Surgical Wound Dressing in Pediatric Surgery: A Prospective Study of The Role of The Mölndal Technique

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Abstract

Introduction: Surgical wounds require appropriate management to prevent complications and promote healing. The Mölndal technique combines hydrofiber wound dressing with polyurethane film to maintain a moist environment and optimize healing conditions. While this technique has demonstrated benefits in adults, its efficacy in children remains unclear.

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Materials and Methods: A prospective study was conducted from September 2020 to November 2022 in children undergoing laparoscopic surgery. Patients younger than 15 years of age who received Mölndal dressings on all incisions and completed evaluation and satisfaction questionnaires were included. Patients with allergies, concurrent open surgery, or non-wound-related complications were excluded. Wound dressings were evaluated daily and were removed on the eighth postoperative day. Patients were classified according to their surgical wound classification (clean, clean-contaminated, contaminated or infected). The sample size was calculated for a 2% margin of error at a 95% confidence level.

Results: A total of 189 patients (63% male; median age, 9.4 years) were included. Appendectomy was the most common procedure (77.2%). The surgical site infection rate was 3.7%. Dressing changes were required in 12.2% of patients, most frequently in the umbilical region. Family satisfaction was very high, and all families recommended the technique. There were no significant differences in the surgical site infection rates according to wound classification.

Conclusion: The Mölndal technique seems to be effective and safe for preventing postoperative wound infection in pediatric laparoscopic surgery. Dressing changes were infrequent and significantly associated with older age and male sex. High family satisfaction and universal recommendation support its clinical acceptability.

Keywords

- Surgical wound
- Laparoscopy
- Child
- Occlusive Dressings

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Introduction

As the body's largest organ, the main role of the epidermal skin is to provide an external barrier against the outside elements and protect us against mechanical, thermal, ultraviolet and chemical injuries, liquid loss and infections.[1] A wound is defined as a discontinuity in the external epidermal barrier or mucous membrane, which may result in significant morbidity if not closed properly.[1,2] Surgical wounds, also known as incisions, are healing by primary intention, where the edges of the wound are brought together with sutures or other closure techniques.[1,3] Wound healing depends on the size, depth, and degree of the incision, as well as the patient's characteristics.[2]

The history of wound care has been extensively documented from prehistory to modern medicine. Since the beginning of time, the main healing strategies have consisted of washing the wound, applying dressings and bandaging.[2] A large variety of substances, such as honey or animal oils, have been applied to wounds over the years.[1,2] However, nowadays, the most common treatment is to apply wound dressings.[4] Surgical wounds are covered to provide a barrier against external contamination and to maintain a warm, moist and clean environment in order to improve and accelerate wound healing. With the significant advances in biotechnology, the development of wound dressings also evolved significantly. [1,4] Modern dressings have better biocompatibility, degradability and moisture retention in comparison with traditional dressings. These benefits lead to easier application and faster healing. [2,4] The principal characteristics of an ideal wound dressing are: ability to protect from external agents, absorb exudates, maintain a moist environment to reduce wound dryness and improve tissue regeneration.[4]

Since Folestad's research, which described the use of Mölndal technique in patients undergoing trauma surgery, several studies have reported the beneficial effects of this technique. [5,6] Mölndal technique consists of applying a hydrofiber wound dressing and secure it with a transparent polyurethane film after the closure of the surgical wounds. [5,6] The possible advantages of this technique are easier application, fewer dressing changes, better patient comfort and protection from external contamination. [3,5]

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The aim of our study was to describe the results of Mölndal technique after laparoscopic surgeries in children. The primary hypothesis was that Mölndal technique would be effective in preventing wound infection in pediatric patients after laparoscopic surgery. It was considered effective when more than 80% of the patients did not develop wound infections. The secondary objectives of this study were to compare the results of Mölndal technique according to the type of surgery, as well as to investigate if there were differences between patients who needed dressing changes and those who did not and family's satisfaction with this technique.

Materials and Methods

After approval by local ethics committee, we performed a prospective study from September 2020 to November 2022. Data from pediatric patients who underwent laparoscopic procedures and had their wounds dressed with Mölndal technique were collected. Each procedure was performed by one of four laparoscopic pediatric surgeons at our institution. Informed consent to participate in the study was obtained from the patient's legal representatives before surgery. Patients older than 12 years also signed an informed consent document and received information tailored to their level of comprehension.

The Mölndal technique consisted of cleaning the wound with physiological saline solution and alcoholic chlorhexidine, applying a hydrofiber wound dressing, and securing it with a transparent polyurethane film. All surgical wounds were closed with polyglactin absorbable sutures. After suturing the incisions, the nurse in the operating room placed Mölndal dressings under aseptic conditions and if possible, left them undisturbed for at least 7 days. Mölndal dressings were removed on the eighth postoperative day. Wound dressings were evaluated daily by the surgical team if the patient was hospitalized or by their caregivers if the patient was discharged. Mölndal dressings were changed if they became soaked, there was a leakage or detachment of the dressing, there were signs or symptoms suggestive of wound complications or the patient felt uncomfortable. Every time a dressing was changed, a new Mölndal dressing was applied. An evaluation questionnaire with instructions was given to the caregivers of patients after surgery (Figure 1). Patients and caregivers were asked to record

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analgesic consumption and monitor wound dressings daily. Ibuprofen (7 mg/kg) was prescribed three times daily for the first postoperative day (except in patients younger than 6 months). The following postoperative days, ibuprofen was administered if the patient needed it. Paracetamol (10 mg/kg) was prescribed as complementary analgesia. If patients were admitted to the hospital, intravenous metamizole and paracetamol were administered every six hours for the first 24 hours.

An outpatient visit was performed 8-10 days after the surgery. During this visit, wounds were inspected for complications such as infection, maceration, erosion or dehiscence. Wounds were left uncovered if there were no complications. However, patients who had wound complications were treated individually according to their problems. Any complications or dressing changes were recorded in the electronic medical record. After the wound revision, a satisfaction questionnaire was given to patient's caregivers (Figure 2). Finally, we collected the self-created questionnaires back. Both questionnaires were rated on Likert-type scales ranging from 1 (strongly disagree) to 5 (strongly agree). A phone number was provided in case there were additional problems and clinical records were tracked for the following 3 months to record any late complications or emergency visits.

Patient demographics, preoperative history, intraoperative details, wound classification and postoperative outcomes were collected from the clinical electronic medical record system. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Patients older than 5 years were classified according to their BMI level as underweight (< 18.5 kg/m^2), normal (18.5 to 24.9 kg/m^2), overweight (25.0 to 29.9 kg/m^2) and obese (≥ 30.0 kg/m^2), while patients younger than 5 years were classified according to gender- and age-specific percentiles using World Health Organization (WHO) tables as underweight (< 3), normal (3 to 85), overweight (86 to 97) and obese (> 97).

Antibiotic prophylaxis was administered according to the anti-microbial protocol established in our hospital. Surgical wound classification (SWC) was documented based on findings described in the operative note. The classification includes four options depending on the level of contamination present: Class I or clean, class II or clean-contaminated, class III or

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contaminated and class IV or infected **(Table 1)**.

Class I or clean: Uninfected. No inflammation. Respiratory, alimentary, genital or urinary tract are not entered. - Inguinal hernia repair - Pyloromyotomy - Nissen fundoplication - Stephens-Fowler technique - Varicocelectomy - Lysis of adhesions - Ovarian cystectomy (not entering ovarian tissue) - Ovarian detorsion - Diagnostic laparoscopy - Lymph node biopsy - Intussusception reduction - Oophorectomy
Class II or clean-contaminated: Respiratory, alimentary, genital or urinary tract are entered under controlled conditions and without unusual contamination. - Incidental appendectomy - Cholecystectomy - Liver biopsy - Ovarian cystectomy (ruptured cyst or entering ovarian tissue) - Meckel diverticulectomy
Class III or contaminated: Respiratory, alimentary, genital or urinary tract are entered with any visible spillage after the incision is made. Inflammation, necrosis or gangrene is present. - Nonperforated appendectomy
Class IV or infected: Respiratory, alimentary, genital or urinary tract are entered with any visible spillage before the incision is made. Pus or perforation.

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- Perforated appendectomy

Surgical wound classification

Table 1: Definitions of the four surgical wound classes (clean, clean-contaminated, contaminated, and infected) and examples of procedures assigned to each class.

When multiple procedures were performed on one patient, SWC was based on the most contaminated procedure. Surgical site infection (SSI) was defined as the presence of clinical signs or symptoms of infection such as redness, pain, tenderness or swelling at the site of the incision, purulent drainage from the wound or positive bacterial culture. The inclusion criteria were as follows: patients were 15 years of age or younger; surgeries were performed by laparoscopic approach; Mölndal dressings were applied in all the incisions; and both questionnaries were completed. Patients with allergies to skin adhesives or analgesic drugs used in this study, those who underwent simultaneous open surgery, those with postoperative complications (except wound-related complications), and those whose dressings were removed before seven days were excluded from the study. Sample size estimation was based on a review of previous literature. The required sample size for this study was calculated to be 189 to achieve a margin of error of 2% at a 95% confidence level. Descriptive data analysis was performed. The Kolmogorov-Smirnov test was used to analyze the normality of the data distribution in each group. All variables, except height, were non-normally distributed. Categorical variables were presented with their absolute frequency and percentage. Quantitative variables were expressed as the median and interquartile range (IQR: 25^{th} – 75^{th} percentile). A comparative analysis was performed depending on the type of SWC. The chi-square test was used for the comparison of the categorical variables. Parametric tests (Student's t-test, ANOVA) or non-parametric test (Mann-Whitney, Kruskal-Wallis) were used to compare quantitative variables. Multivariate logistic regression analysis was performed, including as independent variables those that were

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significant in the univariate analysis. The significance level accepted for all statistical tests was $P < 0.05$.

Result

A total of 189 patients were included in this study. There were 119 males (63%) and 70 females (37%) with a median age of 9.4 years (IQR 7-12). The median BMI was 18.9 kg/m^2 (IQR 16-21): 1.6% of the children were underweight (n=3), 67.7% normal (n=128), 20.1% overweight (n=38), and 10.6% obese (n=20). The most frequent operation was appendectomy (77.2%), followed by indirect inguinal hernia repair (8.5%).

Among the procedures reviewed, there were 29 clean surgeries (15.3%), 18 clean-contaminated surgeries (9.5%), 115 contaminated surgeries (60.8%), and 27 infected surgeries (14.3%). The median number of surgeries performed per patient was 1.0 and the median number of incisions per patient was 2.3 (IQR 2-3). Peritoneal fluid culture was obtained in 48 patients (25.4%), and it was positive in 22 (45.8%). Among the 22 patients with positive peritoneal fluid culture, E. Coli was the most common bacteria (81.8%). The median operative time was 45.6 minutes (IQR 30-60), and the median length of hospital stay was 1.9 days (IQR 1-2.5). SSI was observed in 7 patients (3.7%).

Regarding the first survey, the median duration of ibuprofen therapy was 1.8 days (IQR 0-3) with a median of 3.4 doses (IQR 0-5), while the median duration of paracetamol therapy was 0.7 days (IQR 0-1) with a median of 0.9 doses (IQR 0-2). The need for dressing changes was observed in 23 patients (12.2%). The median number of dressing changes was 0.1 (IQR 0-0), and the median number of consultations and emergency visits was 0.08 (IQR 0-0) and 0.02 (IQR 0-0), respectively. Dressing changes were more frequent in the umbilical incision (10.1%), followed by the hypogastric region (2.1%). The median postoperative day on which patients required a dressing change was the fourth postoperative day.

Regarding the satisfaction questionnaire, satisfaction levels for the number of dressing changes performed, complexity of wound care, postoperative pain and aesthetic results were 4.9 (IQR 2 – 5), 4.9 (IQR 2 – 5), 4.8 (IQR 2 – 5) and 4.8 (IQR 2 – 5), respectively. All families (100%) recommended the Mölndal technique.

In the comparison according to SWC, there were no differences between the four

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groups regarding the rate of SSI. However, there were statistically significant differences regarding sex, age, and length of stay. There were also significant differences regarding the duration of analgesic therapy and the number of incisions. The median number of dressing changes, consultations, and emergency visits were similar in all groups, as were satisfaction levels. **(Table 2).**

	Class I (n=29)	Class II (n=18)	Class III (n=115)	Class IV (n=27)	p-value
Age (years)	3	13	10	9	< 0.0001
Males/Females	22/7	4/14	80/35	13/14	< 0.0001
Number of incisions	3	3	2	3	< 0.0001
Length of stay (days)	0	1	1	5	< 0.0001
Analgesic therapy (days)	2	2	3	4	< 0.0001
Dressing changes	0	0	0	0	n/s
Consult visit	0	0	0	0	n/s
Emergency visit	0	0	0	0	n/s
SSI (%)	3.4	11.1	1.7	7.5	n/s
Satisfaction changes	5	5	5	5	n/s
Satisfaction complexity	5	5	5	5	n/s
Satisfaction pain	5	5	5	5	n/s
Satisfaction aesthetics	5	5	5	5	n/s
Recommendation (%)	100	100	100	100	n/s

Comparison according to SWC

Table 2: SSI, surgical site infection; SWC, surgical wound classification; n/s, not statistically significant. P-values indicate comparisons across the four wound classification groups.

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The comparison of patients who required dressing changes and those who did not is shown in **Table 3**. There were significant differences regarding age, sex, number of consultations, and emergency visits. BMI, diagnosis, SWC and number of incisions did not differ between the two groups. All satisfaction levels were similar in both groups.

	Patients who required change (n=23)	Patients who did not (n=166)	p-value
Age (years)	12	10	0.03
BMI (kg/m^2)	19	18	n/s
Males/Females	19/4	100/66	0.04
Number of incisions	3	3	n/s
Length of stay (days)	1	1	n/s
Analgesic therapy (days)	3	3	n/s
Dressing changes	1	0	<0.0001
Consult visit	1	0	<0.0001
Emergency visit	0	0	0.003
SSI (%)	0	2.4	n/s
Satisfaction changes	5	5	n/s
Satisfaction complexity	5	5	n/s
Satisfaction pain	5	5	n/s
Satisfaction aesthetics	5	5	n/s
Recommendation (%)	100	100	n/s

Comparison between patients who required changes and those who did not.

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Table 3: BMI, body mass index; SSI, surgical site infection; SWC, surgical wound classification; n/s, not statistically significant. P-values indicate comparisons between the two groups.

Discussion

In 1962, George Winter, known as "the father of moist wound healing", demonstrated the advantages of keeping wounds moist for faster healing.[7] A moist environment has several benefits: regulation of oxygen tension, promotion of capillary formation and cellular proliferation and differentiation, dissolution of necrotic tissue, and prevention of wound infection. [8] Although gauzes and bandages have been used for covering incisions for hundreds of years, their functions are limited.[8] Modern moist dressings have replaced them because of their improved functions. However, sometimes it is difficult to decide which dressing is best, since there is a lack of evidence in this area.[8]

The Mölndal technique is an occlusive dressing that combines a hydrofiber absorbent wound pad with a transparent polyurethane film. [5,6] This technique has been successfully tested in orthopedic, thoracic, and general surgery in adults. [5,6] Marinovic et al., in their study about the benefits of the Mölndal technique after laparoscopic cholecystectomy, found a lower wound infection rate in the Mölndal group (2%) compared with the traditional technique group (14%).[9] Subsequently, the same group studied the application of the Mölndal technique after excision of pilonidal sinus and after implantation of partial endoprostheses in hip fractures. They found a lower wound infection rate in the Mölndal group in both scenarios.[6] In our study, SSI was observed in 3.7% of the patients. Therefore, the Mölndal technique seems to be effective in preventing SSI in pediatric patients after laparoscopic surgery. To our knowledge, this is the first study investigating the effectiveness of the Mölndal technique in children.

SWC measures the degree of contamination during surgery and is used to stratify the risk of SSI.[10] It is known that the

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cleaner the surgery, the lower the risk of postoperative infection.[11] Therefore, we decided to study SSI rates according to SWC. There were no statistically significant differences between the four groups, so SWC did not alter postoperative wound infection rates. Some authors argue that it is uncertain whether covering surgical wounds with dressings reduces the risk of SSI, or whether any particular dressing is more effective than others in reducing the risk of SSI. [3,12] These authors advocate that the decision to use wound dressings should be based on the patient's characteristics and the relative risks and benefits of the availably dressings. Among the advantages of the Mölndal technique are a reduction in the number of dressing changes and, therefore, a reduction in nursing time; lower pain and anxiety scores; higher comfort; waterproof properties; and a reduction in the cost of medical care. [5,6] In our study, the median duration of analgesic treatment was less than 2 days. Only the 12.2% of patients needed a dressing change. Patients who required dressing changes were statistically significant older and predominantly male, but there were not significant differences regarding diagnosis, SWC and number of incisions between patients who needed dressing changes and those who did not. Our results agreed with those of Marinovic et al., who found that dressing changes were more frequent in the umbilical region.[9] Reducing the number of dressing changes diminishes patient pain and anxiety and avoids inaccurate wound management, which in turn reduces the risk of SSI.[6,8,13] Wu et al. investigated the pain management of wound dressing in children and they found that children did not receive accurate analgesic treatment in more than 75% of the hospitals of their study.[14] Our patients reported a high level of satisfaction with pain management.

Parents play a key role in postoperative wound care. They are often concerned about pain and cosmetic appearance. Tandan et al. evaluated parental knowledge of wound care to determine the need for educational programs.[15] Although most parents in their study had previous surgical experience, there were no significant differences between surgically experienced and inexperienced parents. The majority of parents felt that daily dressing changes were necessary, and several patients visited a primary care physician for wound review and dressing changes due to parental anxiety. The authors concluded that there is a deficiency in parental knowledge of how

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to manage surgical wounds. Therefore, standardized discharge instructions may improve parental understanding, leading to better outcomes.[15] In our study, we provided an evaluation questionnaire with instructions after surgery and a satisfaction questionnaire after wound revision. We observed a very low rate of postoperative visits, even among patients who needed dressing changes. We believe this is due to precise postoperative wound care instructions. In addition, satisfaction levels regarding the number of changes, complexity of wound care, and aesthetic results were high, and all families recommended the Mölndal technique.

The limitations of our study are that some assessments are performed by parents and patients and thus may be subject to subjectivity. SWC and SSI may also be biased by interobserver variability. It is well known in the literature that there are significant inaccuracies in the reporting of SWC. On the other hand, the definition of SSI varies between hospitals, and it can also be difficult to diagnose because some signs can be confused with those that occur in a normal healing wound. Furthermore, the comparison between different surgical dressings can be challenging due to the imprecise classification of dressings and the lack of studies in pediatric patients. It should also be taken into account that we will only include patients with no postoperative complications, except wound-related complications, because we believe that other complications could interfere with the results.

Conclusion

The Mölndal technique seems to be effective and safe for preventing SSI in pediatric laparoscopic surgery, achieving a low SSI rate of 3.7%. Dressing changes were infrequent and significantly associated with older age and male sex, while family satisfaction was exceptionally high. This is the first study evaluating the Mölndal technique efficacy in children, supporting its routine adoption over traditional dressings. Future projects should include randomized controlled trials comparing Mölndal versus traditional dressing and cost-effectiveness analyses.

Ethical Consideration

The study was approved by the Pontevedra-Vigo-Ourense Research Ethics Committee (approval date: June 23, 2020; approval number: 2020/133).

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Conflict of interests

There is no conflict of interest

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