

## Current surgical concepts for type III hiatal hernia: a survey among members of the Swiss Society of Visceral Surgery

Stephan Gerdes, Diana Vetter, Philip C. Müller, Joshua R. Kapp, Christian A. Gutschow

Department of Surgery and Transplantation, University Hospital Zurich, Switzerland

### Summary

**AIMS OF THE STUDY:** Surgery for large hiatal hernias has greatly evolved over the last decade, but there is an ongoing controversy regarding many technical aspects, such as the use of meshes or the necessity to add a fundoplication. The purpose of this survey was to assess the current spectrum of surgical care for mixed axial and paraoesophageal hiatal hernias (type III hiatal hernia) in Switzerland.

**METHODS:** In April 2020, we conducted a web-based survey comprising 25 questions on surgical management of type III hiatal hernia among members of the Swiss Society for Visceral Surgery. The survey focused exclusively on primary hernias in an elective setting. Responses were graded on a five-point Likert scale and analysed using descriptive statistics. Consensus was defined as agreement (agree or strongly agree)  $\geq 75\%$ .

**RESULTS:** Forty-seven visceral surgeons with a median annual institutional caseload of 15 (interquartile range 10–30) type III hiatal hernia participated in the survey (response rate 15%). Agreement  $\geq 75\%$  was found for several basic technical steps (access via laparoscopy, hernia sac resection, preservation of vagus nerves, preservation of aberrant left hepatic artery, single-stitch posterior suture repair of hiatus with braided, non-resorbable material, complementary antireflux procedure). In contrast, consensus was not achieved for several important surgical details (mesh hiatoplasty, type of antireflux procedure, gastropexy, management of short oesophagus). A high percentage of participating surgeons experienced mesh related complications in their own or assigned patients: erosions (15% and 36%, respectively), stenoses (26% and 24%, respectively) and pericardial tamponades (9% and 15%, respectively). Nevertheless, hiatal reinforcement with mesh (in all or in selected cases) was reported by 91% of participants without consensus regarding mesh type, shape, placement and fixation technique.

**CONCLUSIONS:** Apart from a few generally accepted technical steps, surgical management of type III hiatal hernia is highly variable amongst visceral surgeons in

Switzerland. Although mesh-related complications appear to be common, most Swiss surgeons report routine mesh use for hiatal reinforcement.

### Introduction

Optimal treatment of large hiatal hernias remains a hotly contested topic in upper gastrointestinal surgery. Numerous aspects of the surgical management of this clinical entity are not broadly accepted, and even experts disagree on critical components including the application of surgical meshes for hiatal reinforcement, the indication for complementary antireflux repair and the diagnosis and treatment of short oesophagus.

Based on our own clinical experience, we hypothesised that current surgical practice in Switzerland mirrors the aforementioned uncertainties. Since there are no official national recommendations or guidelines on this topic, we found it pertinent to perform a snapshot survey of members of the Swiss Society of Visceral Surgeons (SGVC) to ascertain potential variation in current surgical management of type III hiatal hernia.

### Material and methods

#### Panel of participants and details of the questionnaire

In April 2020, we invited all members of the SGVC via email to participate in an anonymous online survey regarding current surgical strategies for hiatal hernia. In order to minimise bias, the focus was strictly on type III (mixed axial and paraoesophageal) hiatal hernia; other hernia types, emergencies and recurrences were considered outside the scope of this study. We designed a 25-question survey to elicit respondent feedback on the following points: personal and institutional experience of participants, diagnostic work-up, indications and technical details of hiatal repair (surgical access routes, crural dissection and reconstruction phase). An online survey tool (SurveyMonkey, Palo Alto, CA, USA) was employed to disseminate the survey and collect answers. Participants were asked to rank their agreement on predefined answers to each question using a five-point Likert scale. Two scale variations

#### Correspondence:

Prof. Christian A. Gutschow  
Department of Surgery and Transplantation  
University Hospital Zurich  
Rämistrasse 100  
CH-8091 Zurich  
christian.gutschow[at]usz.ch

were employed. The first indicated the level of agreement with a certain technique (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree). The second concerned the frequency with which technical steps are performed by the participant (1 = always, 2 = very often, 3 = sometimes, 4 = rarely, 5 = never). The attendees were also invited to leave comments on each question. A reminder was sent via email after 2 weeks. Details of the questionnaire are shown in the appendix.

### Data analysis

Data were analysed using descriptive statistics and expressed as percentage of agreement and median (interquartile range; IQR) using SPSS version 26.0 (IBM Inc., Chicago, Ill, USA). Consensus was defined as  $\geq 75\%$  of experts agreeing (strongly agree or agree and always or very often) on a given question.

## Results

### Participants

Three-hundred-and-ten members of the SGVC were invited, and 47 surgeons (response rate 15%) across 12 cantons participated in the survey. All respondents were specialist visceral surgeons with a median experience of 15.7 years (IQR 7.3–23) after board examination in surgery. The median personal and institutional annual caseload of type III hiatal hernia was 10 (IQR 5–17) and 15 (10–30), respectively. The hospitals' levels of care and participants' positions within each hospital hierarchy are summarised in table 1. Standardised treatment algorithms for hiatal hernia had been established by 76%.

### Diagnostic work-up and Indication for surgery

Most surgeons agreed that the preoperative diagnostic work-up for patients with type III hiatal hernia should entail upper gastrointestinal tract endoscopy (100%) and computed tomography (CT) (78%). Conversely, there was no consensus regarding contrast radiography, oesophageal manometry, oesophageal pH-metry, plain chest radiography, magnetic resonance imaging (MRI) or endoscopic ultrasound prior to surgery (table 2).

There was strong agreement amongst respondents that both older and younger patients with relevant symptoms (98% and 100%, respectively) or chronic anaemia with Cameron lesions (96% and 100%, respectively) should undergo surgery. Likewise, there was clear consensus on operating on younger (<70 years, physically fit) asymptomatic patients (64% agreement). In contrast, no agreement was found regarding older (>70 years, physically fit) asymptomatic patients without Cameron lesions (36%).

### Surgical access route and hiatal dissection

Surgical access via laparoscopy was preferred by all participants (100% agreement). In contrast, laparotomy or robot-assisted techniques were rarely used, and none of the participants reported a preference for the transthoracic route (fig. 1).

Technical steps during dissection of the hiatus are summarised in Table 3. Most participants agreed upon the necessity of division of the phreno-oesophageal ligament, the mobilisation and resection of the hernia sac, and an extensive mediastinal mobilisation to obtain sufficient oesophageal length. Furthermore, there was consensus in favour of visualising both vagus nerves and ensuring preservation of an aberrant left hepatic artery. Conversely, no consensus  $\geq 75\%$  was achieved pertaining to preserva-

**Table 1:**  
Participating experts and institutions.

Participating expert characteristics		n (%)
Per region	German-speaking canton	38 (81)
	French-speaking canton	5 (11)
	Italian-speaking canton	4 (8)
Per institution	Private hospital	11 (23)
	General hospital	11 (23)
	Teaching hospital	16 (34)
	Maximum care hospital	9 (19)
Clinical position of participants	Department head	15 (32)
	Senior consultant	21 (45)
	Consultant	1 (2)
	Attending surgeon	5 (11)
	Other position	5 (11)

**Table 2:**  
Preoperative work-up

	Strongly agree/agree	Neither agree nor disagree	Disagree/strongly disagree
Upper gastrointestinal tract endoscopy	100.0%	0.0%	0.0%
Contrast radiography	42.6%	34.0%	23.4%
CT scan	78.7%	17.0%	4.3%
Oesophageal manometry	59.6%	23.4%	17.0%
Oesophageal pH-metry / impedance pH-metry	40.4%	34.0%	25.5%
Chest X-ray	17.0%	34.0%	48.9%
Other diagnostic modalities (MRI, endosonography, oesophageal scintigraphy)	0.0%	25.5%	74.5%

CT: computed tomography; MRI: magnetic resonance imaging

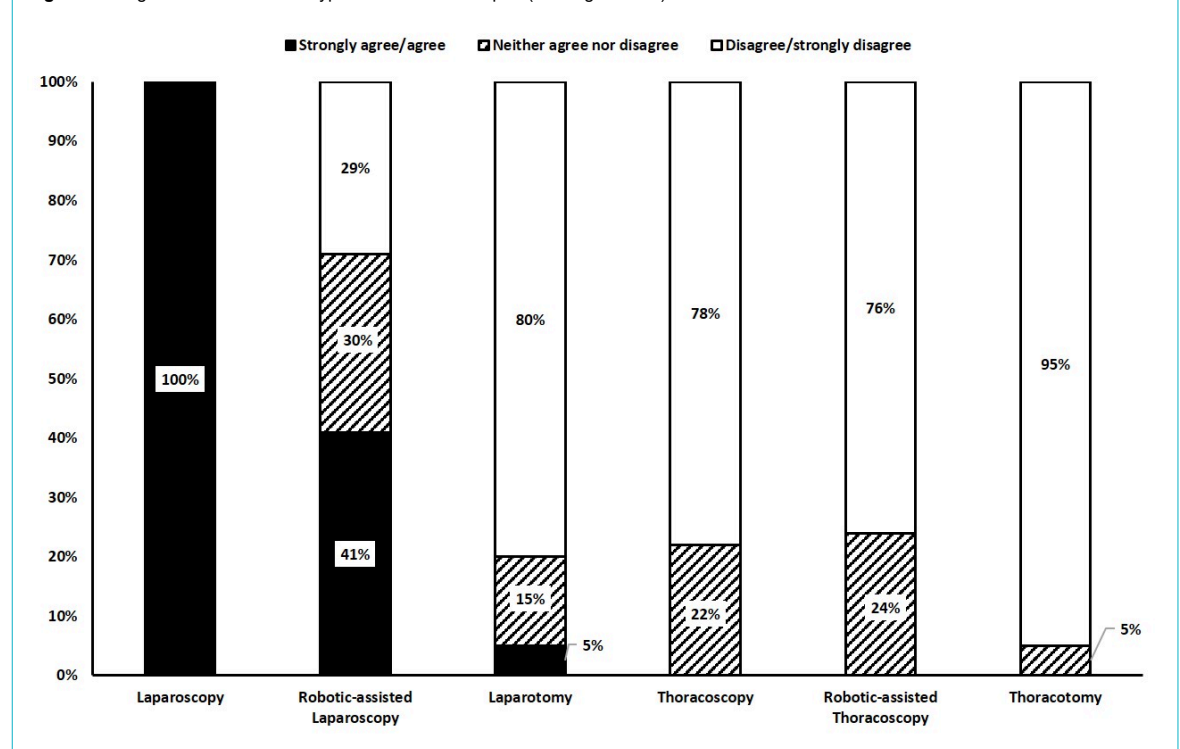
tion of the hepatic branches of the vagus, mobilisation of the gastric fundus, and resection of a posterior retro-cardiac lipoma or pre-cardiac fat pad. Similarly, intraoperative endoscopy aimed at determining the length of the oesophagus in the case of suspected short oesophagus was deemed necessary by just a minority of respondents.

### Hiatal repair and mesh augmentation

There was a clear consensus for crurorraphy of the posterior aspect of the hiatus with single stitches using braided, non-resorbable suture material (size 0 or 2-0) (table 4). Lower agreement scores were reported for combined anterior and posterior or exclusive anterior crurorraphy, the use of pledgets, running sutures, or single form-8 sutures. Very few surgeons reported performing relaxing incisions on the diaphragm to reduce tension (table 4).

Although a relevant percentage of participants reported having encountered mesh-related complications in own or assigned patients (table 5), most surgeons indicated regular (in all or most cases) use of surgical mesh for hiatal reinforcement (always 28%, in most cases 30%, in selected cases 34%). The most common indications for mesh use included fragile texture of the diaphragmatic musculature (79%) and large hiatal defects (85%). In contrast, consensus was not achieved for other potentially predisposing factors such as biologically young (40%) or old (45%) age, history of other abdominal hernia (34%) and obesity (51%). Likewise, agreement was limited regarding the choice of mesh types (fig. 2) and mesh placement (exclusively on posterior hiatoplasty 26%, on posterior hiatoplasty and crura 79%, on anterior hiatoplasty and crura 29%, circular around the oesophagus 34%, individually adapted to the specific patho-anatomy 50%, and avoiding contact with the oesophagus 61%). Most surgeons agreed on

**Figure 1:** Surgical access routes in type III hiatal hernia repair (% of agreement).



**Table 3:**  
Technical details of hiatal dissection.

	Strongly agree/ agree	Neither agree nor dis- agree	Disagree / strongly dis- agree
Repositioning of hernia sac contents into the abdominal cavity as initial surgical step	70.2%	8.5%	21.3%
Dissection/transsection of the phreno-oesophageal ligament	80.9%	17.0%	2.1%
Resection of hernia sac	78.7%	12.8%	8.5%
Wide mediastinal dissection to achieve sufficient oesophageal length	95.8%	4.3%	0.0%
Visualisation and dissection of both vagus nerves	83.0%	8.5%	8.5%
Mobilisation of gastric fundus / division of gastro-splenic ligament including short gastric vessels	66.0%	21.3%	12.8%
Resection or dissection of posterior retro-cardiac lipoma (if present)	68.1%	27.7%	4.3%
Resection or dissection of the pre-cardiac fat pad	31.9%	38.3%	29.8%
Intraoperative endoscopy to determine oesophageal length (in the case of suspected oesophageal shortening)	21.3%	42.6%	36.2%
Preservation of the crural fascia	68.1%	29.8%	2.1%
Preservation of aberrant left hepatic artery	80.9%	14.9%	4.3%
Preservation of hepatic branches of vagus nerves	51.1%	31.9%	17.0%
Preservation of pulmonary branches of vagus nerves	48.9%	38.3%	12.8%

fixing the mesh with sutures (71%), whereas other techniques of mesh fixation (tacks 22%, fibrin glue 32%) did not achieve consensus.

### Antireflux procedures, fundo-phrenicopexy and management of short oesophagus

Most participants (77%) reported regularly performing an additional antireflux procedure in combination with cruror-

**Table 4:**  
Technical details of hiatal reconstruction.

	Always/very often	Sometimes	Rarely/never
Suture repair of hiatus	100.0%	0.0%	0.0%
Use of mesh to reinforce hiatal repair	57.5%	21.3%	21.3%
Other options to reinforce hiatal repair	0.0%	6.4%	93.6%
Use of relaxing diaphragmatic incisions	2.1%	4.3%	93.6%
Gastropexy / fundo-phrenicopexy	61.7%	10.6%	27.7%
Antireflux procedure	76.6%	14.9%	8.5%
Oesophageal lengthening procedure	10.6%	12.8%	76.6%

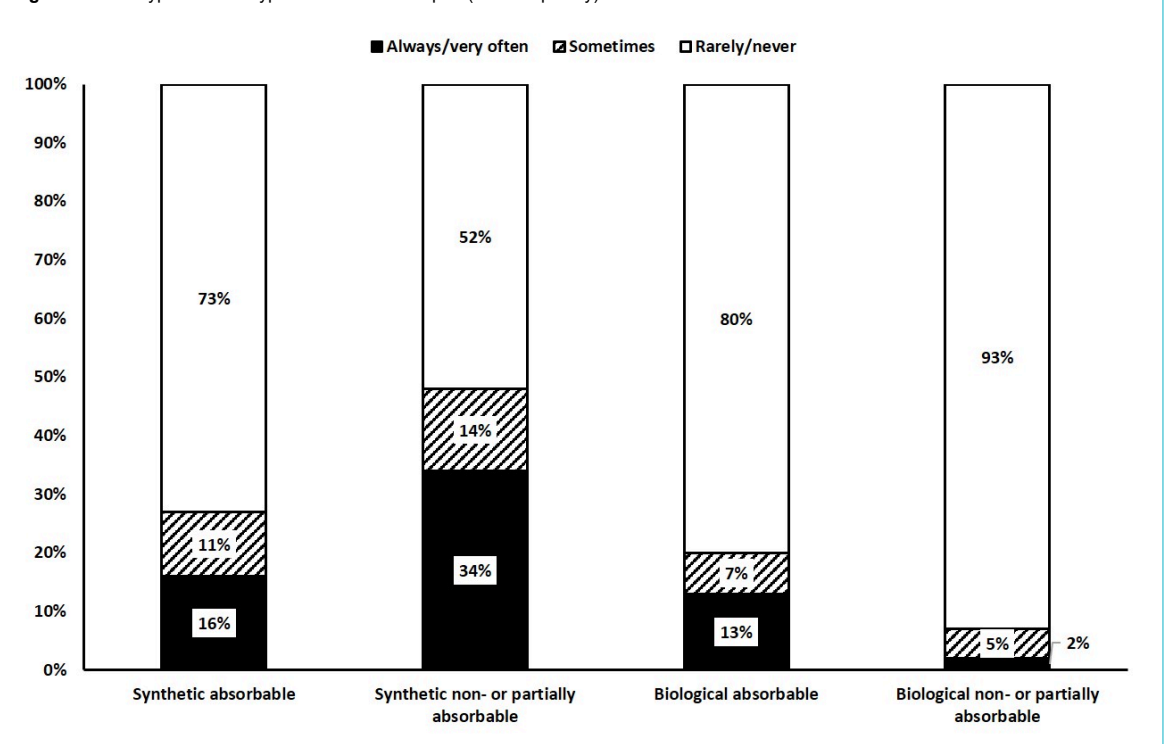
**Table 5:**  
Mesh-related complications.

	Yes, in own patients	Yes, in referred patients	Never
Mesh erosion to oesophagus	8.5%	36.2%	59.6%
Mesh erosion to stomach <sup>a</sup>	2.2%	21.7%	76.1%
Mesh erosion to oesophago-gastric junction <sup>a</sup>	6.5%	30.4%	65.2%
Mesh erosion to other organs (aorta, lung) <sup>b</sup>	0.0%	6.7%	93.3%
Stenosis distal oesophagus / oesophago-gastric junction <sup>a</sup>	26.1%	23.9%	56.5%
Mesh migration <sup>a</sup>	10.9%	32.6%	56.5%
Mesh infection <sup>a</sup>	6.5%	10.9%	82.6%
Pericardial haemorrhage/effusion <sup>a</sup>	8.7%	15.2%	78.3%
Pleural haemorrhage/effusion <sup>b</sup>	15.6%	11.1%	77.8%
Perioperative haemorrhage caused by tacks during mesh fixation <sup>a</sup>	4.4%	10.9%	84.8%
Perioperative haemorrhage caused by sutures during mesh fixation <sup>a</sup>	6.5%	8.7%	84.8%
Pneumothorax <sup>a</sup>	37.0%	13.0%	54.4%
Chronic pain <sup>a</sup>	21.7%	26.1%	58.7%
Seroma formation <sup>a</sup>	21.7%	15.2%	67.4%

<sup>a</sup> Question answered by 46 respondents.

<sup>b</sup> Question answered by 45 respondents.

**Figure 2:** Mesh types used in type III hiatal hernia repair (% of frequency).



raphy. The majority of participants (64%) employed braided, non-absorbable suture material (size 2-0). In particular, biologically younger (<70 years) or physically fit patients (70%) and individuals with reflux symptoms (89%), oesophagitis or Barrett's metaplasia (83%), or positive functional reflux tests (impedance/pH-metry) (87%) were considered ideal candidates for an additional antireflux repair. However, there was no clear preference regarding specific surgical techniques (table 6). Gastro- or fundophrnicopexy was regularly performed by the majority of surgeons (62%) despite not reaching consensus.

Short oesophagus has been defined as a tension-free intra-abdominal oesophageal segment <2–2.5cm after extensive mediastinal (type II) dissection [1]. No consensus was achieved (agreement 38%) amongst respondents on whether short oesophagus represents a relevant clinical finding during type III hiatal hernia repair. However, oesophageal lengthening (Collis procedure) in combination with fundoplication (agreement 62%) or with fundophrnicopexy (agreement 26%) was the most popular surgical strategy amongst those who agreed on the clinical relevance of oesophageal shortening.

## Discussion

This comprehensive survey amongst SGVC members demonstrates that presently, there is very limited standardisation or consensus on elementary steps of type III hiatal hernia treatment in Switzerland, reflecting the results of other surveys on hiatal hernia surgery from the US and Europe [2–5].

In this context, we observed consensus (agreement  $\geq 75\%$ ) for indications for surgery (symptoms, chronic anaemia with Cameron lesions), preoperative work-up (endoscopy and CT scan), and surgical access routes (laparoscopy). Furthermore, several basic technical steps during surgical dissection (resection of the hernia sac, wide mediastinal dissection, preservation of vagus nerves and aberrant left hepatic arteries) and of the reconstruction phase (single-stitch posterior cruroplasty and complementary antireflux procedure) achieved high rates of agreement. However, this survey also revealed considerable inconsistencies in many important technical details such as the use of meshes, gastro- or fundophrnicopexy, type of antireflux procedure and the management of short oesophagus.

The strengths of our survey include a high rate of experienced participants and a well-defined index procedure (type III hiatal hernia). The questionnaires were exclusively targeted at visceral surgeons, the majority of whom were

experienced specialists holding appointments as chiefs or senior consultants. Most participants had an annual case load >10 type III hiatal hernia, and 76% followed standardised work-up and surgical procedures for this entity. We selected type III hiatal hernia as index procedure because this entity is by far the most prevalent paraoesophageal hernia type (about 15% of all hiatal hernia cases) and excluded other hiatal hernia types to allow for a more precise interpretation of results and conclusions. Our focus on type III hiatal hernia is in contrast to the available published literature, which comprises four surveys from the last decade, addressed to either members of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) [2, 3] or the European Association for Endoscopic Surgery (EAES) [4, 5]. Of note, except for the European study, which focussed on “large” type II–IV hiatal hernia [4], the other surveys were designed to gather data on all types of hiatal hernia including gastro-oesophageal reflux disease. Therefore, comparison with our results remains partly elusive. In addition, two retrospective population-based analyses on outcomes of mesh use in paraoesophageal (type II–IV) hiatal hernia repair using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database have been recently reported [6, 7]. The prospective multi-national HERNIAMED data collection included 5462 paraoesophageal hernia repairs and remains another important source of information on the subject [8].

Laparoscopy was the preferred surgical access route amongst Swiss visceral surgeons (100% agreement), which compares favourably with data from the NSQIP and HERNIAMED databases [6, 8], and the SAGES surveys [2, 3]. In accordance with existing literature, this study confirmed that transthoracic access has been largely abandoned by most surgeons. Of note, robot-assisted procedures appear to be gaining popularity with 41% agreement among our participants.

The use of mesh to reinforce hiatal repairs remains a controversial subject. Current scientific evidence is extremely fragmented owing to different mesh types, shapes, fixation techniques and follow-up periods. In addition, the incidence of the much-feared mesh-related complications, such as erosion, stenosis and infection is not precisely known [9]. Although most randomised controlled trials have demonstrated reduced recurrence rates after mesh reinforcement at short- and mid-term follow-up [10–15], long-term data beyond 3 years of follow-up show no clear benefit regarding clinical results or objective recurrence rates [13, 15], or even inferior symptomatic outcomes [15].

**Table 6:**  
Antireflux procedures.

	Always/very often	Sometimes	Rarely/ Never
Floppy 360° (Nissen type) fundoplication	29.8%	14.9%	55.3%
Anterior partial 90–200° (Dor/Thal type) fundoplication <sup>a</sup>	13.1%	10.9%	76.1%
Posterior partial 180–270° (Toupet type) fundoplication	44.7%	31.9%	23.4%
His-angle reconstruction techniques (Hill gastropexy, Lortat-Jacob or similar) <sup>a</sup>	10.9%	8.7%	80.4%
Transthoracic antireflux techniques (i.e., Belsey Mark IV) <sup>a</sup>	0.0%	0.0%	100.0%
Tailored approach: No 360° fundoplication in patients with signs of oesophageal motility disorder	17.0%	12.8%	70.2%
Other antireflux procedures (magnetic sphincter augmentation [LINX], EndoStim, RefluxStop or similar)	2.1%	2.1%	95.8%
Endoscopic interventional (via gastroscopy) antireflux procedures <sup>a</sup>	0.0%	0.0%	100.0%

<sup>a</sup> Question answered by 46 respondents.

However, in a recent meta-analysis of randomised controlled trials, mesh reinforcement was associated with fewer reoperations but similar recurrence rates [16]. Data from the HERNIAMED registry suggests a rather constant utilisation of mesh in paraoesophageal hernia repair in Austria, Germany and Switzerland (33.0% and 38.9% in 2013 and 2019, respectively) [8], whereas in the US, this rate decreased from 45% in 2010 to 36% in 2017 [7]. With this in mind, we were surprised that more than 90% of respondents reported performing mesh reinforcement in all or selected cases. Likewise, 28% of our participants reported routine mesh use in all type III hiatal hernia repairs, which corresponds to a significantly higher rate than in previous surveys performed in Europe [4, 5] and the US [2, 3]. In contrast to earlier research, biological meshes play a minor role in the current surgical armamentarium, probably owing to the disappointing long-term results from two randomised controlled trials [13, 15]. Thus, most of our participants chose synthetic non-absorbable mesh, which is in line with other recent surveys [4, 5]. In this context, the significance of synthetic long-term absorbable materials remains unclear. Recent retrospective cohort studies have shown promising results, but long-term follow-up is currently not available [17, 18].

Antireflux procedures are frequently performed adjuncts to type III hiatal hernia repair with a high acceptance rate among our participants. Our results confirm recent data from the multi-institutional HERNIAMED registry reporting additional fundoplication in paraoesophageal hernia repair in 60–70% [8, 19]. However, routine and selective antireflux procedures are performed by 55% and 36% of our participants, respectively, which contrasts with the 84% (routine) and 9% (selective) funduplications in the EAES survey [4]. We assume that these differences reflect the rather weak scientific evidence for additional antireflux surgery in the literature, which is mainly based on a single randomised controlled trial [20], and a number of case series and small cohort studies [21]. Consistent with other studies [4, 19], Toupet and Nissen fundoplication were the dominant antireflux techniques in our survey.

As observed in other publications, the present survey did not establish any clear pattern regarding gastro- or fundophrenicopexy. The high agreement rate in the survey (62%) suggests that this surgical adjunct may be performed both in combination with antireflux surgery (as part of a Toupet fundoplication) or as a stand-alone procedure. However, evidence supporting fundophrenicopexy in paraoesophageal hiatal hernia is conflicting and limited to just a few retrospective case series [21–24]. Similarly, we found a mixed attitude towards short oesophagus, which was defined as a tension-free intra-abdominal oesophageal segment <2–2.5cm after extensive mediastinal dissection: only 38% of participants acknowledged that oesophageal shortening represents a relevant finding during type III hiatal hernia repair. Of these, 62% agreed that an oesophageal lengthening (Collis) procedure and fundoplication around the neo-oesophagus should be performed in this situation, which is in line with current expert recommendations [25].

There are certain limitations associated with our study. First, similar to other surveys on the subject [2–5], our questionnaire did not go through a formal validation

process before dissemination. Second, despite a response rate in the upper range of similar surveys, only 47 experts completed the full questionnaire, potentially limiting the relevance of our results. However, as stated above, this work had a clear focus on national specialists in the field, which represents a rather confined target group in a small country like Switzerland. Other limitations include the definition of the index procedure. Although classification of hiatal hernia into four types according to Skinner and Belsey [26–27] is accepted by most surgeons, major uncertainties remain, particularly regarding an inconsistent and synonymous use of the terms “type III hiatal hernia”, “mixed hiatal hernia”, “large hiatal hernia”, “paraoesophageal hernia”, “upside-down stomach”, and “(intra)thoracic stomach”. Thus, in the US, the term “paraoesophageal hiatal hernia” generally refers to all large hiatal hernia (types I–IV) with migration of the fundus into the mediastinum, whereas many European surgeons strictly reserve this term for paraoesophageal hernia type II (without any sliding component) independent of its size [28–32]. Therefore, despite our effort to adequately define the index procedure of our survey, we cannot guarantee that all participants share a similar understanding of type III hiatal hernia.

In conclusion, consensus amongst Swiss visceral surgeons is limited to just a few basic components of type III hiatal hernia surgical management. Although the observed therapeutic pragmatism may simply manifest the necessity to adapt to the clinical variability and to the complexity of type III hiatal hernia, it may also reflect a lack of standardisation of care. Therefore, as a next step, our group intends to follow-up with a multinational expert Delphi survey aimed at establishing treatment algorithms and guidelines for paraoesophageal hiatal hernia.

#### Author contributions

SG, PCM: study design, performing the experiments, drafting the manuscript; DV, JRK: performing the experiments, interpretation of data, critical revision of the manuscript; SG, CAG: statistical analysis, interpretation of data, critical revision of the manuscript; CAG: study design, performing the experiments, interpretation of data, drafted the manuscript. All authors gave their final approval.

#### Conflict of interest statement

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. No potential conflict of interest was disclosed.

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# Appendix: Questionnaire

Question		Answer
Please indicate your place of work.		Canton
Please state your hospital's level of care		Private Hospital/General Hospital (Grund- und Regelversorgung)/Teaching Hospital (Schwerpunktkrankenhaus)/Maximum Care Hospital (Krankenhaus der höchsten Versorgungsstufe)/Other institution (please specify):
Please state your current position		Head of department / Chefarzt / Klinikdirektor; Senior consultant / Leitender Oberarzt; Consultant / Oberarzt; Attending surgeon / Facharzt; Other position (please specify):
Please indicate the year of your specialization as surgeon / visceral surgeon		Years
Please indicate the approximate annual number of surgeries for Type III hiatal hernia performed in your department.		Number
Please indicate the approximate annual number of surgeries for Type III hiatal hernia performed by yourself.		Number
Would you agree with the indication for surgery in the following patients with primary Type III hernia and acceptable perioperative risk?	Older patient >70 years, no/minor symptoms	Strongly agree / agree / Neither agree nor disagree / Strongly disagree / agree
	Older patient >70 years, relevant symptoms	
	Younger patient <70 years, no/minor symptoms	
	Younger patient <70 years, relevant symptoms	
	Older patient >70 years, chronic anemia with Cameron lesion, no/minor symptoms	
	Younger patient <70 years, chronic anemia with Cameron lesion, no/minor symptoms	
In your opinion, are the following diagnostic procedures essential prior to elective primary Type III hiatal hernia repair?	Upper-GI endoscopy	Strongly agree / agree / Neither agree nor disagree / Strongly disagree / agree
	Contrast radiography	
	CT scan	
	Esophageal manometry	
	Esophageal pH-metry / Impedance-pH-metry	
	Chest X-ray	
	Other diagnostic modalities (MRI, endosonography, esophageal scintigraphy)	
	Other (please specify):	
Do you have established a standardized surgical strategy or treatment algorithm for elective primary Type III hiatal hernia in your department?		yes / no
What is your preferred surgical approach for elective primary Type III hiatal hernia repair?	Laparoscopy	Strongly agree / agree / Neither agree nor disagree / Strongly disagree / agree
	Robotic-assisted laparoscopy	
	Laparotomy	



	Thoracoscopy	
	Robotic-assisted thoracoscopy	
	Thoracotomy	
	Other (please specify):	
Dissection phase: Please rate your agreement with the following technical steps in elective primary Type III hiatal hernia repair.	Repositioning of hernia sac contents into the abdominal cavity as initial surgical step	Strongly agree / agree / Neither agree nor disagree / Strongly disagree / agree
	Dissection of hernia sac (central approach) as initial surgical step	
	Dissection of hernia sac (left crus approach) as initial surgical step	
	Dissection of hernia sac (right crus approach) as initial surgical step	
	Resection of hernia sac	
	Dissection/transsection of the phreno-esophageal ligament	
	Wide mediastinal dissection to achieve sufficient esophageal length	
	Visualization and dissection of both vagal nerves	
	Mobilization of gastric fundus / division of gastro-splenic ligament including short gastric vessels	
	Resection or dissection of posterior retro-cardial lipoma (if present)	
	Resection or dissection of the pre-cardial fat-pad	
	Intraoperative endoscopy to determine esophageal length (in case of suspected esophageal shortening)	
	Preservation of the crural fascia	
	Preservation of aberrant left hepatic artery	
	Preservation of hepatic branches of vagus nerves	
Preservation of pulmonary branches of vagus nerves		
Other (please specify):		
Reconstruction phase: How frequently do you perform the following technical steps in elective primary Type III hiatal hernia.	Suture repair of hiatus	Always / very often / Sometimes / Rarely / never
	Use of mesh to reinforce hiatal repair	
	Other options (ligamentum teres or left liver) to reinforce hiatal repair	
	Use of relaxing diaphragmatic incisions	
	Gastropexy / fundoplication	
	Antireflux-procedure (fundoplication or other)	
	Esophageal lengthening procedure (Collis or other) in case of short esophagus	
	Other (please specify):	
Please rate your agreement with the following technical steps during suture repair of	Posterior suture repair only	Strongly agree / agree / Neither agree nor disagree / Strongly disagree / agree
	Anterior suture repair only	
	Combined anterior and posterior suture repair	

the hiatus in elective primary Type III hiatal hernia repair.	Use of pledgets to reinforce suture repair	
	Single stitches	
	Running sutures	
	Single form-8-stitches	
	Other (please specify):	
Please state the name and size of sutures used for hiatal closure in your department.		Name/Grösse
Please rate your agreement with the following technical steps during gastropexy in elective primary Type III hernia repair. You may skip this question if you strictly never perform a gastropexy in this situation.	Single stitches	Strongly agree / agree / Neither agree nor disagree / Strongly disagree / agree
	Running sutures	
	Pexy of anterior fundic wall to the diaphragm.	
	Use of pledgets to reinforce suture repair	
	Pexy of posterior fundic wall to the diaphragm or diaphragmatic crus	
	Other (please specify):	
Please state the name and size of sutures used for gastropexy in your department. Please state "no sutures" if you strictly never perform a gastropexy in this situation.		Name/Grösse
Please rate your agreement with the following statements regarding indications for mesh utilization in patients undergoing elective primary Type III hernia repair. Mesh augmentation should be performed...	...in older (>70years) or frail patients	Strongly agree / agree / Neither agree nor disagree / Strongly disagree / agree
	...in younger (<70 years) or physically fit patients	
	...in patients with weak / fragile diaphragmatic musculature / structure	
	...in patients with a large hiatal defect / increased hiatal surface area	
	...in patients with intraoperative opening of the pleural space	
	...in patients with a history of other abdominal hernia	
	...in obese patients	
	Other (please specify):	
How frequently do you use the following mesh types in elective primary Type III hernia repair? You may skip this question if you never use meshes in this situation.	Synthetic absorbable mesh	Always / very often / Sometimes / Rarely / never
	Synthetic non- or partially absorbable mesh	
	Biological absorbable mesh	
	Biological non- or partially absorbable mesh	
	Circular shaped mesh	
	U- or horseshoe shaped mesh	
	Rectangular shaped mesh	
	Individually shaped mesh	
	Other (please specify):	
Please rate your agreement with the following technical steps during mesh-reinforcement in elective primary Type III hernia repair. You may skip this	Mesh placement exclusively on posterior hiatoplasty	Strongly agree / agree / Neither agree nor disagree / Strongly disagree / agree
	Mesh placement on posterior hiatoplasty and crura	
	Mesh placement on anterior hiatoplasty and crura	
	Circular mesh placement around the esophagus	

question if you strictly do not use meshes in this situation.	Individual mesh placement (adapted to specific patho-anatomy)	
	Mesh placement avoiding contact to esophagus	
	Mesh fixation with sutures	
	Mesh fixation with (non-)absorbable tacks	
	Mesh fixation with fibrin glue	
	No mesh fixation	
	"Bridging" / "tension-free" mesh without prior suture hiatoplasty	
	"Incorporated" mesh fixation (sewing-in of mesh during hiatal closure)	
Other (please specify):		
Did you encounter the following complications after mesh-inforced Type III hiatal hernia repair?	Mesh erosion to esophagus	Yes, in own patients / Yes, in referred patients / Never
	Mesh erosion to stomach	
	Mesh erosion to esophago-gastric junction	
	Mesh erosion to other organs (aorta, lung)	
	Stenosis distal esophagus / esophago-gastric junction	
	Mesh migration	
	Mesh infection	
	Pericardial hemorrhage / effusion	
	Pleural hemorrhage / effusion	
	Perioperative hemorrhage caused by tacks during mesh fixation (aorta, V.cava, phrenic vein...)	
	Perioperative hemorrhage caused by sutures during mesh fixation (aorta, V.cava, phrenic vein...)	
	Pneumothorax	
	Chronic pain	
Seroma formation		
Other (please specify):		
Please rate your agreement with the following statements regarding indications for antireflux procedures in elective primary Type III hernia repair. An antireflux procedure should be performed...	...in older (>70 years) or frail patients	Strongly agree / agree / Neither agree nor disagree / Strongly disagree / agree
	...in younger (<70 years) or physically fit patients	
	...in patients with increased risk of hernia recurrence	
	...in patients with reflux symptoms	
	...in patients with esophagitis or Barrett metaplasia	
	...in patients with positive functional reflux tests (impedance / pH-metry)	
	Other (please specify):	
How frequently do you perform the following antireflux procedures in	Floppy 360° (Nissen type) fundoplication	Always / very often / Sometimes / Rarely / never
	Anterior partial 90-200° (Dor / Thal type) fundoplication	

patients with elective primary Type III hernia repair?	Posterior partial 180-270° (Toupet type) fundoplication	
	His-angle reconstruction techniques (Hill gastropexy, Lortat-Jacob or similar)	
	Transthoracic antireflux techniques (i.e. Belsey Mark IV)	
	Tailored approach: No 360° fundoplication in patients with signs of esophageal motility disorder	
	Other antireflux procedures (magnetic sphincter augmentation (LINX), EndoStim, RefluxStop or similar)	
	Endoscopic interventional (via gastroscopy) antireflux procedures	
Please indicate the name and size of the suture material and the number of sutures typically used for classic antireflux procedures (fundoplication) in your department.		Name/Grösse
Short Esophagus has been defined as a tension-free intraabdominal esophageal segment <2-2.5cm after extensive mediastinal (Type II) dissection. Please rate your agreement whether Short Esophagus (brachyesophagus) is a relevant finding in Type III hiatal hernia repair.		Strongly agree / agree / Neither agree nor disagree / Strongly disagree / agree
Please rate your agreement with the following surgical procedures for Short Esophagus in elective primary Type III hiatal hernia. You may skip this question if you think that Short Esophagus does not exist in this situation.	Esophageal lengthening (Collis) procedure and fundoplication around neoesophagus	Strongly agree / agree / Neither agree nor disagree / Strongly disagree / agree
	Esophageal lengthening (Collis) procedure +/- gastropexy without fundoplication	
	No lengthening (Collis) procedure and intrathoracic fundoplication around esophagus	
	No lengthening (Collis) procedure and fundoplication around upper stomach (Maillet's procedure)	
	No lengthening (Collis) procedure and gastropexy	
	Partial esophagectomy and reconstruction with gastric tube, jejunum or colon	
	Esophageal lengthening with circular esophageal myotomy and vagotomy	
	Transposition of diaphragmatic crura	
	Other (please specify):	