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REVIEW

Perioperative optimization in major abdominal surgery: impact of hemodynamic and metabolic management protocols in patients with critical comorbidities: a systematic review

Optimización perioperatoria en cirugía abdominal mayor: impacto de los protocolos de manejo hemodinámico y metabólico en pacientes con comorbilidades críticas: una revisión sistemática

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ABSTRACT

Introduction: patients with critical comorbidities undergoing major abdominal surgery face elevated risks of complications due to reduced physiological reserve. Hemodynamic and metabolic optimization strategies, including goal-directed fluid therapy and glycemic or nutritional protocols, may improve perioperative outcomes. This systematic review evaluates the effectiveness of such interventions in high-risk patients.
Method: a systematic search was performed in PubMed, Google Scholar and Cochrane Library up to May 2025. Eligible studies included randomized controlled trials and cohort observational studies. Risk of bias was assessed using the Cochrane RoB 2.0 tool for RCTs and the Newcastle-Ottawa Scale for observational studies. Two reviewers independently screened and extracted data.
Results: seventeen studies evaluated hemodynamic and metabolic optimization in high-risk abdominal surgery. Hemodynamic strategies—such as goal-directed fluid therapy guided by cardiac index or stroke volume variation—were associated with reductions in 30-day mortality (15,5 % vs. 21,8 %, p=0,005), complications, ICU admissions, and length of stay in several trials. However, outcomes were inconsistent across studies, with some showing no significant benefits. Metabolic optimization, including glycemic control and individualized nutrition, improved nitrogen balance, body composition, glycemic targets, and reduced liver dysfunction. Malnutrition was linked to increased complications and prolonged hospital stay. While many interventions showed promising results, variability in study designs and outcomes limits definitive conclusions.
Conclusions: hemodynamic and metabolic optimization may improve outcomes in high-risk abdominal surgery, though effects vary. Multimodal strategies targeting fluid balance, glycemic control, and nutrition appear beneficial.

Keywords: Perioperative Care; Hemodynamic Monitoring; Metabolic Diseases; Abdominal Surgery; Comorbidity.

RESUMEN

Introducción: los pacientes con comorbilidades críticas sometidos a cirugía abdominal mayor enfrentan riesgos elevados de complicaciones debido a la disminución de la reserva fisiológica. Las estrategias de optimización hemodinámica y metabólica, incluida la fluidoterapia dirigida a objetivos y los protocolos glucémicos o nutricionales, pueden mejorar los resultados perioperatorios. Esta revisión sistemática evalúa la efectividad de dichas intervenciones en pacientes de alto riesgo.
Método: se realizó una búsqueda sistemática en PubMed, Google Scholar y Cochrane Library hasta mayo de 2025. Los estudios elegibles incluyeron ensayos controlados aleatorios y estudios observacionales de cohortes. El riesgo de sesgo se evaluó mediante la herramienta Cochrane RoB 2.0 para los ECA y la escala de Newcastle-Ottawa para los estudios observacionales. Dos revisores examinaron y extrajeron los datos de forma independiente.
Resultados: diecisiete estudios evaluaron la optimización hemodinámica y metabólica en cirugía abdominal de alto riesgo. Las estrategias hemodinámicas, como la fluidoterapia dirigida a objetivos guiados por el índice cardíaco o la variación del volumen sistólico, se asociaron con reducciones en la mortalidad a los 30 días (15,5 % vs. 21,8 %, p = 0,005), complicaciones, ingresos en UCI y duración de la estancia hospitalaria en varios ensayos. Sin embargo, los resultados fueron inconsistentes entre los estudios, y algunos no mostraron beneficios significativos. Optimización metabólica, incluido el control glucémico y la nutrición individualizada, mejora del equilibrio de nitrógeno, la composición corporal, los objetivos glucémicos y la reducción de la disfunción hepática. La desnutrición se relacionó con un aumento de las complicaciones y una estancia hospitalaria prolongada. Si bien muchas intervenciones mostraron resultados prometedores, la variabilidad en los diseños y resultados de los estudios limita las conclusiones definitivas.
Conclusiones: la optimización hemodinámica y metabólica puede mejorar los resultados en la cirugía abdominal de alto riesgo, aunque los efectos varían. Las estrategias multimodales dirigidas al equilibrio de líquidos, el control glucémico y la nutrición parecen beneficiosas.

Palabras clave: Cuidados Perioperatorios; Monitoreo Hemodinámico; Enfermedades Metabólicas; Cirugía Abdominal; Comorbilidad.

INTRODUCTION

Major abdominal surgery poses substantial physiological challenges and is associated with considerable perioperative morbidity and mortality, particularly in patients with critical comorbidities such as cardiovascular disease, diabetes, advanced age, and malnutrition. These patients often exhibit reduced physiological reserve, altered fluid homeostasis, and impaired metabolic adaptation, placing them at greater risk for postoperative complications and prolonged recovery.[1] To mitigate these risks, perioperative optimization strategies have increasingly focused on targeted hemodynamic and metabolic interventions. Hemodynamic optimization, particularly through goal-directed therapy (GDT) or goal-directed fluid therapy (GDFT), employs advanced hemodynamic monitoring to tailor fluid administration and inotropic support according to dynamic parameters such as stroke volume variation (SVV), cardiac index (CI), and pulse pressure variation (PPV).[2] These strategies aim to optimize oxygen delivery and organ perfusion, thereby reducing complications related to hypovolemia and fluid overload.

In parallel, perioperative metabolic management has emerged as a key determinant of surgical outcomes. Strategies such as preoperative carbohydrate loading, early enteral nutrition, perioperative insulin therapy, and nurse-led glycemic protocols have shown promise in reducing insulin resistance, preserving lean body mass, and improving immune function.[3,4,5] Nutritional optimization has also been associated with better functional recovery and reduced complication rates, particularly in malnourished and elderly patients.[5]

Despite a growing body of literature, there remains a need for a comprehensive synthesis of evidence assessing the combined impact of these interventions on perioperative outcomes in high-risk populations. Existing reviews have often examined these domains separately, and few have focused exclusively on critically comorbid patients undergoing major abdominal procedures.[6,7,8] This systematic review was therefore conducted to evaluate and synthesize the current evidence on perioperative hemodynamic and metabolic optimization protocols in major abdominal surgery, with particular attention to high-risk patients. By consolidating findings from randomized controlled trials, cohort studies, and performance improvement initiatives, this review aims to provide a clearer understanding of which interventions are most effective in reducing complications, improving recovery, and optimizing outcomes in this vulnerable patient population.

METHOD

Study Design

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.[9]

Eligibility Criteria

Inclusion Criteria

Study Type: randomized controlled trials, prospective or retrospective cohort studies, and controlled before-and-after studies.

Population: adult patients (≥18 years) undergoing elective or emergency abdominal surgery.

Interventions: perioperative hemodynamic optimization strategies (e.g., stroke volume or cardiac index-guided fluid therapy, goal-directed fluid therapy) and metabolic optimization strategies (e.g., glucose control protocols, nutritional interventions).

Comparators: standard care or alternative fluid/metabolic management protocols.

Outcomes: postoperative complications, mortality, length of stay, gastrointestinal recovery, pulmonary outcomes, ICU admissions, glycemic control, nutritional status, or functional recovery.

Language: only studies published in English were included.

Exclusion Criteria

Case reports, editorials, review articles, abstracts, and conference proceedings without full-text availability.

Studies not reporting clinical outcomes of interest.

Studies focused solely on non-abdominal surgeries or pediatric populations.

Search Strategy

A comprehensive literature search was conducted using PubMed/MEDLINE, Scopus, Web of Science, and Cochrane Library databases. The search covered studies published from inception until May 2025. The following keywords and MeSH terms were used in various combinations:"goal-directed therapy," "fluid optimization," "stroke volume variation," "cardiac index," "hemodynamic monitoring," "glycemic control," "perioperative glucose," "nutritional support," "abdominal surgery," and "postoperative outcomes."

Manual screening of reference lists from included articles and related reviews was also performed to identify additional eligible studies.

Study Selection

After removal of duplicates, all titles and abstracts were screened independently by two reviewers. Full texts of potentially relevant articles were then retrieved and assessed for eligibility against the inclusion criteria. Disagreements were resolved through discussion or consultation with a third reviewer.

Data Extraction

Data were extracted using a standardized form to ensure consistency and accuracy across all included studies. The extracted information comprised study characteristics such as the author, year of publication, and study design. Additional details collected included sample size, baseline patient characteristics, and the type of abdominal surgical procedure performed. Specifics of the hemodynamic or metabolic interventions were documented, including the methods used for optimization and the comparator or control strategies employed. Furthermore, both primary and secondary clinical outcomes were extracted, focusing on postoperative complications, mortality, length of stay, and functional recovery, among others. Two reviewers independently performed the data extraction process, and any discrepancies were resolved through mutual discussion and consensus to maintain the integrity of the data.

Quality Assessment

The Cochrane Risk of Bias 2.0 tool was used to assess the quality of RCTs. For non-randomized studies, the Newcastle–Ottawa Scale (NOS) was applied. Each study was graded for selection, comparability, and outcome assessment. Quality assessments were independently performed by two reviewers, with disagreements resolved through discussion.

Data Synthesis

Given the heterogeneity in study designs, interventions, outcome definitions, and reporting formats, a narrative synthesis of the results was undertaken. Studies were grouped based on intervention type (hemodynamic vs. metabolic) and clinical outcomes. Key findings, statistical significance, and direction of effect were summarized to provide a comprehensive overview of the evidence.

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RESULTS

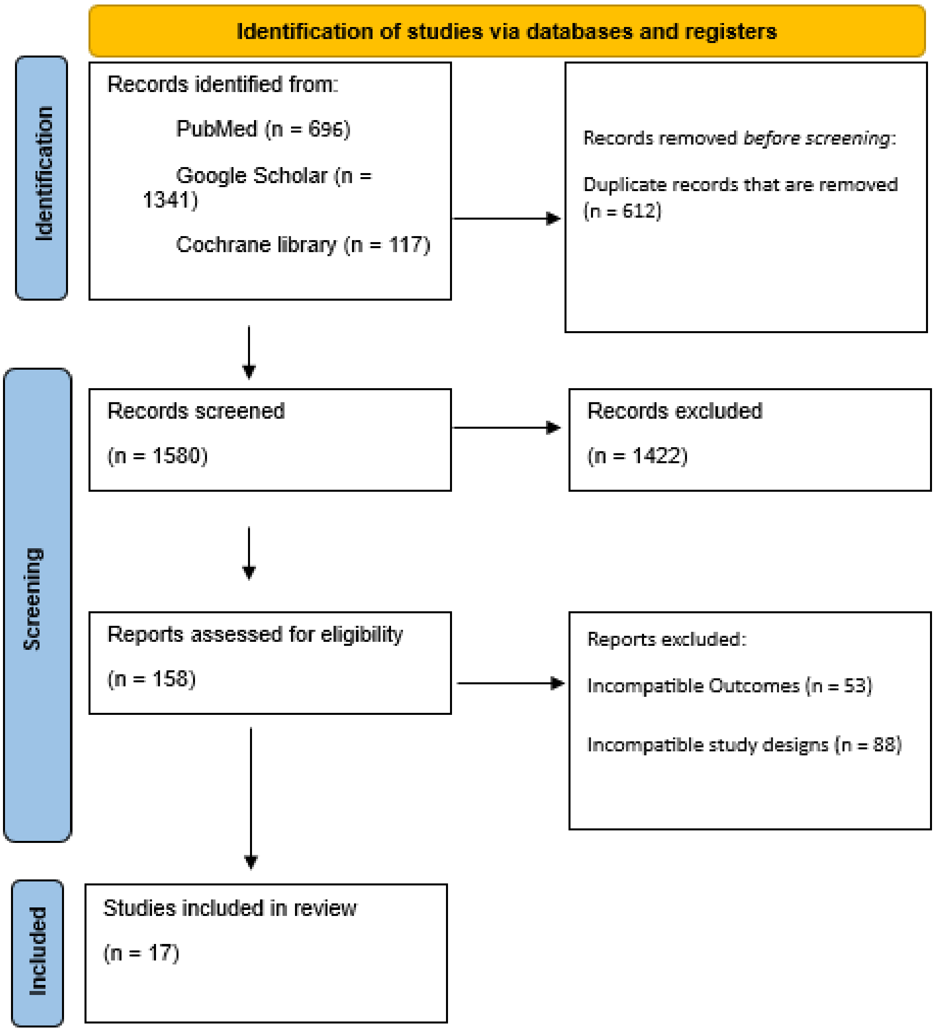

Figure 1. PRISMA flow diagram

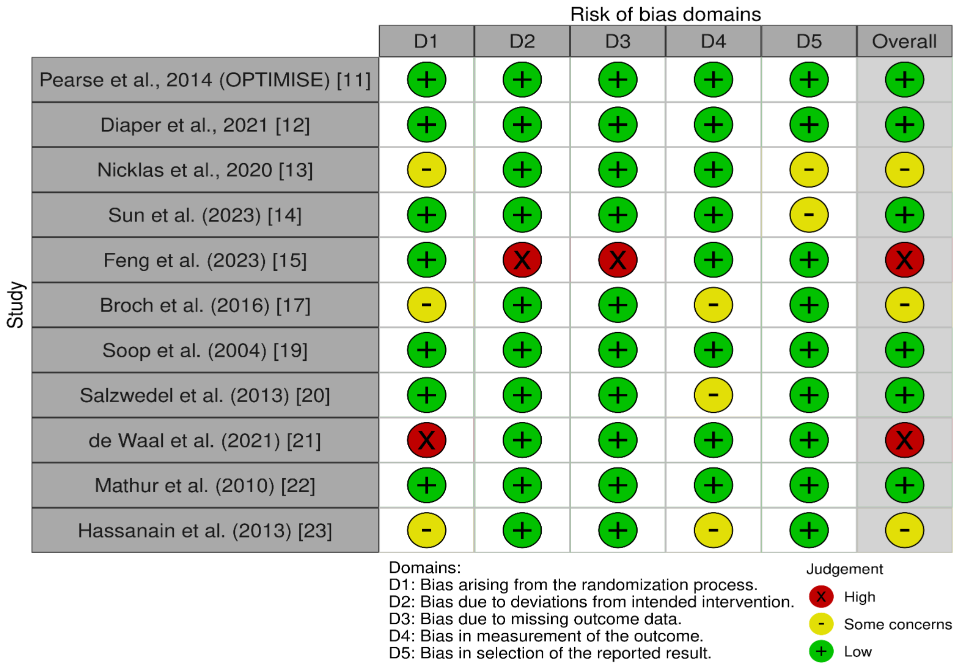

Figure 2. Quality assessment of RCTs by RoB 2.0 (Own elaboration)

Table 1. Characteristics and results of the studies included

Author, Year	Study Design	Population (Type & N)	Hemodynamic Intervention	Metabolic Intervention	Outcomes Assessed	Results	Conclusion
Tengberg et al.[10]	Prospective controlled cohort study	Acute high-risk abdominal surgery; 600 in intervention group and 600 historical controls	Stroke volume-guided fluid optimization, early surgery within 6 hours, early resuscitation, consultant-led care	High-dose antibiotics, early enteral nutrition, standardized analgesia, early ambulation	30-day and 180-day mortality	30-day mortality was 15,5 % in the intervention group compared to 21,8 % in the control group (P=0,005). 180-day mortality was 22,2 % vs 29,5 % (P=0,004). Intervention group showed improved survival outcomes.	Multidisciplinary perioperative protocol significantly reduced short- and long-term mortality.
Pearse et al.[11]	Multicenter RCT	High-risk patients undergoing major gastrointestinal surgery; RCT with 734 patients (368 intervention, 366 control); Meta-analysis included 38 trials with over 6,000 patients	Cardiac output-guided hemodynamic therapy using fluids and dopexamine during surgery and 6 hours after	None specific	30-day composite of complications and mortality; infections, ICU-free days, 30- and 180-day mortality	In the RCT, the primary outcome occurred in 36,6 % of the intervention group vs 43,4 % of the control group (relative risk 0,84; P=0,07). Not statistically significant. In the meta-analysis, the complication rate was significantly lower in the intervention group (31,5 % vs 41,6 %, relative risk 0,77). 30-day mortality was lower in the intervention group (4,9 % vs 6,5 %), but not statistically significant (RR 0,82). 180-day mortality was 8,3 % vs 10,3 % (RR 0,86). Cardiovascular serious adverse events occurred in 1,4 % of intervention patients vs none in controls.	RCT alone did not show significant benefit, but meta-analysis showed reduced complications and a trend toward reduced mortality.
Diaper et al.[12]	Multicenter RCT	Elective major open abdominal surgery; 401 patients (200 goal-directed, 201 restrictive)	Goal-directed hemodynamic therapy with cardiac output monitoring vs restrictive normovolemic fluid therapy	Not specified	30-day mortality and complications (Dindo-Clavien grade 2–4); pulmonary, cardiovascular, renal complications; hospital stay; midterm survival	Goal-directed group received higher intraoperative fluid (10,8 vs 7,2 mL/kg/h; P<0,001). The primary outcome occurred in 57,7 % of the goal-directed group and 53,0 % of the restrictive group (RR 1,09; not statistically significant). No significant difference in secondary outcomes such as pulmonary, cardiovascular, renal complications or hospital stay.	No significant difference in postoperative outcomes between goal-directed and restrictive strategies.

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Nicklas et al.[13]	Single-centre RCT	High-risk patients undergoing major abdominal surgery; 188 total (94 in each group)	Personalized hemodynamic management based on each patient's resting cardiac index, using fluid and/or dobutamine	Not specified	30-day major complications or death; 90-day mortality; postoperative morbidity; neurocognitive function	The primary outcome occurred in 29,8 % of the personalized group vs 55,3 % of the routine group (relative risk 0,54; P<0,001). 30-day mortality was 1 patient in the personalized group vs 5 in routine group (not statistically significant). No significant difference in neurocognitive outcomes or hospital length of stay.	Personalized hemodynamic strategy significantly reduced major complications or death within 30 days compared to routine care.
Sun et al.[14]	Randomized Controlled Trial	100 adult patients undergoing major abdominal oncologic surgery (50 GDFT, 50 control)	GDFT guided by Stroke Volume Variation <12 % and Cardiac Index ≥2,5 L/min/m²	Not specified	Length of hospital stay, postoperative GI function (time to first flatus and oral intake), incidence of GI dysfunction	Group receiving GDFT had significantly shorter hospital stay (9,0 ± 5,8 vs. 12,0 ± 4,6 days, p=0,001). Incidence of GI dysfunction was lower in GDFT group (4 % vs. 32 %, p<0,001). Time to first flatus was 11 hours earlier (p=0,009), and oral diet was tolerated 2 days sooner (p<0,001).	GDFT using SVV and CI improved GI recovery and reduced hospital stay duration.
Feng et al.[15]	Randomized Controlled Trial	100 older patients undergoing radical resection of gastrointestinal tumors (3 groups: C=31, S1=34, S2=35)	Group S2: GDT based on SVV and Colloid Osmotic Pressure (COP); Group S1: GDT based on SVV; Group C: conventional fluid therapy	Colloid management guided by COP	Pulmonary complications, PaO_2/FiO_2 ratio, Lung Injury Score (LIS), fluid balance	S2 group had fewer pulmonary complications compared to C (p<0,05). PaO_2/FiO_2 ratio was higher (better oxygenation), and LIS was lower in S2 (p<0,05). Total fluid infusion was less in S2 vs. C, while colloid use was higher in S2 vs. both S1 and C (p<0,05). Urine output was not significantly different.	GDT guided by SVV and COP reduced pulmonary complications and supported better postoperative pulmonary outcomes in older patients.
Cannesson et al.[16]	Historical Prospective Quality Improvement Study	330 high-risk abdominal surgery patients (128 pre-implementation, 202 post-implementation)	PGDT protocol implemented via performance improvement initiative using CI-guided fluid boluses and baseline crystalloids	Not specified	Hospital length of stay (LOS), NSQIP postoperative complications	Fluid administration was reduced (9,9 to 6,6 ml/kg/hr, p<0,01). LOS decreased from 10 (6–16) to 7 (5–11) days (p=0,0001). Postoperative complications declined from 39 % to 25 % (p=0,04). Regression analysis showed intervention reduced LOS by 18 % (95 % CI: 9,27 %).	Implementation of PGDT protocol improved fluid management and reduced both LOS and complication rates.

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Broch et al.[17]	Randomized Controlled Feasibility Study	79 patients undergoing elective major abdominal surgery (SG=39, CG=40)	EGDT based on non-invasive CI and PPV (Nexfin™); standard care for control group	Not specified	Postoperative complications, LOS, mortality (up to 28 days)	Number of complications was lower in SG (94 vs. 132) but difference was not statistically significant (p=0,22). No difference in LOS between groups (both median 9 days). No significant difference in mortality observed.	Non-invasive EGDT was feasible but did not significantly improve clinical outcomes in this study.
Kurtoglu et al.[18]	Prospective Cohort Study	47 patients with type 2 diabetes undergoing elective major abdominal surgery (22 intervention, 25 control)	None	Nurse-led perioperative glycemic management protocol vs. routine care	Rate of hyperglycemia, insulin consumption, time to target blood glucose, time in target range, nurse satisfaction	Hyperglycemia in ICU was lower in intervention group (21 % vs. 59 %, p<0,05). Time in target BG range during insulin infusion was higher (76 % vs. 35 %, p<0,05). Time to reach target BG was shorter (6 vs. 15 hours, p<0,05). Insulin use was reduced in the intervention group (p<0,05). Nurse satisfaction was high (92,61 ± 7,93 %).	Nurse-led glycemic protocol improved blood glucose control, reduced insulin use, and achieved better target range faster during surgery.
Soop et al.[19]	Randomized Controlled Trial	18 patients undergoing major colorectal surgery with enhanced recovery protocol	None	Immediate postoperative enteral nutrition (complete vs. hypocaloric)	Nitrogen balance, insulin resistance, blood glucose levels	Nitrogen balance was better in complete nutrition group (+0,1 g/day vs. -12,6 g/day, p<0,001). Insulin resistance was low in both groups and similar (−20 % vs. −27 %). Blood glucose was controlled without hyperglycemia (5,8 vs. 5,0 mmol/L).	Immediate enteral feeding improved nitrogen balance without causing hyperglycemia and did not increase insulin resistance.
Salzwedel et al.[20]	Multicenter Randomized Controlled Trial	160 patients undergoing elective major abdominal surgery (79 study group, 81 control group)	GDT guided by pulse pressure variation, cardiac index trending, and MAP vs. standard care	None	Total complications, infection rate, return of bowel function, PACU stay, LOS	Total complications were fewer in the study group (52 vs. 72, p=0,038). Infections were reduced (13 vs. 26, p=0,023). No significant differences in bowel movement recovery (3 vs. 2 days, p=0,316), PACU time (180 min each), or LOS (11 vs. 10 days, p=0,929).	GDT significantly reduced overall and infection-related complications but did not affect hospital stay or bowel recovery time.
de Waal et al.[21]	Multicenter RCT	482 patients undergoing elective high-risk abdominal surgery	Perioperative goal-directed therapy (PGDT) based on CI and SVV for 24h	None	Major and minor complications, LOS, fluid and vasoactive use	No significant difference in major complications (0,79 vs. 0,69, p=0,195), minor complications, or LOS. PGDT group received more fluids and dobutamine; control group used more phenylephrine.	PGDT using CI and SVV did not improve outcomes in high-risk abdominal surgery.

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Mathur et al.[22]	Double-blind RCT	142 patients undergoing elective colorectal or liver surgery (69 CHO, 73 placebo)	None	Oral carbohydrate drinks evening before and 2h pre-op vs. placebo	Postoperative LOS, fatigue scores	Median hospital stay: 7 vs. 8 days (p=0,344). No significant differences in fatigue scores. Subgroup without epidural/laparoscopy showed trend toward shorter stay (7 vs. 9 days, p=0,054).	Pre-op CHO treatment did not significantly affect LOS or fatigue; possible benefit in specific subgroups.
Hassanain et al.[23]	RCT	56 patients undergoing liver resection (29 insulin group, 27 control)	None	Hyperinsulinaemic normoglycaemic clamp (HNC) with pre-op dextrose and insulin infusion	Liver dysfunction score, glycogen content, complications	Liver dysfunction score was significantly lower in HNC group (range 0-4 vs. 0-8, p=0,031). Liver glycogen content higher (431 vs. 278 µmol/g, p=0,011). Complications increased with dysfunction severity (p=0,032).	Perioperative insulin therapy reduced liver dysfunction and improved glycogen storage after hepatectomy.
Chen et al.[24]	Prospective Cohort Study	96 patients undergoing pancreatic surgery (48 trial, 48 control)	None	Individualized nutritional intervention (targeted energy & protein intake)	Body composition, time to bowel recovery, LOS, serum nutritional markers	Trial group had better BCM, FFM, SMM at POD 3 and discharge (P<0,001). Shorter hospital stay (15,9 vs. 20,4 days, P=0,046). Improved serum protein ratio (P<0,05), no significant difference in albumin/prealbumin/hemoglobin.	Individualized nutrition improved nutritional status and shortened postoperative hospital stay.
Kanemoto et al.[25]	Prospective cohort study	1248 patients ≥55 years undergoing elective abdominal surgery	None	Nutritional status assessed preoperatively using MNA-SF	Major postoperative complications (Clavien-Dindo ≥3a), hospital LOS, unplanned readmission	12,4 % had major complications. Lower MNA-SF score predicted higher risk (OR 0,92, 95 % CI 0,86–0,99). Malnourished and at-risk patients had significantly longer hospital stays (P = 0,001), but no significant difference in unplanned readmission (P = 0,14).	Preoperative malnutrition was common and associated with increased risk of major complications and prolonged hospital stay.
Koo et al.[26]	Interventional comparative study (with PS-matched control)	294 patients undergoing laparoscopic hepatobiliary or pancreatic surgery (147 GDFT, 147 controls)	Goal-directed fluid therapy using SV and CI vs. conventional fluid management	None	Postoperative complications, ICU admission, intraoperative fluid usage	GDFT group had fewer adverse events overall (57,8 % vs. 70,1 %, P = 0,038). Pleural effusion was lower (9,5 % vs. 19,7 %, P = 0,024). Fewer ICU admissions in GDFT group (4,1 % vs. 10,2 %, P = 0,049). Crystalloid volume lower in GDFT group (5,1 vs. 6,3 ml/kg/h, P < 0,001).	GDFT improved fluid balance and reduced postoperative complications and ICU admission in laparoscopic surgery.

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Table 2. Quality assessment of the reviewed studies by Newcastle Ottawa Scale

Study	Representativeness of the exposed cohort (1)	Selection of them non-exposed cohort (1)	Ascertainment of exposure (1)	Demonstration that outcome of interest was not present at start of Study (1)	Compare ability of cohorts on the basis of the design or analysis (2)	Assessment of outcome (1)	Was follow-up long enough for outcomes to occur (1)	Adequacy of follow up of cohorts (1)	Representativeness of the exposed cohort (1)
Tengberg et al.[10]	1	1	1		2	1	1	1	1
Cannesson et al.[16]	1	1	1	1	2	1	1	1	1
Kurtoglu et al.[18]	1	1	1		2	1	1	1	1
Chen et al.[24]	1		1		1	1	1	1	1
Kanemoto et al.[26]	1		1		1	1	1	1	1
Koo et al.[26]	1	1	1		2	1	1	1	1

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A comprehensive literature search was conducted across major databases including PubMed, Cochrane Library, and Google Scholar, yielding 2154 records. After removing 612 duplicates, 1580 unique records were screened based on titles and abstracts; of these, 1422 were excluded for not meeting the inclusion criteria, primarily due to irrelevance to perioperative optimization protocols or lack of focus on critically comorbid patients undergoing major abdominal surgery. Full texts of 158 articles were then assessed for eligibility. Following detailed evaluation, 141 studies were excluded for reasons such as being reviews, editorials, or not reporting relevant clinical outcomes. Ultimately, 17 studies met the inclusion criteria and were included in the systematic review. Characteristics and results are summarized in table 1. Quality assessment of randomized controlled trials is done by the RoB 2.0 tool (figure 2) and of non-randomized controlled trials by the Newcastle Ottawa Scale (table 2).

Hemodynamic Management

Impact on Mortality and Major Complications: Tengberg et al.[10] demonstrated that a comprehensive multidisciplinary perioperative strategy—incorporating stroke volume-guided fluid optimization, early surgery, and early resuscitation—significantly improved survival outcomes in high-risk abdominal surgery patients, reducing both 30-day (15,5 % vs. 21,8 %, p=0,005) and 180-day mortality (22,2 % vs. 29,5 %,). Similarly, Nicklas et al.[13] found that personalized hemodynamic management based on resting cardiac index significantly reduced major complications or death within 30 days compared to routine care (29,8 % vs. 55,3 %, p<0,001). In contrast, the OPTIMISE trial by Pearse et al.[10] showed a non-significant trend toward reduced 30-day mortality and complications in the intervention group (36,6 % vs. 43,4 %, p=0,07), while the accompanying meta-analysis reported significantly lower complication rates (31,5 % vs. 41,6 %) and a trend toward lower 30-day and 180-day mortality.

In the study by Salzwedel et al.[20], goal-directed therapy (GDT) guided by pulse pressure variation and cardiac index significantly reduced the total number of complications (52 vs. 72, p=0,038) and infections (13 vs. 26, p=0,023), though it did not influence other postoperative outcomes. Conversely, Diaper et al.[12] and de Waal et al.[21] found no significant benefit of goal-directed or perioperative GDT strategies in reducing major complications or mortality when compared to restrictive or standard fluid strategies.

Impact on Length of Stay (LOS): multiple studies reported a favorable impact of hemodynamic optimization on hospital length of stay. Cannesson et al.[16] observed a reduction in LOS from 10 to 7 days (p=0,0001) following the implementation of a CI-guided protocol. Similarly, Sun et al.[14] demonstrated that stroke volume variation- and cardiac index-guided GDFT significantly shortened hospital stays in patients undergoing oncologic abdominal surgery (9,0 ± 5,8 vs. 12,0 ± 4,6 days, p=0,001). Broch et al.[17], however, found no significant difference in LOS between enhanced GDT and standard care groups (both median 9 days), and Salzwedel et al.[20] also reported similar LOS between groups. De Waal et al.[21] observed no impact on LOS with 24-hour CI- and SVV-guided therapy in high-risk patients. Similarly, Diaper et al.[12] did not find significant differences in LOS between goal-directed and restrictive groups.

Impact on Gastrointestinal Recovery: Sun et al.[14] demonstrated that GDFT using SVV and CI significantly improved gastrointestinal function, leading to an earlier time to first flatus (11 hours earlier, p=0,009) and earlier tolerance of oral intake by two days (p<0,001). There was also a reduced incidence of gastrointestinal dysfunction (4 % vs. 32 %, p<0,001), indicating enhanced GI recovery with hemodynamic monitoring.

Impact on Pulmonary Outcomes: Feng et al.[15] explored the role of goal-directed therapy based on SVV and colloid osmotic pressure (COP) in elderly patients. The group managed with SVV and COP had significantly fewer pulmonary complications and better oxygenation (higher PaO_2/FiO_2 ratio) and lower Lung Injury Scores compared to conventional therapy (all p<0,05).

Impact on Fluid Balance and ICU Admission: Koo et al.[26] found that GDFT improved intraoperative fluid balance, resulting in lower crystalloid use (5,1 vs. 6,3 ml/kg/h, p<0,001), fewer overall postoperative complications (57,8 % vs. 70,1 %, p=0,038), and reduced ICU admission rates (4,1 % vs. 10,2 %, p=0,049). Likewise, Cannesson et al.[16] reported improved fluid management with reduced intraoperative fluids (9,9 to 6,6 ml/kg/hr, p<0,01), which contributed to fewer complications and shorter hospital stays. On the contrary, de Waal et al.[21] noted that the PGDT group received more fluids and dobutamine, while the control group used more vasopressors, with no difference in outcomes.

Metabolic Management

Impact on Glycemic Control: Kurtoglu et al.[18] evaluated a nurse-led glycemic protocol in diabetic patients and found significantly better glucose control during the perioperative period. The intervention group had lower ICU hyperglycemia rates (21 % vs. 59 %, p<0,05), a higher percentage of time in the target range during insulin infusion (76 % vs. 35 %, p<0,05), and reached target glucose levels more rapidly (6 vs. 15 hours, p<0,05). Insulin consumption was also reduced, and nurse satisfaction with the protocol was high (92,61 ± 7,93 %).

Hassanain et al.[23] showed that hyperinsulinaemic normoglycaemic clamp therapy with pre-op glucose and insulin infusion in liver resection patients resulted in significantly lower liver dysfunction scores (p=0,031) and higher liver glycogen content (431 vs. 278 µmol/g, p=0,011). Complication rates increased with worsening dysfunction, indicating the protective role of perioperative insulin.

Impact on Nutritional Status and Functional Recovery: Soop et al.[19] found that immediate postoperative enteral nutrition in colorectal surgery patients improved nitrogen balance (+0,1 g/day vs. -12,6 g/day, p<0,001) without inducing hyperglycemia or increasing insulin resistance. Similarly, Chen et al.[24] showed that individualized nutrition after pancreatic surgery improved body composition (better BCM, FFM, SMM on POD 3 and discharge, all p<0,001), reduced LOS (15,9 vs. 20,4 days, p=0,046), and improved serum protein ratios (p<0,05).

Mathur et al.[22] assessed the effect of preoperative carbohydrate loading and found no significant impact on hospital stay or fatigue scores in the general cohort; however, a subgroup analysis indicated a potential benefit in patients without epidurals or laparoscopy (median stay 7 vs. 9 days, p=0,054).

Impact of Preoperative Nutritional Risk: Kanemoto et al.[25] found that 12,4 % of older patients undergoing elective abdominal surgery experienced major postoperative complications, with malnourished and at-risk patients (based on MNA-SF score) showing a significantly higher risk of complications (OR 0,92, 95 % CI 0,86-0,99) and prolonged hospital stays (p=0,001).

DISCUSSION

This systematic review synthesized evidence from 17 studies evaluating the impact of perioperative hemodynamic and metabolic management strategies on outcomes in major abdominal surgery. The findings underscore a growing consensus around the value of protocolized and individualized perioperative care, particularly when these strategies are guided by patient-specific physiological parameters. While heterogeneity in methodology and endpoints limits direct comparisons, several consistent themes emerged.

A cluster of studies supports the effectiveness of personalized or goal-directed hemodynamic management in reducing postoperative morbidity and enhancing recovery. Tengberg et al.[10], Nicklas et al.[13], and Koo et al.[26] each implemented individualized hemodynamic strategies—whether based on stroke volume, cardiac index, or overall perfusion goals—and consistently reported reductions in complications, ICU admissions, or fluid overload. Their shared use of dynamic monitoring tools and early intraoperative interventions appears central to these outcomes. Similarly, Cannesson et al.[14] and Sun et al.[16] demonstrated how protocol-driven, cardiac index-guided management could lead to fewer complications and shorter hospital stays. Feng et al.[15] approach, which added colloid osmotic pressure monitoring to GDT protocols, also yielded improvements in pulmonary outcomes, highlighting how refined hemodynamic targets may provide even greater Benefit.

However, not all studies reached the same conclusion, reflecting the complexity of applying hemodynamic protocols across diverse surgical contexts. Pearse et al.'s OPTIMISE trial—a landmark in this field—did not find statistically significant differences in its RCT phase, though its accompanying meta-analysis suggested some Benefit.[11] Likewise, studies by Diaper et al.[12], de Waal et al.[21], and Broch et al.[17] found no consistent advantages to GDT, either because of similar outcomes between groups or lack of power to detect differences. These discrepancies may stem from differences in protocol fidelity, patient risk profiles, or variability in surgical complexity. Salzwedel et al., while not showing reduced length of stay, did report fewer infectious complications, suggesting some selective Benefit.[20] Altogether, while the evidence leans toward support for GDT, it also highlights the need for nuanced application rather than a one-size-fits-all approach.

In parallel, the metabolic optimization strategies—particularly glycemic control and nutritional support—showed considerable promise. The studies by Kurtoglu et al.[18] and Hassanain et al.[23] both reinforce the importance of targeted glycemic management in the perioperative period. Protocol-driven glucose control improved glycemic stability and seemed to mitigate insulin-related metabolic disturbances, especially in high-risk settings like hepatectomy or ICU care. The consistency of their findings strengthens the case for structured insulin protocols as part of enhanced recovery programs.

Nutritional interventions were also highlighted as pivotal components of perioperative care. Chen et al.[19] and Soop et al.[26] demonstrated that individualized nutritional support and early enteral feeding could enhance metabolic recovery without adverse glycemic effects. These findings support a broader movement toward early, aggressive nutritional therapy to preserve muscle mass and immune competence. Kanemoto et al.[25] work further stressed the need to assess and address preoperative nutritional status, as malnourishment was linked to poor surgical outcomes. While Mathur et al.[22] study on carbohydrate loading showed only modest or subgroup-specific effects, it contributes to an evolving understanding of how even preoperative strategies can influence the postoperative course.

This systematic review has several limitations that must be considered when interpreting the findings. First, the included studies exhibited significant heterogeneity in terms of intervention types, monitoring techniques, outcome measures, and surgical populations, which precluded a formal meta-analysis and limited the ability to draw generalized conclusions. While some studies focused on individualized hemodynamic strategies (e.g., based on stroke volume or cardiac index), others assessed metabolic interventions such as glucose control and nutritional optimization, making direct comparisons challenging. Second, despite the inclusion of randomized controlled trials and high-quality cohort studies, variation in study quality and methodological rigor was evident. Some studies, such as those by Pearse et al. and Broch et al., had inconclusive or non-significant results, potentially due to limited sample sizes, underpowered analyses, or variations in protocol adherence. Third, the majority of studies were conducted in high-income settings, which may limit the applicability of findings to resource-limited environments where access to advanced hemodynamic monitoring or perioperative nutrition support is limited. Additionally, differences in perioperative care protocols across institutions may have influenced outcomes. Fourth, the risk of performance and detection bias cannot be entirely ruled out, as blinding was not uniformly applied in many studies. Lastly, while efforts were made to comprehensively search the literature and screen studies rigorously, the possibility of publication bias and missed relevant studies cannot be completely excluded.

CONCLUSIONS

This systematic review highlights that targeted hemodynamic and metabolic interventions can improve perioperative outcomes in patients undergoing major abdominal surgery. Hemodynamic strategies such as goal-directed fluid therapy (GDFT) and stroke volume variation-guided optimization were associated with reduced postoperative complications, improved gastrointestinal recovery, and, in some cases, reduced mortality. Similarly, metabolic interventions—including early enteral nutrition, individualized nutritional support, and nurse-led glycemic control—were linked to better nutritional status, reduced hyperglycemia, and shorter hospital stays. However, findings across studies were not uniformly consistent, and the heterogeneity of interventions and patient populations underscores the need for more standardized, high-quality research.

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