

Technical approaches to single port/incision laparoscopic appendicectomy: a literature review

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ABSTRACT

INTRODUCTION Single port/incision laparoscopic surgery (SPILS) is a modern advancement toward stealth surgery. Despite the paucity of high-quality scientific studies assessing its effectiveness, this procedure is being used increasingly. This review aims to describe commonly used techniques for SPILS appendicectomies (SPILA), to summarise complication rates in the literature and to provide discussion on indications and implementation.

METHODS All available databases including the Cochrane Central Register of Controlled Trials, MEDLINE® and Embase™ were searched in February 2011 and cross-referenced for available English literature describing SPILA in patients of any age.

RESULTS Three broad technical approaches are described: procedures using laparoscopic instruments through a single skin incision in the abdominal wall, regardless of the number of fascial incisions, with or without the additional use of percutaneous sutures or wires to 'assist' the operation, and hybrid procedures, in which the appendix is exteriorised using a single incision laparoscopically assisted operation but subsequently divided using a conventional 'open' appendicectomy technique. Complication rates seem to be highest in SPILA procedures unassisted by sutures or wires.

CONCLUSIONS Future research assessing the efficacy of single incision laparoscopic procedures should consider variation in technique as a possible factor affecting outcome.

KEYWORDS

Single – Incision – Laparoscopic – Appendicectomy – Techniques

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Single port/incision laparoscopic surgery (SPILS) is a modern advancement toward stealth surgery. The effectiveness of these procedures remains to be proved by well-conducted scientific trials. Increasing interest in novel concepts in surgery is leading to a rise in the number and variation of procedures being performed, and literature reporting them. As appendicectomy is a commonly performed therapeutic procedure, it lends itself neatly as an operation with which to compare current technical approaches to SPILS.

The aims of this review were to provide a brief description of the surgical techniques currently used in performing single port/incision laparoscopic appendicectomy (SPILA), briefly review complications reported in the literature on SPILA and provide general discussion on SPILA and SPILS.

Methods

All available databases including the Cochrane Central Register of Controlled Trials, MEDLINE® and Embase™ were searched in February 2011 and cross-referenced for available English literature describing SPILA in patients of any age. The search was conducted using the keywords: single and one incision/port/trocar/site, invisible, scarless, scar free or transumbilical. There was no restriction on

publication date. Papers included reports of patients admitted for emergency or interval appendicectomies for acute or chronic appendicitis, complicated or simple. Articles were excluded if they provided an inadequate description of surgical methodology, insufficient data on outcomes or if they were 'experimental' reports with fewer than five patients.

Results

The database query yielded 79 references. One randomised controlled trial and thirty-eight case series met the inclusion criteria.^{1–39} All studies reviewed had similar patient inclusion criteria, including both acute cases and interval appendicectomy. There were minor variations in exclusions, including previous surgery, body mass index and ASA (American Society of Anesthesiologists) grade. Most series excluded complicated cases of appendicitis. In those series in which a few complicated cases were operated on, outcomes were not reported separately. Studies had varying sample sizes ranging from 7 to 262. The total number of SPILA performed across the studies was 2,656.

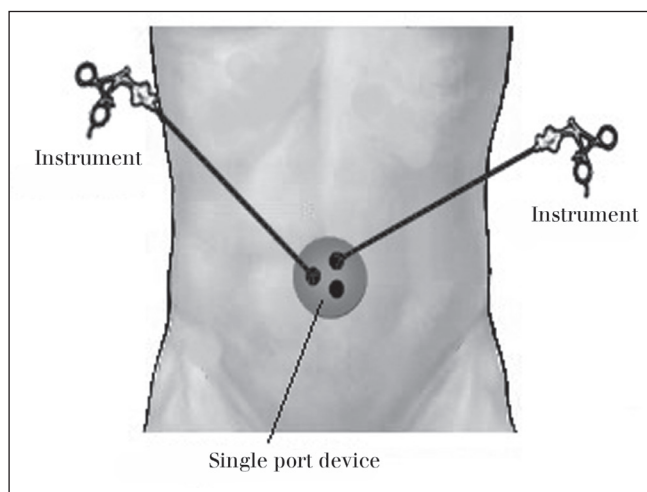


Figure 1 Multi-luminal, single port device placed transumbilically

Surgical techniques

All studies reported a single skin incision through the umbilicus except four,¹⁻⁴ in which surgeons performed an infraumbilical incision. The literature broadly describes three approaches to SPILA referred to throughout this review as:

- > SPILA unassisted: any procedure using specialised or conventional laparoscopic instruments through a single skin incision in the abdominal wall, regardless of the number of fascial incisions
- > SPILA assisted: as SPILA with the additional use of percutaneous sutures or wires to ‘assist’ the operation
- > Hybrid: any procedure in which the appendix was exteriorised using a single incision, laparoscopically assisted operation but divided subsequently using a conventional ‘open’ appendicectomy technique

SPILA unassisted

Twenty studies⁴⁻²⁵ including 584 patients met the definition criteria for ‘SPILA unassisted’ approaches. The use of special multi-conduit ports was reported in four studies¹⁻⁷ (Fig 1). Vidal *et al* made a 25mm transverse, infraumbilical, suprapubic incision in order to place a SILS flexible laparoscopic port (SILS™ port, Covidien, Norwalk, CT, US) in 20 patients.⁴ A 5mm 30° laparoscopic camera was used with 5mm graspers and flexible scissors to dissect the mesoappendix. The appendix was divided using a multifire stapler (Endo GIA™ 30, Covidien). Kössi and Luostarinen performed a transumbilical version of the same procedure using the SILS™ port but used straight and curved graspers, and ligated the appendix with an absorbable suture material (Endoloop®, Ethicon Inc, Somerville, NJ, US) before sharply dividing the appendix with laparoscopic scissors.⁵ SILS devices were removed preceding extraction of the appendix.

Fourteen ‘SPILA unassisted’ studies described the use of conventional laparoscopic equipment without commercially available, specialised ‘single ports’. Techniques placing multiple ports through closely spaced fascial incisions

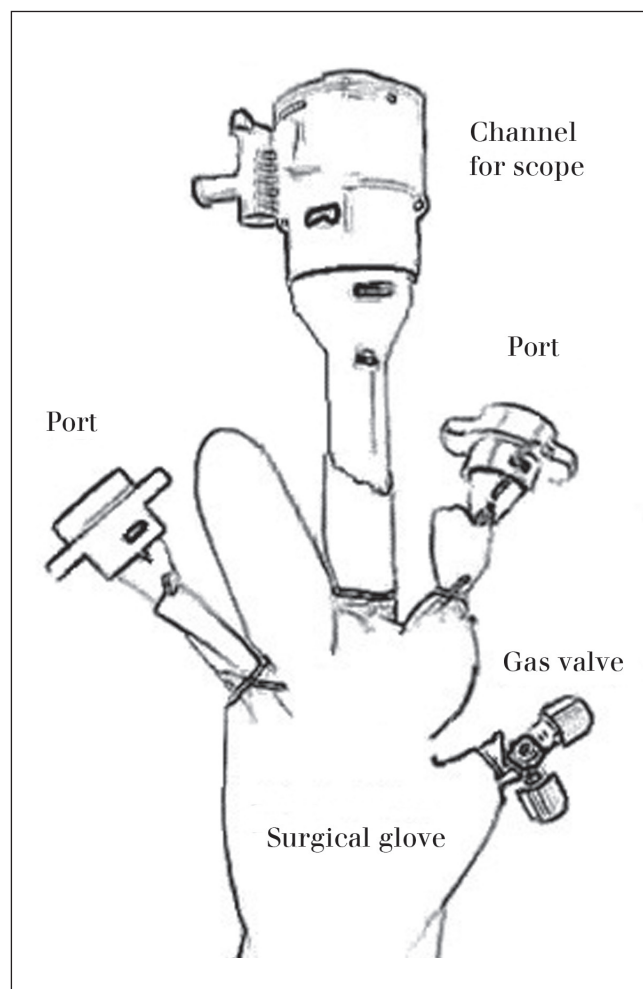


Figure 2 Improvised single port device using surgical glove

with a single abdominal skin incision were reported in ten studies.⁸⁻¹⁷ Generally, papers described the introduction of three trocars through the fascia, two providing channels for instruments and one providing access for a 5–10mm laparoscopic camera with an angulated lens. In studies where three ports were not placed, a third instrument, often a grasper, was placed directly through a fascial stab incision.^{8,9} A single study used only two 5mm ports, though which a 4mm 30° camera, bipolar cautery and absorbable suture material could be placed.¹⁰ The authors enlarged one of their port sites to retrieve the appendix.

Dapri *et al* described a transumbilical SPILA technique using curved instruments whereby a single 11mm trocar alongside a 5mm instrument (introduced through stab incision) were contained within a purse string suture in the umbilical fascia to provide a ‘tight seal’.¹¹ A separate 5mm opening for additional instruments was made outside the purse string within the umbilical fascia. Rothenburg *et al* placed a 5mm single instrument through a separate stab wound incision or 5mm port suprapubically to aid the SPILA procedure.¹² Palanivelu *et al* achieved successful SPILA

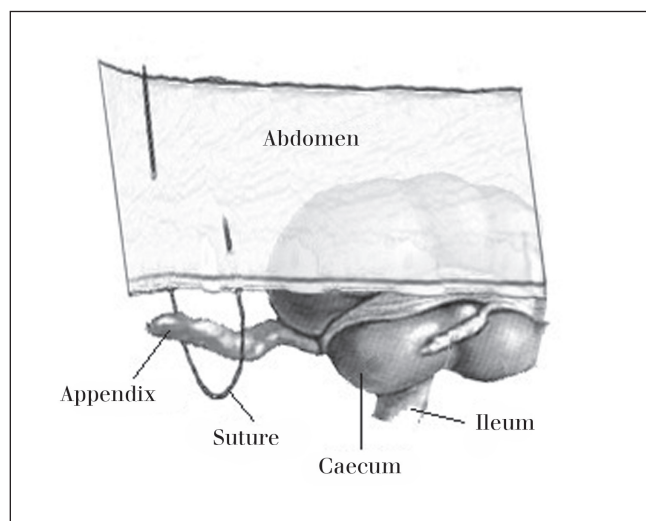


Figure 3 Suspensory suture passed through abdominal wall and around appendix to create sling

procedures in children with only a 15mm trocar and double channel endoscope.¹⁸

The 'surgical glove' method (in which trocars are placed through the holes of a surgical glove with cut fingertips and the 'device' is subsequently applied to a retractor inserted into the abdomen through a single transumbilical incision) was described by Park *et al*,¹⁹ Kim *et al*²⁰ and Lee *et al*²¹ in 20, 43 and 75 patients respectively (Fig 2). The surgical glove can be considered an improvised multi-luminal single port device. CO₂ insufflation was achieved through the glove in at least two of the studies.

SPILA assisted

Five studies^{1,24-27} reported SPILA procedures that were 'assisted' with a transabdominal sling suture, or wire, to suspend the appendix (Fig 3). All studies described the introduction of instruments through a single umbilical incision with a single port or multiple closely spaced ports. Suspension of the appendix was achieved with various methods. Jiang *et al* suspended the root of the appendix intracorporeally with fine copper wire once identified.²⁴ Roberts achieved suspension of the appendix by creating an innovative, intracorporeal 'pulley'.¹ An 'air' loop was tied in the internal anterior wall of the abdomen that functioned as an axle through which a separate 'string' with a looped end was threaded and passed around the appendix; the opposite end rested outside the umbilical port.

Three studies²⁵⁻²⁷ used suture material introduced percutaneously. Akgür *et al* placed a 16G angiographic catheter transabdominally in the lower right quadrant through which a folded polypropylene suture could be introduced to function as a 'grasper'.²⁵ Ateş *et al*²⁶ and Lee *et al*²⁷ inserted a suture in the right lower quadrant percutaneously and subsequently through the mesoappendix under visualisation of a laparoscope. The tip of the needle was then exteriorised, allowing the appendix to be pulled toward the abdominal

wall. Following dissection of the mesoappendix, the authors of all three studies ligated the appendix with a fishermen's knot tied extracorporeally, allowing the appendix to be divided intracorporeally over the ligature, with laparoscopic scissors.

Hybrid

Fourteen articles^{2,5,28-59} reported a hybrid approach to appendicectomy in which a single abdominal incision facilitated the use of laparoscopic equipment to exteriorise the appendix, subsequently allowing a conventional 'open' appendicectomy to be performed. All authors described the use of a single transumbilical port through which a laparoscope with a working channel was used to identify and exteriorise the appendix. Open appendicectomy was performed, the appendix coagulated, iodised and repositioned. Most authors explicitly mentioned reinflating the abdomen after returning the appendix to assess haemostasis.

Complication rates

No mortality was recorded for any of the procedures. The highest number of intraoperative complications, including serosal injury, intra-abdominal haemorrhage and perforation, was reported by Muensterer *et al* (4/75, 5%)⁹ and the highest rate by Palanivelu *et al* (2/8, 25%).¹⁸ Both groups of authors describe the SPILS unassisted approach to SPILA.

Generally, there were very few wound infections reported in the literature. The highest rates were reported by Min *et al* (2/10, 20%)¹⁵ and Visnjic *et al* (4/29, 14%),²⁸ using 'SPILA unassisted' and 'hybrid' methods respectively. The highest number of postoperative complications overall was reported by Valla *et al* (10/200, 5%),⁵ who used a 'hybrid' approach to SPILA. The highest rates, however, were reported in papers using the 'SPILA unassisted' technique (2/10, 20%).¹⁵ There were six intra-abdominal abscesses across all of the studies: five were reported in four 'SPILA unassisted' papers^{9,11,19,21} and one in a 'hybrid' paper.²⁹

In total, complication rates appear to be highest for those procedures in which SPILA is not assisted by sutures or wire. Table 1 summarises complications reported in the literature according to technique.

Discussion

In its early days, laparoscopic appendicectomy failed to gain unequivocal acceptance by the surgical community. Today, it is a commonly practised and accepted emergency procedure.⁴⁰

Although claims of enhanced recovery and pain as well as blood loss and complication reduction as compared with conventional laparoscopic and open procedures have yet to be substantiated objectively, single port/incision laparoscopic procedures are increasingly being performed.^{4,12,25} Although level 1 and 2 evidence is still awaited, there are a lot of available data suggesting that it could be a safe and reproducible method of surgery. Currently, there are clinical trials being conducted that will provide important level 1 evidence for this new approach. (See <http://clinicaltrials.gov/>.)

Table 1 Complications reported in the literature, stratified according to technique

	SPILS unassisted (20 studies)	SPILS assisted (5 studies)	Hybrid (14 studies)
Intra-operative	9/584 (1.54%)	1/409 (0.24%)	1/1,511 (0.07%)
Serosal injury	1	0	1
Haemorrhage	7	0	0
Perforation	1	0	0
Other	0	0	0
Undefined	0	1	0
Post-operative	39/584 (6.68%)	10/409 (2.44%)	47/1,511 (3.11%)
Wound infection	17	1	15
Wound haematoma	2	0	4
Intra-abdominal abscess	5	0	1
Intra-abdominal fluid	3	0	6
Intra-abdominal haemorrhage	2	0	0
Ileus	3	1	0
Other	4	8	11
Undefined	3	0	10
Total complications	48/584 (8.22%)	11/409 (2.69%)	48/1,511 (3.18%)
Conversion	20/584 (3.42%)	7/409 (1.71%)	61/1,511 (4.04%)
To conventional	16	0	16
To open operation	4	7	45
Additional trocar use	25	13	54
Mortality	0 (0%)	0 (0%)	0 (0%)

SPILS = single port/incision laparoscopic surgery

The surgical technologies industry has developed a vast range of multi-conduit, single port devices and specialised laparoscopic instruments with flexible handles and tips. This equipment may be useful in more complex procedures by restoring some of the triangulation lost with a single port approach when compared with conventional laparoscopic surgery. However, 'hybrid' methods such as removal of the appendix extracorporeally in appendicectomy may be an alternative to expensive intracorporeal devices.

Generally, studies identified for this review described a single umbilical skin incision with single or multiple fascial incisions to achieve access to the peritoneal cavity. Reduced scarring is the most evident advantage of SPILS. Optimal cosmetic results are obtained through intraumbilical incision as the scar will be concealed within the umbilicus but a major concern may be injury to the epigastric vessels.⁴¹ Advantages to infraumbilical or suprapubic incisions include safety and reduced risk of incisional hernia.⁴² SPILS may increase hernia risk as they necessitate midline fascial incisions. Furthermore, some authors consider large single fascial incisions to be more traumatic than a few 5mm or 12mm wounds by dilating trocars.⁵

As it is based loosely on current practice, surgeons may embrace SPILS more willingly than other novel surgical procedures (eg natural orifice transluminal endoscopic surgery [NOTES]). Intraoperative procedure-related challenges include instrument crowding ('sword fighting') and cross-over, limited 'inline' single axis view and inadequate retraction (overcome by the 'hybrid' approach).⁴⁵

Problems inherent to SPILA include concerns over accidental tears when manipulating friable appendices, resulting in abdominal contamination, and port site contamination, given that the inflamed appendix makes direct contact with the wound (especially with 'hybrid' methods).⁵⁰ Navigating instruments in obese patients, in whom the umbilicus ceases to function as a useful landmark for distance to target organ, can further increase the difficulty of the procedure.⁴⁵

Complication rates obtained from SPILA case series appear similar to conventional laparoscopic and open appendicectomy procedures.⁴⁰ At the beginning of the learning curve, patient selection is essential to avoid conversions and lengthy operating times. It is therefore reasonable to assume that patients in the current literature are of favourable selection operated on by experienced and motivated

surgeons, meaning any trends noted are not entirely valid. 'SPILA unassisted' procedures are possibly the most technically challenging of the three approaches described. This may account for the higher intraoperative and postoperative complication rates. A similar case may be made for other SPILS procedures.

There is a known bias of publication with novel techniques in surgery whereby positive findings are often published ahead of negative.⁴⁴ The majority of published literature on SPILA is only two years old and therefore negative results are not so likely to have been published yet.

Conclusions

As an umbrella term for a wider range of operations including liver resection, colectomy, splenectomy and cholecystectomy, SPILS may be a bridge between standard laparoscopic techniques and complete stealth surgery (ie NOTES, which still faces technical and technological limitations). SPILS does not incur the safety problems associated with opening and closing viscera (oesophagus, vagina, colon) and can be converted quickly and easily to multiport laparoscopic or open surgery.

Although feasible, it is technically challenging. Once the learning curve is over, adequately powered randomised controlled trials will be needed to investigate whether the benefits to the patient overcome the technical and technological cost. At present, meta-analysis is not possible. Due to the nature of the currently available evidence, it is difficult to comment specifically on which technical approaches to SPILA are most effective and difficult to generalise for other SPILS procedures. In assessing the efficacy of SPILS, future research should give consideration to the variation in procedural technique as this may alter outcomes.

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