Clinical Outcomes and Resource Utilization Associated With Laparoscopic and Open Colectomy Using a Large National Database

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Objectives: To clarify national clinical and economic laparoscopic colectomy outcomes, we conducted a study of patients who underwent colectomy by laparoscopic or open approaches.

Background: Laparoscopy is becoming the preferred approach for colectomy in benign and malignant diseases. Although it is associated with significant clinical benefits, economic outcomes have varied.

Methods: We analyzed cohorts of patient-level data from Premier Inc.'s Perspective Rx Comparative Database, which collects data from more than 500 hospitals throughout the United States. By reviewing hospital charge data, patients who underwent elective colectomies from July 1, 2004, through June 30, 2006, were identified using *International Classification of Diseases, 9th Revision, Clinical Modification* procedure codes. The colectomy had to be listed as the primary or secondary procedure of the hospitalization. Primary outcomes included transfusion rates, in-hospital complications, readmissions within 30 days, reoperations, length of stay, total hospitalization costs, and discharge dispositions and services.

Results: We identified 32,733 patients who had elective colectomies throughout 402 hospitals; 11,044 (33.7%) were laparoscopic and 21,689 (66.3%) were open colectomies. The mean age was 64.2 ± 13.9 years and 53.8% were women. Laparoscopic colectomy patients had a longer mean operative time (195 ± 76 vs. 178 ± 80 minutes; $P < 0.0001$) and higher total hospital costs ($8076 vs. $7678; $P = 0.0002$). Laparoscopic patients had shorter mean length of stay (7.0 vs. 8.1; $P < 0.0001$) and fewer mean intensive care unit days (0.7 ± 3.8 vs. 1.3 ± 5.2 days; $P < 0.0001$). The laparoscopic cohort also had lower rates of transfusions (odds ratio [OR] = 0.68; $P < 0.0001$), in-hospital complications (OR = 0.89; $P < 0.0001$), and readmissions within 30 days (OR = 0.89; $P = 0.0051$), although reoperation rates were slightly, but significantly increased (OR = 1.78; $P = 0.002$). Laparoscopic colectomy patients were more likely to be discharged home without nursing care (OR = 0.70; $P < 0.0001$).

Conclusion: Evaluation of a national administrative data set showed that patients who underwent laparoscopic colectomy had shorter intensive care unit and total hospital stays, fewer complications, lower mortality, fewer readmissions, and less use of skilled nursing facilities after discharge. There was a small but significant increase in reoperation rates and in-hospital costs with laparoscopic colectomy. Improved application of enhanced recovery programs and operative efficiencies may further improve resource utilization associated with laparoscopic colectomy.

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Laparoscopy is emerging as the preferred approach for colectomy, and several studies have evaluated clinical and economic benefits of laparoscopic colectomy for benign and malignant diseases.[1–5] Laparoscopic colectomy is consistently associated with significant clinical benefits[1–6]; however, the economic outcomes have varied considerably.[1,2,4,5,7] Some studies have shown little reduction in hospital stays, and increased perioperative and global hospitalization costs.[1,2,7] Many of those studies had small samples or nonhomogenous diagnostic groups, so results may not represent the entire colectomy population.[5,8–10] Few, if any, of the studies rigorously implemented an enhanced recovery program in addition to the laparoscopic technique. In many of the larger studies, cost outcomes were not reported or may not be valid when extrapolated to community practice.[11–14] We hypothesized that patients who had laparoscopic colectomies would have better clinical outcomes and require less home health nursing services upon discharge than those who had open colectomies. Therefore, we conducted a study to evaluate clinical and economic outcomes using a large nationally representative sample of patients with benign and malignant colon diseases who underwent colectomies by laparoscopic and open approaches.

METHODS

This was a cohort analysis conducted by retrospectively reviewing Health Insurance Portability and Accountability Act[15]-compliant data from Premier Inc.'s Perspective Rx

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Comparative Database, an inpatient database developed and maintained by Premier Inc. (Charlotte, NC) for quality and utilization benchmarking.[16] This is the largest inpatient database in the United States, with data from over 500 acute-care hospitals. Each hospital submits quarterly updates of aggregated data. Patient-level data go through 95 quality assurance and data validation checks. Once the data have been validated, patient-level information is available, comprising data consistent with the standard hospital discharge file, demographic and disease state information, and information on all billed services, including date-specific logs of medications, laboratory, diagnostics, and therapeutic services.

Sample Selection

We reviewed hospital charge data from all hospitals that contribute data to the Perspective Rx database. Using *International Classification of Diseases, 9th Revision, Clinical Modification*[17] (ICD-9-CM) procedure codes, we identified all patients at least 18 years old who underwent elective colectomies from July 1, 2004, through June 30, 2006. The colectomy had to be listed as the primary or secondary procedure of the hospitalization. Procedures evaluated included right hemicolectomies (ICD-9-CM 45.75), left hemicolectomies (ICD-9-CM 45.73), or sigmoid colectomies (ICD-9-CM 45.76). We did not include rectal excision codes (48.6x), or total colectomy codes. ICD-9-CM procedure codes for colectomies do not specify open or laparoscopic approaches; we reviewed standard instrument charge descriptions to identify laparoscopic equipment and used them to distinguish procedures as laparoscopic or open. In using this approach, cases that required conversion to open colectomy were kept in the laparoscopic group, on an intention-to-treat type principle, because laparoscopic equipment would have been used at some time during the procedure. Once the patient sample was identified, we also identified the hospitals where patients had their colectomies and their characteristics, as outlined below.

Outcomes Measures

Primary outcomes-of-interest included transfusion rates, in-hospital complications, readmissions within 30 days, reoperations, lengths of stays (LOSs), total hospitalization costs, and discharge dispositions and services. We categorized discharge dispositions and services as home, home with nursing care, skilled nursing facility, other healthcare facilities or services, or death. Other healthcare facilities or services included any disposition not mentioned above, such as intermediate care facilities, hospice facilities or services, short-term general hospitals, etc. We identified transfusions, in-hospital complications, and reoperations using ICD-9-CM diagnosis and procedure codes. Reoperations included any abdominal surgeries after coded colectomies, but during the same hospitalization.

Additional metrics included age, gender, diagnosis (colon cancer, inflammatory bowel disease, and diverticular disease), procedure type (right or left hemicolectomy and sigmoidectomy), conversion to laparotomy (identified by using ICD-9-CM code V64.41), surgeon specialty (colorectal, general, and all others), type of hospital (teaching and non-teaching), hospital colectomy volume (low, medium, and high), operative time (in minutes), number of days in an intensive care unit (ICU), and risk of mortality (ROM). Premier Inc. assigns hospital teaching status based on definitions used by the American Hospital Association. After we determined each hospital's colectomy volume, we classified each hospital into low, medium, and high based on the 33.3rd and 66.6th percentiles. ROM was determined by an administrative tool developed by 3M Information Systems. The All Patient Refined–Diagnosis-Related Groups (APR-DRG)[18] is a proprietary patient classification system that uses DRG system methodology to classify patients into disease categories. These disease categories allow hospitals to quantify clinical differences between their patient populations. The APR-DRG ROM assignment conveys the likelihood of dying. ROM has 4 subclasses (minor, moderate, major, and extreme). The subclass designation is determined by secondary diagnoses and interactions between these diagnoses and age, principal diagnosis, and select procedures.

Statistical Analysis

We did all data transformations and statistical analyses using SAS version 9.1 (SAS Institute, Cary, NC).[19] Data were stratified by cohort (laparoscopic or open). For continuous variables, values are presented as means accompanied by SDs. For categorical variables, we presented the number of patients with the metric of interest accompanied by the percent. A detailed analytic plan, including statistical analyses for sample requirements, was developed before beginning the study. We assumed a readmission rate of 10%. To detect a 5% difference with 80% power in readmission rates between laparoscopic and open groups, we would have needed 725 patients in each group. To detect 10% difference with 80% power, we would have needed 219 patients in each group. To detect 1 day of difference in LOS between the laparoscopic and open groups with a SD of 8, we would have needed 1006 patients in each group to reach 80%. Our sample exceeded all of these requirements.

We used multivariate analyses to adjust for differences between cohorts for outcomes-of-interest. Primary outcomes were adjusted by age, gender, teaching hospital status, surgeon specialty, type of diagnosis (colon cancer, inflammatory bowel disease/diverticular disease), APR-DRG ROM, and hospital colectomy volume.

When we used analysis of covariance (to compare LOS and total hospitalization costs) we reported adjusted means (least means) and 95% confidence intervals. When we used logistic regression (to compare rates of transfusion, postoperative in-hospital complication, readmission, and reoperation) we reported odds ratios (OR) and 95% confidence intervals. We conducted a generalized logit model to compare 5 categories (home, home with nursing care, skilled nursing facility, other healthcare facilities or services, and expired) of discharge disposition. The generalized logit model was analogous to the use of 4 separate binary logistic regression models that compared home with nursing care versus home, skilled nursing facility versus home, other healthcare facilities or services versus home, and expired versus home. Therefore, we calculated and reported 4 sets of adjusted ORs.

Using the generalized logit model, we also calculated the expected distribution of discharge status for laparoscopic colectomy by assuming that all patients in the study cohort had laparoscopic colectomies. Similarly, the expected distribution of discharge status for open colectomy was calculated by assuming that all patients in the study had open colectomies. All reported *P* values were 2-sided with a significance level of 0.05.

RESULTS

During the study period, 32,733 patients had elective colectomies at 402 hospitals. Ninety-eight hospitals were excluded because none of their patients met our criteria. Among those included, 11,044 (33.7%) were laparoscopic and 21,689 (66.3%) were open colectomies. The mean age was 64.2 ± 13.9 years and 53.8% were women. Most (71.1%) colectomies were performed by general surgeons, with 15.6% performed by colorectal surgeons and 9.0% by other specialties. The other specialties most cited were non-cardiac vascular disease (3.7%), obstetrics and gynecology (1.3%), oncology (0.6%), pediatric colon/rectal (0.5%), trauma (0.4%), and gastroenterology (0.2%). Laparoscopic procedures were converted to laparotomies in 10.1% of patients (1116). Additional baseline and clinical characteristics are shown in Table 1.

TABLE 1. Baseline Demographics and Clinical Characteristics*

	Laparoscopic Colectomy (N = 11,044)	Open Colectomy (N = 21,689)	All (N = 32,733)
Age, mean (SD)	62.8 (13.9)	64.9 (13.9)	64.2 (13.9)
Female	5751 (52.1)	11,867 (54.7)	17,618 (53.8)
Diagnosis			
Colon cancer	3928 (35.6)	10,341 (47.7)	14,269 (43.6)
Inflammatory bowel or diverticular disease	4414 (40)	7031 (32.4)	11,445 (35.0)
Procedure			
Right hemicolectomy	5015 (45.4)	9977 (46.0)	14,992 (45.8)
Left hemicolectomy	1335 (12.1)	3231 (14.9)	4566 (13.9)
Sigmoidectomy	4694 (42.5)	8481 (39.1)	13,175 (40.2)
Conversion to laparotomy†	1116 (10.1)	—	1116 (3.4)
ARP-DRG mortality level			
Minor	7317 (66.3)	11,057 (51.0)	18,374 (56.1)
Moderate	2780 (25.2)	7188 (33.1)	9968 (30.5)
Major	654 (5.9)	2314 (10.7)	2968 (9.1)
Extreme	293 (2.7)	1130 (5.2)	1423 (4.3)
Surgeon specialty			
General	7823 (70.8)	15,464 (71.3)	23,287 (71.1)
Colorectal	2112 (19.1)	3005 (13.9)	5117 (15.6)
Other	866 (7.8)	2070 (9.5)	2936 (9.0)
Not specified	243 (2.2)	1150 (5.3)	1393 (4.3)
Teaching hospital	4351 (39.4)	10,073 (46.4)	14,424 (44.1)

Values given are number of patients (%) values.
*All $P < 0.05$.
†Identified by ICD-9-CM code V64.41.

Unadjusted clinical outcomes and hospital use are shown in Tables 2 and 3. Compared with the open cohort, the laparoscopic cohort had a longer mean operative time (195 ± 76 vs. 178 ± 80 minutes; $P < 0.0001$), but fewer mean ICU days (0.7 ± 3.8 vs. 1.3 ± 5.2 days; $P < 0.0001$).

After adjusting for age, gender, teaching hospital status, surgeon specialty, type of diagnosis (colon cancer, inflammatory bowel disease/diverticular disease), APR-DRG ROM, and hospital colectomy volume, the laparoscopic cohort had a shorter LOS (7.0 vs. 8.1; $P < 0.0001$) and higher total hospital costs ($8076 vs. $7678; $P = 0.0002$) than the open cohort (Table 4). The laparoscopic cohort also had lower rates of transfusions (OR = 0.68; $P < 0.0001$), in-hospital complications (OR = 0.89; $P < 0.0001$), and readmissions within 30 days (OR =

TABLE 2. Unadjusted Clinical Outcomes* and Hospital Utilization†

	Laparoscopic Colectomy (N = 11,044)	Open Colectomy (N = 21,689)	All (N = 32,733)
Transfusions	794 (7.2)	2946 (13.6)	3740 (11.4)
Reoperations‡ (abdominal surgeries)	54 (0.5)	74 (0.3)	128 (0.4)
Readmission within 30 d	876 (7.9)	2088 (9.6)	2964 (9.1)
Complications			
Any complication	2875 (26.0)	6888 (31.8)	9763 (29.8)
Ileus	1703 (15.4)	3821 (17.6)	5524 (16.9)
Pulmonary	723 (6.5)	1953 (9.0)	2676 (8.2)
Intraoperative	416 (3.8)	951 (4.4)	1367 (4.2)
Infections	319 (2.9)	795 (3.7)	1114 (3.4)
Cardiovascular	209 (1.9)	583 (2.7)	792 (2.4)
Wound	157 (1.4)	453 (2.1)	610 (1.9)
Systemic	124 (1.1)	331 (1.5)	455 (1.4)
Urinary	112 (1.0)	280 (1.3)	392 (1.2)
Operative time, (min)§	195 (76)	178 (80)	183.5 (79)
Intensive care unit (d)§	0.7 (3.8)	1.3 (5.2)	1.1 (4.8)
Length of stay (d)§	6.3 (6.4)	8.5 (8.4)	7.7 (7.8)

Values given are number of patients (%) values.
*Patients may have had more than 1 clinical outcome.
†All $P < 0.05$.
‡Reoperations that occurred during colectomy hospitalization only.
§Mean (SD).

TABLE 3. Reasons for Reoperations in Colectomy Patients

Reason for Reoperation	Laparoscopic Colectomy (N = 11,044)	Open Colectomy (N = 21,689)	All (N = 32,733)
Anastomotic complication	29 (0.26)	39 (0.18)	68 (0.21)
Small bowel obstruction	17 (0.15)	18 (0.08)	35 (0.11)
Intra-abdominal complication (abscess/hematoma)	16 (0.14)	18 (0.08)	34 (0.10)
Wound management	2 (0.02)	0 (0)	2 (0.01)
Other*	12 (0.11)	24 (0.11)	36 (0.12)

Values given are number of patients (%) values.
*Includes, eg, cholecystectomies, gastrostomies other than percutaneous endoscopic gastrostomies, incidental appendectomies.

TABLE 4. Adjusted* Means and 95% Confidence Limits for Length of Stay and Total Costs

	Laparoscopic Colectomy			Open Colectomy			
	Lower Limit	Adjusted Mean	Upper Limit	Lower Limit	Adjusted Mean	Upper Limit	P
Length of stay (d)	6.85	6.97	7.09	8.05	8.14	8.23	<.0001
Total costs ($)	7908.11	8076.30	8244.50	7558.87	7677.93	7796.99	0.0002

*Adjusted by age, gender, teaching hospital, surgeon specialty, diagnosis type (colon cancer, inflammatory bowel/diverticular disease), risk of mortality, and hospital colectomy volume.

0.89; $P = 0.0051$). Reoperation rates were slightly, but significantly increased (OR = 1.78; $P = 0.0020$; Fig. 1).

After adjusting for age, gender, teaching hospital status, surgeon specialty, type of diagnosis (colon cancer, inflammatory bowel disease/diverticular disease), APR-DRG ROM, and hospital colectomy volume, we found a significant difference in discharge disposition and services between cohorts (Table 5). Among the laparoscopic cohort, patients were more likely to be discharged to home without nursing care (home with nursing care compared with home; OR = 0.70; $P < 0.0001$). The generalized logit model showed that if all patients in the study cohort had laparoscopic colectomies, approximately 81% would be discharged to home without nursing care; with the open approach about 5% fewer patients (76%) would be discharged to home without nursing care. Compared with the open cohort, patients in the laparoscopic cohort were less likely to be discharged to a skilled nursing facility (OR = 0.67; $P < 0.0001$), be discharged to other healthcare facilities or services (OR = 0.64; $P = 0.0004$), or die (OR = 0.71; $P = 0.0055$).

TABLE 5. Discharge Disposition

Discharge Disposition*	Laparoscopic Colectomy (N = 11,044)	Open Colectomy (N = 21,689)	All (N = 32,733)
Home	9321 (84.4)	16,111 (74.3)	25,432 (77.7)
Home with nursing care	1038 (9.4)	3054 (14.1)	4092 (12.5)
Nursing facility	482 (4.4)	1742 (8.0)	2224 (6.8)
Expired	118 (1.1)	449 (2.1)	567 (1.7)
Other healthcare facilities or services†	85 (0.8)	333 (1.5)	418 (1.3)

Values given are number of patients (%) values.
*$P < 0.0001$.
†Includes intermediate-care facilities, hospice facilities and services, short-term general hospitals.

DISCUSSION

This study confirms previous research that showed benefits with laparoscopic colectomy that included shorter LOS, fewer readmissions, fewer transfusions, and fewer in-

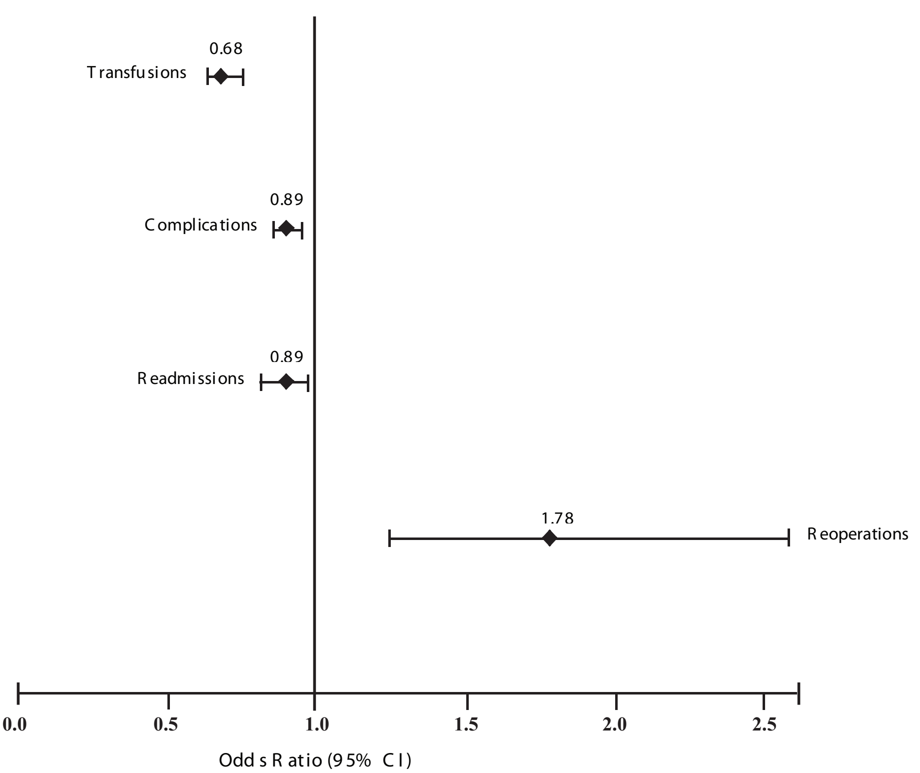

FIGURE 1. Adjusted odds ratios for transfusions, complications, readmissions, and reoperations (odds ratios were adjusted by age, gender, teaching hospital, surgeon specialty, diagnosis [colon cancer, inflammatory bowel/diverticular disease], risk of mortality, and hospital colectomy volume).

hospital complications than seen with open surgery.[1–14] The frequency of reoperation was slightly increased from 0.3% to 0.5% in laparoscopic patients. This is indeed an area of concern; however, when individual causes for reoperation were evaluated in Table 3, little difference between groups was seen. Furthermore, in-hospital mortality was reduced by 1% in laparoscopic patients, and readmission rates were reduced by 1.5%, suggesting that the slight increase in reoperation rate was without other major clinical sequelae. Patients still did better overall with lower mortality and ICU stay.

Major in-hospital complications have been associated with an $11,626 increase in hospital costs.[20] We found that the benefits of laparoscopic colectomy, including reduction of in-hospital complications, readmissions and mortalities, likely outweighed the additional surgical costs. These findings were also consistent with our prior work,[21] demonstrating a 50% reduction in the frequency of conversion of patients from DRG 149 (without complications) to 148 (with complications) because of in-hospital events. This was good for patients, because 6% fewer laparoscopic patients developed complications. One might immediately suspect that this was bad for hospital finances, because reimbursement was reduced with fewer patients being in DRG 148. In fact, this is an area that we previously explored in detail.[21] The apparent reduction in reimbursement is more than made up for by the lower hospital expenses for managing complications, as well as the increased availability of hospital beds because of shorter stays in the laparoscopic cohort.

Nevertheless, in this study total inpatient costs were $400 more for laparoscopic patients. In prior studies we found that by using a combination of standardized postoperative care pathways and laparoscopy, further improvements in outcome were obtained, with a median stay of 3 days and net cost savings to the institution of approximately $400.[1] In the current study we evaluated a national database, meaning that postoperative care practices were more varied. Thus, one would expect that there is potential for improvement in overall costs and shortened LOSs by incorporating postoperative care protocols on a national basis. Other potential benefits offered by laparoscopy included reductions in long-term complications. In a previous report with follow-up of more than 2 years[22] we found a reduction in readmissions for hernia repairs and small bowel obstructions after laparoscopic colectomy, benefits we could not examine in the current study because of the Health Insurance Portability and Accountability Act-compliant nature of this database.

After correcting for age, patients in this study who had open colectomies had a 22.1% chance of being discharged home with nursing care or to a nursing facility, compared with 13.8% after laparoscopic colectomy. Because major small and large bowel procedures are among the most common procedures after which Medicare beneficiaries get posthospital nursing care, increasing the percentage of colectomy cases performed laparoscopically is likely to have financial benefits to the healthcare system. This obviously requires validation in future studies. Nevertheless, the costs of home healthcare are growing quickly; increasing the adoption of techniques like laparoscopy, which can reduce the use of postdischarge nursing, as well as reducing readmission rates, while improving other short-term outcomes, should be considered on a national basis.[23]

Although administrative claims data allow the study of large populations, there were potential limitations to our study. Patients were not randomized to a procedural approach; therefore, the possibility of selection bias existed. Although we controlled for as many factors as were available in our data set, physicians knew the clinical picture in each case and may have used additional factors to select their surgical approaches. Coding errors, documentation errors, and incomplete data may have affected data integrity, although such inconsistencies should be distributed equally through both groups. There was the potential for patients' procedures to be misclassified; however, this was likely corrected by the study design because patients who needed conversions to laparotomies were assigned to the laparoscopic cohort by using an intention-to-treat principle. There were also some differences in diagnoses and ages between groups. These were controlled for using statistical methodology. We could not identify reoperations or readmissions to hospitals outside our database. We reported only those reoperations that occurred during the colectomy hospitalization and only those readmissions that occurred ≤30 days after discharge and were to a hospital in our database. Our readmission and reoperation rates may be underestimated, although this underestimation would be expected to affect both groups equally.

Despite the potential limitations, this study confirms and extends work demonstrating the clinical benefits of laparoscopic colectomy, and for the first time, gives a national-level view of the short-term resource utilization of laparoscopic and open colectomy. Furthermore, for the first time we show a reduction in posthospital nursing support.

CONCLUSION

The benefits of laparoscopic colectomy, including fewer complications, transfusions, readmissions, shorter LOSs, and lower mortality, combined with the need for fewer nursing resources after discharge, may outweigh its slightly higher in-hospital cost. Routine use of enhanced recovery postoperative care pathways in conjunction with improved laparoscopic surgical techniques and reduced variability in resource use may allow us to achieve the optimal and most efficient benefits from this surgical approach.

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