2-weighted images.

Results

Data were retrospectively collected for 25 patients who underwent LM for treatment of uterine leiomyomas. The patients' mean age was 34.6 ± 4.7 years (range, 27–44 years), and their mean body mass index was 21.0 ± 3.2 kg/m^2 (range, 17.21–30.98 kg/m^2). The location of all tumors was either intramural or subserous: anterior, n = 10 (40%); posterior, n = 4 (16%); and lateral, n = 11 (44%). The diameters of the myomas were as follows: longest axis, 60.4 ± 20.6 mm (range, 23–112 mm); occipitofrontal diameter, 55.0 ± 15.7 mm (range, 23–85 mm); ULDs, 53.7 ± 19.3 mm (range, 17–93 mm); and transverse diameter, 56.5 ± 21.7 mm (range, 20–112 mm). The MMAFV was 2.1 ± 0.9 mm (range, 1.1–5.7 mm) (Table 1). The estimated mean blood loss was 105 g (range, 5–450 g). All myoma diameters showed a significant linear

Table 1

Patients' characteristics

Characteristics	n = 25
Age, years	34.6 ± 4.7 (27–44)
Body mass index, kg/m^2	21.0 ± 3.2 (17.2–31.0)
Location of myoma	
Anterior	10 (40)
Posterior	4 (16)
Lateral	11 (44)
Diameter of myoma, mm	
Longest axis	60.4 ± 20.6 (23–112)
Occipitofrontal diameter	55.0 ± 15.7 (23–85)
Upper and lower diameters	53.7 ± 19.3 (17–93)
Transverse diameter	56.5 ± 21.7 (20–112)
MMAFV, mm	2.1 ± 0.9 (1.1–5.7)

Data are presented as mean ± standard deviation (range) or n (%).

MMAFV, maximal minor axis of flow void

Table 2

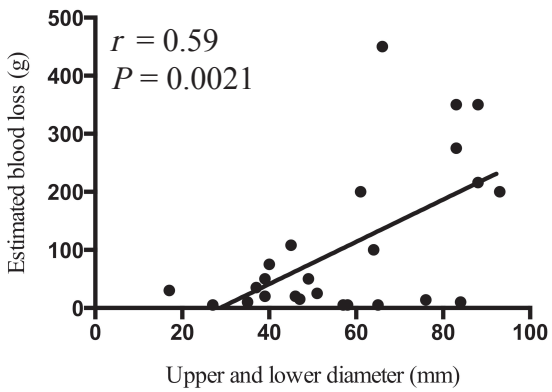
Comparison of estimated blood loss between two groups divided by myoma diameters

Parameters	Upper and lower diameters		
	Smaller group	Larger group	*P* value
	<50 mm	>50 mm	
Number of patients	11	14	
Estimated blood loss, g	38.0 (5–108)	157.5 (5–450)	0.019
	<60 mm	>60 mm	
Number of patients	14	11	
Estimated blood loss, g	32.4 (5–108)	197.3 (5–450)	0.0006
	<70 mm	>70 mm	
Number of patients	18	7	
Estimated blood loss, g	67.1 (5–450)	202.1 (10–350)	0.0017

Estimated blood loss is presented as mean (range).

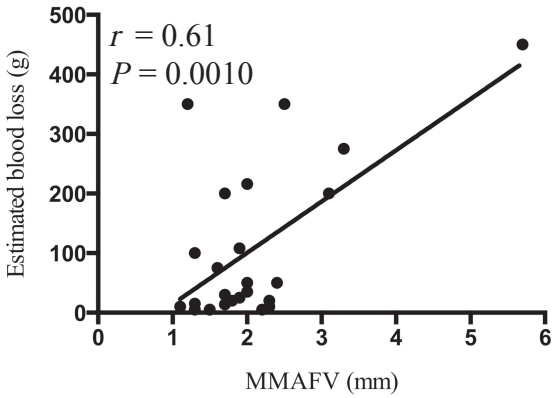
positive correlation with the estimated perioperative blood loss. These correlations were calculated as follows: longest axis: $r = 0.53$, $P = 0.0063$; occipitofrontal diameter: $r = 0.54$, $P = 0.0056$; ULDs: $r = 0.59$, $P = 0.0021$; and transverse diameter: $r = 0.56$, $P = 0.0040$. The correlation of the ULDs was the highest among all diameters of the myomas (Figure 3). Smaller and larger groups were defined according to the value of each diameter that showed the strongest correlation with the estimated perioperative blood loss, and these groups were compared using Student's *t*-test. The comparison between the groups that were established according to the ULDs (50, 60, and 70 mm) showed a significantly greater difference for ULDs of 60 mm ($P = 0.0006$) (Table 2). The MMAFV showed a significant linear positive correlation with the estimated perioperative blood loss ($r = 0.62$, $P = 0.0010$) (Figure 4). The smaller and larger groups, defined according to each MMAFV, were compared using Student's *t*-test. The comparison between the groups that were established according to the MMAFV (2.0 and 2.5 mm) showed a significantly greater difference for an MMAFV of 2.5 mm ($P < 0.0001$) (Table 3). Comparison of patients who had and had not used GnRH agonists before LM revealed no significant difference in either the size of the myoma or the MMAFV of the myoma margins (Table 4). The mean operation time was 187.8 min (range, 96–272 min). The operation time showed a significant linear positive correlation with the estimated perioperative blood loss ($r = 0.51$, $P = 0.0095$). However, neither the difference among the operators (A, B, and C) nor the number of surgeons was correlated with the estimated blood loss (Tables 5, 6).

Figure 3.



The correlation between the upper and lower diameters and the estimated blood loss is shown. All myoma diameters show an overall significant linear positive correlation with the estimated perioperative blood loss. The correlation coefficients of the upper and lower diameters are the highest among all diameters of the myomas.

Figure 4.



The correlation between the maximal minor axis of flow void (MMAFV) and the estimated blood loss is shown. The MMAFV shows a significant linear positive correlation with the estimated perioperative blood loss.

Table 3

Comparison of estimated blood loss between two groups divided by diameters of flow void

Parameters	MMAFV		
	Smaller group	Larger group	*P* value
	<2.0 mm	>2.0 mm	
Number of patients	15	10	
Estimated blood loss, g	68.7 (5–350)	151.0 (5–450)	*NS*
	<2.5 mm	>2.5 mm	
Number of patients	21	4	
Estimated blood loss, g	64.2 (5–350)	318.8 (200–450)	<0.0001

Estimated blood loss is presented as mean (range).

MMAFV, maximal minor axis of flow void

Table 4

Comparison of estimated blood loss between two groups divided by GnRH agonists

Parameters	GnRH agonist before LM		
	No use (n = 13)	Use (n =12)	*P* value
Longest axis, mm	57.1 (23–112)	71.8 (46–93)	*NS*
ULDs, mm	50.0 (17–84)	65.7 (37–93)	*NS*
Estimated blood loss, g	65.6 (5–275)	147.5 (5–450)	*NS*

Data are presented as mean (range).

GnRH, gonadotropin-releasing hormone; LM, laparoscopic myomectomy;

ULDs, upper and lower diameters

Table 5

Comparison of estimated blood loss among the three operators

Parameters	Operator			
	A	B	C	*P* value
Number of patients	9	8	8	
Estimated blood loss, g	137.8 (5–450)	58.6 (5–108)	114.3 (5–350)	*NS*

Estimated blood loss is presented as mean (range).

Table 6

Comparison of estimated blood loss between two groups divided by the number of total surgeons

Parameters	Number of surgeons		
	2	3	*P* value
Number of patients	4	21	
Estimated blood loss, g	93.5 (5–350)	107.0 (5–450)	*NS*

Estimated blood loss is presented as mean (range).

Discussion

In the present study, both the size of the myoma and the MMAFV of the myoma margins showed a significant linear positive correlation with the estimated perioperative blood loss. Furthermore, the operation time showed a significant linear positive correlation with the estimated perioperative blood loss. Blood loss depends on the size of the myoma[14] and occurs mainly during the removal of fibroids and the repair of the uterus during myomectomy.[2] Because the uterine myoma enlarges, the range of enucleation and uterine repair must be extended and the risk of bleeding accordingly increases. We therefore believe that the operation time is also correlated with the estimated blood loss. In the present study, we measured the longest axis, occipitofrontal diameter, ULDs, and transverse diameter on T2-weighted images (Figure 2) and found that the correlation coefficient of the ULDs was the highest among all myoma diameters (r = 0.59, P = 0.0021) (Figure 3). The camera port was placed at the umbilicus for cosmetic reasons (Figure 1). We believe that uterine myomas with higher ULDs are associated with an increased risk of perioperative difficulties because surgeons are unable to observe global images when the distance between the uterine myoma and the camera is too short (Figure 1). Theeuwes et al.[15] reported that a poor view is a disadvantage of laparoscopic surgery and one of the most important challenges faced by endoscopic surgeons. In addition, the uterus is supplied by the left and right uterine arteries. These vessels give rise to uterine arcuate arteries that pass medially and penetrate the myometrium.[16,17] However, myomas are often enucleated through a longitudinal incision on the uterine wall during LM[1,18] because of the difficulty of the laparoscopic suture technique. Therefore, we believe that uterine myomas with higher ULDs are associated with an increased risk of perioperative blood loss. In the present study, comparisons among patient groups established according to the ULDs of myomas (50, 60, and 70 mm) showed significantly higher differences in blood loss for ULDs of 60 mm (P = 0.0006) (Table 2).

The MMAFV showed a significant linear positive correlation with the estimated perioperative blood loss. A pathological analysis by Torashima et al.[13] demonstrated that dilated feeding arteries and draining veins were frequently present within the surrounding myometrium when the flow-void sign was present. Therefore, blood vessels within the myoma margins may be injured during enucleation of uterine myomas. Poiseuille's law relates to the rate (Q) of blood flow through a blood vessel as a function of the difference in blood pressure at the two ends ($\Delta P = P_1 - P_2$), the radius (r) and length (L) of the artery, and the viscosity (μ) of blood. This law is expressed as $Q = \pi r^4 \Delta P / 8L\mu$. For example, an increase in the diameter of the vessel from 1 to 2 mm will increase the flow rate by 16 times (for $r = 2$, $r^4 = 16$) if other variables remain constant.[19] We believe that blood flow increases if the MMAFV becomes longer and that this increased flow may in turn increase the blood loss during LM. In the present study, comparisons between the above-described groups showed significantly higher differences in blood loss for an MMAFV of 2.5 mm (P < 0.0001) (Table 3).

The use of a GnRH agonist before LM was not correlated with the estimated blood loss (Table 4). Treatment with a GnRH agonist effectively reduces the size of myomatous nodules.[4] Therefore, we originally considered that gynecologists tend to use GnRH agonists in patients with larger myomas. However, the use of a GnRH agonist before LM was not correlated with the size of the myoma in the present study (Table 4). Additionally, the correlation between use of a GnRH agonist and the perioperative blood loss was not statistically significant[4,20] (Table 4). Campo and Garcea[4] reported that GnRH analogue therapy may soften uterine fibroids, rendering identification of the cleavage plane more difficult and hence lengthening the operative time. Therefore, we believe that treating patients with a GnRH agonist does not offer a significant advantage in terms of controlling bleeding during LM.

Neither the difference among the three operators (A, B, and C) nor the number of surgeons was correlated with the estimated blood loss. This outcome is considered to be due to the following factors. (1) We focused on patients with uterine leiomyomas to exclude several potentially confounding factors. (2) Each LM was performed by an operator who had performed >100 major and advanced laparoscopic procedures. (3) All LM procedures were performed in the same hospital. (4) All operators had 15 to 20 years of experience in surgery. Therefore, we believe that this outcome clearly indicates that the ULDs and MMAFV are more effective than the factor of surgery when evaluating the risk factors for blood loss in LM.

The present study had several limitations. First, the number of patients was small. Second, this study included imaging data acquired using both 1.5-T and 3.0-T MRI instruments because few patients who underwent LM were diagnosed with a uterine leiomyoma without an ovarian tumor and endometriosis. In a study by Torashima et al.,[13] the frequency of flow void did not vary with the field strength of the MRI unit; however, the authors used 1.0-T and 1.5-T MRI instruments. We did not evaluate the influence of the field strength between our 1.5-T and 3.0-T MRI instruments. The field strength of MRI instruments should be unified for accurate comparisons. Third, the MMAFV measurements were a potential source of error, but each MMAFV was measured three times to minimize the error. Fourth, we were unable to confirm the duration of GnRH agonist therapy because the patients had been treated at other hospitals.

In conclusion, parameters pertaining to the size of the myoma (particularly ULDs) and the MMAFV of the myoma margins determined using preoperative MRI were found to be risk factors for bleeding during LM.

Conflict of interest

The authors declare no conflicts of interest or commercial involvement in this study.

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