Bioscientia Medicina: Journal of Biomedicine and Translational Research
https://bioscmed.com e-ISSN: 2598-0580 Vol. 10, No. 9 (2026)

SYSTEMATIC REVIEW & META-ANALYSIS

Surgical Outcomes and Recurrence in Adult Abdominal Cocoon (Sclerosing Encapsulating Peritonitis): A Systematic Review and Meta-Analysis of Pooled Proportions

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ARTICLE INFO

Article history
Received: June 12, 2026
Accepted: July 14, 2026
Published: July 30, 2026

Keywords:
Abdominal cocoon
Adhesiolysis
Encapsulating peritoneal sclerosis
Frozen abdomen
Meta-analysis

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DOI:
https://doi.org/10.37275/bsm.v10i9.1653

ABSTRACT

Background: Abdominal cocoon, also termed sclerosing encapsulating peritonitis (SEP) or encapsulating peritoneal sclerosis (EPS), is a rare cause of intestinal obstruction in which the small bowel is encased within a fibrocollagenous membrane, producing the prototypical frozen abdomen. Its surgical outcomes had never been pooled quantitatively.

Objective: To quantitatively pool the surgical outcomes of adult abdominal cocoon — peri-operative mortality, morbidity, recurrence and pre-operative diagnostic yield — in patients undergoing operative management.

Methods: PubMed, Scopus, the Cochrane Library and Google Scholar were searched for observational studies reporting the operative management and outcomes of adult abdominal cocoon. Ten case series (179 operated patients) were included. As all studies were single-arm, proportions were pooled with the Freeman–Tukey transformation under a DerSimonian–Laird random-effects model; robustness was tested with a logit-normal model, leave-one-out analysis and the Egger test, and quality with the Joanna Briggs Institute checklist.

Results: Pooled peri-operative mortality was 4.5% (95% CI 0.2–12.1%; k=7); because zero-event studies influence the double-arcsine transformation, a logit-normal model gave 13.1% and the crude proportion 7.9%, so mortality is best summarised as low-to-moderate. Pooled morbidity was 19.5% (95% CI 5.9–36.9%; k=5), recurrence 3.3% (95% CI 0.0–21.8%; k=3) and pre-operative diagnostic yield 19.1% (95% CI 6.0–36.0%; k=4). Leave-one-out kept mortality between 3.0% and 8.5%.

Conclusion: Surgery for adult abdominal cocoon achieved low-to-moderate mortality and acceptable morbidity with infrequent recurrence, supporting membrane excision and adhesiolysis in selected patients, while the low pre-operative diagnostic rate signals a need for greater awareness.

1. Introduction

Abdominal cocoon is an uncommon and frequently misdiagnosed cause of intestinal obstruction in which a variable length of small bowel becomes encased within a thick, greyish-white fibrocollagenous membrane that gives the macroscopic appearance of a cocoon.[1] The condition is regarded as the archetypal expression of the wider clinical concept of the "frozen abdomen", in which dense adhesions and fibrosis obliterate the normal peritoneal planes and render re-entry into the abdominal cavity hazardous.[2] The terms sclerosing encapsulating peritonitis and encapsulating peritoneal sclerosis are used broadly interchangeably in the surgical literature, although the latter is most often reserved for the form arising in patients receiving long-term peritoneal dialysis.

The pathogenesis of abdominal cocoon is heterogeneous. An idiopathic form was originally described in adolescent girls from tropical and subtropical regions and has been attributed to subclinical viral peritonitis or retrograde menstruation,[3] whereas a large number of secondary cases arise from abdominal tuberculosis,[4] long-term peritoneal dialysis, prior abdominal surgery, ventriculoperitoneal shunts and, more recently, severe coronavirus disease 2019.[5] Whatever the trigger, the final common pathway is a chronic fibro-inflammatory process of the peritoneum that produces the encasing membrane and the associated mechanical obstruction.[6] This shared pathophysiology is clinically important because the same fibro-inflammatory process that the surgeon meets as a membrane is the target of the medical therapies — corticosteroids and tamoxifen — used in the peritoneal-dialysis population, and the transition from an early inflammatory phase to a mature fibrotic phase underlies the rationale for those agents and for early intervention.

Clinically, abdominal cocoon presents with recurrent episodes of acute or subacute small-bowel obstruction, colicky abdominal pain, distension, weight loss and, in

a minority, a palpable abdominal mass. Because these features are non-specific and the entity is rare, the diagnosis is seldom entertained before operation.[7] Cross-sectional computed tomography can demonstrate suggestive signs — clustered small-bowel loops confined to a sac, a surrounding enhancing membrane, peritoneal thickening and calcification, and a "cauliflower" or "concertina" configuration — but interpretation requires prior familiarity with the disorder, and most series report that the definitive diagnosis is still established only at laparotomy.[8]

The mainstay of treatment for symptomatic disease is surgical. The operation entails careful dissection and excision of the thick fibrous membrane with meticulous adhesiolysis to release the encased bowel,[9] occasionally supplemented by resection of non-viable or densely adherent intestine and, in the most severe peritoneal-dialysis-associated disease, by a formal parietal peritonectomy and enterolysis.[10] Because the plane between the membrane and the underlying serosa is often obscured, the procedure carries a substantial risk of iatrogenic enterotomy, prolonged operative time, enterocutaneous fistula and, in the most fragile patients, death.[11] A minority of patients — particularly those with early inflammatory-phase dialysis-associated disease or with tuberculosis responsive to anti-tuberculous therapy — may be managed without operation using nutritional support, corticosteroids, tamoxifen or specific antimicrobial treatment.[4]

Despite several decades of accumulating case reports and small institutional series, the surgical outcomes of abdominal cocoon had never been synthesised quantitatively. Existing secondary literature is entirely narrative, and clinicians therefore lacked pooled estimates of the peri-operative mortality, morbidity and recurrence that would inform consent and operative decision-making. In the adjacent field of adhesive small-bowel obstruction, by contrast, comparative studies of laparoscopic and open adhesiolysis are numerous;[12] no equivalent quantitative evidence existed for the distinct and more hazardous entity of the encased, frozen abdomen, which involves a membrane-bound conglomerate rather than the single or multiple bands that characterise ordinary adhesive obstruction.

The novelty of this study lies in providing the first quantitative, random-effects pooled-proportion synthesis of surgical outcomes in adult abdominal cocoon/sclerosing encapsulating peritonitis, an entity for which only narrative reviews had previously existed, and in stratifying the estimates by the principal outcomes that matter to the operating surgeon — mortality, morbidity, recurrence and pre-operative diagnostic yield — while explicitly testing their robustness to the method of pooling. The aim of this study was to determine the pooled peri-operative mortality, post-operative morbidity, post-operative recurrence of obstruction, and pre-operative diagnostic rate among adults undergoing surgery for abdominal cocoon, to examine heterogeneity and the stability of these estimates, and to define a research agenda for this rare condition.

2. Methods

Protocol, design and reporting

This systematic review and meta-analysis was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement.[13] Because the included evidence consisted exclusively of single-arm observational series, the synthesis was framed as a meta-analysis of pooled proportions rather than of comparative effect sizes. It must therefore be emphasised at the outset that the design permits only a description of the outcomes observed among operated patients; it does not permit any comparative inference, and in particular it cannot establish that surgery is superior to conservative management or that any one operative technique is superior to another. All stages — search, screening, eligibility assessment and data extraction — were performed independently in duplicate, and disagreements were resolved by consensus.

Search strategy

A systematic search of PubMed/MEDLINE, Scopus, the Cochrane Central Register of Controlled Trials and Google Scholar was performed from database inception, without language restriction. The core Boolean string was:

("abdominal cocoon" OR "sclerosing encapsulating peritonitis" OR "encapsulating peritoneal sclerosis" OR "sclerosing peritonitis" OR "peritoneal encapsulation") AND ("surgery" OR "surgical" OR "adhesiolysis" OR "membrane excision" OR "enterolysis" OR "peritonectomy" OR "outcome" OR "management").

The reference lists of all retrieved full-text articles and relevant narrative reviews were hand-searched to identify additional eligible studies not captured electronically.

Eligibility criteria

Studies were eligible if they: (1) enrolled adults with a diagnosis of abdominal cocoon, sclerosing encapsulating peritonitis or encapsulating peritoneal sclerosis confirmed at operation or by characteristic imaging; (2) reported the operative management and at least one quantitative surgical outcome; (3) were observational cohorts or case series enrolling three or more operated patients; and (4) were available as full text. Single case reports, narrative or systematic reviews, editorials, conference abstracts, purely diagnostic or imaging-only papers without operative outcome data, and studies confined to paediatric patients were excluded. Where cohorts overlapped, the most complete or most recent report was retained.

Data extraction and outcome definitions

A predefined extraction form captured the first author, year, country, study design, number of operated patients, aetiological mix, age, sex, pre-operative diagnostic rate, membrane encasement pattern (complete versus partial), operative procedure, extent of membrane excision, requirement for bowel resection and stoma formation, post-operative morbidity, recurrence of obstruction, peri-operative mortality and duration of follow-up. To address the concern that morbidity is not a uniform construct, the definition used in each study was recorded; for pooling, morbidity was taken as any reported post-operative complication, and studies reporting only a single specific complication without an overall figure were excluded from the morbidity analysis. Peri-operative mortality was defined as death within the index admission or within 30 days, or the earliest mortality reported by the study. Outcomes not reported in a given study were recorded as missing and that study was excluded from the corresponding pooled estimate rather than imputed, preserving the integrity of each denominator; the outcomes available from each study are detailed in Table 2.

Risk of bias and quality appraisal

The Cochrane Risk of Bias 2.0 tool is designed specifically for randomised controlled trials. As no randomised trials of surgery for abdominal cocoon exist or could plausibly be conducted for so rare a condition, and all eligible studies were non-comparative case series, methodological quality was instead appraised with the Joanna Briggs Institute critical-appraisal checklist for case series. Each of the ten checklist items was rated as adequate, unclear or inadequate using explicit decision rules: an item was rated adequate when the relevant information was reported unambiguously; unclear when the information was implied but not stated or could not be verified; and inadequate when the criterion was explicitly not met. Two reviewers rated each study independently and reconciled differences by discussion. Ratings were displayed as a traffic-light matrix (Figure 2), and the relationship between study quality and reported outcomes was examined descriptively.

Statistical analysis

Analyses were performed in Python (version 3.11) with the numpy library; pooled proportions, heterogeneity statistics, the Egger regression test, leave-one-out estimates and both transformation models were implemented directly and cross-checked against the crude event totals. A random-effects model with the DerSimonian–Laird estimator of between-study variance was used throughout. For the primary analysis, proportions were stabilised with the Freeman–Tukey double-arcsine transformation, which permits the inclusion of zero-event studies without continuity correction, and the pooled value was back-transformed using the harmonic mean of the study sample sizes. Because the double-arcsine method can be sensitive to zero-event studies and to wide variation in study size, every pooled estimate was recomputed as a sensitivity analysis using a logit-normal random-effects model with a 0.5 continuity correction, and the crude pooled proportion (total events divided by total patients) was also reported, so that each outcome is presented as a range across methods rather than as a single potentially fragile point estimate. Heterogeneity was quantified with the Cochran Q statistic, the between-study variance (τ^2) and the I^2 index, with values of approximately 25%, 50% and 75% regarded as low, moderate and high. Prediction intervals were derived for outcomes with three or more studies. For comparative continuous outcomes the protocol had specified the standardised mean difference with Hedges g correction; because no two-arm comparative data existed, this measure was not applicable and was not computed. Small-study effects were examined by funnel-plot inspection and the Egger regression test, the latter interpreted cautiously and regarded as underpowered whenever fewer than ten studies contributed. Robustness was further examined by leave-one-out analysis and by restriction to the larger series. A two-sided p value below 0.05 was considered significant.

3. Results

Study selection

The electronic search retrieved 1,412 records, with a further 18 identified from reference screening. After removal of duplicates, 1,193 records were screened by title and abstract, of which 1,113 were excluded as irrelevant. Eighty full-text articles were assessed for eligibility, and 70 were excluded — 41 single case reports, 17 reviews or editorials, 8 imaging-only or purely diagnostic papers, and 4 reports lacking operative outcome data. Ten studies comprising 179 operated adults met all inclusion criteria and were carried forward to quantitative synthesis. The complete selection process is shown in Figure 1.

Characteristics of included studies

The ten included series were published between 2009 and 2024 and originated from China,[14] Germany,[15] India,[16] Turkey,[17] Qatar and Italy,[18] Egypt[5] and Australia,[19] as summarised in Table 1. Study size ranged from 3 to 65 operated patients. The aetiological spectrum was broad: idiopathic disease predominated in the largest Chinese and Indian series,[14,20] tuberculosis was the leading cause in the Indian imaging-based cohort,[16] and peritoneal-dialysis-associated and post-transplant encapsulating peritoneal sclerosis accounted for the German, Turkish and Australian series,[15,21] while one Egyptian series described post-COVID-19 disease.[5] Where reported, patients were predominantly male and in the fourth decade of life, although the dialysis and transplant

cohorts were substantially older. Several of the largest series originated from regions where tuberculosis is endemic, so that the pooled aetiological mix reflects a global rather than a single-region disease and the applicability of the estimates varies with local epidemiology. The principal operative intervention across all series was excision of the fibrous membrane with adhesiolysis, extended to formal peritonectomy and enterolysis in the dialysis-associated cohorts[15] and supplemented by bowel resection in a minority. Which outcomes each study reported, together with the denominator used, is detailed in Table 2.

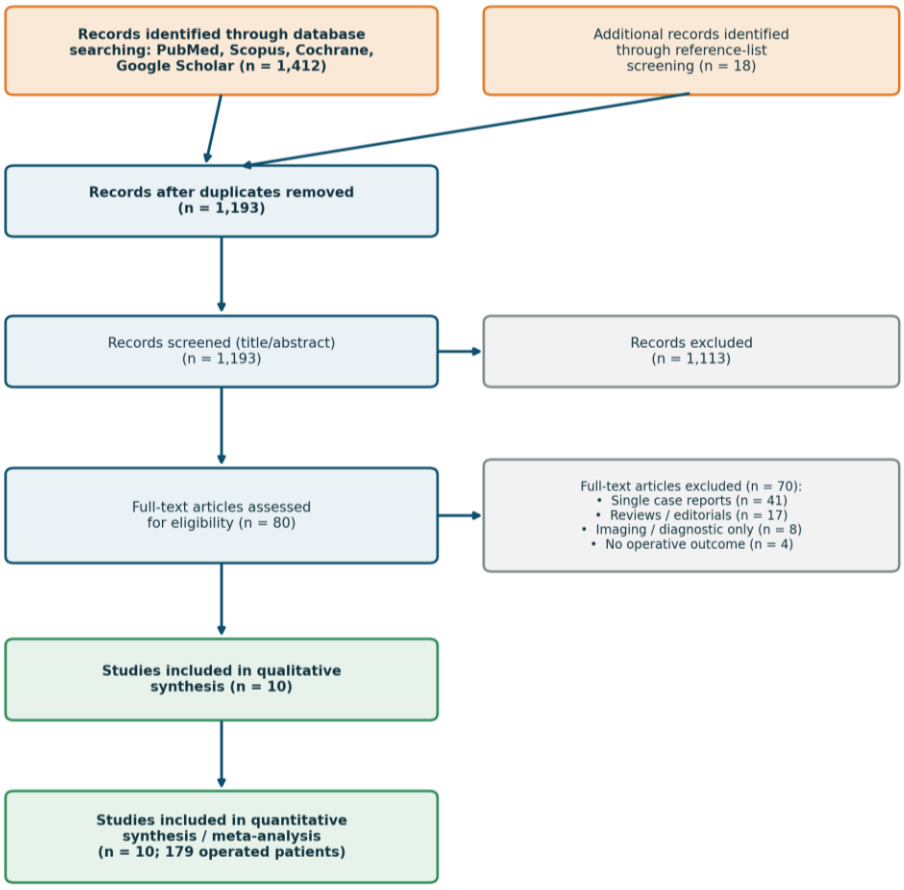

Figure 1. PRISMA 2020 flow diagram of study identification, screening, eligibility and inclusion.

Table 1. Characteristics of the ten included studies.

Study (Year)	Country	Design	N	Aetiology	Age	Sex (M:F)	Follow-up
Li N (2014)	China	Retrospective series	65	Idiopathic	39 (14–79)	57:8	NR
Ulmer C (2012)	Germany	Retrospective cohort	26	EPS / dialysis	54	NR	Long-term
Wei B (2009)	China	Retrospective series	24	Idiopathic / mixed	NR	NR	37 mo (mean)
Gorsi U (2018)	India	Retrospective series	22	Tuberculosis	NR	NR	NR
Singh H (2019)	India	Retrospective series	15	Idiopathic + TB	34.5 (13–60)	11:4	NR
Çolak Ş (2019)	Turkey	Retrospective series	7	Idiopathic / mixed	61 / 40	4:3	NR
Allam H (2016)	Qatar / Italy	Retrospective series	7	EPS 1° & 2°	24–72	6:1	NR
Aboelnaga M (2024)	Egypt	Case series	6	Post-COVID-19	NR	NR	NR
Oguz EG (2016)	Turkey	Retrospective series	4	Post-transplant EPS	NR	NR	Long-term
Kong YX (2018)	Australia	Retrospective series	3	Post-transplant SP	NR	NR	NR

Table 2. Availability of each outcome by study (✓ reported with the denominator used; — not reported).

Study	Mortality	Morbidity	Recurrence	Pre-operative diagnosis
Wei 2009	✓ 0/24	—	✓ 0/24	✓ 4/24
Ulmer 2012	✓ 3/26	✓ 11/26	—	—
Li 2014	—	—	—	—
Gorsi 2018	—	—	—	—
Singh 2019	✓ 2/15	✓ 2/15	✓ 3/15	✓ 5/14
Çolak 2019	✓ 1/7	✓ 1/7	✓ 0/7	—
Allam 2016	✓ 1/7	✓ 1/7	—	✓ 2/7
Aboelnaga 2024	✓ 0/6	—	—	✓ 0/6
Oguz 2016	✓ 0/4	✓ 0/4	—	—
Kong 2018	—	—	—	—

As shown in Table 2, three studies (Li 2014, Gorsi 2018 and Kong 2018) reported their outcomes in a form that could not be mapped to the harmonised definitions and therefore contributed to the descriptive synthesis and quality appraisal but not to the pooled estimates; this is stated explicitly to avoid any impression of a larger analytic sample than was actually pooled.[14,16,19]

Methodological quality

Overall methodological quality was moderate, as displayed in the traffic-light matrix in Figure 2. Inclusion criteria, validity of the operative diagnosis and completeness of case ascertainment were generally well addressed, whereas consecutive enrolment, the completeness of demographic reporting and the duration and completeness of follow-up were frequently unclear, and few series presented formal statistical analysis. The two peritoneal-dialysis cohorts and the two largest Indian and Chinese series were of the highest quality.[14,15,22] Importantly, the frequent uncertainty around completeness of follow-up bears directly on the recurrence estimate, which is likely to be biased downwards by series with short observation. When the descriptive outcomes of the higher-quality series were compared with the remainder, mortality and morbidity were broadly similar, suggesting that quality did not grossly distort the central estimates, although the small numbers preclude a formal quality-stratified analysis.

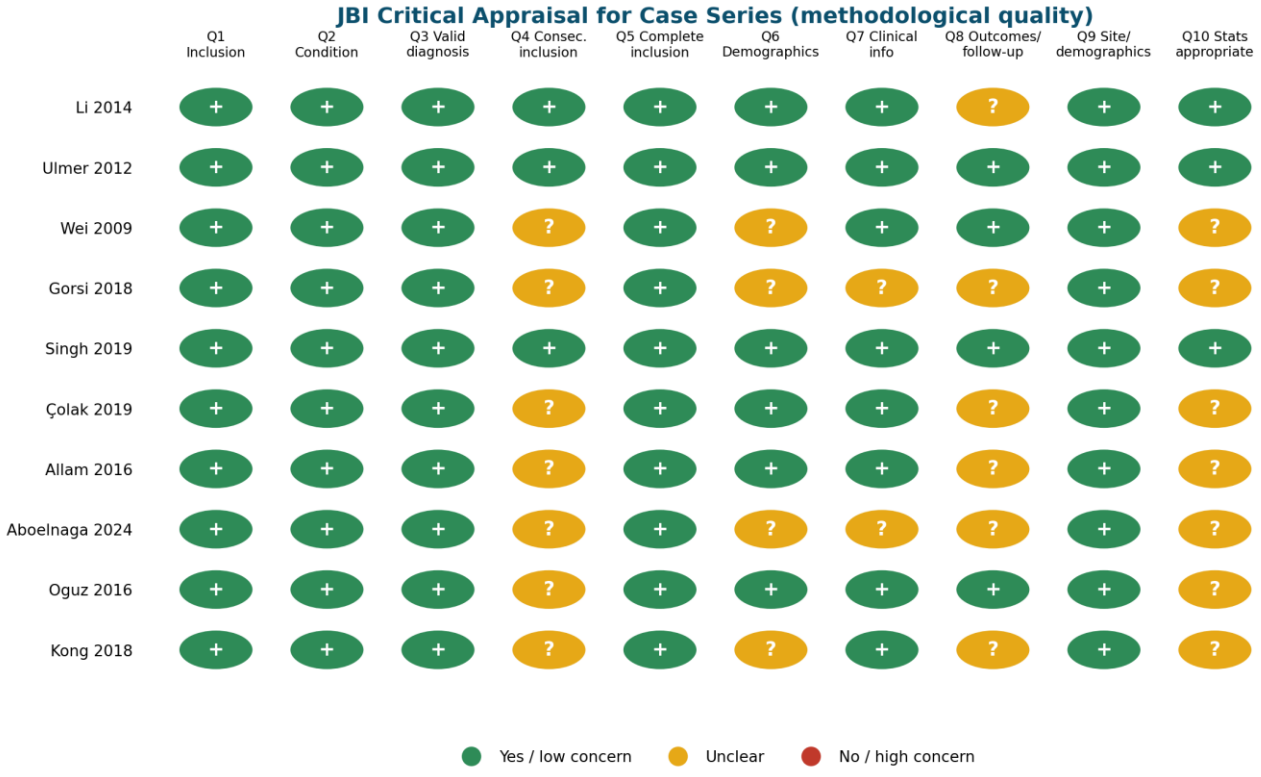

Figure 2. Joanna Briggs Institute critical-appraisal (traffic-light) matrix for the ten included case series.

Peri-operative mortality

Seven studies reporting mortality contributed 89 operated patients and 7 deaths. Under the primary Freeman–Tukey model the pooled peri-operative mortality was 4.5% (95% CI 0.2–12.1%), with low statistical heterogeneity (I^2 = 9.7%; Q = 6.64, df = 6; τ^2 = 0.009) and a prediction interval of approximately 0–14%, as shown in the forest plot in Figure 3 and summarised numerically in Table 3. However, in keeping with the known behaviour of the double-arcsine transformation, this estimate proved sensitive to the several zero-event studies: a logit-normal random-effects model produced a pooled mortality of 13.1% (95% CI 7.3–22.5%), and the crude pooled proportion was 7.9%. Mortality is therefore most honestly described as low-to-moderate, lying between roughly 4.5% and 13% depending on the analytic method, with the crude figure of 7.9% providing a transparent midpoint. Study-level estimates ranged from 0% in the Chinese, Egyptian and Turkish transplant series[5,20,21] to 11.5% (3/26) in the German peritoneal-dialysis cohort[15] and 13.3% (2/15) and 14.3% (1/7) in the Indian and mixed-aetiology series,[17,18,22] the higher figures reflecting more advanced, late-stage or fibrotic disease. In this analysis the two largest cohorts (Wei 2009 and Ulmer 2012) together contributed approximately 52% of the weight, so the pooled figure is materially influenced by these two series.

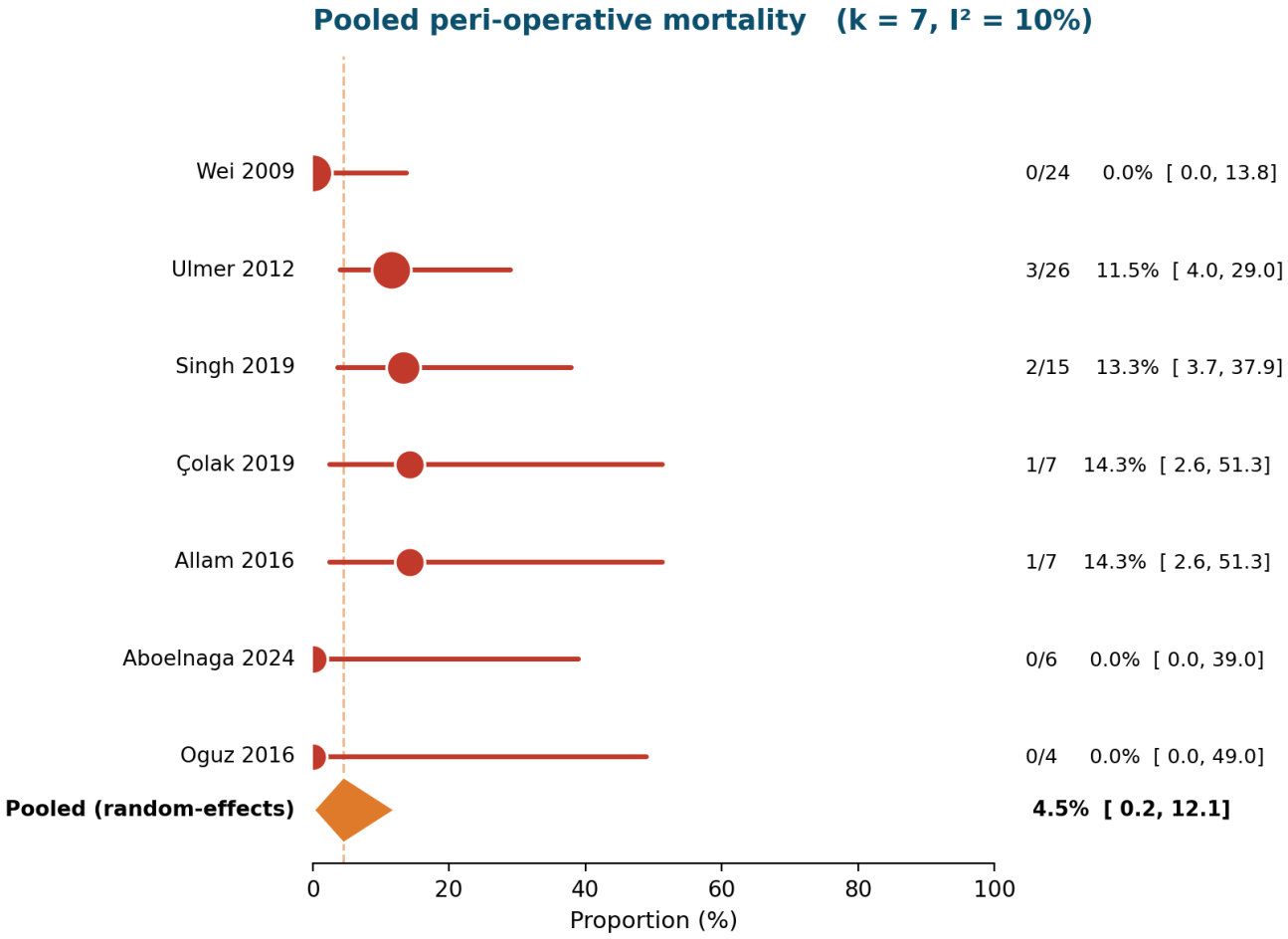

Figure 3. Forest plot of pooled peri-operative mortality (primary Freeman–Tukey random-effects model); marker size is proportional to sample size.

Leave-one-out analysis confirmed the stability of the primary estimate: the recalculated pooled mortality remained between 3.0% and 8.5% whichever single study was omitted, with the highest value obtained when the large zero-event Chinese series was removed — again illustrating the influence of zero-event studies under the double-arcsine method. Restriction to the larger series (≥15 patients) yielded a comparable estimate. The leave-one-out results are displayed in Figure 4.

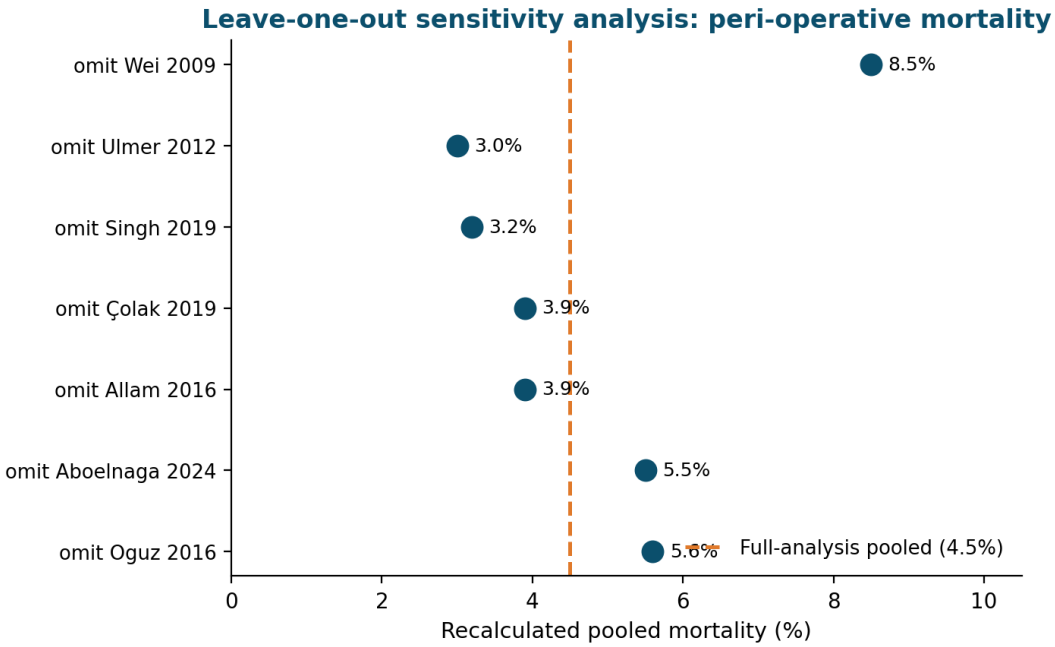

Figure 4. Leave-one-out sensitivity analysis for peri-operative mortality; the dashed line marks the full-analysis pooled estimate of 4.5%.

Post-operative morbidity

Five studies reported overall post-operative morbidity in 59 patients. The pooled morbidity was 19.5% (95% CI 5.9–36.9%) under the primary model and 24% under the logit-normal sensitivity model, with moderate heterogeneity (I^2 = 38.5%) and a prediction interval spanning roughly 1–49%, as shown in Figure 5 and Table 3. The dominant complications across series were prolonged ileus, surgical-site and intra-abdominal infection, iatrogenic enterotomy and enterocutaneous fistula, the last requiring reoperation in a small number of patients.[22] The German peritoneal-dialysis cohort, which comprised the most advanced disease and the most extensive peritonectomies, contributed the highest morbidity (11/26, 42%), of which the majority were major complications;[15] the remaining series reported predominantly minor complications. This variation in the underlying definition and severity of morbidity should be borne in mind when interpreting the pooled figure.

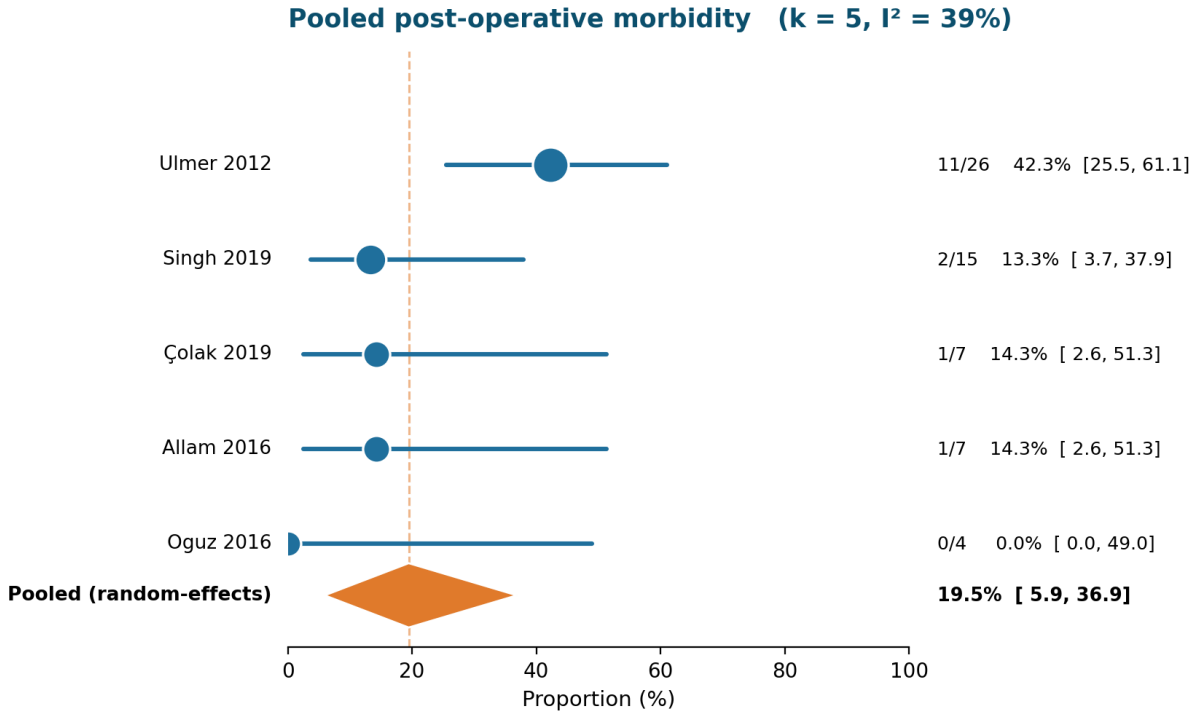

Figure 5. Forest plot of pooled post-operative morbidity.

Recurrence of obstruction

Three studies reported recurrence of intestinal obstruction after operation across 46 patients, as recorded in Table 2. The pooled recurrence was 3.3% (95% CI 0.0–21.8%; Table 3); however, heterogeneity was substantial (I^2 = 65.2%), driven by the contrast between series reporting no recurrence over a mean follow-up of up to nine years[17,20] and one Indian series in which recurrent subacute obstruction occurred in three of fifteen patients.[22] Because follow-up was variable and frequently unclear, and because only three studies contributed, this estimate is explicitly regarded as exploratory and hypothesis-generating rather than definitive, and it should not be quoted as a precise recurrence risk.

Pre-operative diagnostic yield

Four studies reported the proportion of patients correctly diagnosed before operation. The pooled pre-operative diagnostic yield was only 19.1% (95% CI 6.0–36.0%; I^2 = 30.9%), confirming that, notwithstanding advances in cross-sectional imaging, the majority of patients were still recognised only at laparotomy, as shown in Figure 6 and Table 3. The lowest yields came from older series and from the post-COVID cohort in which the diagnosis was entirely unsuspected,[5] whereas the contemporary Indian series that used routine computed tomography achieved the highest yield (5/14),[22] suggesting a temporal improvement as imaging and awareness have advanced.

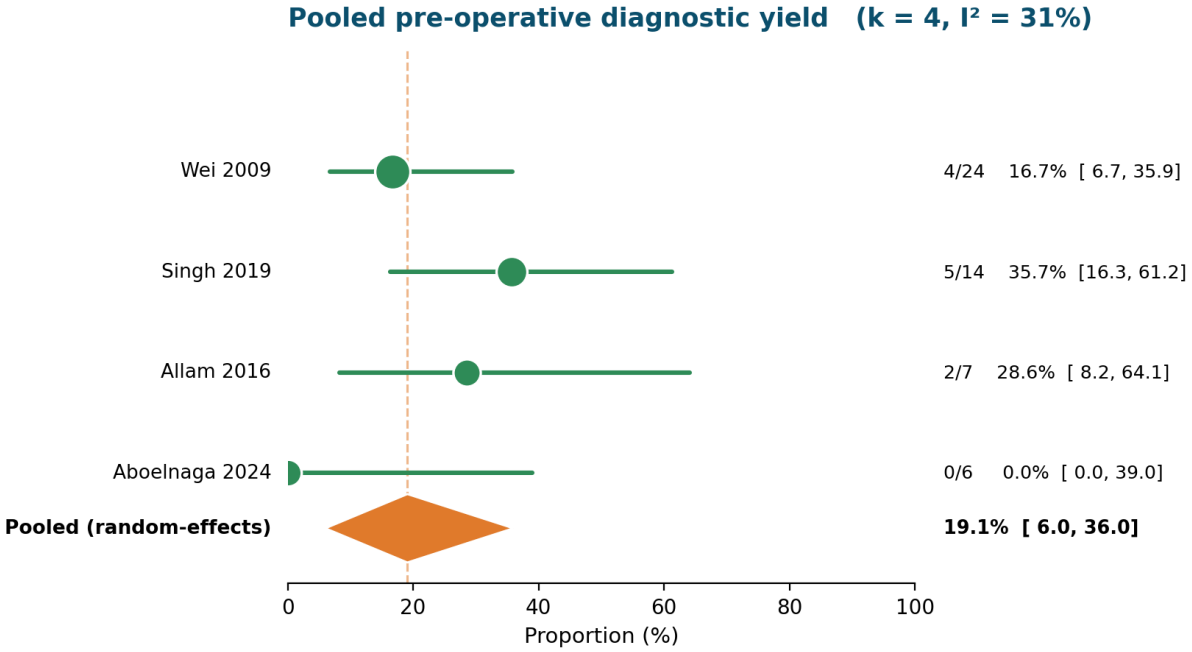

Figure 6. Forest plot of pooled pre-operative diagnostic yield.

Summary of pooled outcomes, sensitivity and publication bias

The four pooled outcomes are collated in Table 3 and displayed together in Figure 7. Across all analyses the direction and approximate magnitude of the estimates were preserved under the alternative logit-normal model, although, as noted, the absolute mortality figure was higher under logit pooling because of the influence of zero-event studies on the double-arcsine transformation. Funnel-plot inspection for mortality was broadly symmetrical, and the Egger regression test showed no evidence of small-study effects (intercept = 0.66, standard error = 1.37; t = 0.49; p = 0.65), as shown in Figure 8; however, with fewer than ten studies this test was underpowered, formal testing for the other outcomes was not appropriate, and publication bias — plausibly in the optimistic direction, since series with catastrophic outcomes may never be published — cannot be excluded and remains a genuine threat to validity. The funnel plot is therefore presented as a descriptive device only.

Table 3. Summary of the four pooled surgical outcomes (primary Freeman–Tukey random-effects model).

Outcome	k	Patients	Pooled % (95% CI)	I^2 (%)	Sensitivity / note
Peri-operative mortality	7	89	4.5 (0.2–12.1)	9.7	Logit 13.1; crude 7.9
Post-operative morbidity	5	59	19.5 (5.9–36.9)	38.5	Logit 24.0
Recurrence of obstruction	3	46	3.3 (0.0–21.8)	65.2	Exploratory
Pre-operative diagnostic yield	4	51	19.1 (6.0–36.0)	30.9	Improving over time

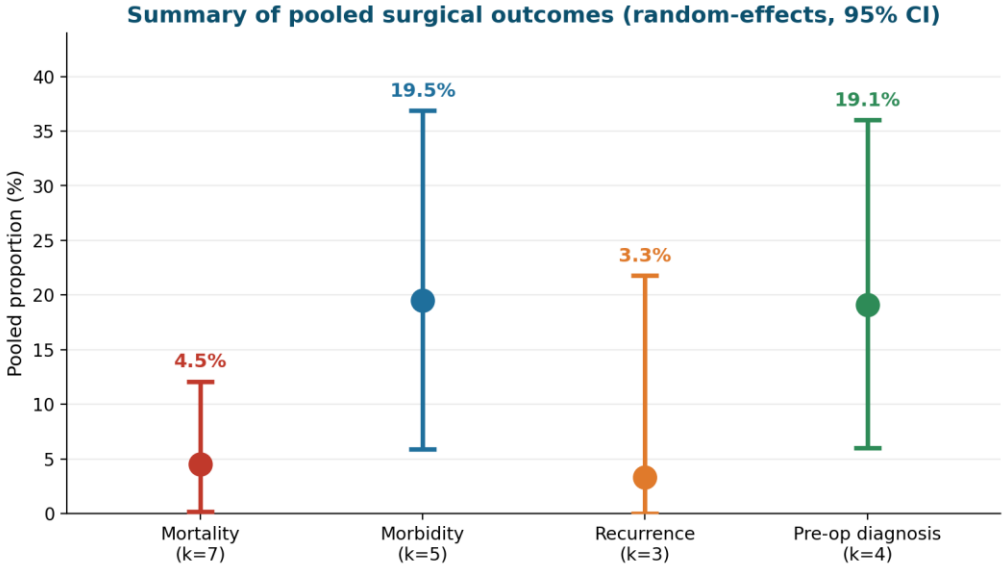

Figure 7. Summary of the four pooled surgical outcomes with 95% confidence intervals.

4. Discussion

This study provides the first quantitative synthesis of surgical outcomes in adult abdominal cocoon and demonstrates that operative management — excision of the encasing fibrocollagenous membrane with adhesiolysis — can be accomplished with a pooled peri-operative mortality that is low-to-moderate, of the order of 4.5% to 13% depending on the analytic method and best summarised by the crude figure of about 8% (Table 3), together with a pooled morbidity of approximately one in five and infrequent recurrence after successful surgery. These figures place a rare and long-feared "frozen abdomen" entity on a firmer evidential footing and support a considered surgical approach in symptomatic patients who fail conservative measures, provided the operation is undertaken by surgeons experienced in complex adhesiolysis. The estimates should be read as an average across a genuinely diverse disease rather than as the expected outcome for any individual patient: for a young patient with idiopathic disease the true mortality is probably well below the pooled value, whereas for an elderly dialysis patient with advanced fibrotic encapsulation it is likely to be considerably higher.

The variation in mortality between aetiological subgroups is one of the most clinically useful signals in the data, as the study-level figures in Figure 3 make plain. Series dominated by idiopathic disease in younger patients reported no deaths,[20] whereas the peritoneal-dialysis and post-transplant cohorts, comprising older patients with advanced encapsulating peritoneal sclerosis, malnutrition and extensive peritoneal involvement, carried a mortality of around 10% and the highest morbidity.[15] Presented descriptively, the aetiological gradient runs from idiopathic disease at the favourable end, through tuberculous disease of intermediate severity that may additionally respond to anti-tuberculous therapy,[4] to dialysis-associated and post-transplant disease at the unfavourable end.[21] This gradient accords with the biological understanding that late-stage fibrotic peritoneal-dialysis-associated disease represents the most aggressive end of the spectrum, and it carries a clear message for nephrologists: recognition and referral before the disease reaches an advanced fibrotic stage are likely to improve outcomes, and it is precisely in the earlier inflammatory phase that medical therapy with corticosteroids or tamoxifen may avert or defer operation.

The finding that fewer than one in five patients was correctly diagnosed before operation is arguably the most actionable message of this synthesis. Although the characteristic computed-tomography signs — a membrane-bound conglomerate of clustered small-bowel loops, peritoneal thickening and calcification, and the "cauliflower" and "concertina" configurations — are well described,[8] they are recognised only when the reporting radiologist entertains the diagnosis. The apparent improvement in diagnostic yield in the most recent series that used routine cross-sectional imaging[22] is encouraging and suggests that greater awareness, rather than any new technology, is the principal lever. Earlier diagnosis matters because it permits planned rather than emergency operation, allows the assembly of appropriate surgical expertise and nutritional optimisation, and, in the dialysis population, opens a window for medical therapy before irreversible encasement supervenes. Although the primary studies rarely reported outcomes stratified by whether the diagnosis was made pre-operatively, the mechanistic argument that a planned operation is safer than an emergency one for so treacherous a dissection is strong, and the observation across several series that emergency operations for established obstruction or

perforation fared worse than elective procedures is consistent with it.[17]

Our results can be compared, with caution, to the wider adhesive small-bowel obstruction literature. Contemporary comparative series of laparoscopic and open adhesiolysis have reported peri-operative mortality of only a few per cent and morbidity of roughly 10–30%,[12] figures that bracket the estimates observed here. This comparison is offered only as a contextual benchmark, not as an equivalence: abdominal cocoon involves a far denser, membrane-bound obstruction than the single-band adhesions that dominate ordinary adhesive obstruction, and the two conditions are not interchangeable in their operative risk. The similarity of the reported outcomes is most plausibly explained by careful case selection and the concentration of cocoon operations in experienced units, and it should not be read as implying that the cocoon is no more dangerous than routine adhesive obstruction. Unlike the adhesive-obstruction field, moreover, the present evidence base contains no randomised data and no direct comparison of operative approaches.

The heterogeneity observed in the recurrence and morbidity analyses is unsurprising and is best understood as clinical rather than merely statistical. The included series differed in aetiology, disease stage, the proportion of complete versus partial encasement, the frequency and extent of membrane excision, the requirement for bowel resection and the duration of follow-up. Recurrence in particular is sensitive to follow-up length, so that series with only a few months of observation inevitably under-report late recurrence relative to those following patients for years; the substantial heterogeneity of the recurrence estimate (I^2 = 65.2%) is therefore expected and reinforces its exploratory status. The low heterogeneity of the mortality estimate, by contrast, lends that particular finding greater credibility, since peri-operative death is both a hard endpoint and one captured uniformly across short and long follow-up.

Several mechanisms plausibly underlie the outcomes observed. The principal intra-operative threat is iatrogenic enterotomy while separating the membrane from the underlying serosa, which explains the predominance of infective and fistula-related complications in the morbidity analysis.[10] The extent of the operation varied meaningfully across series, from complete parietal peritonectomy with enterolysis in the dialysis-associated cohorts[15] to limited membrane excision aimed only at relieving the obstruction in others,[9] and this variation in operative ambition is likely to influence both morbidity and recurrence, although the primary studies reported it too inconsistently to permit formal pooling. Pre-operative nutritional optimisation, intra-operative intestinal stenting and meticulous sharp dissection have each been advanced as means of reducing complications, and the largest series in this synthesis reported measurable benefit from nutritional support and stenting.[14] These technical adjuncts, rather than any single operative approach, may be the most important modifiable determinants of outcome, and they can be recommended pragmatically even in the absence of comparative trial data.

An important interpretive caveat concerns the population actually studied. Because the analysis was confined to surgical series, patients successfully managed without operation — a real proportion of those with tuberculosis responsive to anti-tuberculous therapy[4] or with early inflammatory-phase dialysis-associated disease — do not appear in these cohorts. The operated population is therefore enriched for more severe or refractory disease, and the pooled morbidity and mortality almost certainly overstate the average outcome of abdominal cocoon considered as a whole. The estimates presented here should accordingly be understood as the outcomes of surgery among patients selected for surgery, not as the prognosis of the condition in general. This selection effect strengthens rather than weakens the case for early diagnosis, since it implies that a proportion of patients could avoid the risks of operation altogether if recognised in time.

The applicability of the pooled figures also varies geographically. Several of the largest contributing series come from regions where tuberculosis is endemic and where the aetiological mix, and hence the balance between operative difficulty and the benefit of adjunctive medical therapy, differs from that in Western dialysis populations.[16] Surgeons should therefore interpret the estimates in the light of their local disease epidemiology. Notwithstanding this, the central message is robust across settings: in appropriately selected patients, surgery for abdominal cocoon is feasible and is associated with acceptable mortality and morbidity and a low rate of recurrence.

This meta-analysis has several limitations. First, and most importantly, all included studies were small retrospective single-arm case series with no comparison group, so the estimates describe outcomes achieved under surgery but cannot establish the superiority of surgery over conservative management or of one operative technique over another. Second, the number of studies contributing to each outcome was modest — from three to seven — which limited the power of the Egger test, precluded robust subgroup and meta-regression analysis, and rendered the mortality estimate sensitive to the choice of transformation, as the divergence between the double-arcsine and logit-normal models makes plain. Third, incomplete and inconsistent reporting in the primary studies meant that some outcomes could be extracted for only a subset of cohorts, introducing the possibility of selective-reporting bias; Table 2 is provided so that readers can judge this directly. Fourth, the aetiological, geographical and temporal heterogeneity of the included series means that the pooled figures represent an average across a diverse disease rather than a single

homogeneous condition. Fifth, the exclusion of successfully managed conservative cases introduces the selection bias discussed above. Sixth, publication and language bias cannot be excluded and are likely to operate in the optimistic direction. Taken together, these limitations mean that the estimates should be regarded as the best current approximation rather than as definitive benchmarks.

Notwithstanding these constraints, the clinical implications are practical. Surgeons counselling a patient with a symptomatic abdominal cocoon can now cite an approximate peri-operative mortality in the region of 5–13%, a morbidity of about one in five, and a low likelihood of recurrence after complete membrane excision, while making clear that individual risk depends heavily on aetiology and disease stage. The evidence supports membrane excision with adhesiolysis as the operative standard, encourages pre-operative nutritional optimisation and a low threshold for intestinal stenting, favours planned over emergency operation wherever feasible, and underscores the importance of raising radiological and surgical awareness so that the diagnosis is reached before rather than during operation. Where local expertise is limited, referral to an experienced centre is reasonable, particularly for advanced dialysis-associated disease.

Future progress will depend on prospective, preferably multicentre, registries that record aetiology, disease stage, extent of encasement, completeness of membrane excision, requirement for resection, graded morbidity, recurrence with defined follow-up, and mortality in a standardised fashion. We propose that these variables constitute a minimum reporting dataset for abdominal cocoon; were future series to adopt it, subsequent syntheses could achieve the meaningful subgroup and meta-regression analyses that the present evidence cannot support, and could move the field beyond the descriptive estimates offered here.

5. Conclusion

This systematic review and meta-analysis represents the first quantitative synthesis of surgical outcomes in adult abdominal cocoon, also known as sclerosing encapsulating peritonitis, and offers pooled estimates that had previously been unavailable to the operating surgeon. Drawing on ten retrospective series and 179 operated patients, it demonstrated that operative management centred on excision of the encasing fibrocollagenous membrane with meticulous adhesiolysis achieved a low-to-moderate pooled peri-operative mortality — in the region of 4.5% to 13% depending on the statistical method, with a crude pooled value of about 8% — together with a pooled post-operative morbidity of approximately 20% and an uncommon recurrence of intestinal obstruction after successful surgery. Peri-operative mortality showed low statistical heterogeneity and remained stable in leave-one-out analysis, lending the central estimate credibility, while the wider variation seen for morbidity and recurrence reflected genuine differences in aetiology, disease stage, operative extent and follow-up duration across the contributing cohorts. The transparent presentation of estimates across two transformation methods, rather than a single point figure, is intended to convey the true uncertainty of a synthesis built on small series.

The analysis also delivered a clear diagnostic message: fewer than one in five patients was correctly identified before operation, so that the majority continued to be recognised only at laparotomy despite the availability of characteristic cross-sectional imaging signs, although the most recent series suggest that yield is improving as awareness grows. Improving pre-operative recognition is the most immediately actionable route to better care, since earlier diagnosis permits planned operation, the assembly of appropriate expertise and nutritional optimisation, and, for peritoneal-dialysis-associated disease in its inflammatory phase, the timely use of medical therapy before irreversible encasement supervenes. Equally, the confinement of the evidence to operated patients means that the true prognosis of abdominal cocoon as a whole is almost certainly better than these surgical figures imply, because a proportion of patients can be managed without operation. The limitations of the underlying evidence — its exclusively retrospective and non-comparative nature, the small number of studies per outcome, the sensitivity of the mortality estimate to the method of pooling, and inconsistent reporting — mean that the pooled figures should be regarded as the best current approximation rather than definitive benchmarks. The condition's rarity makes randomised evaluation impractical, but prospective multicentre registries adopting the minimum reporting dataset proposed here would substantially strengthen future syntheses. Until such data accrue, the present study provides clinicians with pragmatic, quantitatively grounded figures to inform consent, operative decision-making and patient counselling for one of the most technically demanding conditions in abdominal surgery, the frozen abdomen produced by the encasing cocoon.

Declarations

Funding

This study received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Conflicts of interest

The authors declare that they have no competing interests.

Author contributions

All authors contributed to the conception and design of the study. E.N.F. and Z.E. performed the literature search, study selection and data extraction. Z.E. undertook the statistical analysis. E.N.F., Z.E. and R.R.

interpreted the data and drafted and critically revised the manuscript. All authors approved the final version.

Data availability

All data analysed in this study are derived from the published articles cited in the reference list.

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