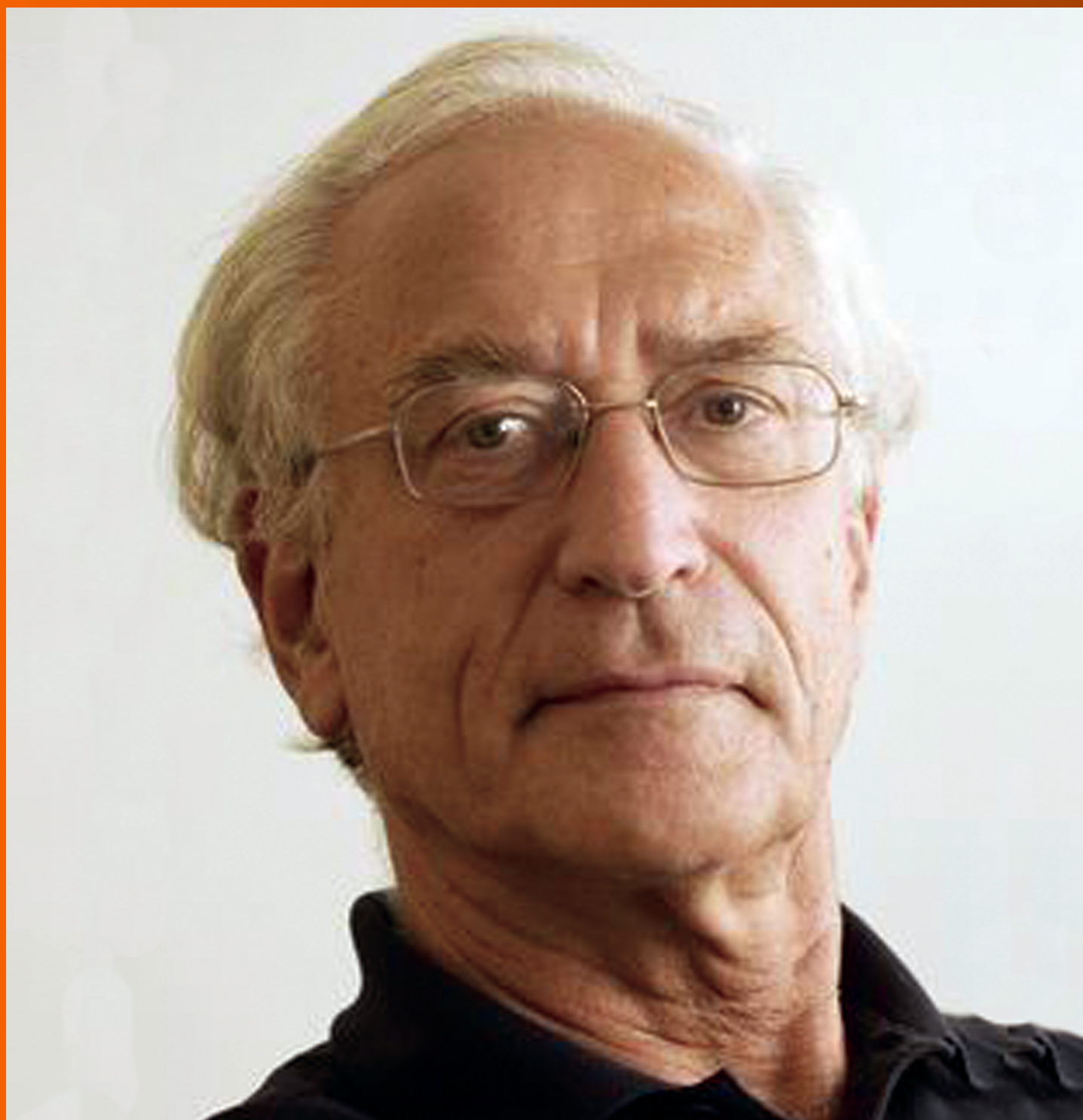


World Journal of *Gastrointestinal Surgery*

World J Gastrointest Surg 2019 March 27; 11(3): 117-197





EDITORIAL

- 117 Classification and guidelines of hemorrhoidal disease: Present and future
Rubbini M, Ascanelli S
- 122 Liver preservation prior to transplantation: Past, present, and future
Chedid MF, Pinto MA, Juchem JFG, Grezzana-Filho TJM, Kruel CRP

REVIEW

- 126 Liver graft preservation methods during cold ischemia phase and normothermic machine perfusion
Tchilikidi KY
- 143 Management of pancreatic head adenocarcinoma: From where to where?
Dolay K, Malya FU, Akbulut S

MINIREVIEWS

- 155 Conduit necrosis following esophagectomy: An up-to-date literature review
Athanasiou A, Hennessy M, Spartalis E, Tan BHL, Griffiths EA

ORIGINAL ARTICLE

Prospective Study

- 169 Learning curve of enhanced recovery after surgery program in open colorectal surgery
Lohsiriwat V

SYSTEMATIC REVIEW

- 179 Single incision laparoscopic fundoplication: A systematic review of the literature
Perivoliotis K, Sarakatsianou C, Tepetes K, Baloyiannis I

CASE REPORT

- 191 Laparoscopic celiac plexus ganglioneuroma resection: A video case report
Hemmati P, Ghanem O, Bingener J

ABOUT COVER

Editorial Board of *World Journal of Gastrointestinal Surgery*, Robert AFM Chamuleau, MD, PhD, Professor, Department of Hepatology, Academic Medical Center, University of Amsterdam, Amsterdam BK 1105, Netherlands

AIMS AND SCOPE

World Journal of Gastrointestinal Surgery (*World J Gastrointest Surg*, *WJGS*, online ISSN 1948-9366, DOI: 10.4240) is a peer-reviewed open access academic journal that aims to guide clinical practice and improve diagnostic and therapeutic skills of clinicians.

The *WJGS* covers topics concerning micro-invasive surgery; laparoscopy; hepatic, biliary, pancreatic and splenic surgery; surgical nutrition; portal hypertension, as well as associated subjects. The current columns of *WJGS* include editorial, frontier, diagnostic advances, therapeutics advances, field of vision, mini-reviews, review, original articles, case report, etc.

We encourage authors to submit their manuscripts to *WJGS*. We will give priority to manuscripts that are supported by major national and international foundations and those that are of great basic and clinical significance.

INDEXING/ABSTRACTING

The *WJGS* is now abstracted and indexed in PubMed, PubMed Central, Emerging Sources Citation Index (Web of Science), China National Knowledge Infrastructure (CNKI), China Science and Technology Journal Database (CSTJ), and Superstar Journals Database.

**RESPONSIBLE EDITORS
FOR THIS ISSUE**

Responsible Electronic Editor: Yan-Liang Zhang Proofing Editorial Office Director: Jin-Lei Wang

NAME OF JOURNAL

World Journal of Gastrointestinal Surgery

ISSN

ISSN 1948-9366 (online)

LAUNCH DATE

November 30, 2009

FREQUENCY

Monthly

EDITORS-IN-CHIEF

Varut Lohsirirawat, Shu-You Peng

EDITORIAL BOARD MEMBERS

<https://www.wjgnet.com/1948-9366/editorialboard.htm>

EDITORIAL OFFICE

Jin-Lei Wang, Director

PUBLICATION DATE

March 27, 2019

COPYRIGHT

© 2019 Baishideng Publishing Group Inc

INSTRUCTIONS TO AUTHORS

<https://www.wjgnet.com/bpg/gerinfo/204>

GUIDELINES FOR ETHICS DOCUMENTS

<https://www.wjgnet.com/bpg/GerInfo/287>

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH

<https://www.wjgnet.com/bpg/gerinfo/240>

PUBLICATION MISCONDUCT

<https://www.wjgnet.com/bpg/gerinfo/208>

ARTICLE PROCESSING CHARGE

<https://www.wjgnet.com/bpg/gerinfo/242>

STEPS FOR SUBMITTING MANUSCRIPTS

<https://www.wjgnet.com/bpg/GerInfo/239>

ONLINE SUBMISSION

<https://www.f6publishing.com>

Single incision laparoscopic fundoplication: A systematic review of the literature

Konstantinos Perivoliotis, Chamaidi Sarakatsianou, Konstantinos Tepetes, Ioannis Baloyiannis

ORCID number: Konstantinos Perivoliotis (0000-0002-6622-5734); Chamaidi Sarakatsianou (0000-0002-9509-581X); Konstantinos Tepetes (0000-0001-9435-6849); Ioannis Baloyiannis (0000-0002-6050-3000).

Author contributions: Baloyiannis I contributed to study conception and design; Perivoliotis K and Sarakatsianou C contributed to acquisition of data, analysis and interpretation of data; Perivoliotis K contributed to drafting of manuscript; Tepetes K and Baloyiannis I contributed to critical revision.

Conflict-of-interest statement: The authors declare no potential conflicts of interest.

PRISMA 2009 Checklist statement: This Systematic Review was conducted according to PRISMA Guidelines.

Open-Access: This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

Manuscript source: Invited

Konstantinos Perivoliotis, Konstantinos Tepetes, Ioannis Baloyiannis, Department of Surgery, University Hospital of Larissa, Larissa 41110, Greece

Chamaidi Sarakatsianou, Department of Anesthesiology, University Hospital of Larissa, Larissa 41110, Greece

Corresponding author: Ioannis Baloyiannis, MD, PhD, Assistant Professor, Department of Surgery, University Hospital of Larissa, Mezourlo, Larissa 41110, Greece.

ibalogian@med.uth.gr

Telephone: +30-241-3502731

Abstract

BACKGROUND

Fundoplication, was first introduced as a surgical treatment method of gastroesophageal reflux disease. Consequently, several modifications of this method have been described, whereas laparoscopic fundoplication was recently introduced. Although single incision (SI) fundoplication was considered as an alternative to the conventional laparoscopic approach, several studies reported an increased operation duration, and high rates of multiport conversion and incisional hernia.

AIM

To provide a current overview of the technical variations and the postoperative outcomes of patients submitted to SI fundoplication.

METHODS

The present systematic review of the literature was designed and conducted on the basis of the PRISMA guidelines. A systematic screening of the electronic scholar databases (Medline, Scopus and Web of Science) was performed.

RESULTS

Literature search resulted in the identification of 19 studies. Overall, 266, 137 and 110 SI Nissen, Dor and Toupet fundoplications were reported, respectively. In the majority of the trials, standard laparoscopic instruments were used. The left liver lobe was displayed through the use of forceps, graspers, retractors, drains or even glue. Both intra-corporeal and extracorporeal suturing was described. Mean operative time was 136.3 min. Overall complication rate was 5.2% and the rate of incisional hernia was 0.9%. No mortality was reported.

CONCLUSION

manuscript

Received: February 10, 2019

Peer-review started: February 11, 2019

First decision: February 26, 2019

Revised: March 12, 2019

Accepted: March 16, 2019

Article in press: March 16, 2019

Published online: March 27, 2019

P-Reviewer: Amorniyotin S, Morini S

S-Editor: Ji FF

L-Editor: A

E-Editor: Zhang YL


Due to the methodological heterogeneity and the lack of high quality studies comparing multi to single access techniques and the several variations, we conclude that further well designed studies are necessary, in order to evaluate the role of SI fundoplication.

Key words: Single incision; Single port; Fundoplication; Nissen; Dor; Toupet

©The Author(s) 2019. Published by Baishideng Publishing Group Inc. All rights reserved.

Core tip: This systematic review summarizes all available data about the use of single incision laparoscopic fundoplication. Although the technique is not yet standardized, this study validates the safety and efficacy of the single port approach compared to conventional multiport approach.

Citation: Perivoliotis K, Sarakatsianou C, Tepetes K, Baloyiannis I. Single incision laparoscopic fundoplication: A systematic review of the literature. *World J Gastrointest Surg* 2019; 11(3): 179-190

URL: <https://www.wjgnet.com/1948-9366/full/v11/i3/179.htm>

DOI: <https://dx.doi.org/10.4240/wjgs.v11.i3.179>

INTRODUCTION

Fundoplication, the wrap of the gastric fundus around the distal part of the esophagus, was introduced by Nissen^[1] in 1956, as a surgical treatment of gastroesophageal reflux disease (GERD), and is currently considered as the operation of choice, when conservative approaches fail^[2]. Since the extent of the plication was correlated with postoperative functional complications, various modifications (*e.g.*, Hill, Toupet) of the original technique have been described^[3-5]. Besides these, fundoplication has been, also, an important restoration element in other procedures, such as, Heller myotomy for esophageal achalasia^[6].

The implementation of the minimal invasive principles in fundoplication, was justified under the auspice of a better cosmetic result, reduced postoperative pain and a faster recovery^[7]. However, proponents of the open approach, linked laparoscopy to increased perioperative costs, pneumoperitoneum related complications, and technical difficulties leading to a steeper learning curve, such as, narrowing of the field of vision, fixed instrument positions and loss of freedom degrees^[8]. Due to the fact that subsequent studies, associated laparoscopic fundoplication with a reduced length of hospital stay (LOS), return to daily activities and overall morbidity, resulted in the establishment of laparoscopy as the gold standard approach^[7,9].

In order to further enhance the advantages of minimally invasive operations, single incision (SI) laparoscopic surgery was introduced. Navarra *et al*^[10], in 1997, reported the first SI cholecystectomy, whereas Hamzaoglu *et al*^[11], performed the first single incision laparoscopic surgery (SILS) Nissen in 2010. Single port fundoplications, although characterized by minimization of postoperative scars and better cosmesis, are more demanding in terms of laparoscopic skills, due to the inert loss of triangulation and intraoperative instrument clashing^[12]. Although, initial studies comparing SILS fundoplications to the conventional multiport approaches, reported that the two techniques were comparable in terms of efficacy and safety^[13,14], the increased operative time and the high rate of conversion to multiport and port-site hernia were considered as inhibitory factors for the wider acceptance of the method^[13].

Therefore, taking into consideration the above mentioned body of evidence, the present systematic review of the literature was designed and conducted. Our study, mainly, focuses in providing a comprehensive appraisal of the intraoperative technical variations and the postoperative outcomes in adult patients submitted to SI fundoplication.

MATERIALS AND METHODS

Study protocol

The PRISMA guidelines were utilized for the completion of this systematic review^[15].

Eligibility criteria

All human trials that reported results on SI fundoplication, with an adult study population, whose outcomes of interest were reported in English and were retrievable, were considered as eligible. Eligible studies should provide perioperative results (*i.e.*, complication, mortality or conversion rates, operation duration and follow up) on SI fundoplication. Exclusion criteria for this systematic review were studies: (1) with a pediatric study sample; (2) with no outcome of interest; (3) with inadequate outcome data; (4) without human objects; or (5) in the form of reviews, editorials, letters, conference abstracts and expert opinions.

Literature search

A systematic screening of the literature available in the electronic scholar databases (Medline, Scopus and Web of Science) was performed. The last search date was 2/1/2019. The following keywords were used: "SILS", "single site", "single port", "single incision", "laparoendoscopic single site", "fundoplication".

Study selection and data collection

After the completion of the literature search, the duplicate entries were identified and removed. The next step included the screening of titles and abstracts. Finally, the remaining articles were submitted to a full text review, in order to assess consistency with the above mentioned eligibility criteria. All electronic search, study selection and data extraction were performed in duplicate and blindly by two independent investigators (PK and SC). In case of a discrepancy, through mutual discussion and revision, a consensus was reached. If the disagreement was not resolved, the opinion of a third investigator was considered (BI).

Data extraction included the recording of data regarding the included studies (first author, country and type of study, follow up, number and experience of surgeons, sample size and gender, age and body mass index (BMI) allocation of the patients), patient characteristics (ASA score, previous operations and surgery indication), technical characteristics (single port device, instrument type, liver retraction method, dissection device, boogie size, suturing method and pneumoperitoneum pressure) and perioperative outcomes (operation duration LOS, blood loss and conversion, complications, recurrence mortality and incisional hernia rates).

Only the information available in the full text article of the trials were reported. In case that the mean and the standard deviation (SD) of the continuous variables were not provided, then they were estimated from the respective median, range or interquartile range, according to the formula by Hozo *et al*^[16]. Moreover, outcome percentages were calculated according to the following formula: Total number of events regarding a specific complication/Sum of patients sample of studies reporting the specific complication.

RESULTS

Study selection

The application of the search algorithm resulted in the identification of 2040 records (Figure 1). More specifically, 746, 1102 and 192 citations were retrieved through Medline, Web of Science and Scopus, respectively. After the removal of the duplicate entries, 1444 titles and abstracts were screened. In this phase, 1404 records (5 conference abstracts or letters, 10 non human studies, 86 reviews or meta-analyses and 1303 irrelevant studies) were excluded. The next step included the full text screening of the remaining 40 articles, on the basis of the inclusion criteria. In total 21 full text articles were not considered as eligible (2 trials with inadequate data, 8 trials with duplicate patient data and 11 irrelevant studies). Therefore, 19 studies^[11,12,14,17-32] were included in our systematic review.

Study characteristics

The characteristics of the included studies are summarized in Table 1. Publication year ranged from 2010^[11] to 2016^[14,30]. Although initial references consisted of case reports^[11,12,18,23,27,29], subsequent trials included retrospective^[14,19-22,24-26,30,31] and prospective^[17,32] studies. All eligible trials were performed in a single institution. Regarding the operation type, 14 studies^[11,12,17-26,30,31] reported on Nissen fundoplication, whereas Dor and Toupet fundoplication was performed in 6^[14,25,27-29,32] and 1 trial^[17], respectively. Although the number of operating surgeons ranged from 1^[22,24,27] to multiple^[14,19,30,32], experience in laparoendoscopic techniques was documented only in 3^[24,26,27] studies. In total, 513 patients were submitted to a SI laparoscopic fundoplication. More specifically, 266, 137 and 110 SI Nissen, Heller and Dor and

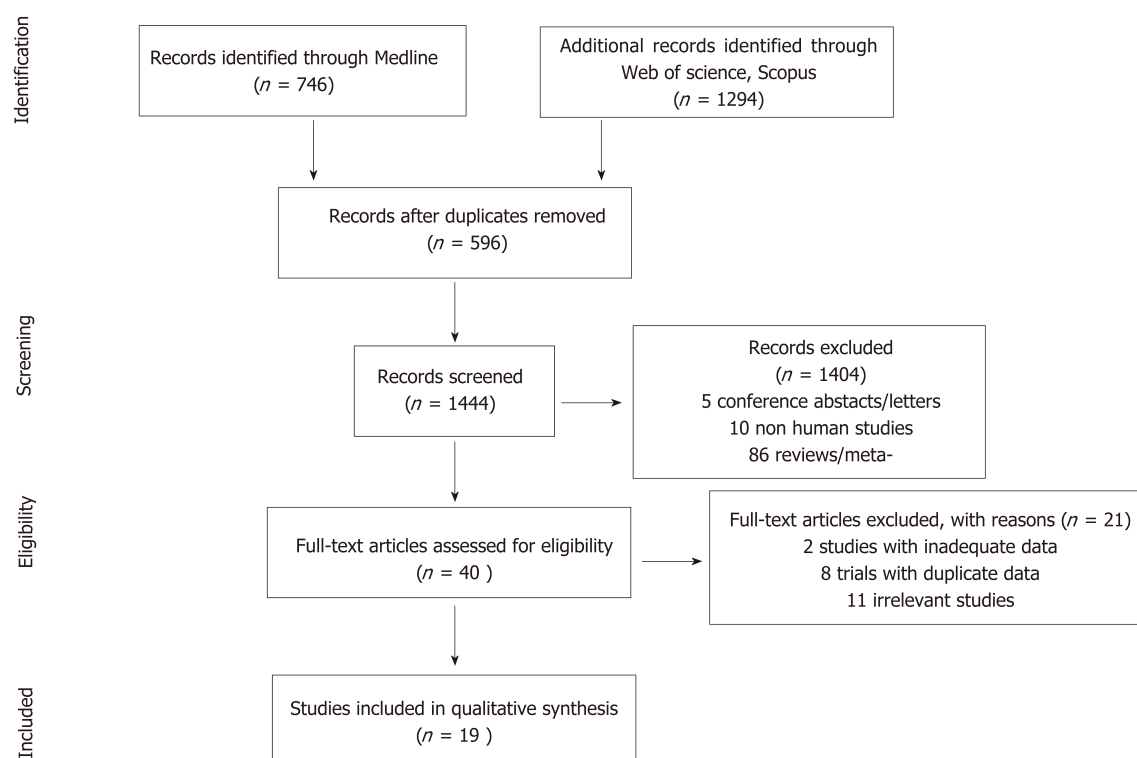


Figure 1 Study flow diagram.

Toupet funduplications were recorded, respectively. Mean age, gender and BMI allocation is, also, displayed in Table 1. Mean follow up period extended from 1 wk^[11] to 60 mo^[26].

Data considering the ASA classification of the included patients were systematically not provided (Table 2). The indications for performing surgery were hiatus hernia^[18,25] and GERD^[11,12,17,19-24,26,30,31] for the Nissen and Toupet fundoplication and achalasia^[14,27-29,32] for the Heller myotomy and Dor fundoplication. Reports were inconsistent, regarding the included patients that had undergone a previous abdominal operation.

Despite the fact that, in the majority of the included studies (Table 3), a commercial SP device, such as SILSTM^[11,18-22], Triport PlusTM^[32], WrapdiskTM^[28], X-CONE^[19], or EZ AccessTM^[14], was applied, several trials^[12,14,19,20,23,25,29,32] reported the introduction of conventional or low profile trocars through a single abdominal incision. In most operations^[14,21,22,25,28,30], conventional laparoscopic instruments were used. However, the application of articulating^[11,12,18,21,27,32] or curved^[23] instruments has, also, been described. Heterogeneity in terms of the liver retraction method was identified. Several techniques, such as, the use of forceps^[14], graspers^[23], retractors^[11,17,19,20,24,32], drains^[28,29] or even glue^[25], have been documented for the elevation and displacement of the liver left lobe. In the larger part of the included trials^[11,12,14,17,18,20,22,25,27,32], commercial energy devices were applied for tissue dissection. A transesophageal boogie was used only in 4 studies^[12,22,23,29], and the respective diameter ranged from 32Fr^[22] to 60Fr^[12]. Intracorporeal suturing with conventional sutures was documented in 4 trials^[23,25,29,32]. In the remaining trials, extracorporeal suturing^[22], EndostichTM^[12,17,18,20,32], SILS STICH^[11], or V LockTM sutures^[17] were applied. The intraabdominal pneumoperitoneum pressure spanned from 8 mmHg^[28] to 15 mmHg^[12,26].

Although no conversion to open was reported, the multiport conversion rates for Nissen and Dor funduplications were 9.8% and 14%, respectively (Table 4). Mean overall operation duration was 136.3 min. The mean operative time for Nissen fundoplication was 130.7 min. Similarly pooled LOS was 2.49 d. Mean intraoperative blood loss was retained at very low levels (17.04 mL). Overall morbidity rate was estimated at the rate of 5.2%. No mortality event was documented. In all subgroups, recurrence of primary symptoms was minimal (0%). The rate of postoperative incisional hernia was calculated at the level of 0.9%.

Table 1 Included studies

Included studies													
ID	Ref.	Country	Type of study	Center	Year	Operation type	Surgeons	Experience	Sample	Gender (M/F)	Age	BMI	Follow up
27417943	Buckley <i>et al</i> ^[20]	United States	Retrospective	Single center	2016	Nissen	3	No	21	n/a	n/a	n/a	34 (8.3) mo
26350663	Sukharamwala <i>et al</i> ^[17]	United States	Prospective	Single center	2015	Nissen	n/a	n/a	190	67/123	55(14.7)	27(3.9)	n/a
24960483	Agaba <i>et al</i> ^[26]	United States	Retrospective	Single center	2014	Nissen	2	Yes	3	n/a	n/a	n/a	60 mo
24686364	Galvani <i>et al</i> ^[24]	United States	Retrospective	Single center	2014	Nissen	1	Yes	2	0/2	43.4 (4)	22(3)	n/a
24615563	Wu <i>et al</i> ^[25]	China	Retrospective	Single center	2014	Nissen	n/a	n/a	5	n/a	n/a	n/a	1 mo
23585169	Strzalka <i>et al</i> ^[31]	Poland	Retrospective	Single center	2013	Nissen	n/a	n/a	1	n/a	n/a	n/a	n/a
10.5336/medsci.2012-31954	Yilmaz <i>et al</i> ^[22]	Turkey	Retrospective	Single center	2013	Nissen	1	n/a	10	3/7	35(8.5)	24.6 (3)	n/a
22146016	Eyuboglu <i>et al</i> ^[20]	Turkey	Retrospective	Single center	2012	Nissen	n/a	n/a	22	5/17	28(5.75)	n/a	8 mo
20306152	Miyazaki <i>et al</i> ^[19]	Japan	Retrospective	Single center	2012	Nissen	Surgical team	n/a	4	2/2	52.5 (11.7)	20.9 (1.1)	n/a
22278618	Mizuno <i>et al</i> ^[21]	Japan	Retrospective	Single center	2012	Nissen	n/a	n/a	2	1/1	65.5 (13.4)	30.5 (0.7)	18 mo
21991503	Barbaros <i>et al</i> ^[18]	Turkey	Case report	Single center	2011	Nissen	n/a	n/a	1	1/0	29	n/a	n/a
21059609	Dapri <i>et al</i> ^[23]	Belgium	Case report	Single center	2011	Nissen	n/a	n/a	1	0/1	21	n/a	6 mo
21471786	Hawasli <i>et al</i> ^[12]	United States	Case report	Single center	2011	Nissen	n/a	n/a	1	0/1	36	29	1 wk
20306152	Hamzaoglu <i>et al</i> ^[11]	Turkey	Case series	Single center	2010	Nissen	n/a	n/a	3	1/2	40(17.5)	26.3 (4.93)	1 wk
Total									266	79/156	51.05	26.75	19.27
26315292	Fukuda <i>et al</i> ^[14]	Japan	Retrospective	Single center	2016	Heller and Dor	Surgical team	No	10	1/9	53.6 (18.3)	19.7 (2)	n/a
24615563	Wu <i>et al</i> ^[25]	China	Retrospective	Single center	2014	Heller and Dor	n/a	n/a	4	n/a	n/a	n/a	1 mo
23896255	Ross <i>et al</i> ^[32]	United States	Prospective	Single center	2013	Heller and Dor	Surgical team	No	120	56/64	53(17.4)	25(4.7)	33 (7.9) mo
23088902	Yamada <i>et al</i> ^[28]	Japan	Case report	Single center	2013	Heller and Dor	n/a	n/a	1	0/1	56	n/a	12 mo
22218875	Yano <i>et al</i> ^[29]	Japan	Case report	Single center	2012	Heller and Dor	n/a	n/a	1	1/0	31	n/a	n/a
21969159	Nakajima <i>et al</i> ^[27]	Japan	Case report	Single center	2011	Heller and Dor	1	yes	1	1/0	58	n/a	1 mo
Total									137	59/74	52.9	24.59	31.5
26350663	Sukharamwala <i>et al</i> ^[17]	United States	Prospective	Single center	2015	Toupet	n/a	n/a	110	28/82	66(13.2)	26(3.8)	n/a
Total									513	166/312	55.01	25.9	27.6

¹Only data for Nissen extracted- Heller and Dor data duplicate;²In the study of Mizuno *et al*^[21] only data from adult patients extracted. n/a: Not available.

DISCUSSION

The pooled overall complication rate in SI fundoplication was calculated at the level of 5.2%, validating thus the safety profile of the single port approach. This is in accordance to the current literature, where morbidity rate of minimal invasive fundoplication is estimated at 7%-12%^[7,33]. In addition to this, a very small percentage (0.9%) of the operated patients developed incisional hernia at the port site. Based on

Table 2 Patient characteristics

Patient characteristics							
Ref.	Operation type	ASA I	ASA II	ASA III	ASA IV	Previous operation	Indication
Buckley <i>et al</i> ^[30]	Nissen	n/a	n/a	n/a	n/a	n/a	GERD
Sukharamwala <i>et al</i> ^[17]	Nissen	n/a	n/a	n/a	n/a	14	GERD
Agaba <i>et al</i> ^[26]	Nissen	n/a	n/a	n/a	n/a	n/a	GERD
Galvani <i>et al</i> ^[24]	Nissen	n/a	n/a	n/a	n/a	n/a	GERD
Wu <i>et al</i> ^[25]	Nissen	n/a	n/a	n/a	n/a	n/a	Hiatus Hernia
Strzalka <i>et al</i> ^[31]	Nissen	n/a	n/a	n/a	n/a	n/a	GERD
Yilmaz <i>et al</i> ^[22]	Nissen	n/a	n/a	n/a	n/a	n/a	GERD
Eyuboglu <i>et al</i> ^[20]	Nissen	n/a	n/a	n/a	n/a	n/a	GERD
Miyazaki <i>et al</i> ^[19] *	Nissen	n/a	n/a	n/a	n/a	n/a	GERD
Mizuno <i>et al</i> ^{[21]**}	Nissen	n/a	n/a	n/a	n/a	n/a	GERD
Barbaros <i>et al</i> ^[18]	Nissen	n/a	n/a	n/a	n/a	n/a	Hiatus Hernia
Dapri <i>et al</i> ^[23]	Nissen	n/a	n/a	n/a	n/a	n/a	GERD
Hawasli <i>et al</i> ^[12]	Nissen	n/a	n/a	n/a	n/a	n/a	GERD
Hamzaoglu <i>et al</i> ^[11]	Nissen	n/a	n/a	n/a	n/a	n/a	GERD
Fukuda <i>et al</i> ^[14]	Heller and Dor	n/a	n/a	n/a	n/a	n/a	Achalasia
Wu <i>et al</i> ^[25]	Heller and Dor	n/a	n/a	n/a	n/a	n/a	Achalasia
Ross <i>et al</i> ^[32]	Heller and Dor	n/a	n/a	n/a	n/a	5	Achalasia
Yamada <i>et al</i> ^[28]	Heller and Dor	n/a	n/a	n/a	n/a	n/a	Achalasia
Yano <i>et al</i> ^[29]	Heller and Dor	n/a	n/a	n/a	n/a	n/a	Achalasia
Nakajima <i>et al</i> ^[27]	Heller and Dor	n/a	n/a	n/a	n/a	n/a	Achalasia
Sukharamwala <i>et al</i> ^[17]	Toupet	n/a	n/a	n/a	n/a	14	GERD

n/a: Not available; ASA: American Society of Anesthesiologists; GERD: Gastroesophageal reflux disease.

the included studies, the mean operative time was 136.3 minutes. Although SI Nissen and Dor operative times were comparable (130.71 and 138.3, respectively), the duration of SI Toupet procedure was longer (145 min). According to the study of Peters *et al*^[7], the mean operative time of laparoscopic fundoplication was 112.59 minutes. These results, validate the elongation of the procedure time, when the SI approach is implemented. The high multiport conversion rate, reported in previous trials^[14], was not confirmed in our review (12.9%). More specifically, Rao *et al*^[34], reported that the multiport conversion rate in SI surgery ranges from 2% to 40%. In contrast to the considerable treatment failure rates (14.4%) in laparoscopic fundoplication^[7], in our review, recurrence of symptoms in SI, were minimal. Similarly our findings show a comparable LOS (2.49 ds) in SI fundoplication, considering the respective hospitalization duration (4 d) in the multi port approach^[7].

Despite the advantages derived from laparoscopy, minimal invasive techniques require the completion, of a steeper learning curve by the operating surgeon, in order to be performed safely and efficiently^[35-37]. Through systematic repetition of the operative steps, the surgeon accumulates the necessary technical skills and achieves proficiency^[36,37]. The clinical relevance of these, is that the operative volume and the location of an individual on the learning curve is directly associated with postoperative outcomes^[38]. More specifically, in laparoscopic fundoplication the estimated learning curve cut-off value is approximately 20 patients^[39,40]. SI fundoplication is technically more demanding and as so, a larger number of cases would be regarded as necessary for achieving adequacy. According to Ross *et al*^[32], multiport conversion rates in SI Dor fundoplication were minimized after 60 patients, whereas the learning curve for SI Nissen and Toupet fundoplication was calculated at 25 cases^[41]. In our review, single port adequacy, was scarcely reported^[24,26,27]. Since previous experience is linked to perioperative endpoints, like operative time, conversion rate and morbidity, future studies should systematically report the learning curve status of the surgical team.

Although fundoplication is considered by many as a straightforward procedure, the respective minimal invasive application requires the possession of advanced skills, like laparoscopic suturing. Secure laparoscopic knot tying is a difficultly acquired dexterity and it can make the difference between an uneventful postoperative period and an increased morbidity rate^[42,43]. Therefore, in order to

Table 3 Technical characteristics

Technical characteristics									
Ref.	Operation type	Single port device	Instruments	Liver retraction	Dissection device	Boogie	Suturing	Gas	Gas pressure
Buckley <i>et al</i> ^[30]	Nissen	SILS™	Conventional	n/a	n/a	n/a	n/a	n/a	n/a
Sukharamwala <i>et al</i> ^[17]	Nissen	SILS™	n/a	Pretzel Retractor	Monopolar or Ultrasonic dissectors	n/a	Endostich™ or V Lock™	n/a	n/a
Agaba <i>et al</i> ^[26]	Nissen	SILS™	n/a	n/a	n/a	n/a	n/a	n/a	15mmHg
Galvani <i>et al</i> ^[24]	Nissen	n/a	n/a	CINCH™ retractor	n/a	n/a	n/a	n/a	n/a
Wu <i>et al</i> ^[25]	Nissen	Conventional trocars in a single incision	Conventional	Cyanoacrylate glue	Harmonic™	n/a	Intracorporeal	n/a	n/a
Strzalka <i>et al</i> ^[31]	Nissen	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Yilmaz <i>et al</i> ^[22]	Nissen	SILS™	Conventional	Berk technique	Harmonic™	32Fr	Extracorporeally	CO2	13mmHg
Eyuboglu <i>et al</i> ^[20]	Nissen	Conventional trocars in a single incision or SILS™	n/a	Cerrahpasa retractor	Ligasure™ or Monopolar	n/a	Endostich™	n/a	n/a
Miyazaki <i>et al</i> ^[19] *	Nissen	Conventional trocars in a single incision or SILS™ or X-CONET™	n/a	Loop Retractor	n/a	n/a	n/a	n/a	n/a
Mizuno <i>et al</i> ^{[21]**}	Nissen	SILS™	ProSeed™ and Conventional	Loop Retractor	n/a	n/a	n/a	CO2	8mmHg
Barbaros <i>et al</i> ^[18]	Nissen	SILS™	Rotulating	Snowden Pencer™	Ligasure™	n/a	Endostich™	n/a	14mmHg
Dapri <i>et al</i> ^[23]	Nissen	Conventional trocars in a single incision	Dapri™ Karl Storz	Grasper	n/a	34Fr	Intracorporeal	n/a	n/a
Hawasli <i>et al</i> ^[12]	Nissen	Conventional trocars in a single incision	Rotulating	Veress	Sono-surg™	60FR	Endostich™	CO2	15mmHg
Hamzaoglu <i>et al</i> ^[11]	Nissen	SILS™	Rotulating	Istanbul Technique	Harmonic™	no	SILS™ STICH	n/a	n/a
Fukuda <i>et al</i> ^[14]	Heller and Dor	Conventional trocars in a single incision or SILS™ or EZ Access™	Conventional	Mini loop Retractor™ or Forceps	Harmonic™	n/a	n/a	CO2	n/a
Wu <i>et al</i> ^[25]	Heller and Dor	Conventional trocars in a single incision	Conventional	Cyanoacrylate glue	Harmonic™	n/a	Intracorporeal	n/a	n/a
Ross <i>et al</i> ^[32]	Heller and Dor	Conventional trocars in a single incision or SILS™ or Triport Plus™	Rotulating	Retractor	Bipolar or Ultrasonic dissectors	n/a	Intracorporeal or Endostich™	CO2	n/a
Yamada <i>et al</i> ^[28]	Heller and Dor	Wrapdisk™	Conventional	Silicon drain	Monopolar	n/a	n/a	CO2	8mmHg
Yano <i>et al</i> ^[29]	Heller and Dor	Conventional trocars in a single incision	n/a	Penrose drain	Monopolar	56Fr	Intracorporeal	CO2	12mmHg
Nakajima <i>et al</i> ^[27]	Heller and Dor	SILS™	Rotulating	Endo Close™	Monopolar or Enseal™	n/a	n/a	n/a	10mmHg
Sukharamwala <i>et al</i> ^[17]	Toupet	SILS™	n/a	Pretzel Retractor	Monopolar or Ultrasonic dissectors	n/a	Endostich™ or V Lock™	n/a	n/a

n/a: Not available.

Table 4 Perioperative outcomes

Perioperative outcomes										
Ref.	Operation type	Open conversion	Multiport conversion	Operation duration	LOS	Blood loss	Complications	Recurrence	Mortality	Incisional hernia
Buckley <i>et al</i> ^[30]	Nissen	0	n/a	n/a	n/a	n/a	2	0	0	2
Sukharamwala <i>et al</i> ^[17]	Nissen	n/a	n/a	130 (42.7)	2 (1.1)	n/a	n/a	n/a	n/a	n/a
Agaba <i>et al</i> ^[26]	Nissen	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Galvani <i>et al</i> ^[24]	Nissen	0	1	164 (83)	n/a	23 (4)	n/a	n/a	n/a	n/a
Wu <i>et al</i> ^[25]	Nissen	0	0	146 (13)	n/a	n/a	0	0	0	0
Strzalka <i>et al</i> ^[31]	Nissen	0	0	100	1	n/a	0	n/a	0	0
Yilmaz <i>et al</i> ^[22]	Nissen	0	2	93 (14.1)	2.2(0.9)	n/a	0	0	0	0
Eyuboglu <i>et al</i> ^[20]	Nissen	0	0	n/a	1	n/a	0	0	0	0
Miyazaki <i>et al</i> ^[19] *	Nissen	0	2	202.7 (61.1)	15.5 (10.6)	25 (23)	0	0	0	0
Mizuno <i>et al</i> ^{[21]**}	Nissen	0	0	147.5 (45.9)	10 (2)	10 (7)	0	0	0	0
Barbaros <i>et al</i> ^[18]	Nissen	0	0	120	1	n/a	0	0	0	0
Dapri <i>et al</i> ^[23]	Nissen	n/a	n/a	122	2	0	0	0	0	0
Hawasli <i>et al</i> ^[12]	Nissen	0	0	52	1	n/a	0	0	0	0
Hamzaoglu <i>et al</i> ^[11]	Nissen	0	0	190 (17.3)	2	30 (17.3)	0	0	0	0
		0 (0%)	5 (9.8%)	130.71	2.2	21.3	2 (2.8%)	0 (0%)	0 (0%)	2 (2.8%)
Fukuda <i>et al</i> ^[14]	Heller and Dor	0	7	223.5 (46.3)	9.7(2.4)	16 (17.8)	0	0	0	0
Wu <i>et al</i> ^[25]	Heller and Dor	0	0	133 (20)	n/a	n/a	0	0	0	0
Ross <i>et al</i> ^[32]	Heller and Dor	0	12	129 (39.2)	2 (2.7)	n/a	9	n/a	0	0
Yamada <i>et al</i> ^[28]	Heller and Dor	n/a	n/a	248	2	0	0	0	0	0
Yano <i>et al</i> ^[29]	Heller and Dor	n/a	n/a	236	4	0	0	0	0	0
Nakajima <i>et al</i> ^[27]	Heller and Dor	0	0	220	4	10	0	0	0	0
		0 (0%)	19 (14%)	138.3	2.6	13.07	9 (6.5%)	0 (0%)	0 (0%)	0 (0%)
Sukharamwala <i>et al</i> ^[17]	Toupet	n/a	n/a	145 (58.4)	3 (5.2)	n/a	n/a	n/a	n/a	n/a
Total		0 (0%)	24 (12.9%)	136.3	2.49	17.04	11 (5.2%)	0 (0%)	0 (0%)	2 (0.9%)

n/a: Not available.

reduce operative time and complement the inexperience of younger surgeons in intracorporeal knotting, endoscopic suturing devices have been imported in clinical practice, with comparable results^[44-46]. In SILS, the limited working area, the restricted vision, the minimization of the manipulation angle and the parallelization of the optics and hand instruments increases the overall difficulty level^[47,48]. In single port fundoplication, intracorporeal suturing has been extensively performed^[17,23,25,29,32] with various techniques, like side-winding and the utilization of articulating graspers and needle holders^[49]. Alternative approaches were the extracorporeal formation of a knot, with the subsequent completion through a suture passer^[22] and the use of suturing devices^[11,12,17,18,20].

Besides experience with the minimal invasive techniques, successful completion of the intracorporeal laparoscopic operative steps, like suturing or dissection, is associated with the intraoperative setting of the hand instruments. In single port surgery, the access point is usually umbilicus, through which the working ports are introduced^[34]. As a result, the working angle, which should optimally be at about 60°, is significantly reduced^[50,51]. Moreover, in operations like fundoplication, where the distance between the operating site and the access point is increased, the working angle further decreases, and with the synchronous alterations of the elevation angle, the derived ergonomic stress further escalates^[48,49]. Therefore, in order to technically increase the manipulation angle, pre bent and articulating instruments have been introduced. Despite the fact that, simulation studies displayed a difficulty of novice surgeons in using articulating instruments^[52], the combination of an dynamically bending and a pre bent tool minimizes the task completion time^[53]. In the setting of SI fundoplication, both the standard^[14,21,22,27,28,30] and the articulating setup^[11,12,18,27,32] has been applied. Dapri *et al*^[23,54], proposed the use of specialized reusable pre bent instruments that enabled intracorporeal and extracorporeal triangulation, thus avoiding conflict between the instruments and the scope.

Moreover, adequate exposure of the working field is another important factor for the performance of the operative tasks. The efficient displacement of the left liver lobe is a crucial step in SI fundoplication and therefore numerous techniques have been devised. The most simple method, is the use of a working instrument such as forceps^[14] or graspers^[23]. Commercially available retractors have been extensively utilized^[17,18,32]. A long Veress needle has been, also, used as a retractor^[12]. Similarly, relocating of left lobe by silicon drains and elastic loops was described in various cases^[14,19,21,28,29]. Nakajima *et al*^[27], after applying a silk thread in the left triangular ligament with a suturing device, suspended the liver lobe in the epigastric region. Furthermore, Galvani *et al*^[24], used an internal retraction device, which after applying the retraction clip in the pars flaccida, the hook part was placed in the falciform ligament or the parietal peritoneum. The role of cyanoacrylate glue as a retracting method has been also studied^[25]. According to Wu *et al*^[25], the adhesion of the left liver lobe on the diaphragm, using cyanoacrylate glue, is a fast, safe and totally reversible technique.

Since our study is a systematic review of previously published trials, the validity of its estimations is inherently influenced by the methodology of the eligible studies. In this case, the majority of the included trials consisted of, either case reports, or retrospective analyses and only a few prospective studies were identified. In addition to this, most of these series incorporated a small sample size, thus inhibiting the strength of our results. Due to the fact that the learning curve is directly associated with the postoperative outcomes, another bias introducing factor could possibly be the inconsistent reporting of the number of the operating surgeons and their experience in single port surgery. Finally, although the identification of the various technical methodologies was considered as an endpoint in our study, the existence of these variations contributes in the overall heterogeneity levels.

Our study is an attempt to provide an overview regarding the application of SI fundoplication. Pooled results validate the safety and efficacy of the single port approach, although the technique is not yet standardized and many methodological variations have been described. The majority of the trials reporting on SI fundoplication were case reports and studies of a low quality level, without a comparison arm of the conventional multi port procedure and other methodological variations. Therefore, further randomized controlled trials, of a larger sample size are required, in order to draw a safe conclusion considering the application of SI fundoplication.

ARTICLE HIGHLIGHTS

Research background

The implementation of the minimal invasive principles in fundoplication resulted in reduced length of hospital stay, overall morbidity, and earlier return to daily activities. In order to further enhance the advantages of minimally invasive operations, single incision (SI) laparoscopic fundoplication was introduced.

Research motivation

Several studies comparing SI laparoscopic fundoplications to the conventional multiport approaches reported an increased operation duration, and high rates of multiport conversion and incisional hernia.

Research objectives

This study was designed in order to provide a comprehensive appraisal of the intraoperative

technical variations and the postoperative outcomes in patients submitted to SI fundoplication.

Research methods

A systematic review of the literature available, in the electronic scholar databases (Medline, Scopus and Web of Science) was performed. All human trials that reported results on SI fundoplication, with an adult study population were considered eligible to be included in the study.

Research results

In total, 19 studies were included in this systematic review, comprising 266, 137 and 110 SI Nissen, Heller and Dor and Toupet fundoplications, respectively. Mean overall operation duration was 136.3 min. The total conversion rate to multiport laparoscopic fundoplication was 12.9%. Overall complication rate was 5.2%, while the rate of incisional hernia was 0.9%.

Research conclusions

The results of this systematic review confirm the safety and efficacy of the single port laparoscopic fundoplication, although the technique is not yet standardized.

Research perspectives

Due to the lack of high-quality studies, further well designed studies are necessary to determine the role of SI fundoplication.

REFERENCES

- 1 Nissen R. [A simple operation for control of reflux esophagitis]. *Schweiz Med Wochenschr* 1956; **86**: 590-592 [PMID: 13337262]
- 2 Iwakiri K, Kinoshita Y, Habu Y, Oshima T, Manabe N, Fujiwara Y, Nagahara A, Kawamura O, Iwakiri R, Ozawa S, Ashida K, Ohara S, Kashiwagi H, Adachi K, Higuchi K, Miwa H, Fujimoto K, Kusano M, Hoshihara Y, Kawano T, Haruma K, Hongo M, Sugano K, Watanabe M, Shimosegawa T. Evidence-based clinical practice guidelines for gastroesophageal reflux disease 2015. *J Gastroenterol* 2016; **51**: 751-767 [PMID: 27325300 DOI: 10.1007/s00535-016-1227-8]
- 3 Andolfi C, Plana A, Furno S, Fisichella PM. Paraesophageal Hernia and Reflux Prevention: Is One Fundoplication Better than the Other? *World J Surg* 2017; **41**: 2573-2582 [PMID: 28484816 DOI: 10.1007/s00268-017-4040-5]
- 4 Amer MA, Smith MD, Khoo CH, Herbison GP, McCall JL. Network meta-analysis of surgical management of gastro-oesophageal reflux disease in adults. *Br J Surg* 2018; **105**: 1398-1407 [PMID: 30004114 DOI: 10.1002/bjs.10924]
- 5 Du X, Wu JM, Hu ZW, Wang F, Wang ZG, Zhang C, Yan C, Chen MP. Laparoscopic Nissen (total) versus anterior 180° fundoplication for gastro-esophageal reflux disease: A meta-analysis and systematic review. *Medicine (Baltimore)* 2017; **96**: e8085 [PMID: 28906412 DOI: 10.1097/MD.00000000000008085]
- 6 Little VR. Laparoscopic Heller myotomy for achalasia: a review of the controversies. *Ann Thorac Surg* 2008; **85**: S743-S746 [PMID: 18222208 DOI: 10.1016/j.athoracsur.2007.12.004]
- 7 Peters MJ, Mukhtar A, Yunus RM, Khan S, Pappalardo J, Memon B, Memon MA. Meta-analysis of randomized clinical trials comparing open and laparoscopic anti-reflux surgery. *Am J Gastroenterol* 2009; **104**: 1548-61; quiz 1547, 1562 [PMID: 19491872 DOI: 10.1038/ajg.2009.176]
- 8 Westebring-van der Putten EP, Goossens RH, Jakimowicz JJ, Dankelman J. Haptics in minimally invasive surgery--a review. *Minim Invasive Ther Allied Technol* 2008; **17**: 3-16 [PMID: 18270873 DOI: 10.1080/13645700701820242]
- 9 Allaix ME, Patti MG. Heller myotomy for achalasia. From the open to the laparoscopic approach. *World J Surg* 2015; **39**: 1603-1607 [PMID: 25526923 DOI: 10.1007/s00268-014-2914-3]
- 10 Navarra G, Pozza E, Occhionorelli S, Carcoforo P, Donini I. One-wound laparoscopic cholecystectomy. *Br J Surg* 1997; **84**: 695 [PMID: 9171771 DOI: 10.1002/bjs.1800841126]
- 11 Hamzaoglu I, Karahasanoglu T, Aytac E, Karatas A, Baca B. Transumbilical totally laparoscopic single-port Nissen fundoplication: a new method of liver retraction: the Istanbul technique. *J Gastrointest Surg* 2010; **14**: 1035-1039 [PMID: 20306152 DOI: 10.1007/s11605-010-1183-1]
- 12 Hawasli A, Holman AK. Single incision laparoscopic Nissen fundoplication: step by step. *Surg Laparosc Endosc Percutan Tech* 2011; **21**: e78-e80 [PMID: 21471786 DOI: 10.1097/SLE.0b013e31820d6491]
- 13 Sharp NE, Vassaur J, Buckley FP. Single-site Nissen fundoplication versus laparoscopic Nissen fundoplication. *JSLS* 2014; **18**: pii: e2014.00202 [PMID: 25392613 DOI: 10.4293/JSLS.2014.00202]
- 14 Fukuda S, Nakajima K, Miyazaki Y, Takahashi T, Makino T, Kurokawa Y, Yamasaki M, Miyata H, Takiguchi S, Mori M, Doki Y. Laparoscopic surgery for esophageal achalasia: Multiport vs single-incision approach. *Asian J Endosc Surg* 2016; **9**: 14-20 [PMID: 26315292 DOI: 10.1111/ases.12226]
- 15 Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009; **6**: e1000097 [PMID: 19621072 DOI: 10.1371/journal.pmed.1000097]
- 16 Hozo SP, Djulbegovic B, Hozo I. Estimating the mean and variance from the median, range, and the size of a sample. *BMC Med Res Methodol* 2005; **5**: 13 [PMID: 15840177 DOI: 10.1186/1471-2288-5-13]
- 17 Sukharamwala P, Teta A, Ross S, Co F, Alvarez-Calderon G, Luberic K, Rosemurgy A. Over 250 Laparoendoscopic Single Site (LESS) Fundoplications: Lessons Learned. *Am Surg* 2015; **81**: 870-875 [PMID: 26350663]
- 18 Barbaros U, Demirel T, Sumer A, Deveci U, Tukenmez M, Cansunar MI, Kalayci M, Dincag A, Seven R, Mercan S. Pure SILS Floppy Nissen Fundoplication with Hiatal Repair: A Case Report. *ISRN Gastroenterol* 2011; **2011**: 347487 [PMID: 21991503 DOI: 10.5402/2011/347487]
- 19 Miyazaki Y, Nakajima K, Yamasaki M, Miyata H, Kurokawa Y, Takiguchi S, Fujiwara Y, Mori M, Doki Y. Single-port laparoscopic surgery of the distal esophagus: initial clinical experience. *Surg Laparosc Endosc Percutan Tech* 2012; **22**: e118-e121 [PMID: 22678329 DOI: 10.1097/SLE.0b013e318247c45f]
- 20 Eyuboglu E, Ipek T, Atasoy D. Single-port laparoscopic floppy Nissen fundoplication: a novel technique

- with the aid of the Cerrahpasa retractor. *J Laparoendosc Adv Surg Tech A* 2012; **22**: 173-175 [PMID: 22146016 DOI: 10.1089/lap.2011.0349]
- 21 **Mizuno M**, Kobayashi M, Sasaki A, Nakajima J, Wakabayashi G. Early experience with single-incision laparoscopic Nissen fundoplication for gastroesophageal reflux disease in patients with mental retardation via a gastrotomy site incision: report of five cases. *Surg Today* 2012; **42**: 601-604 [PMID: 22278618 DOI: 10.1007/s00595-012-0120-1]
 - 22 **Yilmaz H**, Alptekin H, Şahin M. Single-incision laparoscopic Nissen fundoplication for gastroesophageal reflux disease using conventional instruments. *Türkiye Klin J Med Sci* 2013; **33**: 1022-1027 [DOI: 10.5336/medsci.2012-31954]
 - 23 **Dapri G**, Bruyns J, Himpens J, Cadière GB. Single-access transumbilical laparoscopic nissen fundoplication performed with new curved reusable instruments. *Surg Innov* 2011; **18**: 61-65 [PMID: 21059609 DOI: 10.1177/1553350610384406]
 - 24 **Galvani CA**, Garza U, Echeverria A, Kaul A, Samamé J. Multipurpose internal retractor for Single-incision surgery (SIS): single-institution case series. *Surg Laparosc Endosc Percutan Tech* 2014; **24**: e59-e62 [PMID: 24686364 DOI: 10.1097/SLE.0b013e31828f720d]
 - 25 **Wu S**, Yu H, Fan Y, Kong J, Yu X. Liver retraction using n-butyl-2-cyanoacrylate glue during single-incision laparoscopic upper abdominal surgery. *Br J Surg* 2014; **101**: 546-549 [PMID: 24615563 DOI: 10.1002/bjs.9446]
 - 26 **Agaba EA**, Rainville H, Ikedilo O, Vemulapali P. Incidence of port-site incisional hernia after single-incision laparoscopic surgery. *JSLS* 2014; **18**: 204-210 [PMID: 24960483 DOI: 10.4293/108680813X13693422518317]
 - 27 **Nakajima J**, Sasaki A, Obuchi T, Baba S, Umemura A, Wakabayashi G. Single-incision laparoscopic Heller myotomy and Dor fundoplication for achalasia: report of a case. *Surg Today* 2011; **41**: 1543-1547 [PMID: 21969159 DOI: 10.1007/s00595-010-4533-4]
 - 28 **Yamada H**, Yano T. Single incision laparoscopic approach for esophageal achalasia: A case report. *Int J Surg Case Rep* 2013; **4**: 1-4 [PMID: 23088902 DOI: 10.1016/j.ijscr.2012.09.003]
 - 29 **Yano F**, Omura N, Tsuboi K, Hoshino M, Yamamoto SR, Kashiwagi H, Yanaga K. Single-incision laparoscopic Heller myotomy and Dor fundoplication for achalasia: report of a case. *Surg Today* 2012; **42**: 299-302 [PMID: 22218875 DOI: 10.1007/s00595-011-0089-1]
 - 30 **Buckley FP**, Vassaur HE, Jupiter DC, Crosby JH, Wheelless CJ, Vassaur JL. Influencing factors for port-site hernias after single-incision laparoscopy. *Hernia* 2016; **20**: 729-733 [PMID: 27417943 DOI: 10.1007/s10029-016-1512-8]
 - 31 **Strzalka M**, Matyja M, Matlok M, Migaczewski M, Budzyński P, Budzyński A. Application of the single access technique in laparoscopic surgery. *Pol Przegl Chir* 2013; **85**: 73-77 [PMID: 23585169 DOI: 10.2478/pjs-2013-0013]
 - 32 **Ross SB**, Luberice K, Kurian TJ, Paul H, Rosemurgy AS. Defining the learning curve of laparoendoscopic single-site Heller myotomy. *Am Surg* 2013; **79**: 837-844 [PMID: 23896255 DOI: 10.1186/1477-7819-11-171]
 - 33 **Rosemurgy A**, Paul H, Madison L, Luberice K, Donn N, Vice M, Hernandez J, Ross SB. A single institution's experience and journey with over 1000 laparoscopic funduplications for gastroesophageal reflux disease. *Am Surg* 2012; **78**: 917-925 [PMID: 22964197]
 - 34 **Rao PP**, Rao PP, Bhagwat S. Single-incision laparoscopic surgery - current status and controversies. *J Minim Access Surg* 2011; **7**: 6-16 [PMID: 21197236 DOI: 10.4103/0972-9941.72360]
 - 35 **Ramsay CR**, Wallace SA, Garthwaite PH, Monk AF, Russell IT, Grant AM. Assessing the learning curve effect in health technologies. Lessons from the nonclinical literature. *Int J Technol Assess Health Care* 2002; **18**: 1-10 [PMID: 11987432]
 - 36 **Ferrarese A**, Gentile V, Bindi M, Rivelli M, Cumbo J, Solej M, Enrico S, Martino V. The learning curve of laparoscopic cholecystectomy in general surgery resident training: old age of the patient may be a risk factor? *Open Med (Wars)* 2016; **11**: 489-496 [PMID: 28352841 DOI: 10.1515/med-2016-0086]
 - 37 **Tekkis PP**, Senagore AJ, Delaney CP, Fazio VW. Evaluation of the learning curve in laparoscopic colorectal surgery: comparison of right-sided and left-sided resections. *Ann Surg* 2005; **242**: 83-91 [PMID: 15973105 DOI: 10.1097/01.SLA.0000167857.14690.68]
 - 38 **Hopper AN**, Jamison MH, Lewis WG. Learning curves in surgical practice. *Postgrad Med J* 2007; **83**: 777-779 [PMID: 18057179 DOI: 10.1136/pgmj.2007.057190]
 - 39 **Yano F**, Omura N, Tsuboi K, Hoshino M, Yamamoto S, Akimoto S, Masuda T, Kashiwagi H, Yanaga K. Learning curve for laparoscopic Heller myotomy and Dor fundoplication for achalasia. *PLoS One* 2017; **12**: e0180515 [PMID: 28686640 DOI: 10.1371/journal.pone.0180515]
 - 40 **Okrañec A**, Ferri LE, Feldman LS, Fried GM. Defining the learning curve in laparoscopic paraesophageal hernia repair: a CUSUM analysis. *Surg Endosc* 2011; **25**: 1083-1087 [PMID: 20835725 DOI: 10.1007/s00464-010-1321-6]
 - 41 **Ross SB**, Choung E, Teta AF, Colibao L, Luberice K, Paul H, Rosemurgy AS. The learning curve of laparoendoscopic single-Site (LESS) fundoplication: definable, short, and safe. *JSLS* 2013; **17**: 376-384 [PMID: 24018072 DOI: 10.4293/108680813X13654754535359]
 - 42 **Amortegui JD**, Restrepo H. Knot security in laparoscopic surgery. A comparative study with conventional knots. *Surg Endosc* 2002; **16**: 1598-1602 [PMID: 12085155 DOI: 10.1007/s00464-002-8545-z]
 - 43 **Lim S**, Ghosh S, Niklewski P, Roy S. Laparoscopic Suturing as a Barrier to Broader Adoption of Laparoscopic Surgery. *JSLS* 2017; **21**: pii: e2017.00021 [PMID: 28694682 DOI: 10.4293/JSLS.2017.00021]
 - 44 **Coleman KA**, Adams S, Smeak DD, Monnet E. Laparoscopic Gastropexy Using Knotless Unidirectional Suture and an Articulated Endoscopic Suturing Device: Seven Cases. *Vet Surg* 2016; **45**: 095-0101 [PMID: 27731517 DOI: 10.1111/vsu.12570]
 - 45 **Bermas H**, Fenoglio M, Haun W, Moore JT. Laparoscopic suturing and knot tying: a comparison of standard techniques to a mechanical assist device. *JSLS* 2004; **8**: 187-189 [PMID: 15119668]
 - 46 **Coleman KA**, Monnet E. Comparison of laparoscopic gastropexy performed via intracorporeal suturing with knotless unidirectional barbed suture using a needle driver versus a roticulated endoscopic suturing device: 30 cases. *Vet Surg* 2017; **46**: 1002-1007 [PMID: 28921666 DOI: 10.1111/vsu.12722]
 - 47 **Ekçi B**. A simple technique for knot tying in single incision laparoscopic surgery (SILS). *Clinics (Sao Paulo)* 2010; **65**: 1055-1057 [PMID: 21120311 DOI: 10.1590/S1807-593220100001000023]
 - 48 **Ishiyama Y**, Inaki N, Bando H, Yamada T. Assessment of Intracorporeal Suturing in Single-Port Surgery Using an Experimental Suturing Model. *Indian J Surg* 2017; **79**: 137-142 [PMID: 28442840 DOI: 10.1007/s12262-016-1445-6]

- 49 **Chung do Y.** The intracorporeal knot tying using rigid instruments in single-incision laparoscopic surgery. *Surg Laparosc Endosc Percutan Tech* 2013; **23**: e90-e92 [PMID: [23752026](#) DOI: [10.1097/SLE.0b013e318274b278](#)]
- 50 **Meng WC,** Kwok SP, Leung KL, Chung CC, Lau WY, Li AK. Optimal position of working ports in laparoscopic surgery: an in vitro study. *Surg Laparosc Endosc* 1996; **6**: 278-281 [PMID: [8840449](#) DOI: [10.1097/00019509-199608000-00006](#)]
- 51 **Fingerhut A,** Hanna GB, Veyrie N, Ferzli G, Millat B, Alexakis N, Leandros E. Optimal trocar placement for ergonomic intracorporeal sewing and knotting in laparoscopic hiatal surgery. *Am J Surg* 2010; **200**: 519-528 [PMID: [20638045](#) DOI: [10.1016/j.amjsurg.2010.01.029](#)]
- 52 **Riggle JD,** Miller EE, McCrory B, Meitl A, Lim E, Hallbeck MS, LaGrange CA. Ergonomic comparison of laparoscopic hand instruments in a single site surgery simulator with novices. *Minim Invasive Ther Allied Technol* 2015; **24**: 68-76 [PMID: [25142199](#) DOI: [10.3109/13645706.2014.946426](#)]
- 53 **Sánchez-Margallo FM,** Matos-Azevedo AM, Pérez-Duarte FJ, Enciso S, Martín-Portugués ID. Performance analysis on physical simulator of four different instrument setups in laparo-endoscopic single-site (LESS) surgery. *Surg Endosc* 2014; **28**: 1479-1488 [PMID: [24357421](#) DOI: [10.1007/s00464-013-3337-1](#)]
- 54 **Dapri G,** Casali L, Bruyns J, Himpens J, Cadiere GB. Single-access laparoscopic surgery using new curved reusable instruments: initial hundred patients. *Surg Technol Int* 2010; **20**: 21-35 [PMID: [21082545](#) DOI: [10.1007/s00464-011-1678-1](#)]



Published By Baishideng Publishing Group Inc
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-2238242
Fax: +1-925-2238243
E-mail: bpgoffice@wjgnet.com
Help Desk: <https://www.f6publishing.com/helpdesk>
<https://www.wjgnet.com>

