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Procedural key steps in laparoscopic colorectal surgery, consensus through Delphi methodology

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Abstract
Background While several procedural training curricula in laparoscopic colorectal surgery have been validated and published, none have focused on dividing surgical procedures into well-identified segments, which can be trained and assessed separately. This enables the surgeon and resident to focus on a specific segment, or combination of segments, of a procedure. Furthermore, it will provide a consistent and uniform method of training for residents rotating through different teaching hospitals. The goal of this study was to determine consensus on the key steps of laparoscopic right hemicolectomy and laparoscopic sigmoid colectomy among experts in our University Medical Center and affiliated hospitals. This will form the basis for the INVEST video-assisted side-by-side training curriculum.
Methods The Delphi method was used for determining consensus on key steps of both procedures. A list of 31 steps for laparoscopic right hemicolectomy and 37 steps for laparoscopic sigmoid colectomy was compiled from textbooks and national and international guidelines. In an online questionnaire, 22 experts in 12 hospitals within our teaching region were invited to rate all steps on a Likert scale on importance for the procedure.
Results Consensus was reached in two rounds. Sixteen experts agreed to participate. Of these 16 experts, 14 (88 %) completed the questionnaire for both procedures. Of the 14 who completed the first round, 13 (93 %) completed the second round. Cronbach's alpha was 0.79 for the right hemicolectomy and 0.91 for the sigmoid colectomy, showing high internal consistency between the experts. For

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the right hemicolectomy, 25 key steps were established; for the sigmoid colectomy, 24 key steps were established.
Conclusion Expert consensus on the key steps for laparoscopic right hemicolectomy and laparoscopic sigmoid colectomy was reached. These key steps will form the basis for a video-assisted teaching curriculum.

Keywords Training · Key steps · Laparoscopy · Colorectal surgery · Delphi method

Introduction

A new laparoscopic training curriculum is being developed for the North-East Surgical School of the Netherlands (NESSN). The NESSN consists of the University Medical Center Groningen and all affiliated teaching hospitals. INtraoperative Video-Enhanced Surgical procedure Training (INVEST) is shown to have a positive effect on the completion of the early learning curve for surgical procedural training by both increased efficiency and increased effectiveness [1, 2]. Based on this, we aim to construct a laparoscopic curriculum that provides a safe, uniform, efficient, and procedure-specific training program for a series of laparoscopic gastrointestinal procedures, transferrable between hospitals throughout the region. This curriculum will consist of well-defined procedure specific key steps that are incorporated in INVEST video fragments and a validated assessment tool based on these key steps. This curriculum is targeted at residents who have successfully completed a preclinical training course including simulator and wet-lab courses.

The aim of this study was to determine expert consensus regarding essential steps for laparoscopic right hemicolectomy and laparoscopic sigmoid colectomy, using a Delphi methodology. The key steps identified in this study will be the basis for creating the INVEST video's for both procedures. Eventually the goal is to create and validate a procedure-specific assessment tool.

While other training curricula in laparoscopic colorectal surgery have been validated and published [3], none have focused on dividing surgical procedures into well-identified segments, which can be trained and assessed separately. This enables the surgeon and resident to focus on a specific segment, or combination of segments, of a procedure. Furthermore, it will provide a consistent and uniform method of training for residents rotating through different teaching hospitals within our region. A structured, visually demonstrated training curriculum might also reduce the risk of miscommunication and therefore add to the safety of resident training. The goal of this study was not to reinvent well-established guidelines, but to determine consensus on these guidelines within our teaching region. Bethlehem et al. successfully determined consensus on the key steps in laparoscopic appendectomy and cholecystectomy within the same teaching region [4]. These key steps will form the basis for the INVEST video-assisted side-by-side training curriculum. Therefore, a deliberate choice was made to only include NESSN teaching staff as experts. When successful in the future, the curriculum can be expanded to other teaching regions.

Methods

Delphi methodology

In order to reach consensus on the essential procedural steps for laparoscopic right hemicolectomy and sigmoid colectomy, the Delphi method was used. The Delphi method is a well-established, anonymous, group process in which ideas are expressed to the participants in the form of a questionnaire [5, 6]. Responses to the items in the questionnaire are collected and analyzed along with added comments of the experts. This leads to the adding, revising, or dropping of items to be used in a subsequent round, until group consensus is reached [6].

Expert panel

The expert panel was selected to represent currently practicing surgeons within the region of the North-East Surgical School of the Netherlands, who are responsible for the training and education of our surgical residents in laparoscopic colorectal surgery. All experts have performed more than 100 laparoscopic colorectal procedures and have more than 5 years experience in the field. For this study, 22 experts in 12 hospitals were asked to participate via email. They were sent a link to an anonymous online questionnaire. Sixteen surgeons agreed to participate by filling out the questionnaire. Throughout a period of 3 months, reminders were sent in the form of a personal email and/or phone call.

Delphi round 1

A list of procedural steps of the laparoscopic right hemicolectomy and laparoscopic sigmoid colectomy was identified. The steps were compiled from surgical textbooks and current guidelines from the Society of American

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Gastrointestinal and Endoscopic Surgeons (SAGES) [7], the European Association for Endoscopic Surgery (EAES) [8, 9] and the Association of Surgeons of the Netherlands (NVvH) [10]. Each step identified from these sources was included in the initial questionnaire (Tables 1, 2). Each expert was asked to rate the steps on a Likert scale from 1 "not important" to 5 "essential", thus valuing the steps as more or less important parts of the total process. The

Table 1 Delphi round 1: steps identified for laparoscopic right hemicolectomy

	95 % CI	Key step
Organization and positioning		
Vacuum mattress, leg holders, left arm along the body	**3.20**–4.55	Yes
Surgeon on left	**3.26**–4.11	Yes
Assistant right of surgeon	2.51–3.74	[a]
OR nurse between patients legs	1.58–**2.67**	No
Monitor on right, additional monitor for OR nurse	**3.46**–4.16	Yes
Antibiotic prophylaxis, sterile exposition	**3.79**–4.71	Yes
Access and port insertion		
12 mm port left paraumbilical, using an open technique or Veress needle	**3.12**–3.94	Yes
5 and 12 mm ports left/left lower quadrant	2.82–3.98	[a]
5 mm port epigastric for assistant	2.32–**3.28**	No
Tilting patient right side up	2.88–3.79	[a]
(anti)Trendelenburg depending on phase of the procedure	**3.07**–4.00	Yes
Diagnostic laparoscopy	2.98–4.08	[a]
Dissection		
Retracting the omentum and transverse colon in the upper abdomen	2.99–3.81	[a]
Retracting the cecum and identifying the ileocolic vessels	**3.62**–4.51	Yes
Incising peritoneum dorsal of, and parallel to, the ileocolic vessels	**3.19**–4.01	Yes
Blunt dissection of Toldt's fascia toward the lateral abdominal wall	**3.36**–4.37	Yes
Continuing the dissection until above the duodenum and until the gastrocolic trunk runs into the SMV	**3.05**–4.15	Yes
Dividing the ileocolic vessels with a sealing device or laparoscopic stapler	**3.13**–4.21	Yes
Identifying the right branch of the middle colic artery	2.77–3.63	[a]
Dividing the lateral peritoneal reflection of the ascending colon along the white line of Toldt	**3.17**–4.16	Yes
Dividing the omental attachments at the transverse colon (medial to lateral) and entering the lesser sac	2.96–3.97	[a]
Mobilizing the hepatic flexure	**3.05**–3.75	Yes
Dividing the right mesocolon, including the right colic artery and the right branch of the middle colic artery (this may be done extracorporeally)	**3.40**–4.33	Yes
Dividing the mesentery of the ileum	**3.32**–4.28	Yes
Specimen extraction and anastomosis		
Transecting the terminal ileum and transverse colon with a linear stapler intracorporeally or extracorporeally	**3.36**–4.37	Yes
Minilaparotomy	**3.32**–4.28	Yes
Use of a wound protector	2.96–3.97	[a]
Specimen extraction	**3.40**–4.47	Yes
Anastomosis according to the surgeon's preference (intra- or extracorporeally)	**3.32**–4.28	Yes
Concluding the operation		
Laparoscopic inspection (hemostasis and confirm no torsion of the bowel)	**3.00**–3.93	Yes
Closing extraction site and port sites 10 mm or greater	**3.17**–4.16	Yes

Bold values indicate the 95 % CI upper or lower limit

IMA inferior mesenteric artery, *SMV* superior mesenteric vein

[a] Reassess in round 2

Table 2 Delphi round 1: steps identified for laparoscopic sigmoid colectomy

	95 % CI	Key step
Organization and positioning		
Vacuum mattress, leg holders, right arm along the body	**4.06**–4.80	Yes
Surgeon on right	**4.06**–4.80	Yes
Assistant left of surgeon	2.94–4.34	[a]
OR nurse between patients legs	2.18–**3.39**	No
Monitor on left, additional monitor for OR nurse	**3.28**–4.01	Yes
Antibiotic prophylaxis, sterile exposition	**3.93**–4.79	Yes
Access and port insertion		
12 mm port right paraumbilical, using an open technique or Veress needle	**3.31**–4.41	Yes
5 mm and 12 mm ports right lower quadrant	**3.29**–4.13	Yes
5 mm port epigastric for assistant	2.36–**3.36**	No
Tilting patient left side up and in Trendelenburg position	**3.76**–4.53	Yes
Diagnostic laparoscopy	2.94–4.20	[a]
Dissection		
Identifying left ureter	2.14–**3.29**	No
Identifying right ureter	1.55–**2.45**	No
Identifying the origin of the IMA and the superior rectal artery	**3.49**–4.51	Yes
Incising the retrorectal fascia at the level of the promontory	**3.41**–4.30	Yes
Blunt dissection of the TME plane, ventral of the presacral nerves	**3.27**–4.30	Yes
Incising the peritoneal fascia toward the level of de superior rectal artery/sigmoidal arteries	**3.41**–4.30	Yes
Blunt dissection of the plane posterior to the left colon (Toldt's fascia) in a medial to lateral direction	**3.51**–4.35	Yes
Isolating and dividing the superior rectal artery/sigmoidal arteries (depending on location of pathology) with a sealing device or vascular stapler	**3.40**–4.46	Yes
Identifying and dividing the IMV (high tie or low tie)	2.71–3.86	[a]
Dividing the lateral peritoneal reflection of the descending colon and sigmoid along the white line of Toldt	**3.36**–4.36	Yes
Choosing a proximal and distal resection site, with an appropriate margin from the tumor	**3.45**–4.41	Yes
Mobilizing the splenic flexure (depending on residual length of the colon)	2.26–**3.45**	No
Blunt dissection of the posterior aspect of the left colon, cranially to the level of the spleen	2.65–3.78	[a]
Identifying the pancreas	1.64–**2.64**	No
Dissecting the greater omentum off the distal transverse colon in a medial to lateral direction (entering the lesser sac)	1.90–**3.24**	No
Dividing the splenocolic and phrenicocolic ligaments	2.06–**3.37**	No
Checking the length of the mobilized specimen to ensure a tension free anastomosis	**3.50**–4.65	Yes
Dividing the mesocolon/mesorectum at a right angle to the bowel	**3.27**–4.30	Yes
Specimen extraction and anastomosis		
Dividing the bowel intra- or extra-corporeally with a (endo)stapler	**3.22**–4.35	Yes
Creating a minilaparotomy	**3.27**–4.30	Yes
Using a wound protector	**3.06**–3.94	Yes
Extracting the bowel	**3.40**–4.46	Yes
Creating an anastomosis, stapled or hand sewn depending on location	**3.54**–4.60	Yes
Concluding the operation		
Laparoscopic inspection (hemostasis and confirm no torsion of the bowel)	**3.06**–3.94	Yes
Anastomotic air testing	1.82–**2.89**	No
Closing extraction site and port sites 10 mm or greater	**3.14**–4.29	Yes

Bold values indicate the 95 % CI upper or lower limit

IMA inferior mesenteric artery, *IMV* inferior mesenteric vein, *TME* total mesorectal excision

[a] Reassess in round 2

opportunity to comment or clarify was offered at the end of the questionnaire.

Delphi round 2

As the responders could not be identified from the non-responders in this anonymous online questionnaire, all experts were invited for round 2. Based on statistical analysis of round 1, steps were either excluded, considered a key step, or in need of reassessment in round 2. This time, the experts were asked to motivate their answer when they rated a step as 1 "not important" or 2 "sometimes important". Feedback from the first round taken into consideration and two questions were rephrased. We decided in advance to stop after two rounds, whether consensus was reached or not, because identification of essential steps was not to be expected in subsequent rounds.

Statistical analysis and consensus

SAS version 9.2 (SAS Institute Inc., Cary NC, USA) was used for statistical analysis. Cronbach's alpha was calculated for internal consistency between the experts. There are no established criteria for determining consensus using a Delphi methodology. The aim of this method is to reach consensus on relevance of each item. Means and 95 % confidence intervals (CI) were calculated for each step to identify relevant steps. The 95 % CI were used to quantify the variability of the experts' responses. Rated on a Likert scale 1–5, the CI were between 1.00 and 5.00. A step was *accepted* as a key step if the lower confidence limit was $\geq$3.00. A step was *excluded* if the upper confidence limit was $<$3.50. All steps that did not meet the above-mentioned criteria were reassessed in round 2, as insufficient consensus was established in the first round.

In Delphi round 2, a cutoff point for consensus was predetermined. Consensus was established when at least 80 % of the respondents rated the step as $\geq$3. This step was then accepted as a key step. If the 80 % threshold was not reached, the step was excluded.

Results

Of the 22 experts who were asked to participate, 16 agreed. Of these 16 experts, 15 (94 %) completed the questionnaire for the laparoscopic sigmoid colectomy and 14 (88 %) completed the questionnaire for both procedures. Of the 14 who completed the first round, 13 (93 %) completed the second round. Cronbach's alpha was calculated to be 0.79 for laparoscopic right hemicolectomy and 0.91 for laparoscopic sigmoid colectomy, showing high internal consistency between the experts.

Table 3 Delphi round 2: reassessed steps for laparoscopic right hemicolectomy

	Likert score 1–2 (%)	Likert score 3–5 (%)
Assistant right of surgeon	54	46
5 and 12 mm ports left/left lower quadrant	54	46
Tilting patient right side up	8	92[a]
Diagnostic laparoscopy	31	69
Retracting the omentum and transverse colon in the upper abdomen	8	92[a]
Identifying the right branch of the middle colic artery	23	77
Dividing the omental attachments at the transverse colon	15	85[a]
Use of a wound protector	8	92[a]

[a] Accepted as key step

Table 4 Delphi round 2: reassessed steps for laparoscopic sigmoid colectomy

	Likert score 1–2 (%)	Likert score 3–5 (%)
Assistant left of surgeon	31	69
Diagnostic laparoscopy	31	69
Identifying and (if necessary) dividing the IMV	54	46
Blunt dissection of the posterior aspect of the left colon, cranially to the level of the spleen	38	62

IMV inferior mesenteric vein

Accepted as key step: none

In Delphi round 1 (Tables 1, 2), consensus was reached on 23 steps of the right hemicolectomy (two steps were excluded, 21 steps were accepted as key steps); the remaining eight steps were reassessed in round 2. For the sigmoid colectomy, consensus was reached on 33 steps (nine steps were excluded, 24 steps were accepted as key steps) and the remaining four steps were reassessed in round 2.

In Delphi round 2, of the eight reassessed steps of the right hemicolectomy, four steps were accepted as key steps, the other four were excluded (Table 3). For the sigmoid colectomy, all four reassessed steps were excluded (Table 4). A list of final key steps for both procedures is presented in Tables 5, 6.

Discussion

Statistical analysis showed good consistency between experts and between answers. On average, scores for

Table 5 Key steps identified for laparoscopic right hemicolectomy

Organization and positioning
Vacuum mattress, leg holders, left arm along the body
Surgeon on left
Monitor on right, additional monitor for OR nurse
Antibiotic prophylaxis, sterile exposition
Access and port insertion
12 mm port left paraumbilical, using an open technique or Veress needle
Tilting patient right side up
(anti)Trendelenburg depending on phase of the procedure
Dissection
Retracting the omentum and transverse colon in the upper abdomen
Retracting the cecum and identifying the ileocolic vessels
Incising peritoneum dorsal of, and parallel to, the ileocolic vessels
Blunt dissection of Toldt's fascia toward the lateral abdominal wall
Continuing the dissection until above the duodenum and until the gastrocolic trunk runs into the SMV
Dividing the ileocolic vessels with a sealing device or laparoscopic stapler
Dividing the lateral peritoneal reflection of the ascending colon along the white line of Toldt
Dividing the omental attachments at the transverse colon
Mobilizing the hepatic flexure
Dividing the right mesocolon, including the right colic artery and the right branch of the middle colic artery (this may be done extracorporeally)
Dividing the mesentery of the ileum
Specimen extraction and anastomosis
Transecting the terminal ileum and transverse colon with a linear stapler intracorporeally or extracorporeally
Minilaparotomy
Use of a wound protector
Specimen extraction
Anastomosis according to the surgeon's preference (intra- or extra-corporeally)
Concluding the operation
Laparoscopic inspection (hemostasis and confirm no torsion of the bowel)
Closing extraction site and port sites 10 mm or greater

IMA inferior mesenteric artery, *SMV* superior mesenteric vein

Table 6 Key steps identified for laparoscopic sigmoid colectomy

Organization and positioning
Vacuum mattress, leg holders, right arm along the body
Surgeon on right
Monitor on left, additional monitor for OR nurse
Antibiotic prophylaxis, sterile exposition
Access and port insertion
12 mm port right paraumbilical, using an open technique or Veress needle
5 and 12 mm ports right lower quadrant
Tilting patient left side up and Trendelenburg position
Dissection
Identifying the origin of the IMA and the superior rectal artery
Incising the retrorectal fascia at the level of the promontory
Blunt dissection of the TME plane, ventral of the presacral nerves
Incising the peritoneal fascia toward the level of de superior rectal artery/sigmoidal arteries
Blunt dissection of the plane posterior to the left colon (Toldt's fascia) in a medial to lateral direction
Isolating and dividing the superior rectal artery/sigmoidal arteries (depending on location of pathology) with a sealing device or vascular stapler
Dividing the lateral peritoneal reflection of the descending colon and sigmoid along the white line of Toldt
Choosing a proximal and distal resection site, with an appropriate margin from the tumor
Checking the length of the mobilized specimen to ensure a tension free anastomosis
Dividing the mesocolon/mesorectum at a right angle to the bowel
Specimen extraction and anastomosis
Dividing the bowel intra- or extra-corporeally with a (endo)stapler
Creating a minilaparotomy
Using a wound protector
Extracting the bowel
Creating an anastomosis, stapled or hand sewn depending on location
Concluding the operation
Laparoscopic inspection (hemostasis and confirm no torsion of the bowel)
Closing extraction site and port sites 10 mm or greater

IMA inferior mesenteric artery, *IMV* inferior mesenteric vein, *TME* total mesorectal excision

individual steps were lower than expected. In part, this can be explained by how the Likert scale was labeled. Labeling steps as "1 not important, 2 sometimes important, 3 important, 4 very important, 5 essential", resulted in many respondents frequently scoring "3 important". We considered "important" the minimum threshold for a key step, in this study meaning a Likert score of 3 and above.

Some steps were excluded almost unanimously; others were excluded with a large variety of scores. Of the latter, many steps can be very important in only certain situations, i.e., they are important sometimes. Though these steps cannot be included in a list of key steps, they could be added to the INVEST video curriculum as optional steps for specific situations.

Steps excluded in round 1

Of the steps excluded by the experts in round 1, both for the right hemicolectomy and the sigmoid colectomy, three types can be identified. Firstly, practical and ergonomic steps concerned with positioning of the surgeon's assistant and port placement. These steps may have been scored as "not important" because of personal preference, not necessarily influencing the quality of the procedure. Placement of ports is based on the experience and preference of the individual surgeon [9].

Secondly, a procedural set of steps was excluded: mobilizing the splenic flexure in the sigmoid colectomy. This typically represents the type of step that is very important in some situations, but not routinely required and therefore not a key step.

Lastly, three steps concerning safety were excluded: identification of the left and right ureter and the airleak test in the sigmoid colectomy. Of the latter, it could be argued that airleak testing can only be performed on a distal anastomosis and this step may be valued differently in a low anterior resection, though the expert panel listed no arguments for excluding the step. Recommendations on the identification of ureters are scarce. Identification of both ureters is advised in American guidelines, and identification of the right ureter in right hemicolectomy is advised on the EAES website [7, 8], whereas official EAES and NVvH guidelines do not address the issue [9, 10]. Our experts do not routinely perform this step. Ureter injuries are rare, but when they occur they are associated with significantly higher morbidity and mortality [11]. Risk of injury can be a legitimate reason not to open the retroperitoneum for the sole purpose of identifying the ureters, though in situations where this plane is opened for other reasons, good arguments can be made for exploration and identification. Consistent with this, the vast majority of our expert panel scored identification of the ureters as "sometimes important". This step may be considered as an optional step in the video curriculum.

Steps excluded in round 2

For the right hemicolectomy, four steps were excluded after reassessment. Two of these steps were of a practical nature concerning port placement and positioning. A diagnostic laparoscopy is not routinely performed by our experts. Some experts commented that a quick inspection of liver and peritoneum will inevitably be part of the procedure, while no formal inspection of all quadrants is performed. This does not qualify as a diagnostic laparoscopy as such and cannot be included as a key step. Lastly, identifying the middle colic artery was excluded based on 23 % of experts scoring it "sometimes important", mainly related to tumor localization.

For the sigmoid colectomy, all four reassessed steps were excluded. Again, the diagnostic laparoscopy was excluded for previously mentioned reasons, as was a practical step. Identifying and dividing the inferior mesenteric vein, and blunt dissection of the left colon to the level of the spleen, are only performed when there is insufficient length for an anastomosis.

The list of key steps identified in this study is less extensive than other published curricula and international guidelines. In a large international survey, Cheung et al. have shown that there is no consensus between experts in the adjacent field of laparoscopic TME surgery, and many differences seem to be related to experience and local protocol [12]. Differences between international guidelines and local practice illustrate the impact of local protocol and the value of obtaining consensus within a specific academic region. It can be speculated that every country, region, and even every hospital have its own protocol, and this Delphi consensus study could be expanded to different regions to develop a nationwide teaching curriculum in the future. Currently, local practice dictates our resident' training curriculum. By reaching consensus on the laparoscopic right hemicolectomy and sigmoid colectomy, we can make the step toward a structured teaching curriculum that is exchangeable throughout the teaching region. It is important to stress that the steps eliminated by our experts for good reason are not necessarily unimportant steps. The procedural key steps determined in this study are a 'minimum requirement', and a procedure should not be limited strictly to these steps. Many steps that were excluded as key step may be very important depending on case-by-case variables.

In the traditional master-apprentice model of surgical training, demonstration by the supervising surgeon has the clear disadvantage that part of the procedure is lost to the trainee, who has to wait until the next procedure to perform the step himself. Intraoperative video demonstration minimizes the frequency of intervention by the supervisor and maximizes the actual operating time for the trainee. INtraoperative Video-Enhanced Surgical procedure Training (INVEST) is shown to have a positive effect on Objective Structured Assessment of Technical Skills (OSATS) items 'knowledge of the procedure', 'time and motion', 'use of assistance,' and OSATS sum score. INVEST significantly enhances technical and procedural skill development during the early learning curve for laparoscopic cholecystectomy, compared to the traditional master-apprentice model [1, 2]. No other laparoscopic training curriculum has used video fragments intraoperatively. Key steps identified in this study will be used to create INVEST video's for both procedures. Eventually the goal is to create and validate a procedure-specific assessment tool, suitable for incorporation in the training and certification process of gastrointestinal surgeons.

Conclusion

The procedural key steps for laparoscopic right hemicolectomy and laparoscopic sigmoid colectomy were established, using a Delphi methodology with an expert panel of 22 surgeons within our teaching region. This will form the basis of a uniform, transferrable, and efficient video-assisted training curriculum, which is being developed.

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