Single Incision Laparoscopic Surgery (SILS) appendicectomy as alternative surgical procedure in diagnosis and treatment of acute appendicitis: Review Article

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Abstract

Appendectomy is the most common abdominal operation performed as an emergency basis [1]. The advantage of laparoscopic technique over the conventional open surgery technique has been proven especially in women and obese patients [2-4]. The further improved version at present is the introduction of Single-incision laparoscopic surgery (SILS). It is a new technique developed for performing operations without a visible scar and has become an area of active research and interest within general surgeons community.
A number of procedures such as cholecystectomy, appendectomy and ect has been currently being performed using this method. In Single Incision Laparoscopic Surgery (SILS) appendectomy, it may be more advantageous to the patients by eliminating the scars and potentially diminishing postoperative pain. However, the role of the SILS appendectomy is still evolving since all published reports of the technique should be regarded as preliminary [5–7]. More studies evaluating the technique in different clinical situations as well as randomized controlled trials are needed in order to assess the real benefits of the SILS appendectomy in general surgical practice.

Here, we reviewed the feasibility and acceptance among surgeons towards the technique of single incision laparoscopic surgery (SILS) in the diagnosis and treatment of acute appendicitis.

Keywords

Single incision laparoscopic appendicectomy, Single incision laparoscopic surgery (SILS), acute appendicitis, appendicectomy.

Introduction

Acute appendicitis is a common intra-abdominal inflammatory disease which requires emergency surgery, and a surgical appendectomy is the only treatment. Since the introduction of the laparoscopic appendectomy, it has become an alternative method of treatment to an open appendectomy because of less pain, less abdominal scarring, and quick recovery to daily life [8].

The location of the trocar in a laparoscopic appendectomy varies depending on the surgeon's preference. There are three trocars which mean three incisions were necessary in conventional laparoscopic surgery, but a method using a single incision was developed through the accumulation of experience and the development of instruments. The greatest benefit of single-incision laparoscopic surgery is the superior esthetic results after surgery. The single-incision Laparoscopic surgery has been used in nephrectomies [9], adrenalectomies [10], lap-band stomach surgery [11], and surgery for many other diseases.

Single incision laparoscopic surgery (SILS) is also known as laparoendoscopic single-site surgery or single-port access surgery (SPAS) [12]. In the era of laparoscopic surgery, the common trend has been towards performing less invasive technique. An extension of the trend is to perform operations with least visible scars. The most prominent techniques representing scarless surgery are transumbilical single-incision laparoscopic surgery (SILS) and natural orifice transluminal endoscopic surgery (NOTES).As the latter is still struggling with technical and equipmental difficulties, SILS seems to be more ready for wider use. There are reliable and simpler equipment available for SILS procedures although there are slightl difference to conventional laparoscopy. Several operations have, thus, been until now performed by SILS technique including, for example, cholecystectomy, appendectomy, splenectomy, and sleeve gastrectomy.

A number of advantages have been proposed related to this approach which including cosmesis (scarless abdominal surgery performed through an umbilical incision), less incisional pain, and the ability to convert to standard multiport laparoscopic surgery if needed without denying the disadvantage and complication related to this new technique.

Thus, here we make a review articles in the intention of finding the feasibility and safety with the technique of single incision laparoscopic surgery (SILS) in the diagnosis and treatment of acute appendicitis.

Objective

The aim of the present study was to evaluate the feasibility and safety of single incision laparoscopic surgery (SILS) as an alternative surgical procedur in making diagnosis and also performing appendectomy in patient presenting with symptom suggestive for appendicitis.

Material and Methods

Data Extraction and Study Selection:

Literature search was performed using the following search engines: Google, Yahoo, Medline, pub med and the online Springer link metapress Library available at the Laparoscopy hospital, New Delhi India.

The following terms were used for the search:
"Single incision laparoscopic appendicectomy , single incision laparoscopic surgery".

We have limited the search to the main operations of laparoscopic appendicectomy and single incision laparoscopic appendicectomy. Articles that matched the search criteria were selected.

Results

There has been many data available with regard to the single incision laparoscopic surgery in the literature. Most of the articles were case reports, results of retrospective clinical study comparing the SILS to conventional lap surgery and prospective study on SILS technique but no prospective randomized clinical trial with direct comparison between the two was found. There were at least two ongoing trials comparing the SILS vs conventional lap appendicectomy in which the results are still not available. Here we have selected twenty eight articles for the review.

Discussion

The evolution of surgery toward less invasive approaches has act as stimulant effect towards the development of new less invasive techniques in entering the abdominal cavity. An example of such technique is the use of a single skin incision through which multiple instruments can be inserted into the abdomen. This single-incision laparoscopic technique has been described by a variety of names as we have discussed earlier.

With this single incision of entry, Single-incision laparoscopic surgery (SILS) is theoretically less invasive approach compared to the standard multi port laparoscopic surgery. However, SILS may not allow the same level of manual dexterity and technical performance compared to conventional laparoscopic surgery that in certain aspect, it even violates the principal of laparoscopic surgery.

In this review, while looking into the aspects of SILS with regard to its feasibility and as alternative diagnostic and surgical procedur in acute appendicitis, we have recognized the issues for discussion in SILS into categories as below:

i). Surgeon skill/learning curve
ii). Surgical technique
iii). Procedure related specific complications
iv). Feasibility and safety of SILS technique

I) Surgeons skill/Learning Curve

Usually, when a new surgical technique is introduced, the focus will be on the feasibility, safety, and clinical advantage of the method. On the other hand, safety is highly dependent on how easily the new technique can be learned by average surgeons. It is a well known fact that the implementation phase of new techniques is associated with an increased risk of complications emphasizing the importance of thorough training and education for the operating surgeon.

The first report of single incision laparoscopic surgery (SILS) was by Navarra et al. who performed a SILS cholecystectomy in 1997[13]. Since then, there have been many reports regarding the use of single incision laparoscopic surgery for appendectomy, splenectomy, nephrectomy, prostatectomy, colectomy, sleeve gastrectomy, adrenalectomy, and adjustable gastric band [14]. However, there have been no reported randomized clinical trials with direct comparison between SILS to conventional laparoscopic surgery.

Despite the lack of evidence demonstrating any superiority of SILS, it is being increasingly performed unfortunately in a largely unregulated fashion without formal training. Concern has been raised that this new procedur is more technically challenging and is likely associated with a significant learning curve and also it own disadvantage and complication.

Byron F. et al, reported a study which had compared the performance of standardized tasks from the Fundamentals of Laparoscopic Surgery (FLS) program using either the LAP or the SILS technique[15] (figure 1). His study had demonstrates that performing tasks using SILS techniques is more technically challenging than when using standard laparoscopic techniques, even for surgeons with previous SILS experience. Overall performance of standardized tasks using a SILS port and static articulating instruments was inferior compared to a standard, multiport, laparoscopic technique. The study also provides evidence that surgeons with SILS experience perform better at SILS compared to surgeons without SILS experience, despite having similar laparoscopic performance.

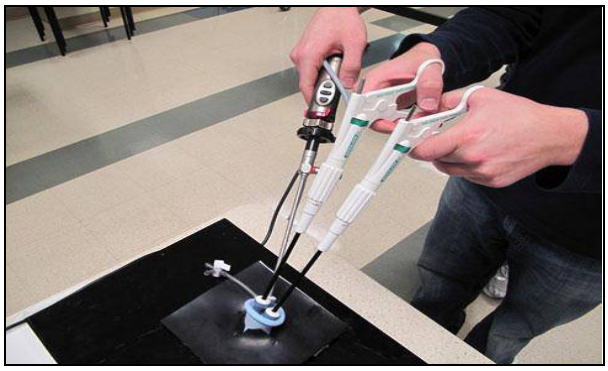

Figure 1: SILS simulator-single port with multiple instrument

The study conclusions were:

a) SILS is more technically challenging than standard laparoscopy.

b) Surgeon experience still however influences performance. Surgeons with SILS experience had the best performance on SILS. Subjects with LAP experience alone performed worse on SILS than those with SILS experience.

c) Suggests that eventhough LAP experience is helpful for performing SILS, it is not substitute for SILS experience.

This finding has implications for the adoption of SILS technique by surgeons without previous SILS experience. Surgeons generally may perform SILS cases without any training or verifications of proficiency. Most surgeons who begin performing SILS likely receive training from short training and courses, similar by which many surgeons learned to perform laparoscopic cholecystectomies early in the laparoscopic era. With the advancement of laparoscopic surgery technology however, surgeons described a definite learning curve inherent to the procedures. This may also applicable in SILS.

The study also had demonstrated the importance of developing formal and minimum training requirements for SILS to minimize the potential negative effects of its learning curve. Most importantly, the study demonstrated that SILS is more technically challenging than standard laparoscopy, even for surgeons with SILS experience. These observations support a cautionary approach to the rapid adoption of this SILS technique for an increasingly complicated range of procedures. The risk of inferior performance using SILS needs to be balanced against the potential benefit to the patient.

At the end, this study in conclusion made a suggestion which support the adoption of a cautious approach to SILS from an investigational perspective, identify the need for further instrument development and emphasize the need to develop proper training for surgeons who ant to perform SILS procedures.

This study was however had the limitation that their findings were limited by the use of the laboratory setting which allowed the author to control many aspects of the experiment, including the use of standardized tasks with objective performance metrics. There are still questions that need to be answered by randomized clinical trials.

ii). Surgical Technique

When a new technique is introduced to the surgical community, the focus should be concentrated on the feasibility, safety, and clinical advantage of the method. Jyrki K¨ossi and Markku Luostarinen et al reported study on their experience on Initial Experience of the Feasibility of Single-Incision Laparoscopic Appendectomy in Different Clinical Conditions at their institution [16]. They stated that the SILS technique differs from traditional multiple port laparoscopic technique. Although the concept of SILS seems similar to standard laparoscopy, theoretically there are major differences in technique. In fact, some "rules" of laparoscopy need to be "broken" in order to perform SILS mainly by:

a). The use of only single incision for entry into abdominal cavity which is used as site of entry for the specially modified instruments to perform the surgery. In SILS, intraumbilical cutaneous vertical incision was made and the umbilicus was detached from the fascia. The fascia was opened (2-3 cm) and the SILS port was introduced into the abdomen. Then only the instrument port is introduced (figure 2). A number of methods have been described for port access in SILS, including multiple fascial punctures through one skin incision, the use of additional transabdominal sutures to stabilize the target organ, and use of novel port access devices such as the SILS port (Covidien, Norwalk, CT, USA). Unix-XTM (Pnavel Systems, Brooklyn, NY, USA) 7 and R-portTM (Advanced Surgical Concepts, Wicklow, Ireland) [17].

Figure 2: Single port with multiple instrument-"crowding"

b). In SILS, use of grasping and dissecting instruments, but use common site of entry through single ports at the same fascial plane make it unavoidable crossing(swording) among the instruments.

SILS technique has violated the basic principal of laparoscopic surgery such as "base ball diamond concept" of port placement. This in another word means compromising the ergonomic of laparoscopic surgery which is very much crusial.This has lead towards the primary disadvantages of SILS in the aspect of instruments movement.

Here, there is restricted degree of freedom of movement due to the single port factor itself. This cause proximity of the instruments to each other (crowding of all the working instruments within one incision) during the operation again disobeying the laparoscopic concept of 60 degree angle between two working instruments to maintain good ergonomic—all of which increase the complexity and technical challenges of the operation.

c). Generally, when performing appendectomy, one must also consider other finding or differential diagosis. The appendicitis can be of at various forms such as oedematic, gangrenous, perforated with varying degree of peritonitis, or even associated with peritoneal abscess. The surgical technique chosen to treat the patients should be suitable for all these situations.

In same study by Jyrki et al [16], there were both uncomplicated and complicated cases with even different degrees of peritonitis. All were managed by SILS technique without conversions or additional ports and they had an uneventful recovery. **(Table 1)**

(Table 1)

Patient description	Operative finding	Operation	Operative time (min)	Discharge (days)	Note
Male, 40 years	Appendicitis	Appendectomy	38	1	Typical uncomplicated appendicitis
Female, 18 years	Perforated appendicitis, covered by terminal ileum	Appendectomy	44	4	Restricted infection, incipient abscessus formation
Female, 63 years	Perforated appendicitis, diffuse peritonitis	Appendectomy, lavation	50	5	Hospital stay prolonged due to peritonitis
Female, 63 years	Appendicitis	Appendectomy	37	1	Obese patient, BMI 31, operative time reasonable
Female, 16 years	Ovarian cyst rupture	Appendectomy, explorative laparoscopy	34	2	Aspiration of pelvic fluid collection

Their mean operating time was 40 minutes comparing well to the operating time of conventional laparoscopic appendectomy in their hospital (mean 43 minutes, range 18–103) and in a recent Cochrane review (mean 23.5–102 minutes) [18]. According to the study, they concluded that, although their study number was limited, SILS technique seems to be suitable for variety of appendiceal infections.

Another study by Jin A Lee, Ki Young Sung, Jun Hyun Lee, Do Sang Lee et al. They presented a retrospective study on Laparoscopic Appendectomy with a Single Incision carried out in their institution [20]. They had 75 acute appendicitis cases where laparoscopic appendectomy with a single incision had been performed from October 2008 to June 2009 at The Catholic University of Korea, Bucheon St. Mary's Hospital and then were retrospectively analyzed. The purpose of their research was to establish the safety and the benefits of a single-incision laparoscopic appendectomy.

The results were as follow. (26.2%); 37 were males and 38 were females. The average BMI of the patients was 21.84 kg/m2, and the average duration of symptoms was 1.92 days. The average suggested discharge was 1.68 days after surgery, and the actual length to patient discharge was 2.88 days **(Table 2)** [20].

Table 2. Characteristics of patients [20]

Characteristics	Male (n = 37)	Female (n = 38)	All (n = 75)
Age (yr)	27.08 ± 14.89	26.37 ± 15.70	26.72 ± 15.20
BMI (kg/m_2)	22.81 ± 3.93	20.87 ± 3.20	21.84 ± 3.70
Symptom duration (day)	1.68 ± 0.58	2.16 ± 0.80	1.92 ± 0.74
Operation time (min)	64.32 ± 36.23	52.92 ± 26.03	58.55 ± 31.80
Pre.op WBC	12,594.59 ± 3,636	11,921.08 ± 4,882	12,257.84 ± 4,288
Pre.op seg. Neutrophil (%)	76.67 ± 10.0	77.3 ± 10.55	76.98 ± 10.22
Discharge recommend (POD)	1.7 ± 1.08	1.65 ± 0.72	1.68 ± 0.90
Hospital stay (POD)	3.03 ± 1.48	2.73 ± 0.87	2.88 ± 1.22

BMI, body mass index; Pre.op, pre-operative; WBC, white blood cell; seg., segment; POD, post-operative day.

In the study, the severity of inflammation in appendicitis was categorized as suppurative or perforating appendicitis based on the biopsy results after the surgery. Among patients, 55 of them had suppurative appendicitis, and 20 of them had perforating appendicitis.

Table 3. Perioperative surgical outcomes in relation to inflammation [20]

	Suppurative appendicitis	Perforative appendicitis	Pvalue
Patients (n)	55	20	0.108
Age (yr)	24.69 ± 14.22	32.3 ± 16.76	0.461
BMI	21.55 ± 3.82	22.64 ± 3.28	0.097
Symptom duration (day)	1.8 ± 0.60	2.25 ± 0.97	0.49
Operation time (min)	23.73 ± 25.72	71.8 ± 42.47	0.639
Pre.op WBC	11,915.93 ± 4,392.69	13,181 ± 3,951.34	0.008
Pre.op seg. Neutrophil (%)	75.77 ± 11.14	80.27 ± 6.32	0.012
Discharge recommend (POD	1.39 ± 0.66	2.45 ± 1.05	0.012
Hospital stay (POD)	2.54 ± 0.89	3.8 ± 1.51	0.032

BMI, body mass index; Pre.op, pre-operative; WBC, white blood cell; seg., segment; POD, post-operative day.

They found out that there were significant differences in the suggested day of discharge and the hospitalization period after surgery. There were no significant differences in other factors **(Table 3)**.

There were no significant differences in age, operation time, preoperative white blood cell or segmented neutrophil count, discharge suggestion day, and hospitalization period after dividing the total patient group with BMI 23 as thestandard **(Table 4)**[20].

Table 4. Perioperative surgical outcomes in relation to BMI [20]

	BMI < 23	BMI ≥ 23	Pvalue
Patients (n)	45	29	
Age (yr)	23.51 ± 14.34	32.51 ± 15.24	0.286
Operation time (min)	55.22 ± 25.62	64.86 ± 39.25	0.72
Pre.op WBC	11,772 ± 3,620.2	13,011.72 ± 5,137.11	0.244
Pre.op seg. Neutrophil (%)	76.47 ± 11.02	77.79 ± 8.97	0.255
Discharge recommend (POD)	1.47 ± 0.73	2 ± 1.07	0.069
Hospital stay (POD)	2.73 ± 1.05	3.1 ± 1.42	0.233

BMI, body mass index; Pre.op, pre-operative; WBC, white blood cell; seg., segment; POD, post-operative day.

However, in case of perforated appendicitis, the operation time was found to be increased. Their result showed that there were significant operation-time difference between suppurative appendicitis and perforating appendicitis (opposite to the results from study result by Jyrki et al). The average operation time was 58.55 ± 31.79 minutes which was about twenty minute longer compare to the previous study by Jyerki et al. The cause of this increase is thought to be the small size of the incision, which increased the time to secure single trocar insertion, increased equipment collision, and increased the time to restore the abdominal and muscular cavities, hemorrhage or by abscess and adhesion that washing and installation of a drainage tube was performed

The study also had also analyzed on how the BMI value may affect the operation time and the hospitalization period. They stated that there was no significance in the effects of BMI on the operation time, the hospitalization period, and the complications.

Another important issue in relation to the feasibility of SILS technique for performing exploratory laparoscopy is when normal appendix was encountered and the nature of the disease should be determined. Again in this study, Jyerki et a proposed that a proper diagnostic laparoscopy can be performed by SILS technique relatively easily and rapidly [16]. Even the examination of distal ileum, female genital organs, and other organs situated in pelvic area could be accomplished.

According to literature, obese patients were especially benefit from laparoscopic appendectomy compared to open surgery [18]. Thus, it is also important that SILS techniques are suitable for this patient population as well.

Table 1, (study by Jyerki et) showed a male patient with BMI 31 who was operated on by SILS technique in a reasonable time and his postoperative recovery was excellent. Although the study experience with the technique was relatively limited, it can be suggested that SILS technique for appendectomy is probably suitable.

In the issue of different techniques use for ligation of appendix in order to find out how feasible they are such as thread loop, absorbable clip, and endoscopic stapler, this study also found out that these options seemed to be suitable for SILS appendectomy[16].

With regard to the fact that SILS produce least visible scar, there has been only one small study in the literature focusing on the issue of the influence of abdominal scar on the cosmesis and body image. That study also showed that there were no difference between open and traditional laparoscopic appendectomies [19] related to scar issue. As the main advantage of the SILS technique is that the visible scar can be avoided (figure 3), further studies stressing this issue should be carried out. Conventional laparoscopic appendectomy produces relatively already small scars thus the superiority of SILS in that respect remains to be shown.

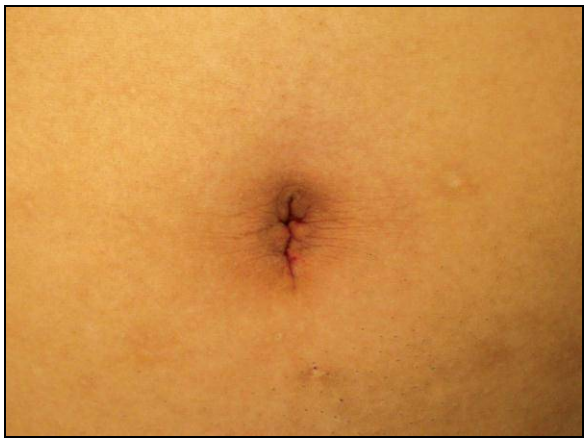

Figure 3 : A barely visible scar of SILS-"better cosmesis"

iii). SILS Procedur specific complication

Although SILS seemed to be promising and offers potential benefits for patients compared to conventional laparoscopy, there are possible disadvantages one should consider. Firstly, this technique may be associated with increased risk of hernias. The technique has made it necessary for fascial incision through the abdominal midline that has been considered to be prone to hernia formation. Further, the fascial incision is more considered more traumatic compared to 10 or 12mm trocar wounds made with dilating trocars. Port site hernia is a rare complication following laparoscopic surgery.

Tonouchi et al[21] reported that the incidence of port site hernia was 0.65%-2.80%. In SILS, the risk is relatively higher due to larger incision length made and then further stretching of the wound edge by the bigger umbilical port. Secondly is in the additional costs caused by the procedure that need specific port and specialized modified instruments that at these era where cost effective has been of high concern, it is a definitely one factor one should take into account.

iv) ***Feasibility and safety of SILS technique-The conclusion***

From literature, we found eight studies that had reported result in favor towards SILS. (22-28). No prospective cliical trial was found. All the study have agreed that Single-port appendectomy may require a longer operative time than laparoscopic appendectomy, but it is a safe and feasible technique with good cosmetic results. It could be one of the alternative methods for treating acute appendicitis

In the end, before we can answer these questions, there needs to be proper randomized, prospective clinical trial and studies with direct comparison between SILS and standard laparoscopy. Theoretically benefits are obvious, but it is unclear whether they will outweigh the potential risks. Similar to the development of laparoscopy, it appears that dissemination of the SILS techniques will precede careful study. Although many surgeons are already performing SILS procedures, disciplined, evidenced-based investigations must be performed to determine the proper place of SILS in surgical practice.

Conclusion

SILS technique is feasible and safe for a variety of appendiceal inflammatory conditions and for diagnostic explorative laparoscopy. The technique suit was even better for obese patients and different technical methods for appendiceal ligation can be easily used. Appendectomy is also may be suitable procedure for the training of SILS technique. However, this technique may have few disadvantages that the true benefit of the technique remains to be shown by the ongoing randomized controlled trials.

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