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LIVER RETRACTION AND ASSOCIATED- COMPLICATIONS IN LAPAROSCOPIC BARIATRIC SURGERY: A SYSTEMATIC REVIEW OF THE CURRENT LITERATURE

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ABSTRACT

Background: Adequate visualization of the operative field and workspace is essential in laparoscopic bariatric surgery (LBS). Therefore, different methods have been described to retract the left lobe of the liver. This review aims to appraise all existing published data on liver retractor methods in LBS and assess their feasibility and associated complications. **Methods:** A systematic literature search was performed on PubMed, Google Scholar, and the Cochrane Library, to identify eligible retrospective and randomized clinical trial (RCT) studies conducted and published before June 2023. Data on different liver retraction methods in LBS and associated complications were included in this review. **Results:** A total of 16 studies met the inclusion criteria and 5096 patients were included in this review. Various liver retraction methods have been described in LBS. Traditional liver retractors (snake retractor, PretzeFlex, and Nathanson), were associated with significant liver function derangement, postoperative pain, and longer hospital stay. Portless liver retractor methods were shown to be effective, however, with an increased retraction fixation time and additional instruments. **Conclusion:** Traditional liver retractors have shown to be effective, however, with significant adverse effects on liver function, postoperative pain, longer hospital stays, and trocar port-associated complications. On the other hand, portless liver retractor methods have proved to be less traumatic and flexible to adapt to the many different aspects of foregut surgery with the implication for single-incision bariatric surgery.

KEYWORDS: Bariatric surgery, Roux-en-Y gastric bypass, Sleeve gastrectomy, Gastric band, Biliopancreatic diversion with duodenal switch, Liver retractor, Complication.

INTRODUCTION

Retraction of the left lobe of the liver is essential in laparoscopic bariatric surgery (LBS), for adequate visualization of the operative field and workspace around the stomach and surrounding organs. Bariatric patients are often found with an enlarged liver, making the retraction more challenging for surgeons.[1] The retraction of the liver has commonly been achieved in LBS using traditional retractors (the snake retractor, diamond-shaped and Nathanson), which require an additional trocar port and an incision at the subxiphoid region.[2,3] However, these retractor methods have been shown to increase the risks of local wound infection, postoperative pain, and inferior cosmesis.[4]

Consequently, various portless retractors have been reported. These retractors are preferred due to their advantage of reducing the number of trocar ports and being convenient in single-port sleeve gastrectomy, though, with minimal injury to the abdominal wall during the insertion of the retractor instruments (suture, needle, needle passer) in the abdominal cavity. Despite their many benefits, portless liver retractors can be technically challenging for surgeons to perform, time-consuming, requiring extra instruments, and puncture site bleeding of the abdominal wall.[4-10] A more recent innovative retractor method was described using the magnetic surgical system; although more costly, this method proved to be effective with a pronounced minimally invasive approach for retracting the left lobe of the liver and minimally traumatic to the liver.[11-13]

Although various liver retractor methods have been incorporated in clinical practice in LBS, an ideal retractor is yet to be desired, which should be easy and quick to perform, inexpensive, with minimal to no scars for bariatric patients with cosmesis concern, and more importantly a retractor method with no adverse effect on the liver function.

In this systematic review, we thought to appraise all existing published data on liver retractor methods in LBS to assess their feasibility and associated adverse effects.

MATERIALS AND METHODS

This systematic review was conducted in accordance with the guidelines for the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocol (PRISMA) 2015 statement.[14] All stages of literature search, study selection, data extraction, and quality assessment were performed independently by 2 authors. Any disagreement was resolved by discussion and consensus with a third reviewer (HA).

Literature search

A systematic search was performed using an electronic search in the PubMed database, Google Scholar, and the Cochrane Library. The appropriate key terms and free text field search were performed for "Liver retraction", "Liver retractor", "Bariatric surgery", "Sleeve gastrectomy", and "Roux-en-Y gastric bypass". The search included all study designs, with further studies not captured by the search identified via bibliographic cross-referencing. Titles and abstracts were screened independently for full-text review by two authors.

Inclusion criteria

Included studies were limited to adults (≥18 years) who met the international criteria for bariatric surgery,[15] who underwent a primary or revision Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG), biliopancreatic diversion with duodenal switch (BPD-DS) and the adjustable gastric band (AGB). Prospective and retrospective observational studies, randomized clinical trials, and non-comparative clinical studies were included. The date ranges from June 2000 and the last search was performed in June 2023.

Exclusion criteria

Only studies published in English were included in the systematic review. Abstracts, conference articles, opinion pieces, editorial letters, case studies, reviews, and meta-analyses were excluded from the final review. Nonhuman studies were not included. Those without appropriate data published related to this study's primary and secondary outcomes were also excluded.

Data extraction

The primary outcome was different methods of liver retraction in primary or revisional LBS. The second outcome included specific complications related to each retractor method namely, LFTs-related effects, postoperative pain, length of hospital stay, and retractor fixation time. Data of study samples and length of follow-up were also recorded.

RESULTS

A total of 4925 studies were retrieved by initial literature search. An additional four studies were located through a manual search of the bibliography cross-referencing. After screening the study's titles, 50 studies qualified for further analysis. After a full-text review of the 50 studies, 30 were duplicates; therefore, removed and 16 studies met the final inclusion criteria. The included studies were retrospective, cohort, or randomized control trial studies. A total of 5096 patients were included in this literature review (Fig 1, Table 2)

Fig. 1 PRISMA flowchart of literature search and data extraction and selection (n represents the number of articles included)

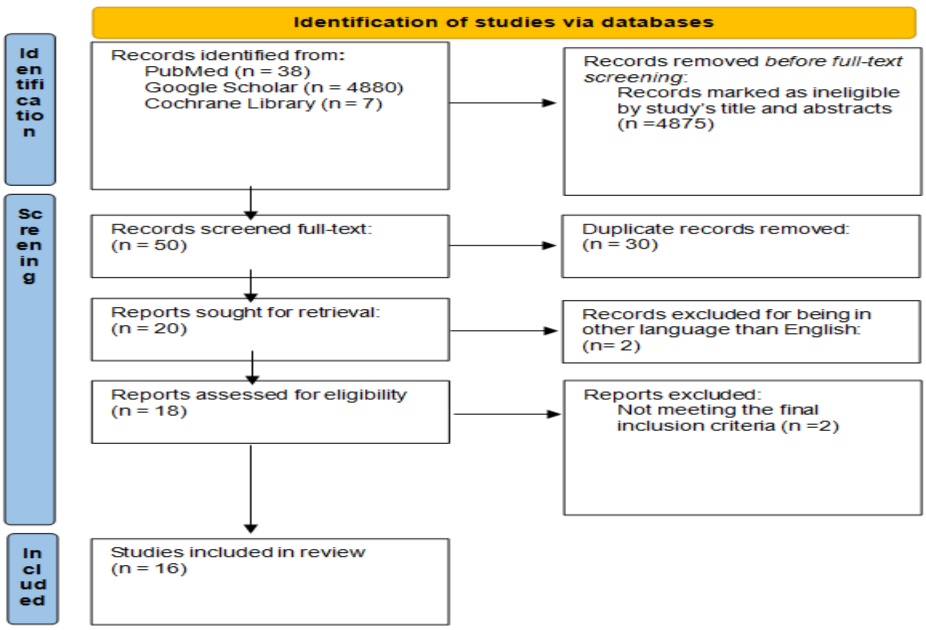

Table 2: Demographics and appraisal of studies included in this review.

Author	Year	N	Study design	Retractor method	Surgery
Huang et al.[25]	2011	14	RNC	Penrose draine and stapler	RYGB, SG, Single incision trans umbilical BS
Goel et al.[4]	2012	60	RCT	Liver suspension tape, V-shaped liver suspension technique and Nathanson	RYGB, SG, Single incision trans umbilical BS
Shimizu et al.[30]	2014	33	RNC	Endolift	RYGB, Single incision SG
de la Torre et al.[6]	2015	487	RNC	Suture-base liver retractor with suture passer	RYGB, SG, GB, BPD-SD
Lee et al.[8]	2015	76	RNC	Suture-base liver retractor with suture straight needle	Total gastrectomy, Nissen fundoplication, RYGB, SG
Ahmad et al.[32]	2016	2601	RNC	Teleflex MiniLap Percutaneous System	RYGB, SG, GB
Midya et al.[17]	2019	167	RC	PretzeFlex liver retractor, Nathanson	RYGB
Davis et al.[11]	2019	73	RNC	Magnetic Surgical System liver retractor	RYGB, SG, GB, BPD-SD
Sweeny et al.[34]	2019	551	RC	Bulldog retractor with lone star banks and hooks, traditional retractors	Robotic and assisted SG, RYGB
Cal et al.[35]	2019	100	RC	Suture string, traditional liver retractors	SG
Zheng et al.[5]	2020	317	RC	K-wire liver retractor, suture-based	RYGB, SG
Welsh et al.[12]	2020	296	RC	Magnetic Surgical System liver retractor, Nathanson	RYGB, SG, BPD-DS
Bures et al.[36]	2020	51	RC	LiVac Sling liver retractor, traditional liver retractors	RYGB, SG, OAGB
Luengas et al.[13]	2020	50	RNC	Magnetic Surgical System liver retractor	RYGB, SG, BPD-DS
Fersahoglu et al.[18]	2020	120	RC	PretzeFlex liver retractor, Nathanson	SG
Babadopulos et al.[37]	2021	100	RCT	Needled Silk Thread Glued with Nelaton Probe liver retractor, traditional liver retractors	RYGB
Roux-en-Y gastric bypass (RYGB); sleeve gastrectomy (SG); gastric band (GB), biliopancreatic diversion with duodenal switch (BPD-DS); bariatric surgery (BS); retrospective non-comparative (RNC); randomized clinical trial (RCT); retrospective comparative (RC)					

Liver retractors outcome

Various liver retractor methods have been described in bariatric surgery and can be subdivided into two major categories. The first retractor category is the traditional liver retractors (snake liver retractor, diamond-shaped, Nathanson, and PretzeFlex), which require an additional trocar port and incision.[16-18] The second category is the portless liver retractors which can be minimally traumatic to the skin in some methods, during the insertion of the retractor instruments (wire, bedrail, suture, needle, etc.) in the abdominal cavity, and percutaneous methods, with no puncture of the skin or abdominal wall.[19-40] Various methods of liver retractor are illustrated in (Table 1).

Table 1: Summary of liver retractor methods in BS and Gastrointestinal Surgery.

Author	Year	Retractor method	Liver puncture	Abdominal wall and skin puncture	Surgery
Liver retractors requiring an additional trocar-port					
Saber et al.[16]	2008	Nathanson Liver retractor	No	Yes	Single-incision SG
Midya et al.[17]	2019	Nathanson, PretzeFlex Liver retractor	No	Yes	RYGB
Fersahuglo et al.[18]	2020	Nathanson, PretzeFlex Liver retractor	No	Yes	SG
Portless liver retractors					
Lee et al.[19]	2007	Suture-based liver retractor with straight needle	Yes	Yes	Gastric surgery
Sakaguchi et al.[20]	2008	Penrose drain, J-shaped retractor, suture with straight needle	No	Yes	-
Huang et al.[21]	2009	Jackson-Pratt drain, suture with straight needle	Yes	Yes	Single incision trans umbilical RYGB
de la Torre et al.[22]	2009	Suture-based liver retractor with suture passer	No	Yes	Trans umbilical single port adjustable GB
Galvani et al.[23]	2010	Lone star retractor hook, bulldog	No	No	Single-incision SG

		clump			
Hamzaoglu et al.[24]	2010	Penrose drain, suture with passer	No	Yes	Trans umbilical totally single-port Nissen fundoplication
Shabir et al.[9]	2010	Suture-based liver retractor with suture passer	No	Yes	Total gastrectomy
Huang et al.[25]	2011	Penrose drain and stapler	No	No	RYGB, SG, single incision trans umbilical BS
Takemura et al.[39]	2011	Silicon disk, suture-based retractor with suture passer	No	Yes	Gastrectomy, gastroplasty, fundoplication
Woo et al.[26]	2011	Suture-based liver retractor with straight needle	No	Yes	Radical gastrectomy
Shinohara et al.[40]	2011	Suture-based liver retractor with suture passer	No	Yes	Gastrectomy
Giamni et al.[27]	2012	Verres needle, nasogastric tube	No	Yes	Single-incision gastric surgery
Yilmaz et al.[28]	2012	Suture-base liver retractor with straight needle	No	Yes	Single-incision Nissen fundoplication
Goel et al.[4]	2012	Liver suspension tape, V-shaped liver suspension technique	No	Yes	RYGB, SG, Single incision trans umbilical BS
Fan et al.[29]	2013	Cyanoacrylate glue	No	No	Trans umbilical single - incision fundoplication
Shimizu et al.[30]	2014	Endolift	No	Yes	RYGB, single-incision SG
de Moura LG jr et al.[31]	2014	Suture-base liver retraction with suture passer	No	Yes	RYGB
de la Torre et al.[6]	2015	Suture-base liver retraction with suture passer	No	Yes	RYGB, SG, GB, BPD-DS
Lee et al.[8]	2015	Suture-base liver retractor with straight needle	No	Yes	Total gastrectomy, Nissen fundoplication, RYGB, SG
Ahmad et al.[32]	2016	Teleflex MiniLap Percutaneous system	No	Yes	RYGB, SG, GB
Ushimaru et al.[33]	2018	Suture-base liver retractor with straight needle	No	Yes	Gastrectomy
Davis et al.[11]	2019	Magnetic surgical system liver retractor	No	No	RYGB, SG, GB, BPD-DS
Sweeny et al.[34]	2019	Bulldog liver retractor with lone star banks and hooks	No	Yes	Robotic and assisted SG, RYGB
Cal et al.[35]	2019	Suture string liver retractor	No	Yes	SG
Zheng et al.[5]	2020	K-wire liver retractor, suture-based	No	Yes	RYGB, SG
Welsh et al.[12]	2020	Magnetic surgical system liver retractor	No	No	RYGB, SG, BPD-DS
Bures et al.[36]	2020	LiVac Sling liver retractor	No	Yes	RYGB, SG, OAGB
Luengas et al.[13]	2020	Magnetic surgical system liver retractor	No	No	RYGB, SG, BPD-DS
Babadopulos et al.[37]	2021	Needled Silk thread glued with Nelaton probe liver retractor	No	Yes	RYGB
Rajkumar et al.[38]	2023	Core shaft of dismantlable laparoscopic instrument liver retractor			
Roux-en-Y gastric bypass (RYGB); sleeve gastrectomy (SG); gastric band (GB), biliopancreatic diversion with duodenal switch (BPD-DS); bariatric surgery (BS)					

Liver function complications

Five studies reported a significant LFTs derangement in patients postoperatively.[4,5,17,18,34] An increase in

AST/ALT levels of 3× higher than the normal range was assessed after the Nathanson and the snake liver retractors than the portless liver retractor methods. These higher levels were assessed from postoperative day 1(POD 1) and gradually decreased in POD 7 to preoperative values at POD 30. Two studies analyzed the effect of two traditional retractor methods (Nathanson and PretzeFlex retractor) on the LFTs. The studies showed significantly higher AST/ALT levels associated with the Nathanson retractor than the PretzeFlex, despite an elevation of the liver enzymes in both retractor methods.[17,18] (Table 3).

Table 3: Liver retractor methods and related postoperative complications (liver enzymes, postoperative pain, hospital length and retractor fixation time).

Liver enzymes							
Author	**Year**	**N**	**Retractor method**	**AST/ALT**			**Surgery**
				AST	ALT	AST/ALT incidence	
Goel et al.[4]	2012	60	Liver suspension tape	72.7	82.6	-	RYGB, SG, Single incision trans umbilical BS
			V-shaped liver suspension technique	53.9	75.9	-	
			Nathanson	174.3	188.1	-	
Midya et al.[17]	2019	167	PretzeFlex liver retractor	-	101.2		RYGB
			Natahnson		185.34	-	
Sweeny et al.[34]	2019	551	Bulldog retractor with lone star baks and hooks	-	-	17.3%	Robotic and assisted SG, RYGB
			Traditional liver retractors	-	-	21.5%	
Zheng et al.[5]	2020	317	K-wire liver retractor	-	-	10.0%	RYGB, SG
			Suture-based liver retractor	-	-	19.8%	
Fersahoglu et al.[18]	2020	120	PretzeFlex liver retractor	-	-	6%	SG
			Nathanson	-	-	6.5%	
Postoperative pain							
Author	Year	N	Retractor method	Postoperative pain			Surgery
				Pain score		NSAIDs dose	
Midya et al.[17]	2019	167	PretzeFlex liver retractor	4.8		-	RYGB
			Nathanson	5.6		-	
Zheng et al.[5]	2020	317	K-wire liver retractor	-		106.8	RYGB, SG
			Suture-based liver retractor	-		117.4	
Hospital length							
Author	year	N	Retractor method	Hospital length			Surgery
Midya et al.[17]	2019	167	PretzeFlex liver retractor	1.54			RYGB
			Nathanson	2.12			
Sweeny et al.[34]	2019	551	Bulldog retractor with lone star banks and hooks	1.2			Robotic and assisted SG, RYGB
			Traditional liver retractors	1.3			
Bures et al.[36]	2020	51	LiVac Sling liver retractor	2			RYGB, SG, OAGB
			Traditional liver retractors	4			
Zheng et al.[5]	2020	317	K-wire liver retractor	3.4			RYGB, SG
			Suture-based liver retractor	3.6			
Retractor fixation time							

Author	Year	N	Retractor method	Retractor fixation time	Surgery
Goel et al.[4]	2012	60	Liver suspension tape	270.7	RYGB, SG, Single incision trans umbilical BS
			V-shaped liver suspension technique	391.7	
			Nathanson	192.7	
Zheng et al.[5]	2020	317	K-wire liver retractor	38.5	RYGB, SG
			Suture-based liver retractor	103.9	
Babadopulos et al.[37]	2021	100	Needled Silk Thread Glue with Neton Probe	120.96	RYGB
			Traditional liver retractors	25.64	

Roux-en-Y gastric bypass (RYGB); sleeve gastrectomy (SG); one anastomosis gastric bypass (OAGB), bariatric surgery (BS); aspartate transaminase (AST), alanine transaminase (ALT); non-steroidal anti-inflammatory drugs (NSAIDs); liver enzymes were expressed in International unit per litter (IU/L); AST/ALT incidence was the percentage of occurrence in the population; the length of hospital stay was expressed in days; the retractor fixation time was expressed in seconds

Postoperative pain

Two studies showed an association between different liver retractor methods and postoperative pain. In one study, the Nathanson retractor was associated with a higher postoperative pain score. In another study, patients who underwent the suture-based retractor were recorded with an elevated dosage of Nonsteroidal anti-inflammatory drugs (NSAIDs) than those in the cohort group.[5,17] (Table 3).

Hospital length

Four studies reported on the length of hospital stay; the traditional liver retractors showed longer hospital stays ranging from 2 to 4 days postoperatively than the portless retractors. In one study, the suture-based retractor method showed a slightly longer hospital stay than the K-wire method.[5,17,34,36] (Table 3).

Retractor fixation time

Three studies investigated the time required for liver retraction fixation and showed that the portless retractor methods, especially the suture-based based were associated with a longer fixation time, which could significantly affect the overall operative time. Furthermore, these retractor methods were associated with a learning curve, more instruments required, and to a certain extent costly.[4,5,37] (Table 3).

DISCUSSION

Liver retraction is essential for adequate visualization of the operative field in LBS and gastrointestinal operations. An ideal retractor method should ensure a good operative view and workspace, minimal trauma to the liver, easy and quick to perform, and higher cosmesis. Traditional liver retractors (snake retractor and Nathanson) have been successfully used for decades in gastrointestinal and bariatric surgeries; however, retractor-associated liver injuries remain consistent in these methods.[2-4] Orr et al. showed liver hypodense lesions associated with the Nathanson retractor in 27% of patients undergoing gastrointestinal surgery and 18% in those with LBS using computed tomography.[41]

Liver function derangement has been associated with traditional liver retractors. In a randomized control trial by Goel et al. three types of liver retractor methods were studied (Nathanson, Liver suspension tape, and V-shaped liver suspension technique). The Nathanson retractor group presented with a significant rise in aspartate aminotransferase (AST) and alanine aminotransferase (ALT) than other groups at 1 week postoperatively.[4] Similar findings were reported by Midya et al. showing a rise in ALT levels at POD1 in the Nathanson group than in the PretzelFlex retractor group. Furthermore, the Nathanson was associated with increased postoperative C-reactive protein (CRP) levels.[17] Sweeny et al. reported an elevation of AST/ALT levels of >3 times higher than the normal levels associated with the traditional retractor and the bulldog retractor method. Although the liver enzymes were elevated in both retractor methods in their study, the AST/ALT in the snake retractor group was higher than in the bulldog retractor group; however, with a difference that did not amount to statistical significance.[34]

Moreover, a derangement in liver function has been reported in portless liver retractor methods. Zheng et al. found an elevation of the AST/ALT in the suture-based liver retractor than in the K-wire retractor method.[5] Various factors have been associated with elevated AST/ALT levels. Sweeny et al., showed the Roux-en-Y gastric bypass (RYGB) and longer operative time were associated with an increased odds ratio of AST/ALT elevation, supporting the fact that the length of retraction plays a major role in the liver function derangement.[34] Other factors such as CO_2 pressure in the peritoneum and the effect of anesthetic agents have been suggested; however, their association with the elevation of the liver enzyme has not been elucidated.[5,42] In all the above-mentioned studies where the liver retractor was associated with the derangement of the LFT, none of the patients in these studies showed overt clinical signs of liver failure. Still, the clinically significant rise in LFTs among the patients with borderline liver function could become significant in patients whom the traditional liver retractors were performed.

Postoperative pain is a concern in LBS, it is suggested that the additional trocar for liver retraction contributes to postoperative pain. Midya et al. demonstrated an association between the Nathanson retractor with a higher postoperative pain score; however, in their study, the difference did not amount to statistical significance.[17] Furthermore, in a study by Zheng et al. two types of portless liver retractors (K-wire retractor and suture-based), were compared and a significant difference in the dosage of pain medications was assessed; the authors suggested that the difference in the dosage of NSAIDs used between the two groups could be related to other factors than the retraction method used.[5] The association between trocar number and liver retraction method is yet to be determined. In future studies, postoperative pain should be measured between portless and traditional liver retractors to clarify the association between postoperative pain and the number of trocar ports.

Traditional liver retractors have been associated with longer hospital stays. Bures et al. showed a difference in the hospital stay of 2 days on average when 4 trocars were used in the LiVac Sling retractor group versus 4 days on average with 5 trocars in the standard retractor group.[36] Similar results were reported by Midya et al., whereby the Nathanson was associated with a longer hospital stay; however, with a difference that was not statistically significant. A longer hospital stay may be explained by an increase in pain due to an additional trocar or other complications (nausea) that were associated with the traditional retractors.[5,17,34,36]

Portless retractor methods appear to require more time for fixation compared to traditional retractors, which might affect the operative time.[5,18,37] In a randomized study by Goel et al. where the liver retractor fixation time was compared between the Nathanson liver retractor, liver suspension tape, and V-LIST retractor. As a result, the time required for retractor fixation in the V-LIST group was longer than in the Nathanson retractor group; however, the authors attributed the familiarity with the Nathanson retractor to having interfered with these results.[4] An increase in fixation time for portless retractors tends to be associated with the learning curve of the retractor method; the higher the repetition of the retractor method, the quicker and easier it is to fix. Few studies reported their experience with the suture-based liver retractor; and showed that the retractor fixation time was less than 3 min, furthermore, a retractor fixation time of less than a minute was reported in the K-wire method, which was unlikely to significantly affect the operative time.[5,10]

As previously shown, patients with BMI >50kg/m^2 were associated with higher odds of using an additional liver retractor (traditional retractor), in cases where the portless retractor was performed initially.[34,5] In one study where the K-wire was the primary liver retractor used, a second K-wise was used as an additional retractor.[5] In another study, the suture was the primary retractor; in patients with an enlarged liver or BMI>50kg/m^2, the V-disposition hepatic refraction model was proposed to optimize visualization of the angle of His in these patients.[37] These studies showed the flexibility of portless liver retractors over traditional ones when an additional retractor is needed.

More innovative portless liver retractors have been described in LBS. Some portless liver retractors may use available surgical tools in the operating room; others may involve extra instruments and cost. A study by Welsh et al. compared the operating room supply cost between the magnetic liver retractor versus the bedrail-mounted retractor, they showed the magnetic liver retractor was associated with an increased operating supply cost than the bedrail-mounted retractor, though, with decreased postoperative pain and shorter hospital stay in the magnetic liver retractor group.[12]

Minor complications worth mentioning were associated with portless liver retractors. In the suture-based retractor, bleeding from the suture, and tearing of the liver by the suture were reported, fortunately without further sequelae.[6] A mild liver hematoma was observed in the K-wire retractor.[5] Furthermore, abdominal wall bleeding at the puncture site was assessed.[5,6,10]

STRENGTH AND LIMITATIONS

The strength of this review includes being the first to report, thoroughly review, and critique the literature on different types of liver retractor methods in LBS in the context of retractor-related benefits and adverse effects.

Limitations that should be considered in the setting of this review were that a few studies were of the highest quality. A variety of liver retractor methods were reported without associated complications data.

CONCLUSION

A good visualization of the operative field and workspace is essential in LBS. Traditional liver retractors have shown to be effective, however, with significant adverse effects on liver function, postoperative pain, longer hospital stay, and trocar port-associated complications. On the other hand, portless liver retractor methods have proved to be less traumatic and flexible to adapt to the many different aspects of foregut surgery with the implication for single-incision bariatric surgery. Although, with the concern for using specific instruments or adaptation and learning curve, portless liver retractor methods appear to be as effective as the traditional retractor methods.

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Fidele kakule kitaghenda contributed to the conception and design of the study, acquisition of data, interpretation, and analysis of data. Sakarie Mustafe Hidig contributed to the drafting and revision of the manuscript and the acquisition of data.

Declarations

Conflict of interest

There are no conflicts of interest.

Human and Animal Rights

This article does not contain any studies with human participants or animals performed by any of the authors.

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