Adv Ther (2018) 35:2176–2185
https://doi.org/10.1007/s12325-018-0829-3

ORIGINAL RESEARCH

Mini-Incision Open Appendectomy with Incision Skin Tissue Retractor vs. Laparoscopic Appendectomy: A Retrospective Study of the Management of Child Acute Appendicitis

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Received: August 27, 2018 / Published online: November 13, 2018
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ABSTRACT

Introduction: This study aims to compare the clinical effects of an incision skin tissue retractor for mini-incision open appendectomy and laparoscopic surgery for pediatric appendicitis.
Methods: From January 2014 to July 2017, a total of 248 patients were included in the present study. Laparoscopic appendectomy was performed for 108 cases (LA group), and mini-incision open appendectomy with an incision skin tissue retractor was performed for 140 cases (MOA-ISTR group). Then, medical history, age, gender, operative duration, amount of bleeding during the operation, the determination of whether or not the appendix was perforated during the operation, hospitalization days, total cost of hospitalization, and complications after the operation (incision infection or intestinal obstruction) were compared. The SPSS 20.0 software package was used for the statistical analysis.
Results: There were no statistically significant differences in history, age, gender, perioperative perforation of the appendix, postoperative hospital stay and postoperative complications (incisional infection or intestinal obstruction, $P > 0.05$). However, the values for duration of surgery, intraoperative blood loss and total hospitalization expense were smaller, when compared with the LA group ($P < 0.05$).
Conclusion: Mini-incision open appendectomy with an incision skin tissue retractor has similar efficacy and incision appearance when compared with laparoscopic appendectomy. Furthermore, this approach leads to shorter operation time, less intraoperative blood loss and less hospitalization time, and is more convenient, especially for perforated appendicitis. Moreover, it can be widely used for pediatric appendicitis, and is more suitable for doctors who are not skilled in basic hospitals and laparoscopy.

Keywords: Appendicitis; Incision skin tissue retractor; Laparoscopic surgery; Mini-incision open appendectomy

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INTRODUCTION

Acute appendicitis is a common disease in children, and appendectomy is the most

common emergency operation performed in this population [1]. Open appendectomy (OA) was first described by McBurney in 1894. It has been the gold standard for treating patients with acute appendicitis for more than a century [2]. With the improvements in anesthetics and antibiotic treatment, appendectomy has evolved into routine practice, and further development came with the introduction of laparoscopic appendectomy (LA), which was first presented in adults by Semm [3] and in children by Ure et al. [4]. The first study was presented by Gilchrist et al., which discussed the benefit of LA over OA in children in 1992 [5]. Unlike laparoscopic cholecystectomy, LA has not gained much popularity since its introduction [6]. Furthermore, its optimal treatment modality is still being debated, even if recent data have suggested that laparoscopic surgery may result in shorter postoperative length of stay without an increase in the number of complications. In terms of complications, the data revealed no differences in outcomes between open and laparoscopic surgery for acute appendicitis in children. The initial assumption that patients treated with laparoscopic surgery have shorter postoperative stay has not been confirmed through linear regression, showing that the assumed difference was only due to a trend towards shorter postoperative length of stay over time, regardless of the surgical intervention [1]. Despite the number of randomized controlled trials published to date, in comparing OA and LA, the relative advantages of these two procedures remains to be established [7–10].

Acute appendicitis is the most common acute abdominal disease in daily routine. Studies on decreasing morbidity and mortality are still needed, although it is well known that hospital stay, operative duration and postoperative complication rates are important for the management of acute appendicitis. Therefore, the investigators [11] suggest that LA should be accepted as a standard treatment for acute appendicitis. Mini-incision appendectomy (MA) is an alternative for a selected group of patients. In the present study, an incision skin tissue retractor (ISTR) was applied to a small incision during OA. Compared with LA, this approach has achieved good results. The summary report is detailed as follows.

The present study aims to compare the clinical effects of applying an ISTR for mini-incision open appendectomy and laparoscopic surgery for pediatric appendicitis.

METHODS

Materials

ISTR (Membrane Type)

Product standard number: YZB/Anhui 0041-2014. Product model: AF-B; product specification: PG-80/90-80/150 (Fig. 1).

ISTR Product Introduction

Guidance

360° harmless retraction

- Expands vision and visibility during an operation.
- Even with tension, it prevents causing harm to tissues inside the incision during the procedure and reduces post-operation pain.
- Sufficient exposure is realized with minimum incision.

360° wound protection

- Effectively reduce risk of infection in surgical incisions and prevent the re-transplant of tumors during incision.
- Allows the edges of the tumor to be clearly visible during the incision.
- Maintains moisture at the incision site.
- Prevents the oozing of blood from tissues inside the incision and postoperative congestion.

Advantages

- Simple and easy, and widely applicable for various types of operations.
- 360° harmless retractional protection with reduced operator requirements for surgeries.
- During endoscopic operations, it can be used as an entrance port for devices.

Applicability

Thoracoscopic (laparoscopic) surgery; resection of the thyroid gland; extracardiac incision

◀**Fig. 1** **a** Incision skin tissue retractor (membrane type) product package front. **b** The back part of the product package and the product qualification certificate

operation; gastrectomy; colonic operation; appendix operation; hysteromyoma resection; hepatobiliary surgery; pancreatic operation.

Instructions

Preparation for Installation

- A portion of the inner ring (lower ring) is reversely rotated to lift and pull it out through the middle of the outer ring (upper ring). Then, the inner ring is inclined inside the outer ring, making it look like a high-heel shoe.

Installation

- The end of the inner ring, which is shaped like a high-heel shoe, is inserted into the incision, while closely touching the abdominal wall and slowly expanding the inside of the incision. Finally, a part of the inner ring is pushed back to make it reversely rotate, allowing it to be inserted into the incision.

Disassembly

- The fingertips were inserted through the incision to hold a portion of the inner ring inside the abdomen, which was pulled out. If the fingertips could not reach this, a tool was used to grasp a portion of the inner ring through the incision to take it out without causing any harm to the tissues.

Patients

From January 2014 to July 2017, a total of 256 patients were operated in the Emergency Surgery Ward of Beijing Children's Hospital by a physician proficient in mini-incision open appendectomy with an incision skin tissue retractor (MOA-ISTR) and LA. Among these patients, three patients who were lost, two patients who were combined with ovarian cyst culling, and three patients who were converted from laparoscopy to open surgery were excluded. Hence, a total of 248 patients were enrolled in the present study. Among these 248 patients,

108 patients underwent LA (LA group). Among these 108 patients, 59 patients were male and 49 patients were female, the average age was 8.5 ± 3.2 years old, and the course of disease from abdominal pain or fever to admission was 47.9 ± 45.3 h. MOA-ISTR was performed on the remaining 140 patients. Among these patients, 87 patients were male and 53 patients were female, the average age was 7.7 ± 3.7 years old, and the course of disease from abdominal pain or fever to admission was 43.5 ± 32.4 h. There was no statistical difference between these two groups in terms of age, gender and medical history ($P > 0.05$), but they were comparable.

The present study was conducted in accordance with the declaration of Helsinki, and was approved by the Ethics Committee of Beijing Children's Hospital Affiliated to Capital Medical University. Written informed consent was obtained from the legal guardians of all participants.

Surgical Methods

MOA-ISTR

After the intravenous infusion of compound anesthesia, routine disinfectant and covering sterile towels was used to make a 2- to 3-cm transverse skin incision near the McBurney's point (Fig. 2a). The oblique opening of the external oblique aponeurosis allowed the field of vision to be expanded into the abdominal cavity in a fan-shaped area, obtaining a visual field larger than the incision. Then, a small pack was opened, the product was taken out (ISTR), and the implanted ring was pinched to form a long ellipse and placed inside the incision. After completely placing this inside the incision, the index finger of the surgeon was inserted between the peritoneal membrane and the ISTR to determine the absence of bowel, omentum and other organs and soft tissues (Fig. 2b, c). Depending on the surgical need, the outer ring was turned over and adjusted to a suitable height or position, in order to distract the tissue around the incision, and expose the tissues, blood vessels and internal organs, and form a passage for the operation (Fig. 2d, e). In principle, the appendix was resected under the incision, and this could be pulled out for the operation, when necessary. Next, the appendicular stump was pouch-sutured, and the abdominal cavity was thoroughly rinsed, when necessary. When rinsing the abdominal cavity, the outer ring can be loosened for 2–3 laps to form a funnel, in order to help to thoroughly wash the abdominal cavity (Fig. 2f). Then, the abdominal wall was sutured in order, and the skin was intradermally sutured with 6-0 Prolene lines.

Laparoscopic Appendectomy

After intravenous–inhalation compound anesthesia, a 1-cm arc incision was taken from the upper umbilical cord, and CO_2 pneumoperitoneum was established using a pneumoperitoneum needle. Then, a 10-mm Trocar was inserted, and intraperitoneal pressure was maintained at 10–14 mmHg. Subsequently, the laparoscopic lens was inserted and, under laparoscopic guidance, 5-mm Trocars were used to puncture the left inferior abdominal wall and right ventral wall of the suprapubic. Afterwards, the abdominal cavity was probed, and the appendix was lifted by inserting two grasping forceps. After the appendix was dissociated, the appendix mesangial and root were ligated, and the mesangial membrane was isolated using an electric hook. Then, the appendix was cut off at 0.5 cm from the root and taken out of the umbilical cord using the bag from the trocar. Then, the pneumoperitoneum was removed and the umbilical incision was sutured. Suction and irrigation were performed according to the preference of the surgeon. Furthermore, a needle was subcutaneously sutured on both sides of the operation hole, and glued with biological tissue glue.

Observation Indexes

Patient history, age, gender, operative time, intraoperative blood loss, the presence or absence of intraoperative appendix perforation, postoperative hospitalization time, total hospitalization expenses, and postoperative complications (incision infection or intestinal

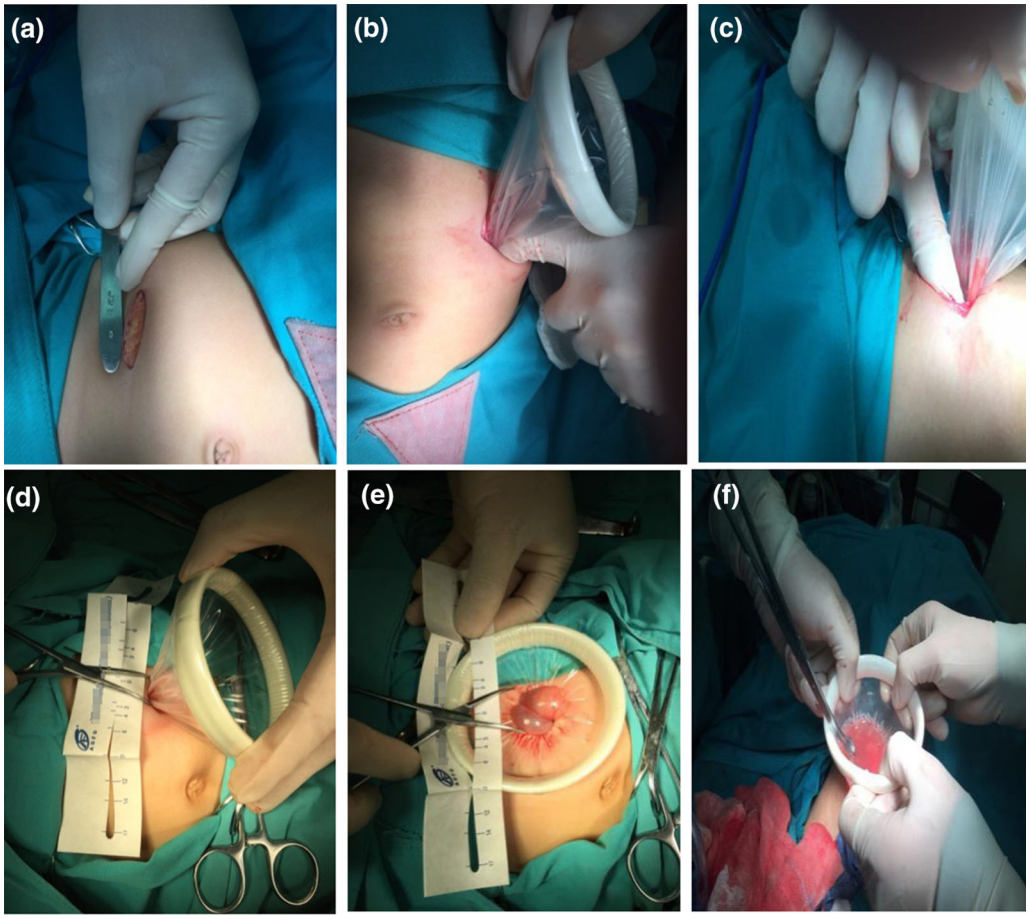

Fig. 2 The methods and steps of mini-incision open appendectomy with an incision skin tissue retractor (MOA-ISTR). **a** Performing a 2- to 3-cm transverse skin incision near the McBurney's point. **b**, **c** The index finger of the surgeon was inserted between the peritoneal membrane and the ISTR to determine the absence of bowel, omentum and other organs and soft tissue. **d**, **e** Destruction of tissues around the incision to expose the tissues, blood vessels and internal organs, in order to form a passage for the operation. **f** Loosening of the outer ring 2–3 laps to form a funnel, which would help to thoroughly wash the abdominal cavity

obstruction) were compared between the two operative groups.

Statistical Processing Methods

The SPSS 20.0 software package (IBM SPSS Statistics) was used for statistical analysis. Continuous variables, such as age, hospital stay and operative duration, were presented as mean ± standard deviation (SD), while categorical variables, such as gender and postoperative complication, were expressed as frequency and percentages using 95% confidence intervals. Student's *t* test was used to compare the means of continuous variables, while categorical variables were compared using Chi square or Fisher's exact test, as appropriate. A probability of ≤ 0.05 ($P \leq 0.05$) was considered statistically significant.

RESULTS

Gender proportion of the two groups of patients: LA ($n = 108$), 59 patients were male, while 49 patients were female; MOA-ISTR ($n = 140$), 87 patients were male, while 53 patients were female ($P = 0.233$). There was no statistical difference between these two groups.

Age (year) distribution of the two groups: LA, 8.5 ± 3.2 years old; MOA-ISTR, 7.7 ± 3.7 years old (P = 0.078). There was no statistical difference between the two groups. Medical history (h) distribution of the two groups: LA, 47.9 ± 45.3 h; MOA-ISTR, 43.5 ± 32.4 h (P = 0.379). There was no statistical difference between the two groups. Intraoperative perforation distribution between the two groups: LA, 46; MOA-ISTR, 68 (P = 0.349). There was no statistical difference between the two groups. Postoperative complications (incision infection or intestinal obstruction): LA, two patients; MOA-ISTR, three patients (P = 1.000). One patient in the LA group had incomplete intestinal obstruction at 9 days after surgery, and improved after conservative treatment. No obstruction occurred after half a year. For the other patient, symptoms of intestinal obstruction occurred at 15 days after surgery, which gradually increased. The obstruction gradually tended to be complete. Since hemorrhagic ascites were withdrawn during abdominal puncture, the disease was suspected to be intestinal strangulation obstruction, and exploratory laparotomy was performed. The adhesion band was found during the operation, and 40 cm of the small intestine had a U-shaped closure necrosis. Hence, the necrotic intestinal tube was removed, and enteral end anastomosis was performed. At 2 weeks after surgery, the child was discharged from hospital, and the postoperative review revealed no abnormalities. A patient who received MOA-ISTR had 5 days of incision infection, which was treated with anti-inflammatory drugs and daily change of dressing. At 10 days after the operation, a debridement suture operation was performed. The patient was successfully discharged at 4 days after the operation, and no abnormalities were observed during the follow-up. In another patient, after a month of adhesion of the intestinal obstruction after surgery, a laparotomy operation was performed. After 10 days, the patient recovered well and was discharged. Another patient had incomplete intestinal obstruction at 10 days after the surgery. After conservative treatment, the patient was discharged. There were no abnormalities during the 6-month follow-up in clinic. There was no statistical difference between the two groups ($P > 0.05$). Hospitalization days: LA, 6.3 ± 2.6 days; MOA-ISTR, 5.8 ± 2.1 days (P = 0.165). There was no statistical difference between the two groups. Operative duration (min): LA, 75.0 ± 27.5 min; MOA-ISTR, 58.1 ± 19.0 min (P = 0.000). The difference was statistically significant. Amount of bleeding (ml): LA, 4.4 ± 4.3 ml; MOA-ISTR, 3.0 ± 2.2 ml (P = 0.002). Although there was not much bleeding, there was a statistically significant difference between these two groups. Total hospital expenses: expenses were lesser in the MOA-ISTR group than in the LA group ($P < 0.001$), and the difference was statistically significant ($P < 0.05$) (Table 1).

DISCUSSION

OA was first described by McBurney in 1894, and this has become the gold standard for treating patients with acute appendicitis for more than a century [2]. In contrast, the first LA was performed in 1983 by Semm, a German gynecologist [3]. In recent years, a great majority of surgeons have embarked on LA, which was mainly attributable to its excellent results. However, OA did not lag behind LA, and it flourished as a minimally invasive procedure due to shorter operative duration and cosmetically acceptable incision. In the study conducted by Khalil et al. [12], a total of 160 patients were divided into two groups: groups A and B. After randomization, 72 patients in group A and 75 patients in group B were analyzed. For the mean age of patients in groups A and B, P = 0.981. For the mean hospital stay of these two groups, P = 0.294. The mean operative duration in groups A and B were 47.54 ± 12.82 min and 31.36 ± 11.43 min, respectively ($P < 0.001$). Pain (overall level) was significantly reduced in group A, when compared with group B (P = 0.004). These two groups were comparable in terms of other postoperative complications, such as hematoma (P = 0.87), paralytic ileus (P = 0.086), urinary retention (P = 0.504), and wound infection (P = 0.134). Therefore, it was concluded that LA is an equivalent procedure and not superior to OA, in terms of primary outcome measures.

Table 1 Observation indexes of mini-incision open appendectomy with incision skin tissue retractor versus laparoscopic appendectomy

	LA (n = 108)	MOA-ISTR (n = 140)	P
Gender			0.233
Male	59	87	
Female	49	53	
Age (years)	8.5 ± 3.2	7.7 ± 3.7	0.078
Operative duration (min)	75.0 ± 27.5	58.1 ± 19.0	0.000
Medical history (h)	47.9 ± 45.3	43.5 ± 32.4	0.379
Amount of bleeding (ml)	4.4 ± 4.3	3.0 ± 2.2	0.002
Intraoperative perforation			0.349
Yes	46	68	
No	62	72	
Complications			1.000
Have	2	3	
None	106	137	
Hospitalization days	6.3 ± 2.6	5.8 ± 2.1	0.165
Total hospital expenses	18,426 ± 5530	15,183 ± 4821	< 0.001

The present study revealed that there was no significant difference in hospital stay between these two modalities of treatments. Hospitalization days: LA, 6.3 ± 2.6 days; MOA-ISTR, 5.8 ± 2.1 days (P = 0.165). This was in corroboration with those in other studies [13, 14]. However, it remains controversial whether LA is associated with shorter hospital stay. Studies have revealed a significantly shorter hospital stay in favor of LA [15, 16]. The study conducted by Milewczyk et al. revealed that hospital stay was longer in the LA group versus the OA group [17]. The difference in hospital stay between these two modalities of treatments may be due to the difference in the healthcare system, rather than the difference in the two modalities of treatments [14]. This appears to be one area where OA has fast caught up with LA [12]. In related case studies, the average hospital stay was 2–5 days [18–20]. However, domestic treatment is relatively conservative, and the use of antibiotics is usually stopped when infection indexes, such as blood routine white blood cells, return to normal levels. Hence, length of hospital stay is also relatively prolonged. In the present study, the length of hospital stay in both methods was long, but the difference was not statistically significant. The reason may be correlated with the excessive dependence on the use of intravenous antibiotics in China.

Operative duration has been an eternal topic among experts when comparing LA and OA [14]. The operating time was longer for LA than for OA, but there was a large intersurgeon difference in operating time, supporting the need for training and continuous assessment in individual surgeons in order to decrease operating time [21]. Since all cases in the present study were operated by the same doctor, differences in operative time due to proficiency were avoided. The present study revealed that operative duration was significantly longer in LA, when compared with OA. Operative duration (min): LA, 75.0 ± 27.5 min; MOA-ISTR,

58.1 ± 19.0 min (P = 0.000). The difference was statistically significant, which is consistent with other studies [7, 12, 17, 22, 23]. All procedures in the present study were performed by an attending physician who had sufficient minimal invasive surgery experience. The difference could be explained by the fact that LA involves additional steps of gas insufflation, trocar entry and diagnostic laparoscopy. In the present study, the MOA-ISTR group used ISTR, which bypassed the manual pull hook-pulling procedure, and abdominal cavity flushing was convenient. Therefore, operative duration was minimized, when compared with LA.

Masoomi et al. [22] conducted a retrospective study of 212,958 cases. It was concluded that laparoscopic surgery for children with perforative appendicitis was better when compared with children in the small incision surgery group, in terms of hospital time and postoperative recovery. However, for unperforated appendicitis, there was no difference between these two groups. In the present study, there was no difference between the two groups, regardless of whether or not the appendicitis was perforated. However, appendicitis perforation in the present study refers to intraoperative visual perforation. There may be some differences in the number of perforations with pathological diagnosis.

Although there was not much bleeding in the LA group and MOA-ISTR group (amount of bleeding: LA, 4.4 ± 4.3 ml; MOA-ISTR, 3.0 ± 2.2 ml; P = 0.002), there was a statistically significant difference between these two groups. The amount of bleeding in the MOA-ISTR group was less than that in the LA group. This may be associated with the compression induced by the ISTR on the peripheral vascular soft tissue surrounding the incision. Hence, the hemostasis effect was good. Moreover, the short duration of the operation was also a cause of less bleeding.

Wound infections may not be a serious complication, but can cause inconvenience to the patient, impacting convalescence and quality of life [7]. A patient with MOA-ISTR had an infection due to incision at 5 days after the surgery. Anti-inflammatory therapy was given and wound-dressing processes were performed every day. After 10 days, the wound was debrided and sutured. Then, at 4 days after postoperative debridement and suture, the patient was discharged from the hospital, and the follow-ups did not reveal any abnormalities. In the present study, the postoperative complications (incision infection or ileus) were as follows: LA group (two cases of intestinal obstruction), occurrence ratio of 2/108 ≈ 1.85%; MOA-ISTR group (two cases of intestinal obstruction and one case of wound infection), occurrence ratio of 3/140 ≈ 2.14%. This did not reach statistical significance (P = 1.000). This finding was similar to other studies [24, 25]. Postoperative ileus along with pain and wound infection may hamper the mobility of the patient, which in turn, prolongs hospital stay and increases the cost of treatment [12].

In all of the above studies, there was no comparison in total hospitalization expenses. Due to different medical units, technical levels, patients, uses of drugs and equipment, and regions and countries, the expenses also differed. This made it difficult to effectively compare. The present study is a single-center study that merely compared different treatment modes. The total hospital expense in the MOA-ISTR group was less than that in the LA group (P < 0.001), which greatly reduced the financial burden on patients and families.

CONCLUSION

Mini-incision open appendectomy with an ISTR exhibited similar efficacy and incision appearance when compared with LA. Furthermore, this approach lead to shorter operation time, less intraoperative blood loss, less hospitalization time, and more convenience, especially for perforated appendicitis. This approach can be widely used for pediatric appendicitis, and is more suitable for doctors who are not skilled in basic hospitals and laparoscopy.

ACKNOWLEDGEMENTS

We would like to thank Benefit Bino Health Medicines Limited for their contribution to the

present study. We thank the participants of the study.

Funding. The study and the Article Processing charges were funded by The Beijing Hospital Authority "yangfan plan": pediatric urology (ZYLX201709).

Authorship. All named authors met the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this manuscript, takes responsibility for the integrity of the work as a whole, and approved for this version for publication.

Disclosures. Xian-Ling Li, Qin-Ming Zhang, Wei-Ping Zhang and Ting-Ting Liu have nothing to disclose.

Compliance with Ethics Guidelines. The present study was conducted in accordance with the declaration of Helsinki, and was approved by the Ethics Committee of Beijing Children's Hospital Affiliated to Capital Medical University. A written informed consent was obtained from the legal guardians of all participants. Written informed consent for the publication of the images in this manuscript was obtained from the parents or legal guardians of the participants.

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