

# Analysis of postoperative pain in robotic versus traditional laparoscopic hysterectomy

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**Abstract** The aim of this study was to assess postoperative pain and narcotic use in the first 23 h following robotic versus traditional laparoscopic hysterectomy for benign pathology. The study design was that of a retrospective case–control study of robotic (first 100 consecutive) versus traditional (last 100 consecutive) total laparoscopic hysterectomy cases at an obstetrics and gynecology multi-institutional community practice. Patient characteristics were equivalent in both groups (age,  $p = 0.364$ ; body mass index,  $p = 0.326$ ; uterine weight,  $p = 0.565$ ), except for a higher number of Caucasians in the traditional laparoscopic group ( $p = 0.017$ ). Compared to patients who underwent robotic laparoscopic hysterectomy, those who underwent the traditional procedure had higher visual analog scale pain scores ( $3.1 \pm 1.5$  vs.  $4.6 \pm 2.4$ , respectively;  $p < 0.001$ ) and used more narcotics ( $27.5$  vs.  $35.4$  mg hydrocodone, respectively;  $p < 0.05$ ). Factors that could potentially increase pain (more procedures, more ports, total incision size, and longer operative time) were significantly higher in the robotic group, but only surgical

approach, amount of narcotic, and age correlated with pain levels when evaluated with regression analysis. Complication rates were equivalent between groups. In conclusion, patients who underwent robotic assisted laparoscopic hysterectomy had statistically decreased postoperative pain scores and narcotic use than those who underwent the traditional laparoscopic approach, even when the robotic cases involved more procedures and ports and were associated with longer operative time.

**Keywords** da Vinci · Laparoscopic hysterectomy · Minimally invasive surgery · Narcotics · Pain · Robotic

## Introduction

Hysterectomy for benign pathology is the most common non-pregnancy procedure performed in the USA [1], and the pain associated with this procedure can be a concern for many women [2]. The use of minimally invasive approaches for benign hysterectomy has recently increased [3]. For example, several studies have compared the perioperative outcomes of robotic assisted total laparoscopic hysterectomy (RALH) to traditional total laparoscopic hysterectomy (TLH) [4–11]. One of the more consistent findings of these studies is a shorter length of hospital stay following robotic surgery [4, 5, 8, 9], possibly at least partially a result of decreased postoperative pain due to the fulcrum effect and the increased precision of the robotic system. In support of this notion, one of the comparative studies mentioned above reported significantly reduced narcotic use following robotic surgery [5]: however, the small sample size of this study and the lack of collaborating pain scores or analysis of parameters correlating with narcotic use limit the interpretation of these results.

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In the study we report here, we retrospectively analyzed 200 cases of benign total hysterectomy performed using a robotic or traditional laparoscopic approach to test if pain levels as measured by visual analog scale (VAS) scores and analgesic use measured by milligrams of hydrocodone differed between groups. We also report on perioperative outcomes, including potential causes of postoperative pain, and test for factors affecting pain levels using higher order statistics in the form of regression analysis.

## Materials and methods

In our daily practice, we standardly perform minimally invasive surgery for benign gynecological procedures using traditional laparoscopy. The da Vinci S four-arm surgical system (Intuitive Surgical, Sunnyvale, CA) was added to our practice in March of 2007. We have retrospectively compared the outcomes of the first 100 consecutive benign total hysterectomy cases performed with the robot (from 14 June 2007 to 20 September 2010) to the last 100 consecutive benign total hysterectomy cases performed using traditional laparoscopy (from 4 April 2009 to 30 December 2010). All robotic surgeries were performed at the Baptist Memorial Hospital-Golden Triangle by one of the five surgeons in the group and represent the first 100 robotic cases performed in the practice. The traditional laparoscopic surgeries were performed by all five surgeons at the same hospital (Baptist Memorial Hospital-Golden Triangle) as well as a second hospital (Gilmore Memorial Regional Medical Center). All of the surgeons were experienced in traditional laparoscopy and the two surgeons who performed the majority of the laparoscopic cases were high-volume surgeons.

Our practice focuses on minimally invasive surgery, so there were no pre-specified contraindications to robotic or laparoscopic hysterectomy, and the choice of surgical approach was based on robot availability along with surgeon and patient preference. All patients provided appropriate consent for the procedure; the women were informed about the risks of the procedure (including conversion to an open procedure) and about their options for a robotic-assisted or traditional laparoscopic approach during a pre-operative counseling session. This study was approved by our institutional ethics committee and received exemption from the Western Institutional Review Board due to the retrospective nature of the study and to the de-identification of patient charts.

Patients presenting with abnormal uterine bleeding, pelvic pain, fibroids, pelvic prolapse, endometriosis, ovarian cysts, or other benign pathology were included in the analysis. Additional procedures included unilateral or bilateral

salpingo-oophorectomy, pelvic reconstruction without mesh, sacrocolpopexy, sling urethropexy, cystoscopy, ureteral stents, endometriosis excision/ablation, ovarian cystectomy, uterine morcellation, lysis of adhesions, or breast biopsy. Patients with malignant pathology and patients who underwent conversion to open surgery were excluded, as were cases where part of the procedure was done vaginally (laparoscopic assisted vaginal hysterectomy).

## Surgical procedure

The surgical procedures for RALH and TLH were identical with few exceptions. A brief description of the procedure and of any differences due to choice of surgical approach is outlined below.

Patients were admitted the day of surgery and were kept in the hospital for a 23 h observational period. For surgery, patients were placed in the low dorsal lithotomy position with arms tucked and padded at the side. The bladder was drained with a Foley catheter, and a V-care (Conmed, Utica, NY) or Rumi (Cooper Surgical, Trumbull, CT) uterine manipulator was placed. The first incision was made, and the Veress needle was placed. All additional ports were placed under direct visualization, and the location was based on the size of the uterus. Insufflation of the abdomen to 15 mm Hg pressure was achieved. The patient was then placed in the steep Trendelenburg position. An assistant/accessory port was placed in the right upper quadrant for robotic surgeries. For the robotic cases, a PK dissecting forceps (Olympus/Gyrus ACMI, Southborough, MA and Intuitive Surgical) and Hotshears (Intuitive Surgical) monopolar cautery scissors were used. A harmonic scalpel (Ethicon Endo-Surgery, Cincinnati, OH) and PK dissecting forceps were used for the traditional laparoscopic surgeries. Dissection started with the round ligament, and then the adnexa (if removed). Dissection continued with the broad ligament, skeletonization of the uterine vessels, and cautery and transection of the uterine vessels. Development of the bladder flap was followed by colpotomy incision, and the uterus was delivered vaginally (in some cases morcellation via the vagina was necessary in both groups). Vaginal cuff closure was done laparoscopically for both the traditional laparoscopic cases (extracorporeal knot tying) and robotic cases (intracorporeal knot tying). Patients were released from the recovery room once pain was well controlled and the patient was stable based on the anesthesiologist's opinion. The patients were then transferred to the gynecology floor for the remainder of the hospitalization period. The postoperative orders, pain management protocol, and discharge protocol were the same for both hospitals and both surgical approaches. Patients were discharged following flatus, ambulation,

toleration of an oral diet, and acceptance of oral pain medications with good pain control.

### Measurements

The primary outcomes measured were pain levels and narcotic use during the first 23 h following surgery. A VAS was used to rate pain levels on a scale of 0–10. Patients were asked to rate their pain as soon as they were able to talk in the recovery room and again every 4 h until discharged, so that at least five pain scores were available for each patient. Additional pain measurements were taken each time the patient requested pain medication, prior to receiving the medication. All patients received ketorolac [standard 30 mg intravenous (IV) every 6 h  $\times$  3 doses] unless contraindicated. Standard protocols were followed for narcotic administration based on the patient's VAS score. Hydrocodone was the standard narcotic and was utilized by the majority of patients (5–15 mg/dose every 4 h as needed for pain). Alternative narcotics were used if hydrocodone was contraindicated (allergy, gastrointestinal upset, or inadequate pain relief), and all additional doses of IV or different oral narcotics given for pain management were included in the analysis by converting all narcotic amounts to hydrocodone (milligram) using a web-based calculator (<http://www.medcalc.com/narcotics.html>).

Secondary outcomes included patient characteristics [age, body mass index (BMI), and race], procedures performed, operative time (skin incision to skin closure), the number of ports used, uterine weight, and complications. Complications were reported for up to 30 days using the Clavien classification [12].

### Statistics

Statistical analysis was performed with SAS System ver. 9.2 (SAS Institute, Cary, NC). Power analysis was performed to check for adequacy of the sample size. Standard univariate methods were used to express continuous variables with respect to mean, standard deviation, and 95 % confidence intervals. Discrete variables were expressed as proportions. Conversion cases were excluded from analysis due to the larger incision, which could directly affect pain levels and confound the results. Groups were compared using chi-squared or *t* tests. In all cases a two-sided *p* value of  $<0.05$  was considered to be significant. Regression analysis was performed to check for factors that correlated with pain levels, including surgical approach, amount of narcotic, nonsteroidal anti-inflammatory drugs (NSAIDS), age, BMI, number of procedures, other procedures, number of ports, operative time, blood loss, and complications.

### Results

Patient characteristics for the RALH and TLH groups are reported in Table 1. There were no significant differences in age ( $p = 0.364$ ), BMI ( $p = 0.326$ ), or uterine weight ( $p = 0.565$ ) between groups. There was a statistically significant difference in race, with significantly more Caucasians in the traditional laparoscopic group ( $p = 0.017$ ). Patients in the RALH group underwent significantly more procedures than did patients in the laparoscopic group [average number of additional procedures per patient:  $2.0 \pm 1.5$  (RALH) vs.  $0.9 \pm 1.1$  (TLH);  $p < 0.001$ ], with only 18 patients undergoing hysterectomy alone (no additional procedures) in the RALH group compared with 32 patients in the TLH group ( $p = 0.022$ ). More laparoscopic ports were used for RALH patients than for TLH patients [average number of ports:  $5.0 \pm 0.3$  (RALH) vs.  $3.2 \pm 0.4$  (TLH);  $p < 0.001$ ], resulting in a larger total incision size for the former [average of all incisions added together: 25.5 (TLH) mm vs. 48.2 mm (RALH);  $p < 0.001$ ]. Operative time was on average 1 h shorter for the traditional group (102.5 min) than for the robotic group (169.5 min) ( $p < 0.001$ ). Robotic operative time decreased significantly with experience [243.1 (first ten cases) vs. 143.6 min (last ten cases);  $p = 0.013$ ].

There was one intraoperative injury in the RALH group; a ureteral injury that required replacement of the ports and a urology consult with repair. This patient later developed pyelonephritis, resulting in a 5-day hospital stay. In the TLH group, there were two cases of bladder cystotomy, both of which were recognized and repaired during surgery. One of these patients went on to develop a vaginal cuff dehiscence that required a return to the operating room. In both groups, one patient had one minor vaginal laceration during vaginal uterine morcellation that was repaired intraoperatively.

Further postoperative complications in the robotic group included a case of ileus that responded to bowel rest, a prolonged extubation (admission to Intensive Care Unit with ventilator) along with transfusion (pre-operative anemia), a delayed thermal injury that resulted in a ureteral–vaginal fistula requiring repair, a vaginal cuff dehiscence that required repair (the result of the patient resuming intercourse despite counseling of pelvic rest), a superficial cuff dehiscence that required placement of a suture to stop minor bleeding, and an infected cuff hematoma that required drainage and IV antibiotics (see Table 1). In the TLH group, postoperative complications included a ureteral–vaginal fistula that required repair, an ileus combined with an urinary tract infection that required IV antibiotics, and a vaginal cuff cellulitis that required IV antibiotics for treatment.

**Table 1** Patient characteristics and operative outcomes

Parameter	RALH (N = 100)	TLH (N = 100)	p value <sup>a</sup>
Age (years)			
Mean ± SD	44.8 ± 10.3	43.6 ± 9.0	0.364
Range	30–87	18–79	
95 % CI	42.8, 46.8	41.8, 45.4	
BMI (k/m <sup>2</sup> )			
Mean ± SD	31.4 ± 7.3	30.4 ± 6.8	0.326
Range	20–59	18–47	
95 % CI	30.0, 32.8	29.1, 31.7	
Race (n)			
Caucasian	71	85	0.017 <sup>b</sup>
Hispanic	1	0	
Asian	1	1	
Black	27	14	
Other	0	0	
Uterine weight (g)			
Mean ± SD	160.3 ± 99.8	169.0 ± 111.6	0.565
Range	45–550	32–631	
95 % CI	140.7, 179.8	147.1, 190.8	
Procedures, n (%)			
Hysterectomy	18 (18.0)	32 (32.0)	0.007 <sup>c</sup>
Hysterectomy + B/USO	15 (15.0)	24 (24.0)	
Hysterectomy + other	17 (17.0)	16 (16.0)	
Hysterectomy + B/USO + other	50 (50.0)	28 (28.0)	
Additional procedures			
Mean ± SD	2.0 ± 1.5	0.9 ± 1.1	<0.001
Range	0–6	0–3	
95 % CI	1.7, 2.2	0.7, 1.1	
Number of ports			
Mean ± SD	5.0 ± 0.3	3.2 ± 0.4	<0.001
Range	4–6	3–4	
95 % CI	5.0, 5.1	3.1, 3.2	
Operative time (min)			
Mean ± SD	169.5 ± 75.6	102.5 ± 34.4	<0.001
Range	75–398	60–245	
95 % CI	154.7, 184.3	95.7, 109.2	
Postoperative complications (Clavien grade)			
	1 seroma/pyelonephritis (II)	1 vaginal cuff dehiscence (IIIb)	0.352
	1 ileus (I)	1 ureteral vaginal fistula (IIIb)	
	1 difficulty extubation/anemia (II)	1 ureteral vaginal fistula (IIIb)	
	1 ureteral vaginal fistula (IIIb)	1 ileus/urinary tract infection (II)	
	1 vaginal cuff dehiscence (IIIb)	1 infection (II)	
	1 superficial cuff dehiscence (IIIa)	1 cellulitis (II)	
	1 infected cuff hematoma (IIIa)		

RALH robotic-assisted total laparoscopic hysterectomy, TLH total laparoscopic hysterectomy, SD standard deviation, CI confidence interval, BMI body mass index, B/USO bilateral or unilateral salpingo-oophorectomy

<sup>a</sup> p values are based on t tests unless indicated otherwise

<sup>b</sup> p value Caucasian RALH vs. TLH based on chi-squared test

<sup>c</sup> p value based on contingency table

An equivalent number of patients in each group were given standard amounts of NSAIDs following surgery (94 RALH patients vs. 98 TLH patients;  $p = 0.149$ ). Patients in the RALH group reported experiencing less pain than those in the TLH group, with average VAS pain scores of

3.1 versus 4.6, respectively ( $p < 0.001$ ) (a 33 % decrease) (see Table 2). These decreased pain levels corresponded to a decreased narcotic requirement, with the average total narcotic requirement for patients in the RALH group being lower than that for those in the TLH group (27.5 vs.

**Table 2** Pain levels and drug use

Parameter	RALH (N = 100)	TLH (N = 100)	p value
No NSAIDs (%)	6	2	0.149 <sup>a</sup>
VAS pain score			
Mean ± SD	3.1 ± 1.5	4.6 ± 2.4	<0.001
Range	0–7	0–8.5	
95 % CI	2.8, 3.4	4.1, 5.0	
Hydrocodone (mg)			
Mean ± SD	27.5 ± 26.0	35.4 ± 28.1	0.041
Range	0–128	0–131	
95 % CI	22.4, 32.6	29.9, 40.9	

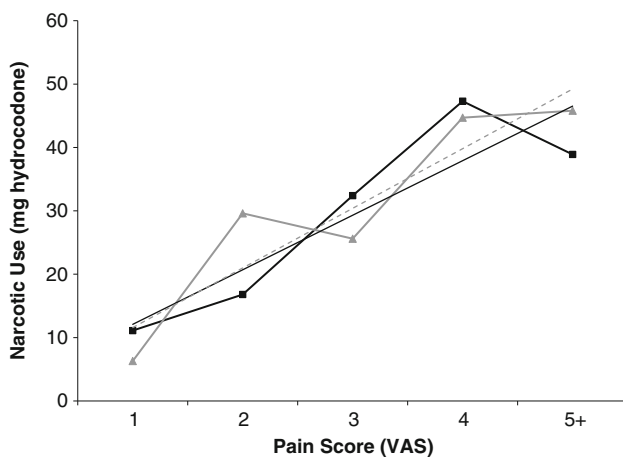
RALH robotic-assisted total laparoscopic hysterectomy, TLH total laparoscopic hysterectomy, VAS visual analog scale (0–10)

<sup>a</sup> p-value chi-squared, all other p-values t-tests

35.4 mg hydrocodone, respectively;  $p < 0.05$ ) (a 22 % decrease).

For the power analysis assuming a difference of at least 1.5 units in the VAS score between groups with standard deviations of between 1.5 and 2.4, a sample size of 80 patients (40 in each group) would be adequate to detect such a difference with 80 % power at the 5 % significance level.

Regression analysis to test for factors affecting pain level and narcotic use demonstrated that the only factors which influenced pain were surgical approach ( $p < 0.001$ ) and age ( $p = 0.020$ ). The robotic approach was correlated with decreased pain levels regardless of age ( $p < 0.001$ ), and increased age was correlated with increased pain regardless of surgical approach ( $p = 0.020$ ). There were no differences in age of patients between surgical approaches ( $p = 0.364$ ). As a control to test for bias in drug



**Fig. 1** Relationship between pain score and narcotic use. Graph showing narcotic use (in milligrams hydrocodone) as a function of pain scores [based on a visual analog scale (VAS) of 1–10] for robotic-assisted total laparoscopic hysterectomy (RALH; filled squares) and total laparoscopic hysterectomy (TLH; filled triangles). Best fit linear regression curves are shown as a solid line (RALH) or a dotted line (TLH)

administration (to test for deviations in following the standard protocols, which called for a set milligrams of narcotics to be administered for a set VAS score), we confirmed that increased pain levels were significantly correlated with increased narcotic use regardless of surgical approach ( $p < 0.001$ ; see Fig. 1). There was no correlation between pain levels and BMI, the number of procedures performed, the number of ports used, the operative time, blood loss, NSAIDs, or complications ( $p > 0.05$ ).

## Discussion

Based on the results of our retrospective study, we report that our patients who underwent RALH had decreased postoperative pain and narcotic use than those who underwent traditional laparoscopy. This was not due to differences in patient characteristics (age, BMI, uterine weight), operative outcomes (surgical procedure, operative time, number of ports or procedures), or postoperative protocols, as shown by the regression analysis.

We provide a minimally invasive approach whenever possible (only contraindication malignancy—which is typically referred to a gynecologic oncologist), with the choice of surgical approach based on robotic availability, patient choice, and surgeon preference. Consistent with this, the compositions of our patient groups were similar, with the difference in race distribution attributed to the demographics of the two communities where robotic and laparoscopy took place: there is a higher representation of African Americans in the Baptist Memorial Hospital-Golden Triangle region where robotics surgery was performed.

The preoperative, surgical, and postoperative procedures and protocols were standardized between the two hospitals and between all of the surgeons and nurses, including the use of standard pain assessment protocols (VAS screening every 4 h) and standard pain management orders (a set milligram dose of hydrocodone was given for a set pain score). There were, however, a few surgical procedural differences. The harmonic scalpel was used during the majority of traditional laparoscopic cases and monopolar cautery was used for the colpotomy incision in robotic cases. We do not believe that this difference in instrumentation could account for the pain level differences, and if it did, we might expect the opposite effect, that the increased width of thermal tissue injury due to monopolar electrocautery would increase postoperative pain in the robotic laparoscopic group. In the robotic cohort, we took advantage of the fourth arm to assist with uterine manipulation (given the lack of a dedicated robotic team and varied experience of operating technicians) and used an assistant port. We expected more ports to cause more pain [13–15], due to a longer total incision length, the potential for tension

(pulling forces), and tissue trauma around the incision sites. Surprisingly, pain levels in our study cohort did not correlate with the number of ports. The robotic platform sets a fulcrum point at the level of entry so the portion of the instrument in contact with the skin does not move from side to side, unlike with traditional laparoscopy; this stability theoretically could decrease pulling and shearing trauma, translating into decreased pain for the patient.

Operative time was longer in the robotic group; however, this cohort represents our first 100 robotic cases and thus includes our learning curve. Shashoua et al. [5] also reported a longer operative time for the robotic group, but similar to our findings, also reported that a longer operative time did not result in higher narcotic usage. Operative time decreased significantly in the robotic group with increasing experience [243.1 (first 10 cases) vs. 143.6 min (last 10 cases);  $p = 0.013$ ], so we would expect this to become even less of an issue for future cases. Other differences due to surgeon experience would give the advantage to the laparoscopic group.

While all of the robotic cases were performed at a single hospital, and traditional laparoscopic cases were performed at this same hospital and a second hospital, a subgroup analysis of laparoscopic cases performed at the same hospital showed the same result, i.e., lower pain levels and narcotic use with a robotic approach (data not shown), suggesting that any differences between hospitals or surgeons did not skew the results.

This study is limited by its retrospective nature, but is strengthened by the standardization of all protocols and large sample size shown to be adequate through power analysis. Although pain is subjective, by measuring pain levels at set time points and by measuring narcotic administration using pre-defined protocols, we have attempted to provide objective measures and have performed regression analysis to check for factors that were significant predictors of pain. In addition, bias was limited by keeping the anesthesiologists, nurse anesthetists, post-anaesthetic care unit nurses, and gynecology nurses unaware of the existence of the study. Although we cannot completely rule out intraoperative procedural differences made by anesthesiologists or nurse anesthetists involved in individual cases, we have no reason to believe that there were consistent surgical approach-specific differences. We attempted to limit investigator bias by waiting to review charts and analyze data until after all 200 cases were complete. We cannot rule out patient bias; there is always the possibility that patients choosing a robotic approach expect less pain and thus report experiencing less pain. However, this type of patient bias can work in the opposite fashion; it has been suggested that an expectation of improved outcomes can result in decreased satisfaction regardless of actual outcomes [16].

In general, our outcomes are consistent with those reported in large sample size, robotic benign total hysterectomy papers [17–19] and other robotic versus laparoscopic comparison papers [4–11, 20] and with those obtained in studies reporting decreased pain with robotic assistance when compared to traditional laparoscopy for hysterectomy [5], endometrial cancer [21], and radical nephrectomy [22]. Recently, there have also been studies showing no difference [23, 24] or an increase in pain with robotics when compared to conventional laparoscopy [25]. Hachem and colleagues [23] also reported increased operative time and overall increased incision size with robotics, but these authors did not see a difference in pain scores or narcotic requirement when compared to conventional laparoscopy. In the Swiss study by Sarlos et al. [24], patients were randomly assigned to robotic or laparoscopic treatment by expert laparoscopic surgeons who had performed at least 30 prior robotic cases; these authors found an equivalent analgesic usage between groups. Complications were also equivalent between groups, but operative time was significantly longer for robotic hysterectomy. In their study on robotic versus laparoscopic sacrocolpopexy, Paraiso et al. [25] reported increased pain 3–6 weeks following robotic surgery. Although this study was randomized, there were differences between the robotic and laparoscopic groups that could potentially affect pain outcomes, including differences in port locations, the experience level of the surgeon (ten prior robotic cases vs. “advanced laparoscopic skills”), and complication rates. These authors reported no difference in individual complication rates; however, when taken together, overall there were 19 complications in the robotic group (19/35, 54.3 %) and only six complications in the laparoscopic group (6/33, 18.2 %;  $p < 0.01$ ).

Differences in surgeon experience, sample size, number of surgeons, surgical procedure, and outcomes make comparisons between our studies and the other pain studies challenging. It is possible that the decrease in pain that we observed in the robotic group is due to factors we did not consider or to differences between groups of which we were unaware and could not control for in a retrospective study. However, our use of regression analysis allowed us to test for the effects of several factors thought to have a direct effect on pain levels. Without a similar analysis in these other studies, it is difficult to determine whether their findings of reduced, equivalent, or higher pain levels were due to surgical approach alone or combined with other factors.

Previous studies have suggested that decreasing pain levels can speed recovery [19] and decrease costs [21]. In addition, the anticipation of pain is a major source of apprehension for patients contemplating surgery [2], which could result in the patient delaying surgery. Any available technology, such as robotic surgery, that has the ability to

remove barriers to treatment and increase patient quality of life should be considered. The findings of this study suggest that the use of robotics may have the ability to decrease pain levels for patients immediately after surgery. Further studies examining the reasons for the discrepancies between the conflicting pain studies published to date are needed.

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