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Research Article

Total Laparoscopic Hysterectomy for Enlarged Uteri (300g-1000g): Procedural Analysis and Optimization

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Abstract

Background: The goal of the study was to analyze different aspects of Total Laparoscopic Hysterectomy (TLH) in cases involving enlarged uteri with myomas and to additionally identify surgical phases that significantly impact longer operation durations. The assumption was that the standard operative time for enlarged uteri with myomas should be less than 150 minutes.

Methods: Data was collected from video recordings of surgical procedures. Two groups were distinguished: fast (F) with a duration less than 150 minutes and slow (S) with a duration greater than 150 minutes. The time was calculated from the beginning skin cutting to the extraction of specimen. The study predominantly included enlarged uteri with myomas weighing between 300 and 1000 grams.

Results: Erythrocytes, hemoglobin, and hematocrit were significantly lower in the S group ($p < 0.01$). The S group had significantly higher BMI values ($p = 0.036$). No significant differences were found in age and parity. Significant differences in the short surgical phases between the F and S groups were observed in the time for coagulation and cutting of the right round ligament ($p = 0.006$), as well as cutting and coagulation of the left ligamentum proprium with the left uterine tube ($p = 0.001$). Multiple regression analysis with the duration of surgery showed a positive correlation with cutting the vagina, time for morcellation of uterus, time for suturing the vagina and time for cleaning instruments and suction ($p < 0.001$). The Kruskal-Wallis test indicated a significant association between uterine shape and duration of operation ($p < 0.001$).

Conclusion: The surgical phases most significantly affecting the duration of TLH procedures in S group were: vaginal cutting, vaginal morcellation of uterus, cleaning instruments and suction. These phases are the most significant contributors to the duration of operation. Surgeons aiming for a duration of surgery less than 150 min (median uterine weight 658 g) must expedite these longer phases. For faster vaginal cutting phases, surgical gauze can be used to push the rectum away from the monopolar hook, while suction can be used simultaneously for smoke evacuation. During vaginal morcellation of the uterus, a surgical knife could be more efficient than scissors for faster cutting and specimen evacuation. Shortening the cleaning time for the bipolar tip, optics and suction is possible by minimizing bleeding through precise dissection of blood vessels before coagulation, though this may be challenging with large fragile veins.

Background

Hysterectomy is the most common surgical procedure in gynecology for cases involving an enlarged uterus with myomas. The potential next step in development could be to establish laparoscopy as the standard procedure for uteri with myomas weighing under 1000 grams. Lower weight thresholds for defining a large uterus vary depending on the author, ranging from about 300 to 500 grams [1]. Ucela, et al. analyzed TLH in cases of enlarged uteri and found that uterus size exceeded 1000 grams in less than 5.7% of cases [2]. Currently, most cases of an enlarged uterus are treated via laparotomy. Opponents of laparoscopy cite three major concerns regarding its use in cases of enlarged uterus with myomas: longer operative time,

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potential excessive bleeding due to enlarged uterine vessels and limited operative space during the procedure. The approach to ligaments and vessels varies depending on the position of myomas, making each surgery unique and demanding. Cianci, et al. underscore the challenge of operating in confined spaces due to uterine size [3]. Research also investigates the impact of different uterine shapes on surgical complications. Uccela, et al. proposed a classification system known as the large uteri classification system (LUCS) [4].

Methods

To identify the most effective and efficient surgical approach, video recordings of 74 TLH procedures conducted between 2016 and 2022 were analyzed. All TLH procedures were done by the same surgeon. The surgical procedure is disassembled into 10 parts and subparts. The time taken for every part of the procedure was calculated (in minutes). First, the uterine manipulator Clermont Ferran positioning time was recorded (Uterine manip.). Second, the pneumoperitoneum and positioning of trocars time was recorded (Pneumoperit.+trocar). Third, involves coagulation and cutting of the ligament rotunda on left (Ligament rotunda L) and right side (Ligament rotunda R). Fourth, comprises of opening the plica vesicouterina and mobilization of the bladder caudally (mobilization of the bladder). Fifth, involves coagulation and cutting of vasa uterina left (Vasa uterina L) and right (Vasa uterina R). Sixth, includes coagulation and cutting ligament proprii, tuba left (Ligamentpropr.+tub. L), and right (Ligamentpropr.+tub. R). Every part of the surgery starts with the time measured from coagulation and cutting (preparation, if necessary,) and finishing when eventual bleeding is stopped after coagulation therefore the time taken can be calculated.

The most demanding part of the surgical procedure lasting the longest in duration is the seventh part with its subparts: Cutting the anterior part of vagina (A Ant. vag.), left side of the vaginal wall with the left sacrouterine ligament (B Vag.+sacrout. L), right part with the right sacrouterine ligament (C Vag.+ sacrout R) and posterior wall of vagina (D Post. vag.). Every subpart starts with time measured from the start of preparation in the above-described anatomic position followed by cutting and coagulation hence when no bleeding is present following coagulation then the time is stopped.

In the end when vaginal wall dissection is completed, total vaginal cutting time (Vcut) is calculated. The reason for this is to better notice difficulties in cutting the vaginal wall in situations when it is impossible to make anteversion and flexion of the cervix or uterus, to cut the left and right sacrouterine ligaments and posterior vaginal wall.

Longer parts of procedure are the: eighth part which involves vaginal morcellation of the uterus (UTMors), suturing of the vagina (Vsut) and cleaning of optics, evacuation of smoke, cleaning of the bipolar coagulator and suction (CleaSuc). All times are expressed in minutes (min).

The surgeries are divided in two groups on the basis of total duration of procedure. The first group is called fast (F), less than 150 minutes while the second group is called slow (S), greater than150 minutes duration of TLH procedure. Time was chosen on the basis of the opinion that normal time for classical laparotomy hysterectomy in the case of uterus with myomas lasts about 150 minutes.

Coagulating procedure was done by Erbe Elektromedizin VIO® 300D biporal and Enseal X1 tissue sealer with bipolar coagulation with a knife. For smoke and blood aspiration a standard suction instrument was used.

Morcellation was done using scissors with a rounded tip. The vagina is sutured by a laparoscopic approach. Time needed for smoke evacuation, cleaning of instruments and positioning of the uterus is calculated from the video source.

Uterus weight, patient BMI index, age, number of deliveries, change in standard blood values such as erythrocytes (Er), haemoglobin (Hgb) and haematocrit (HTC) before the surgery and on the third post-operative day were compared for these two groups.

Comparisons between different shapes of uteri was made. Time of surgery in different shape groups was analysed by the Kruskal Wallis test. The following groups were formed: fundal corporal large myoma group (FC), pedicular myomas group (PE), large myoma on left side of uteri group (LL, large myoma on right side of uterus (LR) and round ball-like uterus with short cervix (RO). Three different uterus shape types (Type I, Type II and Type III) were defined by Uccella, et al. [4] Type I and II were like our FC shape and Type III was like our LR and LL type. For better distinction and comparison with time of surgery two more types were added to cover the pedicular and round type of uterus with short cervix, in addition to the aforementioned groups of shapes the position of each myoma was included.

Before surgery, each patient underwent uterine MRI scans, and the groups established based on these scans. Statistical analysis was made with MedCalc® Statistical Software version 20.118.

Results

Between F and S groups haematological findings Er, Hgb and HTC are significantly different three days after surgery (Table 1). In three cases blood was administered in operating room during surgery.

Comparison between F and S group for BMI showed a significant heavier S group. No significant differences in the age of patients as well in number of deliveries between F and S groups were found (Table 2).

Significant differences between the F and S groups were found in time of coagulation and cutting of right round ligament (p = 0,006), as well as cutting and coagulating left ligament proprii with the left uterine tube (p = 0,001) (Table 3).

Significant differences were found between the F and S groups in time of cutting of the left vaginal wall with coagulation and cutting of the left sacrouterine ligament (Vag.+sacrout. L)

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Table 1: Blood tests before and on the third day after surgery comparison of the Fast (F) and Slow (S) groups.

Variable	At day of surgery	Three day after surgery	CI – confidence interval for 95%	*p*
(F) Erythrocytes (Er) x 10^{12}/L	3,5 (2,7-4,3)	3,4 (2,4-4,4)	-0.1 (-0,1 to -0.10)	0,129
(S) Erythrocytes (Er) x 10^{12}/L	3,2 (2,6-3,9)	3 (2,6-3,8)	-0,15 (-0,3 to -0,10)	**< 0,001**
(F) Hemoglobin (Hgb) g/L	101 (78-143)	107 (80-139)	-2,5 (-5 to 1,5)	0,18
(S) Hemoglobin (Hgb) g/L	112 (89-135)	107 (80-134)	-7,5 (-12 to -4)	**< 0,001**
(F) Hematocrit (HTC) %	0,28 (0,22-0,37)	0,27 (0,25-0,35)	-0,005 (-0,015 to 0)	0,154
(S) Hematocrit (HTC) %	0,29 (0,25-0,35)	0,27 (0,25-0,34)	-0,02 (-0,03 to -0,01)	**0,002**

Wilcoxon pair test: median (min – max value); Confidence interval for 95% and statistical significant (bold) *p* <0,05

Table 2: Significance of the difference between the F and S groups in relation to BMI, age and number of births.

Variable	F group (N = 47)	S group (N = 27)	Difference median (95% CI)	*p*
BMI (kg/m2)	28 (24 – 34)	29 (25 - 35)	1 (0 to 2)	**0,036***
Age of patient (yr.)	48 (43 – 52)	49 (44 - 53)	1 (-1 to 2)	0,267*
No of birth	N (%)	N (%)		0,612**
0	7 (15)	2 (6)		
1	21 (45)	14 (53)		
2	12 (25)	9 (33)		
3	5 (10)	2 (8)		
4	2 (5)	0		

Mann – Whitney U test * Chi – squared test **

Table 3: Parts of surgery with a short time and limited impact on duration of surgery – comparison between the F and S groups.

Variable	F group (*n* = 47)	S group (*n* = 27)	Difference CI 95% for median	*p*
Uterine manip.	6 (3 – 9)	6 (4 – 8)	5 – 8	0,86
Pneumoperit.+troakar	6 (3 – 8)	5 (4 – 8)	5 – 7	0,29
Ligament rotunda L	1 (1 – 4)	1 (1 - 4)	1 – 2	0,13
Ligament rotunda R	1 (1 – 3)	2(1 – 4)	1 – 3	**0,006**
Pushing bladd.	4 (3 – 10)	5 (3 – 7)	4 – 6	0,51
Vasa uterina L	7 (3 – 9)	7(4 - 11)	5 – 9	0,171
Vasa uterina R	7 (4 – 10)	8(4 – 10)	7 – 9	0,172
Ligamentpropr.+tub. L	8 (5 - 15)	7(3 – 10)	5 – 9	**0,001**
Ligamentpropr.+tub. R	8 (4 – 11)	8(4 – 9)	7 – 8	0,77

*Mann-Whitney U test

(*p* = 0,011), also between cutting the right lateral vaginal wall with coagulation and cutting of the right sacrouterine ligament (Vag.+sacrout R) (*p* = 0,004) and of cutting the posterior vaginal wall (Post. vag.) (*p* = 0,001). Furthermore the total duration of dissection of uterus from the vaginal wall or complete vaginal cutting time (Vcut) was longer for the S group than for the F group (*p* < 0,001) (Table 4).

Time for vaginal morcellation of the uterus was significantly longer in the S group (*p* = 0,001), while vaginal suturing was significant longer in F group (*p* = 0,003). Time of cleaning of optics, bipolar, smoke evacuation and positioning of uterus was longer in the S group (*p* = 0,0001). Weight of the uterus in the S group was significantly larger than in the F group (*p* = 0,0001) (Table 5).

Multiple regression analysis was done in order to check for correlation between times of surgery. The dependent variable is the time of surgery (Time-Surg) and independent variables are the number of births (No. of birth), time needed for cutting the vagina (Vcut), time for morcellation of the uterus (UTMors), time for suturing the vagina (Vsut) and time for cleaning instruments and suction (CleaSuc). All independent variables are in direct correlation and have significant impact on time of surgery (*p* = 0,0001), except numbers of births (Table 6).

Major reasons for longer times of the S group in the TLH procedure where vaginal cutting (Vcut), vaginal morcellation of uterus (UTMors), cleaning instruments and suction (ClearSuc) (Graph 1).

Table 4: Long parts of surgery: vaginal wall dissection time divided in four phases and complete vaginal cutting time - Vcut.

Variable	F group (*n* = 47)	S group (*n* = 27)	CI 95% for median	*p*
Ant. vag.	2 (1 - 4)	2 (1 - 3)	1 – 2	0,43
Vag.+sacrout. L	3 (1 - 5)	4 (2 – 8)	3 – 5	**0,011**
Vag.+sacrout R	3 (1 – 5)	4 (1 - 9)	2 – 7	**0,004**
Post. vag.	3 (1 - 7)	12 (8 - 17)	3-13	**0,001**
Vcut	12 (6 - 16)	24 (17 - 29)	10 - 25	**< 0,001**

*Mann-Whitney U test

Table 5: Long parts of surgery: Comparison of the time in F and S groups needed for vaginal morcellation of uterus and extraction (UTMors), vaginal suturing (Vsut) and cleaning of optics and instruments with suction of smoke and blood (CleaSuc).

VARIABLE	F group (*n* = 47)	S group (*n* = 27)	CI 95% for median	*p*
UTMors	19(10 - 30)	52(10 - 71)	18 - 60	**< 0,001**
Vsut	15(9 – 29)	13(6 – 19)	9 – 17	**0,003**
CleaSuc	32(20 – 48)	47(32 - 68)	30 - 54	**< 0,001**
Uterus weight	440(300-720)	658(350-1000)	372-840	**< 0,001**

*Mann-Whitney U test

Table 6: Surgery time compared to some independent variables - multiple regression analysis.

Indipendent Variable	Dependent Variable		
	Coefficient (std.error)	r partial	*p*
No. of birth	0,74 (0,510)	0,17	0,2128
Vcut cutting the vagina	0,60 (0,140)	0,45	**< 0,001**
UTMors morcellation of uterus	1,01 (0,053)	0,92	**< 0,001**
Vsut suturing vagina	0,80 (0,11)	0,65	**< 0,001**
CleaSuc cleaning instruments and suction	0,94 (0,063)	0,88	**< 0,001**

R2 adjusted = 0,991

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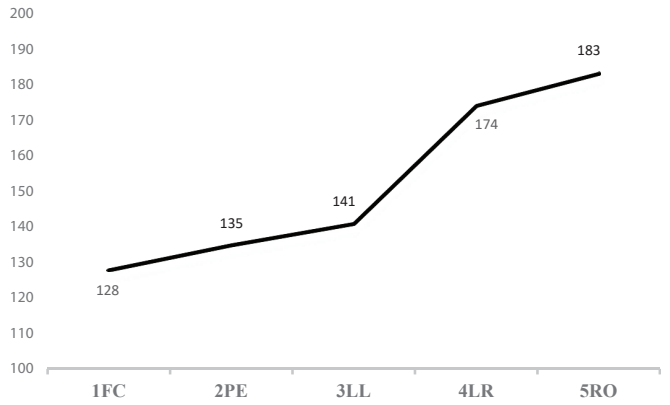

Graph 1: Duration of surgery in groups FC, PE, LL, LR and RO shapes of uterus - median in minutes.
Legend: FC: Fundal corporal myoma with long cervix; PE: Pedunculated myoma; LL: Large left side myoma; LR: Large right side myoma; RO: Round shape uterus like ball with short cervix.

Discussion

As some authors conclude in their research, total laparoscopic hysterectomy of an enlarged uterus is a safe and reasonable alternative to classic abdominal hysterectomy in terms of operative and postoperative short-term outcomes. [5]

Values of erythrocytes, haemoglobin and haematocrit on the third postoperative day in comparison with values on the day of surgery are significantly lower in the S group. Kondo, et al. did not find a difference in erythrocytes values, but Wu, et al. Yamamoto and Yoshida found a difference in a group with a uterus larger than 500 grams [6-8].

Analysis of the video data shows that problems with coagulation of vessels occur more commonly in cases with an enlarged uterus, requiring repeated coagulation and slow cutting. The BMI values were significantly lower in the F group.

Significant differences in the duration of operation between F and S groups were time of coagulation and cutting of right round ligament and left ligament proprii with left uterine vessels. Short parts of surgery have a small impact on complete duration of operation. Reasons for this could be asymmetry of the uterus caused by position of single large myoma or smaller groups of myomas and problems with the approach with instruments to anatomic positions for coagulation and cutting. Similar to the presented data, some authors in their works point out a significant difference in the length of operation duration with an increase in uterine weight [8,9].

Another contributing factor may be the placement of trocars, with the primary surgical instruments often positioned on the left side of the patient. As a result, accessing structures on the right side, particularly those obscured by myomas, can prove challenging and extend the duration of surgery. Additionally, in certain cases, abnormal positioning of the ligamentum ovarii proprium, stretched out by myomas, can complicate access to these structures and potentially lead to increased bleeding.

Significant differences were found between the F and S groups in the time taken to cut the left vaginal wall while coagulating and cutting the left sacrouterine ligament, as well as between cutting the right lateral vaginal wall and coagulating and cutting the right sacrouterine ligament. Additionally, significant differences were observed between these groups in the time taken to cut the posterior vaginal wall. The total duration of dissection of the uterus from the vaginal wall, or complete vaginal cutting time, was longer for the S group compared to the F group.

The total duration of dissection of the uterus from the vaginal wall, or complete vaginal cutting time, was longer for the S group than for the F group. This could be attributed to difficulties in approaching the posterior vaginal wall due to the fixed position of the cervix. Vaginal suturing was significantly longer in F group but could be due to most TLH in F group being done at an earlier phase of the learning of procedure.

The multiple regression analysis shows a strong correlation between cutting the vagina, time for morcellation of uterus, time for suturing vagina and time for cleaning instruments, suction and the duration of operation. The longer duration of cutting the vaginal wall in the S group results from the larger size of the uterus, making it difficult to visualize and access the correct position for cutting the vaginal wall with the monopolar needle. Additionally, the bowel must be mobilized away from the monopolar hook, further prolonging the procedure. Similarly, the longer duration of vaginal morcellation in the S group is also due to the larger uterus size in this group. Surprisingly, cleaning of the optics, evacuation of smoke, cleaning of the bipolar coagulator and suction - the tenth part of the procedure - was the longest in duration in the F group and second longest in the S group after vaginal morcellation of the uterus. Upon repeated review of the surgical videos, it became apparent that numerous small intervals of cleaning and suction throughout the operation contributed significantly to the overall time for cleaning instruments and suction.

A significant amount of time is consumed by vaginal uterine morcellation and the cleaning of instruments and suction phase. Vaginal morcellation, as opposed to mechanical abdominal morcellation, is the preferred method to prevent the spread of myoma particles in the upper abdomen. Wang, et al. assert that vaginal morcellation is slower than mechanical morcellation [10].

Kondo, et al. found significant differences in operative times between groups with less than 250grams, 250 to 500grams and greater than 500 grams [6]. In the works of O'Hanlan, et al. and Ishibashi, et al. uterine weight is correlated with the time of surgery and duration of surgery, furthermore it is similar to duration in our work [9,11].

Based on video analysis, the position of larger myomas or groups of myomas significantly influenced the duration of the procedure, particularly in areas where there was the most pronounced deformation of the normal pear-shaped uterus. The Kruskal-Wallis test demonstrates a significant impact on the surgery time due to different shapes of the uterus. In his work, Cianci, et al. found a higher conversion rate in cases of myomas larger than 8 cm and when dealing with an

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inexperienced surgeon [3]. In our study, the position and size of the uterus presented challenges, yet the conversion rate was zero. The most unfavorable shape is a round uterus with a short cervix and a ball-like appearance, often associated with a larger size. This may be due to the difficulty in moving and positioning the uterus, particularly when it is confined within a small pelvis. The most conducive shape for faster surgery is a uterus with fundal myomas (pear-shaped) or a uterus with pedunculated myomas. Myomas located laterally on the left (LL) and right (LR) sides fall somewhere in between. Nakayama, et al. reported three cases of cervical myomas, demonstrating varying durations of TLH surgery due to differences in the position and size of the enlarged myomas, ranging from the left posterior side of the cervix (lasting 285 min.) to the anterior side of the cervix (lasting 145 min.) and the left side (lasting 192 min.) [12]. Uccella, et al. proposed a classification system for uteri larger than 500 grams, categorizing them into three types; we added two more groups with a similar concept [4]. Yavuzcan, et al. found similar operative times to our study for uteri sized greater than 250 grams, with a maximum size less than 600 grams having an operative time of approximately 150 min [13]. Streeter, et al. confirm that despite an enlarged uterus filling the abdominal cavity (5300 g), a laparoscopic approach is feasible and can have excellent postoperative outcomes [14]. Halimah Jaafar, et al. confirmed a similar finding in their work in a patient with an extremely high BMI (60.1 kg/m2) [15].

Sinha, et al. defined 50 cases with enlarged uterus and significant variations in the position and size of the uterus, coupled with the uniqueness of each case, contribute to the complexity of the situation [16]. The most important skill for surgeons is the ability to adapt to different scenarios, along with extensive experience in performing TLH surgery on standard-sized uteri before transitioning to laparoscopic surgery in enlarged uteri. Despite extensive review, there is no available literature on time analysis of different parts of TLH surgery with a focus on shortening the total duration of surgery, similar to what was conducted in this study. The nuances of laparoscopic treatment of a large uterus are also addressed by Jain, et al. [17].

Strengths and weaknesses of the study

The results of the study are generally consistent with previously published studies and provide additional insight into TLH for enlarged uteri, although there are few studies describing the surgical procedure on uteri weighing 1000 g. There are no studies analyzing the phases of the surgical procedure with a suggestion for a possible shortening of the time spent.

This study has certain shortcomings. Since this was a retrospective study, it is not possible to completely reliably determine the cause-and-effect relationship between the studied phenomena. Furthermore, it is a small sample, since the respondents who participated in the study were from only one hospital, so the conclusions of this study cannot be generalized to others. A disadvantage of this study is the fact that the surgical procedures were performed by the same surgical team, which over time improved individual phases of the surgery and, with the acquired experience, shortened the observed times of certain phases.

Suggestions for future research

In future research, the same design of a prospective study should be used on a larger number of patients. It is possible that some factors were not taken into account, so including additional variables would give a better insight into the proposed techniques for performing TLH for enlarged uteri.

Conclusion

Size and shape of uterus and position of large myoma group has a considerable impact on the length of the procedure. In order to improve operative time, vaginal morcellation of uterus and extraction, cleaning of optics and instruments with suction of smoke and blood must be reduced. This time can be achieved by using suction instrument, bipolar and cutting device simultaneously. Also, the monopolar hook should be used simultaneously with a suction instrument because of excessive smoke production from the monopolar hook. Vaginal morcellation can be done faster with the usage of a knife instead of scissors but with higher risks for lesions of vaginal wall, bladder and rectum.

Criteria for inclusion in the authors' list

Authors: Boris Bačić(BB), Zlatko Hrgović(ZH), Žana Saratlija(ŽS), Blagoja Markoski(BM), Martin Pelin(MP), Ina Stašević(IS).

1. Conception, design, data collection, or analysis. (BB, ŽS, BM)
2. Drafting or revising the manuscript critically for important intellectual content. (BB, ZH, ŽS, BM, MP, IS)
3. Final approval of the version to be published. (BB, ZH, ŽS, BM, MP, IS)
4. Accountability for all aspects of the work, ensuring integrity and accuracy. (BB, ZH, ŽS, BM, MP, IS)

Authorship statement

The manuscript has been read and approved by all authors, meets the authorship criteria and each author believes the manuscript represents honest and genuine work.

Ethical approval

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 as well as its later amendments or comparable ethical standards. For this type of study, formal consent is not required. This article does not contain any studies with animals performed by any of the authors. The

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Clinical Hospital Split institutional ethical board approved the study (reg. num. 181-23), with a waiver of informed consent due to the retrospective observational design of the study.

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