Diagnosis of Acute Appendicitis and Laparoscopic Appendectomy

The diagnosis of acute appendicitis is mainly clinical. Several methods have been suggested to diminish the diagnostic error that occurs if diagnosis is based solely on the clinical picture of suspected appendicitis. The symptoms of appendicitis can initially be difficult to differentiate from gastroenteritis. Early symptoms may include vague bloating, indigestion and mild pain which generally is perceived as being in the area of the umbilicus.

As the infection worsens, the pain becomes more prominent in the right lower quadrant. There is usually nausea, vomiting and loss of appetite. The pain is generally constant and progressive. There may be *diarrhea*, fever, and chills. These symptoms progress over several hours to several days. However, many patients may not report the sequence of symptoms outlined above. Therefore, an accurate diagnosis of appendicitis can often be challenging. Many other conditions can mimic appendicitis such as *gastroenteritis*, kidney stones, urinary infections, ulcerative colitis and Crohn's disease. In women, problems such as *ovarian cysts* and pelvic infections can mimic appendicitis. In fact appendicitis is a disease which can mimic most of the causes of abdominal pain as well as some chest pathology.

Despite new X-ray techniques, CT scans and ultrasounds, the diagnosis of appendicitis can be challenging. So far the most accurate non-invasive method of diagnosis is ultrasonography but this is not totally reliable. The history and physical examination will generally lead to the correct diagnosis. According to one prospective non-randomized study laparoscopy may prevent unnecessary appendectomy in 24% of patients. Laparoscopy reveals a misdiagnosis rate of 8% in males and 41% in females of reproductive age group.[54,55] Laparoscopic appendectomy gives a better evaluation of the peritoneal cavity than that obtained by the standard gridiron exposure. The procedure allows rapid and thorough inspection of the para-colic gutters and the pelvic cavity that is not possible with the open gridiron approach. The laparoscopic approach for patient with suspected appendicitis improves the diagnostic accuracy and is therefore recommended.[70]

There is also debate on whether a normal looking appendix be removed at the time of laparoscopy or not? The major criticism against leaving the appendix in place is that mucosal inflammation might be overlooked because only serosa can be inspected. Walker, et al reported that 3.2% of the intraoperatively normal appearing appendices demonstrated acute inflammation after pathological examination.[51] Mucosal inflammation obviously can never be determined if the appendix is left in place. The majority of surgeons state that normal looking appendix should not be removed.[52] Previously there was doubt on the color reliability of the image of inflamed appendix on the monitor, but after the advent of the three chip camera the sensitivity of laparoscopic diagnosis of appendix is 92%.[53]

Laparoscopic Appendectomy Women vs Men

Most surgeons agree on the use of laparoscopy when a patient is a young female with vague lower abdominal pain and its progress to appendectomy. There are innumerable reports showing that laparoscopy improves diagnosis and reduces unnecessary appendectomies in fertile women.[29,30,41,50,63,65,70]

The diagnostic problem of suspected appendicitis is not limited to fertile women. It is also a problem of premenopausal women. One study was done in Dublin on 100 premenopausal women who were admitted with abdominal pain. After final assessment, patients were placed in following diagnostic categories; gynecological (30%); renal (9%); acute appendicitis (23%); nonspecific abdominal pain (29%) and miscellaneous (9%).

The mean duration of hospital stay for patient with non specific abdominal pain was 67 days and one third of these patients, underwent appendectomy for normal appendix.[75] Abdominal pain in premenopausal women is often psychosomatic and the laparoscopic intervention may be considered in these women with nonspecific pain abdomen to prevent removal of a normal appendix.

Even though laparoscopic appendectomy has been claimed to reduce postoperative pain, length of hospitalization, analgesic doses and surgery associated complication, many surgeons do not advocate this procedure on men because they do not find any superiority of laparoscopy over the open procedure.[20,28,31,36] Cox et al conducted a prospective randomized comparison of open versus laparoscopic appendectomy exclusively in men and they reported that laparoscopic appendectomy in men has significant advantages in terms of more rapid recovery.[60]

Appendectomy in Pediatric Patients

Although laparoscopic appendectomy is gaining popularity, open appendectomy has remained popular with surgeons caring for children. The reasons for this include the increased skill level necessary for pediatric laparoscopic procedures, concerns over increased operating times and costs, and fears that the laparoscopic approach to appendicitis is somehow associated with an increased complication rate.

There is a group of surgeons who are advocating laparoscopic appendectomy in all cases of appendicitis in pediatric patients. In one prospective nonrandomized trial 500 appendectomies were studied, 362 children underwent open procedure and 138 underwent laparoscopic appendectomy. There was no mortality in either group. Major complications were 3% in open group but no major complications were seen in

the laparoscopic group. Minor complications were 20% in open and 13% in laparoscopic appendectomy.[76]

Paya et al published a prospective study of 75 children with perforated appendicitis. Ten underwent laparoscopic appendectomy and the remainder underwent open operation. There were no postoperative abscesses in the laparoscopic group but 2 (3.1%) of 65 patients who had open appendectomies developed postoperative intra-abdominal abscesses.[38]

In a prospective series of children aged 4-12 years, reported from Cairo, 48 underwent open appendectomy and 34 laparoscopic operation, over a 6 month period. Wound complications were fewer, cosmetic appearance better, and time to return to normal activities quicker (7 cf 12 days) in the laparoscopic group.[59] Lintula H, et al studied the effect of laparoscopic appendectomy in children between 4-15 yr of age and demonstrated that laparoscopic appendectomy was not associated with any increase risk of intraoperative or long-term complications.[32]

Appendectomy in Pregnancy

Is laparoscopic appendectomy safe in pregnancy? There has been increased interest in using laparoscopic procedures during pregnancy. A prospective study was done to evaluate the safety and outcome of pregnancy after both open and laparoscopic procedures. 11 pregnant women underwent laparoscopic appendectomy and 11 underwent open appendectomy. Their gestation age ranged from 7 to 34 weeks. The following parameters were analyzed:

- Obstetric and gynecologic risk factors
- Length of procedure
- Perioperative complications
- Length of stay and outcome of pregnancy.

The study showed that laparoscopic appendectomy is safe in all trimesters of pregnancy. There was no significant difference in the length of operation. (60 vs 46 min). There was no fetal loss or other adverse outcome of pregnancy after laparoscopic appendectomy. The development of the infant was normal in both the group of patients.[33]

While these reports indicate that laparoscopy can be safely performed during pregnancy, some surgeons are suggesting that whenever possible, operative intervention should be deferred until the second trimester when fetal risk is lowest.[68] Pneumoperitoneum enhances lower-extremity venous stasis, which already present in gravid patient. Pregnancy also induces a hypercoagulable state, so pneumatic compression devices must be utilized in pregnant women at the time of appendectomy to prevent thromboembolism.

Appendectomy of Obese Patients

In the obese patient laparoscopic appendectomy has shown advantage over the open procedure in a faster postoperative recovery. A group of 106 patients with a body mass index (BMI) > 26.4, representing the upper quintile of 500 prospectively randomized patients, were included in the study. They were randomized to undergo either laparoscopic or open appendectomy. Following parameters were evaluated:

- Operating and anesthesia times
- Postoperative pain
- Complications
- Hospital stay
- Functional index (1 week postoperatively)
- Sick leave, and
- Time to full recovery.

The prolonged hospital stay and sick leave noted in overweight patients undergoing open appendectomy was abolished when overweight patients were treated with laparoscopic appendectomy. Laparoscopic procedures are however more prolonged in the obese than in the normally nourished.[13,57] There is opinion of some surgeons that laparoscopy is beneficial in obese females and those presenting with appendiceal abscess, who are treated by intravenous antibiotics and percutaneous drainage followed by interval appendectomy. But in their opinion laparoscopic appendectomy is not indicated in all patients presenting with periappendicular abscess.[57]

Postoperative Pain

It is proved that laparoscopic procedures cause less post-operative pain than their conventional counterparts. In this study none of the literature reviewed found more pain after laparoscopic procedure. The postoperative narcotic use is less after laparoscopic appendectomy. In one study done by Ortega et al; linear analogue pain scores were recorded in 135 patients blinded to the procedure of operation by special dressing and pain score was very less in laparoscopic group compared to open. Another interesting observation has been the patient's perception of pain after appendectomy. Those who underwent laparoscopic appendectomy were more vocal of pain although it was of a lower intensity. However, after 48 hours they had a better sense of well-being and showed earlier postoperative food intake, ambulation and return to work and sport. This could have arisen from the expectation that laparoscopic procedures are painless or a lower level of endorphins released or the peritoneal injury from the pneumoperitoneum.

Postoperative Recovery after Appendectomy

It has been shown that those patients who underwent successful laparoscopic appendectomy have a better postoperative recovery. The reduced trauma to the abdominal wall is a very significant factor in postsurgical discomfort. The better mobility of the abdominal musculature and the earlier ambulation, reduce

the risk of the early postoperative complications of pneumonia and embolism.

A prospective randomized multi centre study was performed to compare the outcome of laparoscopic and open appendicectomy in patients with suspected acute appendicitis by Hellberg A et al. Patients having laparoscopic appendectomy recovered more quickly than their open counterpart, but interestingly there was no significant difference in sick leave than after laparoscopic operation.[19] An insignificant reduction in sick leave after laparoscopic appendectomy may be due to unawareness of general practitioners about recovery time difference between both the procedures, or patient expectation in terms of time off work.

Laparoscopic Appendectomy and Wound Infection

The risk of wound infection is less in laparoscopic appendectomy compared to the open procedure. A meta-analysis of randomized controlled trials has been reported with outcomes of 2877 patients included in 28 trials. Overall complication rates were comparable, but wound infections were definitely reduced after laparoscopy (2.3% to 6.1%).[17] Rohr et al reported higher wound infection rates after laparoscopic appendectomy, but most of the literature supports the view that wound infection is less common after a laparoscopic procedure. It should be cautioned that the definition of wound infection varies between studies.

Laparoscopic Appendectomy and Intra-abdominal Abscess

Some studies have shown a significantly increased incidence of postoperative intra-abdominal abscess with perforated appendicitis after laparoscopic appendectomy.[9,11,27,45,15,47]

More reports show that there is no increased incidence of intra-abdominal abscess formation after laparoscopic appendectomy. Barkhausen S et al conducted one trial, in which 930 patients were analyzed retrospectively. Conventional appendectomy was performed in 330 patients; laparoscopic in 554 others. The analysis shows that the incidence of intra-abdominal abscess formation rate was same in both groups.[8]

In Los Angeles, 2497 appendectomies were reviewed retrospectively. Indications for these procedures included acute appendicitis 57%, gangrenous appendicitis 12%, and perforated appendicitis in 31%. There was no difference in the rate of intra-abdominal abscess formation between the groups undergoing open and laparoscopic appendectomies for acute and gangrenous appendicitis. For perforated appendicitis, however, there was significantly higher rate of abscess formation following laparoscopic appendectomy compared to open appendectomy (9.0% vs 2.6%, P = 0.015%).[69]

Laparoscopic Appendectomy in Complicated Appendicitis

Due to the risk of intra-abdominal abscess formation there is a strong controversy among surgeons regarding the use of the laparoscopic procedure in complicated appendicitis (gangrenous or perforated).

There are several reports which state that if gangrene or perforation is found at the time of laparoscopic appendectomy than the procedure should be converted. Frazee and Bohannon published a retrospective analysis of 15 patients with gangrenous appendicitis and 19 patients with perforated appendicitis who underwent laparoscopic appendectomy. They found a 7% rate of postoperative intra-abdominal abscess in the gangrenous group and a 26% rate of postoperative intra-abdominal abscess in the perforated group.[15]

A prospective randomized study by Bonnani et al. found that among adult patients, 2 of 66 (3.03%) patients undergoing open appendectomy for complicated (gangrenous or perforated) appendicitis developed postoperative pelvic abscesses. Three of 11 patients (27%), developed postoperative pelvic abscesses following laparoscopic appendectomy for complicated appendicitis, and 1 patient developed a postoperative hepatic abscess.[9]

Tang et al found a postoperative intra-abdominal abscess rate of 11% for perforated appendicitis treated laparoscopically compared with a rate of 3% treated by the open method.[47]

In contrast, there is a group of laparoscopic surgeons, who are now gaining confidence in handling complicated cases of appendicitis. Johnson, after a retrospective trial of 112 patients, advocates that most cases of acute appendicitis with suspected perforation could be managed laparoscopically. There is a large group of surgeons who believe that laparoscopic appendectomy is safe in all form of appendicitis, even in perforated appendicitis.[8,23,24,40,66,67] Some believe that even if the patient presents with fresh lower abdominal early peritonitis or even if there is chance of fresh abscess formation, laparoscopic appendectomy is not only justifiable but also even recommended as the procedure of choice.[48] In generalized peritonitis laparoscopic is not advocated.

Operating Time and Laparoscopic Appendectomy

In almost all the literature the operating time of laparoscopic appendectomy was found to be more than that of open appendectomy. The difference in mean operating time ranged from 8.3 to 29 minute. The operating time of laparoscopic appendectomy also depends on the experience of the surgeon and the competence of their team.[10]

In considering operating time, the exact identification of the timing of the start of the procedure and its conclusion vary. In

general the time should be calculated from the insertion of first trocar to the end of skin suturing. Cox, et al defined operating time as the time from incision to wound closure.[60] Tate et al calculated the time as use of anesthesia to the administration of a reversal agent.[71] Generally all laparoscopic procedures are more time consuming for the following reasons.

- Inherent nature of slow manoeuvre of laparoscopic techniques
- Time taken by careful slow insufflation
- Routine diagnostic laparoscopy before starting any laparoscopic procedure.

A meta-analysis of randomized controlled trial has been reported with outcomes for 2877 patients. The mean operating time was 16 minutes longer for laparoscopic appendectomy.

A prospective randomized trial comparing laparoscopic appendectomy with open appendectomy was conducted in 158 patients by Hansen et al. They reported that despite of longer operating time, (63 versus 40 minutes) the advantages of laparoscopy (such as fewer wound infection and earlier return to normal activity) make it a worthwhile alternative for patients with a clinical diagnosis of acute appendicitis.[61,60]

Kazemier et al in their report of a randomized clinical trial of 201 patients found that laparoscopic appendectomy is superior to open surgery regarding postoperative pain and postoperative complications, recovery time and financial.[66]

Long-term Complications and Laparoscopic Appendectomy

Adhesion formation is now one of the most common causes of intestinal obstruction. The role of adhesion in the development of chronic abdominal pain, although less certain, cannot be ignored.[1] Reduced adhesion formation is a substantive long term advantage of laparoscopic appendectomy.

A study reported an adhesion rate of 80% after open appendectomy compared to 10% after laparoscopic appendectomy, when patients were laparoscoped three months after surgery.[1] It has been shown that the tissue trauma of the incision increases the total inflammatory response, thereby inhibiting fibrinolysis and promoting fibroblast migration and collagen formation.

These results strongly suggest that laparoscopic surgical techniques lead to fewer intra-abdominal adhesions by reducing tissue trauma, which in turn reduces circulating inflammatory mediators.[56]

LAPAROSCOPIC APPENDECTOMY IN SOME DISEASED CONDITIONS

There are some diseases where laparoscopic appendectomy has found clear benefit over open appendectomy.

Cirrhosis

The immunity of the cirrhotic patient is compromised and there is more chance of wound infection with the open procedure. Patients with cirrhosis have shown a faster recovery when treated by laparoscopic procedure, for acute appendicitis.[48] These patients were benefited by this less traumatic method of surgery.

Sickle Cell Disease

There is also a report that laparoscopic appendectomy has clear benefit over open inpatients with sickle disease. Patients with acute appendicitis will certainly require surgery that may be associated with high morbidity and mortality as a result of perioperative and postoperative complications, mainly vaso-occlusive crises (VOC). The introduction of minimally access surgery is believed to be associated with minimal risks to the patients due to its numerous advantages over conventional methods.[5] The morbidity associated with surgery in sickle cell patients can be further reduced by the use of preoperative exchange transfusion and adequate maintenance of hydration in the patient with sickle cell disease.

LAPAROSCOPY AND IMMUNITY

All surgery and anesthesia can cause depression of cell-mediated immunity in the postoperative period, including reduction in the number of circulating lymphocytes, impairment of natural killer cell cytotoxicity, depression of T cell proliferation, and diminished neutrophil function. Animal and clinical studies have shown that laparoscopic surgery impairs a patient's immune state less than open surgery. Cell-mediated immunity is less impaired after laparoscopic operation than after open. Interleukin 6 levels were less in a study on newborn infants undergoing laparoscopic procedures when compared to open.[55]

LAPAROSCOPY AND RISK OF ANESTHESIA

The general anesthesia and the pneumoperitoneum required as part of the laparoscopic procedure does increase risk in certain patient groups. Most surgeons would not recommend laparoscopic appendicectomy in;

- Patients with cardiac diseases and COPD
  - — Should not be considered a good candidate for laparoscopic appendectomy.
- In patients who have had previous lower abdominal surgery
  - — Laparoscopic appendectomy may also be more difficult.
- The elderly
  - — May also be at increased risk for complications with general anesthesia combined with pneumoperitoneum.

- Those with lowered cardiopulmonary reserve
  — With regard to the consequences of the pneumoperitoneum and a longer operative time.

COST EFFECTIVENESS OF LAPAROSCOPIC APPENDECTOMY

Debate still exists about the cost comparison between laparoscopic and open surgery. Most surgeons have the opinion that laparoscopic appendectomy is cost effective. It may be more expensive for the hospital but it offers diagnostic accuracy, and among employed patients, offers cost savings to society as a result of faster return to work.[2,14,18,64]

Heikkinen TJ, et al reported a randomized study for cost effectiveness of laparoscopic appendectomy, the hospital cost for laparoscopic appendectomy was higher, but it offers significant cost savings from the rapid convalescence. Return to normal life and work was faster in the laparoscopic group (14 versus 26.5 days).[18] The Hospital costs of laparoscopic appendectomy were higher but the total costs were lower, such that a saving of $1481 was realized by laparoscopic appendectomy.[2]

LAPAROSCOPIC APPENDECTOMY AND SURGICAL EXPERIENCE

The outcome of any laparoscopic procedure greatly depends on the experience of the surgeon. In a study of two groups, conducted at Los Angeles, general surgical services operated on 413 patients, and 232 cases underwent the same procedure by trained specialized laparoscopic surgeons.

General surgical services	285 acute	61 gangrenous	67 perforated
Laparoscopic surgeons	126 acute	46 gangrenous	60 perforated

10 abscesses occurred postoperatively (2.4%) in the group of patients whose operation was done by general surgical services, and only one case of intra-abdominal abscess (0.025%) were reported in the group of patients whose operation were performed by a standardized laparoscopic method, using skilled dissection, careful use of retrieval bag, proper ligation of stump and thorough peritoneal toilet). This study may be taken to indicate that complications such as intra-abdominal abscess following laparoscopic appendectomy for perforated appendices can be reduced significantly by training.

DISCUSSION

Laparoscopic appendectomy has gained lot of attention around the world. However, the role of laparoscopy for appendectomy, one of the commonest indications, remains controversial. Several controlled trials have been conducted, some are in favor of laparoscopy, others not. The goal of this review was to ascertain that if the laparoscopic appendectomy is superior to conventional, and if so what are the benefits and how it could it be instituted more widely. There is also diversity in the quality of the randomized controlled trials. The main variable in these trials are following parameters:

- Number of patients in trial
- Withdrawal of cases
- Exclusion of cases
- Blinding
- Intention to treat analysis
- Publication biases
- Local practice variation
- Prophylaxis antibiotic used
- Follow-up failure.

Without proper attention to the detail of all the parameters it is very difficult to draw a conclusion. It has been found among the surgeons that; there is a hidden competition between laparoscopic surgeons and the surgeons who are still doing conventional surgery, and this competition influences the result of study. One should always think of laparoscopic surgery and open as being complimentary to each other.

A successful outcome requires greater skills from the operator. The result of many comparative studies have shown that outcome of laparoscopic appendectomy was influenced by the experience and technique of the operator. Minimal access surgery requires different skills and technological knowledge. With a clear diagnosis of complicated appendicitis, the skill and experience of the surgeon should be considered for the selection of operating method. Surgeons should perform the procedure with which they are more comfortable.

RELATIVE RISK FACTORS OF LAPAROSCOPIC APPENDECTOMY

Missed Diagnosis

There is report also of Mucinous cystadenoma of the cecum missed at laparoscopic appendectomy.[49] Less than 1% of all patients with suspected acute appendicitis are found to have an associated malignant process. During conventional appendectomy through a laparotomy incision, the caecum and the appendix are easily palpated, and an obvious mass can be detected and properly managed at the time of appendectomy. The inability to palpate any mass is an inherent problem of laparoscopic surgery.

Bleeding

From the mesoappendix, omental vessels or retroperitoneum. Bleeding is usually recognized intraoperatively via adequate exposure, lighting, and suction. It is recognized postoperatively by tachycardia, hypotension, decreased urine output, anemia, or other evidence of hemorrhagic shock.

Visceral Injury

Risk of accidental burns is higher with monopolar system because electricity seeks the path of least resistance, which may be adjacent bowel. In a bipolar system since the current does not have to travel through the patient, there is little chance of injury to remote viscera. In laparoscopic appendectomy only bipolar current should be used. Laparoscopists should also routinely explore the rest of the abdomen.

Wound Infection

It is recognized by erythema, fluctuation and purulent drainage from port sites. The absence of wound infections after laparoscopic appendectomy can be attributed to the practice of placing the appendix in a sterile bag or into the trocar sleeve prior to removal from the abdomen. The regular use of retrieval bag is a very good practice for preventing infection of the wound.

Incomplete Appendectomy

If surgeon is not experienced, the stump of the appendix may be to long. There is a report of intra-abdominal abscess formation due to retained faecolith after laparoscopic appendectomy. It is strongly advised that the surgeons performing laparoscopic appendectomy should remove faecolith if found, and the stump of appendix should not big enough to contain any thing.[11] Incomplete appendectomy is a result of ligation of the appendix too far from the base. It may lead to recurrent appendicitis, which presents with symptoms and signs of appendicitis even after laparoscopic appendectomy.

Some surgeons prefer stapling of the appendiceal stump for laparoscopic appendectomy for the treatment of all forms of appendicitis.[34] But most of the surgeons now agree that ligation of the appendectomy stump is the best approach. There is report of slippage of clip, residual appendicitis followed by abscess formation after using clip for appendiceal stump.[74] The ligation should be preformed by using endoloop, an intra-corporeal surgeon's knot, or done extra corporeally using a Meltzer's knot or Tayside knot. The security of the knot is essential. It is influenced by the proper port location and experience of the surgeon.[4]

Leakage of Purulent Exudates from Appendix at the time of Operation

Usually seen intraoperatively while dissecting appendix. Copious irrigation and suction followed by continued antibiotics can prevent this complication until patient is afebrile with a normal white blood cell count. Use a retrieval bag. to prevent the spillage of infected material from the appendiceal lumen.

Intra-abdominal Abscess

This postoperative morbidity is recognized by prolonged ileus, sluggish recovery, rising leukocytosis, spiking fevers, tachycardia, and rarely a palpable mass. After confirmation of the intra-abdominal abscess drainage of pus followed by antibiotic therapy is essential. Sometime laparotomy may be required.

Hernia

Trocar site hernia as visible or palpable bulge is sometime encountered. Possible occult hernia manifested by pain or symptoms of bowel obstruction.

Laparoscopic appendectomy is now safe in experienced hands. In experienced hands, satisfactory peritoneal toilet can be performed even in the presence of Peri-appendiceal pus and regional peritonitis. Laparoscopic appendectomy is not advocated when the patient has generalized peritonitis.

Indications for the surgical treatment of appendicitis:

Laparoscopic appendectomy	*Open appendectomy*
Female of reproductive age group	Complicated appendicitis
Female of premenopausal group	COPD or cardiac disease
Suspected appendicitis	Generalized peritonitis
High working class	Previous lower abdominal surgery
Obese patients	Hypercoagulable sates
Disease conditions like cirrhosis of liver and sickle cell disease	Stump appendicitis after previous Incomplete appendectomy
Immune-compromised patients	

Future Prospects of Laparoscopic Appendectomy

In the future, remote handling technology will overcome some of the manipulative restriction of current instruments. There is no doubt that 20 years from now some surgeons will be operating exclusively via a computer interface controlling a master–slave manipulator. But the future of any new technology depends upon applications and training.[3]

CONCLUSION

Laparoscopic appendectomy is equally safe, and can provide less postoperative morbidity in experienced hands, as open appendectomy. Most cases of acute appendicitis can be treated laparoscopically. Laparoscopic appendectomy is a useful method for reducing hospital stay, complications and return to normal activity. With better training in minimal access surgery now available, the time has arrived for it to take its place in the surgeon's repertoire.

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