A novel approach for minimally invasive everted esophagectomy in pigs

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Background: Minimally invasive esophagectomy has been developed to reduce surgical injury. In this current study, we have designed a new operative procedure to dissect the esophagus with less chest injury.

Methods: Three pigs (Sus domesticus) underwent the same procedures: routine laparoscopic techniques, anastomosis at left neck and right thoracoscopic everted esophagectomy utilizing one thoracoscopic operative hole.

Results: The everted resection of the esophagus was successfully accomplished in the three pigs utilizing one thoracoscopic operative hole.

Conclusions: A novel technique was described here. The procedure of the operation was modified with anastomosis operated before esophagectomy. Only one thoracic operative hole was needed, which reduced the injury on chest wall.

Keywords: Minimally invasive esophagectomy; everted; thoracoscopic

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Introduction

Esophagectomy generally incorporates procedures from two or three different surgical fields (1,2), resulting in substantial surgical damage. Minimally invasive esophagectomy (MIE) is a good approach that can reduce the surgical injury compared with open surgery methods (3). But no surgeon would give up the efforts to improve surgical procedures. In this paper, we designed a novel operative procedure, minimally invasive everted esophagectomy in pigs.

Methods

Animals

For the purposes of this study, three pigs (*Sus domesticus*) were provided by Johnson & Johnson China Ltd. The experiment was conducted in the Beijing science center of Johnson & Johnson China Ltd. The studies were approved by Animal Care of Xi'an Jiaotong University. The 'Principles of Laboratory Animal Care' (NIH Publication Vol 25, No. 28 revised 1996; http://grants.nih.gov.ezp-prod1.hul.harvard.edu/grants/guide/notice-files/not96-208.htmL) as well as the current version of the Chinese Law on the Protection of Animals were followed.

Procedure

The three pigs each underwent the same procedures: routine laparoscopic techniques, anastomosis of the cervical esophagus with a gastric conduit and thoracoscopic everted esophagectomy. After anesthesia, but prior to the operation, a gastrointestinal decompression tube (GIDT) was placed inside of the stomach. All of the pigs were anesthetized and intubated with a double-lumen endotracheal tube in the conventional manner. A 10 mm thirty-degree scope (Olympus Co.) was used throughout the whole procedure. The ports were shown in *Figure 1* (*Figure 1A*,*B*). Firstly, we performed the laparoscopic mobilization of the stomach in supine position. The abdominal esophagus and GIDT were simultaneously transected using the endoscopic linear cutter

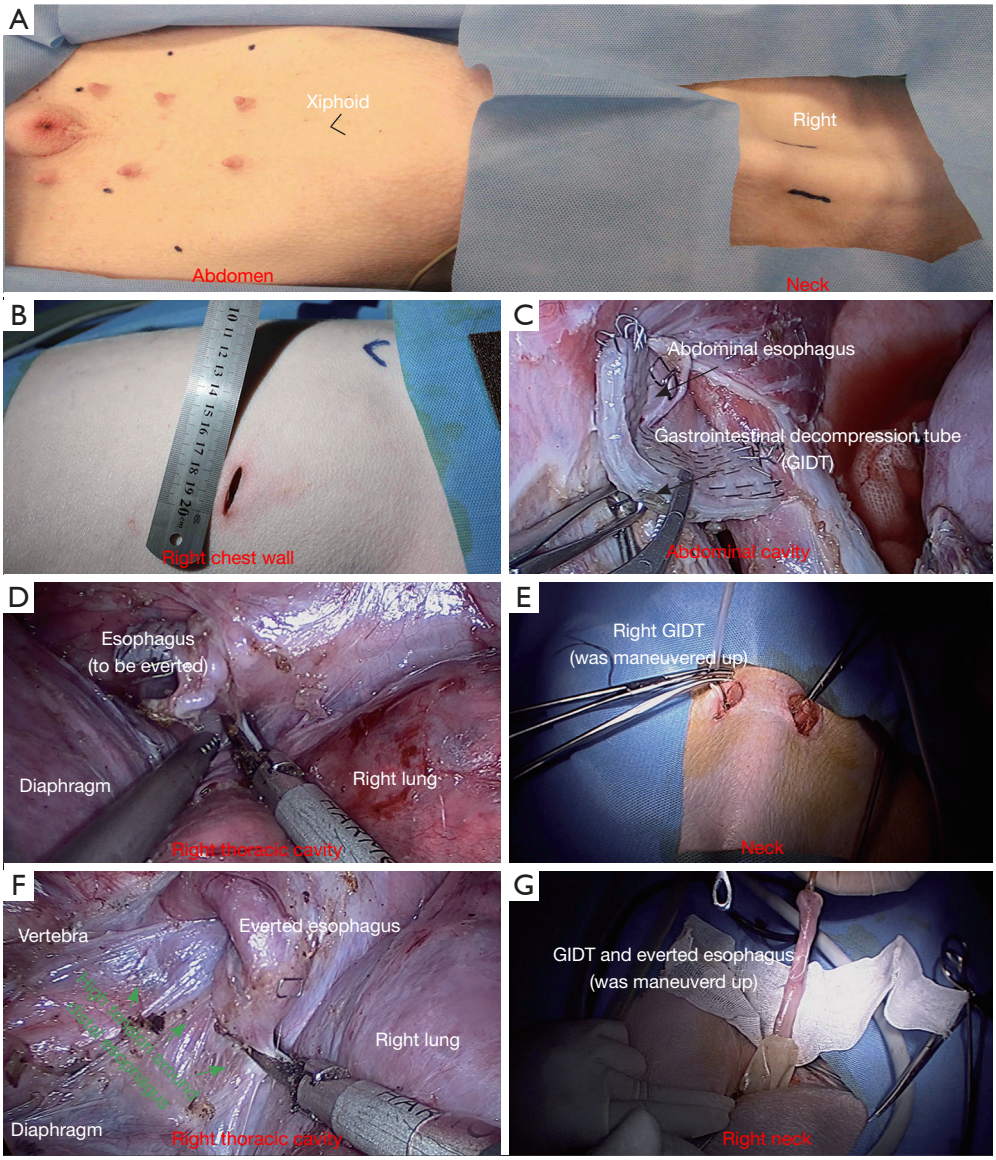

Figure 1 Port positions and key procedures for everted esophagectomy. (A) The port positions on the abdominal wall and neck were labeled; (B) the seventh intercostal space at right middle axillary line was demonstrated on the right chest wall; (C) the abdominal esophagus and gastrointestinal decompression tube (GIDT) were simultaneously transected using the endoscopic linear cutter stapler; (D,E,F) the esophagus was drawn up and everted while the GIDT was maneuvered up into the right cervical incision; (F) high tension was formed around the distal esophagus while pulling up GIDT during thoracic everted esophagectomy; (G) the specimen (everted esophagus) was extracted from the right thoracic cavity.

stapler (Johnson & Johnson, *Figure 1C*). The 30–40 mm gastric conduit was formed from the pylorus to the gastric fundus along the lesser curvature of the stomach using the endoscopic linear cutter staplers (Johnson & Johnson). The substernal tunnel was made from the xiphoid to the leftmost cervical incision. Secondly, the cervical esophagus was dissected through the leftmost cervical incision. The cervical esophagus and the GIDT were transected at the level of the suprasternal fossa. Then, the distal cervical esophagus and the GIDT were pulled from the leftmost cervical incision to the right through the space between the trachea and spine. The gastric conduit was maneuvered up

Figure 2 Minimally invasive everted esophagectomy in pig (4). Available online: http://www.asvide.com/articles/1416

to the left cervical incision through the substernal tunnel. All wounds in the left of the neck and abdomen were closed after the anastomosis of the cervical esophagus with the gastric conduit. Finally, we performed an everted resection of esophagus in the left lateral decubitus position. The abdominal esophagus was drawn up and everted while the GIDT was maneuvered up into the right cervical incision (*Figure 1D,E*). High tension was present around the distal esophagus while repositioning the GIDT (*Figure 1F*). Then, the thoracic esophagus was easily dissected from the esophageal hiatus to the thoracic inlet through just one thoracic operative hole and extracted out of the thoracic cavity via the right cervical incision (*Figure 2*). After the specimen extraction (*Figure 1G*) and the suture of the thoracic and cervical wounds, the animals were euthanized with an intravenous injection of 10% potassium chloride (20 mL per animal).

Results

The same uniform operations were conducted on all three of the pigs and were completed without incident. The everted resection of the esophagus was successfully accomplished in the three pigs utilizing one thoracoscopic operative hole.

The overall elapsed time of the operation was 130±39 min (range, 123–201 min). The mean operating time was 61±35 min (range, 23–92 min) for dissecting the stomach and abdominal esophagus. It took 9±4 min (range, 5–13 min) for making the gastric conduit. It took about 12±4.5 min (range 8–17 min) for the esophagogastric anastomosis and then, 41±13.6 min (29–56 min) for the everted esophagectomy. Additionally, the mean estimated blood loss was 22±12.5 mL (range, 10–35 mL) during the dissection of the stomach and abdominal esophagus. Very limited bleeding was observed during the formation of the gastric conduit. The mean estimated blood loss during the esophagogastric anastomosis is 14±6 mL (range, 8–20 mL) and 13±6 mL (range, 5–15 mL) during the everted esophagectomy.

Conclusions

The eversion technique has been widely performed in colorectal resections during the modified Dixon operation (5,6), but not yet in esophagectomy. In this improved and modified procedure, we designed the various steps of the operation compared with those MIE previously reported. The routine steps of a three-hole MIE were: thoracoscopic esophageal dissection followed by laparoscopic gastric mobilization and cervical anastomosis (7). In our study, the thoracoscopic everted esophagectomy was instead performed as the last step following the laparoscopic gastric mobilization and the cervical anastomosis. Furthermore, only one thoracic operative hole was needed for the procedure, which reduced the injury on chest wall.

However, one shortcomings of our study was only three animal models were performed. The animals were not continuously fed to see the survival status and complication after operation for limited conditions. So greater confirmation and validation would be necessary with more animal work and human studies going forward.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.

org/10.21037/vats.2016.12.05). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The experiment was conducted in the Beijing science center of Johnson & Johnson China Ltd. The studies were approved by Animal Care of Xi'an Jiaotong University. The 'Principles of Laboratory Animal Care' (NIH Publication Vol 25, No. 28 revised 1996; http://grants.nih.gov.ezp-prod1.hul.harvard.edu/grants/guide/notice-files/not96-208.htmL) as well as the current version of the Chinese Law on the Protection of Animals were followed.

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