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ORIGINAL ARTICLE

MILOS and EMILOS repair of primary umbilical and epigastric hernias

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Abstract

Background The currently mainly used techniques of primary ventral hernia repair have specific disadvantages and risks.

Methods To minimize complications of the existing open and laparoscopic techniques of ventral hernia repair, the endoscopic-assisted or endoscopic Mini- or Less-Open Sublay (E/MILOS) concept was developed. This paper reports on our experience with the E/MILOS concept for the management of primary umbilical and epigastric hernias. All E/MILOS operations were prospectively documented in the German hernia registry "Herniamed". For 1 year follow-up, all patients and their general practitioners received a questionnaire.

Results Five hundred and twenty primary umbilical and 554 epigastric E/MILOS operations with complete 1-year follow-up were included. Concomitant RD were treated in 18.3% and 14.1% of the umbilical and epigastric hernia cohort, respectively. Total perioperative complication rates and reoperation rates were 1.2% and 0.9% for both umbilical and epigastric hernias, respectively. Infection rates were 0.0% and 0.2% after umbilical and epigastric hernia operations, respectively. Recurrence rates 1 year after E/MILOS umbilical and epigastric hernia were 0.0% and 0.5%, respectively. One year rates of chronic pain at rest, chronic pain during physical activities, and chronic pain requiring treatment after umbilical and epigastric hernia repair were 1.5% and 2.7%, 2.1% and 4.2%, and 0.6% and 1.8%; respectively.

Conclusion The E/MILOS concept allows the endoscopically assisted (MILOS) or endoscopic (EMILOS) transhernial minimal invasive sublay mesh repair of primary umbilical and epigastric hernias with or without rectus diastasis with low complication, recurrence, and chronic pain rates.

Keywords Umbilical hernia · Epigastric hernia · Endoscopic retromuscular hernia repair · Endoscopic ventral hernia repair · Minimal invasive sublay repair · Primary abdominal wall hernia

Introduction

Primary ventral hernias are the second most common hernias worldwide. In Germany, more than 100,000 primary ventral hernias are operated on every year. According to the current evidence in the literature, mesh-related operation techniques are associated with lower recurrence rates than suture repair [1–13]. A recent publication from the Danish Database concludes that even small hernia defects require the use of mesh [10]. Furthermore, a concomitant rectus diastasis was recognized as a significant risk factor for recurrence [14]. Laparoscopic intraperitoneal onlay mesh (IPOM) repair and open sublay mesh repair are currently the most widely used techniques for the treatment of primary and recurrent abdominal wall hernias worldwide [1–9, 11]. While the open techniques are burdened with higher wound complication rates [3–9, 11], the lap. IPOM repair carries an increased risk of intraoperative bowel injury, adhesions, and bowel obstruction [4, 6, 11]. Despite the development of coated meshes designed to lower risk of adhesion formation, the potential risks associated with an intraperitoneal foreign body have not yet been eliminated [4–8, 11] and traumatic mesh fixation increases the risk of adhesions, visceral damage, nerve injury, acute, and chronic pain [4–8, 11, 15]. According to the current evidence, the retromuscular/preperitoneal (= sublay) space is the best option for

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Fig. 1 E/MILOS instruments: standard laparoscopic instruments, set of rectangular retractors, and Endotorch TM, Wolf, Knittlingen in Germany

mesh placement in abdominal wall hernia repair [7, 8, 11]. Recent years are characterized by the advent of new minimal invasive laparoendoscopic techniques including robotics [15–37]. To minimize complications and pain in abdominal wall hernia repair, we have developed the MILOS and EMILOS (=E/MILOS) technique which permits placement of large sublay meshes via a small transhernial incision, thus avoiding major trauma to the abdominal wall [15, 21, 25]. The present study reports on our results of primary umbilical and epigastric hernia repair using the E/MILOS technique.

Methods

Beginning in 2010, all E/MILOS operations were prospectively registered in the German Hernia Registry "Herniamed". "The Herniamed quality assurance study is a multicenter Internet-based hernia registry with 712 voluntary participating institutions in Germany, Austria, and Switzerland which incorporate prospective data of patients who have undergone routine hernia surgery" [38]. All patients gave informed consent agreeing to participate [38] and were requested to report any complications to the treatment providing institution. One year after the operation, all patients and general practitioners received a questionnaire. Patients that did not respond twice received a telephone call. Patients who reported complications, a recurrence or chronic pain, were invited for a physical examination. Chronic pain was assessed by numerical rating scale (NRS, 0–10). The EHS classification of primary and incisional hernias was used [39]. Only elective operations were included in the analysis. Primary outcome parameters were recurrence after 1 year and chronic pain after 1 year at rest, during physical activity,

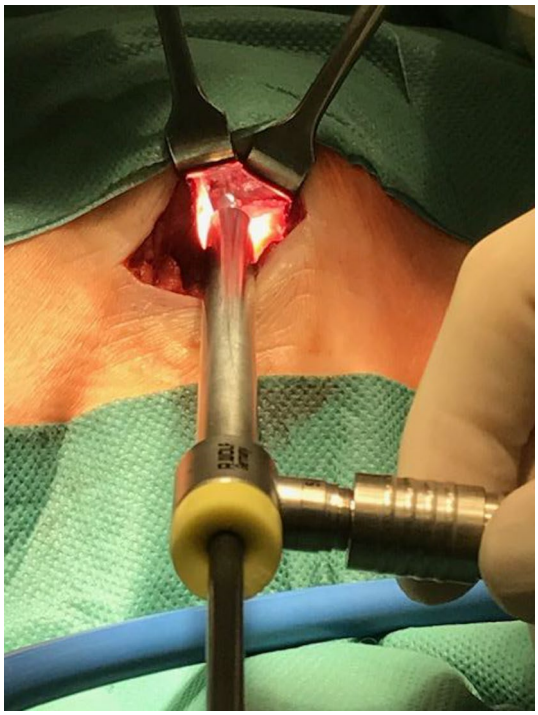

Fig. 2 Mini open transhernial dissection in sublay plane with laparoscopic forceps armed with Endotorch TM light source

and chronic pain requiring treatment. Secondary target variables were: intraoperative visceral injury, postoperative bleed, complication-related reoperation, infection, prolonged wound healing, and general complications.

Operation technique

Mini-open and less-open access were defined as incisions of at most 5 cm and 12 cm, respectively, with a maximum length of less than one-fourth of the longest mesh diameter. Operations with incisions longer than 12 cm were excluded from the trial. Only primary ventral hernias of the midline were included. The technical details of the E/MILOS operation have been published previously [15, 21, 25]. The instruments are shown in Fig. 1. In summary: Step 1: small horizontal incision directly above the center of the hernia defect, followed by complete exposure of the hernia sac. Step 2: if adhesions and or other intraabdominal pathologies are suspected, a small incision of the hernia sac for transhernial laparoscopy is advisable. Excessive parts of the hernia sac which pose a risk of bowel obstruction are excised. Step 3: the border of the fascial hernia ring is circumferentially exposed and elevated with sharp clamps. Step 4: the peritoneum is detached from the abdominal wall at the edge of the fascia defect with a radius of at least 2 cm. Step 5: the posterior rectus sheath is incised on both sides about 1 cm lateral to the medial border of the rectus

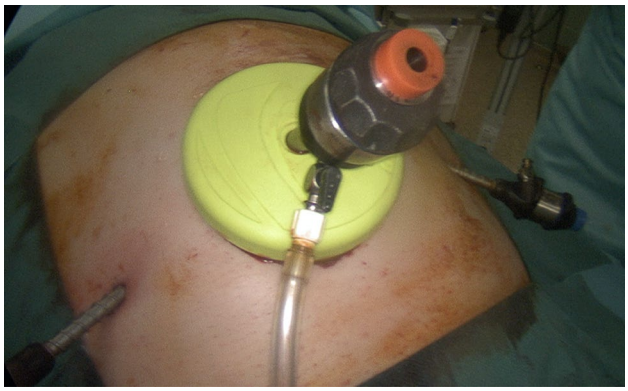

Fig. 3 EMILOS operation of umbilical hernia and rectus diastasis: transhernial flexible plastic sheet monoport (Alexis TM, Applied Medical) for 10-mm optic and two 5-mm working ports

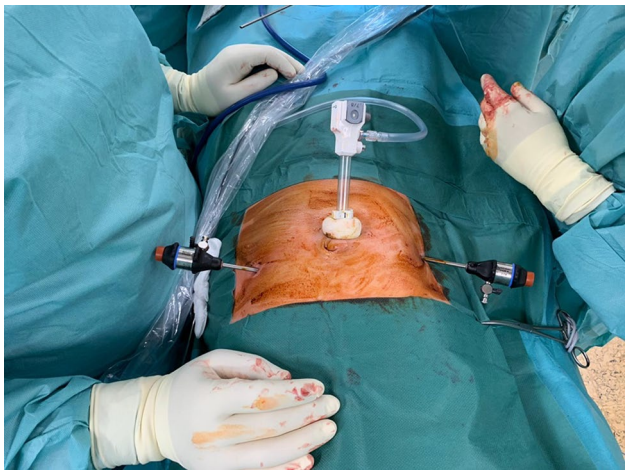

Fig. 4 EMILOS operation of umbilical hernia and rectus diastasis: transhernial ten optic ports with ballon tip (Blunt tip TM, Medtronic) and two 3-mm working ports

muscle. Step 6: the peritoneum is separated from the linea alba. The posterior rectus sheath is extensively mobilized from the rectus muscle with laparoscopic instruments. The abdominal wall is elevated around the hernia defect by the assistant using pairs of narrow retractors of different size. Dissection is performed circumferentially around the hernia defect either under direct visualization or endoscopic view using laparoscopic instruments armed with a 10-mm light tube which was specifically designed by our working group and Wolf Company (Endotorch TM, Wolf, Knittlingen, Germany, Figs. 1, 2). The Endotorch TM gives maximum light at the tip of the light holding laparoscopic instrument, thus automatically pointing to the center of the surgeon's dissection field. Step 7: the posterior layer of the rectus sheath is longitudinally incised in all quadrants, about 1 cm lateral to the medial border of the rectus muscle corresponding to the size of the hernia defect and planned alloplastic mesh insertion. After creation of an extraperitoneal space of at least 8 cm in diameter, closure of the peritoneum, gas tight closure of the transhernial incision, and CO2 insufflation, the operation can be continued as an endoscopic ventral hernia total extraperitoneal repair (EMILOS = VTEP repair). Reusable standard ports or a transhernial single-port technique may be used. The more expensive single-port technique is the original and first published EMILOS technique [21]. When using standard ports, the transhernial incision can be temporarily closed with a running suture or flexible monoports (i.e., Alexis TM, Applied Medical, Fig. 3). Incisions up to 3 cm can be locked gas tight with balloon optic ports (i.e., Blunt tip optic port TM, Medtronic, Fig. 4). The standard port positions of a primary midline ventral hernia EMILOS operation are shown in Figs. 3, 4. Step 9: a large pore standard alloplastic mesh, preferably polypropylene or polyvinylidenfluoride (PVDF) is double rolled and inserted transhernially with two long-curved clamps without skin contact and then unfolded with light-armed laparoscopic instruments under direct or endoscopic vision. In an EMILOS operation, the mesh is positioned endoscopically. The mesh posteriorly overlaps the hernia defect by at least 5 cm. In most cases, due to large overlap, there is no need for mesh fixation. In the case of subxiphoidal or suprapubic hernia defects, the mesh is secured with absorbable sutures to the paraxiphoidal fascia or Cooper´s ligaments. One suction Redon drain (8 Charr.) is inserted into the extraperitoneal space. Step 10: additional hernia defects are closed transhernially under direct vision or endoscopically. The main hernia defect is closed with minimal tension. Anatomical reconstruction of the abdominal wall is always the primary goal. Step 11: management of subcutaneous tissue and skin: large hernia sacs are removed. If necessary, contracted scar tissue is mobilized and resected, and the umbilicus is reconstructed. The skin is closed with a running subcutaneous suture.

Treatment algorithm

The algorithm of primary umbilical and epigastric hernia management with or without concomitant Rectus diastasis is shown in Table 1: small umbilical or epigastric hernias with a single hernia defect of at most 1.5 cm in diameter without risk factors for hernias (Table 2) are treated with a long-term absorbable suture repair. In case of all other single primary umbilical or epigastric hernias, an MILOS or EMILOS operation is performed via a 2–4-cm horizontal incision above the center of the hernia defect with a minimum circumferential sublay mesh overlap of at least 5 cm. In case of multiple primary ventral midline hernias, all hernia defects are augmented with one piece of mesh with a minimum overlap of 5 cm. If a concomitant asymptomatic Rectus

Table 1 Algorithm of management of primary umbilical and epigastric ventral hernias with or without concomitant Rectus Diastasis (Reference Hernia Center Gross-Sand Hospital)

1. Umbilical or epigastric hernia without risk factors for hernias (Table 2) and without Rectus Diastasis:	
Hernia defect </= 1.5 cm	Suture repair with long-term absorbable suture material
Hernia defect > 1.5 cm	E/MILOS repair with at least 5-cm overlap and defect closure with long-term absorbable suture material
2. Any umbilical or epigastric hernia with risk factors for hernias (Table 2) without Rectus Diastasis:	
E/MILOS repair with at least 5-cm overlap and defect closure with long-term absorbable suture material	
3. Any umbilical or epigastric hernia and asymptomatic Rectus Diastasis (DHG classification W2 and W3 without instability):	
E/MILOS repair with hernia defect mesh overlap of at least 5 cm, hernia defect closure, and mesh augmentation of Rectus Diastasis	
4. Umbilical or epigastric hernia and symptomatic (pain or functional deficit) Rectus Diastasis:	
E/MILOS repair with hernia defect mesh overlap of at least 5 cm, hernia defect closure, mesh augmentation of Rectus Diastasis, and plication of linea alba (obese patients: posterior inverting suture of linea alba, slim patients: E/MILOS repair and additional (=epifascial) dissection with anterior inverting suture.	

Table 2 Risk factors for Hernias

Multiple hernias/history of previous hernias
Steroid/immunosuppression therapy
Connective tissue disorder
Obesity

Diastasis (RD) is present mesh size is extended to linea alba (LA) mesh augmentation with a minimum horizontal overlap of 5 cm. If the LA is fragile, mesh size is extended to 4 cm behind the xiphoid. In patients with a concomitant symptomatic RD, i.e., functional deficit of the abdominal wall and/or pain, an additional plication of the linea alba is indicated. In obese patients, an endoscopic posterior inverting suture of the LA is performed. In slim and normal weight patients, especially postpartum women, an EMILOS repair with additional subcutaneous (=epifascial) skin mobilization and anterior inverting suture of the LA is carried out. The onlay dissection of the skin (EMILOO) is performed via the same incisions and ports that are used for the transhernial retromuscular EMILOS dissection (Figs. 3, 4). In all E/MILOS operations, the posterior rectus sheath is only closed if this is possible with low tension.

Statistics

All analyses were performed with the software SAS 9.4 (SAS Institute Inc., Cary, NY, USA) and intentionally calculated to a full significance level of 5%, i.e., they were not corrected in respect of multiple tests, and each p value ≤ 0.05 represents a significant result.

Table 3 **a** Herniamed registry—operation techniques for umbilical hernias and **b** operation techniques for epigastric hernias

(a) Umbilical hernia—Operation technique		
Laparoscopic—IPOM	5985	13.70
Open—Onlay	1519	3.48
Open—IPOM	6353	14.54
Other	5650	12.93
Component separation	272	0.62
Open—direct suture	23,919	54.74
Total	43,698	100.00
(b) Epigastric hernia—operation technique		
Laparoscopic—IPOM	2430	24.92
Open—onlay	283	2.90
Open—sublay	1960	20.10
Open—IPOM	1030	10.56
Other	802	8.22
Component separation	190	1.95
Open—direct suture	3057	31.35
Total	9752	100.00

Results

Of the 53.450 primary ventral hernia operations currently documented in the German Hernia Database "Herniamed", 43.698 (82%) are umbilical hernias and 9.752 (18%) epigastric hernias. According to "Herniamed", more than half of the umbilical and one-third of epigastric hernias are treated with suture repair. The most commonly used mesh repair techniques for umbilical and epigastric hernias are open IPOM (14.5%) followed by laparoscopic IPOM (13.7%) and laparoscopic IPOM (24.9%), respectively. The frequency of the different operation techniques, postoperative

Table 4 Postoperative complications after primary umbilical and epigastric hernia operations—total Herniamed registry data including suture repairs

		Type of hernia			
		Umbilical		Epigastric	
		n	%	*n*	%
Postoperative complications—total	Yes	1266	2.9	318	3.3
	No	42,432	97.1	9434	96.7
Complication-related reoperations	Yes	365	0.8	87	0.9
	No	43,333	99.2	9665	99.1
Bleeding	Yes	347	0.8	80	0.8
	No	43,351	99.2	9672	99.2
Seroma	Yes	421	1.0	159	1.6
	No	43,277	99.0	9593	98.4
Prolonged ileus or obstruction	Yes	31	< 0.1	16	0.2
	No	43,667	> 99.9	9736	99.8
Bowel injury/anastomotic insufficiency	Yes	9	< 0.1	7	< 0.1
	No	43,689	> 99.9	9745	> 99.9
Wound healing disorder	Yes	363	0.8	53	0.5
	No	43,335	99.2	9699	99.5
Infection	Yes	291	0.7	53	0.5
	No	43,407	99.3	9699	99.5

Table 5 Herniamed registry data of complications at 1-year follow-up after primary umbilical and epigastric hernia repair—total Herniamed registry data including suture repairs

		Type of hernia			
		Umbilical		Epigastric	
		n	%	*n*	%
Recurrence on 1-year follow-up	Yes	847	1.9	354	3.6
	No	42,851	98.1	9398	96.4
Pain on exertion on 1-year follow-up	Yes	2932	6.7	1050	10.8
	No	40,766	93.3	8702	89.2
Pain at rest on 1-year follow-up	Yes	1395	3.2	498	5.1
	No	42,303	96.8	9254	94.9
Pain requiring treatment on 1-year follow-up	Yes	851	1.9	353	3.6
	No	42,847	98.1	9399	96.4
Trocar hernia on 1-year follow-up	Yes	58	0.1	11	0.1
	No	43,640	99.9	9741	99.9
Secondary haemorrhage on 1-year follow-up	Yes	428	1.0	97	1.0
	No	43,270	99.0	9655	99.0
Seroma on 1-year follow-up	Yes	808	1.8	278	2.9
	No	42,890	98.2	9474	97.1
Infection on 1-year follow-up	Yes	1087	2.5	172	1.8
	No	42,611	97.5	9580	98.2

complications and complications, recurrence rates, and chronic pain at 1 year follow-up in the Herniamed database are shown in Tables 3a, b, 4, 5, respectively.

From February 15, 2010 to May 31, 2019, there were 582 primary umbilical and 682 epigastric E/MILOS operations performed and included in the trial. Combined hernias were registered in the epigastric hernia cohort (Table 6). Concomitant RD were treated in 18.3% and 14.1% of the umbilical and epigastric hernia cohort, respectively. Complete 1-year follow-up data were obtained from 520 (97.3%) and 554 (96.8%) patients in the umbilical and epigastric hernia cohort, respectively (Table 7). In the first 2 years (2010–2012), all MILOS operations were performed by two, after 2012 by all four, specialized hernia surgeons

Table 6 Perioperative complications after E/MILOS operations of umbilical and epigastric hernias (Herniamed data)

		Type of hernia			
		Umbilical		Epigastric	
		n	%	*n*	%
Postoperative complications—total	Yes	7	1.2	8	1.2
	No	575	99.1	648	99.1
Complication-related reoperations	Yes	5	0.9	6	0.9
	No	577	99.1	650	99.1
Bleeding with reoperation	Yes	2	0.4	2	0.4
	No	580	99.6	654	99.6
Seroma with operative treatment	Yes	1	0.2	0	0.0
	No	581	99.8	656	100.0
Prolonged ileus or obstruction with reoperation	Yes	1	0.2	1	0.2
	No	581	99.8	655	99.8
Bowel injury	Yes	1	0.2	1	0.2
	No	581	99.8	655	99.8
Wound healing disorder/no reoperation	Yes	2	0.4	2	0.4
	No	580	99.6	654	99.6
Infection	Yes	0	0.0	2	0.4
	No	582	100.0	654	99.6

Table 7 Complications at 1-year follow-up after umbilical and epigastric E/MILOS hernia repair (Herniamed data)

		Type of hernia			
		Umbilical		Epigastric	
		n	%	*n*	%
Recurrence on 1-year follow-up	Yes	0	0.0	3	0.5
	No	520	100.0	551	99.3
Pain on exertion on 1-year follow-up	Yes	11	2.1	23	4.2
	No	509	97.9	531	95.2
Pain at rest on 1-year follow-up	Yes	8	1.5	15	2.7
	No	512	98.5	539	97.3
Pain requiring treatment on 1-year follow-up	Yes	3	0.6	10	1.8
	No	517	520	544	96.4
Trocar hernia on 1-year follow-up	Yes	0	0.0	0	0.0
	No	520	100.0	554	100.0
Secondary haemorrhage on 1-year follow-up	Yes	1	0.2	0	0.0
	No	519	99.8	554	100.0
Seroma on 1-year follow-up	Yes	1	0.2	7	1.3
	No	519	99.8	547	98.7
Infection on 1-year follow-up	Yes	2	0.4	2	0.4
	No	518	99.6	552	99.6

of our department. From 2015, E/MILOS operations are teaching operations for residents. There were 68.2% and 39.8% medium size and 21.5% and 54.1% large hernias in the umbilical and epigastric cohort, respectively (Table 8a, b). Average incision length above the main hernia defect was 3.7 cm and 3.9 cm in umbilical and epigastric hernia operations, respectively. Mean mesh sizes in umbilical and epigastric E/MILOS repairs were 2.1 and 1.8 times larger than mean mesh size in total Herniamed registry, respectively (Table 9a–c). Complete defect closure was achieved in all E/MILOS operations. Average operating times of umbilical and epigastric E/MILOS operations were 66 and 75 min, respectively. There was one small bowel lesion without spillage in one umbilical and one epigastric hernia MILOS repair

which were intraoperatively diagnosed and treated with a suture repair. The postoperative courses were uneventful. No intraoperative complications occurred in epigastric E/MILOS operations. Total postoperative complications, reoperations, bleeding, seroma, bowel obstruction, visceral injury, prolonged wound healing, and infection after umbilical and epigastric E/MILOS operations are given in Table 6. Complications, recurrence, and chronic pain rates at 1 year follow-up are reported in Table 7. In all E/MILOS operations, light-armed laparoscopic instruments were used under direct vision. Mini-open dissection under additional endoscopic visualization was performed in 302 (51.9%) umbilical and 352 (53.7%) epigastric hernia operations. In 52.2% of the E/MILOS operations, transhernial laparoscopy was performed. The EMILOS technique was used in 147 (25.3%) umbilical hernia and 218 (33.2%) epigastric hernia operations. Single ports and standard ports (Figs. 3, 4) were used in 37 (6.4%) and 110 (18.9) umbilical and 45 (6.9%) and 173 (26.4%) epigastric EMILOS operations, respectively. Conversion to gas endoscopy was indicated when the mini-open approach gave insufficient exposure of the operative field. There was no difference in complication rates between MILOS and EMILOS ($p = 1.0$) and EMILOS operations with single port or standard ports ($p = 1.0$). Umbilical and epigastric hernia patient cohorts were comparable with respect to age, sex, BMI, and comorbidities.

Table 8 **a** Defect diameter (EHS classification) in umbilical E/MILOS hernia repair ($N = 582$). **b** Defect diameter (EHS classification) in epigastric E/MILOS hernia repair ($N = 656$)

(a) Small (< 2 cm)	Medium (2–4 cm)	Large (> 4 cm)
60 (10.3%)	397 (68.2%)	125 (21.5%)
(b) Small (< 2 cm)	Medium (2–4 cm)	Large (> 4 cm)
40 (6.1%)	261 (39.8%)	355 (54.1%)

Discussion

The E/MILOS concept has been developed by Reinpold et al. to overcome the obvious disadvantages of the currently most widely used operations [15, 21, 25]. In recent years, the new minimal invasive techniques of ventral hernia extraperitoneal mesh repair are the hot topic of abdominal wall repair [15–37]. A recent matched pair analysis with propensity score matching of the German hernia database "Herniamed" comparing 615 E/MILOS incisional hernia operations with the same amount of open sublay and laparoscopic IPOM operations of other institutions reported significantly less perioperative complications, reoperations, recurrences, and chronic pain at 1-year follow-up [15]. The present prospective non-randomized "Herniamed" register trial reports on the results of all elective primary umbilical and epigastric hernias operated on with the E/MILOS technique since the beginning of the MILOS project in 2010. The favorable results of E/MILOS incisional hernia operations are confirmed in primary ventral hernia repair. Intraoperative complications including bowel injuries, postoperative complications including infections, reoperations, recurrences, and chronic pain rates at 1-year follow-up after umbilical and epigastric E/MILOS hernia repair are low. However, despite the fact that the complication, chronic pain, and recurrence rates appear lower compared to the total Herniamed data, a direct statistical comparison is not possible. For this, a propensity score matching analysis is necessary and planned for a future publication. Compared to the mean operation times of all umbilical and epigastric hernias in the Herniamed database, E/MILOS operations lasted about 20 min longer.

Table 9 **a** Mean mesh size in umbilical and epigastric hernia repair: total Herniamed registry and E/MILOS operations. **b** Mesh size in E/MILOS umbilical hernia repair (cm^2; $N = 582$). **c** Mesh size in E/MILOS epigastric hernia repair (cm^2; $N = 656$)

(a)							
			Umbilical hernia			Epigastric hernia	
			N/mean mesh size (cm^2) ± STD			*N*/mean mesh size (cm^2) ± STD	
Total Herniamed registry			18,943/111.7 ± 132.7			6464/180.8 ± 146.6	
E/MILOS operations			582/242.7 ± 124.8			656/320.1 ± 143.5	
(b)							
Mesh size (cm^2)	0–5	5–10	10–20	20–50	50–100	100–200	> 200
$N = 582$	0	1	2	15	25	230	309
(c)							
Mesh size (cm^2)	0–5	5–10	10–20	20–50	50–100	100–200	> 200
$N = 656$	0	0	1	2	6	155	492

It has to be considered that in the Herniamed data base, 55% and 31% of the umbilical and epigastric hernia operations, respectively, are suture repairs with shorter operation times. Moreover, in 18.1% and 14.3% of umbilical and epigastric E/MILOS operations, a time-consuming additional RD repair was performed.

E/MILOS repair of primary ventral hernias and concomitant Rectus Diastasis

The evidence for the management of RD is very low. Recently, Reinpold et al. have published a suggestion of a DR classification [40]. There is only cosmetic indication for an operative treatment of asymptomatic RD without concomitant hernia. According to Köhler et al., suture repair of an umbilical hernia with concomitant RD is associated with a high recurrence rate [14]. Primary midline hernias with concomitant RD are a very good indication for an EMILOS repair. In the vast majority of obese 40 + year old men with an umbilical and/or epigastric hernia and concomitant asymptomatic RD, prophylactic mesh augmentation of the weak linea alba without plication is probably a sufficient treatment. After plication of an asymptomatic RD, we had a few not fully satisfied patients who changed the painless bulge against minor discomfort. The sublay mesh should have a width of at least 15 cm. Hernia defects are closed at all circumstances with long-term absorbable suture material. Women with symptomatic postpartum RD and concomitant umbilical or epigastric hernia require an EMILOS repair with additional endoscopic plication of the LA. In slim or normal weight patients, an anterior inverting plication with long-term absorbable or nonabsorbable suture material should be performed after additional endoscopic mini open (EMILOO) skin mobilization. The functional and cosmetic results (Fig. 5) of EMILOS repair of ventral hernias and concomitant RD are favorable. In obese patients, a posterior inverting suture of the LA is recommended, since obese patients have a lower risk of a visible rim after posterior LA plication. Obese patients carry a higher risk of seroma formation after onlay skin dissection. Detailed results of E/MILOS management of concomitant RD will be published separately.

Fig. 5 Young women after EMILOS umbilical hernia and rectus diastasis repair with 10-mm blunt tip port and two 3-mm working ports

MILOS versus EMILOS dissection

The MILOS concept comprises mini-open transhernial dissection under direct or endoscopic vision and after creation of an adequate extraperitoneal space conversion to gas endoscopy (standard or single-port ventral hernia TEP). The introduction of the Endotorch TM facilitates mini-open dissection. Via a 4 cm incision, mini-open circumferential dissection with Endotorch TM armed laparoscopic instruments (Fig. 2) can be performed with a radius of at least 15 cm. Dissection at far distance of the incision is exhausting for the assistant. After the introduction of flexible monoports (i.e., Alexis TM, Applied Medical, Fig. 3), conversion to gas endoscopy (EMILOS) is fast and inexpensive. Even in operations with smaller mesh sizes up to 15 × 15 cm, the EMILOS approach allows easier mesh implantation. We now use the EMILOS technique in about two-thirds of all E/MILOS operations.

Advantages of the E/MILOS operation

Compared to the traditional open techniques, the access trauma is considerably reduced. Except for the posterior rectus sheath, intact structures of the abdominal wall are not compromised. After atraumatic sublay mesh placement with large overlap the hernia defect is closed anatomically, restoring the abdominal wall. The E/MILOS operation is also suitable for obese patients. In contrast to the laparoscopic IPOM technique where expensive meshes with an adhesion barrier have to be used, standard large pore meshes can be inserted in the preperitoneal/retromuscular plane without traumatic fixation. This reduces the risk of bowel adhesions, visceral lesions, nerve damage, and acute and chronic pain. Meshes with a circumferential overlap of at least 5 cm reduce the risk of recurrence. Except for laparoscopy and potential laparoscopic adhesiolysis, the abdominal cavity is not compromised. Unlike in laparoscopic IPOM repair, only adhesions with a risk of bowel obstruction require adhesiolysis. The hernia sac is always completely mobilized. In this series in all cases, low tension closure of the hernia defect with anatomical reconstruction of the abdominal wall was feasible. If necessary, E/MILOS-TAR can be performed. In comparison with a laparoscopic IPOM operation, every E/MILOS repair saves about 1200,– € in material costs. Compared to the eTEP approach [31], the small transhernial incision allows fast dissection of the hernia sac, fast defect closure, skin mobilization, and limited scar resection for better cosmetic results.

Conclusion

The vast majority of primary and incisional hernias can be successfully treated with the E/MILOS repair. It allows (a) exposure of the entire extraperitoneal rectus compartment from the retroxiphoid to the retropubic region, (b) closure of concomitant diastasis recti, (c) dissection of the complete lateral compartment, and (d) additional endoscopic m. transversus abdominis release (TAR). Complication rates are low. The technique is reproducible, cost effective, and easy to standardize, and combines the advantages of open sublay and laparoscopic IPOM repair. For the better evaluation of the E/MILOS repair and the other new techniques of minimal invasive extraperitoneal mesh repair, including robotics, high-quality registry data, and trials, are of utmost importance.

Compliance with ethical standards

Conflict of interest There was no funding of the trial. The authors have nothing to disclose.

Ethical approval The Herniamed database with anonymous prospective data collection has ethical approval.

Human and animal rights Human and animal rights are respected.

Informed consent All patients have given informed consent for inclusion in this trial.

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