World Journal of Surgical Oncology

REVIEW

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Risk factors for postoperative acute kidney injury after cytoreductive surgery combined with hyperthermic intraperitoneal chemotherapy: a meta-analysis and systematic review

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Abstract

Background Acute kidney injury after CRS + HIPEC is a serious postoperative complication, but only a few studies have reported its postoperative risk factors. In addition, there are large discrepancies in the results of available observational studies.

Methods We searched The Cochrane Library, Embase, Web of Science,and PubMed to identify observational studies reporting risk factors for AKI after CRS + HIPEC. A meta-analysis was performed to investigate the effect of various preoperative and intraoperative risk factors on AKI after CRS + HIPEC.

Results A total of 7 studies were included in this study, comprising 1550 patients who developed AKI after CRS + HIPEC. The results of meta-analysis showed that the significant preoperative risk factors were age, sex, BMI, eGFR, Hb, PCI, diabetes mellitus, and hypertension. IO cisplatin, IO SBP < 100 was identified as an intraoperative risk factor, whereas IO mitomycin emerged as a protective factor for postoperative AKI. In addition, the risk of postoperative AKI varied by primary tumor site, with Appendix being less prone to AKI, while mesothelioma and ovarian, two sites with a greatly elevated risk of postoperative AKI.

Conclusions This meta-analysis identified a number of risk factors for postoperative AKI after CRS + HIPEC. By identifying these risk factors, it is more beneficial for clinicians to perform early preoperative interventions and select the most appropriate treatment strategy for their patients, thus minimizing the risk of postoperative AKI.

Trial registration PROSPERO CRD42024585269.

Keywords CRS, HIPEC, AKI, Risk factors

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Introduction

Peritoneal surface malignancies (PSM) are usually associated with poor prognosis and severe complications in patients [1]. PSM can be either primary tumors of the peritoneum or peritoneal metastases originating from secondary spread of tumors from other organs, including intra-abdominal organs (e.g., gastrointestinal and ovarian tumors) or extra-abdominal organs (e.g., lung, breast, and kidney tumors) [2]. The poor prognosis of PSM patients has always been a challenge for clinicians, despite the adoption of maximal tumor resection combined with preoperative as well as postoperative adjuvant intravenous chemotherapy [3]. Cytoreductive surgery (CRS) combined with hyperthermic intraperitoneal chemotherapy (HIPEC) has been used as a first-line treatment option for patients with progressive tumors of PSM and related abdominal organs [4–11]. Maximum resection of the tumor visible to the naked eye by CRS and continuous infusion of chemotherapeutic agents into the peritoneal cavity by means of HIPEC thereby inhibiting or killing microscopic residual cancer cells in the peritoneal cavity [3]. In patients with peritoneal metastases (PM), this is the only treatment that has been proven in studies to significantly improve patients' 5-year survival [12, 13]. According to the results of the study, the 5-year survival rate of colorectal cancer-derived peritoneal metastases increased to 25–51% with CRS combined with HIPEC, while the 5-year survival rate of pseudomucinous tumors was as high as 60–80% [14–16]. In addition, encouraging results have been achieved with prophylactic CRS + HIPEC in patients with progressive abdominal tumors at high risk of peritoneal metastases [17, 18]. PSM patients can be treated with CRS + HIPEC to improve survival, but the concern is that this combination is often accompanied by terribly high morbidity and mortality, and not everyone can tolerate this aggressive treatment modality [19–21]. On the other hand, patients receiving combination therapy were more likely to experience grade 3 or higher grade adverse events compared to patients receiving CRS alone (34 of 131 patients vs. 20 of 130 patients, $p = 0.035$) [22].

Acute kidney injury (AKI) is one of the most common complications after CRS + HIPEC, and its incidence has been reported to range from 1 to 48%, especially common in patients who possess a history of cisplatin use [23–25]. And AKI as a potentially dangerous complication has been reported in several studies [26, 27]. And the occurrence of AKI is closely associated with considerable morbidity and mortality [28]. The results of several studies have been shown that some risk factors are important predictors of postoperative CRS + HIPEC, including cisplatin use, decreased eGFR, age, gender, obesity, hypertension, and diabetes mellitus [29–33]. However, no studies have systematically summarized and evaluated the association between these risk factors and the occurrence of AKI after CRS + HIPEC.CRS + HIPEC improves the prognosis of patients, but the occurrence of postoperative AKI is often accompanied by prolonged hospitalization with increased mortality [24, 34, 35]. Therefore, we will focus on the effects of preoperative risk factors such as age, gender, body mass index (BMI), peritoneal cancer index (PCI), estimated glomerular filtration rate (eGFR), hemoglobin (Hb), diabetes mellitus, and hypertension, intraoperative risk factors such as intraoperative hypotension, intraoperative fluid management, and chemotherapeutic drug selection on AKI. In addition, the potential impact of different primary tumor sites on AKI risk will be explored. Through these analyses, we aim to provide clinicians with more accurate risk assessment tools and guide them to take targeted preventive measures preoperatively and intraoperatively to reduce the incidence of AKI and improve patient prognosis.

In patients undergoing CRS + HIPEC, AKI is a serious postoperative complication that is closely related to patient prognosis. Although studies have examined the risk factors for AKI, the results vary widely and lack systematic summarization. Therefore, the main objectives of this meta-analysis were (1) to determine the incidence of AKI after CRS + HIPEC. (2) To identify the major risk factors associated with the development of AKI after CRS + HIPEC. (3) To assess the effectiveness of reported prevention strategies and interventions in reducing the incidence and severity of AKI. (4) To identify gaps in existing research and suggest directions for future studies to improve patient outcomes and optimize perioperative management.

Materials and methods

This meta-analysis was conducted using the guidelines reported in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) declarative agreement as the primary guideline [36] and was pre-registered in PROSPERO (CRD42024585269). The PRISMA checklist specific to this meta-analysis can be found in Appendix Table S1.

Search strategy

Two investigators (CDZ and WL) independently conducted a systematic search in the Cochrane Library, Embase, Web of Science, and PubMed databases with the aim of identifying studies up to September 1, 2024 on risk factors for AKI after CRS combined with HIPEC. We used MeSH terms and keywords including CRS, HIPEC, and AKI, connecting synonyms by "OR" and combining different terms by "AND". We focused on English-language journal articles, excluded unpublished

and non-English literature, and reviewed only titles and abstracts to simplify screening. The detailed search strategy is described in the Appendix document.

Inclusion and exclusion criteria

All included literature for this meta-analysis met the inclusion and exclusion criteria.

The inclusion criteria were as follows:

(1) The design was a case–control, cohort, or cross-sectional study.
(2) Participants were adults (≥18 years of age) with primary or metastatic peritoneal tumors treated with CRS + HIPEC.
(3) Studies provided definitions of CRS and HIPEC and complete patient baseline data.
(4) Risk factors for AKI or the relationship between AKI and prognosis of patients after CRS + HIPEC were reported, and detailed event counts or odds ratios for the AKI and non-AKI groups were provided.
(5) AKI diagnosis using KDIGO or AKIN criteria [37, 38].
(6) Study quality with a Newcastle–Ottawa Scale (NOS) score ≥ 6.

Exclusion criteria were as follows:

(1) reviews, conference reports, letters, case reports, and animal experiments.
(2) Studies of poor quality and lacking complete data or results.
(3) Articles with inaccessible full text or missing content.

Study selection and data extraction

The study screening process began with de-duplication of all retrieved literature using Endnote 20.0 software. Two authors (CDZ and LLF) then performed an initial screening of the literature by reviewing titles and abstracts to exclude studies that did not meet the predetermined inclusion and exclusion criteria. After the initial screening, the full text was evaluated to identify eligible studies. Any disagreements between the two authors were resolved through discussion with a third researcher who made the final decision. The study screening process is shown in Fig. 1.

We extracted the following data from the included studies using a specially designed form:

(1) Basic information about the article: first author, year of publication and type of study.
(2) Information about the participant population, including sample size, age, sex ratio, and region.
(3) Information on risk factors, divided into preoperative risk factors, intraoperative risk factors, and different primary tumor sites, the specific classification can be found in the results section.
(4) Study data and results, including event counts in the AKI and non-AKI groups for different risk factors, the magnitude of independent risk factors, and the incidence of potential risk factors in different studies.

Quality assessment and statistical analysis

Quality assessment was performed using the Newcastle–Ottawa Scale (NOS) for case–control and cohort studies and the Cochrane Manual for randomized clinical trials. Two authors (CDZ and WL) independently assessed studies in three domains: selection, comparability, and outcome/exposure. Scoring was done using a checklist containing 8 items, where 1–3 stars indicated low quality, 4–6 stars indicated moderate quality, and 7–9 stars indicated high quality. All included studies were rated as high quality with a score of ≥ 7 stars. See Appendix Table S2 for a detailed rating scale.

We conducted this meta-analysis using Review Manager 5.4 and Stata 17.0 to assess the effect sizes of the risk factors, including the mean difference (MD) and the ratio of ratios (OR) and their 95% confidence intervals. Heterogeneity between studies was assessed using the Cochrane Q-test and I^2 statistic. Where significant heterogeneity was detected ($I^2 \geq 50\%$), it was analyzed using a random-effects model, and sensitivity analyses were performed to determine the source of heterogeneity. Conversely, if heterogeneity was not significant ($I^2 < 50\%$), a fixed-effects model was used. Publication bias was assessed using funnel plots, Begg's test, and Egger's test to ensure stability of the findings. All tests were two-tailed and $P < 0.05$ was considered statistically significant.

Results

Literature search results and study characteristics

A total of 63 articles on AKI after CRS + HIPEC were retrieved through the developed search strategy (Fig. 1). All retrieved articles were imported into Endnote 20.0 software, and 16 duplicate articles were excluded using the software de-duplication function. By reading the titles and abstracts, 22 papers that did not meet the inclusion criteria were initially excluded. A total of 25 papers were retained after the initial screening. Among the remaining papers, we performed full-text reading and excluded a total of 18 articles that did not meet the inclusion requirements, including 6 papers that could not extract data, 3 papers with Newcastle–Ottawa Scale

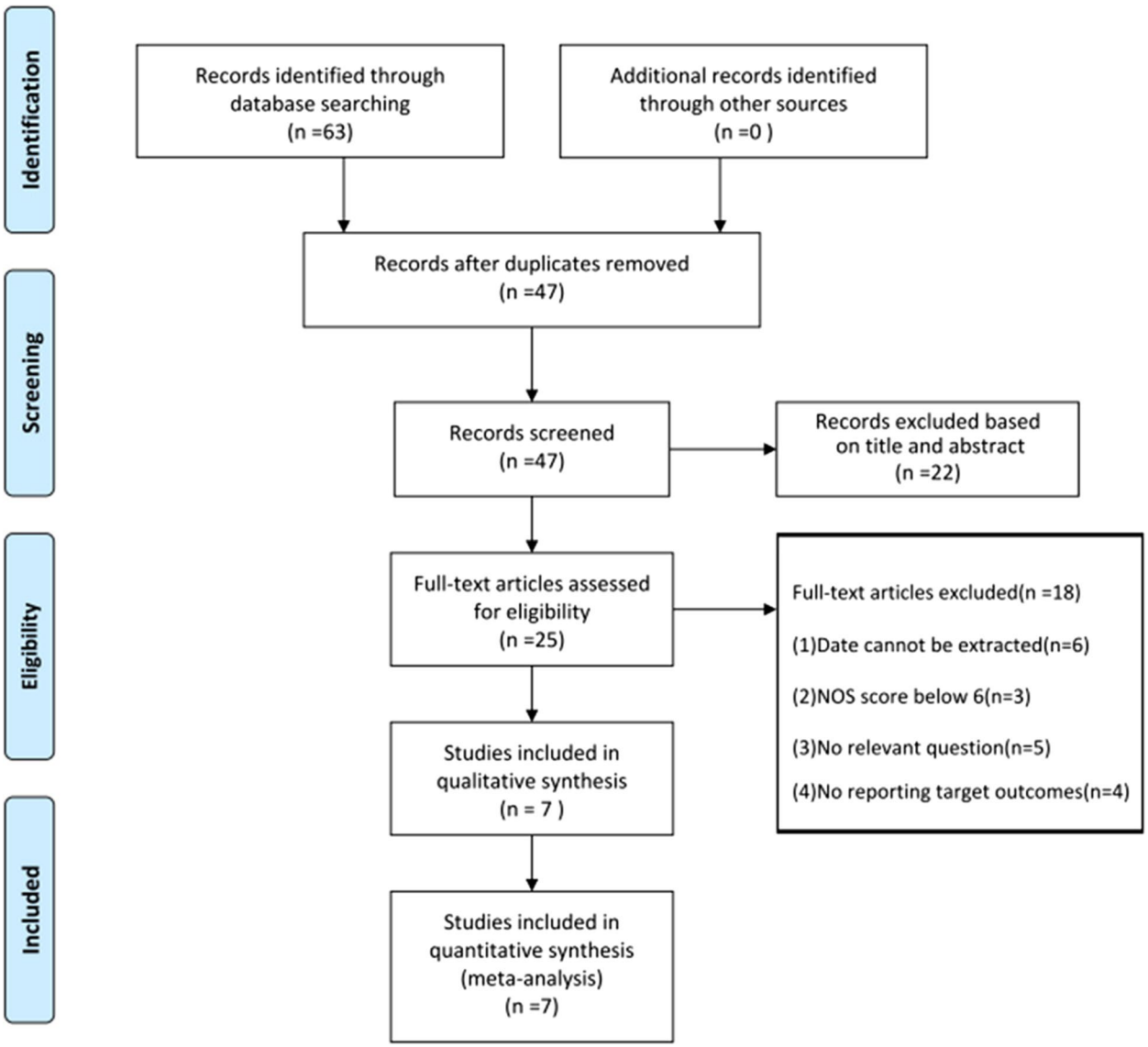

Fig. 1 PRISMA fow diagram for study selection

(NOS) scores lower than 6, 5 papers describing problems that were not related to the topic, and 4 papers that did not record the target results. In the end, a total of 7 papers were included in this systematic review and meta-analysis, all of which were retrospective studies and all of which described in detail the number of events or specific values of the different risk factors for postoperative AKI in the AKI group versus the Non-AKI group (Table 1).

This systematic review and meta-analysis investigated a total of 1550 patients who developed AKI after CRS + HIPEC in seven studies. The included studies were published online from 2017 to 2024. Two of the included studies were from the United States, two from China, two from Germany, and one from Portugal. The largest proportion of all patients were from the United States (34.39%), followed by China (28.39%), Germany (25.48%), and Portugal (11.74%). A total of 28 risk factors as well as 6 different tumor primary sites were involved in the analysis of the impact of postoperative AKI. The risk factors were divided into preoperative and intraoperative for independent analysis, and a summary of the detailed analysis results can be found in Table 2. The main primary sites of the tumors were appendix (39%) and colorectal cancer (21%), followed by gastric (13%),pseudomyxoma peritonei (9%), mesothelioma (6%),ovarian (6%), andothers (4%). detailed distribution can be found in Appendix Figure S1. Detailed characteristics of the seven included studies can be found in Table 1.

Table 1 Information on the basic characteristics of the included studies

Study	Country	Study period	Study design	Center	Sample size, n	Sex(M/F)	Age	Incidence of AKI, n (%)	Diagnostic criteria of AKI	HIPEC Regimen	Chemotherapy drugs and doses	NOS score	Risk factors
Annika et al.,2022 [29]	Germany	2017 and 2020	retrospective cohort study	Single	238	105/133	57 (19–83)	62 (26.1%)	AKIN	Cisplatin (CDDP) 75 mg/m^2 body surface area, Doxorubicin 15 mg/m^2 body surface area or Mitomycin C 15 mg/m^2 body surface area	Cisplatin 75 mg/m^2, Doxorubicin 15 mg/m^2, Mitomycin C 15 mg/m^2	7	②⑩⑪⑫⑭㉔㉙㉚㉛㉜㉝㉞
Bai et al.,2023 [30]	China	2018 and 2021	retrospective cohort study	Single	282	NA	65.03 ± 6.63	33 (26.1%)	KDIGO	Cisplatin (CDDP) dose range 50 to 80 mg/m^2, heated to 41 °C to 43 °C, duration 60 min	Cisplatin 50–80 mg/m^2	8	①③⑤⑥⑦⑩⑪⑫⑭㉒㉕㉖㉗
Eduarda et al.,2022 [31]	Portugal	2016 and 2019	retrospective cohort study	Single	182	125/57	58.0 ± 12.1	23 (12.6%)	KDIGO	Cisplatin (CDDP) 50 mg/m^2/2 L for ovarian cancer; Mitomycin C 15 mg/m^2/2 L for other types of cancer	Cisplatin 50 mg/m^2/2 L, Mitomycin C 15 mg/m^2/2 L	8	①②③④⑦⑭⑮⑯㉓㉔㉕㉙㉚㉛㉜㉝㉞
Juan et al.,2017 [23]	America	2006 and 2016	retrospective cohort study	Single	475	213/262	50.99 ± 12.65	101 (21.3%)	AKIN	Did not specify the exact regimen, but mentioned Cisplatin and Oxaliplatin as platinum agents	Cisplatin/ Oxaliplatin	7	①②③⑧⑨⑩⑪⑬⑭⑰㉓㉔㉖㉙㉚㉝㉞
Lu et al.,2024 [32]	China	2018 and 2021	retrospective cohort study	Single	158	63/95	59.5 ± 11.9	34 (21.5%)	KDIGO	Various regimens, including Cisplatin and Mitomycin C, etc., but specific doses not mentioned	Various regimens, specific doses not mentioned	7	①②④⑤⑥⑦⑩⑪⑫⑬⑰⑱⑲⑳㉑㉒㉓㉘㉙㉚㉛㉜

Table 1 (continued)

Study	Country	Study period	Study design	Center	Sample size, n	Sex(M/F)	Age	Incidence of AKI, n (%)	Diagnostic criteria of AKI	HIPEC Regimen	Chemotherapy drugs and doses	NOS score	Risk factors
Lukas et al.,2022 [33]	Germany	2007 and 2016	retrospective cohort study	Single	157	65/92	58 ± 12.6	50 (31.8%)	KDIGO	Various regimens, including 5-Fluorouracil (5-FU), Cisplatin, Docetaxel, and Raltitrexed	5-FU, Cisplatin, Docetaxel, Raltitrexed	8	①②③⑧⑨⑩⑪⑫⑬⑮⑯⑰⑱⑲㉑㉓㉖㉗㉘㉙㉚㉛㉜㉝
Samer et al.,2018 [24]	America	2013 and 2015	retrospective cohort study	Single	58	19/39	58.8 ± 12.4	12 (20.7%)	KDIGO	Mitomycin C 40 mg; Cisplatin 45 mg/L ± Doxorubicin 15 mg/L; Melphalan 50 mg/m^2	Mitomycin C 40 mg, Cisplatin 45 mg/L, Doxorubicin 15 mg/L, Melphalan 50 mg/m^2	7	①②③④⑧⑳㉒

Age is Mean ± SD/median (IQR); M/F: Men/Female

Abbreviations: ① Age; ② Gender; ③ BMI; ④PCI; ⑤ Alb; ⑥ Hb; ⑦ eGFR; ⑧ Preoperative creatinine; ⑨ Chronic kidney disease; ⑩ Diabetes mellitus; ⑪ Heart disease; ⑫ Hypertension; ⑬ Neoadjuvant therapy; ⑭ Preoperative chemotherapy; ⑮ Hospitalization (days); ⑯ ICU duration (days); ⑰ IO transfusion; ⑱ IO vasopressors; ⑲ Urine output; ⑳ IO fluid; ㉑ IO SBP < 100; ㉒ Operation time; ㉓ Cisplatin; ㉔ Mitomycin; ㉕ NSAIDs; ㉖ ACEI\ARB; ㉗ Diuretics; ㉘ Urea; ㉙Colorectal; ㉚Appendix; ㉛Gastric; ㉜ Ovarian; ㉝ Mesothelioma; ㉞ Pseudomyxoma peritonei; *NOS* Newcastle-Ottawa scale, *NA* not applicable

Table 2 Results of meta-analysis of risk factors

	Studies(n)	Patients (Yes/No)	AKI (%) (Yes/No)	OR/MD (95%CI)	P	$P_{heterogeneity}$	I^2
Preoperative risk factors							
Age	6	253/1059	NA	2.04 (0.55,3.52)	0.007	0.50	0%
Sex	3	187/267	0.267/0.217	1.29 (0.84,2.00)	0.25	0.24	31%
BMI	5	219/935	NA	1.22 (0.42,2.03)	0.003	0.65	0%
ACEI or ARB	3	184/730	0.071/0.059	1.16 (0.28,4.81)	0.84	0.04	69%
Diuretics	2	83/356	0.145/0.096	1.80 (0.86,3.76)	0.12	0.87	0%
NSAIDs	2	56/408	0.589/0.532	1.69 (0.78,3.67)	0.19	0.41	0%
PCI	3	69/329	NA	3.79 (1.49,6.10)	0.001	0.51	0%
Alb	2	67/373	NA	-0.06 (-1.08,0.97)	0.91	0.32	0%
Hb	2	67/373	NA	-5.87 (-10.90,-0.83)	0.02	0.94	0%
eGFR	3	90/532	NA	-11.53 (-17.89,-5.17)	0.0004	0.97	0%
Urea	2	84/231	NA	2.40 (-0.28,5.09)	0.08	0.07	69%
Creatinine	3	163/527	NA	0.04 (-0.01,0.09)	0.14	0.24	31%
Chronic kidney disease	2	151/481	0.033/0.010	3.36 (0.96,11.80)	0.06	0.72	0%
Heart disease	5	280/1030	0.054/0.043	1.56 (0.83,2.92)	0.17	0.19	35%
Diabetes mellitus	5	280/1030	0.118/0.084	1.78 (1.15,2.75)	**0.01**	0.37	6%
Hypertension	4	179/656	0.453/0.268	2.43 (1.37,4.31)	0.002	0.06	59%
Neoadjuvant therapy	3	185/605	0.405/0.379	1.13 (0.80,1.60)	0.49	0.47	0%
Preoperative chemotherapy	4	219/958	0.461/0.506	0.76 (0.47,1.24)	0.28	0.08	56%
Hospitalization (days)	2	73/266	NA	4.69 (-2.46,11.84)	0.20	0.09	65%
ICU duration (days)	2	73/266	NA	1.95 (-0.72,4.62)	0.15	0.11	61%
Intraoperative risk factors							
IO fluid	2	46/170	NA	79.20 (-135.33,293.72)	0.47	0.31	0%
IO SBP < 100	2	84/231	NA	10.95 (3.15,18.75)	0.006	0.50	0%
IO transfusion	3	185/605	0.330/0.344	0.90 (0.47,1.72)	0.74	0.08	60%
IO transfusion(correction)	2	135/498	0.378/0.339	1.20 (0.80,1.79)	0.38	0.79	0%
IO vasopressors	2	84/231	0.738/0.766	0.51 (0.09,2.99)	0.45	0.01	85%
IO urine output	2	84/231	NA	27.15 (-127.21,181.51)	0.73	0.75	0%
Operation time	3	79/419	NA	21.92 (-20.25,64.08)	0.31	0.14	50%
Chemotherapy regimens							
Mitomycin	3	186/709	0.695/0.803	0.53 (0.26,1.10)	0.09	0.04	70%
Mitomycin (correction)	2	124/533	0.645/0.812	0.41 (0.26,0.63)	< 0.0001	0.33	0%
Cisplatin	4	208/764	0.457/0.251	2.84 (1.27–6.35)	0.01	0.003	79%
Tumor site							
Appendix	5	270/940	0.289/0.421	0.48 (0.24,0.98)	0.04	0.04	61%
Ovary	4	169/566	0.159/0.088	2.31 (1.37,3.89)	0.002	0.45	0%
Mesothelioma	4	236/816	0.161/0.069	1.21 (0.69,2.12)	0.01	0.07	57%
Mesothelioma(correction)	3	174/640	0.178/0.058	3.53 (2.09,5.94)	< 0.00001	0.86	0%
Gastric	4	169/566	0.237/0.196	1.22 (0.40,3.75)	0.73	0.001	81%
Gastric(correction)	3	119/459	0.193/0.220	0.71 (0.42,1.19)	0.19	0.37	0%
Pseudomyxoma peritone	3	186/709	0.129/0.111	1.10 (0.66,1.83)	0.71	0.52	0%
CRC	5	270/940	0.167/0.223	0.69 (0.48,0.99)	0.05	0.48	0%

Preoperative risk factors

In the seven studies included in this meta-analysis, we pooled and analyzed a total of 20 potential preoperative risk factors. These included the use of drugs such as ACEI or ARB, Diuretics, and NSAIDs, as well as patient age, gender, BMI, and PCI. We also performed a pooled analysis of patients' preoperative Alb, preoperative Hb, preoperative eGFR, preoperative Urea, and Preoperative creatinine. In addition, the effect of various preoperative underlying diseases of the patients, such as Chronic

kidney diseas, Diabetes mellitus, Heart disease, Hypertension, and the patients' preoperative Neoadjuvant therapy and Preoperative chemotherapy on the Postoperative AKI were also included in our analysis.Hospitalization (days) and ICU duration (days) as potential risk factors for postoperative AKI were also explored. All the data related to the above risk factors were collected through specially designed and scientifically based statistical forms, and preoperative risk factors with complete and comparable data were analyzed in a pooled manner, in which eight risk factors such as age, gender, BMI, PCI, eGFR, Hb, Diabetes mellitus, and Hypertension were considered to have a statistically significant ($p < 0.05$), and the results of meta-analysis of all the above potential risk factors can be found in Table 2.

Age

A total of six studies [23, 24, 30–33] recorded information on the distribution of age in the AKI group versus the Non-AKI group, and information on age was reported as mean ± standard deviation. The heterogeneity test suggested that there was no heterogeneity between studies ($I^2 = 0\%$, $P = 0.50$). Therefore, a fixed-effects model was chosen for the analysis and the pooled analysis showed (MD = 2.04, 95% CI: 0.55,3.52, $p = 0.007$) (Fig. 2A). We therefore conclude that advanced age is one of the preoperative risk factors for AKI after CRS + HIPEC.

Sex

A total of six studies [23, 24, 29, 31–33] described the gender distribution of patients, recorded using dichotomous variables. After performing the test for heterogeneity ($I^2 = 21\%$, $P = 0.27$), meta-analysis was performed using a fixed-effects model. The results suggested a significant and statistically significant difference between the two groups (OR = 1.53, 95% CI: 1.17,2.00, $p = 0.002$) (Fig. 2B). Therefore, we conclude that the risk of AKI after CRS + HIPEC is greater in male patients than in female patients. Gender is one of the preoperative risk factors for postoperative AKI.

BMI

A total of five studies [23, 24, 30, 31, 33] reported detailed information on patients' BMI using mean ± standard deviation data recording. The heterogeneity test suggested no heterogeneity between studies ($I^2 = 0\%$, $P = 0.65$). Analysis using the fixed effect model showed a significant and statistically significant difference between the two groups (MD = 1.22, 95% CI: 0.42,2.03, $p = 0.003$) (Fig. 2C). Therefore, we can conclude that the risk of postoperative AKI after CRS + HIPEC increases as the value of BMI increases.

Peritoneal cancer index

A total of three studies [24, 31, 32] referred to patients' preoperative Peritoneal cancer index (PCI), and the data were described using mean ± standard deviation recording. By heterogeneity test ($I^2 = 0\%$, $P = 0.51$), $P > 0.1$ suggests that there is no heterogeneity between studies, so we used fixed effect model for pooled analysis. The results showed a significant difference between the AKI and Non-AKI groups, and the results were statistically significant (MD = 3.79, 95% CI: 1.49,3.79, $p = 0.003$) (Fig. 2D). Therefore, we conclude that higher preoperative PCI is one of the significant risk factors for postoperative AKI.

Preoperative eGFR and Hb

A total of three studies [30–32] reported details of Preoperative eGFR, recorded as mean ± standard deviation. Pooled analysis of the data using continuous variables and random effects model ($I^2 = 0\%$, $p = 0.97$) suggested that there was no heterogeneity between the two and there was a significant difference between the two groups (MD = -11.53, 95%CI: -17.89,-5.17, $p = 0.0004$) (Fig. 2E). Therefore, we conclude that a decrease in Preoperative eGFR leads to an increase in the incidence of AKI after CRS + HIPEC and that Preoperative eGFR is a significant preoperative risk factor.

In addition, a total of 2 studies [30, 32] referred to the Preoperative Hb of patients and recorded detailed data in the form of mean ± standard deviation. Heterogeneity analysis showed no heterogeneity between the two ($I^2 = 0\%$, $P = 0.94$), which was analyzed using continuous variables and fixed effects model. The results suggested a significant difference between the two groups (MD = -5.87, 95%CI: -10.90,-0.83, $p = 0.02$) (Fig. 2F) and were statistically significant. In other words, a decrease in preoperative Hb increased the incidence of postoperative AKI.

Diabetes mellitus and hypertension

A total of five studies [23, 29, 30, 32, 33] reported diabetes in 1310 patients, detailing the number of people in the AKI group compared with those in the Non-AKI group. The heterogeneity test suggested that there was no heterogeneity among the studies ($I^2 = 6\%$, $P = 0.37$), so we used a fixed-effects model for meta-analysis. The results suggested that diabetes mellitus was one of the significant risk factors for AKI after CRS + HIPEC, and the results were statistically significant (OR = 1.78, 95% CI: 1.15,2.75, $p = 0.01$) (Fig. 2G).

In addition a total of four studies [29, 30, 32, 33] reported information on patients' hypertension, of which the results of Annika et al. versus Bai et al. indicated that

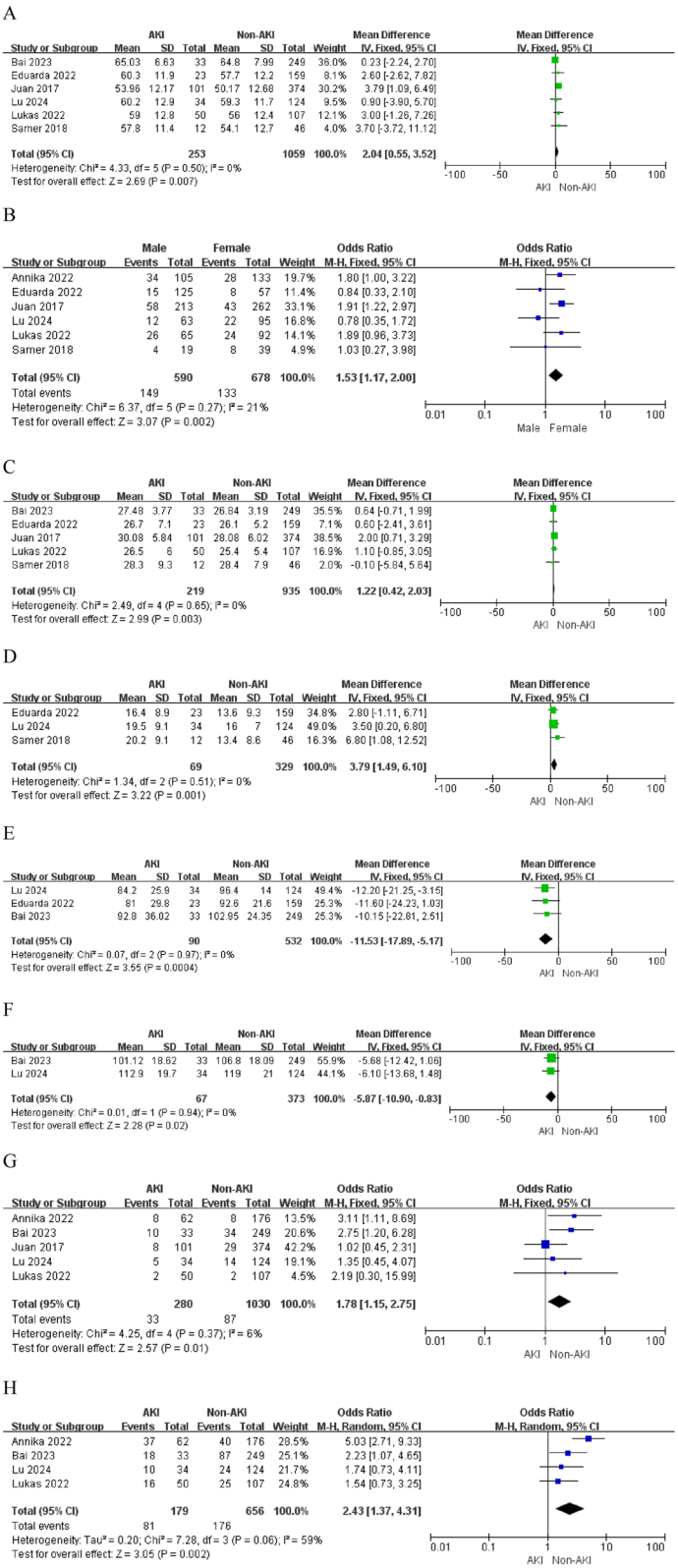

Fig. 2 Forest plot of preoperative risk factors: **A** age; **B** sex; **C** BMI; **D** peritoneal cancer index (PCI); **E** preoperative eGFR; **F** preoperative Hb; **G** diabetes mellitus; **H** hypertension

preoperative hypertension was a risk factor for postoperative AKI ($P > 0.05$). On the contrary, the findings of Lu et al. versus Lukas et al. concluded that hypertension does not lead to an increased risk of postoperative AKI. Therefore, we performed a meta-analysis using a random-effects model ($I^2 = 59\%$, $p = 0.06$), which showed a significant difference between the two groups (OR = 2.43, 95% CI: 1.37,4.31, $p = 0.002$) (Fig. 2H), and the results were statistically significant. For the high heterogeneity of the pooled analysis, we used a case-by-case exclusion method to explore the source of heterogeneity, and the results showed that the I^2 values stabilized and no significant source of heterogeneity was found.

Other preoperative risk factors

Other preoperative risk factors included the use of drugs such as ACEI or ARB, Diuretics, NSAIDs, laboratory findings such as preoperative Alb, preoperative Urea and Preoperative creatinine. Similarly, we performed a pooled analysis of the above risk factors, but the results suggested that there was no significant difference between the two groups (P > 0.05). Detailed results of heterogeneity analysis and pooled analysis can be found in Table 2.

Intraoperative risk factors

In our seven included articles, we defined a total of eight risk factors as intraoperative risk factors, including the use of chemotherapeutic agents cisplatin and mitomycin in HIPEC, IO fluid, IO SBP < 100, IO transfusion, IO vasopressors, operation time, urine output, and other parameters. We tested the heterogeneity of the above risk factors and selected the appropriate effect model for pooled analysis based on their results to obtain scientific conclusions. The results suggested that the use of chemotherapeutic drugs cisplatin, mitomycin and IO SBP < 100(min) were significantly and statistically different between the two groups. Detailed results are shown in Table 2.

Operative time

A total of three studies [24, 30, 32] reported specific surgical times, using a mean ± standard deviation form of data recording. After testing for heterogeneity ($I^2 = 50\%$, $P = 0.14$), the pooled data were analyzed using a random effects model. The results showed that the duration of surgery was not significantly different between the two groups (MD = 21.92, 95%CI: -20.25,64.08, $p = 0.31$) (Fig. 3A) and the results were not statistically significant. In other words, it is not yet possible to consider the duration of surgery as one of the risk factors for AKI after CRS + HIPEC.

Chemotherapy regimens

A total of 5 of the 7 included studies in this meta-analysis mentioned and documented the number of events in the AKI group compared with the number of events in the Non-AKI group with different intraoperative chemotherapy regimens. Intraoperative chemotherapy regimens included the use of drugs such as cistplatin, oxilaplatin, and mitomycin, of which the data for cistplatin and mitomycin were comparable, so we analyzed the data for these two drugs separately.

A total of four studies [24, 31–33] reported a comparison of the number of events in patients using the chemotherapeutic agent cistplatin in HIPEC, using a dichotomous variable recording format. Heterogeneity analysis was performed and revealed heterogeneity among the studies ($I^2 = 79\%$, $p = 0.01$), and the results suggested that intraoperative use of cistplatin greatly increased the risk of postoperative AKI (OR = 2.84, 95% CI: 1.27,6.35, $p < 0.0001$) (Fig. 3B). When we explored the source of heterogeneity using a cull-by-cull approach, we found that I^2 values stabilized (66%-79%) and no source of heterogeneity was identified.

Three studies [23, 29, 31] reported the use of the drug mitomycin between the two groups, and the heterogeneity analysis revealed a large heterogeneity between the studies ($I^2 = 70\%$, $P = 0.04$), so we used a case-by-case exclusion method to explore the source of heterogeneity. When we excluded the data from Annika et al. [29] study, we found that the heterogeneity disappeared ($I^2 = 0\%$, $P = 0.33$), and thus we determined that the data from Annika et al.'s study was the source of heterogeneity. After eliminating the source of heterogeneity, we found that the data from the studies of Eduarda [31] et al. and Juan et al. [23] had considerable homogeneity, and by pooling and analyzing the data from both, we found that the use of mitomycin was significantly different between the two groups, and that the use of mitomycin was one of the protective factors given for postoperative AKI, and the results had a statistically significant (OR = 0.41, 95% CI: 0.26,0.63, $p < 0.0001$) (Fig. 3C).

IO SBP < 100 mmHg(min)

A total of 2 studies [32, 33] recorded the specific time (min) for intraoperative IO SBP < 100 mmHg and described the data as mean ± standard deviation. Pooled analysis of the data from Lu et al. and Lukas et al. using a random-effects model ($I^2 = 0\%$, $p = 0.50$) revealed a significant difference between the two groups and the results were statistically significant (MD = 10.95, 95%CI:3.15,18.75, $p = 0.006$) (Fig. 3D). Therefore, we got the conclusion that prolonged duration of intraoperative IO SBP < 100 leads to increased risk of postoperative AKI

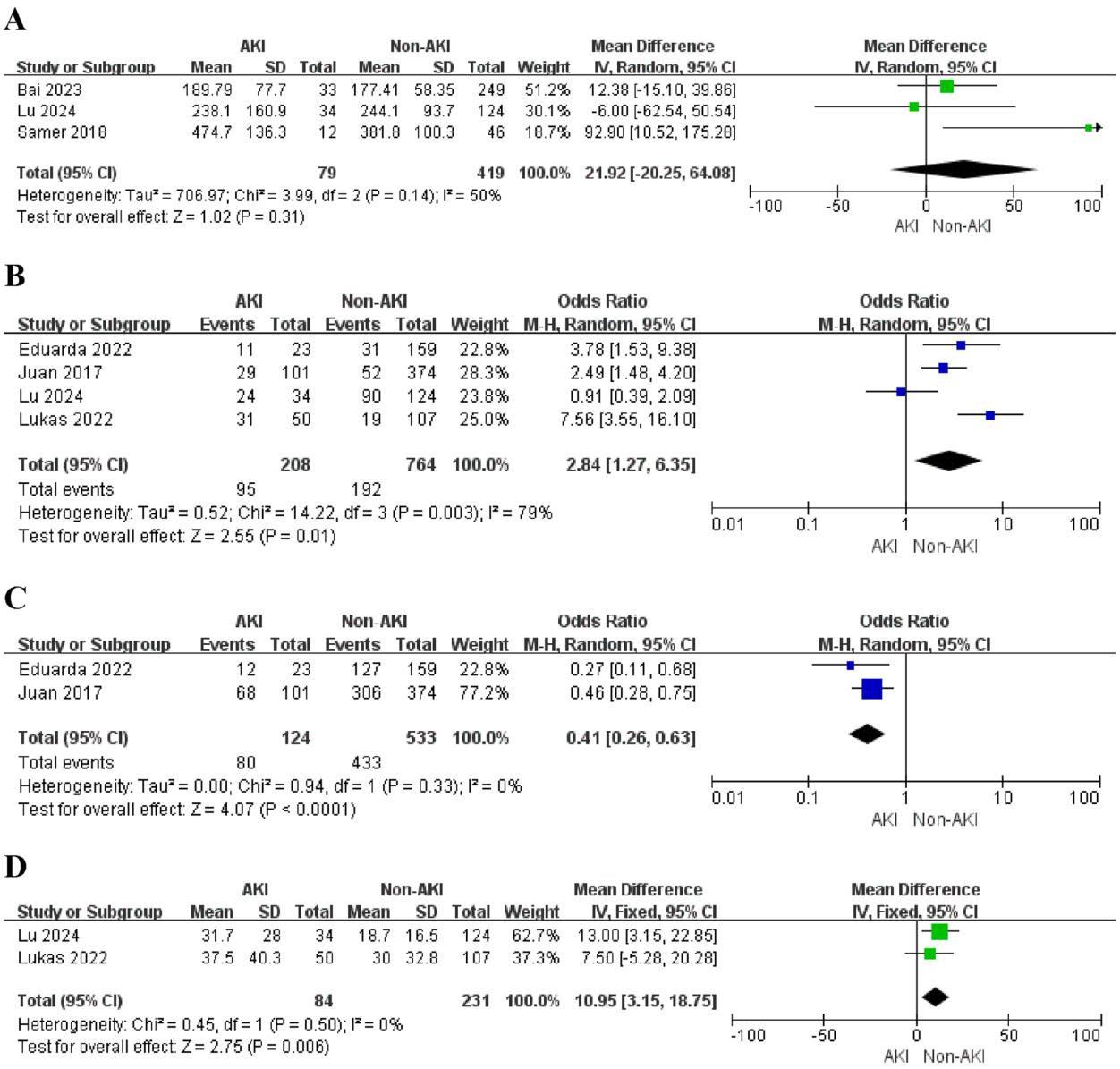

Fig. 3 Forest plot of intraoperative risk factors: **A** operative time; **B** cistplatin; **C** mitomycin; **D** IO SBP < 100

after CRS + HIPEC and is one of the intraoperative risk factors.

Other intraoperative risk factors

Other intraoperative risk factors included parameters such as IO fluid, IO transfusion, IO vasopressors, and urine output. Detailed results of heterogeneity analysis with meta-analysis can be found in Table 2.

Two studies [24, 32] explored the effect of IO fluid on postoperative AKI, and the results told us that IO fluid was not one of the intraoperative risk factors (MD = 79.20, 95%CI:-135.33,293.72, $p = 0.47$).

Three studies [23, 32, 33] mentioned detailed data on IO transfusion, analyzed by random effects model ($I^2 = 60\%$, $p = 0.08$), which suggested that IO transfusion was not significantly different between the two groups (OR = 0.90, 95%CI:0.47,1.72, $p = 0.74$). Heterogeneity between studies disappeared after excluding data from

the study by Lukas et al. (I^2 = 0%, p = 0.79). However, the conclusions did not change (OR = 1.20, 95%CI:0.80,1.79, p = 0.38).

2 studies [32, 33] reported the effect of IO vasopressors on postoperative AKI, and the data were pooled and analyzed using a random-effects model, and the results suggested that the use of intraoperative vasopressors did not increase the risk of AKI.

In addition, a total of 2 studies [32, 33] recorded patients' intraoperative urine output, and complete data were recorded by mean ± standard deviation. We also performed a meta-analysis, and the results suggested that the increase or decrease in intraoperative urine output was not one of the risk factors for postoperative AKI, and the results were not statistically significant (MD = 27.15, 95% CI:-127.21,181.51, p = 0.73).

Primary tumor site

A total of five out of seven included studies reported the comparative number of events and incidence of AKI after CRC + HIPEC for different primary tumor sites. In our dataset, the most common primary site was appendix (39%), followed by colorectal (21%) and gastric (13%), and the other sites and their percentages were pseudomyxoma peritonei (9%), mesothelioma (8%), ovarian (6%), and others (4%), respectively. For different sites of primary tumors, we separately and independently performed heterogeneity tests and selected appropriate models for meta-analysis to investigate whether the primary tumor site was a potential risk factor for postoperative AKI. The detailed results of the heterogeneity analysis and meta-analysis are shown in Table 2.

Among them, a total of five studies [23, 29, 31–33] reported the number of events of appendiceal site between the AKI group and Non-AKI group, and the data were pooled and analyzed by using a dichotomous variable with a random-effects model (I^2 = 61%, P = 0.04), and the exclusion of the studies one by one revealed that the I^2 values stabilized, and no source of heterogeneity was found. The results suggested that patients with tumors at the appendix site had a significantly lower risk of postoperative AKI (OR = 0.48, 95%CI:0.24,0.98, p = 0.04) (Fig. 4A).

In addition, four studies reported the role of primary tumors at mesothelioma [23, 29, 31, 33] and ovarian [29, 31–33] sites on postoperative AKI, respectively. Our pooled analysis of the data revealed that the risk of postoperative AKI, regardless of whether the tumor was at mesothelioma (OR = 2.54, 95%CI:1.21,5.30, p = 0.01) (Fig. 4B) or ovarian (OR = 2.31, 95%CI:1.37,3.89, p = 0.002) (Fig. 4C) sites, was substantially increased.

Subgroup analysis

Considering that the populations studied in our inclusion study came from all over the world, we divided them into three regions, including Europe, Asia, and the Americas, and conducted subgroup analyses of the age and gender factors to explore whether regional factors contribute to the creation of greater heterogeneity. The results suggested that in the Asian subgroup (p = 0.74) and the European subgroup (p = 0.09), the age factor was not significantly different between the AKI and Non-AKI groups, and the results were not statistically significant. In contrast, in the Americas subgroup, older patients were more likely to develop AKI after CRS + HIPEC (p = 0.003) (Fig. 5A). Therefore, we conclude that the concept of age as a risk factor for postoperative AKI may be more appropriate for the American population. Subgroup analysis of the gender factor suggested that the results were consistent with the total effect in the American (p = 0.007) and European (p = 0.04) populations. In contrast, the Asian population showed the opposite results (Fig. 5B).

In addition, since the included studies used two different diagnostic criteria, AKIN and KDIGO, for the definition of AKI, we grouped them with different diagnostic criteria for subgroup analysis. For diabetes mellitus, a preoperative risk factor, the results suggested that diabetes mellitus did not lead to an increased risk of postoperative AKI under the AKIN diagnostic criteria (p = 0.34). And under the KDIGO diagnostic criteria, the results were consistent with the total effect (p = 0.02) (Fig. 5D). In addition, we also performed subgroup analysis for appendix (Fig. 5E) and mesothelioma (Fig. 5F). The results all suggested significant differences between the two groups only under the KDIGO diagnostic criteria. Therefore, we conclude that for part of the meta-analysis results may be more accurate under the KDIGO diagnostic criteria. On the contrary, the subgroup analysis of the gender factor suggested that there was a significant difference between the two groups only under the AKIN diagnostic criteria (Fig. 5C). The results of the detailed subgroup analysis are shown in Table 3.

Publication bias

Due to the limited number of included studies, it was not possible to visualize publication bias among studies using funnel plots, so we used the Egger test and Begg test to explore whether there was significant publication bias among the included studies. In addition, we used a sensitivity analysis of the relevant risk factors using round-by-round exclusion hair to ensure the stability of the study results.

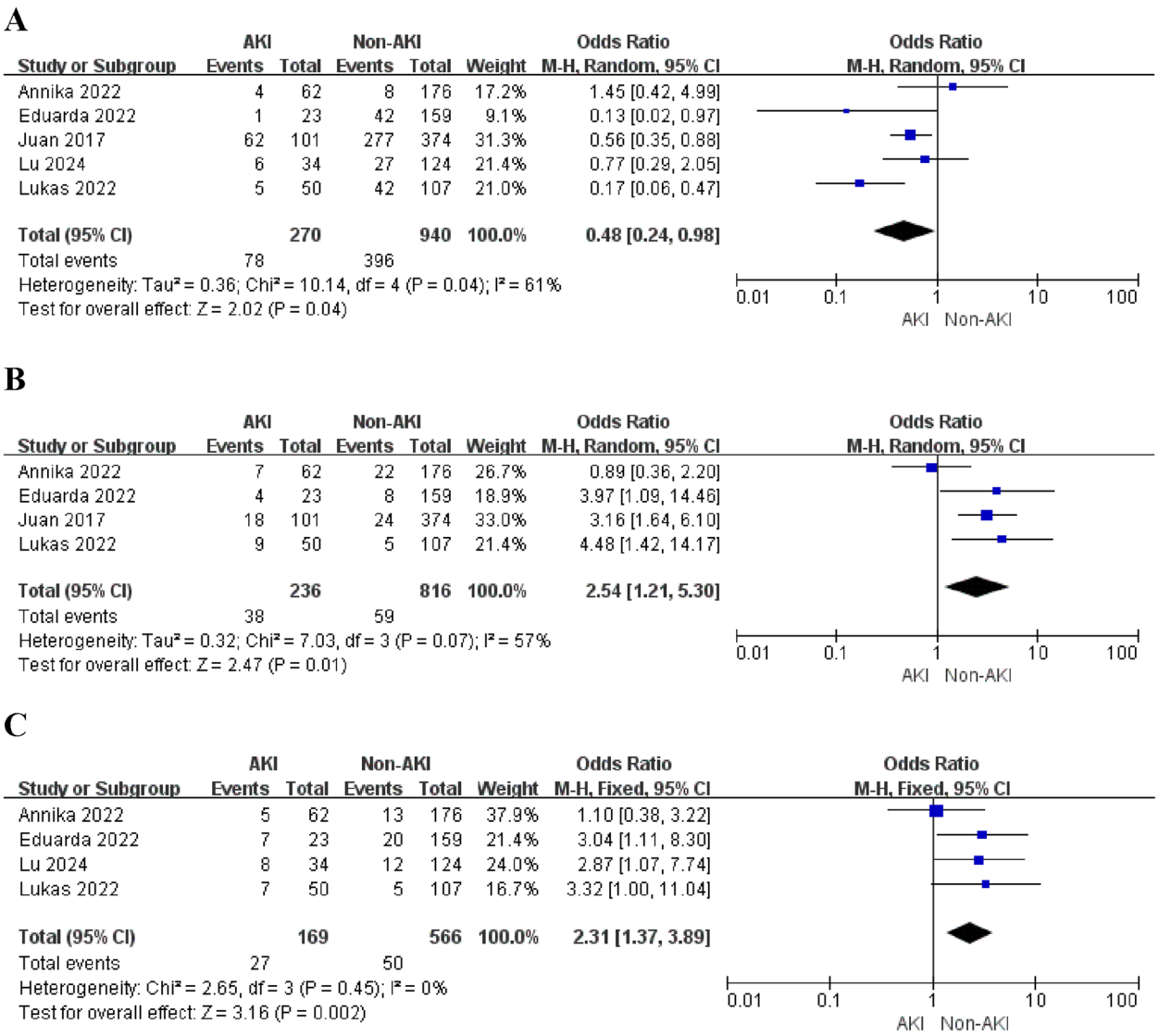

Fig. 4 Forest plot of primary tumor site: **A** appendix; **B** mesothelioma; **C** ovarian

We conducted Egger's test and Begg's test for age (Appendix Figure S2A-S2D), gender (Appendix Figure S3A-S3D), BMI (Appendix Figure S4A-S4D), DM (Appendix Figure S5A-S5D), and appendix (Appendix Figure S6A-S6D), respectively, and observed the change of the total effect value after excluding the included literature one by one. The results suggested that the p-values of Egger's test and Begg's test for the risk factors mentioned above were greater than 0.05, suggesting that there was no significant publication bias among the studies. Therefore, we conclude that publication bias has no significant effect on the findings of this meta-analysis, and the results are highly stable. The detailed Egger test and Begg test results are shown in Table 4.

Discussion

Patients with peritoneal surface malignancies (PSM) often face severe complications and poor survival prognosis [1, 39]. Currently, cytoreductive surgery (CRS) combined with hyperthermic intraperitoneal chemotherapy (HIPEC) has become the primary treatment modality for the treatment of patients with primary or metastatic peritoneal tumors [4–11].CRS + HIPEC significantly improves the survival prognosis of the patients [40, 41], but HIPEC is associated with higher mortality and morbidity along with the improvement in the prognosis [42,

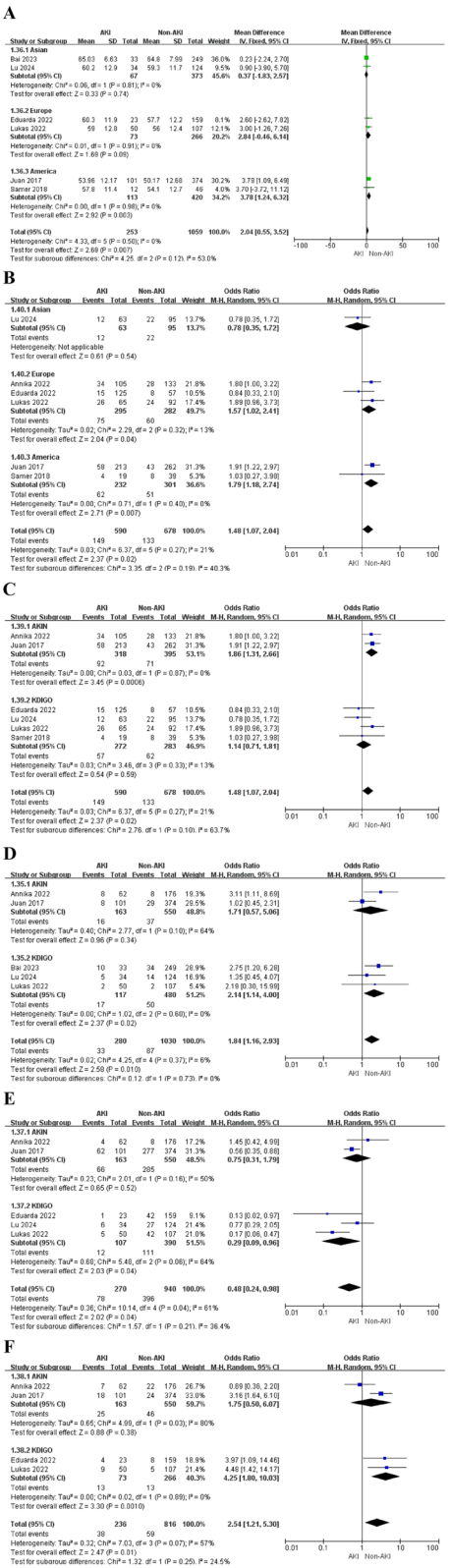

Fig. 5 Forest plot of subgroup analysis: **A** age; **B** sex(region); **C** sex(diagnostic criteria); **D** diabetes mellitus; **E** appendix; **F** mesothelioma

Table 3 Results of subgroup analysis of risk factors

	Studies(n)	OR/MD (95%CI)	P	$P_{heterogeneity}$	I^2
Age					
America	2	3.78 (1.24,6.32)	0.003	0.98	0%
Asian	2	0.37 (-1.83,2.57)	0.74	0.81	0%
Europe	2	2.84 (-0.46,6.14)	0.09	0.91	0%
Sex					
America	2	1.79 (1.18,2.74)	0.007	0.40	0%
Asian	1	0.78 (0.35,1.72)	0.54	NA	NA
Europe	2	1.57 (1.02,2.41)	0.04	0.32	13%
Diabetes mellitus					
AKIN	2	1.71 (0.57,5.06)	0.34	0.10	64%
KDIGO	3	2.14 (1.14,4.00)	0.02	0.60	0%
Sex					
AKIN	2	1.86 (1.31,2.66)	0.0006	0.87	0%
KDIGO	4	1.14 (0.71,1.81)	0.59	0.33	0%
Appendix					
AKIN	2	0.75 (0.31,1.79)	0.52	0.16	50%
KDIGO	3	0.29 (0.09,0.96)	0.04	0.06	64%
Mesothelioma					
AKIN	2	1.75 (0.50,6.07)	0.38	0.03	80%
KDIGO	2	4.25 (1.80.10.03)	0.001	0.89	0%

Table 4 Begg's and Egger's p value of postoperative risks factors for AKI after CRS + HIPEC

Risk factors	Begg's *p*-Value	Egger's *p*-Value
Age	1.00	0.432
Sex	0.26	0.079
BMI	0.06	0.123
Diabetes mellitus	0.806	0.880
Appendix	1.00	0.836

43].CRS + HIPEC has a perioperative mortality rate of approximately 4% and a combined incidence of postoperative related complications of up to 40% [19, 44]. Acute kidney injury (AKI), one of the most serious complications in cancer treatment, significantly increases the length of hospitalization and is strongly associated with high morbidity and mortality [45]. Despite continuous improvement in perioperative management, the incidence of complications after major surgery still exceeds 30% [46], of which AKI accounts for 13%, and patients with these AKIs face more than a six-fold increased risk of death [47–49]. Therefore, early identification of risk factors for AKI after CRS + HIPEC and preoperative interventions targeting reversible risk factors are essential to improve patient prognosis. In this study,

the combined incidence and risk factors of AKI in PSM patients after CRS + HIPEC were comprehensively analyzed by meta-analysis.

This meta-analysis of the incidence of postoperative AKI after CRS + HIPEC in the seven included articles suggested that the combined incidence of postoperative AKI was approximately 22.9%. In contrast, the incidence of postoperative AKI after CRS + HIPEC ranged from 1 to 48% as reported in previous studies [33]. The large differences in incidence rates among studies may stem from differences in sample size or differences in diagnostic criteria for AKI. In this study, a total of five studies used the most widely recognized KDIGO diagnostic criteria and two studies used the AKIN criteria. The incidence of AKI under different diagnostic criteria was counted separately, resulting in 23.7% for the AKIN criterion and 22.54% for the KDIGO criterion, which were close to each other and within the range of 1–48%.

Our study showed that higher body mass index (BMI) was associated with an increased risk of acute kidney injury (AKI) after CRS + HIPEC ($p < 0.05$), which is consistent with the findings of Juan et al. However, the studies by Samer et al. and Eduarda et al. did not find a significant association between BMI and AKI. We note that there were differences between the study by Juan et al. using the AKIN diagnostic criteria and other studies using the KDIGO criteria. After excluding the data from Juan et al., there was no significant association between BMI and AKI ($p > 0.05$), suggesting that BMI as a risk factor for AKI may be applicable only to the AKIN criteria. Obesity is associated with a variety of inflammatory responses and diseases, including heart disease, hypertension, and osteoarthritis [50, 51], and has been linked to the development and progression of cancer [52–54]. Obese patients face a higher risk of complications in the perioperative period [55, 56]. Conversely, underweight patients have higher surgical mortality associated with low albumin levels and energy reserves [57, 58]. Therefore, preoperative weight management is crucial for postoperative recovery.

The Peritoneal Cancer Index (PCI) scoring system, proposed by Sugarbaker et al., is widely used to assess peritoneal metastasis of abdominal tumors [59–61]. The system divides the abdomen into 13 regions and assesses tumor spread and the feasibility of CRS by scoring tumor size [62].PCI has also been associated with a high risk of death in patients after CRS + HIPEC [63]. Our meta-analysis showed that higher preoperative PCI values were associated with a higher incidence of postoperative AKI. This finding is consistent with the study of Samer et al. but contrary to the studies of Eduarda et al. and Lu et al. It may be related to the different PCI scoring methods and the subjectivity of the scorers.PCI is a powerful tool for assessing patients' preoperative risk and postoperative prognosis, and our study also demonstrated that PCI reliably predicts postoperative AKI.Therefore, PCI scoring should be routinely performed in patients with peritoneal carcinomatosis preoperatively performed to assess tumor load and risk of postoperative complications and to guide treatment selection.

The highly correlated relationship between advanced age and various renal function indices with AKI has been confirmed by several studies [64, 65].People aged 65 years or older are defined as traditionally elderly, and this segment of the population is currently the fastest growing in developed countries [66]. Acute kidney injury (AKI), however, is one of the most common emergencies among elderly patients, and its incidence has been on the rise in recent years. Its main pathogenesis lies in the fact that aging kidneys are often accompanied by structural changes and functional decline. As the kidneys age, the renal blood vessels and glomeruli gradually become sclerotic, leading to a series of functional changes. For example, the decline of eGFR, the decrease of ultrafiltration coefficient, and the decreasing ability of the kidney to regulate itself [67, 68]. The results of our meta-analysis suggest that two factors, advanced age and decline in eGFR, are among the high-risk factors for AKI after CRS + HIPEC. For the elderly aged 65 years or above, we should pay more attention to the changes of preoperative renal function indexes in patients during preoperative evaluation, and timely monitoring and early intervention are particularly important. In addition, for the identification of patients with acute kidney injury, proteinuria and eGFR should be monitored at the same time, which not only improves the identification rate of AKI, but also further evaluates the long-term prognosis of patients [69].

In our study, diabetes mellitus and hypertension were identified as preoperative risk factors for AKI after CRS + HIPEC.DM and hypertension have gained widespread attention as serious global public health problems. And, their high correlation with AKI has been confirmed by several studies [70, 71]. DM-associated AKI, which mainly originates from circulatory disorders and changes in the renal microenvironment caused by metabolic disorders, thus affecting the self-repairing ability of the kidneys, has led to the development of a series of complications [72]. The pathological mechanism of hypertension-related AKI is mainly that the sustained elevation of blood pressure puts the kidneys in a state of hyperperfusion leading to thickening and hardening of the vessel wall, and ultimately the formation of atherosclerosis. In addition, glomerular injury and tubulointerstitial fibrosis are also important causes. Therefore, before CRS + HIPEC is performed in patients with DM and hypertension, the main strategy of treatment

should be focused on glycemic control and blood pressure management.

We performed a meta-analysis of a total of eight intraoperative factors and finally identified IO SBP < 100 mmHg(min) as an intraoperative risk factor for AKI. It is also mentioned in the KDIGO guidelines that maintaining stable blood pressure intraoperatively, especially avoiding hypotension, will reduce the risk of kidney injury. Several studies (single and multicenter) exist to demonstrate the association between intraoperative hypotension and postoperative AKI [49, 73, 74]. However, blood pressure was described in the studies as mean arterial pressure (MAP), and in 40% of these patients, MAP was below 65 mmHg (for 10–12 min) during surgery. Therefore, although we confirmed that intraoperative SBP < 100 mmHg increases the risk of developing postoperative AKI, limited by the limited number of studies we included, more future studies are needed to confirm the association between intraoperative hypotension and postoperative AKI after CRS + HIPEC. In addition, the effect of different mean arterial pressure (MAP) gradients on AKI in hypotensive states will be one of our future research directions.

Common chemotherapeutic agents used in HIPEC surgery, including oxaliplatin, cisplatin (CDDP), and mitomycin C (MMC). Our study conducted a meta-analysis of the role of MMC and cisplatin on postoperative AKI. One of the surprises was that MMC appeared to be relatively protective against postoperative AKI. Extant studies have explored various aspects of the use of MMC with oxaliplatin in HIPEC. Among them, the results of van et al. suggested that oxaliplatin not only shortened the time but also had no adverse effect on postoperative complications or short-term survival compared with MMC infusion therapy [75]. In a retrospective study of patients with colon cancer by the American Society for Peritoneal Surface Malignancies (ASPSM), a total of 539 patients who received MMC and oxaliplatin respectively were analyzed for survival [76]. The results suggested that the MMC group appeared to have a better survival prognosis (32.7 months) compared to the OS of the oxaliplatin group (31.4 months). In addition, moreover, the results of a study showed that intraoperative coadministration of cisplatin and MMC was not associated with an increase in the incidence of postoperative AKI [77]. As an alkylating agent, cisplatin is widely used in the treatment of tumors, and is particularly effective in gastrointestinal and gynecological tumors. However, the use of cisplatin is associated with several complications, including nephrotoxicity, ototoxicity, neurotoxicity, and vomiting. The most significant complication is nephrotoxicity. The main pathogenesis of nephrotoxicity is acute or subacute tubular necrosis due to injury of proximal tubules. According to the KDIGO guidelines, we recommend avoiding nephrotoxic drugs and using renoprotective measures such as sodium thiosulfate and amifostine when necessary, especially after cisplatin chemotherapy. Among them, the prevention of nephrotoxicity after HIPEC by sodium thiosulfate has been confirmed by several studies [29, 78, 79]. The effectiveness of the drug has been gradually proved as the studies continue, but for the nephrotoxicity of cisplatin we still need to develop a standardized treatment regimen with the aim of reducing the postoperative AKI caused by nephrotoxicity.In addition, in the KDIGO guidelines, the importance of establishing a multidisciplinary team that includes nephrologists, intensivists, surgeons, and anesthesiologists to work together in the management of patients with AKI is specifically mentioned.

Finally, in this study, we specifically focused on the effect of the dose of chemotherapeutic agents used in HIPEC on postoperative acute kidney injury (AKI). Although we provided detailed information on the doses of chemotherapeutic agents used in different studies, we found it challenging to perform a direct meta-analysis due to the heterogeneity of the data. Our analysis revealed a possible association between the type and dose of chemotherapeutic agents and the risk of AKI, especially when cisplatin (Cisplatin) was used, which was significantly associated with an increased risk of postoperative AKI. In contrast, mitomycin (Mitomycin C) showed a protective effect against postoperative AKI. These findings underscore the importance of optimizing chemotherapeutic drug dosing in HIPEC treatment and the need for further studies to determine the impact of different chemotherapy regimens on AKI risk. Future studies require more standardized data collection and more refined dose–response analyses to better understand the role of chemotherapeutic agents in HIPEC and provide guidance for clinical practice.

Strengths and limitations

This systematic review and meta-analysis provides the first complete search and scientific analysis of the risk factors for AKI after CRS + HIPEC and a comprehensive analysis of the incidence of postoperative AKI in extant. It fills the gap of incomplete data on AKI risk factors and innovatively evaluates the impact of different primary tumor sites on the incidence of postoperative AKI.Although our study provides valuable information about risk factors for AKI after CRS + HIPEC, there are some limitations. All included studies were retrospective cohort studies, which may be subject to selection bias and information bias. In addition, heterogeneity

among studies may have affected the interpretation of the results. Although we used random effects models and sensitivity analyses to deal with heterogeneity, the influence of these factors on the overall conclusions cannot be excluded. Our study may also have been affected by publication bias, although Begg's and Egger's tests did not detect significant publication bias. Among the included studies, there were differences in the specific modalities of CRS and HIPEC, the selection and dosage of chemotherapeutic agents, and the diagnostic criteria for AKI. This diversity may have influenced the assessment and comparison of AKI risk factors.In addition, data completeness and reporting bias are potential limitations of our study, as only published studies were included and some unpublished results may be missing. Finally, the results of our study may be limited by geographic and population distribution, with most studies coming from specific regions and may not be fully representative of the global picture.

Future directions

Due to the limited number of included studies, we lacked detailed information on some of the potential risk factors and thus the corresponding analyzed results. For example, Annika et al. [29] found that patients possessing coronary artery disease increased the risk of AKI after CRS + HIPEC. In addition, only one study [31] reported the effect of preoperative antibiotic use on AKI, whereas prophylactic antibiotic use is a very common treatment in laparotomy reduction. In a study by Lu et al. [32], it was mentioned that ascites was also one of the risk factors for AKI, but the amount of ascites was not counted. For malignant tumors in the abdominal cavity, ascites is an unavoidable challenge, and understanding the effect of different gradients of ascites volume on postoperative AKI will also be one of the future research directions.Finally, it is also particularly important to explore the effect of the dose of chemotherapeutic agents during HIPEC on postoperative AKI.

Conclusion

The results of this systematic review and meta-analysis showed that the preoperative risk factors for postoperative AKI after CRS + HIPEC include age, gender, BMI, PCI, eGFR, Hb, Diabetes mellitus, and Hypertension.All of the above factors, except for age, gender, and PCI, are potential risk factors that can be controlled or reversible. Early identification as well as advance intervention in the perioperative period will greatly reduce the incidence of postoperative AKI in patients. For example, preoperative monitoring and management of renal function, Hb, blood glucose, and blood pressure. In addition, IO SBP < 100 mmHg(min) is an intraoperative risk factor for postoperative AKI. Close attention to intraoperative anesthesia management and maintenance of normal range intraoperative blood pressure will reduce the incidence of AKI. Finally, for the selection of intraoperative chemotherapeutic agents, MMC can significantly reduce the risk of postoperative AKI compared with cisplatin. The results of this study may provide clinicians with more epidemiological evidence on the prevention of postoperative AKI after CRS + HIPEC, so as to establish personalized treatment plans and optimize the perioperative management of patients, with a view to improving the prognosis of patients.

Abbreviations

PSM	Peritoneal surface malignancy
NOS	Newcastle–Ottawa scale
AKI	Acute kidney injury
CRS	Cytoreductive surgery
HIPEC	Hyperthermic intraperitoneal chemotherapy
PCI	Peritoneal cancer index
CRC	Colorectal cancer
SBP	Systolic blood pressure
IO	Intraoperative
DM	Diabetes mellitus
AKIN	Acute Kidney Injury Network
KDIGO	Kidney Disease Improving Global Outcomes

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12957-025-03657-w.

Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

Acknowledgements

We sincerely thank all the researchers who contributed to our research.

Authors' contributions

Conception/design: CDZ, JL, CH,HK, WL, and XY. Provision of study material or patients: CDZ, JL, YM,LF, WL, and GZ. Data collection and/or assembly: JL, YM, WL,HK, and GZ. Data analysis and interpretation: CDZ, JL, YM, WL, GZ, CH, HK, and YX. Manuscript writing: CDZ, JL, YM,LL, WL, GZ, CH, JW, and YX. Final approval of the manuscript: CDZ, JL, YM, WL, GZ,HK, CH, WL, and YX.

Funding

This work was supported by the Leading Innovation Specialist Support Program of Guangdong Province, the Science and Technology Planning Project of Ganzhou (No. 202101074816), the National Key Clinical Specialty Construction Project (2021–2024, No. 2022YW030009), the Science and Technology Plan of Guangzhou, Guangdong Province, China (No. 202201011416), the Ganzhou Zhanggong District Major Projects (2022–23-6) and the National Natural Science Foundation of China (No. 82260501).

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Our study does not require approval since it is a meta-analysis.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Received: 17 October 2024 Accepted: 7 January 2025
Published online: 04 February 2025

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