Laparoscopic Specimen Extraction in Vitro and in Vivo

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Abstract

Objectives: To explore the maximum diameter of specimens that can be extracted with different adjuvant incision length and shape by in vitro physical experiments.

Materials and Methods: The abdominal wall with the muscle layer of pigs was fixed on a square wooden frame to simulate the abdominal wall of humans. Then, circular, inverted Y-shaped and straight-line incisions with different sizes and lengths were made for specimen extraction. Specimens of different sizes and textures were then extracted by a force device. The specimen with the largest diameter could be extracted using the smallest incision. The results were analysed by recording the maximum pull force (N).

Results: The maximum diameters of specimens that can be extracted with circular ostomy diameters of 2.4, 2.7 and 3.3 cm are 4.0, 4.5 and 6.0 cm, respectively. Specimens with diameters of 6.0, 8.0 and 10.0 cm could be extracted with inverted Y-shaped incisions with the length around umbilicus of 1 cm and extension length of 1.0, 3.0, 4.0 cm, respectively. Moreover, these same specimens could be extracted with inverted Y-shaped incisions with the length around umbilicus of 2 cm and extension length of 0.0, 1.0 and 2.0 cm, respectively. In straight-line incisions, tough tissue specimens (made from chicken gizzard) with diameters of 1.0, 2.0, 4.0 and 6.0 cm could be removed from incisions with diameters of 1.0, 2.0, 3.0 and 4.0 cm, respectively.

Conclusion: Along with preoperative imaging, surgical planning and trocar position, the shape and length of adjuvant incisions can be used to improve the extraction of specimens via laparoscopy.

Introduction

Laparoscopy is commonly used in general surgery, urologic surgery, obstetrics and gynaecology. The retrieval of specimens after the operation is always a challenge for all surgeons. Small specimens can be removed through the trocar or trocar port, and some through the vagina [1] and rectum [2]. However, most large specimens, especially tumour specimens, need to be removed through an adjuvant incision, which needs to be performed in consideration of cosmetic appearance, minimisation of trauma and complications, preservation of tumour integrity and the needs of the procedure itself. Some studies show that the minimally invasive effect of laparoscopy is not due to the length of the incision, but rather to the reduction of dehydration of the exposed abdominal organ and mechanical damage caused by gauze, glove contact and traction during the course of surgery. No difference was observed in postoperative complications and postoperative recovery between <5 cm and >5 cm adjuvant incisions [3]. However, a small adjuvant incision for specimen extraction can reduce postoperative pain and obtain good cosmetic effect. Therefore, the maximum diameter of specimens that can be extracted with different adjuvant incision length and shape needs to be explored. At present, few studies have investigated the relationship between tumour size and the shape of specimen extraction and the length of adjuvant incision. Casciola et al. [4] extended 3–5 cm around the umbilicus 3/4 times through the trocar port of the superior umbilicus and successfully extracted specimens with a length of 6–7 cm without causing ischemic

necrosis of the umbilicus. However, their study was limited to 3/4 of the length around the umbilicus, and the authors could not remove more than 7 cm from the surgical specimen. Some researchers [5] have also removed nephrectomy specimens from the trocar hole by morcellation. The specimen diameter can be measured by preoperative imaging, so we can design the adjuvant incision shape and length preoperatively. In clinical practice, we have attempted to extract laparoscopic specimens (prostate and bladder) from the abdominal wall stoma of patients undergoing complete laparoscopic radical cystectomy and ileostomy, and to extract the laparoscopic radical prostatectomy specimens by enlarging the trocar port of the superior umbilicus into an inverted Y-shaped adjuvant incision, and also to extract adrenal pheochromocytoma specimens by enlarging the trocar port into a straight-line adjuvant incision. However, no study has investigated the relationship between the abdominal wall stoma, the extension of the adjuvant incision and the specimen diameter.

Based on the above-mentioned theory and clinical practice, we used pig's abdominal wall to simulate a human's abdominal wall in order to extract specimens in vitro and explore the relationship between the diameter of different specimens and the length and shape of adjuvant incision.

Materials And Methods

Experimental materials and groupings

Three pieces of pig's abdominal wall with a thickness of 2.0 cm were divided into three portions for repeated experiments. A self-made wooden frame was used to fix the pig's abdominal wall to simulate a human's abdominal wall. Chicken gizzard, black sheep bladder and minced pig's musculature were used to make specimens of different diameters (chicken gizzard was used for specimens with a diameter ≤ 6.0 cm, and the minced pork was packed in 7.5 sterile surgical gloves to make specimens with a diameter ≥ 6.0 cm) (Figure. 2). The incision shape was divided into three groups, namely, round, inverted Y and straight-line, and set with different sizes (Figure. 1). The round-shape group (with 3.0 cm as the centre, interval of 0.3 cm and 5 gradient values: 2.4, 2.7, 3.0, 3.3 and 3.6 cm). Inverted Y shape (divided into two subgroups, according to the length of the incision around the umbilicus (L): L1 = 1.0 cm and L2 = 2.0 cm; extension length (H): H1 = 0 cm, H2 = 1.0 cm, H3 = 2.0 cm, H4 = 3.0 cm, H5 = 4.0 cm). Straight-line group (set as 1.0, 2.0, 3.0, 4.0, 5.0, 6.0 and 7.0 cm). This study was approved by the Ethics Committee of the Affiliated Cancer Hospital of Guangxi Medical University (No. 20170308-4) and complied with the Declaration of Helsinki. Informed written consent was obtained from all participants. No animals were involved in this experimental study, and all materials were purchased from supermarkets.

Specimen preparation and experimental procedures

Round group: Chicken gizzards were made into circular specimens with diameters of 3.5, 4.0, 4.5, 5.0, 5.5 and 6.0 cm. They were sutured and connected with the black sheep bladder. Inverted Y group: The fingers of 7.5 sterile surgical gloves were tied tightly with knots and turn-over to formed into a pouch, and then the minced pork was pressed into the glove, shaped and tied tightly. The diameter of the specimen was set to 6.0, 8.0 and 10.0 cm. Straight-line group: The chicken gizzard and minced pork were made into two

groups of specimens with different textures: tough tissue group (made from chicken gizzard) and soft tissue group (made from minced pork) with diameters of 1.0, 2.0, 3.0, 4.0, 5.0 and 6.0 cm, respectively. (Figure. 2)

The pig's abdominal wall was fixed on the wooden frame with screws. The specimens were placed into the specimen pouch, and the weight of each specimen was measured separately. The Shuangjie force measuring device with an accuracy of 0.5 N and total pulling force of 30 N was used for the measurements. Then, the specimens from each group of incision shape and size were extracted. At the same time, the extraction process of each specimen was video-recorded. Each experimental process was repeated three times, by watching the video to recordings of the three measured tensile force (N) in the end of each experiment. (Video.)

Observation index

The pull force for each specimen extraction was recorded. If the pull force is greater than the scale of the force measuring device but the force measuring device can extract the specimen, the force is recorded as 30.0 N. If the force measuring device cannot extract the specimen but the specimen can be manually extracted, the force is recorded as 35 N. If the force measuring device cannot extract the specimen, the force is recorded as 0 N.

Data processing and analysis

GraphPad Prism version 8.0 was used for mapping, and the results of the comparative analysis were presented as histograms. The relationship between the diameter of different specimens and the length and shape of adjuvant incision was analysed.

Results

Round -shape group

As shown in Figure. 3, specimens with diameters of 4.0, 4.5 and 6.0 cm could be extracted from a round-shaped stoma with diameters of 2.4, 2.7 and 3.3 cm, respectively.

Inverted Y-shape group

As shown in Figure. 4, specimens with diameters of 6.0, 8.0 and 10.0 cm could be extracted using inverted Y incisions with the length around umbilicus of 1 cm and extension length of 1.0, 3.0 and 4.0cm and with the length around umbilicus of 2 cm and extension length of 0.0, 1.0 and 2.0 cm, respectively.

Straight-line group

As shown in Figure. 5, tough tissue specimens with diameters of 1.0, 2.0, 4.0 and 6.0 cm could be extracted from smallest incisions with extension length of 1.0, 2.0, 3.0 and 4.0 cm, respectively. Soft

tissue specimens with diameters of 1.0, 3.0, 6.0, 8.0 and 10.0 cm could be extracted from smallest incisions with extension length of 1.0, 2.0, 5.0, 6.0 and 7.0 cm, respectively.

Discussion

In laparoscopic surgery, smaller abdominal adjuvant incisions can offer both cosmetic advantages and important clinical implications, such as less postoperative pain, shorter hospital stay and faster return to daily activities. However, no relevant research has Study Indicated the relationship between the abdominal wall stoma, the extension of the incision and the specimen diameter. The method for extracting the specimen depends on the surgeon's experience and personal preference. Moreover, regardless of the shape and size of the incision, several aspects should be considered: (1) small injury, (2) good cosmetic effect, (3) malignant tumour specimens that can be removed intact, (4) taking into consideration the urinary flow diversion and (5) less complications of adjuvant incision.

In this paper, we discuss for the first time the relationship between the abdominal wall stoma, the extension of the incision and the specimen diameter by simulating postoperative specimen retrieval through in vitro physical experiments, which significance is to guide the clinic to choose the shape and size of the incision based on the diameter of the specimen measured by preoperative imaging combined with the needs of the operation and the position of the trocar.

Ileostomy is widely used in the treatment of muscle-invasive bladder cancer in urological surgery. Its surgical specimens include the prostate and the bladder. The diameter of the ileum is about 3.0 cm [6], and the recommended diameter of the dermal stoma is 3.0 cm [7]. Thus, the diameter of the stoma should be between 3.0 ± 0.3 cm. Combined with the results of this experiment, the ileum abdominal wall stoma can be used to extract a specimen with a diameter of about 4.5–6.0 cm (Figure. 3). In clinical practice, we have attempted to extract laparoscopic specimens (prostate and bladder) from the abdominal wall stoma of patients undergoing complete laparoscopic radical cystectomy and ileostomy and verify that the extraction method is feasible.

In our experimental design, the shape of inverted Y incision is mainly used for the extraction specimens from around the umbilicus. In clinical practice, many transabdominal laparoscopy trocar ports are located around the umbilicus, including laparoscopic hepatectomy, splenectomy and resection of other large abdominal tumours. The results of the experiment showed that specimens with diameters of 6.0, 8.0 and 10.0 cm can be extracted using inverted Y-shaped incisions with the length around umbilicus of 1 cm and extension length of 1.0, 3.0 and 4.0 cm and with the length around umbilicus of 2 cm and extension length of 0.0, 1.0 and 2.0 cm, respectively. Thus, this incision compensates for the shortcomings of the study by Casciola et al. to some extent [4]. We have also attempted to extract laparoscopic radical prostatectomy specimens by enlarging the trocar port of the superior umbilicus into an inverted Y shape in clinical practice, and the results are consistent with the present findings. (Figure. 4)

Extending the trocar port as an auxiliary incision for specimen retrieval is the most common method of specimen extraction for most laparoscopic procedures. In tough tissue specimens (e.g., renal tumours,

adrenal tumours and other tumours of the abdominal cavity), incisions with length of 1.0, 2.0, 3.0 and 4.0 cm could be used to extract specimens with maximum diameters of 1.0, 2.0, 4.0 and 6.0 cm, respectively. Moreover, for soft tissue specimens (e.g., spleen and liver), incisions with length of 1.0, 2.0, 5.0, 6.0 and 7.0 cm could be used to extract specimens with maximum diameters of 1.0, 3.0, 6.0, 8.0 and 10.0 cm, respectively. We have also attempted to extract adrenal pheochromocytoma specimens by enlarging the trocar port into a straight line in clinical practice. The specimen diameter was about 6.0 cm, and the adjuvant incision was about 4.0 cm. This is consistent with the results of our experiment. (Figure. 5)

In addition, when comparing specimens of the same diameter and different textures in the straight-line group, we found that soft tissue specimens with a diameter ≤ 3.0 cm were easier to extract than tough tissue specimens, whereas the opposite phenomenon was observed for specimens with a diameter > 3.0 cm. These findings may be related to the fact that soft tissues were squeezed and deformed more when they pass through the adjuvant incision, making it difficult for them to pass through the incision. In addition, comparing the straight-line incision and inverted Y-shaped incision for soft tissue specimens with diameters of 6.0, 8.0 and 10.0 cm, we found that for larger specimens, the inverted Y-shaped incision can reduce the length of the extended incision, and the longer the incision is around the umbilicus, the more obvious this advantage is. (Figure. 6-7)

However, our experiment also has some shortcomings. First, we chose pig's abdominal wall with the muscle layer instead of the whole abdominal wall. In the human body, there is a peritoneal layer in the wall in addition to the muscle layer, which also increases the resistance of specimen extraction. Second, specimens with different textures and shapes were lacking in the experiment, but in fact, the clinical surgical specimens of different texture and shape, and, so there may be result in the factor of differences between the experimental results and clinical practice. Third, to observe the measurement results, we extracted the specimen vertically upwards with a force measuring device (≤ 30 N). We manually removed the specimen only when the device was unable to extract the specimen (35 N). In clinical practice, the specimen needs to be extracted manually. Thus, the results may vary, which is the biggest limitation of our experiment.

In summary, although some studies have found that the adjuvant incision length is unrelated to complications, the fact that laparoscopic specimens can be removed through smaller adjuvant incisions not only has a cosmetic effect, but also relieve postoperative pain, short hospital stay and fast recovery of daily activities. Therefore, exploring the largest specimen that can be extracted by different sizes and shapes of adjuvant incision by simulating the extraction of laparoscopic specimens is of great clinical significance.

Declarations

- **Consent to publish:** Consent for publication was obtained in written from the patients.

- **Availability of data and materials:** Additional unpublished data are available by request to the lead author.

- **Competing interests:** no competing interests.

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- **Author contribution:** Yuanbi Huang, Tian Yi, Huajie He are joint first authors. Study design: Yuanbi Huang Tian Yi Huajie He Xianlin Yi. Purchase experimental materials, record and organize data: Qiguang Li, Xian Long, Gaohua Hu, Qiwei Chen, Yongpeng Li, Rongchao Chen, Drafting of the manuscript: Yuanbi Huang, Xianlin Yi. All authors have read and approved the final manuscript. Written consent to publication was obtained.

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- **Ethics approval and consent to participate** Yes. Approved by Cancer Hospital of Guangxi Medical University NO:20170308-4. Informed written consent was obtained from all participants.

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Figures

schematic of the experimental incisions

Figure 1

three types of incisions experimental.

experimental specimens and materials

Figure 2

experiment Related Images A, specimens: tough tissue group (made from chicken gizzard) and soft tissue group (made from minced pork). B, abdominal model. C, pig's abdominal wall. D, prostate and bladder specimens (made from minced pork and black sheep bladder).

B

Specimen diameter (cm)	Ostomy diameter (cm)				
	2.4	2.7	3.0	3.3	3.6
3.5	+	+	+	+	+
4.0	+	+	+	+	+
4.5	-	+	+	+	+
5.0	-	-	-	+	+
5.5	-	-	-	+	+
6.0	-	-	-	+	+

Figure 3

the result of Round-shape group A, Histogram of experimental results. B, "+" for extractable, "-" for not extractable. C, stoma diameter size.

the result of inverted Y-shaped incisions

Figure 4

the result of inverted Y-group: A and B, comparison of two types of incisions. C, extension length(H). D, the length around umbilicus(L). E, deformed incision during specimen extraction. F, specimen diameter.

the results of straight-line incisions

Figure 5

the result of straight-line group: A and B, comparison of two types of incisions. C, specimen diameter and incision length.

Figure 6

comparison of tough tissue group and soft tissue group in the same incision length.

Figure 7

comparison of straight-line and inverted Y shape incision for the same specimen diameter

Supplementary Files

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