

Securing the base of the appendix during laparoscopic appendectomy

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ABSTRACT

In contrast to classical appendectomy where the appendiceal stump is secured by a single or double ligature, in laparoscopic appendectomy various ways of securing the stump are mentioned. Each of these methods has advantages and disadvantages. Since different possibilities exist for closing the stump, it is very important to find the optimum method for closure of the appendiceal stump, bearing in mind their simplicity, biocompatibility and price. The aim of this review article has been to present the problem of securing the base of the appendix during laparoscopic appendectomy.

Key words: appendix, laparoscopic appendectomy, linear stapler, titanium

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INTRODUCTION

In contrast to classical appendectomy where the appendiceal stump is secured by a single or double ligature (1), in laparoscopic appendectomy various ways of securing the stump are described (2). Each of these methods has advantages and disadvantages.

Closure of the appendiceal stump is the most critical part of laparoscopic appendectomy.

The appendiceal stump may be closed using an endoloop, which is the standard method (2), or a stapler which is a more expensive method, but clinical evidence favours this method (3). The use of plastic (4) or titanium clips (5) has been mentioned recently for closure of the appendiceal stump.

Since different possibilities exist for closing the stump (Figure 1), it is very important to find the optimum method for closure of the appendiceal stump, bearing in mind their simplicity, biocompatibility and price.

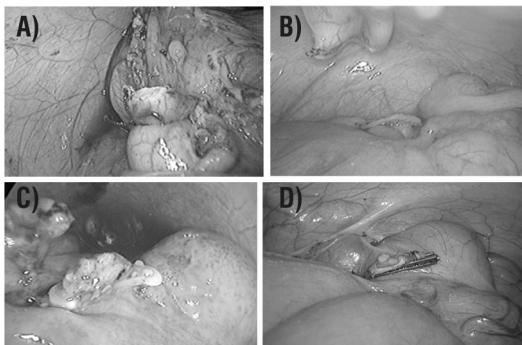


Figure 1. A) The base of the appendix secured by a single endoloop; B) the base of the appendix secured by an endostapler; C) the base of the appendix secured by a single Hem-o-lok, XL size; D) the base of the appendix secured by a DS clip (Delibegović S, 2011)

HANDLING/SIMPLICITY OF APPLYING

Endoloop is the standard method, but a period of training is needed to be able to apply an endoloop correctly. In the limited space of the ileocecal fossa, in a slim person with a small abdomen, placing an endoloop, especially when the appendix is bulging, is not easy.

It must be emphasized that the time needed for application and the duration of the operation were much shorter using a stapler than the other method (6). This is because the instruments only need to be inserted once, and a single movement

is all that is needed to resect the appendix and secure the stump, which reduces the duration of the surgery significantly. Staplers are simple to use and are easy for any surgeon to master.

There is no difference between the Hem-o-lok and titanium DS clip in relation to the time needed or the length of the operation (6). However, one disadvantage of DS clips is that it is impossible to remove and replace them if they are not placed correctly on the appendiceal stump (6). A strength of Hem-o-lok plastic clips is that it is possible to remove them, even though it is necessary to insert another instrument to remove clips that are in the wrong position for some reason. Another advantage of Hem-o-lok is the noise made by the clips as they are used, whereas DS clips do not produce any sound. The opening of Hem-o-lok clips is also wider so they are easier to place on a large, inflamed appendix (6).

In all situations the size of the appendix significantly affects the simplicity of use.

Size of the appendix

It is often forgotten that the size of the appendix can affect the choice of method used to close the appendiceal stump. When the appendix is enlarged, it is sometimes very difficult to place a standard endoloop ligature. In that case, a stapler is the only option (6). The size of the stump is particularly important.

The average size of a phlegmonous appendiceal stump was 10.29 ± 3.13 mm, the size of a gangrenous stump 12.41 ± 3.56 mm, and of a perforated stump 12.42 ± 3.64 mm (7). As a result, in most cases plastic clips, Hem-o-lok XL and titanium DS clips were able to encompass the appendix (6). Sometimes, however, the stump may be as large as 22.75 mm. In this case, only an endoloop or a stapler are able to close the appendiceal stump.

The size of the widest part of the appendix may be up to 45.10 mm (recorded in acute perforated appendicitis), and in this situation it is not easy to place an endoloop. The tip of the appendix was up to 28.68 mm, which should not affect the closure of the appendiceal stump (6).

Thus, the safety of the method used to close the appendiceal stump depends on the size and shape of the endoloop, stapler and the length of the arms of the clip.

Size of the endoloop, length of stapler and clip legs

The endoloop is elliptical in shape, and a polydioxanone (PDS) endoloop has the largest width of 24.0 mm. It can be used to close all appendiceal stumps, but it is difficult to place it in a case of acute perforated appendix, since the stump may be as large as 45.0 mm. An endoloop is 62.44 mm in size, but due to the lack of space in the caecal fossa, in the case of an extremely enlarged appendix, this size is only theoretical (7).

Although the opening of a stapler is large, the largest being an Echelon 60, and it is easier to place, the cost is much higher and it should only be used for forms of acute appendicitis where other methods are impossible (7).

The internal length of the legs of DS clips are longer than Hem-o-lok clips, however, the opening of a Hem-o-lock clip is larger (9.4 mm) so it is much easier to place than a DS clip (Table 1). If we consider the maximum diameter of the appendix (23.13) recorded in the perforated form, the internal diameter of the clip should be greater (6).

Table 1. Characteristics of each method of closure of the appendiceal base

Characteristics	Vycril endoloop	PDS endoloop	Stapler echelon 45	Hem-o-lok XL clip	DS clip
External length of legs (mm)	97.7*	97.7*		17.33	16.2
Internal length of legs (mm)	62.24*	62.24*	42	13.58	14.2
Opening (mm)	24.0 [‡]	29.5 [‡]	12.35	9.4	5.5
Weight (mg)	21.00	14.00	72.00	121.00	176.00
Price (Euro)	38.10	36.99	167.69	7.5	20

PDS, polydioxanone; DS, titanium clip; *volume; †diameter; ‡the greatest width of the endoloop when open and in the form of an extended ellipse

Biocompatibility

The biocompatibility of the different materials used in securing the base of the appendix varies. The PDS causes a milder inflammatory reaction in comparison to Vicryl (polyglactin 910), so an endoloop made from a PDS ligature should be preferred (8,9). However, titanium stapler clips cause the mildest inflammatory reaction and create the least adhesions, when we compare staplers with hem-o-lok and endoloops (10). After staplers, the mildest reaction is caused by plastic clips (10). Therefore, in terms of biocompatibility staplers and titanium clips are most preferable, followed by plastic clips.

Price

Loop ligatures have advantages for reducing medical costs because they are 6–12 times cheaper than stapling devices (11). Using a stapler is a safe method, and staplers rarely malfunction. Their only weakness is their high price in relation to other ways of securing the appendiceal stump. Bearing in mind the fact that in U.S. hospitals operating room charges average \$62/min (range \$22–\$133/min) (12), the use of staplers could reduce these costs in terms of time needed, but since they are a more expensive method, this advantage is lost. However, Hem-o-lok and DS clips are cheaper than loops and staplers, and also have other advantages.

DISCUSSION

The method used for closure is important in terms of the simplicity of application, biocompatibility, price and other characteristics of the instruments themselves.

It is sometimes difficult to insert a loop ligature in the area bordered by the iliac fossa, and a certain level of training is needed (6), but Hem-o-lok and DS clips may be applied by a surgeon with minimal previous training. Using a stapler is simple and safe, and its only weakness is its high price in comparison with other methods of securing the appendiceal stump. Staplers are said to be safer than laparoscopic loop ligatures regarding the formation of intraabdominal abscesses and readmission (11). The biocompatibility of staplers is best in comparison to other forms of closure of the base of the appendix (10).

The malfunction rate of staplers is very low, e.g. 0.003%, although some believe that the incidence is higher (13). There is no case mentioned in the literature of either Hem-o-lok or DS clips slipping or falling out of a closed stump.

In rare cases, when the appendiceal base was necrotic or gangrenous, a postoperative leak may occur following laparoscopic appendectomy (14). However, in most studies comparing endoloop and staplers, or endoloop and clips (15,16), no stump leaks occurred in any group. It is interesting that in a study comparing laparoscopic versus open surgery for complicated appendicitis, leakage was 9.5 % in the laparoscopic group, and 12.8 % in the open appendectomy group. In

the laparoscopic group, securing the appendiceal stump was performed using a stapler (17).

In view of the price, the size of the opening, radiological advantage (18) and biocompatibility (10), Hem-o-lok clips are the most effective, although their internal diameter should be increased. The DS clips are also effective, but the size of the opening sometimes makes application difficult, and any increase in the size of the opening would make this clip ideal, also due to the excellent biocompatibility of the titanium clips (10). Staplers have the best characteristics, but their price means they are only an option for forms where it is not possible to close the stump using other methods.

It may therefore be concluded that none of these methods has reached the ideal and further research

is needed to improve the mechanical features of the available materials, in order to attain the optimum method for securing the appendiceal stump. Bearing all this in mind, it may be said that all these forms of closure of the appendix base are acceptable, but plastic and titanium clips have the best potential for further development, and will probably become the method of choice in securing the base of the appendix.

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