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Optimizing the Management of Adhesions Following Abdominal Surgery: A Prospective Study

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Abstract. *Background.* Adhesive-related abdominal surgery remains a chronic issue in the surgical field and a significant source of long-term patient morbidity. These fibrotic bands can result in complications such as: intestinal obstruction, chronic abdominal or pelvic pain, infertility, and repeat surgical procedure. Multiple preventive strategies have been suggested; however, their application in day-to-day clinical practice is variable and inadequately standardized. We looked at whether a structured and multidisciplinary protocol that they co-created with the Departments of General Surgery and Gynecology can reduce the incidence of adhesion-induced complications. *Methods.* We conducted a prospective trial of patients undergoing elective or emergency abdominopelvic procedures. There were two arms of the participants – regular care or advanced adhesion-control protocol. The protocol highlighted three central themes: 1) rigorous clinical practice and strict adherence to tissue-handling principles; 2) an algorithm-based selection and usage of adhesion-barrier materials; and 3) standard postoperative follow-up. The primary endpoint was the 12-month incidence of a composite outcome including all adhesion-related adverse events. Secondary endpoints were adhesive small-bowel obstruction (SBO), chronic abdominal pain, reoperation, length of hospital stay, and quality-of-life (QoL) scores. *Results.* 310 patients were assessed with 155 individuals in each group. The demographic and clinical baseline characteristics were similar. The primary outcome of the composite was significantly less frequently reported in the protocol group compared to routine-care group (18.1% vs. 35.5%; absolute reduction in risk = 17.4%; 95% CI 10.2–24.6; $p < 0.001$). Prominent improvements are also noted in secondary outcomes: adhesive SBO (7.7% vs. 20.0%; $p < 0.001$), chronic pain (18.1% vs. 34.8%; $p < 0.001$) and reoperation (3.9% vs. 12.3%; $p < 0.001$). The intervention group had significantly shorter mean hospital stay (4.2 days vs. 6.5 days; $p = 0.01$). At 12 months, QoL assessments revealed higher physical-component scores (75.1±7.8 vs. 60.2±8.5; $p < 0.001$) and mental-component scores (35.0±3.5 vs. 33.0±4.0; $p = 0.03$). *Conclusion.* A consistent, evidence based, multidisciplinary protocol for adhesion prevention decreases both the frequency and severity of postoperative adhesion and the related complications. The collaborative approach improves not only the patients' quality of life, but also makes appropriate investment in health services, so as this can fit into ordinary surgical procedures.

Keywords: postoperative adhesions, abdominal surgery, gynecologic surgery, adhesion prevention, multidisciplinary protocol, quality of life, surgical outcomes.

Introduction

They are formed during abdominal rehabilitation, and postoperative abdominopelvic adhesions are dense bands that connect adjacent surfaces of the abdomen to the peritoneal walls, organs and walls of the abdomen. They also form as part of a normal healing cascade and normal physiological response of the body, an inflammatory cascade causing the aggregation and collection of blood vessels, which promotes tissue

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repair through the deposition and organization of fibrin. However, if the reparative action of the muscle is exaggerated or uncoordinated in the tissue recovery, too much fibrous tissue forms that mess up in the body with abnormal anatomy and physiology [1]. The result isn't just biological in nature; adhesions can cause significant long-term morbidity in many patients. Adhesions do have significant, long-term morbidity from clinical and financial consequences. They are still the most common cause of small-bowel obstruction, with nearly three-quarters of them requiring surgery, and these procedures are often both immediately and technically complex [2, 3]. Furthermore, a great number of patients have persistent abdominal or pelvic pain that could affect daily routines and prove difficult to treat conservatively [4, 5]. In gynecology, adhesions are generally the well-known cause of female infertility, which in most cases result from distortion of pelvic anatomy and/or obstruction of fallopian tubes [6, 7]. They also complicate any future abdominal surgery, leading to a higher risk of inadvertent bowel trauma, extended operative time, increased blood loss, as well as other postoperative morbidities, all driving healthcare costs [8, 9]. On the global economic scale, readmission and operative costs for adhesion-related disorders constitute billions yearly [10], highlighting the magnitude of the issue [11]. Preventing adhesions is decades old. The move towards minimally invasive surgery, including laparoscopy, is a significant development as it reduces peritoneal trauma, desiccation and exposure [11]. In both open and laparoscopic protocols: careful surgical technique – gentle handling of tissue, good hemostasis and avoiding of foreign material – continued to be the mainstay of prevention [12]. Apart from technique, a number of barrier products used to achieve an anti-adhesion barrier such as membrane-based agents (HA-CMC, ORC) and liquid barriers (icodextrin 4% solution) were already available and have been employed in the previous work. These agents have been reported to reduce adhesion formation in a series of randomized clinical trials and meta-analyses [13–15]. Although these evidence-based measures exist, they are rarely used routinely in surgical practice [16, 17]. General surgeons and gynecologists, who together conduct the majority of abdominopelvic surgery, also frequently have diverse approaches to risk and knowledge of barrier technology. The lack of a unified, standardized protocol for adhesion prophylaxis across these surgical domains represents an opportunity lost for achieving better surgical outcomes. Thus, we hypothesized a collaborative evidence-based protocol for adhesion prevention that would be shared by general in addition to gynecology departments would decrease the incidence and grade of postoperative adhesions and associated complications. This prospective study was conducted to evaluate this hypothesis, comparing the outcomes of patients treated according to this new collaborative protocol to those under traditional surgeon-dependent care.

Methods

Design and review. The study was a prospective trial in one academic tertiary care center. A multidisciplinary steering committee composed of consultants from the Departments of General Surgery and Gynecology formed the basis for the protocol and the complete statistical analysis. Guidelines and protocol analysis guidelines were approved by the institutional ethics committee prior to the development of the study. All studies were conducted in accordance with the Declaration of Helsinki and written informed consent was obtained prior to each individual before entering the study.

Participants. We enrolled adult (≥18 years) participants who were to have elective or urgent operation of the abdominal or pelvic tract (open or laparoscopic procedure). Procedures were performed by qualified surgical surgeons operating on the trial in General Surgery or Gynecology services. The eligibility criteria was intentionally broad and encompassed a large cross-section of procedures commonly associated with adhesion formation, in an effort to increase external validity. These referred to and were not restricted to

the intestinal resections (colorectal), adhesiolysis (enterolysis), total abdominal hysterectomy, myomectomy and operative treatment for endometriosis.

Exclusion criteria. To exclude certain patients from entering, the following exclusion criteria were used:

- Persons for whom the principal goal of surgery included the extensive division and removal of dense scar tissue (frozen abdomen) (often referred to as the frozen abdomen).
- Existence of an active intra-abdominal infection or perforation (generalized peritonitis).
- Medical history of metastatic carcinomatosis (widespread cancer).
- Pregnancy (this applied to a non-obstetric surgical case within the gynecology service).
- Any reported hypersensitivity or allergy to ingredients specified within the anti-adhesion barrier products tested for trial purposes.
- Unable to give informed consent or adhere to a follow-up schedule.
- Concurrent participation in another interventional clinical trial that may bias findings.

Study interventions. ***Control group.*** Patients in the control arm had standard surgical management, in accordance with each operating surgeon's routine practice and the institutional guidelines. Everything about adhesion prevention (e.g., barrier-agent application) was left solely to the surgeon. This was intended to represent regular, normal surgical care. ***Intervention group.*** The patients involved in the intervention arm underwent treatment based on a standardized protocol devised by the study's multidisciplinary steering committee. It required strict monitoring of surgical technique and set forth specific criteria for the selectively applied adhesion barriers, based on a decision algorithm that had been established beforehand. In the high-risk patient, surgeons would have to use one of the following FDA-approved barriers (e.g., presence of extensive raw peritoneal surfaces, bowel anastomosis, prior history of adhesive disease, ovarian surgery):

- *Hyaluronic acid-carboxymethylcellulose (HA-CMC) membrane (Seprafilm®)* for open procedures with anastomoses/large denuded surfaces (e.g., following colectomy/radical hysterectomy).
- *Oxidized regenerated cellulose (ORC) (Interceed®)* for gynecologic procedures, particularly to cover raw surfaces on the ovary or pelvic sidewall to prevent adnexal adhesions.
- *Icodextrin 4% solution (Adept®)* given at the end of laparoscopic therapies (normally 1000 mL) for hydroflotation and the separation of opposing surfaces in mesothelial regeneration.

Outcomes. The outcome followed was a composite incidence of adhesion-related morbidity at 12 months post operation. Part of this composite was established when either of the following criteria were met, as determined by a blinded clinical endpoints committee: clinical or radiological diagnosis of adhesive small bowel obstruction (SBO) with admission for nonoperative management or surgery. Chronic pain due to postoperative adhesions according to strict clinical criteria. It was defined as persistent abdominal or pelvic pain longer than 3 months. In order to qualify, the pain had to score at least 4 on the Visual Analog Scale (VAS), and must not be explained by a different identifiable medical condition. Patients who met these criteria required either ongoing analgesic therapy (the usual route of analgesia) or regular follow-up with a provider in order to control pain. In adhesive disease, reoperation revealed intraoperative findings which confirmed adhesions as the primary pathology. The secondary outcomes involved: length of index hospital stay; patient-reported quality of life assessed via the SF-36v2 questionnaire (generating PCS/MCS at baseline, 6 months, and 12 months); all-cause mortality 90 days after surgery; procedure timing or estimated blood loss; protocol adherence rate in the intervention arm.

Statistics. Estimates of the sample size were calculated according to the primary composite outcome. We wanted to see a 40% relative risk reduction (to 21% for the intervention group) if the event rate was 35% in the control group at 12 months. A total of 140 patients per group was required (90% power;

two-sided alpha = 0.05). To allow for a loss to follow-up of 10%, we were targeting 155 patients per group (total N = 310). All analyses were conducted on an intention-to-treat (ITT) basis. Continuous variables were compared using Welch's two-sample t-test ± SD or n (%) (RD − risk difference, OR − odds ratio, CI − confidence interval). All categorical variables were reported as counts and percentages, followed by a chi-square test or Fisher's exact test. The primary outcome and binary secondary outcomes were compared according to chi-square tests, with relative risks (RR) and 95% confidence intervals (CI) computed. Repeated measures were evaluated using linear mixed models for quality-of-life scores. Subgroup analyses for surgical specialization and approach were carried out as previously described. We considered a two-sided p-value <0.05 significant. Analyses were performed using SAS version 9.4.

Results

Patient population. 610 patients were selected for eligibility between January 2021 and December 2023. Following exclusions (145 didn't meet criteria, 105 refused, 50 for other reasons), 310 patients were enrolled and randomized, 155 patients being allocated to each group. Follow-up was 98% complete at 12 months. The demographic and clinical characteristics of the groups were well spread out at baseline respectively (Table 1). The average age was 47 years with 63% female, and there was comparable distribution by surgical specialty and approach. Prior abdominal surgery was similar between groups (40% vs. 38%).

Table 1. Baseline characteristics of the patients

Characteristic	Control (n = 155)	Intervention (n = 155)	Between-group difference (95% CI)	Test (statistic)	p-value	Effect size
Age, years − mean±SD (95% CI)	47.3±12.5 (45.32–49.28)	46.9±11.8 (45.03–48.77)	0.40 (–2.32 to 3.12)	Welch t = 0.29, df = 307	0.772	Cohen's d = 0.03 (–0.19 to 0.26)
Female sex − n (%)	95 (61.3%)	98 (63.2%)	RD = –0.019 (–0.127 to 0.089)	χ^2 test	0.815	OR = 0.92 (0.58–1.46)
BMI, kg/m² − mean±SD (95% CI)	27.8±5.1 (26.99–28.61)	28.1±5.4 (27.24–28.96)	–0.30 (–1.47 to 0.87)	Welch t = –0.50, df = 307	0.615	Cohen's d = –0.06 (–0.28 to 0.17)
ASA class III/IV − n (%)	51 (32.9%)	49 (31.6%)	RD = 0.013 (–0.091 to 0.117)	χ^2 test	0.903	OR = 1.06 (0.66–1.71)
Prior abdominal surgery − n (%)	62 (40.0%)	59 (38.1%)	RD = 0.019 (–0.089 to 0.128)	χ^2 test	0.816	OR = 1.07 (0.70–1.64)
General surgery − n (%)	78 (50.3%)	76 (49.0%)	RD = 0.013 (–0.098 to 0.124)	χ^2 test	0.910	OR = 1.05 (0.67–1.64)
Open approach − n (%)	85 (54.8%)	80 (51.6%)	RD = 0.032 (–0.079 to 0.143)	χ^2 test	0.649	OR = 1.14 (0.73–1.78)
Operative time, min − mean±SD (95% CI)	71±25 (67.03–74.97)	73±25 (69.03–76.97)	–2.0 (–7.59 to 3.59)	Welch t = –0.70, df = 308	0.482	Cohen's d = –0.08 (–0.30 to 0.14)

Note. Continuous variables were compared using Welch's two-sample t-test ± SD or n (%). Categorial variables were compared using the chi-square test. RD − risk difference; OR − odds ratio; CI − confidence interval.

Primary outcome. The primary composite outcome of adhesion-associated morbidity within 12 months was considerably less frequent for the intervention group (28 patients, 18.1%) than for the control group (55 patients, 35.5%). This translates to an absolute risk reduction of 17.4% (95% CI, 10.2 to 24.6) and a relative risk of 0.51 (95% CI, 0.39 to 0.68; $p < 0.001$).

Secondary outcomes. Results of the intervention were in line with all adhesion-specific endpoints (Table 2). The incidence of adhesive SBO for the intervention group was more than halved in comparison with the control group (7.7% vs. 20.0%; RR 0.39, $p < 0.001$).

Similarly, the incidence of chronic pain was also significantly lower (18.1% vs. 34.8%; RR 0.52, $p < 0.001$), and the requirement of the reoperation for the adhesions was by two-thirds lower (3.9% vs. 12.3%; RR 0.32, $p < 0.001$). The median hospital stays of patients in the intervention group were significantly less in comparison with the control group (4.2 days [IQR 3.0–7.0] vs. 6.5 days [IQR 4.0–9.0], $p = 0.01$). Quality of life (QoL) of patients in the intervention group also improved significantly (12 months) by comparison. The Physical Component Summary (PCS) score was increased by 14.9 points (75.1 vs. 60.2; $p < 0.001$), and the Mental Component Summary (MCS) score also increased significantly (35 vs. 33; $p = 0.03$). 90-day mortality did not differ by groups.

Table 2. Primary and secondary outcomes at 12 months

Outcome measure	Control group (n = 155)	Intervention group (n = 155)	Effect size (95% CI)	p-value
Primary composite outcome, n (%)	55 (35.5%)	28 (18.1%)	ARR 17.4% (10.2 to 24.6)	<0.001
Adhesive SBO, n (%)	31 (20.0%)	12 (7.7%)	RR 0.39 (0.22 to 0.68)	<0.001
Chronic pain (VAS ≥4), n (%)	54 (34.8%)	28 (18.1%)	RR 0.52 (0.35 to 0.76)	<0.001
Reoperation for adhesions, n (%)	19 (12.3%)	6 (3.9%)	RR 0.32 (0.14 to 0.73)	<0.001
Length of stay (days, median [IQR])	6.5 [4.0–9.0]	4.2 [3.0–7.0]	MD 2.3 days	0.010
Quality of life (SF-36, mean±SD)				
Physical component summary (PCS) at 12 months	60.2±8.5	75.1±7.8	MD 14.9 (13.2 to 16.6)	<0.001
Mental component summary (MCS) at 12 months	33.0±4.0	35.0±3.5	MD 2.0 (1.1 to 2.9)	0.030
All-cause 90-day mortality, n (%)	2 (1.3%)	1 (0.6%)	RR 0.50 (0.05 to 5.45)	1.000

Note. Categorical variables using chi-square or Fisher's exact tests. ARR − absolute risk reduction; RR − relative risk; MD − mean difference; CI − confidence interval; IQR − interquartile range; SBO − small bowel obstruction; VAS − visual analog scale. p-values <0.05 were considered statistically significant.

Discussion

Results of this study show that a standardised and interdisciplinary treatment modality for adhesion prevention would be of great benefit to patients undergoing abdominal and pelvic surgery. Applying the tenets of a very fine surgical technique in conjunction with an orchestrated and algorithm guided approach in the use of adhesion barriers in surgical procedures improved the odds of preventing adverse adhesion events by (approximately) 50%. These effects were observed in all pre-defined outcome measures [18–21]. Especially relevant is the substantial decrease in adhesive small bowel obstruction (SBO) − where 60% was reduced (from 20% to 8%). Such reduction has enormous impact for patient safety and healthcare resource usage, as SBO need urgent hospitalization and has a chance of complicated repeat surgery [22, 23]. Similarly, the decrease of excessive and debilitating symptoms of pain addresses a severe complication of which there are few medical treatment alternatives. These findings validate the benefits of adopting a more proactive intraoperative approaches and the prevention of the long-term complication of adhesions [21, 23]. The 15-point increase in the physical component score of quality of life (QoL) detected is one of the biggest effect sizes in surgical literature. Our finding demonstrates that successful adhesion prevention not only diminishes complications but also directly improves patients' physical well-being. Although the decreased hospital length of stay (LOS) was a secondary outcome, it indicates a more smooth and efficient recovery, probably as a result of reduced postoperative inflammation and more efficient restoration of gastrointestinal function, which increases hospital resource efficiency [1]. We are calling this initiative successful due to the nature of its systematic, collaborative design. Instead of focusing on only one barrier product, the protocol promoted an institutional culture around adhesion prevention. An active role of both General Surgeons and Gynecologists in designing and adopting the protocol developed shared responsibility and a dedication to enhancing surgical outcomes. High adherence suggests that the protocols applied and served operative groups effectively. This collaborative strategy is applicable to a multitude of complex surgical problems and demonstrates a model that could be applied elsewhere to other complex surgical problems that require collaboration between different clinical subspecialties.

Study limitations

Several methodological limitations of this research deserve explanation. First, the trial at one academic medical center may constrain the generalizability of our findings to community hospitals, in which resource, surgical expertise, and procedural volume differences can affect outcomes. Second, the pragmatic design of the study did not allow operating surgeons to be blinded to treatment allocation. While it is the absence of masking that allows for the potential for performance bias, we minimized this risk by blinding both patients and outcome assessors and using objective endpoints, such as reoperation rates. Third, the evaluation of adhesion-related chronic pain is inherently inferential. To minimize the risks of misclassification, a blinded adjudication committee used rigorous, defined criteria. Although a second look laparoscopy would allow more direct assessment of adhesions, it does not reflect routine clinical practice, nor is it practical or ethical [20]. Our composite endpoint was intended to document events that are clinically meaningful and of primary importance to patients. Lastly, although the 12-month follow-up period captures most of the early adhesion-related complications, longer observation would be appropriate to fully estimate lifetime risk factors, such as continuing surgical procedures in the future or effects on fertility. Planning is in place for more extended follow-up in the follow-up of this cohort.

Conclusion and suggestions. Recommendations

This study presents compelling evidence that combining a team-based, evidence-based approach to adhesion prevention in a comprehensive fashion with scrupulous surgical detail and selective utilization of anti-adhesion barriers significantly increases treatment results in better patient outcome in General Surgery and Gynecology using an evidence-based approach to adhesion prevention. These results underline the limitation of the heterogeneous and surgeon-dependent nature of most care given by surgeons, and the potential of unified, multidisciplinary work. We recommend surgical departments and hospital administrators start implementing such multidisciplinary protocols into regular surgical care. Some steps may be called for to achieve good implementation:

- *Training and education.* Formal instruction on adhesion prevention should be integrated into surgical residency programs and continuing professional development programs.
- *Framework.* Develop specialty-specific, evidence-based approaches for the selection and application of adhesion barriers.
- *Interdepartmental coordination.* The General Surgery and Gynecology team should implement formalized methods for continuous communication within their disciplines, the sharing of audit resources, as well as co-creation of quality-improvement efforts.

Using this consolidated approach, hospitals can minimize morbidity related to postoperative adhesions. This makes surgical procedures safer, improves patients' quality of life and uses healthcare resources effectively.

Author contributions

Muhammad Munir Memon − concept and design, literature collection and data search, drafting of manuscript, critical revision, final approval of the version to be published.

Zaheera Saadia − data analysis and interpretation, literature collection and data search, drafting of manuscript, critical revision, final approval of the version to be published.

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