



A prospective, randomized comparison of skin adhesive and subcuticular suture for closure of pediatric hernia incisions: cost and cosmetic considerations[☆]

J. Kristine Brown, Brendan T. Campbell, Robert A. Drongowski,
Amy K. Alderman, James D. Geiger, Daniel H. Teitelbaum, James Quinn,
Arnold G. Coran, Ronald B. Hirschl*

Section of Pediatric Surgery, Department of Surgery, CS Mott Children's Hospital, University of Michigan, Ann Arbor, MI 48109-0245, USA

Received 24 February 2009; accepted 25 February 2009

Key words:

Cyanoacrylates;
Skin adhesive;
Children;
Wound closure

Abstract

Purpose: In this study, we compared the skin adhesive 2-octylcyanoacrylate to subcuticular suture for closure of pediatric inguinal hernia incisions to determine if skin adhesive improves wound cosmesis, shortens skin closure time, and lowers operative costs.

Methods: We prospectively randomized 134 children undergoing inguinal herniorrhaphy at our institution to have skin closure with either skin adhesive (n = 64) or subcuticular closure (n = 70). Data collected included age, sex, weight, type of operation, total operative time, and skin closure time. Digital photographs of healing incisions were taken at the 6-week postoperative visit. The operating surgeon assessed cosmetic outcome of incisions using a previously validated visual analog scale, as well as an ordinate scale. A blinded assessment of cosmetic outcome was then performed by an independent surgeon comparing these photographs to the visual analog scale. Operating room time and resource use (ie, costs) relative to the skin closure were assessed. Comparisons between groups were done using Student's *t* tests and χ^2 tests.

Results: Children enrolled in the study had a mean \pm SE age of 3.7 ± 0.3 years and weighed 16 ± 0.8 kg. Patients were predominantly male (82%). Patients underwent 1 of 3 types of open hernia repair as follows: unilateral herniorrhaphy without peritoneoscopy (n = 41; 31%), unilateral herniorrhaphy with peritoneoscopy (n = 55; 41%), and bilateral herniorrhaphy (n = 38; 28%). Skin closure time was significantly shorter in the skin adhesive group (adhesive = 1.4 ± 0.8 minutes vs suture = 2.4 ± 1.1 minutes; $P = .001$). Mean wound cosmesis scores based on the visual analog scale were similar between groups (adhesive = 78 ± 21 ; suture = 78 ± 18 ; $P = .50$). Material costs related to herniorrhaphy were higher for skin adhesive (adhesive = \$22.63 vs suture = \$11.70; $P < .001$), whereas operating room time costs for adhesive skin closure were lower (adhesive = $\$9.33 \pm 5.33$ vs suture = $\$16.00 \pm 7.33$; $P < .001$). Except for a 7% incidence of erythema in both groups, there were no complications encountered.

[☆] Presented at the British Association of Pediatric Surgeons, Cambridge, United Kingdom, July 24, 2002.

* Corresponding author. Tel.: +1 734 764 6846; fax: +1 734 936 9784.

E-mail address: rhirschl@umich.edu (R.B. Hirschl).

Conclusions: There is no difference in cosmetic outcome between skin adhesive and suture closure in pediatric inguinal herniorrhaphy. Material costs are increased because of the high cost of adhesive relative to suture. This is partially offset, however, by the cost savings from reduction in operating room time.
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Since 1959, cyanoacrylates have been investigated for use as tissue adhesives in wound closure [1]. The advantage of tissue adhesive in settings such as the emergency department for closure of minor lacerations has been demonstrated with an up to 4-fold reduction in time required for wound closure, decreased pain scores, and equivalent cosmetic outcomes [2,3]. Assessment of traumatic lacerations treated with octylcyanoacrylate tissue adhesive or sutures at 1 year also demonstrated no long-term cosmetic differences [4]. The social and psychologic issues associated with suture laceration in the awake patient in the emergency department are not relevant to decisions regarding wound closure in the operating room in children. Thus, decisions on whether to use skin adhesives for wound closure are centered on relative cosmesis, operating room timesavings, costs, and wound complication rate. A trial of 2-octylcyanoacrylate (Dermabond, Johnson & Johnson Inc, New Brunswick, NJ) in children was performed in a randomized controlled fashion to examine these outcomes. In this study, we compared Dermabond to subcuticular suture for closure of pediatric inguinal hernia incisions to determine which method of skin closure is optimal from cosmetic, efficiency, morbidity, and cost standpoints.

1. Methods

All patients undergoing inguinal hernia repair at the CS Mott Children's Hospital (Ann Arbor, Mich) between 1999 and 2000 were approached for inclusion in this trial. We prospectively randomized 134 children between the ages of 1 month and 12 years, with mean \pm SE age of 3.7 ± 0.3 years. Operations performed included isolated unilateral inguinal hernia repair, inguinal hernia repair with or without peritoneoscopy of the opposite internal inguinal ring, and bilateral inguinal hernia repair. Table 1 demonstrates the demographic data on the patient sample as well as the distribution among the type of operations performed. All operations were performed under general anesthesia by 1 of 4 pediatric surgeons (Ronald B. Hirschl, MD; Arnold G. Coran, MD; Daniel H. Teitelbaum, MD; James D. Geiger, MD). Informed consent was obtained from all parents or guardians for operation as well as for inclusion in this trial. The study was reviewed by the University of Michigan Medical Institutional Regulatory Board, and approval was obtained before and during the period of study. The operation was performed up until the point of wound closure without any knowledge of group assignment. Just before wound

closure, a sealed envelope indicating randomization to skin adhesive or suture closure was revealed. The duration of wound closure was assessed by measuring the time from the point at which the surgeon indicated that wound closure was commencing until it was indicated to be complete. After Scarpa's fascia was approximated with the Vicryl suture used for external oblique fascia closure, wound closure was then standardized in the following fashion: with skin adhesive, the 2 ends of the incision were grasped with Adson's toothed forceps and stretched such that the edges were coapted. Dermabond was applied, and the wound was held for 15 to 30 seconds until the adhesive had begun to set. Suture closure was performed with 5.0 Monocryl as per the surgeon's preference.

Masking as to skin adhesive vs suture closure was not possible for the operating surgeon because of the nature of the intervention. However, subsequent interviewers were masked as to group during assessment of cosmetic outcome measures, as well as those related to efficiency, cost, and complications of wound closure.

1.1. Cosmesis

Cosmetic outcome was assessed by a surgeon independent of the study using a previously validated visual analog scale. This surgeon was masked as to assigned closure. The analog scale consisted of a 100-mm line with worst scar at the left end of the line and best scar at the right end of the line [5]. Digital photographs of the scars at the 6-week postoperative visit were obtained using a Nikon Coolpix 900 camera (Nikon, Melville, NY). The photographs were evaluated by the independent observer at completion of the trial in random order. In addition, assessment of the scar at

Table 1 Demographics and operations performed

	Suture closure	Skin adhesive	<i>P</i>
Age (y)	3.3 \pm 3.0	4.1 \pm 3.5	.15
Weight (kg)	14.7 \pm 8.4	16.9 \pm 10.8	.18
Sex			
Male	59	51	.51
Female	11	13	.51
Operation			
UIH – P	19	22	.14
UIH + P	26	29	.14
BIH	25	13	.14

UIH indicates unilateral inguinal hernia repair; BIH, bilateral inguinal hernia repair; P, peritoneoscopy.

the time of the 6-week clinic visit was performed by the operating surgeon using the visual analog scale as well as an ordinate scale that assigns scars to numerical categories ranging from unacceptable to adequate to excellent. The total score was developed for the scar at each visit. When bilateral scars were present, they were assessed independently and an average of the 2 values developed.

1.2. Efficiency

Operating time from initial incision to completion of the operation was assessed for each patient. In addition, the specific time required for skin closure was acquired. The faculty surgeon indicated when the first suture was being placed for suture closure or when the vial of Dermabond was compressed to begin application. Wound closure time was considered complete after the tying of the last suture in the suture closure group and once application of Dermabond and manual coaptation of the wound was completed in the skin adhesive closure group.

1.3. Cost

The cost data for the operating room were assessed using the Transitional Systems Inc (Eclipsys; Boca Raton, Fla) with which cost data are collected and assessed at the University of Michigan. Additional specific costs related to Monocryl sutures used for closure, the Dermabond, and operating room time were assessed via the same system.

1.4. Complications

Wounds were assessed for erythema, purulent drainage, requirement of antibiotic administration, and wound opening. These complications were summarized at the 6-week clinic visit.

1.5. Data analysis

We performed comparisons of the categorical cosmesis score as well as the visual analog cosmesis score using Student's *t* test. Total operating room times as well as time required for wound closure were compared between groups with Student's *t* test. Costs related to wound closure were calculated as the cost of operating room time plus the cost of suture for this group and the cost of time in the operating room plus the cost of the Dermabond for the skin adhesive group.

2. Results

The demographics and the distribution of operations among the patients in the suture closure and skin adhesive

groups is shown in Table 1. Children enrolled in the study had a mean age of 3.7 ± 0.3 years. The weight was 16 ± 0.8 kg. Most patients were male, and all underwent 1 of 3 operations as follows: unilateral inguinal hernia repair without peritoneoscopy ($n = 41$; 31%), unilateral inguinal hernia repair with peritoneoscopy ($n = 55$; 41%), and bilateral inguinal hernia repair ($n = 38$; 28%). Of the 41 children in the first group, 22 were randomized (54%) to the adhesive closure group. Of the 55 children in the second group, 29 were placed (53%) in the adhesive group. Finally, 13 children (34%) were randomized to the adhesive group in the bilateral repair group. No significant differences between groups were noted with regard to any of the parameters of demographics or distribution of type of operation.

2.1. Cosmesis

Mean visual analog scores were not significantly different between the 2 groups measured by the operating surgeon at the 6-week clinic visit (suture = 79.9 ± 2.7 ; skin adhesive = 75 ± 3.7 ; $P = .28$), and the independent masked surgeon assessment using the digital photographs obtained at the time of the 6-week postoperative clinic visit (suture = 78 ± 2.6 ; skin adhesive = 78 ± 3.3 ; $P = .50$). In similar fashion, no difference was appreciated using the ordinate numerical score as assessed by the operating surgeon (suture = 5.7 ± 0.1 ; skin adhesive = 5.7 ± 0.1 ; $P = .88$). These results are demonstrated in Table 2.

2.2. Operating room efficiency

Total operating room times, as shown in Table 2, were similar between the 2 groups (suture = 48.6 ± 2.4 minutes; skin adhesive = 50.4 ± 3.2 minutes; $P = .65$). However, a small but significant difference in skin closure time was noted (suture = 2.4 ± 1.1 minutes; skin adhesive = 1.4 ± 0.8 minutes; $P = .001$). Thus, on average, the skin adhesive closure took approximately 1 minute less than the suture closure, which constituted 2.8% of the overall operative time for the hernia procedures.

2.3. Cost

Material costs related to skin closure were higher for skin adhesive (suture materials = \$11.70; skin adhesive = \$22.63; $P < .001$), whereas the operating room time cost for adhesive closure was lower (suture = $\$16.00 \pm 7.33$; skin adhesive = $\$9.33 \pm 5.33$; $P < .001$). The mean relative costs for skin closure that were assessed as a combination of material cost and operating room time cost favored suture closure (suture = \$27.70; skin adhesive = \$31.96; $P < .001$). However, overall, the total procedure cost between the 2 groups was not significantly different (suture = $\$884.44 \pm 451.35$; skin adhesive = $\$852.95 \pm 352.44$; $P = .65$). These results are shown in Table 2.

Table 2 Cosmetic, efficiency, and cost comparisons

	Suture closure	Skin adhesive	<i>P</i>
Operating surgeon			
Visual analog cosmetic scale	79.9 ± 2.7	75.0 ± 3.7	.28
Ordinate cosmetic scale	5.7 ± 0.1	5.7 ± 0.1	.88
Independent surgeon			
Visual analog cosmetic scale	78.0 ± 2.6	78.0 ± 3.3	.5
OR time total (min)	48.6 ± 2.4	50.4 ± 3.2	.65
Wound closure time (min)	2.4 ± 1.1	1.4 ± 0.8	.001*
OR closure time cost	\$16.00 ± \$7.33	\$9.33 ± \$5.33	<.001*
OR closure materials Cost	\$11.70	\$22.63	<.001*
Total wound closure cost	\$27.70 ± \$7.33	\$31.96 ± \$5.33	<.001*
Total procedure cost	\$884.44 ± \$451.35	\$852.95 ± \$352.44	.65

OR indicates operating room.

Significant at *P* < .05.

2.4. Complications

No significant differences between the 2 groups were noted. Specifically, the wound erythema rate was 7.1% in the suture group and 7.8% in the skin adhesive group (*P* = .99). There were no observed instances of purulent drainage or wound dehiscence.

3. Discussion

The findings in this study suggest that there is no difference in cosmetic outcome between suture closure and skin adhesive in pediatric inguinal herniorrhaphy. Although material costs are higher with the skin adhesive closure when compared to the suture closure, this is balanced by a small reduction in operating room time attributed to wound closure such that total costs between the 2 procedures are equivalent. Complication rates appear to be similar between the 2 approaches.

Initial studies of tissue adhesives involved those using *N*-butyl-2-cyanoacrylate. The first report in children was in 1988 examining the use of this skin adhesive in more than 1500 patients with minor lacerations in the emergency department [6]. A second study in 1989 evaluated the application of glue with closure of facial lacerations less than 3 cm and noted satisfactory cosmetic results [7]. A large case series evaluating *N*-butyl-2-cyanoacrylate in elective pediatric general surgical operation wound closure examined 1033 children, in which inguinal hernias, hydroceles, undescended testes, and umbilical hernias were repaired with a low complication rate and excellent cosmetic outcomes [8]. Unfortunately, although butylcyanoacrylates have wound-breaking strength equivalent to suture repair at 5 to 7 days, the breaking strength at 1 day is approximately 10% to 15% of a 5.0 monofilament-sutured wound. The adhesive is also brittle and tends to fracture easily [9]. A marked increase in wound dehiscence of 26% was found in one recent prospective study in children using *N*-butylcyanoacrylate

to close inguinal incisions, vs subcuticular suture with 0% dehiscence [10].

Most recent studies have evaluated the use of octylcyanoacrylate. Assessment of tensile strength of wound closures with 2-octylcyanoacrylate glue vs staple and subcuticular suture closures in porcine skin demonstrated no statistically significant difference between the adhesive and subcuticular groups. Staple closure proved to be the strongest, whereas Steri-Strips (3M, St Paul, Minn) was the weakest, but suture closure and skin adhesive closure were equivalent [11]. A randomized clinical trial comparing butylcyanoacrylate and octylcyanoacrylate in pediatric facial lacerations failed to demonstrate a difference with regard to cosmesis at 3 months, procedure time, difficulty of the procedure, or parent-perceived pain related to the procedure [12]. A subsequent randomized controlled trial of suture vs octylcyanoacrylate closure of emergency department lacerations demonstrated a significantly decreased time required for wound closure (5.9 vs 10 minutes) and similar cosmetic outcomes. The complication rate was not different between the wound closure technique groups [13].

Although used extensively in the emergency department setting where psychosocial aspects of local anesthetic injection and suture closure are significant issues in children, the use of skin adhesives for wound closure in the operating room has demonstrated limited immediate advantage over suture closure. Studies comparing octylcyanoacrylate tissue adhesive with suture closure of facial plastic surgical incisions showed no difference in cosmetic appearance at 1 to 3 months after operation. However, at 1 year, the mean visual analog scale cosmetic outcome was enhanced in the octyl-2-cyanoacrylate when compared to the suture group [14]. Again, wound closure was faster in the tissue adhesive when compared to the suture closure group, with no difference in complication rates between groups.

These results corroborate our findings of equivalent early cosmesis and complication rates with a significant reduction in time required for wound closure. We applied 2 cosmetic scales that have previously been validated to have good intraobserver

and interobserver agreement for rating wound lacerations and incisions [5]. We assessed operating surgeon ratings at 6 weeks, which have been shown previously to correlate with those observed at 1 year [4]. The third assessment was performed by an independent surgeon using digital photographs. The validity of using photographic analysis for determining scar appearance has also been previously established [15].

We also assessed overall operative time, although variability of operative time required within and between the different types of operations makes identification of an effect difficult to identify because of the small time required for wound closure. A recent prospective trial examining cosmetic outcomes and closure time between adhesive and subcuticular suture in pediatric inguinal incisions failed to demonstrate a difference in timesavings using adhesive. Cost considerations were not examined [16]. We similarly measured the time of wound closure and were able to identify a mean 1-minute reduction in time required for wound closure when skin adhesive was used. Although the wound closure time reduction is small, it is not insignificant for an operation that on average takes 49 minutes.

Likewise, it is not surprising that it was difficult to observe a significant difference in cost between the skin adhesive and suture groups. As such, we examined those costs directly related to wound closure. We expected that there would be timesavings from use of skin adhesive but increased costs associated with Dermabond. This proved to be the case, with the increase in direct cost from the skin adhesive nearly identical to the overall cost savings associated with decreased operative time. Thus, from a cost point of view, there is no apparent advantage or disadvantage to the use of Dermabond in inguinal hernia wound closure. There also was no difference in wound complication rate, although Dermabond is now approved by the Food and Drug Administration as a microbiologic barrier, and there are data to suggest that infection rate may be reduced in wounds closed with Dermabond [17,18].

We chose to perform this trial in patients who were undergoing inguinal hernia repair despite the relatively small incisions involved because these patients formed a relatively homogenous and common group of patients undergoing elective surgery. Our anecdotal experience suggests that skin adhesive closure of larger chest and abdominal incisions, especially in newborns and infants, may be associated with even more pronounced timesavings with similar cosmetic outcomes. The advantages associated with wound closure using skin adhesive may also be distinguishable in the setting of even larger incisions [19]. Currently, we use skin adhesive when closing small incisions less than 1 to 2 cm and occasionally for larger incisions, especially in infants where the edge of the incision nicely coapt when approximated. Further studies evaluating skin adhesive closure in larger general surgery incisions are required. In addition, skin adhesive may not be appropriate for excisional wounds under high tension, as cosmetic outcomes may be poorer in these circumstances [20]. In the meantime, the data from this trial suggest that skin adhesive wound closure in inguinal hernia

repair is associated with a small reduction in operative time without effect upon total cost, complication rate, or cosmesis.

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