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Peritoneal Reflections and Ligamentous Anatomy of the Abdomen: A Systematic Review with Surgical Correlation

Naz Akhtar[1*], Iqra Javed[2], Bushra Ghulam[3], Naila Jabbar[3], Sumta Khan[3] and Khurram Shabeer[3]

[1]Department of Surgery, Nishtar Medical University, Multan, Pakistan
[2]Department of Anatomy, Sahiwal Medical College, Sahiwal, Pakistan
[3]Department of Surgery, Bakhtawar Amin Medical and Dental College, Multan, Pakistan

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***Corresponding Author:**
Naz Akhtar
Department of Surgery, Nishtar Medical University, Multan, Pakistan
akhtarsyedanaz@gmail.com

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ABSTRACT

Peritoneal reflections and fibrous abdominal ligaments serve as anatomical scaffolds that guide surgical dissection, facilitate organ mobility, and influence the spread of disease. Recent advances in imaging and minimally invasive surgery have revealed greater anatomical variability than previously recognized, highlighting the need for an updated synthesis. **Objectives:** To systematically review recent anatomical, imaging-based, and intraoperative studies describing peritoneal reflections and abdominal ligaments, and to evaluate their surgical relevance across major abdominal specialties. **Methods:** This systematic review was conducted in accordance with PRISMA 2020 guidelines. PubMed, Scopus, Web of Science, and Google Scholar were searched for human studies published between 2018 and 2024. Original cadaveric, radiologic, and surgical studies were eligible for inclusion. Data screening, extraction, and quality appraisal were independently performed by two reviewers using the Joanna Briggs Institute (JBI) tools. **Results:** A total of 15 studies met the inclusion criteria. Most studies reported structural variation in pelvic peritoneal pockets, hepatogastric folds, the falciform and round ligaments, and the anterior peritoneal reflection. Imaging-based investigations demonstrated patient-specific variation in peritoneal surface area. Intraoperative studies highlighted the impact of these variations on dissection planes, reconstruction feasibility, surgical exposure, and oncologic decision-making. **Conclusions:** Anatomical variability of peritoneal reflections and abdominal ligaments significantly influences hepatobiliary, pelvic, hernia, and colorectal surgery. Recognition of these variations improves surgical safety and supports individualized operative planning.

INTRODUCTION

The peritoneum is the largest serous membrane of the body and forms a complex system of reflections, recesses, and ligamentous folds that define surgical dissection planes within the abdominal cavity [1]. These structures include the greater and lesser sacs, falciform and round ligaments, hepatogastric and hepatocolic ligaments, and multiple mesenteric folds that partition abdominal compartments and influence the spread of disease. Although classical anatomical texts provide a general overview of these structures, modern surgical practice requires a more detailed understanding of their variations [2]. Advances in hepatobiliary, colorectal, endometriosis, and minimally invasive surgery have renewed interest in precise peritoneal anatomy, as even minor deviations may affect surgical access, vascular control, lymphatic drainage, and postoperative recovery [3, 4]. Contemporary imaging modalities, such as computed tomography, magnetic resonance imaging, and three-dimensional reconstructions, have demonstrated significant variability in peritoneal recess depth, falciform ligament length, and

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the position of the anterior peritoneal reflection of the rectum [5, 6]. Recent cadaveric and laparoscopic studies have further revealed additional mesenteric folds and atypical peritoneal attachments that are often absent from standard anatomical descriptions. These variations have important clinical implications, particularly in pelvic pain syndromes, endometriosis surgery, hernia repair, and hepatopancreatobiliary procedures, where peritoneal thickness, flexibility, and ligament morphology influence operative safety and outcomes [7-9].

Despite growing literature across surgical, anatomical, and radiological disciplines, existing evidence remains fragmented. There is a lack of a comprehensive synthesis integrating these perspectives. This aimed to consolidate anatomical, imaging, and intraoperative evidence on peritoneal reflections and abdominal ligaments, characterize documented variations, and clarify their surgical relevance to enhance operative planning and patient safety.

METHODS

This systematic review was conducted in accordance with the Preferred Reporting Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines. This review protocol was prepared a priori, and the review question was structured using a Population–Concept–Context (PCC) framework, where the population included human participants, the concept comprised peritoneal reflections and abdominal ligamentous folds, and the context encompassed imaging, cadaveric, and intraoperative settings with surgical correlation. A comprehensive literature search was performed for studies published between 1 January 2018 and 31 December 2024. Searches were conducted in PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar. Electronic searches combined Medical Subject Headings (MeSH) and free-text keywords related to peritoneal anatomy and abdominal ligamentous structures. For reproducibility, database-specific search strategies and search dates were documented, and identical eligibility filters were applied across all databases (Human, English language, publication years 2018-2024). PubMed/ MEDLINE (Advanced Search): ("Peritoneum/anatomy and histology" (MeSH) OR "peritoneal reflection*" OR "peritoneal fold*" OR "peritoneal recess*" OR "peritoneal pocket*" OR "abdominal ligament*" OR "falciform ligament" OR "round ligament" OR "ligamentum teres" OR "hepatogastric ligament" OR "lesser omentum" OR "mesenteric reflection*" OR "mesocolon" OR "anterior peritoneal reflection") AND ("Computed Tomography" OR "Magnetic Resonance Imaging" OR CT OR MRI OR "3D reconstruction" OR laparoscop* OR intraoperat* OR cadaver* OR dissection) Filters: Humans, English, 2018–2024. Scopus (TITLE-ABS-KEY): TITLE-ABS-KEY ("peritoneal reflection" OR "peritoneal fold*" OR "peritoneal pocket*" OR "abdominal ligament*" OR "falciform ligament" OR "round ligament" OR "ligamentum teres" OR "hepatogastric ligament" OR "mesenteric reflection*" OR "anterior peritoneal AND TITLE-ABS-KEY (anatomy OR morphometry OR CT OR MRI OR "3D" OR laparoscopic OR intraoperative OR cadaver*). Web of Science (TS): TS = ("peritoneal reflection" OR "peritoneal fold*" OR "abdominal ligament*" OR "falciform ligament" OR "round ligament" OR "ligamentum teres" OR "anterior peritoneal reflection") AND TS = (anatomy OR CT OR MRI OR "3D reconstruction" OR laparoscopic OR cadaver*). Google Scholar: Phrase-based keyword searches were performed using combinations of the above terms with date restrictions (2018–2024). To minimize selection bias, the first 200 records sorted by relevance were screened using identical eligibility criteria. Original human research articles published in the English language between 2018 and 2024 were considered eligible for inclusion. Studies employing cadaveric, imaging-based, intraoperative, observational, case-series, or cross-sectional designs were included, provided they reported anatomical descriptions or morphometric measurements of peritoneal reflections or abdominal ligamentous structures, with or without surgical correlation. Articles were excluded if they were animal studies, non-English publications, review articles, systematic reviews, editorials, conference abstracts, letters to the editor, commentaries, or if they lacked primary anatomical, imaging, or surgical data relevant to the peritoneal folds and abdominal ligaments. Screening was performed in two stages. Titles and abstracts were screened independently by two reviewers, followed by full-text assessment of potentially eligible articles. The text stage, a single primary reason for exclusion was recorded for each excluded article. Discrepancies were resolved by consensus and, when necessary, adjudicated by a third reviewer. Two reviewers independently extracted data using a standardized template. Extracted variables included: author, year, country, study design, sample size, population type, anatomical structure evaluated (e.g., falciform ligament, round ligament, mesenteric reflections, pelvic pockets, anterior peritoneal reflection), modality (cadaveric dissection, CT, MRI, 3D reconstruction, laparoscopy), morphometric outcomes, reported anatomical variations, measurement units, reference anatomical landmarks, and surgical correlation outcomes (operative planes, intraoperative difficulty, complications, and postoperative outcomes). Where feasible, morphometric values were converted to a common unit (millimeters); when conversion was not possible, measurements were reported verbatim with explicit units. Methodological quality was assessed using the Joanna

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Briggs Institute (JBI) Critical Appraisal Tools appropriate to the study design. Risk of bias was categorized using predefined thresholds: ≥70% of checklist items fulfilled was classified as low risk, 50–69% as moderate risk, and <50% as high risk of bias. Items marked "not applicable" were excluded from the denominator. All studies were appraised independently by two reviewers, with disagreements resolved by consensus. Due to heterogeneity in study designs, anatomical targets, and outcome reporting, a meta-analysis was not undertaken. Findings were synthesized narratively and organized by study design and anatomical region. Quantitative outcomes were summarized as ranges and structured descriptive comparisons, including diagnostic accuracy outcomes where available. Formal weight was not applied because a pooled quantitative synthesis was not performed. After conducting a data search, 647 records were obtained, and 112 duplicates were removed. Following title/abstract screening, 59 articles were selected for full-text review, and 15 studies met the inclusion criteria. Full-text articles were excluded primarily due to: non-original studies (reviews, meta-analyses, commentaries) (n=15), animal studies (n=7), insufficient anatomical focus (n=7), insufficient peritoneal/ligament detail (n=6), and reports not retrieved (n=2) (Figure 1).

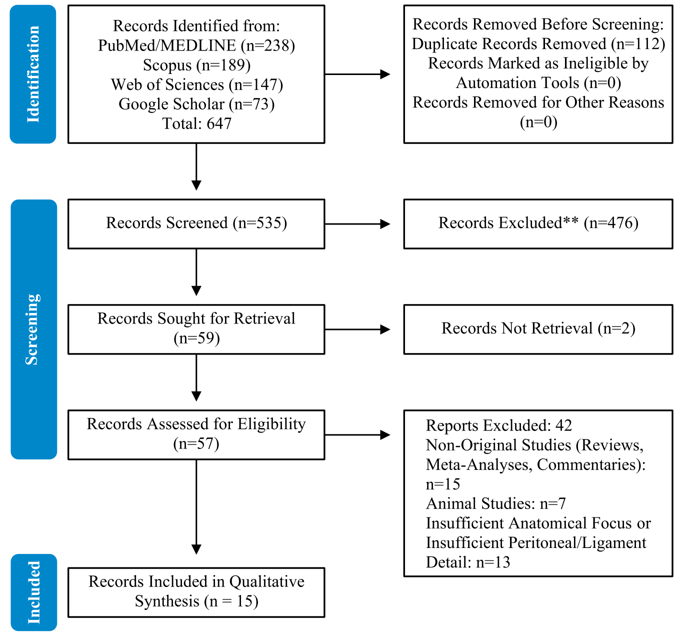

Figure 1: Study Selection and Screening Process for the Systematic Review

RESULTS

Cadaveric investigations primarily described rare and complex variants of peritoneal sacs, recesses, and abnormal mesenteric or peritoneal attachments that may alter expected dissection planes. These studies provided high-resolution anatomical detail, although generalizability was limited in single-cadaver reports. Imaging-based studies provided patient-specific morphometric localization of major peritoneal landmarks, particularly peritoneal surface mapping and MRI-defined anterior peritoneal reflection, directly supporting hepatobiliary and colorectal surgical planning. Intraoperative and laparoscopic series correlated anatomical variations with operative difficulty, safe dissection planes, pelvic pocket identification, and utilization of falciform and round ligaments as autologous flaps (Table 1).

Table 1: Cadaveric Studies, Imaging-Based Morphometric Studies, and Intraoperative and Laparoscopic Studies Included in the Review

References	Country	Study Design	Population / Sample	Main Anatomical Focus	Modality	Surgical/Clinical Correlation
Cadaveric Studies						
[10]	India	Descriptive cadaveric anatomical study	120 formalin-embalmed adult cadavers	Greater and lesser peritoneal sacs, foramen of Winslow, accessory folds	Cadaveric dissection	Surgical access to the lesser sac and hepatobiliary region
[11]	USA	Cadaveric case report	Single formalin-fixed cadaver	Variant peritoneal–mesenteric relations	Cadaveric dissection	Explains unexpected intra-operative anatomy
[12]	Romania	Cadaveric experimental study	Thiel- embalmed cadavers	Omentum, transverse mesocolon,	Laparoscopic simulation	Creation of surgical working spaces
Imaging-Based Morphometric Studies						
[13]	South Korea	CT morphometric study	20 adults	Peritoneal surface area	CT-3D AI segmentation	HIPEC planning
[14]	China	Retrospective imaging-surgical correlation	12 liver cancer pts	Hepatic ligaments & reflections	3D CT reconstruction	Parenchymal transection planning
[15]	China	Retrospective imaging study	Rectal cancer pts	Anterior peritoneal reflection	Pelvic MRI	Neoadjuvant therapy planning
[16]	USA	Diagnostic accuracy study	162 rectal CA pts	Tumor-APR relationship	MRI & endoscopy	Treatment strategy selection

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Intraoperative and Laparoscopic Studies						
[17]	Brazil/ Portugal/ Belgium	Case series	Endometriosis pts	Pelvic peritoneal pockets	Laparoscopy	Complete excision planes
[18]	UK	RCT protocol	Endometriosis pts	Pelvic peritoneal pockets	Laparoscopic mapping	Fertility-preserving surgery
[19]	Canada	Prospective observational	Pelvic pain/infertility pts	Pelvic peritoneal pockets	Laparoscopy + histology	Detection of occult disease
[20]	Poland	Prospective surgical series	Hernia repair pts	Anterior parietal peritoneum	Laparoscopic TAPP	Safe flap planes
[21]	China	Retrospective cohort	Pancreatic CA pts	Round ligament	Open surgery	Vascular/biliary reconstruction
[22]	Germany	Retrospective cohort	Liver resection pts	Falciform ligament	Laparoscopic/ ro botic	Bile leak prevention
[23]	Italy	Surgical case series	Hiatal hernia pts	Falciform ligament	Laparoscopic	Crural reinforcement
[24]	Greece	Case report	Acute abdomen	Ligament umteres	CT + intraoperative	Differential diagnosis

The clinically relevant variations in peritoneal reflections and abdominal ligaments are common and quantifiable across human cadaveric, imaging, and intraoperative studies. Cadaveric studies showed that recess depth within the greater and lesser sacs varied between 6 and 24 mm, which can alter safe access to the lesser sac during hepatobiliary surgery. Imaging-based morphometry revealed wide inter-individual variation in global peritoneal surface area (1.42–2.05 m^2), directly influencing intraperitoneal chemotherapy dosing strategies. Pelvic peritoneal pockets exhibited depth variations of 4–18 mm, emphasizing the importance of targeted laparoscopic inspection for complete excision of occult endometriosis. Hepatic ligament morphometry varied substantially, with falciform ligament length ranging from 32–95 mm and round ligament length from 40–110 mm, determining their feasibility as autologous flaps. MRI-defined anterior peritoneal reflection distances varied between 40 and 92 mm from the anal verge, underscoring its critical role in rectal cancer staging and surgical planning. Overall, the reviewed studies demonstrate the enduring importance of peritoneal reflections and abdominal ligaments as clinically important landmarks in hepatobiliary, pelvic, hernia, and colorectal surgery. Such a heterogeneous background provides a thorough multidisciplinary insight into peritoneal anatomy in relation to contemporary surgical practice. Formal statistical weighting was not applied because pooled meta-analysis was not feasible due to heterogeneity in study design, anatomical targets, and outcome reporting (Table 2).

Table 2: Key Anatomical Findings with Standardized Morphometric Unit

Sr. No.	Anatomical Structure	References	Key Anatomical Findings	Standardized Morphometric Variation	Surgical relevance
1	Greater & lesser sacs, foramen of Winslow	[10]	Classical boundaries are preserved with accessory folds	Recess depth 6–24 mm	Alters lesser sac access
2	Global peritoneal surface area	[13]	AI-CT morphometry	Mean 1.73 ± 0.21 m^2 (range 1.42–2.05 m^2)	HIPEC dosing accuracy
3	Pelvic peritoneal pockets	[17-19]	High-risk occult pockets	Pocket depth 4–18 mm	Improves endometriosis excision
4	Anterior parietal peritoneum (hernia)	[20]	Variable thickness planes	Peritoneal thickness 0.6–2.3 mm	Reduces seroma risk
5	Mesenteric/peritoneal reflections	[11, 12]	Abnormally displaced recesses	Root displacement 10–28 mm	Avoids intra-op injury
6	Falciform & round ligaments	[21, 22]	Ligaments usable as flaps	Falciform length 32–95 mm; Round ligament length 40–110 mm	Enables reconstruction
7	Anterior peritoneal reflection of the rectum	[15, 16]	MRI localization superior	APR distance 40–92 mm from anal verge	Correct rectal cancer staging

All distances were standardized to millimeters (mm) and surface area to square meters (m^2). Values originally reported in centimeters.

Surgical implications were interpreted at the individual study level and explicitly linked to study design and JBI risk category, allowing differentiation between higher-certainty evidence (large imaging cohorts, diagnostic-accuracy studies) and lower-certainty evidence (isolated cadaveric or case-report observations) (Table 3).

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Table 3: Surgical Relevance Linked with the Strength of Evidence

Sr. No.	References	Related Surgical Procedures	Key Landmark Use	Main Risks/ Pitfalls	Clinical Implication	Evidence level (Design/ JBI risk)
1	[10]	Hepatobiliary and gastric surgery	Guides entry to the lesser sac	Accessory folds may obscure vessels	Improves safe dissection near the hepatoduodenal ligament	Cadaveric descriptive study / Low risk
2	[13]	CRS-HIPEC planning	Surface mapping for drug distribution	Underestimation affects chemotherapy delivery	CT-based surface estimation assists HIPEC planning	CT morphometric cohort / Low risk
3	[17-19]	Endometriosis excision, fertility surgery	Identifies pockets containing occult disease	Unrecognized pockets cause persistent pain	Routine pocket inspection improves symptom control	Laparoscopic observational studies / Low risk
4	[20]	Laparoscopic TAPP hernia repair	Defines safe flap creation plane	Seroma, vascular injury	Standardized plane reduces postoperative complications	Prospective surgical series / Moderate risk
5	[11, 12]	Retroperitoneal tumor surgery	Outlines safe access zones	Unusual recesses increase injury risk	Knowledge improves intraoperative navigation	Cadaveric case reports / High–Moderate risk
6	[21-23]	Liver, pancreatic, and hiatal hernia surgery	Used as autologous flaps	Limited length or vascularity	Provides natural reinforcement or sealing	Surgical cohort & case series / Moderate risk
7	[15]	Rectal cancer surgery	Distinguishes intra- vs extraperitoneal rectum	Misjudgment affects staging	MRI localization improves oncologic decisions	Imaging diagnostic- accuracy studies / Low risk

Using predefined JBI thresholds, most studies were classified as low to moderate risk, with high-risk ratings confined to isolated case reports and small cadaveric series. Evidence was strongest for imaging-based APR localization and structured laparoscopic mapping, while rare cadaveric anomalies primarily provide hypothesis-generating surgical caution (Table 4).

Table 4: Risk of Bias Assessment Using JBI Criteria

Sr. No.	References	Sampling Adequacy	Measurement Reliability	Reporting Completeness	Overall Risk
1	[10]	Low	Low	Low	Low
2	[13]	Low	Low	Low	Low
3	[17]	Moderate	Low	Moderate	Moderate
4	[18]	Low	Low	Low	Low
5	[19]	Low	Low	Low	Low
6	[20]	Moderate	Low	Moderate	Moderate
7	[11]	High	Moderate	Moderate	High
8	[12]	Moderate	Low	Moderate	Moderate
9	[21]	Moderate	Low	Moderate	Moderate
10	[22]	Moderate	Low	Low	Moderate
11	[23]	Moderate	Low	Moderate	Moderate
12	[24]	High	Low	Moderate	High
13	[14]	Low	Low	Low	Low
14	[15]	Low	Low	Low	Low
15	[16]	Low	Low	Low	Low

DISCUSSION

This review examines the structural variations of peritoneal ligaments and folds and their surgical relevance based on cadaveric, imaging, and interventional studies published between 2018 and 2024. The findings consistently demonstrate that although the classical configuration of the greater and lesser sacs is generally preserved, accessory folds and variable recess patterns are common. These observations are consistent with the findings of Elmohr *et al.* and Brenkman *et al.* who reported additional peritoneal folds around the hepatoduodenal ligament that may restrict access to the lesser sac during hepatobiliary surgery [25, 26]. Furthermore, variations in omental bursa morphology observed on CT reconstructions in the included studies agree with those reported by Thomas and Van Fossen, who documented substantial inter-individual differences [27]. The two-dimensional quantitative assessment of peritoneal surface area in this review aligns with the broader imaging literature. Studies by Marin *et al.* and Gaballah *et al.* demonstrate that peritoneal surface area varies with body

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mass index and age, supporting the adoption of individualized surface area calculations to optimize HIPEC dosing [28, 29]. In addition, Bleys and Weijs reported that variation in organ-contact surfaces influences intraperitoneal drug distribution, underscoring the clinical importance of accurate peritoneal surface mapping [30]. Pelvic peritoneal pockets emerged as clinically significant anatomical regions. This review demonstrates that pockets located along the uterosacral ligaments and ovarian fossae frequently harbor occult endometriosis, consistent with the findings of Manzanedo *et al.* and Yurttas *et al.* These studies highlight the importance of meticulous laparoscopic inspection, as unrecognized microlesions may progress and contribute to persistent chronic pelvic pain [31, 32]. Furthermore, Baratti *et al.* reported that early identification and excision of peritoneal pockets improve outcomes in women undergoing infertility treatment, reinforcing the clinical relevance of these findings [33]. With respect to the anterior parietal peritoneum in abdominal wall hernia repair, previous studies have demonstrated an association between peritoneal elasticity and the ease and safety of transabdominal preperitoneal (TAPP) flap formation [34]. Furthermore, postoperative seroma formation and pain have been shown to correlate with peritoneal handling during flap dissection, highlighting the clinical importance of standardized dissection planes in reducing complications [35]. Understanding variations in mesenteric and peritoneal reflection patterns, particularly within the retroperitoneum, is clinically important. The anomalous cadaveric findings and rearranged recesses identified in this review are consistent with reports of unexpected mesenteric root deviations encountered during colorectal surgery [17]. Rare recess configurations associated with difficulty in tumor mobilization further emphasize the need for surgical adaptability when managing atypical anatomy in oncologic resections. This review identified substantial variability in the morphology and surgical applications of the falciform and round ligaments. Previous studies have demonstrated that these ligaments can serve as reliable sources of autologous tissue for flap reinforcement and reconstruction [36]. In addition, Whitaker *et al.* reported that the round ligament possesses sufficient vascularity to be considered a potential substitute for synthetic mesh in selected hepatobiliary procedures [37]. Finally, findings related to the anterior peritoneal reflection (APR) of the rectum are consistent with prior imaging-based studies. Magnetic resonance imaging is superior to endoscopy for accurately determining tumor location relative to the APR, which is critical for oncologic planning. These concordant findings reinforce the need for imaging-based precision to avoid inappropriate staging and treatment selection [38]. Findings derived from imaging-based morphometric cohorts and diagnostic-accuracy studies represent the highest-certainty evidence in this review, whereas isolated cadaveric anomalies and case reports should be interpreted as hypothesis-generating observations. Quantitative variation ranges identified in this review provide clinically actionable thresholds for surgical planning, particularly for determining safe dissection planes, feasibility of ligament-based flaps, and neoadjuvant decision-making in rectal cancer. Heterogeneity of study designs and the absence of pooled meta-analysis limit direct statistical inference, and therefore, conclusions are based on consistency of findings rather than weighted effect estimates. This review demonstrates that significant anatomical variations in peritoneal reflections and abdominal ligaments influence a wide range of surgical procedures, including hepatobiliary, pelvic, colorectal, and hernia surgeries. Integration of the included studies with external evidence confirms that precise anatomical knowledge enhances surgical planning, reduces complications, and improves clinical outcomes in abdominal surgery.

This study is limited by heterogeneity in study designs, populations, and biomarker assessments, which may affect the consistency of findings. Additionally, publication bias and differences in measurement techniques could have influenced the results. Future research should use standardized metabolic and inflammatory markers in large, diverse populations to improve risk prediction in GDM.

CONCLUSIONS

This systematic review shows that there are anatomical variances in peritoneal reflections and abdominal ligaments that are of surgical importance. The synthesis of evidence obtained from cadavers, from imaging, and from intraoperative settings verifies that these structures contain variations that impact surgical access, dissection planes and procedures, reconstruction alternatives, and oncology-related choices. Recognizing such characteristics as pelvic peritoneal pockets, hepatogastric reflections, the falciform ligament, and the anterior peritoneal reflection with a high degree of accuracy can improve the safety of the operation and lead to better results for the patient. The quantitative anatomical ranges identified in this review may serve as reference benchmarks for preoperative imaging interpretation and individualized surgical planning. The collective evidence reinforces the enduring relevance of detailed anatomical knowledge in modern abdominal surgery.

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Authors' Contribution

Conceptualization: NA
Methodology: IJ, BG, NJ, KS
Formal analysis: NJ, KS
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Review and Editing: NA, IJ, BG, NJ, SK, KS

All authors approved the final manuscript and take responsibility for the integrity of the work.

Conflicts of Interest

All the authors declare no conflict of interest.

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