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Supramesocolic Laparoscopic Simulator of Omega Loop Gastrajejunoanastomosis with Braun Foot in 3D Printed: Model Proposal

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Abstract

Introduction: Laparoscopic surgery in surgical practice has sparked an interesting debate about its teaching, which in turn has prompted a review of the methods used in teaching traditional open surgery.
Objective: To develop a proposed 3D-printed model for a supramesocolic laparoscopic simulator of omega-loop gastro jejunostomy.
Methods: A prospective, longitudinal study was conducted. The study consisted of 20 practical sessions, which were evaluated using the GOALS scale and by measuring execution time.
Results: The 3D simulation model allows for the recreation of the steps to perform the proposed procedure. A statistically significant improvement was found in the scores of the items on the GOALS scale as the practical sessions of gastro enteroanastomosis and enteroenteroanastomosis were completed, such as depth perception ($p<0.001$), bimanual dexterity ($p=0.01$), tissue handling ($p<0.001$), and autonomy ($p=0.02$). There was a significant inverse correlation between the number of practice sessions and the time taken to develop the skill ($p<0.001$). Conclusion: The 3D simulation model for gastro enteroanastomosis and enteroenteroanastomosis can be a useful tool for recreating the proposed surgical technique, as well as enabling the development of skills and abilities in advanced laparoscopic surgery.

Keywords: Laparoscopic simulator; Omega loop; Gastro enteroanastomosis; GOALS scale; 3D printing

Introduction

The importance that laparoscopic surgery has acquired in surgical practice today has given rise to an interesting debate about its teaching [1], and it must be taken into account that, for its performance, several psychomotor skills are necessary that are completely different from open surgery [2]. For this purpose, models or systems that artificially reproduce the conditions of visualization, spatial orientation, coordination, and manipulation of instruments are indispensable [2,3]. These systems are called simulators, whose main objective is to promote the acquisition of skills in spatial and temporal location, handling of surgical instruments, procedures such as suturing and knot tying, transport and cutting of internal structures, among others [4]. The evolution of simulators is complemented by the usefulness of 3D printing, since this technology and its medical-surgical application have grown exponentially since 2011, generating important advances in the planning, execution and simulation of complex surgeries [5]. Since laparoscopic omega loop gastro enteroanastomosis with

Braun foot is a complex technique that is eventually used for oncological bypass procedures [1] , surgeons in training have little chance of performing a significant number of such procedures, making it relevant and valuable to generate guided training in this type of intervention, allowing them to enjoy the aforementioned simulation benefits and those of minimally invasive surgery, in addition to the incorporation of 3D technology in the field of surgical simulation [5]. A review of the literature in the electronic data sources PubMed, Cochrane Library, Scielo and Google Scholar of scientific articles (original and reviews), published in English and Spanish, did not find results compatible with a training model in gastro enteroanastomosis in omega loop with Braun foot, that allows the acquisition of skills and abilities for the practice of safe laparoscopic surgery, that uses 3D printing technology and that facilitates recreating the necessary steps of this procedure to later be implemented in daily surgical practice.

General Objective

Develop a proposal for a model of a supramesocolic laparoscopic simulator of gastro jejunoanastomosis in omega loop with Braun foot in 3D printing.

Specific Objectives

- Recreate the steps of the surgical technique to perform gastro enteroanastomosis in omega loop with Braun foot in the simulation model.
- Evaluate the surgical skills and abilities acquired in each practical session using the GOALS scale.
- Measure the execution time of each practical session in the simulation of the gastro jejunoanastomosis technique in omega loop with Braun foot.
- Determine the performance during the practical sessions with the training model, comparing the score obtained according to the GOALS scale and the time in which each practice was carried out.
- Determine the participant's level of satisfaction at the end of the practical sessions using the Likert scale.

Procedures

For the execution of this project HE A pre-designed and 3D-printed hybrid supramesocolic model was used , manufactured by VePrint3D CA (Figure 1) , and recreated a Laparoscopic omega loop gastro enteroanastomosis with Braun foot, using 5 mm diameter and 50 cm long latex tourniquets that simulated the jejunum, and a 3D printed stomach with a central oval-shaped hole on the anterior face whose transverse diameter measures 2 cm, to which a 2.5 cm diameter latex membrane recycled from an anesthesia machine reservoir bag was attached. The supramesocolic model was fixed to the floor of the black box, along with complementary structures representing the liver and pancreas made of polystyrene, covered with plasticine and a protective enamel layer.

The biliary tract was also represented with 5 mm green tourniquets and the portal vein with 8 mm blue tourniquets. Subsequently, the following steps were carried out:

1. In the anterior wall of the gastric body using a Maryland clamp and laparoscopic scissors (Figure 2A).
2. Then 20cm of jejunum was ascended to the anterior surface of the stomach, counting from the fixed loop.
3. An assistant held the jejunum close to the gastrostomy.
4. Using laparoscopic scissors and a grasper, the jejunum was cut, 1 cm in length, in what is presumed to be the antimesenteric border (Figure 2B).
5. Subsequently, the gastro enteroanastomosis was performed using 15 cm long Vycril 3-0 CT-2 suture, starting from the posterior aspect from left to right, inserting the needle into the angle of the gastric membrane from inside out and into the external angle of the tourniquet from outside in, and three knots were made on the internal surface (Figure 2C).
6. Subsequently, 5 continuous sutures were made up to the right angle of the anastomosis, where it was knotted again and the posterior aspect of the gastro enteroanastomosis was completed (Figure 2D).
7. The anterior surface was started with a new 3-0 CT-2 vycril suture, 15 cm long, inserting the needle into the angle of the gastric membrane from inside out and into the external angle of the tourniquet from outside in, then three knots were made that remained on the inner surface.
8. Five to six continuous sutures were placed along the entire anterior surface until reaching the initial left angle, where laparoscopic knot tying was performed with three knots (Figure 2E, 2F).
9. A Braun foot was then recreated 10 cm from the previous gastro enteroanastomosis; for this, two 1 cm incisions were made in the afferent and efferent branches of the jejunum (Figure 3A,B,C).
10. The enteroenteroanastomosis was initiated at the superior angle by inserting the needle from inside out into the afferent loop and subsequently from outside in into the efferent loop, and three knots were made that remained on the inner surface (Figure 3D).
11. Were continued until the lower angle was reached, where the posterior face was tied with three intracorporeal knots. (Figure 3E).
12. Using a new 15-centimeter 3-0 CT-2 Vicryl suture, the anterior aspect of the enteroenteroanastomosis was initiated from the inferior angle, incising the needle from inside out in the afferent loop and subsequently from outside in in the

efferent loop, where a laparoscopic knot was made with three knots and the suture was continued with 5-6 stitches to the superior angle where the final knot was made (Figure 3F).

13. The exercise was completed and the patency of the gastro enteroanastomosis was checked using a Braun foot by inserting the tip of a Maryland bridge into the anastomosis towards the afferent and efferent loops (Figure 4).

During the 20 practices, his performance was evaluated in the execution time and GOALS 18 scale score of each session were recorded using a digital record. The practices were evaluated by three specialist surgeons, and at the end of the sessions, the Likert scale was applied to determine satisfaction with the practices performed (Table 1).

Table 1: *Likert satisfaction scale.*

After Compleating the laparoscopic simulation training program, you:	5	4	3	2	1
1. Receved sufficient training within the eastablished timeframe					
2. Perceived constant support from the tutor/instructor during the training					
3. Received timely answers to all questions that arose during the training process					
4. The assessments were developed clearly and precisely					
5. The program enhanced your previous skills in using laparoscopic simulator					
6. The laparoscopic simulation program strengthens your competence in performing complex procedures					

Statistical Treatment

A database was created in Microsoft Excel® and then imported into the Statistical Package for the Social Science (SPSS) version 26 (IBM, Chicago, USA), where the data obtained by the participant when performing each practice were tabulated and represented in figures that allowed the analysis of the GOALS scale score, the time spent in each practical session and the degree of satisfaction of the 3D printed supramesocolic model. Kendall's TAU-c statistical test was applied to associate the directionality of the correlations between the different variables and was considered statistically significant when $p<0.05$.

Results

In the proposed model of a supramesocolic laparoscopic simulator for omega-loop gastro enteroanastomosis with Braun's foot, the steps for performing this surgical technique were successfully reproduced. The first step involved the omega-loop gastro enteroanastomosis, and the second step involved the enteroenteroanastomosis or Braun's foot. The GOALS scale score obtained in these two procedures was equal, with the lowest score being 15 points in the first practice, progressively increasing to 25 points from the 19th practice onwards. There was a directly proportional and statistically significant correlation between the overall score and the number of practices ($p<0.001$) (Graphs 1 AB). Regarding surgical time, a shorter execution time was observed as the practices progressed. In the first session, the gastro enteroanastomosis and the Braun foot were performed in 37.15 and 40 minutes respectively, with a total surgical technique time of 77.15 minutes, which decreased progressively until the last practice where they were performed in 21.3 minutes (gastro enteroanastomosis) and 19.25 minutes (Braun foot), with a total time of 40.55 minutes (Graph 3). Therefore, it is shown that there was an inversely proportional correlation between the number of practice and the execution time of the technique, being statistically significant ($p<0.001$). When comparing surgical time with the GOALS scale score, it was observed that the GOALS scale score tended to increase as the training progressed, while surgical time decreased as the training sessions advanced. The correlation between these variables occurred in practice number 7, both in the gastro enteroanastomosis (Graph 1D) and in the Braun foot (Graph 1E), and when considering the total practice time (Graph 1F), with this association being statistically significant ($p<0.001$). When measuring the degree of satisfaction at the end of the last practical session, it was observed that each item of the Likert scale obtained a score of 5/5 points, with a maximum total score of 30 points, which represents a high degree of satisfaction with the surgical technique used in the proposed model.

Discussion

Simulation in laparoscopic surgery is a fundamental tool in the training of surgeons. It allows training in a safe, controlled, and standardized environment, as well as putting theoretical knowledge into practice and improving dexterity in movements without compromising patient safety [6,7]. There are reports in the literature stating that 3D printed simulators allow the recreation of critical steps of surgical procedures with excellent realism and precision [5, 8,14], as was achieved in the present study where a 3D printed hybrid inorganic model was created that allows the simulation of the steps of an omega loop gastro enteroanastomosis with Braun foot. Hybrid experimental models using materials such as latex, silicone and plastic have also been described in the literature, and these devices are very useful for acquiring the surgical skill necessary to perform maneuvers of greater technical complexity, such as laparoscopic suturing [7,8,11,13]. An inverse correlation was found between the time required to complete the task and the number of training sessions; that is, a greater number of practice sessions resulted in less time spent completing the task with a high degree of satisfaction. These data are comparable to those reported by Rubin [13], who demonstrated that a greater number of practice sessions resulted in less time taken to complete the assigned activity on a 3D-printed gastrostomy model.

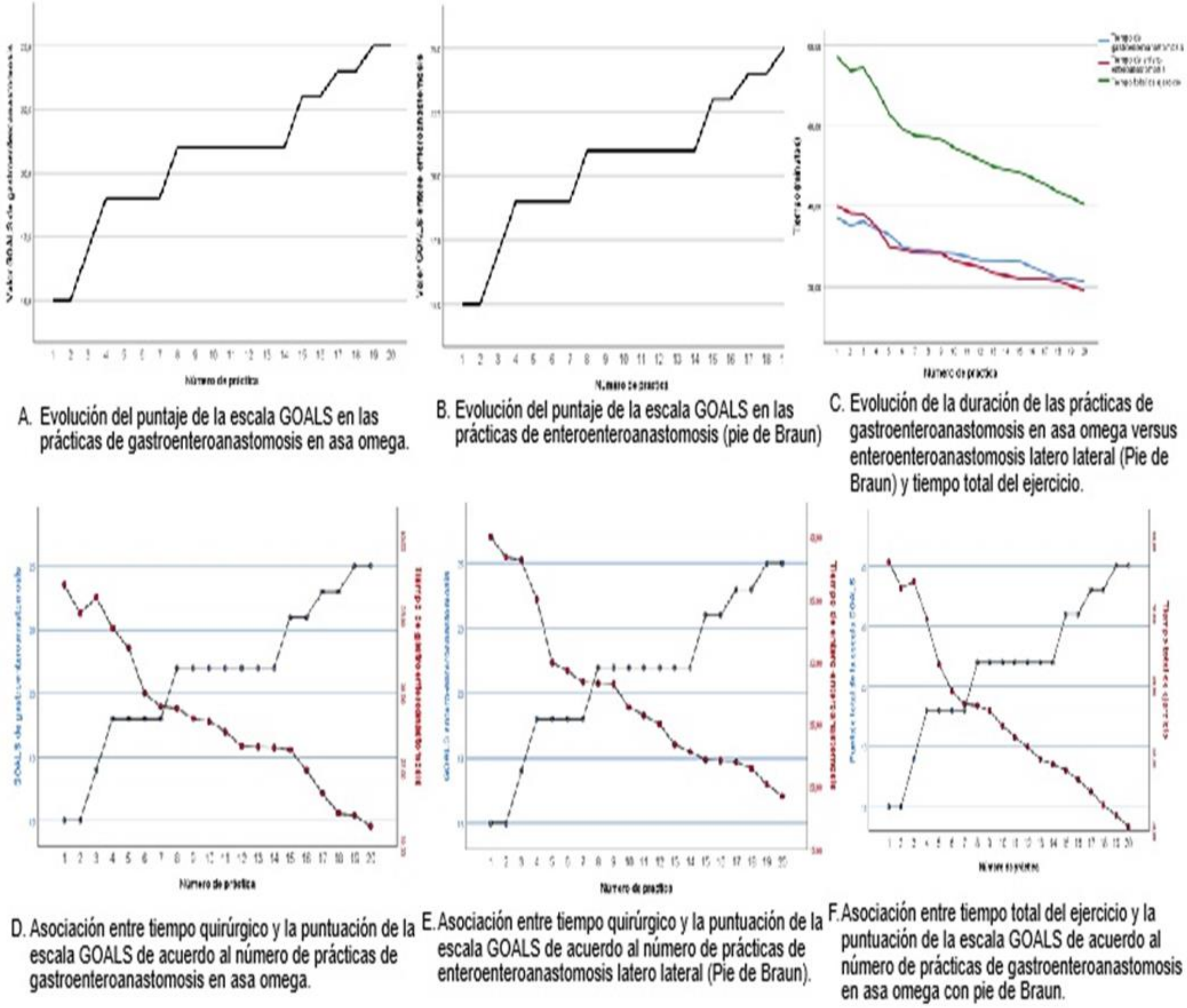

Figure 1: *3D printed hybrid supramesocolic simulator model, showing latex structures and complementary organs*

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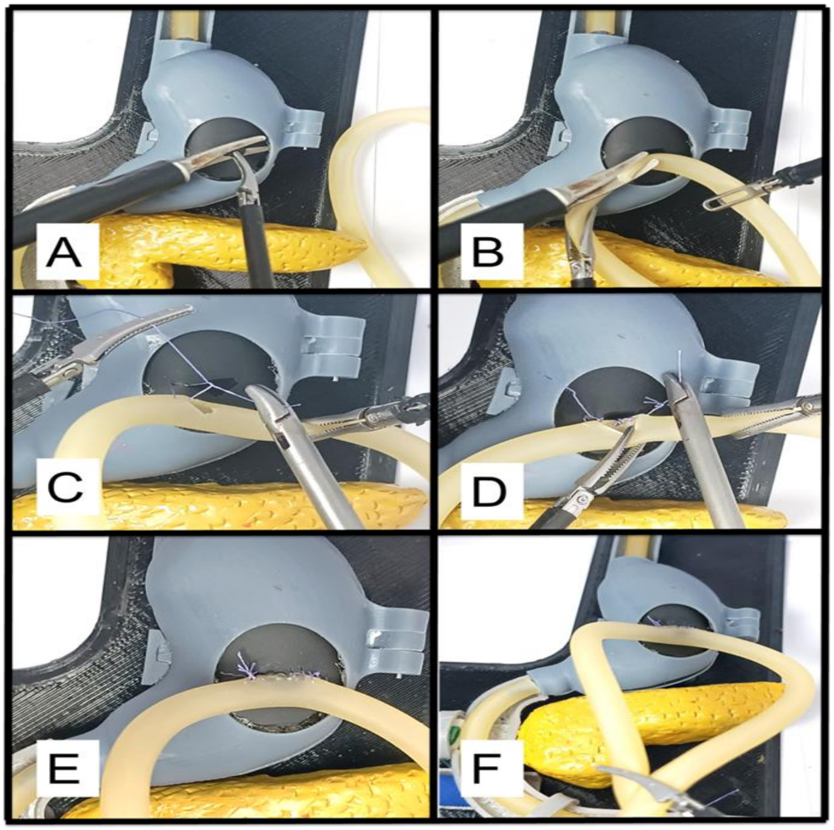

Figure 2: *Image sequence showing the steps for performing omega loop gastroenteroanastomosis in the 3D printed supramesocolic laparoscopic simulator.*

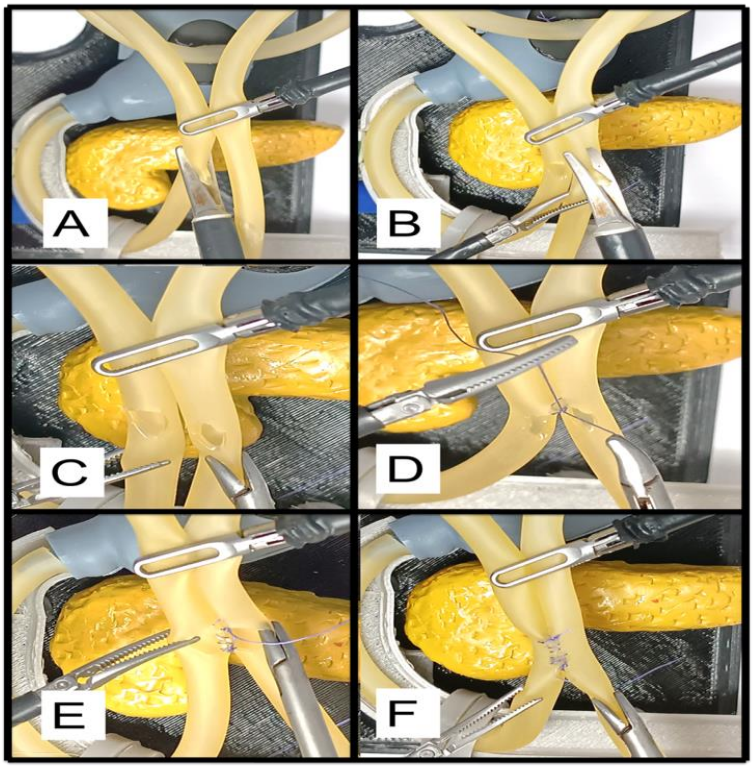

Figure 3: *Image sequence showing the steps for performing side-to-side enteroenteroanastomosis (Braun's foot) in the 3D printed supramesocolic laparoscopic simulator.*

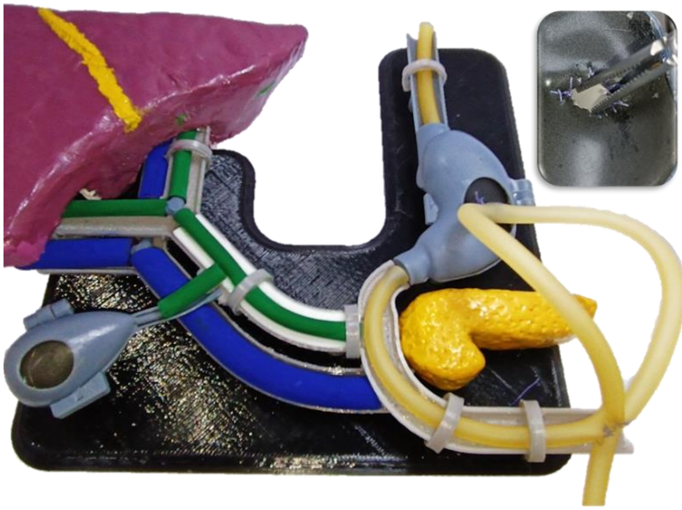

Figure 4: *Image showing the completed surgical procedure: Omega loop gastroenteroanastomosis with Braun foot, in a 3D printed hybrid supramesocolic model.*

Likewise, when performing the cross-tabulation of variables between time and GOALS score, an inversely proportional relationship is obtained between these two variables; that is, the higher the GOALS score, the less practice time. This is observed progressively as the number of exercises increased, similar to what was reported in other studies [13,5,14,15,11]. Therefore, it is demonstrated that the model applied in this study for simulation in gastro enteroanastomosis and entero-enteroanastomosis can be a valuable tool that allows surgeons to practice and perfect their skills before performing procedures on real patients. Establish the application of a Likert-type scale to evaluate the degree of satisfaction with a surgical simulator model is important for obtaining accurate feedback and identifying the simulator's strengths and weaknesses, as well as monitoring the surgeon's progress and improvement [16,17]. In the present study, the application of a Likert scale demonstrated a high degree of satisfaction with the proposed model and the practice sessions where the surgical technique was recreated.

Conclusion

The 3D simulation model for omega-loop gastro enteroanastomosis with Braun foot not only allows for the recreation of the steps involved in performing this highly complex surgical technique and promotes the advancement of surgical education by implementing cutting-edge technology such as 3D printing to enhance didactic resources in targeted training, but it can also be a useful tool for developing skills and abilities in minimally invasive surgery. It demonstrates a direct correlation between the number of practice sessions and GOALS scale score, and an inverse correlation between the number of practice sessions and the total training session time. Furthermore, improved performance was demonstrated, reflected in increased GOALS scale scores and decreased time as the practice sessions progressed. In addition, the training model achieved a high acceptance score on the Likert satisfaction scale used at the end of the final practice session.

Ethical Approval

This research work is governed by the four principles of bioethics established by Beauchamp and Childress.

Conflict of Interest

The authors declare that they have no conflict of interest.

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