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STANDARDIZED ANNOTATION OF ROBOTIC PROCTECTOMY FOR OBJECTIVE PERFORMANCE METRIC ANALYSIS

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Objective: Objective performance metrics (OPMs) derived from instrument kinematics and surgeon console events (i.e., energy use, camera movement and instrument clutching) can be recorded during robotic surgery and used to provide objective information regarding efficiency and safety of certain movements, best practices for training robotic surgeons, and predictors of patient post-operative course. OPMs can be reported for an entire procedure or individual steps. We describe our process to develop an annotation card for robotic proctectomy that enables consistent interpretation of surgical steps through video review.

Methods: We defined individual steps of robotic proctectomy, including indicators of start and stop for each step (table 1), descriptors of events during, and goals of each step. Based on these steps an annotation card was created. We trained three video reviewers to use the annotation card to time-stamp and label each step. We reviewed two procedures as a group to clarify language, start/stop parameters, and then had four additional procedures reviewed by all three reviewers independently. Auditing revealed excellent agreement across reviewers. Elective robotic proctectomies performed by our surgeons were then recorded using an Intuitive Data Recorder (IDR), which captures endoscopic video and OPM data. IDR data was deidentified and sent to Intuitive Surgical Inc. for interrogation. Each video was annotated independently by two reviewers. Discrepancies were resolved by combined review with a third reviewer. Annotations were then used to match IDR data with appropriate steps.

Results: Recorded IDR data from 31 procedures have been matched to annotated video. The resulting data includes more than 1550 discrete surgical steps, each with 162 OPMs per step, and over 2.5 million data points. OPMs are separately reported for each surgeon console and each patient cart arm. Our data reflects instrument movements (distance, speed, acceleration, roll, yaw, pitch), camera movements, energy use and clutch events.

Conclusion: We developed a method of annotation for robotic proctectomy allowing standardization of key steps so that OPMs may be analyzed and compared to provide objective evaluation of robotic surgeon performance and operation flow.

Initial stage
- Literature review
- In-person meetings & debate

Delphi process
- 4 rounds
- 80% agreement required
- Video review annotation

Video Review
- Independent video reviewer training
- 31 proctectomies annotated
- Includes 1,500 individual steps
- 2.5 million data points

Future Direction
- OPM evaluation:
  - Predictors of operative flow
  - Objective surgeon skill assessment
  - Patient outcomes

Task ID	Task Name	Description	Start Parameter	Stop Parameter
1	Initial exposure	Initial exploration of abdomen, inspect for metastasis, adhesiolysis, retract bowel for visualization of target anatomy. Often, omentum is flipped over transverse colon and small bowel is retracted for exposure.	Initial tool interaction with bowel or adhesion	Initiate any dissection task/step below
2	Mesenteric dissection, identification and skeletonization of named artery	Pedicle is exposed by retracting sigmoid mesentery and beginning mobilization near sacral promontory. IMA is skeletonized. Lymph nodes around IMA should be dissected and removed with specimen.	First tool interaction with mesentery (i.e., scoring or grasping or retracting) around IMA with sigmoid on tension.	IMA skeletonized, ready for transection
3	Ligation and division of named artery	IMA is ligated and divided, utilizing vessel sealer, clip applier, vascular stapler, laparoscopic device or stapler.	Tool interaction with IMA	IMA transected
4	Mesenteric dissection, identification and skeletonization of named vein	Pedicle is exposed by retracting left colon mesentery and beginning mobilization near duodenum. Dissection around IMV with fine instrument.	First tool interaction with mesentery (i.e., scoring or grasping or retracting) around the IMV with left colon on tension.	IMV skeletonized, ready for transection
5	Ligation and division of named vein	Transection of IMV with any devices from IMA step.	Tool interaction with IMV	IMV transected
6	Splenic flexure mobilization: Medial to lateral (submesocolic) (optional)	View is redirected towards LUQ, with the aim of freeing up the proximal end of the desending colon for a tension free anastomosis	Tool interation with mesentery in left middle quadrant, inferior to IMV, anterior to the aorta (blunt or sharp dissection)	Splenic flexure mobilized (surgeon backs out camera)
7	Splenic flexure mobilization: Lateral to medial (optional)	View is redirected towards LUQ, with the aim of freeing up the proximal end of the desending colon for a tension free anastomosis	Tool interaction with lateral attachments while left colon is retracted medially	Splenic flexure mobilized (surgeon backs out camera)
8	Splenic flexure mobilization: Supracolic (optional)	View is redirected towards LUQ, with the aim of freeing up the proximal end of the desending colon for a tension free anastomosis	Tool interaction with gastrocolic ligament while colon retracted caudad	Splenic flexure mobilized (surgeon backs out camera)
9	Mobilization of the rectum: Medial to lateral	Mobilization of rectum and mesorectum from sacral attachments. Surgeon will identify and preserve presacral nerves.	First tool interaction with medial mesorectum	Preceeds either IMA ligation or posterior TME
10	Mobilization of sigmoid and left colon: Medial to lateral	The plane between mesentery and posterior peritoneum is bluntly or sharply (vessel sealer) dissected laterally and cranially. Once mesentery has been mobilized, lateral attachments (Line of Toldt) are dissected from the abdominal sidewall.	Tool interaction with the mesentery at the ligated pedicle	Mobilization of the line of Toldt just inferior to the splenic flexure
11	Mobilization of sigmoid and left colon: Lateral to medial	All lateral attachments of descending and sigmoid colon are divided enabling the descending and sigmoid colon to be separated from the left abdominal wall. Ureter often identified at this time.	First tool interaction with Line of Toldt while sigmoid is retracted medially	Surgeon backs out camera, begins to reposition colon for subsequent step
12	Pelvic rectal dissection with TME: Posterior dissection of rectum	Surgical view is moved into pelvis to mobilize the rectum. This is the posterior dissection, operating from 3-9 o'clock. Preserving pelvic autonomic nerves.	Tool interaction to expose posterior peri-rectal tissue	Posterior rectum is dissected (surgeon backs out camera)
13	Pelvic rectal dissection with TME: Anterior dissection of rectum	Preserving pelvic autonomic nerves, the anterior plane for dissection either forward or behind Denovillier's fascia. Protect anterior anatomy (vagina or prostate)	Tool interaction with anterior peri-rectal tissue	Anterior rectum is dissected (surgeon backs out camera)
14	Pelvic rectal dissection with TME: Right lateral dissection of rectum	Separating rectum and mesorectum from lateral pelvic wall.	Tool interaction to expose right lateral dissection	Right lateral dissection is completed (surgeon backs out camera)
15	Pelvic rectal dissection with TME: Left lateral dissection of rectum	Separating the rectum and mesorectum from lateral pelvic wall. Left side can be more difficult because of sub-optimal view (based on port placement)	Tool interaction to expose left lateral dissection	Left lateral dissection is completed (surgeon backs out camera)
16	Division of mesorectum	Dissection and ligation of all vessels of mesorectum to skeletonize rectum	Tool interaction with mesorectum	Rectum skeletonized
17	Rectal transection	Laprascopic or robotic stapler used to divide rectum. Transection line can be verified with Firefly. May require multiple stapler fires and variation in regularity/distance/margin.	Stapler enters the abdomen makes contact with rectum	Rectum is divided (after last staple load fired)
18	Division of mesocolon	Dissection and ligation of all vessels of the mesocolon to skeletonize colon	First tool interaction with proximal colon (typically will begin after surgeon relocates camera higher in abdomen from pelvis)	Colon is skeletonized
19	Proximal colon transection	Identify the location of proximal bowel resection. Transection line can be verified with Firefly. Stapler traditionally used.	Stapler enters the abdomen makes contact with colon	Proximal colon is divided (after last stapler load is fired)
20	Testing for anastomotic leak (optional)	Pelvis filled with saline and rectum insufflated with air to ensure no bubbles are seen. May be done with syringe and/or sigmoidoscopy.	Last tool interaction with newly anastamosed bowel as abdomen is filled with fluid	Start of suction of saline out of abdomen
21	Colorectal anastomosis	Reconnection of proximal colon to rectal stump. Often transanal circular stapler used. Stapler is passed through transected rectal stump. Anvil is connected to stapler. Surgeon ensures no tension and no twisting of colon. Stapler is fired.	First tool interaction with proximal colon in order to insert anvil.	Last tool interaction, anastomosis is complete