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Minimally invasive sublay mesh repair of incisional and primary abdominal wall hernias using the MILOS technique

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Summary
Introduction Primary ventral and incisional hernia repair is a routine operation in general surgery. The most widely used techniques, however, have some disadvantages and risks. In order to minimize complications and postoperative pain, we developed the endoscopically assisted mini and less open sublay (MILOS) operation.
Methods The surgical steps of this novel technique are described here. The operation is performed via a small incision transhernially with light-armed laparoscopic instruments either under direct visualization or endoscopic view. After creating an extraperitoneal space of at least 8 cm and CO_2 insufflation, total extraperitoneal preperitoneal mesh repair (TEP) of ventral and incisional hernias can be performed.
Results The results and complication rates of 715 MILOS operations for incisional hernias are presented. The data of all MILOS operations were prospectively documented in the German hernia database "Herniamed."
Conclusion The MILOS technique facilitates minimally invasive transhernial repair of primary ventral and incisional hernias using large retromuscular/preperitoneal meshes; the technique is associated with a very low morbidity rate and with less chronic pain.

Keywords Incisional hernia · Ventral hernia · Minimally invasive sublay repair · Endoscopic ventral hernia repair · Sublay technique · Total extraperitoneal preperitoneal repair · Endoscopic retromuscular hernia repair

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Incisional hernia is the most common complication after abdominal operations, occurring at a rate of 10–30% worldwide [1, 2]. Abdominal wall hernias never heal spontaneously. The risk of incarceration is 1–2% per year. The main cause seems to be genetically determined insufficient cross-links between the collagen molecules. Since the advent of synthetic meshes [3], recurrence rates decreased from 25–60% to below 15% [4–7].

Open sublay mesh implantation based on the techniques of Jean Rives and René Stoppa and laparoscopic intraperitoneal onlay mesh plasty (lapIPOM) are the internationally leading procedures for the treatment of incisional hernias (Fig. 1a, b; [8–14]).

In open sublay repair, the synthetic mesh is inserted through a large skin incision outside the abdominal cavity between the peritoneum and the abdominal wall. The disadvantages of the procedure are the more invasive access trauma and, according to the literature, the higher infection rates.

Despite the advantages of the small skin incisions in lapIPOM surgery, the pain level is not low. A further concern is the implantation of a foreign body in the abdominal cavity, which is a risk factor for adhesion formation to the bowel and injuries to the viscera. In addition, the mesh has to be fixated with many staples, clips, tacks, or extensive sutures to the pain-sensitive peritoneum (Fig. 1a; [5, 6, 12, 15–17]).

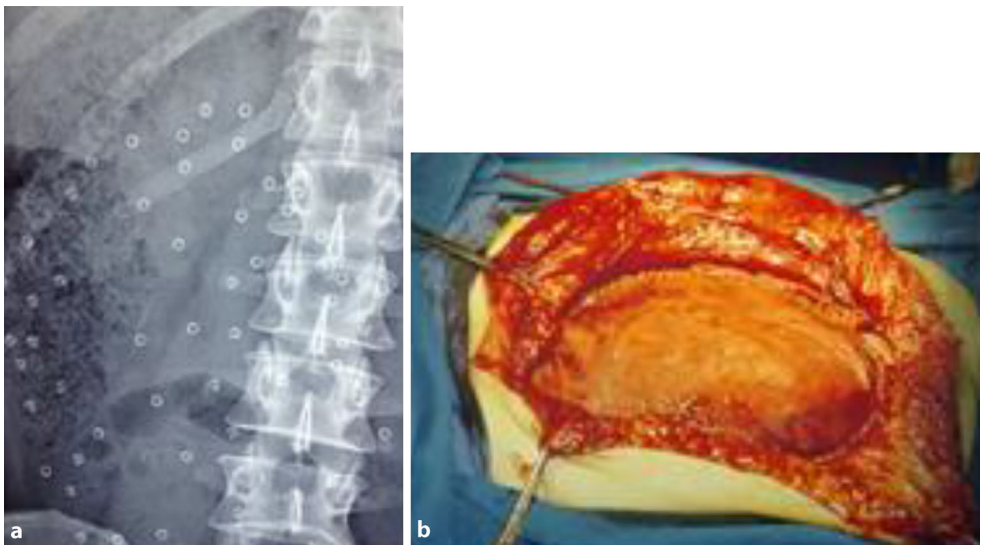

Fig. 1 **a** Extensive tack fixation of the lapIPOM mesh; **b** large incision in open sublay surgery

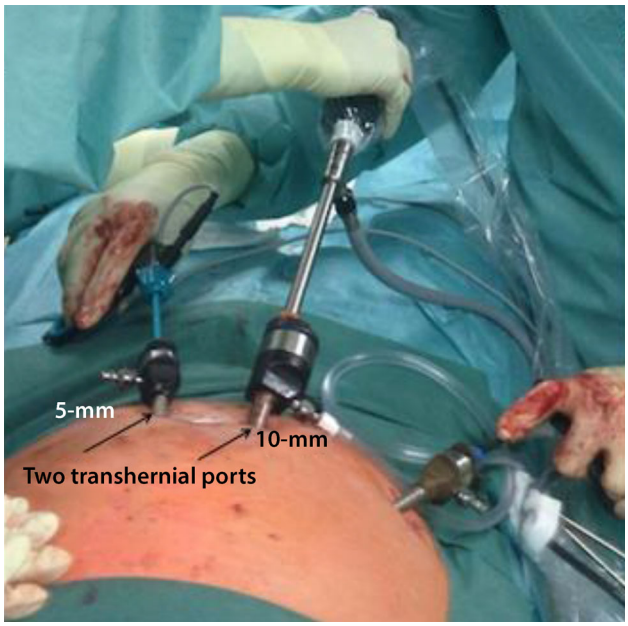

Fig. 2 MILOS operation: gas endoscopy with standard trocars

Fig. 3 MILOS operation: gas endoscopy with transhernial single port

Expensive implants have to be used with adhesion barriers on the area facing the bowel. Re-operations have shown that all IPOM prostheses can lead to massive adhesions and do not provide secure protection of the viscera. Another disadvantage of lapIPOM repair is that the hernia defect is often not fully closed but only bridged by the synthetic prosthesis. This often leads to a persisting protrusion that frequently regresses slowly or not at all. Current data from the German hernia register "Herniamed" show a significantly higher rate of 1-year recurrences after lapIPOM hernia repair than after open sublay operations.

Because of the disadvantages of the established surgical procedures and in order to minimize complications and pain in abdominal wall hernia repair, we developed a new minimally invasive technique: the mini or less open sublay (MILOS) repair. A technique of laparosopic transabdominal sublay repair of ventral hernias had previously been developed by us [7]. The MILOS repair permits placement of a large mesh in the retromuscular/preperitoneal space and anatomical reconstruction of the abdominal wall via a small transhernial incision. Using the MILOS technique, major trauma to the abdominal wall and entering the abdominal cavity is avoided. The MILOS operation can be performed as a mini open procedure with light-armed laparoscopic instruments either under direct visualization or endoscopically assisted. Today, in our institution all patients with primary and incisional abdominal wall hernias are operated on with the MILOS technique. Exceptions are small hernias with a hernia defect diameter smaller than 2 cm and extremely large hernias.

Every MILOS operation starts with an incision of 2–6 cm directly above the center of the hernia defect. The abdominal wall is lifted with retractors. The

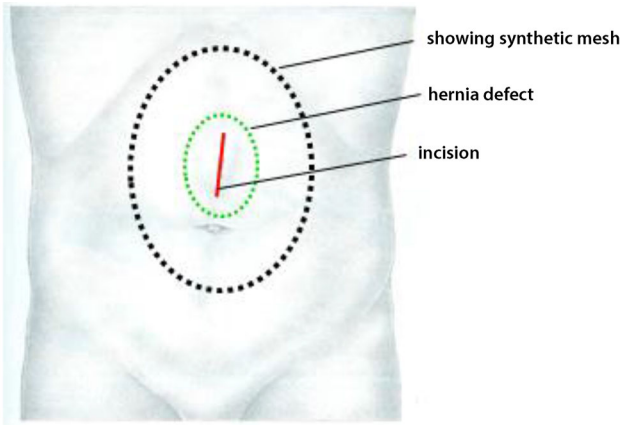

Fig. 4 Incision of 2–6 cm directly above the hernia defect

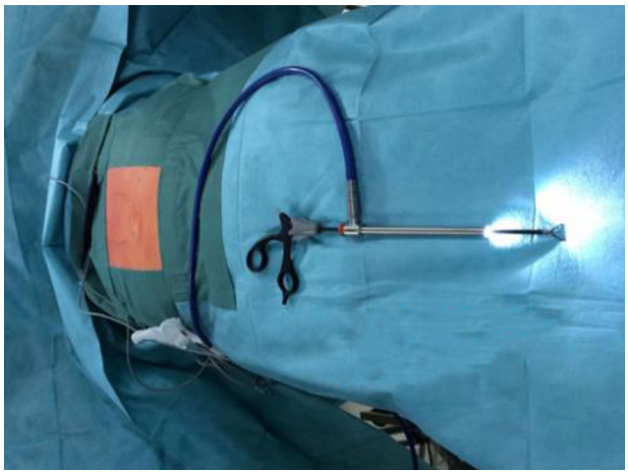

Fig. 5 Laparoscopic forceps fitted with Endotorch™

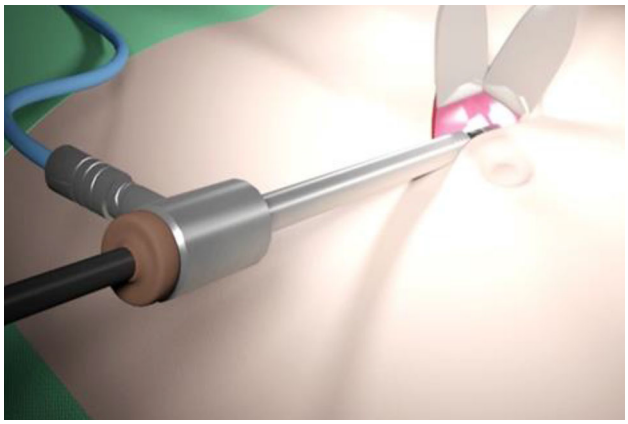

Fig. 6 Transhernial dissection with Endotorch™ under direct visualization

preparation is carried out in "mini-open" technique under direct visualization or endoscopically assisted. After transhernial mini-open preparation of an extraperitoneal space of at least 8 cm in diameter and closing of the abdominal cavity, the procedure can be continued as total extra peritoneal gas endoscopy

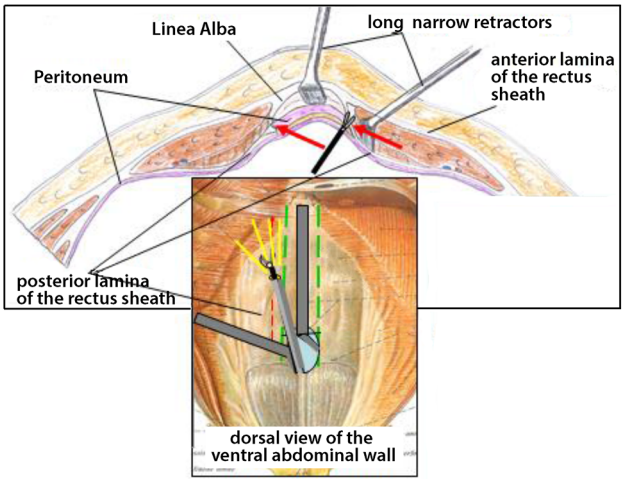

Fig. 7 Lifting of the abdominal wall with retractors and dissection of the extraperitoneal space. The posterior rectus sheath is incised longitudinally on both sides

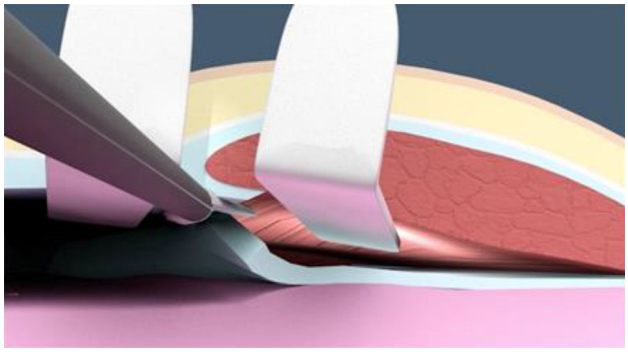

Fig. 8 Incision of the posterior rectus sheath 1 cm lateral to the medial border of muscle

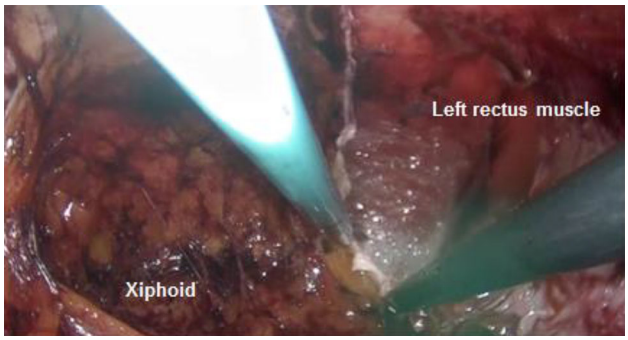

Fig. 9 Single-port TEP: incision of the upper left posterior rectus sheath

(TEP of the abdominal wall) using either standard trocars (Fig. 2) or a transhernial single port (Fig. 3); [18].

The MILOS technique enables the extraperitoneal preparation of the whole rectus compartment and both lateral compartments. Very large synthetic meshes can be implanted (Fig. 12) minimally invasively if the size of the hernia requires it. A total sublay repair of the abdominal wall is possible.

The steps in the surgery are:

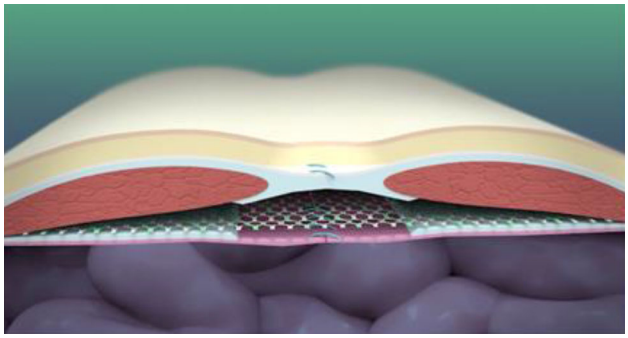

Fig. 10 Retromuscular/preperitoneal mesh position; hernia defect is anatomically closed

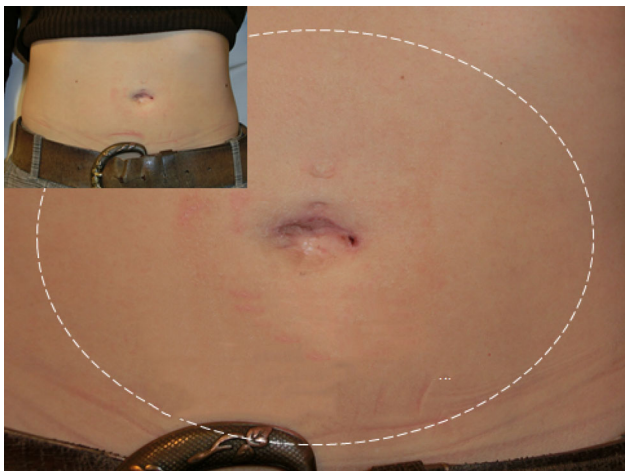

Fig. 11 Young woman with 3-cm incisional hernia after suture closure of an umbilical hernia. MILOS repair with 3-mm instruments, 5-mm endoscope, and 2-cm incision. Implantation of a 15 × 15-cm standard synthetic mesh

1. Small incision directly above the center of the hernia defect (Fig. 4).
2. Hernia sac preparation.
3. Small incision of the peritoneum for diagnostic laparoscopy.
4. Resection of abundant peritoneum of the hernia sac.
5. Complete and precise exposure of the fascial edge of the hernia orifice.
6. While the abdominal wall is lifted with rectangular retractors, transhernial extraperitoneal dissection around the hernia gap is performed using laparoscopic instruments armed with a light tube specifically designed by the company WOLF and us (Endotorch™, Figs. 5 and 6). Via a 4-cm incision, the Endotorch™ allows for circumferential dissection of the extraperitoneal plane with a radius of up to 20 cm from the fascial border of the hernia gap. Transhernial longitudinal incision of the posterior rectus sheath is performed in all quadrants to correspond with mesh size (Figs. 7 and 8). Fig. 9 depicts the endoscopic incision of the cranial section of the left posterior rectus sheath.
7. Closure of the abdominal cavity with peritoneal suture.
8. Transhernial extraperitoneal implantation of synthetic mesh. The posterior rectus sheath is closed if possible with low tension. If the posterior rectus sheath is not adapted, the mesh is the placed in the preperitoneal space in the midline and on both sides laterally in the retromuscular position (Fig. 10).
9. Mesh fixation is only necessary in cases where the hernia defect cannot be closed with low tension (bridging of large hernia defects). The intra-ab-

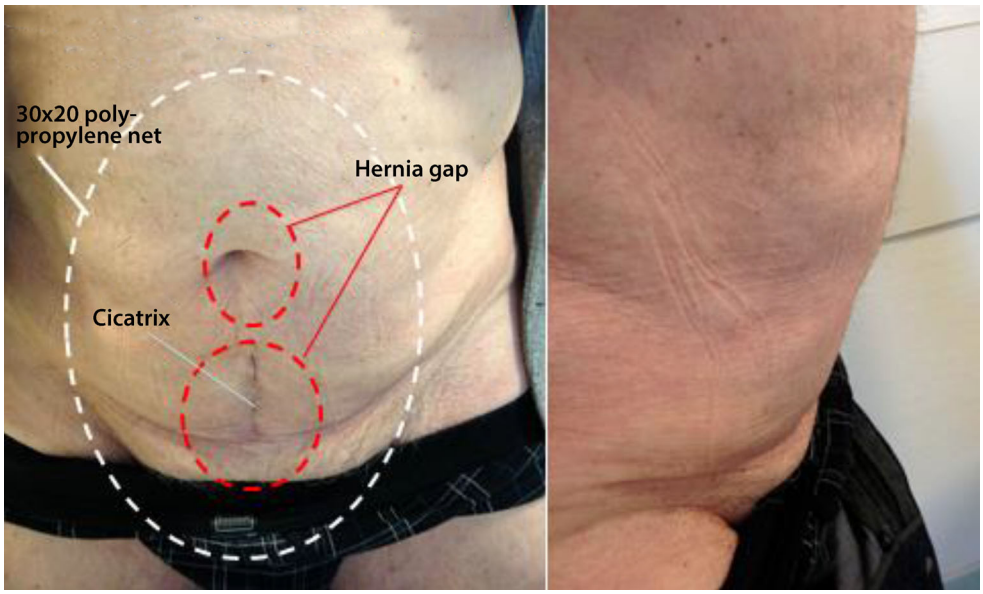

Fig. 12 Abdominal wall after MILOS operation of the fourth recurrence of an incisional hernia following open prostatectomy. Multiple-defect 15 × 9-cm hernia gap marked in *red dashed line*, 30 × 20-cm polypropylene mesh (*marked in white dashed line*)

Table 1 Size of hernia gap in incisional hernia operations (MILOS; $n = 715$)

Area (cm^2)	0–5	5–10	10–20	20–50	50–100	100–200	>200
Number	79	55	91	137	112	150	91

Table 2 Size of mesh in incisional hernia operations (MILOS; $n = 715$)

Area (cm^2)	0–50	50–100	100–200	>200
Number	0	8	77	630

Table 3 MILOS incisional hernia repair at Gross Sand Hospital ($n = 715$) vs. all incisional hernia operations in the Herniamed Register ($n = 23,682$)

	MILOS incisional hernia operations % ($n = 715$)	All incisional hernia operations in Herniamed Register ($n = 23,682$)
No complications	96.0	80.5
Total number of complications	4.0	19.5
Surgical complications:	2.3	9.6
Hemorrhage/postoperative hemorrhage	0.7	1.9
Intestinal injury/suture insufficiency	0.1	0.5
Impaired wound healing	0.3	0.7
Seroma	0.8	4.1
Infection	0.3	1.2
Ileus	0.1	1.2
Revision surgeries	1.8	4.1
General complications	1.6	4.1
Mortality	0.1	0.25

Table 4 MILOS incisional hernia operations at Gross Sand Hospital ($n = 600$) vs. all incisional hernias operations documented in the Herniamed Register ($n = 12,621$) with a 1-year follow-up

	MILOS incisional hernia surgeries in % ($n = 600$)	Incisional hernias in Herniamed Register in % ($n = 12,621$)
Recurrence after 1 year	1.3	5.5 (6.8 lapIPOM; 3.9 open sublay)
Pain at rest	3.8	10.0 (9.9 lapIPOM; 10.1 open sublay)
Chronic stress-induced pain	6.5	18.5 (19.9 lapIPOM; 17.1 open sublay)
Chronic pain requiring therapy	3.0	7.3 (7.7 lapIPOM; 6.9 open sublay)

dominal pressure fixates the mesh between the peritoneum and supporting abdominal wall. We use large-pore standard polypropylene or polyvinylidene fluoride meshes, which cover the hernia defect with a radius of 5–25 cm (Figs. 11 and 12) according to the hernia defect size.

10. The hernia defect is closed anatomically with non-absorbable or long-term absorbable sutures.

The MILOS technique is also appropriate for lateral abdominal wall hernias. In the case of large incisional hernias, the surgery is carried out via a "less open" technique (skin incision >6–12 cm).

From January 2010 to December 2015, we carried out 715 MILOS operations for incisional hernias and an approximately equal number of primary abdominal wall hernias. Data on all patients were documented in the "Herniamed" register.

The hernia orifices and the size of the mesh are given in Tables 1 and 2. Postoperative consumption of analgesics was comparably low. The standard postoperative pain medication was metamizole 4 × 1 g p. o. Additional opioids were necessary in only 10% of the cases. Even in the case of large incisional hernias, a peridural analgesic catheter is dispensable.

In 36 cases of hernia surgery, the MILOS technique was combined with posterior or anterior endoscopic component separation (hybrid procedure) in order to achieve a low-tension anatomical closure of the large hernia defect after the insertion of a large extraperitoneal synthetic mesh.

The average operating time in MILOS incisional hernia repair is 103 min, 8 and 21 min longer than open sublay (95 min) and lapIPOM repair (82 min), respectively. Complication rates after MILOS incisional hernia repair are very low (Tables 3 and 4). There was only one case of enterotomy. Two superficial wound infections healed preserving the synthetic mesh. In four patients, revision was carried out with hematoma evacuation. A recent propensity score matching of MILOS, LapIPOM, and open sublay operations of the German Herniamed registry revealed significantly fewer perioperative complications, reoperations, recurrences, and chronic pain after 1 year in the MILOS cohort [19].

Discussion

To further improve abdominal wall hernia surgery and overcome the obvious disadvantages of the currently most widely used open sublay and lapIPOM repair, we have successfully developed the MILOS technique. This is the first technique that allows the minimally invasive sublay repair of all primary and recurrent abdominal wall hernias, with the exception of giant eventrations. But even in extremely large primary and incisional ventral hernias, the principles of MILOS repair help to reduce surgical trauma to the abdominal wall. Our experience with 715 MILOS incisional hernia operations showed the following advantages of this novel technique:

1. Minimally invasive extraperitoneal implantation of (large) standard synthetic meshes without traumatic mesh fixation.
2. Closure of hernia gaps and anatomical reconstruction of the abdominal wall. Protection of viable abdominal wall structures including nerves.
3. After MILOS operations there were significantly fewer perioperative complications, reoperations, general complications, recurrences, and chronic pain after 1 year compared with open sublay and lapIPOM repair.
4. The MILOS technique allows for minimally invasive repair of rectus diastases.

5. The MILOS repair can be combined with endoscopic anterior and posterior component separation.
6. Very good cosmetic results are achievable.
7. In comparison with lapIPOM operations, there is a saving of around € 1200 in material costs per operation.

Prospective analysis of MILOS repair in primary ventral hernias with 1-year follow-up also revealed very low complication rates.

Conclusion

The novel MILOS technique allows for the minimally invasive endoscopically assisted extraperitoneal repair of primary and incisional eventrations with very low perioperative morbidity, recurrences, and chronic pain after 1 year. The technique has the potential to revolutionize abdominal wall hernia repair if future studies of other working groups can reproduce our very promising results.

Conflict of interest W. Reinpold, M. Schröder, A. Schröder, C. Berger, J. Nehls, W. Stoltenberg, and F. Köckerling declare that they have no competing interests.

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