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Research article

Magnetic anchoring device assisted-laparoscopic sleeve gastrectomy versus conventional laparoscopic sleeve gastrectomy: A retrospective cohort study

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ABSTRACT

Background: Bariatric surgeries, including the sleeve gastrectomy, have been recognized as the most effectively treatment strategy for severe obesity. Magnetic devices have been successfully used in bariatric surgeries. Here, we intended to evaluate the safety and efficiency of magnetic anchoring device assisted-laparoscopic sleeve gastrectomy (MLSG), and to make a comparison of the short-term results between conventional laparoscopic sleeve gastrectomy (CLSG) and MLSG.
Methods: The retrospective cohort study was carried out by analyzing and summarizing the data from a database of routinely collected data. The cohort included the patients who underwent either CLSG ($n = 120$) or MLSG ($n = 115$) at a single center between January 2018 and December 2020 with a two-year follow-up. The effects of these two surgeries on the weight loss, resolution of comorbidities and quality of life (QOL) were analyzed.
Results: The two groups were similar in gender, age, body mass index, abdominal girth, as well as the type and proportion of comorbidities. And the cases in MLSG group had a markedly shorter time of operation (MLSG, 72.59 min vs. CLSG, 76.67 min; $P = 0.003$). Length of stay in hospital was significantly shorter in the MLSG group than that in the CLSG group (MLSG, 5.59 days vs. CLSG, 5.96 days; $P = 0.016$). Neither fatal event nor conversion to open surgery happened among all cases. There were no differences in terms of the postoperative complications between the two groups. Magnetic device-related mild hepatic lacerations occurred and were handled by hemostatic treatments in 3 cases. The QOL of patients in MLSG was better at 6-month after surgery, but there was no significant difference between the two groups at 1-year or 2-year after surgery.
Conclusion: Both MLSG and CLSG prove safe and effective, and the patients underwent MLSG have a shorter length of stay in hospital, and a better QOL during 6 months after surgery.

1. Introduction

Obesity has become one of the most challenging diseases worldwide, and the incidence of obesity is booming [1]. With the growing excessive weight, the comorbidities related to obesity would be induced and involved in diverse systems of the body, such as type 2

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diabetes, hypothyroidism, sleep apnea syndrome, hypertension, hyperlipidemia, coronary heart disease, metabolic associated fatty liver disease (MASLD) and some types of cancers and so on [2–8]. Bariatric surgery, especially the laparoscopic sleeve gastrectomy (LSG), which has been one of the most frequently performed procedures for treatment of obesity and related diseases, have gained the most popularity during the last decades [9–11].

Magnetic-assisted surgery is conducted by using the specially designed magnetic medical instruments or equipment to transform the non-contact magnetic field force between magnetic substances into a force that can play a specific function in clinical diagnosis and treatment [12–14]. Liver retraction during bariatric procedures enables exposure of the surgical field to be adequate, especially for the visual accessibility to the stomach and gastroesophageal junction. And liver retraction with the assistance of magnetic anchoring device is a non-invasive and effective strategy. At present, plenty of researches about magnetic devices have proven the advantages, such as lower infection rate, less pain and shorter hospital stay, which have made them been widely used in laparoscopic cholecystectomy, laparoscopic nephrectomy and laparoscopic appendectomy and so on [15–17]. Recently, magnetic devices are applied in bariatric surgery gradually [18–20]. Here, a retrospective study was implemented to assess the safety and the effects of MLSG on the weight loss, resolution of comorbidities and quality of life compared to CLSG.

2. Material and methods

2.1. Population and study design

We conducted a retrospective study by using a database of routinely collected information on a cohort of patients who underwent CLSG or MLGB between January 2018 and December 2020, and follow-up data came from 2017 through 2022 at the First Affiliated Hospital of Xi'an Jiaotong University. The study protocol was approved and registered with the Ethics Committee of the First Affiliated Hospital of Xi'an Jiaotong University. At the preoperative evaluation stage, the informed consents were signed by both surgeons and all patients, and our multidisciplinary team, including anesthetist, gastroenterologists, nutritionists, pulmonologists and so on, carefully assessed all patients. And we excluded the patients with severe liver parenchymal disease, severe altered coagulation levels, uncontrolled comorbidities, pacemakers or other electromedical implants, or an uncompleted 2-year follow-up. All operations were conducted by the same bariatric surgeons team.

2.2. Surgical techniques

The CLSG was performed routinely with four or five trocars, while the MLSG was performed with three trocars. As shown in Supplemental Fig. 1, the liver retraction of MLSG started by attaching the magnetic tissue clip to the liver lobe. The diameter of the magnetic tissue clip was 12 mm $\pm$ 0.3 mm, which enabled the clips go through the 12 mm trocars. Then, the magnetic traction device, which was adjustable and supported by the self-balancing manipulator, was adjusted to approch to the magnetic clips to perform the liver retraction and improve the surgical field with a better visualization and triangulation.

2.3. Definition of co-morbidities

Obesity-related comorbidities were assessed according to international guidelines. Guidelines from the American Society for Metabolic and Bariatric Surgery were utilized to assess the co-morbidity diagnosis and resolution. Remission means that the patient is able to maintain normal indicators, such as normal fasting glucose level, HbA1c, BP and so on, without any medications any more. And improvement means that the patient is able to maintain normal indicators with less dosages and types of medications than before [21].

2.4. Quality of life (QOL) assessment

In order to quantify the quality of life (QOL) of the patients in our study, the Short-Form-36 (SF-36) was employed. SF-36, which is involved in eight areas, including physical function, role physical, body pain, general health, vitality, social function, role emotional, and mental health, allows people to assess themselves. Then, the values can be classified into physical score and mental score, and summarized to a total score.

2.5. Statistical analysis

SPSS 22.0 statistical software was applied to analyze the data. Data were presented as n (%) or means$\pm$standard deviations. Pearson's chi-squared test or Student's t-test was used for the comparation between two groups. ANOVA test was used for three groups comparation. $P < 0.05$ was considered statistically significant.

3. Results

3.1. Baseline characteristics

The study group included 335 patients who underwent MLSG ($n = 115$) or CLSG ($n = 120$). Patient demographics were displayed in Table 1. There were no significant differences between the two groups in terms of age, gender distribution, BMI, abdominal girth and

co-comorbidities. The mean age in the CLSG and MLSG groups was 32.83 ± 9.185 and 33.33 ± 8.870 respectively, and the mean pre-operative BMI was 38.76 ± 6.881 and 39.28 ± 6.515 respectively.

3.2. Operative parameters

Among all of the surgeries included in our study, none of the them required conversion to open surgery. The MLSG group had a slightly shorter mean operative time compared to the CLSG group (72.59 ± 10.86 vs. 76.67 ± 10.67, $P = 0.0030$) (Table 2). And the MLSG group had a shorter length of stay in hospital than the CLSG group (5.592 ± 0.974 vs. 5.958 ± 1.337, $P = 0.0159$) (Table 2). With regards to the postoperative complications, the prevalent one in both groups was nausea or vomiting, but there was not significant difference (10% vs. 8.7%, $P = 0.902$) (Table 2). And none of these two groups had the event of bleeding or wound infection after the surgery. There was no technical event or surgical device fault during all the operations.

3.3. Two-year post-surgery follow-up

At 2 years after surgery, the mean BMI was 23.39 ± 5.047 in the CLSG group and 23.12 ± 4.795 in the MLSG group (Table 3). The mean excess body weight loss percentage (EBWL%) in the CLSG group was 39.12 ± 11.04%, while 40.57 ± 10.83% in the MLSG group (Table 3). There were no significant differences between the two groups in terms of post-surgery BMI ($P = 0.6793$) or EBWL % ($P = 0.3117$) (Table 3).

Overall, patients in both groups obtained great benefits from the surgeries in terms of the obesity-related comorbidities, though there was no significant difference between the two groups (Table 3). All of the patients in both groups had an obvious remission of type II diabetes mellitus, with significant improvement in more than 20% and complete resolution in more than 70%, though there was no significant difference between the two groups ($P = 0.467$) (Table 3). Analogously, as to hypertension, significant improvement and complete resolution were observed in both groups, with 32.5% vs. 36.5%, and 63.3% vs. 58.3% ($P = 0.472$) (Table 3). In terms of OSA, all patients in both groups turned out to be low risk, especially with 88.33 % in CLSG group and 94.8% in MLSG group (Table 3). In addition, the other main co-comorbidities, such as MASLD, polycystic ovarian syndrome, dyslipidemia and gastroesophageal reflux disease, also got great remission, with most of the patients even got complete resolution after surgery (Table 3).

3.4. Quality of life

There had no significant differences between CLSG group and MLSG group in terms of the baselines of these three kinds of quality of life (QOL) scores, including mental health score (Fig. 1A), physical health score (Fig. 1B) and total score (Fig. 1C). Overall, all of the three kinds of mean QOL score in both groups were increased gradually during the 2 years after surgery compared to the baseline. And, there was no significant difference between these two groups in terms of mental health score, physical health score or total score at 1-year and 2-year after surgery. However, at 6-month after surgery, the mean mental health score, physical health score and total score of MLCG group were significantly higher than that in CLSG group, with mental health score of 65.20 ± 2.588 vs. 59.40 ± 4.219, physical health score of 67.40 ± 3.507 vs. 57.60 ± 3.912, and total score of 69.00 ± 4.583 vs. 60.60 ± 2.608.

4. Discussion

LSG, which was recognized as an acceptable surgery for obesity and the co-comorbidities by ASMBS in 2012, has been performed for an increasing number of patients because of its simple procedures, effective weight loss and the low complication rates [22–24]. In 1948, the studies of magnetic devices in the fields of urology and general surgery means the coming of era of magnetic surgery [25]. Recently, the magnetic anchoring device emerges as an alternative instrument working as an incisionless intra-abdominal retractor.

Table 1
Baseline characteristics.

	CLSG ($n = 120$)	MLSG ($n = 115$)	*P*-value
Gender *N* (%)			
Female	95 (79.2%)	94 (81.7%)	0.619
Male	25 (20.8%)	21 (18.3%)	
Age (years)	32.8 ± 9.2	33.3 ± 8.9	0.668
BMI (kg/m^2)	38.8 ± 6.9	39.3 ± 6.5	0.552
Abdominal girth (cm)	118.9 ± 16.5	122.3 ± 17.7	0.131
Comorbidities (%)			
Hypertension	26 (21.7)	21 (18.3)	0.594
D2M	34 (28.3)	36 (31.3)	0.714
MASLD	117 (97.5)	110 (95.7)	0.918
Hyperlipidemia	25 (20.8)	27 (23.5)	0.697
OSA	113 (94.2)	108 (93.9)	0.989
Polycystic ovarian syndrome	18 (15.0)	20 (17.4)	0.672
Dyslipidemia	68 (56.7)	63 (54.8)	0.877
Gastroesophageal reflux disease	22 (18.3)	18 (15.6)	0.645

Table 2
Operative parameters.

	CLSG ($n = 120$)	MLSG ($n = 115$)	*P*-value
Operative time (Min)	76.7 ± 10.7	72.6 ± 10.9	0.003
length of stay (Days)	6.0 ± 1.3	5.6 ± 1.0	0.016
Postoperative Nausea/Vomiting *N* (%)	12 (10)	10 (8.7)	0.755

Table 3
Two-year post-surgery Follow-up.

	CLSG ($n = 120$)	MLSG ($n = 115$)	*P*-Value
BMI (kg/m^2)	23.4 ± 5.1	23.1 ± 4.8	0.679
EBMIL%	39.1 ± 11.0	40.6 ± 10.8	0.312
Comorbidities remission			
Type II diabetes mellitus			
Significant improvement	27 (22.5%)	23 (20%)	0.467
Complete resolution	88 (73.3%)	83 (72.2%)	
Hypertension			
Significant improvement	39 (32.5%)	42 (36.5%)	0.472
Complete resolution	76 (63.3%)	67 (58.3%)	
OSA: STOP-Bang score			
Low risk	106 (88.3%)	109 (94.8%)	0.077
Intermediate risk	14 (11.7%)	6 (5.2%)	
High risk	0 (0)	0 (0)	
MASLD			
Significant improvement	39 (32.5%)	41 (35.7%)	0.491
Complete resolution	75 (62.5%)	65 (56.5%)	
polycystic ovarian syndrome			
Significant improvement	30 (25.0%)	25 (21.7%)	0.563
Complete resolution	77 (64.2%)	77 (67.0%)	
Dyslipidemia			
Significant improvement	31 (25.8%)	36 (31.3%)	0.344
Complete resolution	84 (70.0%)	74 (64.4%)	
Gastroesophageal reflux disease			
Significant improvement	14 (11.7%)	18 (15.7%)	0.370
Complete resolution	87 (72.5%)	79 (68.7%)	

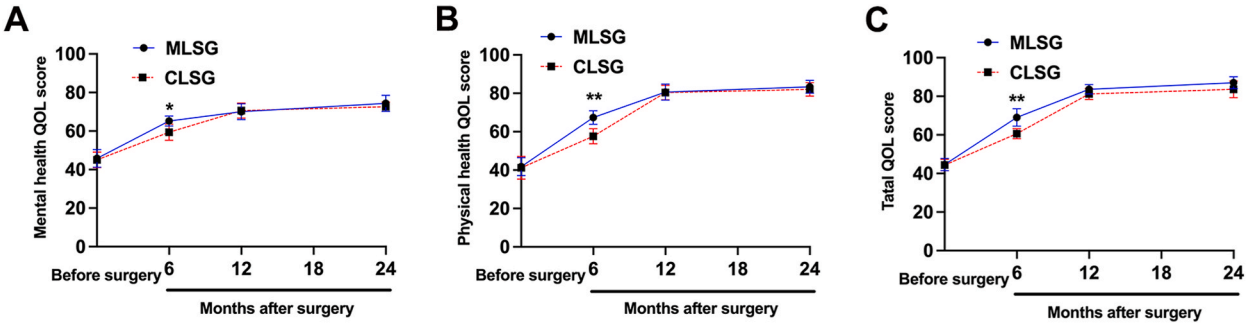

Fig. 1. Quality of life before and after surgery. The SF-36 questionnaire was applied to value the quality of life (QOL) of the patients in CLSG group and MLSG group before and after surgery. (A), (B), (C) represented mental health score, physical health score and total score respectively. *$P < 0.05$, **$P < 0.01$.

More and more cases have been reported about the benefits of using the magnetic anchoring device with its nature of intending to reach the number reduction of trocar port in surgery, as well as less wound in patients [26–28]. Currently, with growing number of studies reporting about the utilization of magnetic devices in bariatric surgery [29–31], the safety and effectiveness need more evaluation.

Here, we evaluated the safety and short-term outcomes in weight loss, resolution of comorbidities and effects on QOL in the patients who had the surgery of CLSG ($n = 120$) or MLSG ($n = 115$) for obesity. Results show that in both groups women with the mean age of around 33 years old make up the majority of patients undergoing the bariatric surgeries, suggesting that the young lady probably have higher acceptance of CLSG and MLSG.

The magnetic anchoring device is mainly used for exposure of the surgical field by adjusting liver retraction, meanwhile reducing the trocar ports. In our study, we found that the mean operative time of MLSG group is significantly shorter compared to the CLSG

group with 72.6 ± 10.9 vs. 76.7 ± 10.7 min, as well as a shorter length of stay in hospital with 5.6 ± 1.0 vs. 6.0 ± 1.3 days. And there is no significant difference in occurrence rate of postoperative nausea or vomiting, which proves the medical safety of MLSG. Based on our findings, MLSG group has a slight shorter operative time and length of stay in hospital, probably because that MLSG has fewer trocar ports and skin wounds, then patients could recover sooner and have better patient experience. As expected, compared to the reports about length of stay in other hospitals, it seems that patients in our center have a longer mean length of stay, with 5–6 days vs. 2 days. Actually, the main reasons why patients stay in hospital for more days after the bariatric surgery in our hospital are aimed to ensure the short-term postoperative complications, such as bleeding, wound infection, nausea and vomiting and so on, can be addressed in time, and to training the patients how to perform a proper postoperative and nutrition management.

As one of the most frequently performed procedures in bariatric surgery, LSG can not only effectively reduce the weight, but can also relieve the obesity-related comorbidities. Next, we compared the effects of CLSG and MLSG on weight loss and co-comorbidities remission at the second year after surgery. Totally speaking, at the second year after surgery, the BMI in both groups were significantly reduced, but there is no difference in terms of EBMIL%, with 39.12 ± 11.04% vs. 40.57 ± 10.83%. As to the co-comorbidity remission, though there is no statistical difference between CLSG and MLSG group, both groups have remarkable positive effects on comorbidities, further confirming the medical safety of MLSG.

Improvement of QOL is a vital index to assess the bariatric surgery. Here, the baselines of QOL of the two groups of patients are similar, and overall trend of QOL, including mental health, physical health and total heath, in both groups during the two years after surgery gradually become better and better. Interestingly, broadly speaking, though it seems that there is no difference in improvement of QOL by CLSG and MLSG, the obvious differences are found at the timepoint of 6-month after surgery, with higher mean mental health score, physical health score and total score in MLSG group. Thus, we speculate that compared to the CLSG, the shorter operative time and shorter length of stay in hospital and some other factors related to MLSG may make patients more psychologically satisfied with the treatment in the short term，but the difference of satisfaction would fade away gradually with passage of time. However, our study still has limitations. In fact, on some certain the patient experience including mental and physical experience is very subjective，and the effect factors are complexed, besides the operative time and length of stay, trocar number, and number of wounds, there probably exists some other factors, which indeed need our further research. And the difference in placement time between magnetic device and trocar needs to be compared, as well as the liver separation efficiency difference between these two groups. In addition, though there was slight difference in terms of mean operative time between thes two groups, the anatomical conditions and technical difficulties in the preparation of the sleeve in surgery could be further evaluated. And, increasing the sample volume and including more centers in our research are also what we need to do in our following study.

5. Conclusions

Collectively, our study may have some limitations, such as the small sample size, the single center study, the short-term follow-up and so on. However, our study provides the evidence regarding safety and clinical efficiency of MLSG in weight loss, comorbidities remission and improvement of QOL. And the patients in MLSG group have a better QOL improvement in short term after surgery.

Ethics approval and consent to participate

Written informed consent was obtained from all subjects involved in the study. Participants consented to have these images published the images, such as internal scans (e.g. x-rays, MRIs, CTs, ultrasound) and/or external photographs. The study protocol was approved and registered with the Ethics Committee of the First Affiliated Hospital of Xi'an Jiaotong University (XJTU1AF-CRF-2022-088).

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Data availability statement

The data associated with this study has not been deposited into a publicly available repository. And data will be made available on request.

CRediT authorship contribution statement

Runkun Liu: Writing – original draft, Software, Investigation, Formal analysis, Data curation, Conceptualization. **Yixian Guo:** Software, Investigation, Formal analysis, Data curation. **Guozhi Yin:** Software, Formal analysis, Data curation. **Hang Tuo:** Software, Investigation, Formal analysis, Data curation. **Yifeng Zhu:** Software, Investigation, Formal analysis, Data curation. **Wei Yang:** Supervision, Conceptualization. **Yufeng Wang:** Writing – review & editing, Writing – original draft, Supervision, Software, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e26875.

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