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Experimental use of a novel single-port gasless laparoendoscopic operative field formation device

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HIGHLIGHTS

- Traditional carbon dioxide laparaendoscopy is a high risk surgery.
- The existing gasless laparaendoscopies have attendant poor visibility of the abdominal cavity.
- We developed an inflatable device for gasless laparoscopic operation field formation (LOFF).

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ABSTRACT

Introduction: Traditional laparaendoscopic surgery using CO2 pneumoperitoneum is associated with complications and the existing gasless laparaendoscopic surgery has shortcomings such as poor visibility in the operation field. To overcome the disadvantages of the current lifting gasless laparaendoscopic operation platforms, we developed an inflatable device for gasless laparoscopic operation field formation (LOFF) that can be internally installed and applied in practice.

Methods: We initially designed operation platforms for gasless laparaendoscopic single-port (GLESP) surgery. Subsequently, a triangular prismatic LOFF device was selected and applied successfully to GLESP cholecystectomy of five pigs. Ultimately, using pigs as a model, three surgical approaches (LOFF-assisted laparaendoscopic single-site (LOFF-LESS), LESS surgery, and traditional lifting (GLESP) were compared, and the advantages and drawbacks of inflatable devices for gasless laparoscopic operation field assessed.

Results: The use of the LOFF device in GLESP cholecystectomy was first evaluated. The time for surgical space formation (4.4 ± 1.2 and 4.8 ± 1.0), the operating time for gallbladder removal (25.2 ± 4.8 and 25.4 ± 2.7), and the loss of blood (9.4 ± 3.1and 9.2 ± 2.4) was similar between LESS and LOFF, respectively (Table 2). In contrast these parameters were higher in GLESP (6.6 ± 1.0, 30.3 ± 4.4 and 10.1 ± 2.0, respectively. The LOFF-LESS surgery exhibited a clearer exposure of the surgical field and shorter operating time than the GLESP surgery. LESS technology showed less postoperation pain, fast recovery, and extremely high cosmetic satisfaction.

Conclusion: The LOFF device provides a safe, effective, and feasible operation platform that can be internally installed and inflated for GLESP surgery during cholescytectomy in animal models.

1. Introduction

Since the establishment of laparaendoscopic technology, a series of laparaendoscopic techniques have been developed, including the traditional laparaendoscopic technique, the laparaendoscopic single-site (LESS) technique, the gasless laparaendoscopic technique, and the gasless laparaendoscopic single-site (GLESP) technique, as well as other newly emerging laparaendoscopic techniques. In traditional laparaendoscopic surgery, the surgical space is formed using carbon dioxide (CO_2) pressure to push aside the surrounding tissue in the body cavity, allowing satisfactory exposure of the operation field. Indeed, CO_2 is the most frequently gas for insufflation into the abdomen during

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laparoscopic abdominal surgery. However, it is associated with complications. However, accumulating clinical data reveal the danger of pneumoperitoneum and the high risks of its associated complications such as adverse effects on the circulatory system [1], the respiratory system [2], blood coagulation – especially venous thrombosis - [10], and the nervous system [11] as well as increasing the risk of maternal-foetal hypoxia [3], and the risk of seeding of free tumour cells in the abdominal cavity [4]. However, the complication rate of pneumoperitoneoum has not been prospectively studied in small animals. Therefore, although traditional surgical approaches continue to be applied and promoted in clinical practice researchers have begun to explore devices for gasless operation. To date, the gasless technique has been used in various surgeries [5–8], including laparaendoscopic radical resection for colorectal cancer, gastrectomy, hepatectomy, and other surgical procedures. Despite the fact that the laparaendoscopic gasless technique offers a number of advantages, it has not been widely used in clinical practice. A major reason for this is that lifting the anterior abdominal wall by mechanical force can cause the lateral walls to move towards the middle and push the gut towards the operation field, thus reducing the surgical space and resulting in poor exposure of the operation field [8]. To overcome this disadvantage, our research group developed a device for gasless laparoscopic operation field formation (LOFF) and tested its use in LOFF-aided LESS operations (LOFF-LESS surgeries) in animal experiments.

2. Methods

2.1. Research and development of the LOFF operation platform

The main components of the proposed device include an inflating hose, a guiding rod, an extension frame, a top platform, and a supporting body (Fig. 1).

2.1.1. The inflating hose and guiding rod

The inflating hose is a tubular hose, 0.3 cm in diameter, made of medical-grade plastic; it is used for the inflation and deflation of the supporting body. The guiding rod is primarily composed of rigid material and is used to place the supporting body in the surgical area.

2.1.2. The platform and the extension frame

The platform is a plastic component with a round surface 2 cm in diameter. Five round holes are placed at intervals on the platform to permit access of surgical tools, the endoscope, and the inflating hose during the operation. The extension frame, which is made of medical thermoplastic polyurethane (TPU) materials, not only connects the platform and the supporting body but also enables depth adjustment of the supporting body within the abdominal cavity to accommodate animals of different body sizes.

2.1.3. The supporting portion

This part is made of medical TPU material and has a hollow triangular prismatic shape (height, 10 cm; two ends, equilateral triangular shape with 11-cm-long sides). This part not only allows the formation of the operation field and space but also prevents entry of the surrounding organs into the operation field.

2.1.4. Application instructions

First, with assistance from the guiding rod, the LOFF device is inserted into the abdominal cavity through a 2.5-cm-long arch-shaped incision in the umbilical region. The device is moved along the anterior abdominal wall until it reaches the surface of the liver, at which point the liver is pulled back until the gallbladder is exposed. Next, the supporting body of the device is inflated through the inflating hose to form a hollow triangular prismatic surgical space at the right visceral surface of the liver. Subsequently, LOFF-LESS surgery is performed under laparaendoscopic monitoring. After the surgery is completed, the supporting body is deflated by allowing the gas to flow out through the inflating hose; the entire LOFF device is then removed through the incision in the umbilical region.

2.2. Animal experiments

Small domestic pigs (body weight 32–35 kg) were provided by the Laboratory Animals Center of Tong-ji University. The animals were housed in an environment with a 12-h light/dark cycle at a controlled temperature and humidity and were given free access to standard feed and clean water. All experiments were carried out under the Approval of the Ethical Research Committee at Tong-ji University and Shanghai province.

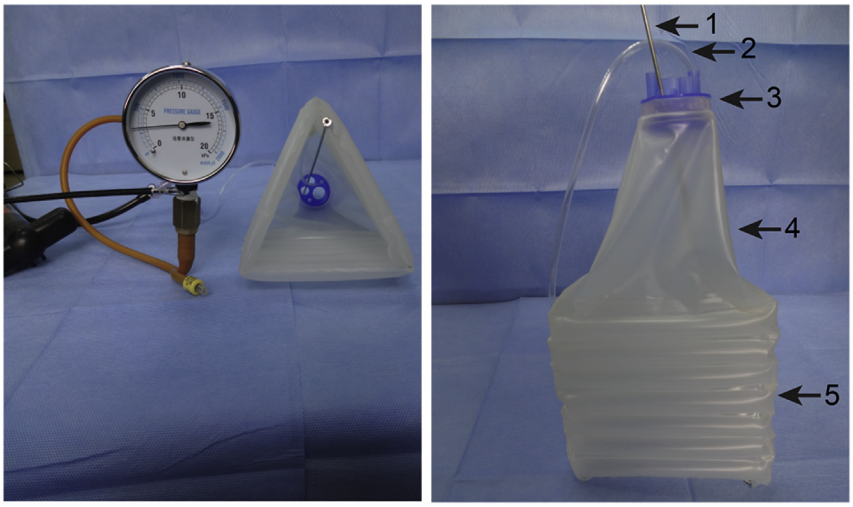

Fig. 1. Structure of the LOFF device. 1. Guiding rod; 2. Inflating hose; 3. Platform; 4. Extension frame; 5. Supporting body.