Assessment of 2D and 3D imaging for patients undergoing laparoscopic bariatric surgery

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ABSTRACT: Aim: The aim of this study is to compare the association of 2D and 3D imagery with technical performance and operative time during laparoscopic surgery.

Material and methods: A systematic review of the literature was conducted through an online search in databases such as PubMed, Cochrane, Embase and CNKI in order to identify articles published in English and Chinese from 2010 to 2020 that compared the clinical results of 2D and 3D laparoscopic gastric bypass surgery.

Results: A total of 50 articles were included in the qualitative analysis. Out of these, 5 articles that met the inclusion criteria were selected for analysis, according to which 3D laparoscopic surgery had a shorter surgery time than 2D laparoscopic surgery.

Conclusions: Compared with a 2D laparoscopic system, a 3D laparoscopic system can significantly reduce the operative time and errors and can increase the comfort of the surgeons performing laparoscopic gastric bypass surgery.

KEYWORDS: 2D vs 3D imaging, laparoscopy, obesity, Roux-en-Y gastric bypass

ABBREVIATIONS

2D – two-dimensional vision
3D – three-dimensional vision
CNKI – China National Knowledge Infrastructure
LGB – laparoscopic gastric bypass
LRYGB – laparoscopic Roux-en-Y gastric bypass
MGB – mini-gastric bypass
MOOSE – Meta-analyses Of Observational Studies in Epidemiology

INTRODUCTION

The prevalence of obesity has been increasing rapidly over the last few decades and has become a global health issue. When lifestyle modification and pharmacological therapies fail to achieve the desired goals, surgery remains the most successful approach for weight reduction. In bariatric surgery, the laparoscopic approach is becoming the gold standard [1]. Gastric bypass surgery is the most common procedure for weight reduction. The development and innovation of the laparoscopic vision platform have promoted the innovation of the whole surgical concept and technology from laparotomy to minimally invasive surgery. 3D and 4K laparoscopy have brought a new perspective to minimally invasive surgical procedures. The 3D laparoscopic system has entered the field of general surgery. 3D stereoscopic vision overcomes the disadvantage of a traditional 2D laparoscopic system, in that it lacks the vertical perception and depth of anatomical positions, provides more accuracy with a better surgical field for surgeons, and reduces errors [2].

The development of 3D stereo vision applied in surgery provides better depth perception and improves hand-eye coordination. Such advantages are particularly relevant when performing complex laparoscopic tasks, such as tissue dissection and manipulation, suturing, and knotting [3].

AIM

This paper aims to compare the association of 2D and 3D in terms of technical performance and operative time during laparoscopic surgery.

MATERIALS AND METHODS

We systematically reviewed the literature with a meta-analysis of observational studies in Epidemiology (MOOSE) guidelines.

Search Strategy

A literature search of databases such as PubMed, Medline, Cochrane, Embase, and CNKI was conducted independently in order to identify articles published in English and Chinese from 2010 to 2020 that compared the clinical results of 2D versus 3D laparoscopic gastric bypass surgery. The search was conducted using various combinations of the following keywords: laparoscopic, bariatric surgery, 2D and 3D assessments (Fig. 1.).

Eligibility Criteria

Articles which compared the clinical results of 2D versus 3D laparoscopic gastric bypass surgery and which were published in a peer-reviewed journal between 2010 and 2021 were considered eligible. Only articles published in English and Chinese were included in this study.

Data collection and outcomes

The authors independently evaluated the titles and abstracts of each article resulting from the search. Irrelevant articles and duplicates were excluded. A total of 50 studies were initially identified; 40 articles were reviewed; after removing 10 duplicate articles, 11 were accepted for a full-text review; and finally, 5 were accepted for inclusion in the study.
RESULTS

The literature search returned a total of 50 articles. Ten duplicates and 10 other articles with unrelated topics were excluded. Another 19 articles with abstracts only as well as 6 articles which did not meet the inclusion criteria were also removed. Finally, 5 full-text articles were further evaluated for inclusion in this review. Five studies with a total of 333 patients were included. The most common cause for exclusion was the lack of a control group. The final result of the literature search was 5 articles whose study design consisted of a randomized cohort and retrospectively analyzed, prospectively collected data. According to the analysis, in comparison to 2D laparoscopic surgery, 3D laparoscopic surgery can reduce the operative time and errors and can increase the comfort of the surgeon performing laparoscopic surgery (Tab. I.).

DISCUSSIONS

With the progress of technology and equipment, laparoscopic technology is being used frequently in bariatric, metabolic, and other abdominal surgeries. The planarization of 2D laparoscopic stereo images can be inconvenient when it comes to recognizing the anatomical structure, layer, and separation. In recent years, 3D laparoscopic technology has restored the surgical field of vision by constructing the depth of field, while the 3D structure provides accurate spatial positioning and retains complete tactile feedback, making the anatomical level clearer, effectively avoiding bleeding and injury during the surgery.

The disadvantages of 2D laparoscopy provide surgeons with real operation experience, which is conducive to accurate resection and reconstruction. For gastric bypass surgery, which is more complex in bariatric and metabolic surgery, it may have different degrees of impact in terms of the operative time, endoscopic operability, and comfort. A long operative time is an independent risk factor for postoperative pulmonary diseases such as pneumonia, atelectasis, pulmonary embolism, and respiratory failure. Shorter operative time also reduces the exposure time to anesthesia and deep venous thrombosis [4, 5]. Therefore, it is important to shorten the operative time in bariatric and metabolic surgery. However, 2D imagery cannot achieve the three-dimensional imaging effect of human vision. It is difficult to recognize the important anatomical structures or anatomical levels in laparoscopic surgery. Especially for beginners, this kind of visual loss may lead to a higher error rate in the operation, thus increasing the operation’s duration. According to some articles, 3D laparoscopic surgery has a shorter surgery time than 2D laparoscopic surgery (Tab. I.) [1, 2, 6–8] and has a lower error rate [6]. Some studies have shown that between 39.6% and 54.2% of medical errors occur in the operating room [9]. In a laparoscopic procedure,
Tab. I. Comparison of the duration of laparoscopic gastric bypass surgery performed using 2D and 3D systems.

<table>
<thead>
<tr>
<th>AUTHORS</th>
<th>DESIGN</th>
<th>NO. OF PATIENTS</th>
<th>PROCEDURE PERFORMED</th>
<th>2D GROUP TIME (MIN)</th>
<th>3D GROUP TIME (MIN)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mauricio E. Gabrielli</td>
<td>cohort study</td>
<td>50</td>
<td>LRYGB</td>
<td>93 (85–100)</td>
<td>80 (70–90)</td>
<td>0.001</td>
</tr>
<tr>
<td>Thapa Dil Momin</td>
<td>randomized study</td>
<td>60</td>
<td>LGB</td>
<td>95 (92–98)</td>
<td>80 (78–82)</td>
<td>0.023</td>
</tr>
<tr>
<td>Francesco Mongelli</td>
<td>retrospectively analyzed,</td>
<td>143</td>
<td>LRYGB</td>
<td>203 (152–254)</td>
<td>167 (135–199)</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>prospectively collected data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Martin Rojano Rodriguez</td>
<td>prospective &amp; randomized</td>
<td>40</td>
<td>LGB</td>
<td>136 (117–170)</td>
<td>120 (112.5–129)</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>comparative study</td>
<td></td>
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</tr>
<tr>
<td>Giuseppe Currò</td>
<td>prospective &amp; randomized</td>
<td>40</td>
<td>MGB</td>
<td>100</td>
<td>88</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>comparative study</td>
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</table>

1 LRYGB—laparoscopic Roux-en-Y gastric bypass; LGB—laparoscopic gastric bypass; MGB—mini-gastric bypass; 2D—two-dimensional vision; 3D—three-dimensional vision

A substantial number of errors are associated with depth perception: one study that evaluated laparoscopic cholecystectomy found that 97% of surgical accidents occurred due to visual misperceptions [10].

A 3D laparoscopic system was associated with a higher level of technical performance among surgeons performing an LRYGB procedure. The 3D laparoscopic vision claims to provide more realistic depth perception and better spatial orientation than the 2D system. Some studies have shown that 3D laparoscopic systems can reduce intra-operative blood loss, operative time, and the learning curve of the surgeon [11, 12]. Despite this potential for improved surgical safety, the use of 3D laparoscopic equipment remains limited in modern surgical centers [13]. This may be explained by the high cost of such technology and the limited evidence of the utility of 3D systems in minimally invasive surgery [14]. Some papers have evaluated the consequences of 3D imaging systems in laparoscopic surgery, but prospective data are limited and robust objective evaluation criteria for technical performance and clinically significant patient outcome measures are lacking [1, 15, 16].

A recent clinical study reported a significant advantage in suturing and cutting anatomical structures while using 3D visualization [17]. It even reduced the mortality rates associated with 3D laparoscopy. It is possible to release patients into postoperative care in a better state of health [18]. A quantitative evaluation showed that 3D images were more effective than 2D images while using laparoscopic forceps [19]. Even for inexperienced surgeons, a system with 3D dimensional images is particularly beneficial. The learning curve of 3D laparoscopic surgery may be shorter and more easily mastered by surgeons without experience in laparoscopic operations.

Some articles reported that due to a lack of depth and space of vision, 2D laparoscopic surgery lacks perception of depth and level of the subject, which may increase the incidence of errors to a certain extent, and may even increase the tension and fatigue of the surgeon’s wrist, head, neck, shoulder and waist [20]. Though 3D technology is superior in a few aspects, we cannot ignore the problems of 3D laparoscopy. For example, current 3D laparoscopy is mostly based on the principle of dual-channel imaging. Thus, it cannot change the 30° inclined plane to form a visual field from different directions and perspectives, as 2D laparoscopy can. If there is occlusion, it will cause difficulties in the operation. Even if the lens is able to rotate in four directions, it still has its disadvantages: 1) the rotatable head is too long, which brings the lens too close to the surgical field and makes the operation more difficult, 2) the lens is easily damaged, and 3) the depth of the 3D images is too long, which causes discomfort to the operator and others. These possible disadvantages are more related to the surgeons’ subjective habit of viewing through 3D glasses as well as with even faster data processing.

A Cochrane meta-analysis concluded that more blind and randomized clinical trials are needed to evaluate the advantages of 3D imaging and that the surgeon’s comfort is a crucial factor [21]. Some studies have reported that the 3D systems improve task efficiency in laparoscopic manipulations, whereas other reports found no significant difference between 3D and 2D systems. 3D laparoscopy equipment has good sense, good depth, and accurate spatial positioning. It can correctly display the 3D structure of the abdominal cavity, it shortens the learning curve, and it facilitates separation of the vascular anatomy and dissection of the lymph nodes. In the future, with the progress of science and technology, the existing problem of 3D laparoscopy can be solved, and 3D laparoscopy can be fully utilized in surgery.

CONCLUSIONS

Compared with 2D technology, a 3D laparoscopic system can significantly reduce the operative time and errors and can increase the comfort of the surgeon while performing laparoscopic surgery. However, more studies with larger data sample sizes are required to better assess the advantages of 3D vision in laparoscopy.

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