



# A novel glue device for fixation of mesh and peritoneal closure during laparoscopic inguinal hernia repair: short- and medium-term results

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## Summary

**Background** Mesh fixation during transabdominal preperitoneal (TAPP) hernia repair should be done using nonpenetrating fixation devices in order to reduce acute and chronic pain. Beside fibrin sealant, N-butyl cyanoacrylate (NBCA) can be applied. However, there are limited data using NBCA exclusively for fixation of mesh and closure of peritoneum following TAPP repair. We therefore studied a novel laparoscopic fixation device (LiquiBand®Fix8™ by Advanced Medical Solutions, Plymouth, UK) addressing these issues.

**Methods** A prospective study was performed in two (different tertiary referral) centres in Austria, including patients undergoing TAPP repair between January and May 2015. The aforementioned device was used for fixation of mesh at predefined reference points (rectus muscle, pubic bone, triangle of doom, triangle of pain) and entire closure of peritoneum whenever possible.

**Results** In a total of 34 (4 female) patients, 40 inguinal hernias were repaired using the TAPP approach. Fixation of mesh at four predefined reference points was successful using a single liquid anchor in 88.1 % (141/160). Thorough closure of peritoneum using NBCA was possible in 36 cases (90.0 %). Twice, additional suturing was done as the device clogged during this step of procedure. Finally, in another 2 patients,

the attending surgeon declined using glue at all, as the sigmoid colon attached exerted too much traction. No device-related complication was recorded during 1-year follow-up.

**Conclusion** Nonpenetrating fixation of mesh during TAPP repair using this novel device is highly effective. In addition, closure of peritoneum using exclusively NBCA is safe and feasible according to our experience

**Keywords** TAPP repair · Mesh fixation · Peritoneal closure · Minimally invasive surgery · Inguinal hernia · Tissue adhesives

## Introduction

Nonpenetrating fixation of meshes during transabdominal preperitoneal (TAPP) hernia repair is associated with less acute and chronic pain [1, 2]. According to the (updated) guidelines of the International Endohernia Society (IEHS), fibrin 'glue' should be considered for this step of procedure [3, 4]. However, the strength of mesh fixation is weak and closure of the peritoneum is impossible using fibrin sealant. Butyl esters provide stronger bonds [5], and fixation of meshes using N-butyl cyanoacrylate (NBCA) during TAPP repair proved to be safe and feasible [6, 7]. However, there are still limited data available using NBCA exclusively for fixation of mesh and closure of peritoneum [8].

We therefore performed a prospective study using a novel laparoscopic fixation device (LiquiBand®Fix8™ by Advanced Medical Solutions, Plymouth, UK) for fixation of mesh and closure of peritoneum during TAPP repair and present our short- and medium-term results.

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**Fig. 1** The LiquiBand®-Fix8™ represents a laparoscopic 5 mm nonpenetrating fixation device. Approximately 33 liquid anchors (containing N-butylcyanoacrylate) can be applied



## Patients and methods

The study was approved by the local ethics committees at St. John of God Hospital in Vienna and Graz (Austria) and registered at [www.clinicaltrials.gov](http://www.clinicaltrials.gov) (NCT02457728). Written informed consent was obtained from each patient before inclusion into this trial. Patients between 18 and 90 years with uni- or bilateral, inguinal or femoral, primary or recurrent hernias undergoing TAPP repair were included. Exclusion criteria were scrotal hernia, poor compliance (language disability, dementia) or pregnancy. Demographic, peri- and postoperative data were recorded prospectively. BD, AS and GS performed all procedures.

Antibiotic prophylaxis was not performed on a routine base. In case of conventional multiport access, three noncutting trocars were placed at the umbilical level. For single-port surgery the Octo™Port (Dalim SurgNET, Seoul, Korea) was used. Type of access was left to discretion of surgeon in charge. Identification of anatomical landmarks and extent of dissection was performed as recommended by the IEHS [3].

### Description of device

The LiquiBand®Fix8™ represents a 5 mm nonpenetrating laparoscopic fixation device (Fig. 1). By pulling the trigger, a well-defined amount of NBCA (0.0125 g) is delivered. In total, approximately 33 such 'liquid anchors' are available (Figs. 2a–c and 3).

### Description of surgical technique

The peritoneal incision was made 1 to 2 cm higher up than we used to do before using NBCA. The upper peritoneal flap was not mobilized at all. Success of mesh fixation at four predefined reference points (rectus muscle, pubic bone, triangle of doom, triangle of pain) using a single liquid anchor was recorded. It was left to surgeon's discretion to add liquid anchors for mesh fixation at other locations. Finally, the intraabdominal pressure was reduced to 8 mm Hg to ease approximation of the peritoneal flaps. NBCA was applied to the nonmobilized upper boarder of peri-

toneum and the lower flap was subsequently pulled over the upper one. Following every single application of NBCA, the peritoneal flaps were compressed for a few seconds (Fig. 2a–c). Several liquid anchors at an interval of less than 1 cm were set using the aforementioned technique, thereby gradually closing the peritoneum. At the end of the procedure, the pneumoperitoneum was released and reestablished after 3 min at 12 mm Hg for study reasons only. The result of the peritoneal closure was reexamined (Fig. 3).

Clinical follow-up was done 6 weeks postoperatively and after 1 year.

## Results

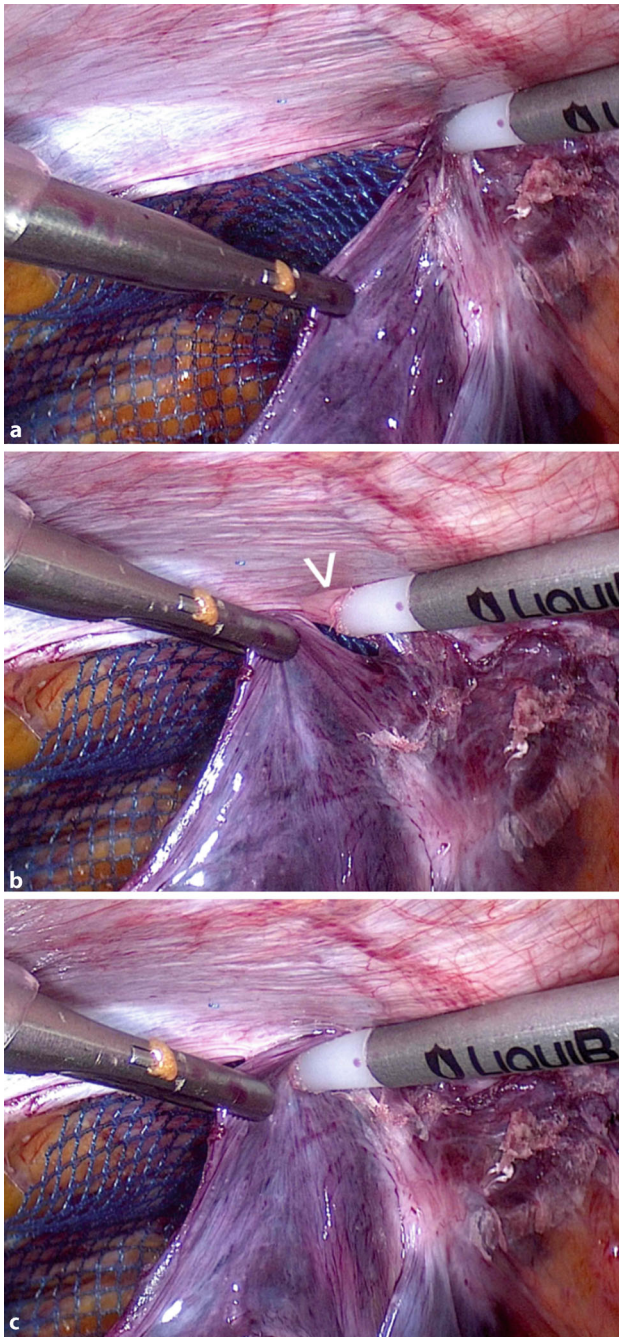
In 34 (4 female) patients, 40 TAPP repairs were performed between January and May 2015. The period included our learning curve with the device. Demographic data of patients and procedural details are listed in Table 1. 34 primary inguinal, five recurrent inguinal and a single femoral hernia were seen. TiO2Mesh™ 10 × 15 cm (BioCer Entwicklungs-GmbH; Bayreuth, Germany), 3DMax™ Light Mesh Extra-Large (C. R. Bard, Inc.; Warwick, RI, USA), VitaMesh™ Blue 10 × 15 cm or C-QUR™ CentriFX Mesh Large (both MAQUET Holding GmbH & Co.KG, Raststatt, Germany) was used in 14, 9, 14 and 3 cases respectively. Results are summarized in Table 2.

### Fixation of mesh

Success rate for transporous glue fixation of lightweight macroporous polypropylene meshes accounted for 91.2 % (135/148). In three initial cases, an omega 3 fatty acid-covered mesh was used, applying the glue underneath the mesh. Despite this technical adaptation, fixation with a single liquid anchor was possible only in 50.0 % (6/12), and the abovementioned coated mesh was not used any longer. The reference point itself had no influence on success rate.

### Closure of peritoneum

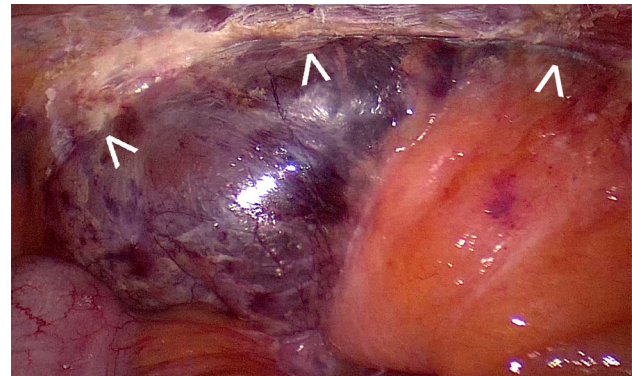
Entire closure of peritoneum was accomplished using 12 (median; range: 8–20) liquid anchors in 36 out of



**Fig. 2** The lower flap is grasped (a), a dot of glue is applied (>) while approximating the peritoneal layers (b). The flaps are compressed (c). These steps are repeated, thereby gradually closing the peritoneal gap

40 cases (90.0%). Twice, the tip of the device clogged during this step and attending surgeon decided to do additional suturing instead of using another glue device. Finally, the same surgeon declined using NBCA for closure of peritoneum in additional two cases, as the sigmoid colon attached exerted too much traction on the lower peritoneal flap.

In six cases (6/34, 17.6%), a single-port approach was used. In order to reduce clashing of instruments, the shaft of the device was bent without compromis-



**Fig. 3** Final result is shown at the end of procedure. The line of closure is indicated (>)

ing its function (Fig. 4). Median time for entire closure of peritoneum using the single-port technique was slightly longer compared to the conventional multi-port approach (184 vs. 170 s;  $p = 0.104$ ).

In total, the tip of the device clogged five times (5/34; 14.7%), but no other device-related problems were observed. Persistent and complete peritoneal closure was seen in all cases after reestablishment of the pneumoperitoneum at 12 mm Hg.

Patients left hospital on postoperative day 2 (median; range: 1–4). One patient undergoing TAPP repair for right-sided femoral hernia reported enduring pain at 6-weeks clinical follow-up and after 1 year. No other complication was recorded.

## Discussion

### Fixation of mesh

Penetrating fixation devices such as tacks, staples or straps should not be used for mesh fixation to avoid nerve injuries and adhesions [9, 10]. According to the (updated) guidelines of the IEHS, fibrin glue is recommended for mesh fixation during TAPP repair [3, 4]. However, butyl esters potentially offer some advantages compared to fibrin sealant: stronger bonds are provided for mesh fixation, the peritoneum can be adapted to facilitate suturing and closure of incisional wounds can be done using one and the same agent. Disadvantageously, nonabsorbable impenetrable glue plaques do impair tissue integration [11] and therefore only distinctive dots of 'superglue' should be used. The LiquiBand®Fix8™ delivers a well-defined amount of NBCA addressing this problem and our results demonstrate that nonpenetrating fixation of lightweight macroporous polypropylene meshes is highly effective using this novel device.

### Closure of peritoneum

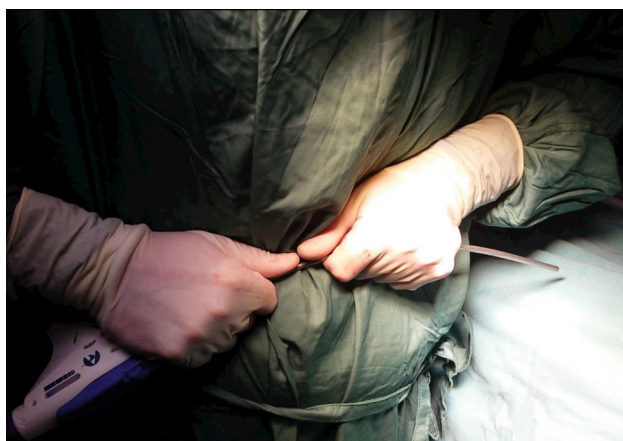
Most surgeons do a running suture and some still use tacks for peritoneal closure to avoid exposure of mesh to the viscera. However, small bowel obstruction after

**Table 1** Demographic and perioperative data

Demographic and perioperative data	
Male/female	30/4
Age (years)	57 (20–82)
BMI (kg/m <sup>2</sup> )	24.6 (18.0–30.6)
Multiport/single port	28/6
Uni-/bilateral hernia	28/6
Primary/recurrent hernia	35/5

**Table 2** Details using N-butyl cyanoacrylate (NBCA) for mesh fixation and peritoneal closure and postoperative data

Mesh fixation using NBCA	
Successful fixation (yes/no)	141/19 (88.1 %)
Peritoneal closure using NBCA	
Successful closure (yes/no)	36/4 (90 %)
Number of liquid anchors needed	12 (8–20)
Time required (s)	170 (60–420)
Device-related problems	
Clogging of device	5/34 (14.7 %)
Postoperative data & complications	
Duration of hospital stay (d)	2 (1–4)
Persistent pain	1

**Fig. 4** The device is customized for single-port surgery by bending the shaft without loss of function

TAPP repair due to insufficient closure of peritoneum or entrapment of bowel at displaced tacks may occur in the early postoperative period [12–14]. In addition, self-anchoring barbed sutures—frequently used as knotting is avoided—may also cause intestinal obstruction if the suture cuts through the peritoneum or the thread is left too long [15]. According to our experience, closure of peritoneum using exclusively NBCA is safe and feasible and could be a viable option. In this series, clinical follow-up was done at 6 weeks and after 12 months to rule out any (severe) adverse events related to the technique applied. A single patient reported on persistent pain, but no other complication (e. g. intestinal obstruction) was seen. However, no recommendation can be made concerning the exclusive use of NBCA for peritoneal closure based on

our experience and due to limited data available at present [8].

Notably, one surgeon could not accomplish peritoneal closure using NBCA exclusively in 30.8 % (4/13). Twice the device clogged and instead of opening another device, additional suturing was performed. In another two cases, closure of the peritoneum with NBCA was declined as traction to the lower peritoneal flap was assessed to be too high. By performing the peritoneal incision higher up and further reduction of the intraabdominal pressure, this problem can be solved. But this observation indicates that there is a relevant learning curve using this novel device, especially for the peritoneal closure.

### *Bilateral hernia, closure of skin incisions*

In principle, the repair of bilateral hernias with a single device containing approximately 33 liquid anchors is possible. In this series, a median of 12 applications were necessary for closure of peritoneum each side. However, a larger number of loads per device would be beneficial; especially if more (than four) liquid anchors are applied for mesh fixation. In addition, the same device could also be used for closure of skin incisions at the end of the procedure, as cyanoacrylate adhesives offer some benefits: faster closure time, less tissue trauma, no requirement for secondary wound dressing, ease of bathing, no need for further appointments to remove suture material while showing comparable cosmetic results [16, 17].

### *Single-port surgery*

Our results confirm that use of LiquiBand®Fix8™ is also feasible for single-port laparoscopy. This approach was developed during recent years to further decrease surgical access trauma and to avoid visible scars [18]. However, clashing of instruments is a major problem and suturing remains challenging. Using this novel fixation device, these drawbacks may be eliminated by bending the shaft of the device (Fig. 4). As glue is delivered via a flexible catheter, full function is not constrained by this manoeuvre. There was no significant difference concerning time required for peritoneal closure using either a conventional multiport or a single-port approach in our series.

### *Device-related problems*

Clogging of the device was seen in a number of cases (5/34; 14.7 %). This was caused by pressing the tip strongly into the tissue during NBCA application. On inspection, this led to complete occlusion of the dispensing cavity in the tip. In addition, 1–2 mm of feeding tube was also blocked. Removing the dispensing cavity and cutting back of tube invariably restored functionality in all cases.

In conclusion, this novel laparoscopic fixation device proved to be a promising alternative for fixation of mesh during TAPP repair. In addition, closure of peritoneum by NBCA only appears to be safe and feasible. Finally, the device can be customized for single-port surgery by bending the shaft without loss of function. We therefore conclude that this novel device represents a viable tool for laparoscopic inguinal hernia repair.

**Conflict of interest** B. Dauser, A. Szyszkowitz, G. Seitingner, R.H. Fortelny and F. Herbst declare that they have no competing interests.

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