

ORIGINAL RESEARCH

N-Butyl Cyanoacrylate Versus Conventional Suturing for Fixation of Meshes in an Incisional Hernia Model

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ABSTRACT

Background: Chronic pain and related complications reported after the use of perforating fixation devices in hernia surgery have led to the use of tissue sealants. Fibrin sealant is a feasible option for mesh fixation; however data on cyanoacrylate glues are limited. **Methods:** 32 Sprague-Dawley rats were divided into two groups and a 1.5 cm abdominal wall defect was created on each animal. The lesions were then repaired with 2 × 2 cm polypropylene meshes, fixed with n-butyl-cyanoacrylate in the first group and with polypropylene sutures in the second group. The rats were sacrificed on the 21st and 42nd days. The presence of infection, recurrence, and abdominal adhesions were evaluated, followed by biomechanical testing and histological examination. **Results:** No mesh infection or hernia recurrences were recorded. There was no statistically significant difference between neither the adhesion scores nor the mean broken pressure of the two groups. Cyanoacrylate sealing was found equivalent to suturing in terms of tissue ingrowth, fibrosis, inflammatory infiltration, abscess formation, and necrosis. Furthermore, cyanoacrylate resulted in less foreign body reaction. **Conclusions:** Mesh fixation by cyanoacrylate may be considered as an alternative to suture fixation.

Keywords: n-butyl-cyanoacrylate, hernia, ventral hernia, sutureless mesh fixation, glue, mesh

INTRODUCTION

Prosthetic mesh repair techniques are currently the most popular choice of treatment for abdominal wall hernias, providing convincing results in terms of recurrence.

The progress in surgical techniques, biomaterials as well as postoperative care has markedly improved outcome and patient satisfaction. However, severe complications have been reported with the use of perforating fixation devices [1–3]. One of the most frequent complications after abdominal wall hernia surgery is post-operative pain, which may persist more than six months and become chronic. Sutures, anchors, tacks, and staples have all been linked to tissue trauma and to the development of chronic pain [4].

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In order to reduce the perforation-associated complications and chronic pain, tissue sealants have been proposed as an alternative to fixation devices. Biological sealants such as fibrin sealant have a long history in surgery, where they are used primarily for sealing and haemostatic purposes. Both clinical and experimental trials demonstrate that fibrin sealant is a feasible option for mesh fixation in hernia repair [5, 6]]. On the other hand, the use of synthetic glues is being still investigated.

This study assesses the adhesive strength and biocompatibility of mesh fixation with n-butyl cyanoacrylate (NBC) in an experimental incisional hernia model.

MATERIALS AND METHODS

Animals

This study was conducted at the Experimental Medical Research Center (DETAM) of Istanbul Medical Faculty. Thirty-two male Sprague-Dawley rats weighing 250–300 g were used in the study. The rats were kept under standard laboratory conditions (temperature 20°C–24°C, relative humidity 50%–60%, 12 hr light/12 hr dark) and fed with standard chow and water ad libitum. The study was approved by the ethical committee of the same center.

Operative Procedure

Anesthesia was induced by intraperitoneal injection of 50 mg/kg ketamine HCl (Ketalar, Eczacibasi, Turkey) and 10 mg/kg xylazine (Romput, Bayer, Turkey). Abdominal hair was shaved, cleansed with disinfectant soap, and prepared with 1% povidone-iodine solution (Isosol, Merkez Laboratory, Turkey). The operations were performed under sterile conditions. The abdominal cavity was entered through a 5 cm vertical midline incision. Skin flaps were raised and a 1.5 cm circular full thickness abdominal wall defect, consisting of the fascia, muscle, and the peritoneum, was created. The rats were randomly assigned into two groups and the abdominal defects were repaired by 2 × 2 cm polypropylene (PP) meshes (Prolene, Ethicon, USA). Postoperative analgesia was obtained by intraperitoneal administration of 1 mg/kg/day meloxicam (Zeloxim, Bilim, Turkey) for three days.

Group 1

In group 1 (16 rats), the defects were repaired with 2 × 2 cm PP meshes with the onlay method as defined by Alexander et al.[7], using N-butyl cyanoacrylate (Glu-bran II, GEM, Italy) for fixation. One drop of glue was used at each corner of the mesh.

Table 1. Adhesion grading by % of affected area

Extent	Adhesion score
None	0
≤25%	1
≤50%	2
≤75%	3
>75%	4

Group 2

In group 2 (16 rats), the defects were repaired using the same technique but conventional suturing with separated 4.0 polypropylene (Prolene, Ethicon, USA) sutures.

In both groups, the skin incisions were closed with continued silk sutures (Doğsan, Turkey). The operations were performed under antiseptic conditions.

Euthanasia and Laparotomy

Half of the rats in each group were sacrificed on the 21st postoperative day and the other half on the 42nd day by 150 mg/kg intraperitoneal pentobarbital (Nembutal sodium, Abfar, Turkey) injection. The presence of infection and recurrent hernia formation were inspected. A median skin incision was made and the abdominal cavity was entered through a U-shaped incision, extending caudal and lateral to the mesh. The presence and degree of adhesions between the bowel and mesh was assessed. Adhesions were scored by an independent investigator using the scale described by Diamond (Table 1) [8].

Tensile Strength

Tensile strength of the meshes was measured to evaluate the quality of mesh integration in the newly formed tissue layer. Meshes were pulled with a hook attached to a spring scale and a pull force of 350 g was applied for 15 s and the force required to disrupt the mesh from the abdominal wall was measured with the dynamometer and registered electronically.

Histology

After biomechanical measurements, all the samples were embedded in paraffin, and 5 μm sections were cut and stained with hematoxylin and eosin. A blinded

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analysis was performed by an experienced pathologist for the pathologic characteristics of tissue ingrowth, inflammatory infiltrate, foreign body reaction, abscess formation, and necrosis. Those parameters were scored semiquantitatively as 0 (none), 1 (mild), 2 (moderate), and 3 (severe).

Statistical Analysis

Statistical analysis was performed using the SPSS-10 program. The macroscopic and mechanical differences between the groups were compared using the Mann-Whitney U-test. Histopathological differences were determined by a two-tailed Student’s *t* test. Statistical significance was defined as $p < .05$.

RESULTS

Macroscopic Evaluation and Mechanical Testing

Two rats of the first group died on the eighth postoperative day, and none of these rats showed signs of inflammation or reherniation. Three rats of group 1 and 2 rats of group 2 had wound infection but no mesh infection or hernia recurrences were recorded. The intraabdominal adhesion scores and mean tensile strengths of the meshes are seen in Tables 2 and 3. None of the meshes were fully detached by the 350 g pull. There was no statistically significant difference neither between the

Table 2. Degree of adhesions and tensile strength, Group 1

No	Adhesion score	Broken weight (gr)
1	4	100
2	4	160
3	1	200
4	1	80
5	2	90
6	1	110
7	1	170
8	1	122
9	2	84
10	1	183
11	1	71
12	1	102
13	1	110
14	1	78
15	Ex	
16	Ex	

Table 3. Degree of adhesions and tensile strength, Group 2

No	Adhesion score	Broken weight (gr)
1	4	80
2	2	170
3	2	170
4	2	123
5	4	110
6	2	91
7	1	110
8	1	97
9	1	118
10	1	79
11	3	112
12	2	186
13	1	56
14	2	97
15	1	80
16	1	172

adhesion scores nor the mean broken pressure of the two groups ($p > .05$) (Table 4).

Histology

Histological analysis of hematoxylin and eosin stained specimens revealed good fibroblast proliferation and collagen accumulation in the wound site resulting in well-formed scar tissue in both groups. NBC is found equivalent to sutures in terms of tissue ingrowth, fibrosis, inflammatory infiltration, abscess formation, and necrosis ($p > .05$). However, foreign body reaction in the PP suture group was more than in the NBC group ($p < .05$) (Table 5).

DISCUSSION

Incisional hernias remain a common complication in abdominal surgery, with a reported incidence of 3%–20% among all laparotomy procedures [9]. Advances in prosthetic meshes have revolutionized surgery of abdominal wall defects by enabling the tension-free repair techniques, resulting in recurrence rates less than 10% [10]. Furthermore, laparoscopic repair of abdominal defects reduces postoperative pain, operating and hospitalization time, wound complications and recurrence [4, 11, 12]. In spite of the benefits of laparoscopic repair of abdominal wall defects, the use of staples for fixation of the meshes is associated with pain in almost one-quarter of patients postoperatively

Table 4. Statistical analysis for adhesion score and tensile strength

	Group 1	Group 2	P
Adhesion score	1, 57 (1–4) ± 1, 08	1, 87 (1–4) ± 1, 02	> 0, 05
Broken weight	118, 5 (71–200) ± 42, 3	114, 5 (56–170) ± 30, 9	> 0, 05

[4]. Pain can persist longer than six months at 1%–3% of patients due to entrapment of nerves [13].

Tissue sealants have been proposed as an alternative to permanent fixation devices in hernia repair. Sealants can be divided into three main categories: synthetic glues (cyanoacrylate based), biologic products (fibrin sealants), and genetically engineered polymer protein glues. The role of human fibrin glue for fixation of meshes has been established as a means of reducing the complications associated with stapling prosthesis [14]. However, data on cyanoacrylate glues for mesh fixation are limited. NBC glues are promoted in hernia mesh fixation but the potential outcomes are not yet widely studied.

The aim of this study was to compare the results of the classical suture fixation of meshes with NBC glue sealing in an incisional hernia model. In our study we observed equivalent results between the suture and NBC groups in terms of infection, recurrence, and intraabdominal adhesions. Recently, Fortelny et al. [15] published contrary results with NBC. They reported that elasticity was significantly impaired in NBC glued meshes and massive seroma formation was recorded in some animals. In our group we did not see any seroma formation. They had also reported that tissue integration of the implant was inhibited combined with pronounced inflammatory response. However, in our study group we observed no statistically significant

difference in terms of tissue ingrowth and inflammation. The tensile strength of the groups was similar and NBC is found equivalent to sutures in terms of tissue ingrowth, fibrosis, inflammatory infiltration, abscess formation, and necrosis. Even more, foreign body reaction was significantly less in the NBC group than in the PP suture group.

A preliminary study on the use of NBC had shown that this sealant can clog mesh pores, promoting septic complications [16]. Then, in 1998, Jourdan reported the first use of NBC glue in laparoscopic hernia repair [17]. In 2003, Helbling published the results of a prospective randomized clinical trial and described excellent results using NBC glue for mesh fixation in inguinal hernias [18].

Nowobilski compared sutures and NBC for mesh fixation in inguinal hernias with Lichtenstein technique and reported lower pain scores, less analgesic doses, and earlier returning time to daily activities with NBC sealant [6].

Birch et al. used octylcyanoacrylate for fixation of the expanded polytetrafluoroethylene mesh on the deep surface of the abdominal wall. In this study, light and scanning electron microscopy showed host cellular migration into the interstices of the mesh with fixation by tacks and suture, whereas an inflammatory infiltrate was seen on the muscular surface with octylcyanoacrylate fixation of the mesh [19].

Table 5. Histopathology

	Group 1	Group 2	P
Tissue ingrowth	1, 07 (0–2) ± 0, 61	1, 25 (0–2) ± 0, 68	p > 0, 05
Inflammation formation	1 ± 0	0, 93 (0–1) ± 0, 25	p > 0, 05
Foreign body reaction	1 ± 0	1, 75 (1–2) ± 0, 44	p < 0, 05
Abscess formation	1, 07 (0–3) ± 0, 99	1, 25 (0–2) ± 0, 85	p > 0, 05
Necrosis	1 (0–3) ± 0, 96	0, 93 (0–2) ± 0, 92	p > 0, 05

Cyanoacrylates (CAs) have been used as surgical tissue adhesives since the 1960s. Experimental studies showed that short-chain CAs such as methyl-CA had an excellent binding strength, but their toxic effects on host tissue limit their use [20]. Longer chain CAs were subsequently developed which are less toxic with similar binding properties. Butyl-CA became very popular because of its excellent binding strength and low histotoxicity compared with low chain CAs. The glue is easy to apply, dries within 5–7 s and only a small amount (some drops at the edges of the mesh) is enough for fixing.

Various in vitro and in vivo tests showed no carcinogenic properties of NBC [21]. Maintaining higher levels of humidity and optimizing room ventilation are suggested in minimizing exposure to volatile CA adhesives [22].

CONCLUSION

In this preliminary experimental study, we demonstrated that n-butyl cyanoacrylate is as effective as sutures for fixation of meshes, it is easy to handle, results in comparable side effects and less foreign body reaction than conventional sutures.

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