

## International survey on opinions and use of minimally invasive surgery in small bowel neuroendocrine neoplasms



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### ABSTRACT

**Introduction:** Although minimally invasive surgery is becoming the standard technique in gastrointestinal surgery, implementation for small bowel neuroendocrine neoplasms (SB-NEN) is lagging behind. The aim of this international survey was to gain insights into attitudes towards minimally invasive surgery for resection of SB-NEN and current practices.

**Methods:** An anonymous survey was sent to surgeons between February and May 2021 via (neuro) endocrine and colorectal societies worldwide. The survey consisted of questions regarding experience of the surgeon with minimally invasive SB-NEN resection and training.

**Results:** A total of 58 responses from five societies across 20 countries were included. Forty-one (71%) respondents worked at academic centers. Thirty-seven (64%) practiced colorectal surgery, 24 (41%) endocrine surgery and 45 (78%) had experience in advanced minimally invasive surgery. An open, laparoscopic or robotic approach was preferred by 23 (42%), 24 (44%), and 8 (15%) respondents, respectively. Reasons to opt for a minimally invasive approach were mainly related to peri-operative benefits, while an open approach was preferred for optimal mesenteric lymphadenectomy and tactile feedback. Additional training in minimally invasive SB-NEN resection was welcomed by 29 (52%) respondents. Forty-three (74%) respondents were interested in collaborating in future studies, with a cumulative median (IQR) annual case load of 172 (86–258).

**Conclusions:** Among respondents, 69% applies minimally invasive surgery for resection of SB-NEN. Arguments for specific operative approaches differ, and insufficient training in advanced laparoscopic techniques seems to be a barrier. Future collaborative studies can provide better insight in selection criteria and optimal technique.

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## 1. Introduction

Although minimally invasive surgery has several generally acknowledged applications in the treatment of gastrointestinal malignancies, its use for small bowel neuroendocrine neoplasms (SB-NEN) is not yet widely accepted. This could be explained by the rarity which limits clinical exposure, and the fact that surgeons

treating SB-NEN are not necessarily those with experience in advanced laparoscopic surgery. One of the technical challenges specific for SB-NEN are the nodal metastases, as these often extend to the mesenteric root and are present in more than 80% of patients [1]. Dissection of the superior mesenteric vessels has the risk of bleeding, and there are concerns about inappropriate oncological clearance of all macroscopic tumour if using a minimally invasive approach.

The lacking evidence for minimally invasive SB-NEN resection is probably also related to restricted advice regarding minimally invasive SB-NEN resection by The North American Neuroendocrine Tumor Society and European Neuroendocrine Tumor Society [1,2]. Arguments against a minimally invasive approach are mainly based

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on risk of missing multifocal primary tumours and challenging vascular dissection due to large mesenteric masses.

These arguments against the minimally invasive approach for SB-NEN are mainly based on expert opinion, as there are only a few studies reporting on minimally invasive SB-NEN resection [3–8]. A comparison between minimally invasive and open resection would be of added value, but is currently impossible due to the lack of comparative studies [3,7,9,10]. This could be explained by low volume, the hampers sufficient accrual in such trials, as well as lack of equipoise with some surgeons advocating that open surgery is still standard of care for SB-NEN resection.

For the purpose of this study, a survey was developed, with the aim to give insights in current practice concerning minimally invasive SB-NEN resection, existing attitudes/future prospects towards minimally invasive SB-NEN resection, and to explore interest and willingness among surgeons to participate in future studies regarding minimally invasive SB-NEN resection.

## 2. Methods

### 2.1. Survey

An invitation to participate to the study was sent to surgeon members of 32 (neuro)endocrine and colorectal societies between 16th February 2021 and 3rd May 2021. The survey was conducted anonymously using Google Forms (Mountain View, California, USA), and was adapted from a survey regarding minimally invasive surgery for pancreatic cancer [11]. Responders were given the option to leave their contact information (irrespective of given answers) to receive the study results, and to be contacted for future collaborative studies. Due to a possible overlap in the membership databases of the associations and their confidentiality requirements, the total amount of invited respondents is unknown.

### 2.2. Investigated parameters

Investigated parameters included demographic characteristics (e.g. country, age, hospital type), experience of the surgeon (e.g. scope of practice, years of experience), minimally invasive SB-NEN resection (e.g. attitudes and possible contraindications), and training (e.g. type of necessary training for these procedures). The full survey can be found in Supplementary File 1.

### 2.3. Definitions

Minimally invasive surgery was defined as laparoscopic or robot-assisted surgery. Advanced gastrointestinal minimally invasive surgery was defined as any minimally invasive procedure of the gastrointestinal tract, excluding cholecystectomy, appendectomy or inguinal hernia repair surgery. Consensus was defined as  $\geq 80\%$  agreement, and moderate consensus was defined as 60–80% agreement.

### 2.4. Statistical analysis

Categorical data are presented as number of cases and percentages, whilst continuous data are presented as either mean with standard deviation (SD) or median with interquartile range (IQR), depending on the data distribution. Incomplete surveys were excluded from analyses. The authors did not fill in the survey to prevent investigator bias. Sensitivity analyses were performed to investigate the influence of hospital type and experience in advanced minimally invasive surgery. Data was analysed using the Statistical Package for Social Sciences (SPSS) version 26 (IBM Corp. Armonk, NY, USA).

## 3. Results

### 3.1. Participants

Five of 32 societies accepted to disseminate the survey without charge (European Society of Endocrine Surgeons, European Neuroendocrine Tumour Society, Spanish Group of Neuroendocrine and Endocrine Tumours, German Society of Coloproctology, and the Colorectal Surgical Society of Australia and New Zealand). This resulted in 58 responses across 20 countries, of which 27 (46%) surgeons were from Europe and 22 (38%) from Oceania (Fig. 1). Forty-one (71%) respondents worked at academic centers, 11 (19%) at non-academic referral centers, and 6 (10%) at regional hospitals. The scope of practice was colorectal in 37 (64%), endocrine in 24 (41%), and hepatopancreatobiliary in 9 (16%) respondents. Forty-five (78%) respondents had experience in advanced minimally invasive surgery with a median of 10 (5–15) years (Table 1).

### 3.2. Preferred surgical approach

An open, laparoscopic or robotic approach was preferred by 23 (42%), 24 (44%), and 8 (14%) of the surgeons, respectively (Table 2). Reasons to prefer an open approach were tactile feedback and better lymphadenectomy (consensus,  $>80\%$ ). Reasons to prefer a laparoscopic approach were less post-operative pain (consensus,  $>80\%$ ), shorter length of stay and time to functional recovery (moderate-consensus, 60–80%). Reasons to prefer a robotic approach were enhanced dexterity and better ergonomics (consensus, 80%).

### 3.3. Minimally invasive SB-NEN resection

The median annual volume of SB-NEN resection for individual surgeons was 4 (2–6) (Table 3). Forty (69%) surgeons performed minimally invasive SB-NEN resection, with a mean (SD) annual volume of 4 (3) resections. The most common reasons for only performing open resection by the remaining 18 (31%) surgeons were: lack of training in this technique, lack of scientific evidence, lack of time in surgical schedules and no supporting guidelines (no consensus).

#### 3.3.1. Opinions

The current value of minimally invasive SB-NEN resection was thought to be superior to open resection by 24 (48%) surgeons, and 58% expects this to rise in the future (Table 4). Patients without pN2 lymph nodes or with distal lymph nodes and no encasement of the main mesenteric vessels are thought to be eligible for a minimally invasive resection (moderate consensus, 60–80%). In general, respondents indicated that patients are expected to benefit from a minimally invasive resection if performed by an experienced surgeon (consensus,  $>80\%$ ). A risk of incomplete resection (R1/R2) is believed to be a contraindication (moderate consensus, 60–80%) (Table 5).

#### 3.3.2. Training and education

Specific training in advanced minimally invasive surgery is thought to be essential to be able to perform minimally invasive SB-NEN resection (moderate consensus, 60–80%) (Table 6). Twenty-nine (52%) surgeons stated that they would potentially benefit from additional training in minimally invasive SB-NEN resection, irrespective of previous training (Table 7). Ideally this would be in the form of video-training (moderate consensus, 60–80%). Implementation of a credentialing system was not supported by the respondents.

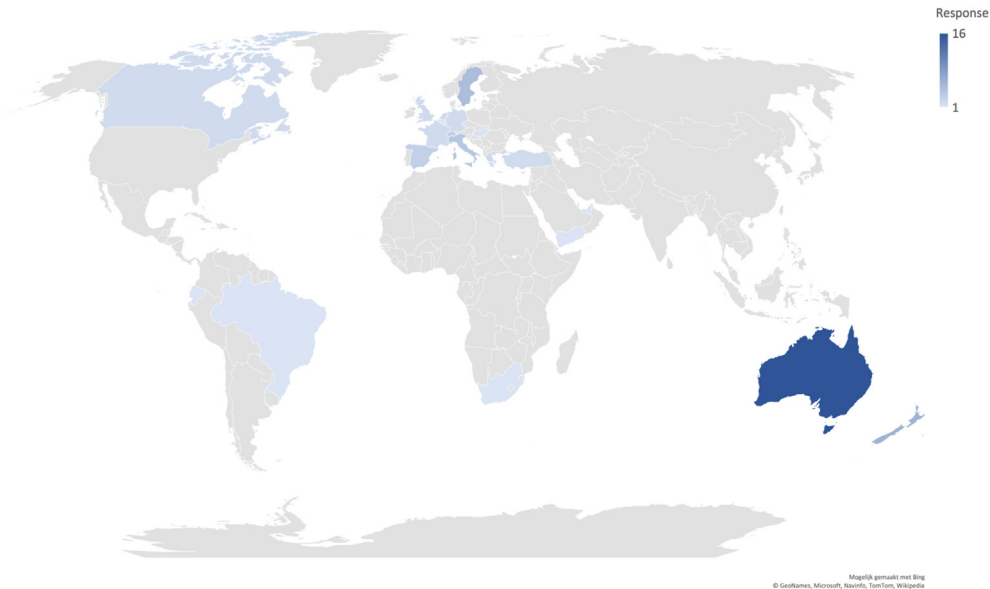


Fig. 1. Response from countries.

**Table 1**  
Characteristics of participating surgeons.

Characteristics, No. (%)	Total (N = 58)	Academic hospitals (N = 41)	Experience in advanced MIS (N = 45)
Sex			
Male	46/56 (82)	34 (83)	35 (78)
Age, years, mean (SD)	50 (9)	50 (10)	48 (9)
Type of hospital			
Academic	41 (71)	41 (100)	33 (73)
Non-academic, referral center	11 (19)	0	8 (18)
Regional	6 (10)	0	4 (9)
Scope of surgical practice <sup>a</sup>			
Colorectal	37 (64)	23 (56)	16 (36)
Endocrine	24 (41)	16 (39)	29 (64)
HPB	9 (16)	7 (17)	8 (18)
General	3 (5)	3 (7)	3 (7)
Experience as an attending surgeon, years, mean (SD)	17 (10)	18 (11)	16 (7–23)
Performs advanced MIS	45 (78)	33 (80)	10 (5–15)
Experience in advanced MIS, years, median (IQR)	10 (5–15)	10 (5–15)	–

<sup>a</sup> multiple answers were possible, cumulative percentage may exceed 100%. IQR: interquartile range, MIS: minimally invasive surgery, SD: standard deviation.

### 3.4. Sensitivity analyses

#### 3.4.1. Academic hospitals

In academic hospitals (41 respondents), the median annual personal case load was 4 (2–6), and 27 (66%) of the surgeons performed minimally invasive SB-NEN resection (Table 3). The most common reasons not to choose this was lack of scientific evidence (50%), lack of supporting guidelines (36%) and lack of training in this technique (36%) (Table 3). Moderate consensus (60–80%) was reached regarding eligibility of patients without N2 lymph nodes for a minimally invasive resection (Table 4). Patients without N2 lymph nodes or with distal lymph nodes and no encasement of the main mesenteric vessels are thought to be eligible for a minimally invasive resection (moderate consensus, 60–80%). Guidelines should give clear criteria for patient selection (moderate consensus, 60–80%). Contraindications were: risk of incomplete resection and venous involvement (moderate consensus, 60–80%) (Table 5).

#### 3.4.2. Experience in advanced minimally invasive surgery

Of the surgeons with prior experience in advanced minimally invasive surgery (N = 45), 38 (84%) stated to perform minimally

invasive SB-NEN resection (Table 3). The preferred technique was laparoscopic dissection, followed by open bowel transection (moderate consensus, 60–80%). Patients without N2 lymph nodes are deemed amenable for a minimally invasive resection (consensus, >80%), as well as lymph nodes without encasement of the mesenteric vessels (moderate consensus, 60–80%) (Table 4). The most important contraindication was risk of incomplete resection (moderate consensus, 60–80%) (Table 5). Despite experience in advanced minimally invasive surgery for other indications, 58% of the surgeons stated that they would benefit from additional training in minimally invasive SB-NEN resection, ideally via video-training (moderate consensus, 60–80%) (Table 7).

## 4. Discussion

This international survey study aimed to give insights in experience and attitudes towards minimally invasive surgery for treatment of SB-NEN. A laparoscopic, robotic or open resection was the preferred technique by 44%, 14% and 42% of the respondents, respectively. In patients with lymph node involvement but without N2 disease or encasement of main mesenteric vessels, consensus

**Table 2**  
Preferred surgical technique and reasons for this technique, multiple answers.

Reasons, No. (%) <sup>a</sup>	Total (N = 58)			Academic hospitals (N = 41)			Experience in advanced MIS (N = 45)		
	Laparoscopic (N = 24/55, 44%)	Robot (N = 8/ 55, 14%)	Open (N = 23/55, 42%)	Laparoscopic (N = 14/41, 34%)	Robot (N = 7/ 41, 17%)	Open (N = 17/41, 41%)	Laparoscopic (N = 24/45, 53%)	Robot (N = 6/ 45, 13%)	Open (N = 15/45, 33%)
Because better/ increased									
Dexterity	1 (4)	<b>7 (88)</b>	6 (26)	1 (7)	<b>6 (86)</b>	5 (29)	1 (4)	<b>5 (83)</b>	5 (33)
Ergonomics	3 (12)	<b>7 (88)</b>	1 (4)	3 (21)	<b>6 (86)</b>	1 (6)	3 (13)	<b>5 (83)</b>	1 (7)
Life expectancy	0	0	1 (4)	0	0	1 (6)	0	0	0
Lymphadenectomy	4 (17)	2 (25)	<b>20 (87)</b>	3 (21)	2 (29)	<b>17 (100)</b>	4 (17)	2 (33)	<b>14 (93)</b>
RO rate	1 (4)	0	9 (39)	0	0	7 (41)	1 (4)	0	5 (33)
Tactile feedback	8 (33)	0	<b>20 (87)</b>	4 (29)	0	<b>16 (94)</b>	8 (33)	0	<b>14 (93)</b>
Tumour staging	0	0	1 (4)	0	0	1 (6)	0	0	1 (7)
Visibility	12 (50)	6 (75)	9 (39)	6 (43)	5 (71)	7 (41)	12 (50)	4 (67)	5 (33)
3D vision	3 (12)	6 (75)	5 (22)	3 (21)	5 (71)	5 (29)	3	4 (67)	3 (20)
Because less/ decreased									
Blood loss	8 (33)	3 (38)	2 (9)	3 (21)	2 (29)	2 (12)	8 (33)	1 (17)	0
Cost	8 (33)	0	6 (26)	4 (29)	0	5 (29)	8 (33)	0	3 (20)
Length of stay	18 (75)	3 (38)	2 (9)	10 (71)	2 (29)	0	18 (75)	1 (17)	0
Pain after surgery	<b>20 (83)</b>	5 (63)	2 (9)	11 (78)	4 (57)	0	<b>20 (83)</b>	3 (50)	0
Post-operative complications	11 (46)	3 (38)	5 (22)	5 (36)	2 (29)	3 (18)	11 (46)	1 (17)	1 (7)
Set-up time	6 (25)	0	10 (43)	3 (21)	0	8 (47)	6 (25)	0	5 (33)
Time to functional recovery	16 (67)	3 (38)	3 (13)	9 (64)	2 (29)	1 (6)	16 (67)	1 (17)	1 (7)

<sup>a</sup> multiple answers were possible, cumulative percentage may exceed 100%. Consensus statements (>80%) are presented in bold, moderate consensus (60–80%) in italic.

**Table 3**  
Minimally invasive SB-NEN resection.

Characteristics, No. (%)	Total (N = 58)	Academic hospitals (N = 41)	Experience in advanced MIS (N = 45)
Annual SB-NEN resections, median (IQR)			
Total performed at hospital	10 (5–15)	10 (5–18)	6 (5–14)
Total performed by surgeon	4 (2–6)	4 (2–6)	3 (2–6)
Performs minimally invasive SB-NEN resection	40/58 (69)	27 (66)	38 (84)
Minimally invasive SB-NEN resections per year, mean (SD)	4 (3)	4 (2)	3 (3)
Type of MIS SB-NEN resection <sup>a</sup>			
Laparoscopic dissection, open bowel transection	25/40 (63)	12/27 (44)	24/38 (63)
Fully laparoscopic	18/40 (45)	2/27 (7)	17/38 (45)
Hand-assisted minimally invasive	7/40 (18)	1/27 (4)	7/38 (18)
Fully robot-assisted	2/40 (5)	15/27 (56)	1/38 (3)
Laparoscopic dissection, with robot-assisted dissection	1/40 (3)	4/27 (15)	1/38 (3)
Does not perform MIS SB-NEN resection	18/58 (31)	14 (34)	6 (13)
Reasons not to perform MIS SB-NEN resection <sup>a</sup>			
Lack of training in this technique	9/18 (50)	7/14 (50)	2/6 (33)
Lack of scientific evidence	7/18 (39)	5/14 (36)	3/6 (50)
Lack of time in surgical schedules	6/18 (33)	5/14 (36)	1/6 (17)
No guidelines by the societies are published on this topic	5/18 (28)	4/14 (29)	3/6 (50)
Difficulty of the surgical technique	4/18 (22)	3/14 (21)	2/6 (33)
Other surgeon(s) perform this procedure in our center	3/18 (17)	2/14 (14)	1/6 (17)
Institutional culture discourages it	2/18 (11)	2/14 (14)	0
The costs are too high	2/18 (11)	1/14 (7)	0
Not relevant in my center	1/18 (6)	0	1/6 (17)
Patient preference for open approach	0	0	0

<sup>a</sup> multiple answers were possible, cumulative percentage may exceed 100%. Consensus statements (>80%) are presented in bold, moderate consensus (60–80%) in italic. IQR: interquartile range, MIS: minimally invasive surgery, SD: standard deviation.

was reached among respondents that minimally invasive surgery is the preferred surgical approach in those patients. Insufficient training appeared to be one of the barriers for using a minimally invasive approach, besides lack of supporting evidence and guideline recommendations.

Reasons to opt for a laparoscopic approach were benefits related to post-operative pain, time to functional recovery, length of stay. Differences in post-operative recovery might also be attributable to the size of the laparotomy. For a minimally invasive approach, an extraction laparotomy of approximately 10 cm would be sufficient

[9]. However, a laparotomy of 10 cm would probably not be sufficient for a fully open approach. The scarcely available literature reports median length of stay of 7–8 days after open resection and 4–6 days after minimally invasive resection of SB-NEN [3,7,9]. Evidence to verify the remaining arguments (post-operative pain and time to functional recovery) in the setting of SB-NEN resection is currently not present, but is expected to be beneficial for the laparoscopic approach, similar to colon cancer surgery [12]. The combination of these factors might explain why respondents opt for a laparoscopic approach.

**Table 4**  
Opinions on MIS SB-NEN resection.

Characteristics, No. (%)	Total respondents (N = 58)	Academic hospitals (N = 41)	Experience in advanced MIS (N = 45)
Current overall value of MIS compared to open approach			
Inferior value of MIS	9/50 (18)	7/33 (21)	5/40 (13)
Equivalent value of MIS	17/50 (34)	10/33 (30)	14/40 (35)
Superior value of MIS	24/50 (48)	16/33 (48)	21/40 (53)
Future value of MIS compared to open approach			
Inferior value of MIS	7/50 (14)	6/33 (18)	5/40 (13)
Equivalent value of MIS	14/50 (28)	8/33 (23)	9/40 (23)
Superior value of MIS	29/50 (58)	19/33 (58)	26/40 (65)
Patients without pN2 lymph node metastases are amenable for MIS	39/51 (76)	26/35 (74)	<b>35/42 (83)</b>
Guidelines should give clear criteria for patients selection in MIS	31/55 (56)	18/28 (64)	24/37 (65)
Patients with distal lymph nodes, without encasement of mesenteric vessels are amenable for MIS	42/55 (76)	27/38 (71)	34/43 (79)
In general, patients benefit from MIS when performed by an experienced surgeon	<b>44/51 (86)</b>	27/34 (79)	<b>37/41 (90)</b>
Expected effect on quality of life after MIS compared to open			
Better quality of life after MIS	25/48 (52)	14/32 (44)	22/40 (55)
Equal quality of life after MIS	23/48 (48)	18/32 (56)	18/40 (45)
Worse quality of life after MIS	0	0	0

<sup>a</sup> multiple answers were possible, cumulative percentage may exceed 100%. Consensus statements (>80%) are presented in bold, moderate consensus (60–80%) in italic.

**Table 5**  
Contraindications for MIS SB-NEN resection.

Contraindications, No. (%) <sup>a</sup>	Total respondents (N = 58)	Academic hospitals (N = 41)	Experience in advanced MIS (N = 45)
Risk of incomplete resection (R1/2)	39 (67)	30 (75)	32 (71)
Arterial involvement of the tumour	32 (55)	22 (55)	26 (58)
Venous involvement of the tumour	30 (52)	24 (60)	25 (56)
Large size of mesenteric metastases (pN2, >2 cm)	27 (47)	18 (45)	19 (42)
Multiple primary tumours	25 (43)	19 (48)	20 (44)
Prior laparotomy	12 (21)	5 (13)	7 (16)
Risk of intra-operative bleeding	7 (12)	5 (13)	6 (13)
Morbid obesity (BMI >30)	4 (7)	3 (8)	3 (7)
None	4 (7)	3 (8)	3 (7)
ASA score >3	2 (3)	1 (3)	2 (4)
Advanced age	0	0	0

<sup>a</sup> multiple answers were possible, cumulative percentage may exceed 100%. Consensus statements (>80%) are presented in bold, moderate consensus (60–80%) in italic.

**Table 6**  
Essentials in MIS SB-NEN resection.

Characteristics, No. (%)	Total respondents (N = 57)	Academic hospitals (N = 41)	Experience in advanced MIS (N = 45)
Specific training in advanced MIS	35 (61)	23/40 (58)	26/44 (59)
Multidisciplinary assessment of patients for MI SB-NEN resection	33 (58)	25/40 (63)	27/44 (61)
High volume NEN center	28 (49)	22/40 (55)	20/44 (45)
High volume advanced MIS center	24 (42)	16/40 (40)	22/44 (50)
Specific training in open SB-NEN resection	21 (37)	18/40 (45)	15/44 (34)
Specific training in MI SB-NEN resection	18 (32)	13/40 (33)	12/44 (27)
At least two surgeons with experience in MI SB-NEN resection	10 (18)	6/40 (15)	5/44 (11)
Specific accreditation for MI SB-NEN resection	1 (2)	1/40 (3)	1/44 (3)

<sup>a</sup> multiple answers were possible, cumulative percentage may exceed 100%. Consensus statements (>80%) are presented in bold, moderate consensus (60–80%) in italic.

Reasons to opt for an open resection were related to better lymphadenectomy and tactile feedback. An adequate lymphadenectomy is of particular importance, as presence of lymph nodes have a negative impact on survival, irrespective of presence of liver metastases, and is complex in case of N2 nodes [8,13]. However, it should be noted that no differences between the number of resected lymph nodes were reported between minimally invasive and open resection by any of the comparative studies, and that R0 resection rates were higher in the minimally invasive group [3,7,9,10]. This is probably a consequence of adequate patient selection. The argument of tactile feedback is expected to be related to the importance of palpating the small bowel to find and resect multiple primaries that are potentially missed on pre-operative imaging [2]. However, palpation of the entire small bowel is also possible in minimally invasive surgery, because the small bowel can

be externalized through the extraction site, which was indeed performed as such by 63% of the respondents. Using this specific technique, Mahuron et al. was able to find a similar number of multifocal tumours (41% minimally invasive resection vs. 36% open resection,  $P = 0.70$ ) [7]. Contrary to these results, Ethun et al. described significantly less multifocal tumours after a minimally invasive resection (21% minimally invasive vs. 50% open,  $P = 0.03$ ), but the operative technique was not described in detail [10].

Risk of incomplete resection was the only contraindication reaching moderate consensus. Appropriate long-term outcome data for minimally invasive resection are still not available. Further studies are required to determine the risk of incomplete resection in minimally invasive SB-NEN resection for different tumour stages and whether this impacts on long-term survival. But oncological safety should not be compromised for the sake of short-term

**Table 7**  
Training and education in MIS SB-NEN resection.

Characteristics, No. (%)	Total respondents (N = 58)	Academic hospitals (N = 41)	Experience in advanced MIS (N = 45)
No. MI SB-NEN resections needed to complete the learning curve, median (IQR)	10 (10–20)	10 (10–20)	10 (5–20)
Proportion MI SB-NEN resection at own hospital ten years from now, mean (SD)	54% (32%)	53% (32%)	59% (29%)
Did you receive training in advanced MIS	33 (57)	25 (61)	29 (64)
Would you benefit from (additional) training in MIS SB-NEN resection? Training form should be <sup>a</sup>	29/56 (52)	17/39 (44)	26 (58)
Video-training	33/55 (60)	21/38 (55)	27/43 (63)
Proctoring	28/55 (51)	20/38 (53)	23/43 (53)
Central-training, e.g. in surgical laboratory	26/55 (47)	18/38 (47)	20/43 (47)
Formalized residency	21/55 (38)	13/38 (34)	15/43 (35)
Credentiailling should be implemented	13 (22)	8/41 (20)	8 (18)
Credentiailling should include: <sup>a</sup>			
Training in advanced minimally invasive surgery	9/13 (69)	6/8 (75)	6/8 (75)
Training in open SB-NEN resection	9/13 (69)	6/8 (75)	5/8 (63)
Training in minimally invasive SB-NEN resection	9/13 (69)	5/8 (63)	5/8 (63)
Participation in registry for minimally invasive SB-NEN resection	8/13 (62)	5/8 (63)	6/8 (75)
Minimum number of cases under proctorship	5/13 (38)	2/8 (25)	1/8 (13)
Video review of procedure	4/13 (31)	1/8 (13)	2/8 (25)

<sup>a</sup> multiple answers were possible, cumulative percentage may exceed 100%. Consensus statements (>80%) are presented in bold, moderate consensus (60–80%) in italic. IQR: interquartile range, MIS: minimally invasive surgery, SD: standard deviation.

benefits during the years that this evidence has to be obtained. Arterial and venous involvement of the tumour was the second and third most common contraindication stated by the respondents. This is indeed a specific challenge for these procedures, as up to 40% of the patients present with this advanced nodal stage [9]. Surgeons could make use of fluorescence angiography with indocyanine green to help aid safe resection, either during a minimally invasive or open procedure [14].

Regarding selection criteria, patients without N2 lymph node metastases and without encasement of the mesenteric vessels were deemed eligible for a minimally invasive resection. In sensitivity analyses for previous experience in advanced minimally invasive surgery and academic hospitals, it was also stated that guidelines should give clear criteria for this. The classification system of mesenteric metastases proposed by Ohrvall et al. could be considered for this purpose [15]. Herein, the location of mesenteric metastases are staged from I to IV, in which stage I consists of nodal disease with a close proximity to the intestine (i.e. distal) and stage IV constitutes metastases extending retroperitoneally or peripancreatic, or encasing the superior mesenteric vessels (i.e. proximal).

Essential items to consider when conducting minimally invasive SB-NEN resection according to the respondents were either previous training in advanced minimally invasive surgery (for other indications), and multidisciplinary assessment to discuss eligibility of patients for a minimally invasive resection. These findings did not differ in sensitivity analyses. Multidisciplinary assessment could be performed during regular tumour board meetings, or can be part of specific technical meetings.

Some (distally located) tumours require a right hemicolectomy/ D3 lymphadenectomy. Careful lymphadenectomy is warranted as 57–62% of patients have lymph nodes along the mesenteric vessels or in the retropancreatic portion, and a cut-off of <8 lymph nodes seems to be associated with poorer prognosis [16,17]. The learning curve associated with this procedure deserves special attention as well, for example by performing a learning curve cumulative sum analysis [18]. Regarding additional training, 52–58% of the respondents stated that they would potentially benefit from this. Video-training was the preferred way to do this. Our group has previously published two video vignettes describing the operative technique, with use of intra-operative fluorescence angiography

using indocyanine green [19,20]. Video-training only might not be sufficient to learn to perform such a complex procedure. An initial wet-lab training focused on laparoscopic D3 dissection might be of benefit, and is something that could be investigated via the ISGSS. Subsequently, a number of cases should ideally be proctored, and this might be tailored to the experience level of the surgeon to be trained and the efficiency of gaining additional skills as perceived by the proctor.

The findings of this study should be seen in light of some limitations. Bias might be introduced due to personal preference of surgeons, which is inherent to qualitative research. Also, three large endocrine and colorectal societies from the United States and Europe did not participate, hence comparison of experiences and attitudes within continents was not possible. Finally, based on the answers as to why certain approaches are preferred (Table 2), respondents might have given the “right” answers to some questions, instead of genuine thoughts or considerations.

Forty-three (74%) respondents were interested in collaboration to conduct future studies. We are currently giving shape to this collaboration by setting up the International Study Group of small bowel neuroendocrine Surgery (ISGSS, <http://www.isgss.org/>). Based on the survey, the median (IQR) annual cumulative case-load of ISGSS is estimated to be 172 (86–258) resections of which 129 (86–215) are minimally invasive. With these numbers, more solid evidence for guidelines could be generated, and studies that were previously thought to be impossible could be performed (e.g. randomized trials). The evidence generated by the international study group can be used to validate the arguments given by the respondents. Furthermore, this infrastructure can be used to organize training for minimally invasive SB-NEN resection.

### Statement of ethics

The paper is exempt from ethical committee approval because no patients were involved in the conduct of this study.

### Funding sources

No funding was received to perform this study.

## Data availability

The collected data is available upon reasonable request from the authors.

## CRediT authorship contribution statement

**Enes Kaçmaz:** Conceptualization, Study design, Funding acquisition, Quality control of data and algorithms, Data analysis and interpretation, Statistical, Formal analysis, Manuscript preparation, Writing – review & editing, Manuscript review. **Anton F. Engelsman:** Conceptualization, Study design, Writing – review & editing, Manuscript review. **Willem A. Bemelman:** Conceptualization, Study design, Writing – review & editing, Manuscript review. **Pieter J. Tanis:** Conceptualization, Study design, Writing – review & editing, Manuscript review. **Elisabeth J.M. Nieveen van Dijkum:** Conceptualization, Study design, Writing – review & editing, Manuscript review.

## Declaration of competing interest

The authors have no conflict of interest.

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