

Review of Techniques in Occluding Appendicular Stump during Laparoscopic Appendectomy

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Abstract

Introduction: Laparoscopic appendectomy is the gold standard method of treatment of acute appendicitis. Closure of appendicular stump is the most important step to prevent complications. There are various methods to occlude the appendix. There is an insufficient analysis of the various methods to close the appendicular stump. The aim of this study was to analysis provide a treatment ranking of different options for securing the appendicular stump among endoloop, endostaplers, titanium clip, suture knots, Hem-o-Lok.

Methods: Online electronic databases were searched to find observation studies, review articles, randomized controlled trials comparing various methods ligation of the appendix. The primary outcomes were cost, availability, biocompatible, safety, learning curve.

Conclusion: The application of Hem-o-Lok for occluding the appendix in laparoscopic appendectomy seems to be superior to other methods but the final decision on the method to be used will depend on the surgeon's experience and training with various techniques, the availability of equipment within the hospital, cost-effectiveness and the extent of appendix inflammation.

Keywords: Methods of closure of appendicular stump; Endoloop; Endostaplers; Metal clips; Suture knots; Hem-o-Lok

Introduction

Acute appendicitis is one of the most common general surgical conditions to be treated as an emergency. Claudius Amyand in 1735 was the first person to do open appendectomy but McBurney in 1894 was the first person to describe it in literature. For more than a century Open Appendectomy (OA) was followed as a gold standard for the treatment of appendicitis. Kurt Semm in 1983 was the first person to perform Laparoscopic Appendectomy (LA), which created a platform for surgeons to research and improve in laparoscopic appendectomy.

Laparoscopic appendectomy was useful in drastically reducing hospital stay, operative duration, post-op complications, post-op pain, better cosmesis and early oral feeding with a quick return to routine work [1,2].

Appendicular stump closure is the most important step in laparoscopic appendectomy. Appendicular stump closure is done to prevent major post-operative complications such as peritonitis, postoperative fistula formation, and sepsis. In open appendectomy, the appendix stump is buried into the cecum or by just ligating the appendicular base with suture without inversion. In LA, ligation of the appendicular base can be difficult because intracorporeal knotting requires high surgical skill in laparoscopy or the surgeon may not be sure of the reliability of the knot. This problem has made surgeons find different alternatives for ligation of the appendicular stump in LA.

The use of various suture materials to ligate the appendix stump may vary in terms of biocompatibility, tissue inflammation, foreign-body reaction, the rate of surgical site infection or the rate of formation of intra-abdominal adhesions.

Tissues respond to sutures and other devices as they would to any foreign object in the body. The response to suture is an important factor because a severe response can break down the suture material or the tissues surrounding the material can lead to various levels of inflammatory response, the formation of gangrene, formations of adhesions, with surgical site infection. The deal suture material should be biocompatible and react less to tissue. The ideal method for appendix stump closure in laparoscopy should be technically easy to use, safe, readily accessible, reliable, with less operative duration and less cost.

Biologically suture material should have good tensile strength and high knot security, can resist infection and contamination, reacts minimally with the tissue in which it is embedded, less cost, decreased operating duration and easy learning curve. This is the reason for which different methods have been invented, researched and used to ligate the appendicular stump [3].

Methods

In this article, we reviewed various observational articles, clinical and experimental studies and from electronic databases (PUBMED and Cochrane Central Register of Controlled Trials) for potentially relevant articles comparing various methods of appendicular closure conducted from January 2000 to December 2018, published in English. Keywords used for the search included: a randomized controlled trial

of open appendectomy, laparoscopic appendectomy, laparoscopic versus open appendectomy, various methods of closure of appendicular stump, endoloop, Hem-o-Lok, endostaplers and metal clips (Table I).

Various methods of closure

Different methods of closure are described such as endoloop, titanium clips, stapler, non-absorbable polymer clips (Hem-o-Lok clip) and handmade loops. The ideal method should be a biocompatible, safe, easily available, less learning curve and cheap. The most appropriate method still remains to be a controversy [4].

Endoloop

Endoloop ligature which can be defined as a modified Roeder loop is a common technique in the closure of the stump in laparoscopic appendectomy. It consists of a long ligature placed within a plastic tube. The ligature may be made from polyglactin or polydioxanone or vicryl or catgut [3]. The Endoloop consists of an 18-inch long suture inside a plastic tube that is sharp at one end and free at the other end. The suture is made into a ligature loop with a locking knot. When the ligature is in the base of the appendix, the loose end is simply snapped and pulled to tighten the loop and secure the knot. A similar technique is used and another knot is applied above the previous knot and the base of the appendix is resected.

Endoloop is the most commonly used device for the closure of appendicular stump. Endoloop has been popularised due to its advantages like to its less tissue reaction, less cost and can be used for all diameters of the appendicular base. Endoloop is cheaper than a stapler. Endoloop also proves to have less local tissue reaction [5,6]. The disadvantages are that it is costlier than many other methods and long duration and once the knot has been in place the knot cannot be removed and has a technique of application which needs a long learning curve and surgical experience in laparoscopy.

To reduce the cost of surgery, the endoloops which are similar to commercially available Endoloop can be prepared manually which can be called as Handmade loops. Handmade loops are manually prepared during surgery with various materials like catgut, polyglactin. The cost of this method is less, can be easily prepared and can be safely applied similarly to Endoloop.

Titanium clips

Titanium clips also known as endo clips, ligature clips or metal clips are commonly used in laparoscopic cholecystectomy for ligation of vessels and cystic duct, metal clips are also used for occlusion of blood vessels in various major laparoscopic surgery. Metal clips are made of titanium which is a good biocompatible material, with less cost and constant high closing force. The clips are designed with two parallel and interconnecting shanks. The tissue to be occluded are placed in the space in between the shanks and closed with the applicator. The shanks are provided with grips which prevent the clips from slipping from the tissue. Recent commercially available clips have pyramid shaped surface or toothed surface which sink into the tissue and further prevent the clips from slipping by increasing the contact surface area and ensuring string grip [7].

For laparoscopic appendectomy, the metal clips have not been used or been less investigated. The advantages of Endoclips are it's less costly, biocompatible, and easily available in the operating room. The disadvantages are that it has restricted the size and each size has a particular applicator. It does not have circumferential support due to which is a chance of slippage.

Endoclips are radiopaque, non-absorbable. Due to its various disadvantages, it is not frequently used for ligation of the appendicular stump. Under these circumstances, the polymeric clips or endostaplers were introduced for the disadvantages of Endoclips [4,8].

Endostaplers

Endostaplers were introduced in 1995 and for the use in laparoscopic appendectomy was started in 2002. Endostaplers are similar to the bowel anastomosis staplers which have the function of simultaneous sealing and division of the bowel or any structure. Endostaplers are easy to use but the surgeon should have sound knowledge in laparoscopy and are biocompatible. The major advantage is endostaplers can be used in any size of the appendicular base and degree of inflammation. Disadvantages are once the staplers are once applied it cannot be removed, have a longer duration of surgery, once staplers applied on the caecum cannot be removed and will lead to major complications; the other major disadvantage is high cost, most of the staplers are disposable which cannot be reused and not easily available. With various other methods which are a cheap, easily available and less learning curve the indication of endostaplers in laparoscopic appendectomy has been on the decline [3,9].

Suture knot

Closure of the appendicular base in LA can be done in a similar fashion to open surgery. To do this, a knot can be prepared within the abdomen after ligation of the base or can be prepared extracorporeally and pushed into the abdomen with the instrument. Intracorporeal tie knot requires more experience than other methods and a high learning curve. Studies have shown that these methods to be performed as safe as the other methods [10]. Ligating the appendix base with sutures is a very cheap method. A disadvantage is that the operation will increase and will require experience with a doubt of the reliability of the knot. The other major factor for suture knot or handmade knot is the type of materials used. The suture materials used should be biocompatible with less tissue reaction. The commonly used materials are polyglactin, catgut [3,11].

Hem-o-Lok clips

In 1999, the Hem-o-Lok system was introduced to the market of endoscopic surgery with the intention for occlusion of vessels. A non-absorbable Hem-o-lok clip (Weck Closure Systems, Research Triangle Park, Durham, NC, USA) is made of polymer. Application of Endoloop requires only a short training, while application of Hem-o-Lok clips is very simple and can be done by almost any surgeon without previous training. This is especially important in developing countries where resources for training with Endoloop are insufficient, and the simplicity of application of Hem-o-Lok can enable easy acceptance of laparoscopic appendectomy as a method in the treatment of acute appendicitis [12,13].

The application of Hem-o-Lok over the base of the appendix is done by a Hem-o-Lok applicator. The applicator has locks and holding mechanism to hold the Hem-o-Lok before application. Various studies have been conducted to study the number of clips for the ligations of the stump. It has been proved that the use of one Hem-o-lok clip is as safe and proved to be cost-effective [14,15].

Hem-o-Lok is a non-absorbable polymer that is inert, nonconductive and radiolucent which does not interfere with X-Ray, MRI Or CT. The structure of Hem-o-Lok are unique, bosses which help in retaining the clips in the upper jaw, the toothed surface help anchor the tissue to the clip prevents the slip. The bow-shaped design allows removal with the instrument. The hinge shape allows for more

flexibility while placing the clip prior to clip locking. The unique locking mechanism provides 360-degree locking which provides maximum locking.

Delibegovic et al studied the size of the appendicular base in various conditions. The average size of the appendicular base in the inflamed form was 10.29 ± 3.13 mm, in the gangrenous form 12.41 ± 3.56 mm and in the perforated form 12.42 ± 3.64 mm. The maximal size of the appendicular base was observed in the perforated form, 23.13 mm [16]. Hem-o-lok is available in a range of clip sizes (Medium, Medium/Large, Large, and XL) to ligate stump ranging from 2 mm to 16 mm. The large size can be used for tissue diameter of 5 mm to 13 mm, with the various studies observed the average diameter of the appendix in the inflamed state is 10 mm so the large size clip was chosen for various studies [17].

Absorbable suture materials lead to various levels of inflammation and foreign body reactions, but non-absorbable sutures lead to a milder tissue reaction. Hem-o-Lok made up of the polymer is a non-absorbable clip and studies show Hem-o-Lok has very less tissue reaction with less post-operative complications [14].

Studies conducted by Christopher Soll showed that the closure of the appendicular stump using the non-absorbable Hem-o-Lok ligation system resulted in a reduced rate of intra-abdominal surgical abscesses as compared to the application of Endoloop [18,19].

It's believed that the Hem-o-Lok clips provide a significant saving in cost without compromising the safety of the patient. Polymeric clips are less costly than either an Endoloop or linear endoscopic stapler. The polymeric clips can be also used for the ligation of the mesoappendix and appendicular artery.

This application resulted in great cost saving since methods to control bleeding and vessel occlusion like bipolar device or ultrasonic dissection devices can be avoided, would contribute to the cost of the surgery [20].

Hem-o-Lok has added advantages in terms of being safe and secure while ligating the appendicular stump and can also be removed with a probe while in Endoloop once applied cannot be removed [21].

The disadvantage of Hem-o-Lok is that the size of clips applied will depend on the intraoperative findings. Each clip size has a different applicator which should be available.

Table I: Comparison of various methods of closure.

Methods of Closure	Biocompatibility and Safety	Cost (Rs)	Availability	Learning Curve
Endoloop	Yes	850	Yes	Long
Titanium Clips	Yes	500	Yes	Less
Endostaplers	Yes	3000	No	Long
Suture Knots	Yes	250	Yes	Long
Hem-O-Lok	Yes	800	Yes	Less

Conclusion

Despite various methods, there is no gold standard agreement to any technique. There is no single method that is recommended in any guidelines as the gold standard for ligation of the appendicular stump. There are also many prospective randomized studies with large sample sizes which compared various methods. Staplers can be used when the appendix base is inflamed or gangrened. It should be considered that stapler and Endoloop are expensive when compared to other methods.

Use of cheaper alternatives like sutures with handmade loops, Hem-o-Lok clips, and intracorporeal knotting will be more feasible, due to the particular conditions of our country. In our practice, we use Hem-o-Lok because it is, cheap, safe and practical. Although Ligasure and bipolar devices are suggested as cheap and easy to use methods, the clinical studies on these methods are very limited and when compared to Hem-o-Lok and handmade knots its comparatively costly. The safety of the methods that is observed in experimental studies must be supported by clinical data.

In conclusion, evaluation of the literature showed that all methods have similar clinical data but in a developing country like India, resources for advanced laparoscopic training are scarce. Hence techniques with an easy learning curve should be incorporated in the different advanced laparoscopic procedures. We propose that Hem-o-Lok will be an easier technique to master by the beginners thus reducing the operating time. Cost comparison analysis has statistically proved that Hem-o-Lok is cheaper to Endoloop, staplers. The average duration of surgery was less with Hem-o-Lok when compared to other methods. Patients in the Hem-o-Lok group had no post-operative complications; hence Hem-o-Lok is a safe method for the ligation of the appendicular stump. On a negative note, a single size clip cannot be used for all appendix base, it would depend on the size of the base and availability of the size with appropriate applicator should be present.

We conclude that the practice of using Hem-o-Lok clips for the ligation of the appendicular stump is a safe, cheaper and better alternative to other methods in laparoscopic appendectomy, Therefore, methods that are cheap and easy learning curve should be considered as the first choice. Nevertheless, the final decision on the method to be used will rely on the surgeon's training and experience with various techniques, the availability of equipment within the hospital, cost-effectiveness and the extent of appendix inflammation.

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