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Original Research Article

Assessment of Peritoneal Adhesion Index in Abdominal Surgeries: A Prospective Observational Study

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Abstract

Background: Peritoneal adhesions are a common consequence of intra-abdominal surgery and may result in significant morbidity, including intestinal obstruction, chronic abdominal pain, infertility, prolonged operative time, and increased surgical difficulty during subsequent procedures. The Peritoneal Adhesion Index (PAI) provides a standardized method for objectively assessing the extent and severity of intra-abdominal adhesions.

Aim: To assess the severity and distribution of peritoneal adhesions using the Peritoneal Adhesion Index and to evaluate their association with previous abdominal surgeries, surgical approach, operative difficulty, and postoperative outcomes.

Materials and Methods: A prospective observational study was conducted among 50 patients aged 18–70 years undergoing abdominal surgery at Narayana Medical College and Hospital, Nellore, over an 18-month period. Patients with intra-abdominal adhesions identifiable during laparotomy or laparoscopy were assessed using the PAI. Demographic characteristics, previous surgical history, type of surgery, adhesion severity, operative parameters, postoperative complications, and duration of hospital stay were recorded. Patients were followed during hospitalization and at 1 and 3 months postoperatively. Statistical analysis was performed using SPSS, with $p<0.05$ considered statistically significant.

Results: The study included 28 males (56%) and 22 females (44%), with a mean age of approximately 42.6 years. Open surgery was performed in 32 patients (64%), while 18 (36%) underwent laparoscopic surgery. Mild adhesions (PAI 0–5) were present in 42% of patients, moderate adhesions (PAI 6–10) in 34%, and severe adhesions (PAI >10) in 24%. Patients undergoing their first abdominal surgery had a lower mean PAI score (4.8 ± 2.1) compared with those with two or more previous surgeries (9.6 ± 3.4), demonstrating a strong association between repeated surgery and adhesion severity. Severe adhesions were more frequent following open surgery than laparoscopic surgery. Higher PAI scores were associated with prolonged operative duration, increased blood loss, postoperative complications, and longer hospital stay. Postoperative complications included bowel obstruction (18%), chronic abdominal pain (28%), and infertility among female patients (14%). Overall, 60% of patients recovered without complications, while 24% developed complications and 16% required intervention.

Conclusion: Peritoneal adhesions are common among patients undergoing abdominal surgery, with greater adhesion severity observed in patients with previous abdominal operations and following open procedures. Increasing PAI scores were associated with greater operative difficulty and postoperative morbidity. The Peritoneal Adhesion Index provides a useful standardized approach for quantifying adhesion burden and may assist in surgical planning, risk stratification, and evaluation of postoperative outcomes. Strategies aimed at minimizing peritoneal trauma and promoting minimally invasive surgery may help reduce adhesion-related morbidity.

Keywords: Peritoneal adhesions; Peritoneal Adhesion Index; Abdominal surgery; Postoperative complications.
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Introduction

Abdominal surgery is an essential component of modern medical practice, offering treatment for a wide range of conditions. However, even when performed under optimal conditions, surgical

intervention within the peritoneal cavity carries the risk of postoperative complications. Among these, the formation of peritoneal adhesions is one of the most frequent and clinically significant [1,2]. Peritoneal adhesions are fibrous bands that develop between abdominal organs or between organs and the abdominal wall, usually as a response to surgical trauma, infection, or inflammation [3]. Although adhesions may remain asymptomatic in some individuals, they can lead to serious complications such as intestinal obstruction, infertility, chronic abdominal pain, and increased technical difficulty during subsequent surgeries [4]. In addition, they contribute significantly to healthcare costs due to repeated hospital admissions and reoperations [5].

Despite their high prevalence and clinical impact, adhesions have often been underestimated and inconsistently described in surgical literature [2]. To address this limitation, the Peritoneal Adhesion Index was developed as a standardized method for adhesion assessment. This scoring system evaluates adhesions based on their severity and distribution across predefined intra-abdominal regions, enabling uniform documentation and facilitating comparison across studies [6].

Elective abdominal surgeries provide an opportunity to study adhesions under relatively controlled conditions compared to emergency procedures. Assessment using PAI in such cases helps in understanding adhesion patterns and identifying relevant risk factors [7]. Peritoneal adhesions represent an almost inevitable consequence of intra-abdominal surgical intervention, arising as part of the normal healing response. Despite advances in surgical techniques and perioperative care, adhesion formation remains a significant challenge due to its multifactorial etiology and unpredictable clinical behavior. The burden of adhesions extends beyond the immediate postoperative period, often presenting later as intestinal obstruction, chronic pelvic pain, or infertility. Furthermore, adhesions complicate reoperative surgery by distorting normal anatomy, increasing operative time, and elevating the risk of inadvertent injury. Therefore, there is a growing need for standardized and objective tools to assess and quantify adhesions in a reproducible manner. This prospective study has been designed to evaluate the Peritoneal Adhesion Index in patients undergoing abdominal surgeries, with the aim of improving documentation, enhancing understanding, and ultimately optimizing patient outcomes.

Aim of the study: To assess the severity and distribution of peritoneal adhesions using the Peritoneal Adhesion Index (PAI) in patients undergoing abdominal surgeries and to correlate adhesion severity with previous surgeries, operative findings, and postoperative outcomes.

Objectives of the study: To evaluate the extent and severity of peritoneal adhesions using the PAI scoring system, to analyze the association between adhesion severity and history of previous abdominal surgeries, to study the influence of surgical approach (open vs laparoscopic) on adhesion formation, to correlate PAI scores with intraoperative parameters such as operative time and blood loss, to assess the relationship between adhesion severity and postoperative outcomes including complications and duration of hospital stay, to examine the clinical relevance of PAI as a predictor of surgical difficulty and morbidity.

Materials and Methods: This was a Prospective Observational Study done in 50 cases admitted in Narayana medical college and hospital with abdominal surgery in a 18 months period.

Inclusion Criteria: Patients aged 18 to 70 yrs undergoing abdominal surgery in whom intra-abdominal adhesions can be directly assessed during laparotomy or laparoscopy. Adults' with previous abdominal operations or intra-abdominal inflammatory conditions. Patients requiring adhesiolysis or secondary abdominal exploration.

Exclusion Criteria: Patients with congenital anomalies of the peritoneum where adhesions cannot be reliably scored. Cases where adequate intra-abdominal visualization is not possible (e.g., massive bleeding, severe contamination). Patients with peritoneal carcinomatosis or advanced intra-abdominal malignancy, where adhesions are not the primary pathology.

Data to be collected: Demographics (age, sex), Clinical history (previous surgeries, indication for surgery, comorbidities), Intraoperative details (type of surgery, PAI score, adhesion location and severity). Postoperative outcomes (pain, bowel function recovery, complications, duration of hospital stay).

Follow-up: Patients will be reviewed during postoperative stay and at discharge. Further follow-up at 1 month and 3 months to assess late complications. Informed and written Consent from each participating patient will be obtained.

Statistical analysis: Data were analysed using SPSS software. Quantitative variables such as age and PAI scores were expressed as mean ± standard deviation (SD). Categorical data were presented as frequencies and percentages. Appropriate statistical tests, including the Chi-square test for categorical variables and Student's t-test for continuous variables, were applied to evaluate associations. A p-value < 0.05 was considered statistically significant.

Results

Table 1: Age-Wise Distribution of Adhesion Severity

Age Group(years)	Mild(0–5)	Moderate(6–10)	Severe(>10)	Total
18–30	6	2	1	9
31–40	5	4	2	11
41–50	4	5	4	13
51–60	3	4	3	10
>60	3	2	2	7
Total	21	17	12	50

Table 2: Demographic Profile

Variable	Value
Total patients	50
Males	28(56%)
Females	22(44%)

Table 3: Sex Vs Adhesion Severity

Sex	Mild(0–5)	Moderate(6–10)	Severe(>10)	Total
Male	12	9	7	28
Female	9	8	5	22
Total	21	17	12	50

24% of cases had more than 2 surgeries and 36% had history of one surgery and the rest 40% did not had any previous surgeries.

Patients undergoing their first surgery had a lower mean PAI (4.8 ± 2.1), whereas those with two or more prior surgeries exhibited significantly higher scores (9.6 ± 3.4). A positive trend is observed, with higher PAI scores correlating with prolonged hospitalization. A higher complication rate is observed in open surgeries, which may be attributed to greater tissue handling and surgical trauma compared to minimally invasive techniques.60% of patients recovered without complications, while a smaller subset de16% needed intervention and 24% had complications.

Table 4: Type of Surgery

Type	Number (%)
Open Surgery	32 (64%)
Laparoscopic Surgery	18 (36%)

Table 5: PAI Scores by Surgery Type

Severity	Open	Laparoscopic
Mild (0–5)	10	11
Moderate (6–10)	12	5
Severe (>10)	10	2

Table 6: Adhesion Severity and Postoperative Complications

Complication	Mild	Moderate	Severe
Bowel Obstruction	1	3	5
Chronic Pain	2	5	7
Infertility	1	2	4

Table 7: Adhesion Scores Vs Number of Surgeries

Group	Mean PAI	SD
First-time Surgery	4.8	±2.1
≥2 Surgeries	9.6	±3.4

Discussion

A total of 50 patients undergoing abdominal surgeries were included in this prospective observational study. The mean age of the study population was 42.6 ± 13.2 years, with a slight male predominance (56% males and 44% females).

Demographic and Surgical Profile: Among the study population, 32 patients (64%) underwent

open surgery, while 18 patients (36%) underwent laparoscopic procedures. The majority of patients belonged to the 40–60-year age group. Laparoscopic procedures were associated with lower adhesion severity compared to open surgeries.

Patients with a history of multiple previous abdominal surgeries demonstrated significantly higher mean PAI scores (9.6 ± 3.4) compared to those undergoing surgery for the first time (4.8 ± 2.1), indicating the cumulative effect of repeated peritoneal injury. A strong positive association was noted between repeated surgical interventions and adhesion severity.

The cumulative effect of peritoneal trauma, inflammation, and impaired fibrinolysis with each subsequent surgery likely contributes to increased adhesion formation. These results are consistent with established literature, which identifies prior abdominal surgery as a major risk factor for dense adhesions.

Adhesion Severity and PAI Scoring: Adhesion severity was assessed using the Peritoneal Adhesion Index. Mild adhesions (PAI 0–5): 21 patients (42%), Moderate adhesions (PAI 6–10): 17 patients (34%), Severe adhesions (PAI >10): 12 patients (24%).

Correlation with Clinical Parameters: Adhesion severity showed a positive correlation with multiple intraoperative and postoperative factors. Higher PAI scores were associated with: Increased operative duration (>120 minutes; mean PAI 12.1 ± 4.3), Greater intraoperative blood loss (>300 ml)

Prolonged hospital stay (>7 days), Female patients demonstrated slightly higher PAI scores, possibly due to previous pelvic or gynecological surgeries.

Postoperative outcomes: Postoperative complications were strongly associated with adhesion severity: Bowel obstruction: 9 patients (18%), predominantly in the severe adhesion group

Chronic abdominal pain: 14 patients (28%) Infertility: 7 female patients (14%). Adhesions were most commonly observed in the central abdominal region and between bowel loops, contributing significantly to the complexity of surgical management, particularly in cases of intestinal obstruction.

Higher PAI scores were also associated with increased postoperative pain and longer hospitalization, indicating their impact on recovery and overall morbidity**.**

Incidence and Burden of Adhesions: In the present study, adhesions were observed in a significant proportion of patients. This finding is consistent with previous reports indicating that postoperative adhesions occur in over 90% of patients undergoing laparotomy [1,2]. Adhesions remain the leading cause of small bowel obstruction worldwide, accounting for up to 75% of cases [4,8]. The associated economic burden is considerable, with studies reporting high rates of readmissions and substantial healthcare costs [9].

Patients with a history of previous laparotomies demonstrated higher adhesion scores, in accordance with the Bologna guidelines, which identify repeat surgery as a major risk factor for dense adhesions and increased morbidity [5]. Additionally, higher adhesion scores observed in open procedures compared to laparoscopic approaches are consistent with experimental and clinical evidence demonstrating reduced adhesion formation following minimally invasive surgery [7].

Adhesions contribute significantly to postoperative morbidity, including intestinal obstruction, chronic abdominal pain, infertility, and increased operative difficulty during repeat surgeries (10). In this study, higher adhesion scores were associated with increased morbidity and prolonged hospital stay, highlighting their clinical significance and impact on patient outcomes [11].

Role of Previous Surgeries: One of the most significant findings of this study was the strong association between prior abdominal surgeries and increased adhesion severity. Patients with a history of multiple surgical interventions demonstrated significantly higher mean Peritoneal Adhesion Index (PAI) scores compared to those undergoing surgery for the first time [11]. This observation can be explained by the cumulative effect of repeated peritoneal injury. Each surgical intervention disrupts the mesothelial lining, leading to fibrin deposition and subsequent fibroblast proliferation. With repeated insults, the normal fibrinolytic mechanisms become overwhelmed, resulting in dense and vascularized adhesions [12].

These findings are in agreement with previous studies, which have consistently identified prior surgery as a major risk factor for adhesion formation [5]. Repeated laparotomies are particularly associated with complex adhesions that increase the risk of intraoperative complications such as bowel injury.

Influence of Surgical Technique: The present study reinforces the importance of careful surgical planning in patients with prior abdominal operations, as anticipation of adhesions aids in selecting appropriate surgical approaches and minimizing intraoperative complications. The comparison between open and laparoscopic procedures revealed a clear difference in adhesion severity. Open surgeries were associated with higher Peritoneal Adhesion Index (PAI) scores,

whereas laparoscopic procedures demonstrated relatively lower adhesion formation [7]. This difference can be attributed to greater tissue handling, prolonged peritoneal exposure, and increased risk of desiccation and ischemia in open surgery, leading to an enhanced inflammatory response [13].

In contrast, laparoscopic surgery minimizes tissue trauma, preserves the peritoneal microenvironment, and reduces adhesion formation. These findings are consistent with existing literature demonstrating the advantages of minimally invasive techniques, although the risk of adhesion formation is not completely eliminated [7].

Adhesion Severity and Operative Difficulty: A key observation in this study was the correlation between adhesion severity and operative difficulty. Higher PAI scores were associated with prolonged operative time and increased intraoperative blood loss [11].

Dense adhesions obscure normal anatomical planes, making dissection more challenging and increasing the risk of inadvertent injury to adjacent structures [14]. In severe cases, this necessitates meticulous and often sharp dissection, further contributing to operative complexity. These findings highlight the importance of preoperative anticipation of adhesions, particularly in patients with prior surgeries. The use of standardized scoring systems such as the PAI facilitates objective assessment and helps correlate adhesion severity with operative difficulty [11].

Postoperative Outcomes and Complications: The present study demonstrated a significant association between adhesion severity and postoperative complications. Patients with higher Peritoneal Adhesion Index (PAI) scores were more likely to develop complications such as bowel obstruction, chronic abdominal pain, and infertility [11]. Adhesive small bowel obstruction remains one of the most serious complications associated with adhesions.

In this study, a notable proportion of patients with severe adhesions developed bowel obstruction, highlighting the clinical significance of adhesion burden [14]. Chronic abdominal pain is another important consequence of adhesions. The presence of sensory nerve fibers within adhesions has been demonstrated in histological studies, providing a physiological basis for pain. Infertility, particularly in female patients, is often associated with pelvic adhesions that interfere with normal reproductive anatomy. The findings of this study are consistent with previous reports linking adhesions to tubal factor infertility [10]. In addition to complications, higher adhesion scores were associated with prolonged hospital stay. This reflects delayed recovery due to increased surgical trauma and postoperative morbidity [11].

Pathophysiological Correlation: The findings of this study can be explained by the underlying pathophysiology of adhesion formation. Surgical trauma leads to disruption of the mesothelial layer and deposition of fibrin-rich exudate. Under normal conditions, fibrinolysis clears this fibrin within a few days [13]. However, in the presence of inflammation, ischemia, or infection, fibrinolytic activity is impaired. This results in persistence of fibrin, which serves as a scaffold for fibroblast proliferation and collagen deposition [13]. Over time, these fibrinous adhesions mature into dense fibrous bands with neovascularization. The involvement of cytokines, growth factors, and hypoxia-inducible pathways further contributes to adhesion formation.

The higher adhesion severity observed in patients with repeated surgeries and open procedures can be attributed to enhanced inflammatory response and impaired fibrinolysis [5].

Clinical Utility of PAI: The Peritoneal Adhesion Index (PAI) proved to be a valuable tool in this study, enabling standardized assessment of adhesions across different anatomical regions and providing a quantitative measure of adhesion burden [8]. Its use reduces subjective variability, improves interobserver reliability, and facilitates comparison across studies [7]. Higher PAI scores were associated with increased operative difficulty and postoperative morbidity, highlighting its potential as a predictive tool [5]. The ability to objectively quantify adhesion severity makes PAI useful not only for documentation but also for risk stratification in clinical practice. These findings support its routine application, particularly in research settings and complex surgical cases [11].

Table 8: Comparison of Mean Age among Studies

Study	Mean Age (years)	Remarks
Present Study (N=50)	42.5 ± 10.3	Middle-aged group; consistent with elective abdominal surgery population.
Coccolini et al., 2013 [6]	Not specified	PAI introduced as a grading tool, not an age-focused cohort.
Imaralu et al., 2023 [11]	41.2 ± 9.6	Similar mean age; younger cohort undergoing diagnostic laparoscopy.
Ellis et al., 1999 [14]	45 ± 12	Comparable middle-aged population in adhesion-related readmission study.

Table 9: Comparison of Gender Distribution

Study	Male: Female (%)	Remarks
Present Study	28: 22 (56%: 44%)	Slight male predominance.
Coccolini et al., 2013 [6]	Equal representation	No significant sex bias reported.
Imaralu et al., 2023 [11]	30% : 70%	Female predominance due to gynecologic laparoscopy series.
Ellis et al., 1999 [14]	52% : 48%	Balanced sex ratio in adhesion-related admissions.

Table 10: Comparison of Type of Surgery and Adhesion Prevalence

Study	Open (%)	Laparoscopic (%)	Adhesion Rate (%)
Present Study	64	36	100 (all scored using PAI)
Coccolini et al., 2013 [6]	—	—	— (index development only)
Gutt et al., 2004 [15]	80	20	Adhesion incidence: Open 70%, Lap 45%
Polymeneas et al., 2001 [15]	50	50	Reduced adhesions after laparoscopy

Table 11: Comparison Table between Study Characteristics (Present Study Vs Selected Published Reports)

Study (year)	Design/ setting	Sample size	PAI used?	Main outcome / note
Present study	Prospective observational elective abdominal surgery	N=50	Yes—PAI scored intra operatively	Mean total PAI 10.2 ± 4.6; Mild 42%, Moderate 34%, Severe 24%; higher severe proportion after open surgery (open:31.3% severe vs lap:11.1%).
Coccolini et al.(2013)	Methodologic paper proposing the index	Not an outcome cohort	PAI introduced	Proposed standardized Peritoneal Adhesion Index (0–30) to improve reporting of adhesion extentand severity.
Imaralu et al.(2023)	Retrospective laparoscopy series using PAI	158	Yes—Coccolini PAI used	26.6% prevalence of adhesions at laparoscopy; prior surgery increased meanPAI (11.16±3.94 vs 8.10±3.14).
PAI multi center validation (2013–2015)	Prospective/multicentre feasibility validation	≈205	Yes	PAI found feasible and reproducible when used across multiple centers.
Large reviews (2021–2023)	Narrative/systematic reviews	Multiple pooled studies	Notprimary PAI studies	Open surgery:70–90% adhesions; Laparoscopy:50–70%; high clinical burden (obstruction, pain, infertility).

Table 12: Comparison of Mean Peritoneal Adhesion Index (PAI) and Severity

Study	Mean PAI ± SD	Severe Adhesions (%)	Remarks
Present Study	10.2 ± 4.6	24	Moderate to severe adhesions more common in open cases.
Coccolini et al., 2013 [6]	Not specified	—	Established scoring system (range 0–30).
Imaralu et al., 2023 [11]	Prior surgery: 11.16 ± 3.94; No prior: 8.10 ± 3.14	26.6	Higher scores in patients with prior surgeries.
Validation studies	—	20–30	Severity consistent with open-surgery cohorts.

Table 13: Comparison of PAI / Adhesion out Comes

Study	Sample size	Prevalence Of adhesions (%)	Mean Total PAI (if reported)	%Severe adhesions (PAI>10)ornotes
This thesis (present study)	50	All patients scored; Mild42%/ Moderate34%/ Severe24%	10.2±4.6	Severe in 12/50(24%); open surgeries accounted form ost severe cases.
Imaralu et al.,2023	158(laparoscopy)	26.6%	Prior-surgery:11.16±3.94;No-prior:8.10±3.14	Prior surgery associated with higher PAI and severe adhesions.
Coccolini et al.,2013	Index proposal	n/a	n/a	Defined 0–30 scale for standardized reporting.
PAI multicenter validation(2013–2015)	≈205	Reported in validation data sets	Various	Feasibility and reproducibility confirmed.
Review summaries (2021–2023)	Multiple studies	Open:~70–90%;Laparoscopy:~50–70%	Not consistently reported	High prevalence and clinical significance emphasized.

Table 14: Direct Numeric Comparison (Selected Metrics)

Metric	This thesis (N=50)	Imaralu 2023 (laparoscopy, N=158)
Meantotal PAI	10.2±4.6	Prior-surgery 11.16 ± 3.94; No-prior 8.10 ± 3.14
Severe adhesions (PAI>10)	24%(12/50)	Higher in prior-surgery group (exact% notgiven)
Adhesion prevalence at laparoscopy	N/A (scored in traopforall)	26.6%

Conclusion:

This study demonstrates that peritoneal adhesions are a common and significant complication following abdominal surgery, particularly after open procedures. Adhesion severity was lower in laparoscopic surgeries, supporting the benefit of minimally invasive techniques. Higher adhesion scores were strongly associated with previous abdominal surgeries, indicating the cumulative effect of repeated peritoneal injury. Severe adhesions were linked to increased postoperative morbidity, including bowel obstruction, chronic pain, and infertility. The Peritoneal Adhesion Index (PAI) proved to be a reliable and standardized method for assessing adhesion severity and distribution. Higher PAI scores correlated with increased operative difficulty and poorer postoperative outcomes.

Overall, PAI is a useful tool for objective evaluation, risk stratification, and surgical planning. Its routine use may help improve clinical outcomes and guide strategies for adhesion prevention.

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