Int J Clin Exp Med 2018;11(2):1254-1259
www.ijcem.com /ISSN:1940-5901/IJCEM0059780

Original Article

Anatomical characteristics of the fascial space during laparoscopic pancreaticoduodenectomy using cadaveric models

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Received April 24, 2017; Accepted December 22, 2017; Epub February 15, 2018; Published February 28, 2018

Abstract: Objective: To investigate the anatomical characteristics of the tissue space during laparoscopic pancreaticoduodenectomy, aiming to provide evidence for the laparoscope-assisted dissection, localization and operation approach. Methods: Ten adult cadavers donated by the Southern Medical University were utilized in this study. The anatomical space among tissues was observed throughout the procedures of pancreatoduodenectomy. The position and anatomical relationship between fascial spaces were explicitly displayed and video-taped during laparoscopic pancreaticoduodenectomy. Results: A large quantity of minute vessels between the pancreatic head and duodenum space vertically penetrated through the intestinal wall of duodenum, mainly including the small branches of gastroduodenal artery and pancreaticodudenal artery. The pre- and retro-pancreatic spaces were used as the two small surgical planes. The retro-pancreatic integrated fascial space was regarded as the major surgical plane. Conclusion: Explicit and comprehensive understanding of the anatomical characteristics among tissues spaces can enhance the clinical efficacy and safety of laparoscopic pancreaticoduodenectomy.

Keywords: Anatomical characteristics, laparoscope, pancreaticoduodenectomy, fascial space

Introduction

Compared with conventional open pancreatoduodenectomy, laparoscopic pancreaticoduodenectomy is a minimally invasive technique. The surgical instruments and devices can reach the target region via multiple fascial spaces [1-3]. Comprehensive understanding of the anatomical features and spaces related to pancreatic gland contributes to enhance the quality of laparoscope-assisted surgery [4]. If combined with clinical practice, the integrated techniques become the most urgent task during laparoscopic pancreaticoduodenectomy for most surgeons and clinicians.

In this study, anatomical experiment was conducted on 10 fresh adult cadavers to thoroughly investigate the anatomical characteristics of the tissue spaces throughout the procedures of laparoscopic pancreaticoduodenectomy, aiming to offer more evidence for the laparoscope-assisted dissection, localization and operation approach.

Materials and methods

Anatomical cadavers

Ten formaldehyde-fixed adult cadavers including 6 male and 4 female were donated by the anatomy teaching and research center of Southern Medical University. The adult cadavers were infused with red emulsion via the femoral artery for proper preservation. When the red emulsion was completely coagulated, the adult cadavers were placed in a supine position on the table. The abdominal cavity was cut open, the root of mesocolon transversum was initially isolated and the first two layers of the greater omentum were lifted. The pre-pancreatic fascia and fascial space were observed. According to the procedures of laparoscope-assisted pancreatoduodenectomy using the posterior approach, the lateral peritoneum was cut open at the second segment of duodenum via the Kocher route. Subsequently, the duodenum and pancreatic head were isolated free, the entire pancreatic head and the duodenum

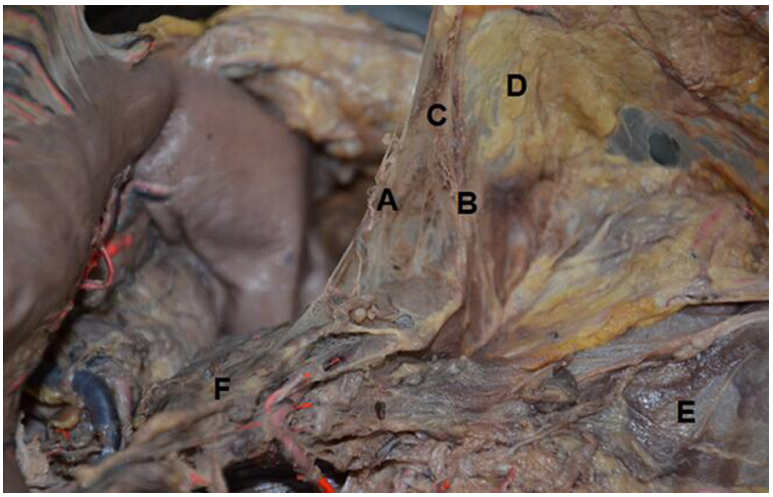

Figure 1. Peripancreatic fascia and fascial space; A: Pre-pancreatic fascia, B: Retro-pancreatic fascia, C: Fusion space, D: Mesocolon transversum anterior lobe, E: Mesocolon transversum posterior lobe, F: Pancreas.

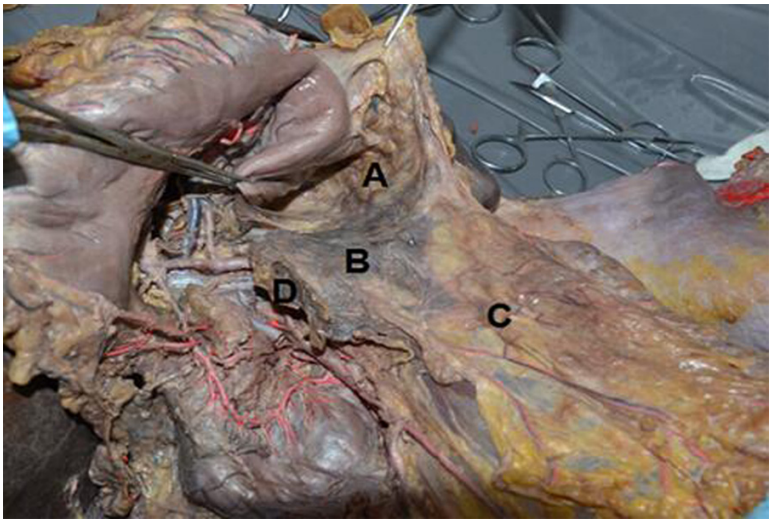

Figure 2. Pre- and retro-pancreatic fascia. A: Gastrosplenic ligament anterior lobe, B: Pre-pancreatic fascia, C: Mesocolon transversum anterior lobe, D: Cross section of pancreatic neck.

the turned around to the left side to fully expose the deep layer of pancreatic head and duodenum for explicit anatomical observation.

Baseline data

Inclusion criteria: Those were diagnosed with stage I or II malignant tumors by imaging and endoscopic retrograde cholangiao-pancreatography (ERCP) examinations. Clinical data of 15 patients undergoing laparoscopic pancreaticoduodenectomy, 6 male and 4 female, aged 29-69 years with a median age of 55 years, in Sun Yat-sen Memorial Hospital of Sun Yat-sen University between April 2013 and March 2014 were retrospectively analyzed. Among them, 4 cases were diagnosed with peri-ampullar cancer, 4 with malignant tumors in the lower segment of common bile duct and 2 diagnosed with early pancreatic head cancer. All patients received fully-prepared preoperative examinations. Written informed consents were obtained from all participants. The study procedures were approved by the ethics committee of our hospital. Intraoperatively, the location and adjacent anatomical relationship among different fasciae were monitored and videotaped during laparoscopic pancreaticoduodenectomy, as illustrated in Supplementary Table 1.

Pancreatoduodenectomy procedures

The operation channel was created by using the 5-hole technique. The exploration of abdominal cavity was carried out. The gastrocolic ligament was cut open along with the upper margin of transverse colon. The pancreatic gland was fully exposed and the lower fascia of pancreatic gland was incised to expose and explore the superior mesenteric vein. The resectability of the malignant tumors was evaluated. The lateral peritoneum incision of the duodenum was made between the Treiz spaces. The duodenum and pancreatic head were shifted to the left side until the right of inferior mesenteric vein. The left renal veins trepassing the upper margin of the aorta were used as the anatomical landmark, which fully exposed the superior mesenteric artery. The duodenum was pulled towards the head and the horizontal part of duodenum was fully isolated free. The Treitz ligament was cut off. The upper segment of jejunum was shifted to the right side of the superior mesenteric vessels. The segment of

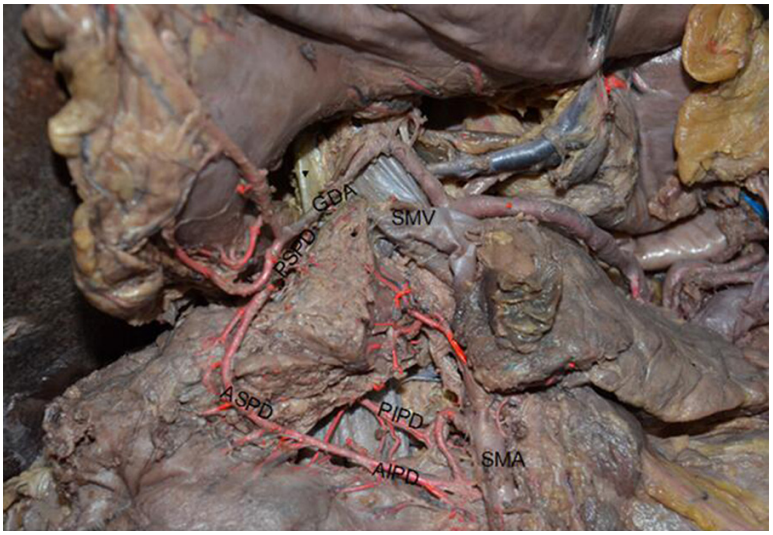

Figure 3. The superior mesenteric vessels isolated from the retro-pancreatic space. SMA represents superior mesenteric artery, SMV as superior mesenteric vein, GDA as gastroduodenal artery, ASPD as anterior superior pancreaticoduodenal artery, AIPD as anterior inferior pancreaticoduodenal artery, PSPD as posterior superior pancreaticoduodenal artery and PIPD as posterior inferior pancreaticoduodenal artery.

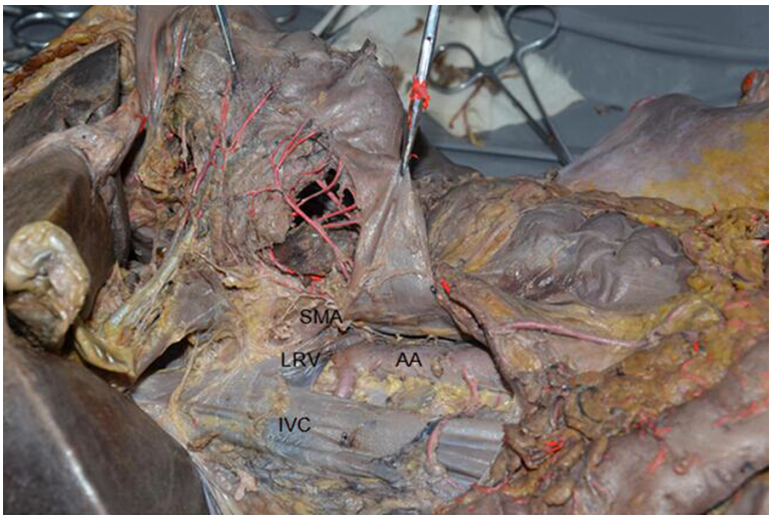

Figure 4. Toldt fusion fascial space. SMA denotes superior mesenteric artery, LRV as left renal vein, AA as abdominal aorta and IVC as inferior vena cava.

jejunum approximately 15 cm from the Treitz ligament was cut off. The upper segment of jejunum, duodenum and pancreatic head were fully pulled upwards. The superior mesenteric artery and pancreatic uncinate process were exposed. The vagina vasorum of the superior mesenteric artery beneath uncinate process was incised. The posterior segment of the pancreatic superior mesenteric artery was cut along with the vagina vasorum. The uncinate process and small branches of the superior mesenteric vein were sutured with the right vagina vasorum of superior mesenteric artery. The duodenum, pancreatic head and uncinate process were completely isolated from the superior mesenteric vessels. The peritoneum beneath hepatoduodenal ligament was incised along with the portal vein to porta hepatis. The portal vein was completely isolated free. The distal stomach and pancreatic neck were isolated. The common hepatic artery sheath was exposed at the upper margin of the pancreas and cut open. The anatomical dissection was performed towards the porta hepatis. The gastroduodenal artery and right gastric artery were ligated and incised. The proper hepatic artery, the left and right artery was completely isolated free. The gallbladder was excised, the common hepatic duct was incised and the specimen was removed. The structure of digestive tract was reconstructed.

Results

Peripancreatic fascial space

The ring-shaped cavity between the pancreatic matrix and pre- and retro-pancreatic fascia was known as the fascial space of pancreas. The fascial space located in front of the pancreatic matrix was the pre-pancreatic fascial space and that situated posterior to the pancreatic matrix as the retro-pancreatic fascial space, as illustrated in **Figure 1**. The pre- and retro-pancreatic fascia was integrated below the pancreas and extended as the horizontal mesocolic anterior lobe, which formed the lower part of omental sac, and stretched upwards to form the gastrosplenic and lienorenal ligaments, as demonstrated in **Figure 2**.

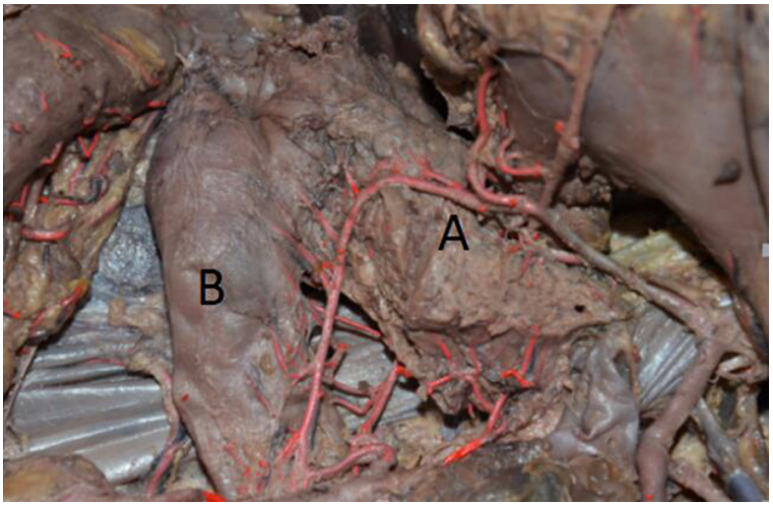

Figure 5. Pancreatic head and duodenum space. (A) Represents pancreatic head and (B) denotes duodenum.

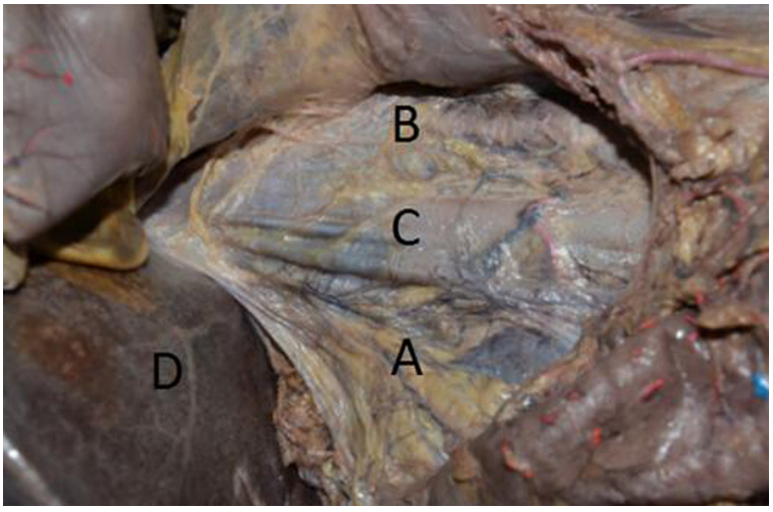

Figure 6. Anterior and posterior fascial space between pancreatic head and duodenum. (A) Represents Treiz space, (B) as Toldt space, (C) as abdominal aorta and (D) as liver.

The superior mesenteric vessels were isolated from the retro-pancreatic space which was connected to the Toldt fusion fascial space, as illustrated in **Figures 3** and **4**. Pre-pancreatic space was mutually connected to the retro-pancreatic space at the upper and lower margins of the pancreas. In addition, it was linked to the upper right hepatoduodenal ligament space, upper left gastrosplenic ligament space, lateral lienorenal ligament space as well as the inferior mesocolon transversum anterior and posterior lobe space. The pancreatic fascial space was located in front of the Treiz and Toldt fascial space, and connected to the superior mesenteric vessels and Toldt fusion fascial space posterior to the colon ascendency with clear margins.

Pancreatic head and duodenum space

A large quantity of minute vessels between the pancreatic head and duodenum space vertically penetrated through the intestinal wall of duodenum, mainly including the small branches of gastroduodenal artery and pancreaticodudenal artery, as demonstrated in **Figure 5**. The mean diameter of the descending branch artery was (1.12±0.33) mm. The average length of superior mesenteric venous truck was (3.8±0.24) cm. During the pancreatoduodenectomy, it was likely to cause vascular injury when isolating the pancreatic head from the duodenum.

Anterior and posterior fascial space between pancreatic head and duodenum

The anterior and posterior pancreatic fascia extended from the pancreatic head and duodenum to surround the pancreatic head and duodenum, which form the anterior and posterior pancreaticodudenal fascia. Due to the space between the pancreaticodudenal fascias, pancreatic matrix and duodenum, the phenomenon of relative dislocation between fascia, pancreatic matrix and duodenum could be observed when the fascia traction was conducted. Evident space surrounded by loose connective tissues was noted between the retro-pancreatic fascia and pre-renal fascia including the retro-pancreatic Toldt space located at the left abdominal aorta, retro-pancreatic Treiz space situated at the right abdominal aorta, and subsequently connected at the posterior right pancreatic head, as illustrated in **Figure 6**. For lymph node dissection posterior to the pancre-

atic head, it should be isolated into the Treiz fascial space, and the pancreatic head and duodenum should be pulled inside.

Discussion

During the procedures of laparoscopic pancreaticoduodenectomy, explicit and comprehensive understanding of the peripancreatic fascial space can pinpoint the excision scope of the lesions, provide optimal surgical approach, enhance surgical efficiency and decrease the risk of postoperative complications. The mesentery is a continuous set of tissues which is formed by the double fold of peritoneum that attaches the intestines to the wall of the abdomen. Mesenteric organ is constantly used to define the rest of the mesentery that incorporates the mesocolon, mesoappendix, mesosigmoid and mesorectum. The mesentery becomes attached to the colon at the gastrointestinal margin and continues as the several mesenteries of the mesocolon, sometimes collectively known the mesenteric organ.

During the development process of archenteron, primary gut and its mesentery, mesentery and organ, and mesentery-mesentery integrate to form loose connective tissues, known as the fusion fascia [5]. Fusion fascial space is an ideal avascular surgical plane in human body [6], which consists of loose connective tissues. This fascia has a high density of elastin fiber that determines its extensibility or resilience.

During the embryonic stage, perigastric mesentery and its mesentery, mesentery and peritoneum, and mesentery and viscera tend to fuse and integrate, which eventually form fusion fascial space [7]. Fusion fascial space contains loose connective tissues and adipose tissues, which is suitable for avascular surgery. Anatomical observation of the peripancreatic space on the cadavers contributes to proper understanding of the anatomical characteristics of fascial space and determines the success of laparoscopic pancreaticoduodenectomy in clinical practice [8]. Under the visual field of laparoscope, a slight quantity of hemorrhage can severely affect the anatomical observation of the structures. Therefore, explicit understanding of the anatomical structure of the fusion fascial space is of clinical significance for the surgeons.

In this article, during the laparoscopic pancreatoduodenectomy, an incision was made at the lateral peritoneum of duodenum to enter the retropancreatic fascial space including Treiz and Toldt spaces. Retropancreatic fusion fascia and fascial space are the major surgical planes during the procedures of laparoscopic pancreaticoduodenectomy, which contributes to convenient differentiation and precise localization under the visual field of laparoscope. Any degree of deviation from the surgical plane is likely to lead to injury to proximal blood vessels and viscera. Pre-renal fascia is located between the adrenal and the kidney. Much attention should be diverted to this tissue when isolating the lower margin of the pancreas. Any mistake tends to damage the adrenal and the blood vessels of the posterior wall of abdomen [9-13]. During the laparoscopic pancreaticoduodenectomy, pre-pancreatic space between the pre-pancreatic fascia and pancreatic matrix can be obtained after dissection from the lower margin of the pancreas to towards the pancreatic head. The gastroduodenal artery can be excised from the pre-pancreatic space. The common hepatic artery, proper hepatic artery and bilateral hepatic artery can be resected close to the gastroduodenal artery wall. The superior mesenteric vessels can be excised through the retro-pancreatic space which connects the superior mesenteric vessels and colon ascendency fusion fascial space. The pre-pancreatic space and retro-pancreatic space act as two small surgical planes during laparoscopic pancreaticoduodenectomy. During laparoscopic pancreaticoduodenectomy, the anatomical dissection was started from the retro-pancreatic fusion fascial space and retropancreatic space, followed by the pre-pancreatic space. The space between duodenum lateral wall, duodenum and transverse colon could be explicitly distinguished, which fully exposed the duodenum posterior wall, superior mesenteric artery, superior mesenteric vein, inferior vena cava, left renal vein and lateral peritoneum of the duodenum, eventually entering the retropancreatic fusion fascial space. Then, the inferior vena cava, superior mesenteric vessels and pancreatic head could be smoothly dissected and explored.

However, this research is limited to the anatomical space related to the surgical approach of laparoscopic pancreaticoduodenectomy. More

comprehensive studies are urgently required to validate the results.

Acknowledgements

Huangpu Science, Technology and Informatization Bureau, Guangzhou (201544-06).

Disclosure of conflict of interest

None.

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