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PerClot® Powder and Surgicel Efficiency on Intra-Abdominal Adhesions in Post-Surgical Hysterectomy in Rat Model

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Abstract

Introduction: Postoperative adhesions are a serious health problem with significant implications for quality of life and healthcare costs. This study aimed to investigate the effect of two substances, PerClot® Powder and Surgicel, in reducing adhesions after hysterectomy in rat models compared to the control group.

Methods: This study used an interventional laboratory trial design. The study population consisted of 30 adult female rats, which were randomly assigned to three groups (n=10 per group) and underwent hysterectomy under standard conditions. The three groups received either Surgicel, PerClot®, or no treatment (control group). Adhesions were graded using the Leach grading system and analyzed using SPSS version 22, through the Chi-square test.

Results: No significant difference was found among the Surgicel, PerClot®, and control groups regarding adhesion grades ($P=0.064$). However, a significant difference was observed between the Surgicel and control groups ($P=0.014$). The Surgicel group had a higher frequency of grade 0 adhesions (60%) and no grade 2 adhesions, while the control group had a frequency of 10% for grade 0 adhesions and 50% for grade 2 adhesions. Additionally, no significant difference was found between the PerClot® and control groups ($P=0.214$), indicating similar adhesion grade distributions. No significant difference was observed between the Surgicel and PerClot® groups ($P=0.301$).

Conclusion: According to the findings, Surgicel significantly reduces adhesion severity compared to the control, while PerClot® does not show a significant effect. In addition, there is no significant difference between the Surgicel and PerClot® groups regarding adhesion.

Keywords: Tissue adhesions, Hysterectomy, Hemostatic, Surgicel

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Introduction

Cesarean delivery is the most frequently performed major surgery worldwide, and its occurrence is rising rapidly. Cesarean sections can lead to both perioperative and postoperative complications, and are linked to immediate and long-term risks, such as a higher likelihood of requiring a hysterectomy (1). Notably, 70% to more than 90% of women undergoing gynecological surgeries experience intra-abdominal adhesions postoperatively (2-4).

These adhesions are fibrous bands of tissue that develop between organs following surgery (5,6). Such adhesions can lead to complications like chronic pelvic pain, infertility, and small bowel obstruction (7).

Adhesion formation begins with damage to the peritoneum during surgery. This damage, often exacerbated by infection or other irritants, triggers an inflammatory response that results in the release of a fibrous exudate containing fibrin. This fibrin then deposits locally, contributing to adhesion formation (8,9). The structure of the fibrin clot, which is key to these processes, depends on factors such as pH, ionic strength, and the concentrations of calcium, fibrinogen, and thrombin during gelation (10).

Hemostatic clot formation occurs when thrombin cleaves fibrinogen into fibrin. The concentration of thrombin during this process determines the final structure of the fibrin clot. Previous in vitro studies have shown that varying thrombin concentrations significantly affect the density and strength of the fibrin network (10).

Understanding the factors influencing fibrin clot formation is essential for developing strategies to prevent adhesion formation after surgeries like hysterectomy. Surgicel and PerClot® are among the most commonly used hemostatic agents in Iran to reduce hemorrhage during surgery. Surgicel is a plant-based local hemostatic agent made from oxidized regenerated cellulose (ORC) (11), while PerClot® is a polysaccharide-based hemostatic compound derived from starch. This powder enhances coagulation by absorbing water and increasing the concentration of clotting factors, thereby accelerating platelet plaque formation and the overall coagulation process (12, 13).

Several studies have investigated the potential of these agents in preventing postoperative adhesions. For instance, Rottenstreich et al. (2020) demonstrated that ORC can reduce the incidence of intraperitoneal adhesions in women undergoing repeated cesarean deliveries (13). Similarly, Raimondo et al. found that cellulose-based absorbable barriers were effective in preventing de novo adhesion formation during laparoscopic myomectomy (14).

However, other studies have shown conflicting results. Naito et al. observed that ORC was ineffective in preventing adhesions in a cohort of 99 patients who had undergone laparoscopic colorectal surgery (15).

The majority of research on the efficacy of hemostatic agents in adhesion prevention has been conducted in animal models (16). For example, Zhang et al. explored the effects of hyaluronic acid and ORC on adhesion formation (9), while Wen et al. studied the impact of PerClot® powder on postoperative intestinal adhesion formation (16). Additionally, Temiz et al. investigated the effect of ORC on peritendinous fibrotic adhesions after tendon repair surgery, all of which were conducted in rat models (17).

Despite the widespread use of Surgicel and PerClot® in clinical practice, there has been no research to date specifically investigating the preventive effects of these agents on intra-abdominal adhesions following hysterectomy. Therefore, this study aimed to evaluate the potential of Surgicel and PerClot® in preventing intra-abdominal adhesions after hysterectomy in a rat model.

Methods

Sample selection and determination of sample size

This study is an interventional laboratory study, classified as a subset of a descriptive analytical study. With a confidence level (α) of 95%, a power (β) of 90%, a standard deviation (σ) of 0.9 for the adhesion score, and a mean difference (Δ) of one unit in the adhesion score between the PerClot® powder and Surgicel groups, the minimum required sample size (n) in each group, based on the following formula, is 10 (18).

$$n = \frac{\left(Z_{1-\alpha/2} + Z_{1-\beta}\right)^2 \times 2\sigma^2}{\Delta^2} \quad \text{Eq. (1)}$$

Procedure

The study population consisted of 30 adult female Wistar albino rats with an average weight of 160 grams, obtained from the Yazd Reproductive Sciences Institute. After approval from the Ethics Committee of Yazd Shahid Sadoughi University and receiving an ethical code, the rats were randomly divided into three groups. The rats were anesthetized intramuscularly with 10% ketamine at a dose of 50 mg/kg and 2% xylazine at a dose of 5 mg/kg. The abdomen was shaved, and preoperative preparation was done using Betadine.

All rats underwent hysterectomy, performed by a surgeon in a clean environment through a 3 cm midline incision (19). In the control group, only the hysterectomy was performed, with no substances introduced into the abdomen. In one intervention group, PerClot® powder was applied, and in the other, Surgicel® was used during the hysterectomy. In all groups, the peritoneum, midline fascia, and the second skin layer were closed with 0.2% Vicryl sutures. No bandages were applied to any of the groups.

After surgery, the rats were placed in clean recovery cages on a heating pad. Once fully conscious, the rats were moved to animal housing under standard conditions (temperature 20–25°C). Four weeks after the surgery, the rats were euthanized by cervical dislocation (CD), which involves applying rapid force to the neck (20), followed by the removal of the anterior abdominal wall.

The entire abdomen was examined for adhesion sites, adhesion scores, and potential side effects. A blinded method was used to minimize bias.

Degree of adhesion

The degree of adhesion formation in laboratory animals (rats) was evaluated using the grading system established by Leach (21). This system assessed adhesion severity based on the following criteria: 0 = no adhesion; 1 = adhesion separable from the tissue with gentle traction; 2 = adhesion separable with moderate traction; and 3 = adhesion requiring sharp dissection for separation. The total adhesion score for each group was calculated as the sum of these individual parameters (21, 22). Notably, none of the laboratory animals exhibited grade 3 adhesions in this study

Statistical analysis

The data were then entered into SPSS version 22, and the Chi-square test was used for data analysis.

Results

In this study, 30 female rats with an average weight of 160 g were divided into three groups of 10 rats.

Table 1 compares the frequency distribution of adhesion

grades among the three studied groups (Surgicel, PerClot®, and control groups).

As shown in Table 1, no significant difference was observed among the 3 groups, including Surgicel, PerClot®, and control groups, regarding adhesion grades ($P=0.064$).

Table 2 compares the frequency distribution of adhesion grades between the two studied groups (Surgicel and the control group).

As shown in Table 2, a significant difference was observed between the Surgicel and control groups ($P=0.014$); the Surgicel group had a higher frequency of grade 0 adhesions (60%) and no grade 2 adhesions. In contrast, the control group had a frequency of 10% for grade 0 adhesions and 50% for grade 2 adhesions.

Table 3 compares the frequency distribution of adhesion grades between the PerClot® and the control group.

As shown in Table 3, no significant difference was observed between the PerClot® and the control group regarding adhesion grades ($P=0.214$).

Table 4 compares the frequency distribution of adhesion grades between the Surgicel and the PerClot® group.

As shown in Table 4, no significant difference was observed between the Surgicel and the PerClot® group regarding adhesion grades ($P=0.301$).

Statistical Analysis

Data were entered into SPSS version 23. Chi-Square test was used for data analysis. $P<0.05$ was assumed significant.

Discussion

One of the most common side effects of hysterectomy is intra-abdominal adhesions, which can result from the surgery and lead to chronic abdominal pain, intestinal obstruction, and fertility disorders (23). These adhesions significantly reduce the patient's quality of life and make subsequent surgeries more difficult (6). Furthermore, hysterectomy often causes hemorrhage, making the use of hemostatic agents to control bleeding necessary.

Aktekin et al. demonstrated that a hydrogel formulation containing carboxymethyl cellulose (CMC) and sodium solution in an aqueous solution of oxidized regenerated cellulose (ORC) can be more effective in preventing adhesions (24). These findings underscore the importance of further investigating the roles of CMC and ORC in reducing intra-abdominal adhesions after hysterectomy, as well as their hemostatic effects.

Recently, several reports have indicated that intra-abdominal adhesions can be prevented through the use of hemostatic compounds. In the current analysis, no significant difference in adhesion formation was observed between the PerClot® and normal saline groups. Similarly, there was no significant difference in adhesion formation between PerClot® and a chitosan derivative. Hoffman et al. studied six different hemostatic agents, including oxidized cellulose, thrombin-coated collagen microspheres, glutaraldehyde-activated collagen, thrombin-activated fibrin polymer, and glycol polymer. They found that activated starch microspheres and polyethylene glycol resulted in fewer adhesions compared to the control groups (6). Therefore, these components may help reduce peritoneal adhesion formation.

Given the common use of PerClot® and Surgicel as hemostatic agents in Iran, and their structural similarity in reducing adhesions, the preventive effects of these agents on adhesion formation were investigated in this study. The results demonstrate that Surgicel significantly reduces intra-abdominal adhesions. These findings are consistent with those of Raimondo et al. (2020) in Italy (14), Güney et al. (2016) in Germany (23), and Zhang et al. (2016) in China (9).

Karimi et al. conducted a comparative analysis of PerClot® powder and a chitosan derivative in animal models. This study involved three groups of rats: one treated with PerClot® powder, another with a chitosan derivative, and a third receiving only a laparotomy

Table 1. Comparison of the frequency distribution of adhesion grades among the studied groups

Group	Adhesion grade				
	0	1	2	Total	*P*-value*
Surgicel	6 (60)	4 (40)	0 (0)	10 (100)	0.064
PerClot®	4 (40)	4 (40)	2 (20)	10 (100)	
Control	1 (10)	4 (40)	5 (50)	10 (100)	
Total	11 (36.7)	12 (40)	7 (23.3)	30 (100)	

* Chi-square test, *P*-value < 0.05 was significant

Table 2. Comparison of the frequency distribution of adhesion grades between the Surgicel and the control group

Group	Adhesion grade				
	0	1	2	Total	*P*-value*
Surgicel	6 (60)	4 (40)	0 (0)	10 (100)	0.014
Control group	1 (10)	4 (40)	5 (50)	10 (100)	
Total	7 (35)	8 (40)	5 (25)	20 (100)	

* Chi-square test, *P*-value < 0.05 was significant.

Table 3. Comparison of frequency distribution of adhesion grades between the PerClot® and the control group

Group	Adhesion grade				
	0	1	2	Total	*P*-value*
PerClot®	4 (40)	4 (40)	2 (20)	10 (100)	0.214
Control group	1 (10)	4 (40)	5 (50)	10 (100)	
Total	5 (25)	8 (40)	7 (35)	20 (100)	

* Chi-square test, *P*-value < 0.05 was significant.

Table 4. Comparison of frequency distribution of adhesion grades between the Surgicel and the PerClot® group

Group	Adhesion grade				
	0	1	2	Total	*P*-value*
Surgicel	6 (60)	4 (40)	0 (0)	10 (100)	0.301
PerClot®	4 (40)	4 (40)	2 (20)	10 (100)	
Total	10 (50)	8 (40)	2 (10)	20 (100)	

* Chi-square test, *P*-value < 0.05 was significant.

(control). The mean adhesion scores for these groups were 2 ± 0.87, 2.11 ± 0.78, and 1.67 ± 0.87, respectively. Notably, no significant difference in adhesion scores was observed among the three groups ($P = 0.571$). Additionally, when comparing pairs of groups (group 1 vs. group 3, group 2 vs. group 3, and group 1 vs. group 2), no meaningful differences were found in the degree of adhesion (25). Despite the existing body of evidence supporting the anti-adhesive properties of chitosan and hemostatic compounds, this study did not yield similar results. The discrepancy may be attributed to variations in the derivatives used or the dosages of the compounds administered in different experiments.

Wen et al. assessed the preventive effect of starch-derived absorbable polysaccharides, such as PerClot®, sodium hyaluronate, and Arista™ AH, on postoperative intestinal adhesions. They found that the extent of adhesion in the intervention groups was significantly lower than in the control group (16).

One of the limitations of this study is the use of the Lynch grading system to classify the degree of adhesions. Surveys have shown that measuring the degree of adhesion, especially when the adhesions could fall into either a higher or lower grade, is a challenging task. Therefore, it is suggested that the capabilities of fuzzy logic decision-making, particularly when variables are closely related, should be considered for determining the different degrees of adhesion.

Conclusion

According to the findings, Surgicel significantly reduces adhesion severity compared to the control, while PerClot® does not show a significant effect. In addition, there is no significant difference between the Surgicel and PerClot® groups regarding adhesion.

In addition, we tend to assess multiple dosages of this manuscript and its effects on adhesion prevention in future studies to explore the dose-response relationship more thoroughly and to ensure a more comprehensive evaluation of the treatments' effectiveness.

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Author's Contribution

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Competing Interests

The authors declare that they have no conflict of interest.

Data Availability Statement

All necessary data will be available from the corresponding author upon reasonable request.

Ethical Approval

The proposal of this study was approved by the Ethics Committee of Yazd Shahid Sadoughi University of Medical Sciences (Ethical code: IR.SSU.MEDICINE.REC.1398.110).

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