

Journal of Visualized Experiments

Robotic Central Pancreatectomy with Roux-en-Y pancreaticojejunostomy

--Manuscript Draft--

Article Type:	Invited Methods Article - Author Produced Video
Manuscript Number:	JoVE62862R2
Full Title:	Robotic Central Pancreatectomy with Roux-en-Y pancreaticojejunostomy
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TITLE:

Robotic Central Pancreatectomy with Roux-en-Y Pancreaticojejunostomy

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SUMMARY:

Robotic central pancreatectomy may be used in selected patients in experienced centers. This protocol presents all steps and the feasibility of a robotic central pancreatectomy with Roux-en-Y pancreaticojejunostomy in a 16-year-old adolescent patient.

ABSTRACT:

Central pancreatectomy is a parenchyma-sparing alternative to distal pancreatectomy in patients with a benign or low-grade malignant tumor in the body of the pancreas. The aim of central pancreatectomy is to prevent postoperative life-long endocrine and exocrine insufficiency. The downside of central pancreatectomy is the high rate of postoperative pancreatic fistula, which is the main reason that many surgeons do not routinely use central pancreatectomy in eligible patients. Most studies report open or laparoscopic central pancreatectomy with a pancreaticogastrostomy anastomosis in adults. This is the first description of a standardized approach to robotic central pancreatectomy with Roux-en-Y pancreaticojejunostomy reconstruction in an

adolescent (16-year-old boy) with a pseudopapillary tumor in the body of the pancreas. The operation time was 248 min with 20 mL of blood loss. The post-operative course was uneventful except for the short-term medical treatment for a grade B pancreatic fistula. Robotic central pancreatectomy can be safely applied in selected patients in experienced centers.

INTRODUCTION:

Central pancreatectomy has been described as a parenchyma-sparing alternative surgical procedure to distal pancreatectomy for benign or low-grade malignant lesions located in the body of the pancreas^{1,2}. Central pancreatectomy will prevent life-long pancreatic endocrine and exocrine dysfunction in most patients. Still, most surgeons chose to perform the distal pancreatectomy over a central pancreatectomy because of the increased risk of postoperative morbidity, mainly due to postoperative pancreatic fistula (POPF) after central pancreatectomy³⁻⁵. In fact, central pancreatectomy combines the POPF risk of a distal pancreatectomy and a pancreato-enteric anastomosis.

Most studies on central pancreatectomy advise to perform a pancreatico-gastrostomy anastomosis because of the presumed lower risk of POPF^{6,7}. However, current randomized trials are inconclusive regarding the risk for POPF incidence for pancreatico-gastrostomy and pancreaticojejunostomy⁸⁻¹⁰. Furthermore, pancreatico-gastrostomy has been suggested to impair long-term pancreatic exocrine function due to gastric mucosal overgrowth¹¹. In addition, the minority of surgeons are experienced with pancreatico-gastrostomy in daily clinical practice, which will also reduce enthusiasm for this solution.

Robotic pancreatoduodenectomy, supported by the work of the Pittsburgh University Medical Center team and large-scale training programs such as the Dutch LAELAPS-3 and the European LEARNBOT programs, has now become an accepted approach in selected patients in many centers across the world¹²⁻¹⁴. For surgeons experienced with robotic pancreatoduodenectomy, including the highly standardized robotic pancreatico-jejunal anastomosis, a robotic central pancreatectomy is an attractive alternative to open or laparoscopic central pancreatectomy or laparoscopic distal pancreatectomy.

In this article, we describe a case of a 16-year-old adolescent patient with a pancreatic lesion suspected for solid pseudopapillary tumor who underwent robotic central pancreatectomy with Roux-en-Y pancreaticojejunostomy reconstruction. Our aim is to demonstrate the technical approach and clinical safety of robotic-assisted central pancreatectomy and its surgical outcomes when performed in high-volume centers by experienced surgeons.

PROTOCOL:

The present protocol follows the ethics guidelines of the Amsterdam UMC. Informed consent was obtained from the patient for this article and the video.

1. Preoperative management

1.1. Perform preoperative imaging to assess the extent of the pancreatic lesion and for indications of vascular involvement.

1.2. Evaluate the eligibility for the surgical approach and relative contraindications.

2. Operative setting

2.1. Place the patient in French position with the right arm lowered on an arm board alongside the patient and the left arm in a 90° abduction. Tilt the table 20-30° to the left and in 20-30° reverse Trendelenburg position.

2.2. Perform the required safety check procedures and create a sterile exposition with chlorohexidine.

2.3. Create a pneumoperitoneum by inserting a Veress needle at Palmer's point, then insufflating to 10-12 mm CO₂.

2.4. After insufflation, mark the positions of the trocars and place them as shown in **Figure 1** and **Figure 2** (4 robot trocars, 2 (12 mm) laparoscopic tableside surgeon trocars, 1 (5 mm) trocar for snake liver retractor).

2.5. After insufflation, place a 12 mm tableside surgeon trocar (preferably, one with a blunt clear dome at the distal end, which encloses a crescent-shaped knife blade) to the right of the umbilicus.

2.6. After inspection and removal of the Veress needle, place the four 8 mm robotic trocars 11-12 cm from the pancreatic body (i.e., target area). Place the trocar at the patient's right side for robot arm 1, more cranial than the others as it is used for contraction.

2.7. Place a second 12 mm table-side surgeon trocar.

NOTE: Make sure the distance between all the trocars is approximately 7 cm.

2.8. Finally, place a 5 mm trocar in the left upper quadrant to hold the laparoscopic stomach/liver retractor.

2.9. Install the robot at the right side of the patient and dock the robot arms to the robotic trocars.

NOTE: The final operative setting is shown in **Figure 3**. Robotic arm 1 holds a cadierre forceps, arm 2 a bipolar forceps, arm 3 the camera and arm 4 a cautery hook. The tableside surgeon is positioned between the patient's legs.

3. Pancreatic identification and mobilization

133
134 3.1 Open the lesser sac by transecting the gastrocolic ligament approximately 2 cm distal
135 from the gastroepiploic vessels with the sealing device, controlled by the tableside surgeon.

136
137 3.2 After this, install the liver retractor (5 mm trocar) in the left upper quadrant just
138 subcostally to retract the stomach and the left side of the liver.

139
140 3.3 Perform an intraoperative ultrasound using a robotic ultrasound probe to identify and
141 locate the tumor and mark the future resection margins with the robotic cautery hook.

142
143 3.4 Mobilize the pancreas first caudally and then cranially using the robotic cautery hook on
144 arm 4 and the laparoscopic sealing device.

145
146 3.5 First, place a 1/3 length vessel loop at the left side of the tumor between the pancreas
147 and the splenic vein.

148
149 3.6 Then, further mobilize the pancreas at the proximal side.

150
151 3.7 Place another 1/3 length vessel loop between the pancreas and the portomesenteric vein.

152
153 NOTE: Fix the vessel loops using clips.

154
155 3.8. Use the robot arm 1 to lift the vessel loops cranially to create a clear window and to
156 further complete the mobilization of the pancreatic body between the pancreas and the
157 portomesenteric vein.

158 159 **4. Pancreatic transection**

160
161 4.1 First, transect the pancreas at the right side of the tumor, typically ventral from the
162 superior mesenteric vein with an endo-stapler with a vascular cartridge.

163
164 NOTE: Closing of the stapler using the grade compression approach as described by Asbun¹⁵, may
165 take up to 4-5 min.

166
167 4.2 Then take care of venous mobilization.

168
169 4.3. After venous mobilization, transect the pancreas at the left side of the tumor using robotic
170 scissors with diathermia. The pancreatic duct is cut without diathermia, i.e., cold cut at the site
171 of the pancreatic duct.

172
173 4.4 Insert a 4.8 French stent to identify the pancreatic duct after the resection.

174 175 **5. Window in the mesocolon**

176

5.1. Create a window in the avascular part of the transverse mesocolon at the (patient's) left side of the colonic vessels using the cautery hook with the mesocolon in the caudal position.

NOTE: Usually, this location can be identified by locating the proximal jejunum, which is visible through the mesocolon.

5.2 Hereafter, place and hold the mesocolon in the cranial position held with arm 1. Identify the window by lifting the transverse colon cranially. Identify the ligament of Treitz.

6. Creating Roux-limb

6.1 Create a small opening in the proximal jejunum approximately 20 cm distally from the ligament of Treitz to divide the proximal jejunum with an endo-stapler with a vascular cartridge.

6.2 Divide the mesentery at the jejunal transection site using the sealing device.

7. Positioning Roux-limb

7.1 While lifting the transverse colon cranially using robotic arm 1, pass the Roux limb cranially through the window in the mesocolon.

7.2 Place the transverse colon back in the caudal position.

7.3 Fixate the end of the Roux limb together with the end of a 50 cm suture using robot arm 1. Use robot arms 2 and 4 to measure a 50 cm distance to the future S-S jejunum-jejunostomy.

7.4 Mark this location with a metal clip on the mesentery and lift the transverse colon cranially again.

8. Jejunum-jejunostomy

8.1 Place a polyglactin 4-0 8 cm stay suture through the small bowel at the location of the metal clip and the transected proximal jejunum to facilitate the anastomosis. Use arm 1 to retract this stay suture cranially to a location ventrally of the colon to facilitate stapling.

8.2 Create two small enterotomies using robotic scissors with diathermia.

8.3 Then, make a side-to-side jejunum-jejunostomy using an endo-stapler with a vascular cartridge.

8.4 Close the remaining opening of the anastomosis with a 3-0 15 cm barbed suture.

9. Pancreaticojejunostomy

9.1 Position the Roux limb for the end-to-side pancreaticojejunostomy. Place a polyglactin 4-0 8 cm suture to close the window in the transverse mesocolon and to fixate the jejunal mesentery.

9.2 Perform the end-to-side pancreaticojejunostomy using a modified Blumgart technique, which is currently highly standardized by the Pittsburgh group and also used in robotic pancreatoduodenectomy¹⁶.

9.3 Mattress

9.3.1 Start the anastomosis with three transpancreatic silk 2-0 20 cm mattress sutures. Drive the first suture at the cranial side of the pancreas through the pancreas and jejunum from a cranial to a caudal position. Drive the suture backward, similar to the anterior side of the pancreas and retract both ends with robot arm 1.

9.3.2 Repeat this step for the remaining two transpancreatic mattress sutures centrally and caudally in the pancreas.

NOTE: Avoid suturing the pancreatic duct by placing a stent in the pancreatic duct.

9.3.3 Tie the three sutures without removing the needles and remove the stent afterward.

9.4 Duct-to-mucosa

9.4.1 Create a small enterotomy in the Roux limb with the robotic scissors in preparation for the future duct-to-mucosa sutures.

9.4.2 Suture the posterior duct-to-mucosa with 4-5 PDS 5-0 8 cm sutures in a clockwise manner.

9.4.2 Replace the 4.8 French 6 cm single loop stent in the pancreatic duct and Roux limb to avoid suturing the pancreatic duct when suturing the anterior duct-to-mucosa side.

9.4.3 Suture the anterior side with 4-5 PDS 5-0 8 cm sutures.

9.4.4 Tie the sutures after performing the last suture for optimal exposure.

NOTE: Through the whole duct-to-mucosa procedure arm 2 and arm 4 are equipped with needle drivers and arm 1 is used to retract the sutures cranially and ventrally, thus releasing tension.

9.5 Buttress

9.5.1 Reuse the three transpancreatic silk sutures from the mattress procedure to perform the anterior buttress layer of the pancreaticojejunostomy.

9.5.2 For all the three sutures, drive the needle through the jejunum and tie these with the remaining end of its suture to complete the anastomosis.

10. Drain placement

10.1 After finishing the pancreaticojejunostomy, introduce a drain through trocar arm 1 to a position cranial of the pancreaticojejunostomy.

11. Postoperative management

11.1. Remove the nasogastric tube. Start a soft liquid diet and expand to a normal diet in 72 h.

11.2. Assess serum CRP on postoperative Day 3, Day 4, and Day 5. Perform a CT or MRI of the abdomen if CRP on day four is elevated compared to day three.

11.3. Assess drain amylase on postoperative Day 3. Remove the drain when amylase levels are less than 660 and the production is less than 250 mL/24 h.

REPRESENTATIVE RESULTS:

Representative results are shown in **Table 1**. The operation time was 248 min with a measured blood loss of 20 mL. The postoperative course was uncomplicated. Because of initially high drain amylase the patient received octreotide and antibiotics for 3 days. This treatment was stopped when drain amylase levels normalized on postoperative day 7, when the drain was also removed. Because of this medical treatment, this was graded as a grade B POPF¹⁷. A normal diet could be restarted after 4 days. The patient was discharged in good condition on postoperative Day 8. The patient did not develop diabetes or pancreatic exocrine insufficiency during the follow-up.

Pathology assessment revealed a 2.2 cm solid pseudopapillary tumor (**Figure 4**) and thus confirming the preoperative diagnosis. Microscopically, an R0 resection was confirmed. One lymph node was excised, in which localization of tumor tissue was not found.

FIGURE AND TABLE LEGENDS:

Figure 1: Trocar placement. Red: 8 mm robotic trocars, blue: 12 mm laparoscopic trocars, yellow: 5 mm trocar for stomach/liver retractor.

Figure 2: Schematic trocar placement.

Figure 3: Set up and installation of the robot during surgery.

Figure 4: Macroscopic specimen.

Table 1: Representative results of the surgery.

DISCUSSION:

This report demonstrates that robotic central pancreatectomy with Roux-en-Y pancreaticojejunostomy is feasible in selected patients and with experienced hands. In our experience, the robotic approach has benefits compared to the laparoscopic approach, especially when an anastomosis has to be made, due to its enhanced technical capabilities such as surgeon controlled high definition three-dimensional vision, facilitated and magnified instrument movement, and inherently to this improved suturing control due to its wristed instruments^{18,19}. In particular, our report demonstrated that the standard pancreatico-jejunal anastomosis from robotic pancreatoduodenectomy could be used.

A recent multicenter NSQIP analysis reported a reduced risk of POPF after robotic as compared to open pancreatoduodenectomy²⁰. Therefore, the question arises whether robotic central pancreatectomy could reduce the risk of POPF when compared to open central pancreatectomy.

Nonetheless, patient characteristics and the risk of a POPF should be taken into account when determining whether to perform a central pancreatectomy. The rate of POPF after central pancreatectomy will remain higher than that for the distal pancreatectomy given the POPF rate of pancreaticojejunostomy. Therefore, central pancreatectomy should be reserved for patients who are at low risk of POPF or other complications. Whereas well-defined contra-indications for central pancreatectomy are lacking, not all patients with pre-malignant or low-grade malignant neoplasms in the body or neck of the pancreas are eligible. The most important selection criteria are probably the patient's age and condition and tumor characteristics as size and location. A central pancreatectomy would seem more indicated for a younger patient with a small tumor, good performance status, and no diabetes than an elderly patient already suffering from diabetes.

In addition to this, patient selection is as important as experience with the operative technique. It has to be noted that complication and mortality rates are reduced in centers performing at least 20 robotic pancreatoduodenectomy procedures per year. For this reason, the Miami guidelines advise to only perform this procedure in high volume centers by experienced surgeons^{18,21}.

With regard to the choice of anastomosis, despite the good clinical outcomes of the pancreaticojejunostomy in our report, the question remains how this anastomosis compares to a pancreatico-gastrostomy. No reliable evidence is available to support the use of one particular anastomosis²².

In conclusion, we have shown that robotic central pancreatectomy with Roux-en-Y pancreaticojejunostomy is a feasible and safe parenchyma-sparing minimally invasive alternative to open or laparoscopic central pancreatectomy or distal pancreatectomy. Unnecessary pancreatic resections with loss of parenchyma and thereby potential loss of long-term pancreatic function could thus be avoided. The general applicability in non-selected patients remains uncertain.

ACKNOWLEDGMENTS:

We would like to acknowledge Melissa Hogg, Herbert Zeh III, Amer Zureikat, and Safi Dokmak for training and advice regarding robotic pancreatic surgery and central pancreatectomy. This clinical research was enabled by HPB-Amsterdam.

DISCLOSURES:

The authors have nothing to disclose.

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Figure 1. Trocar placement

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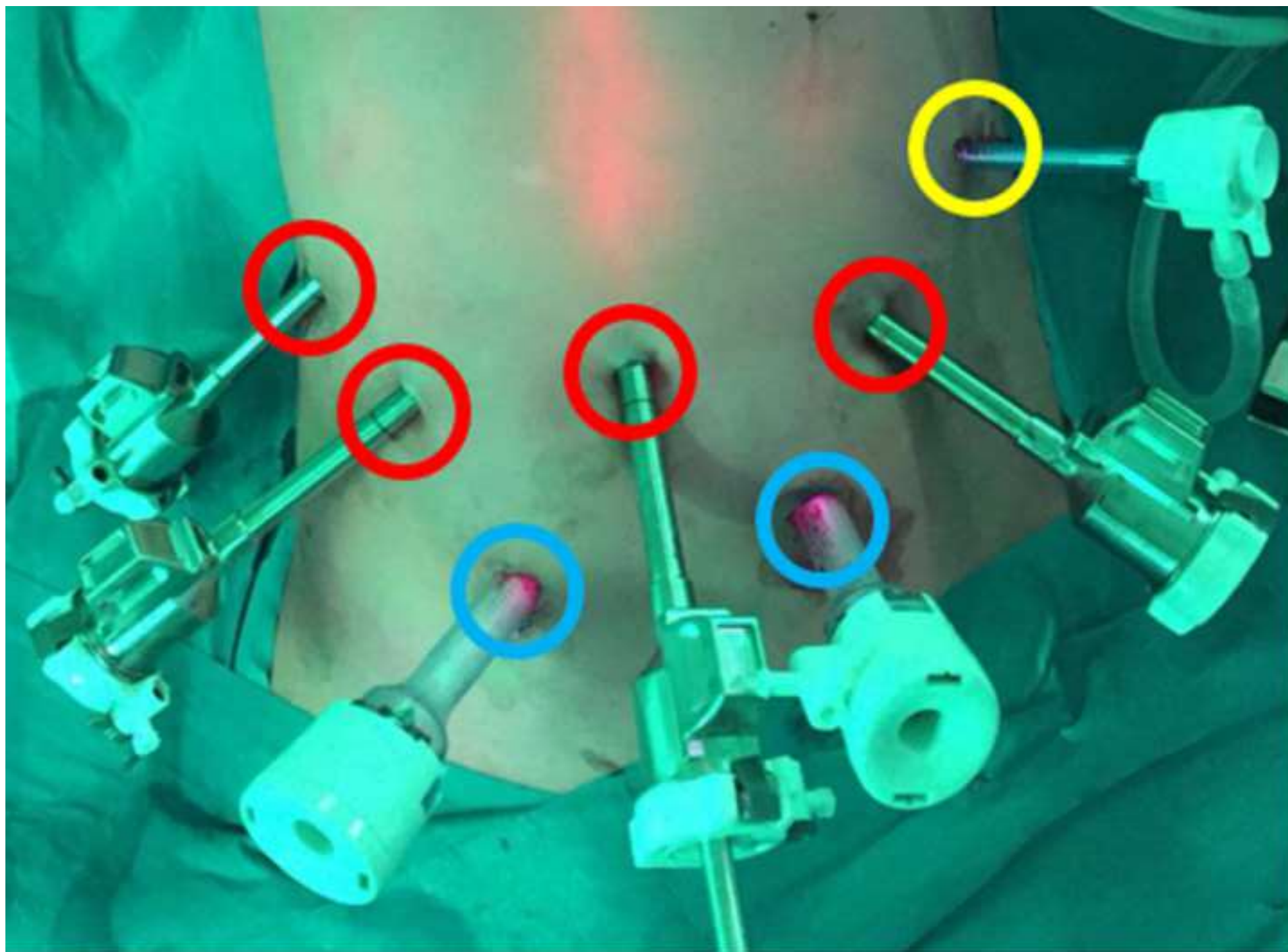
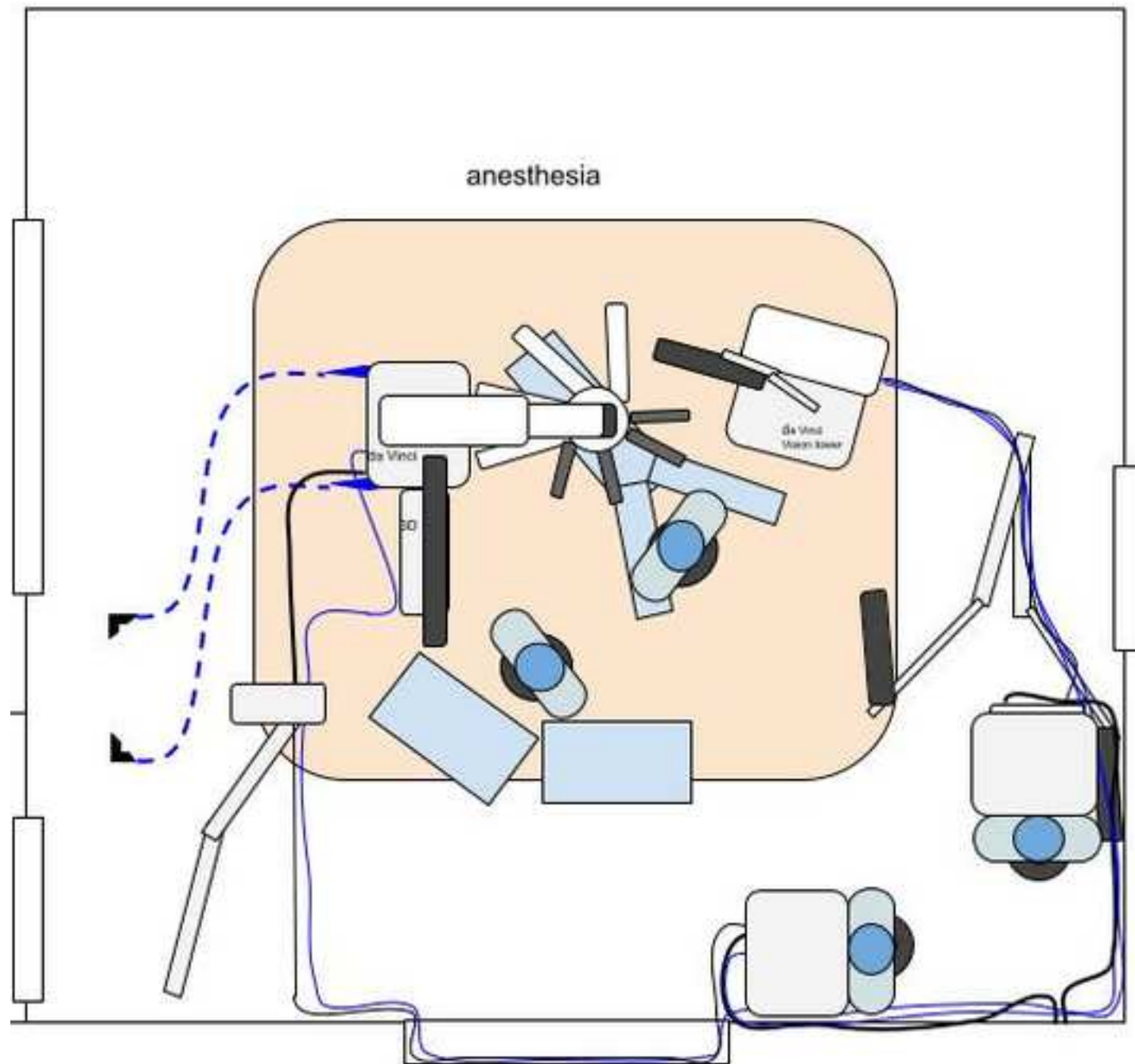


Figure 3. Set up and installation of the da Vinci Xi Robot during surgery

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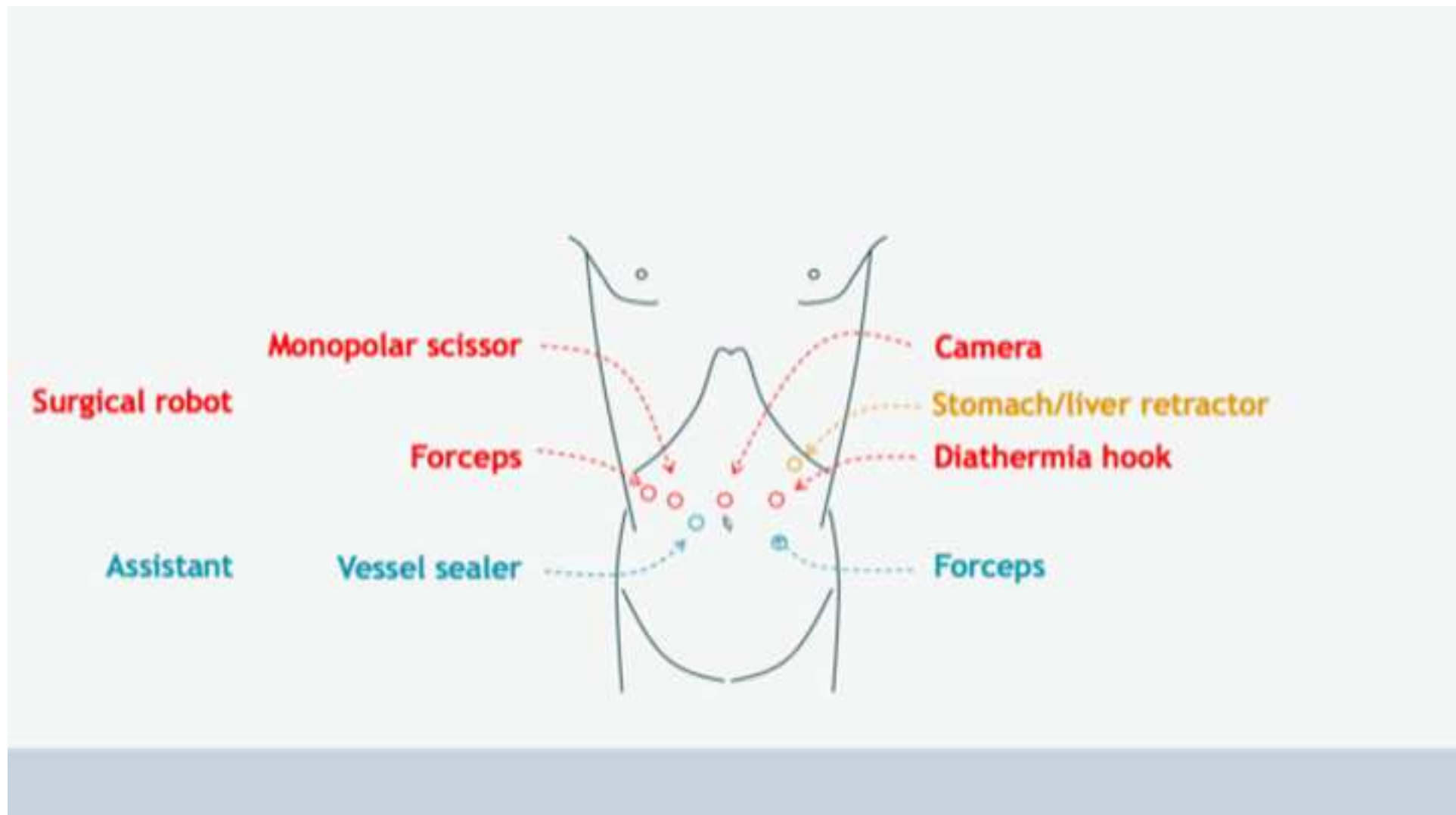


Figure 4. Macroscopic specimen

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Variable	Outcome
<u>Intraoperative</u>	
Operative time, minutes	248
Intraoperative blood loss, mL	20
<u>Postoperative</u>	
Postoperative pancreatic fistula (POPF)	Grade B
Clavien-Dindo complication grade	2
Drain removal, postoperative day	7
Postoperative hospital stay, days	8
Pathological diagnosis	Radically (R0) resected solid pseudopapillary tumor (i.e. Frantz tumor), 2.2 cm

Table 1: Representative results of the surgery.



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Table of Materials

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Amsterdam/Brescia, July 7, 2021

Dear sir/madam,

We want to thank the editorial team and the reviewers for their thoughtful comments and questions regarding manuscript JoVE62862R1: **Robotic Central Pancreatectomy with Roux-en-Y pancreaticojejunostomy**. We feel our manuscript has been improved thanks to the present process. Please find a detailed point-by-point response below and attached a 'track-changes' version of the manuscript.

Yours sincerely, on behalf of all authors,
Tess van Ramshorst, MD
Marc Besselink, MD

Editorial and production comments:

1. Please take this opportunity to thoroughly proofread the manuscript to ensure that there are no spelling or grammar issues. Please use American English throughout.

- Thank you. We have now proofread the entire manuscript for these issues.

2. Please rephrase the Short Abstract/Summary to clearly describe the protocol and its applications in complete sentences between 10-50 words: "This protocol presents..." as the text is also an integral component of the submission.

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3. Please include an ethics statement before the numbered protocol steps, indicating that the protocol follows the guidelines of your institution's human research ethics committee.

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4. Please ensure that all text in the protocol section is written in the imperative tense as if telling someone how to do the technique (e.g., "Do this," "Ensure that," etc.). The actions should be described in the imperative tense in complete sentences wherever possible. Avoid usage of phrases such as "could be," "should be," and "would be" throughout the Protocol. Any text that cannot be written in the imperative tense may be added as a "Note."

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7. Please include pre and post-operative steps in the protocol section. These need not be shown in the video.

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8. Please include a figure or a table in the Representative Results showing the effectiveness of your technique backed up with data e.g., outcome of the surgery, any complications, How do you study these, how many patients have undergone this surgery, etc.

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9. Please ensure the Representative Results is presented in the context of the technique you have described, e.g., how do these results show the technique, suggestions about how to analyze the outcome, etc. The paragraph text should refer to all of the figures/tables. Data from both successful and sub-optimal experiments can be included.

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- d) The significance with respect to existing methods
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- Done

2. Furthermore, please revise the narration to be more homogenous with the written manuscript. Ideally, the narration is a word for word reading of the written protocol.

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09:26 The Results part seems too long duration with the same text image and there is no video or image for explaining the narration. Apart from using the text image for explaining, Please use some video or images to explain the narration which will be easier to understand by the audience.

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Reviewer #1:

1. Manuscript Summary:

This is a well written manuscript (with video vignette) describing technique and results of robotic central pancreatectomy for the surgical management of a low grade tumor of pancreatic body.

Central pancreatectomy is a rarely performed operation for the management of highly selected patients affected by benign or low grade malignant tumor of the pancreatic body. Reluctancy in performing this operation, compared to left pancreatectomy, is related to the double pancreatic transection needed for this operation, which leads to a doubled risk of postoperative pancreatic fistula, related both to the right pancreatic stump closed through stapler and to the pancreatic anastomosis, needed to restore pancreato-enteric continuity between the left pancreatic stump and the gastrointestinal tract.

For patients undergoing minimally invasive central pancreatectomy, different techniques to restore left pancreatic stump enteric continuity, including pancreato-jejunal Roux-en-Y loop anastomosis, pancreato-gastric anastomosis, and end-to-end pancreatic anastomosis. The authors, benefitting from their experience with robotic pancreato-jejunal anastomosis during robotic pancreatoduodenectomy, describe herein their standardized technique for robotic central pancreatectomy with pancreato-jejunal Roux-en-Y loop anastomosis and report related results perioperative.

Major Concerns:

no.

Minor Concerns:

2- some misspelling should be corrected (see in the abstract (line 39): "in patients with a benign or low-grade malignant ..." should be "in patients with a benign or low-grade malignant").

- We thank the reviewer for the thoughtful reviewer of our manuscript. We have corrected this.

3- The discussion could be expanded (with the add of one-two paragraphs) on indications (patient- and pancreas-related) to central pancreatectomy and supposed advantages of pancreato-jejunal Roux-en-Y loop anastomosis reconstruction over other reconstructions.

- We agree and have now added a paragraph regarding anastomosis reconstruction and choice of preference to the discussion.

4- In the table enlisting needed materials, I suggest adding the kind (and eventually the number) of sutures, of elastic loops, of laparoscopic trocars, of clips and of stent for pancreato-jejunal anastomoses used during the operation.

- We have now added these details.

Reviewer #2:

Manuscript Summary:

Congratulation to the authors for this excellent manuscript and video. A very well performed and presented work about this new robotic approach with great future potential, which I recommend for publication with request for only a few small changes listed below.

1. Major Concerns:

none

Minor Concerns:

2.- I would like to know, which author was the principal surgeon, a fact that might be highlighted in the manuscript.

Manuscript lines 164-65: Section 7.4. mentions the use of 3-0 15 cm barbed suture to close the remaining opening of the anastomosis. In the video the use of first a vicryl and on top a barbed suture is shown. Please clarify this in the text.

- The principal surgeon was MG Besselink, secondary surgeon was OR Busch this is now mentioned in the manuscript.

- The vicryl suture was only placed to create cranial retraction on the remaining opening to

close it properly with the v-loc barbed suture. It is now correctly changed in the video and manuscript.

3- Manuscript lines 185-87: Representative Results: You state: "The patient received antibiotics for 3 days as prophylaxis due to an initial high drain amylase (i.e. biochemical leak)...". Please clear out the term prophylaxis: some authors use somatostatin as prophylaxis or therapy of POPF, in your case you are using antibiotics as prophylaxis of an intraabdominal infection based on possible necrosis?

- Thank you. You are correct! We have now double checked the exact dates of medication and it turns out that the somatostatin was started not as prophylaxis but a few days after surgery. This makes this a grade B POPF. This is now clarified in the manuscript..

Regarding the video, some questions remain open for me. Additionally, I would like to add some comments - even though I presume, that changes in the video may not be possible.

4.00:51: Part 1a: trokar placement: check pronunciation "11-12cm"

- Done

5.03:55: Part 3: pancreatic transection: text states, that the pancreas is transected with robotic monopolar scissors, while the video shows additional use of a vessel sealer (LigaSure). Please clarify the use of instruments.

- The pancreas is usually only transected with robotic monopolar scissors, but during this surgery we once additionally used the vessel sealer. The instruments are now correctly clarified in the manuscript and video.

6.06:45: Part 8: for your modified Blumgart anastomosis you use 3 mattress sutures. Please correct wording in video ("matrass").

- Done

7.Can you explain, why you use 3 silk sutures? What is your standard?

- All these steps of the pancreatic anastomosis follow the Pittsburgh modified Blumgart approach. The silk suture has essentially no 'memory' and is thus easy to tie, furthermore, it is very strong which facilitates robotic suturing and finally, and probably most importantly, after the first double suture it is secure and does not slip.

8.Do you vary the number and kind of sutures according to pancreatic consistency?

- Only very rarely. Typically (>95%) we use 3 silk transpancreatic sutures. Very rarely we use 4 if there is a large pancreas.

9.While Blumgart used 4-6 2-0 Vicryl sutures this number and kind of suture is varied by different authors. We use only 2 mattress sutures 2-0 PDS.

- Thank you, the current type of anastomosis is highly standardized by the Pittsburgh team, clearly there are a lot of variations. We have now mentioned this in the manuscript.

10.Further from the video it is unclear how you avoid including the duct into the middle mattress suture. Could you explain your technique?

- Excellent point, thank you. The middle mattress suture goes indeed around the duct, before tying this we insert the stent for a brief moment in the pancreas. After tying we check whether

the stent can move freely. So far we have never experienced it being stuck. If it would have been we leave the stent in situ during completion of the anastomosis. If not, as has always been the case, we remove the stent in order to create the back wall of the duct-to-mucosa/serosa anastomosis. Then the stent is put back in again and the front row is completed.

Video Produced by Author: Less than 50 MB. If your video is greater than 50 MB, click "offline" as the delivery method and our

This piece of the submission is being sent via mail.