Effect of intraoperative blood loss on postoperative complications and prognosis of patients with colorectal cancer: A meta-analysis

ZI-WEI LI[1*], XIN-PENG SHU[1*], ZE-LIN WEN[2], FEI LIU[1], XU-RUI LIU[1], QUAN LV[1], XIAO-YU LIU[1], WEI ZHANG[1] and DONG PENG[1]

[1]Department of Gastrointestinal Surgery, The First Affiliated Hospital of Chongqing Medical University, Chongqing 400016; [2]Department of Gastrointestinal Surgery, Yongchuan Hospital of Chongqing Medical University, Chongqing 402160, P.R. China

Received September 21, 2023; Accepted November 15, 2023

DOI: 10.3892/br.2023.1710

Abstract. The purpose of the present study was to evaluate whether the amount of intraoperative blood loss (IBL) affects the complications and prognosis of patients with colorectal cancer (CRC). The PubMed, EMBASE and the Cochrane Library databases were used to search for eligible studies from inception to November 30, 2020. Hazard ratios (HRs) and 95% confidence intervals (Cls) were pooled up. The overall survival (OS) and disease-free survival (DFS) were compared between the larger IBL group and the smaller IBL group. The present study was performed with RevMan 5.3 (The Cochrane Collaboration). A total of seven studies involving 1,540 patients with CRC were included in the present study. The smaller IBL group had a higher rate of OS (HR=1.45, 95% CI=1.17 to 1.8, P=0.0007) and a higher rate of DFS (HR=1.76, 95% CI=1.40 to 2.21, P<0.00001). Furthermore, the larger IBL group had a higher rate of postoperative complications than the smaller IBL group (odds ratio=2.06, 95% CI=1.72 to 2.15, P<0.00001). In conclusion, a smaller IBL was associated with better OS and DFS, and a lower risk of postoperative complications compared with a larger IBL in patients with CRC, suggesting that surgeons should pay more attention during perioperative management and surgical operation to reduce IBL.

Introduction

Colorectal cancer (CRC) has become the third most common cancer type and the second leading cause of cancer-related death (1). In the past 10 years, the incidence and mortality rate of CRC in China have increased (2). The treatment of CRC includes surgery, chemotherapy, radiotherapy and immunotherapy (3-5). Surgery is still the main treatment for CRC and radical resection is the key to cure (6,7).

At the same time, it is particularly important to reduce the incidence of postoperative complications. It was reported that postoperative complications of CRC may worsen the prognosis and increase the risk of recurrence (8). This has led to increased resource utilization, readmission and decreased patient satisfaction (9). Therefore, it was important to determine the prognostic factors of CRC, as it may help patients benefit from more active treatment. Although surgery has been the key treatment, it is also important for surgeons to control intraoperative blood loss (IBL). Previous studies reported that blood transfusion may increase the risk of complications as well (10). In recent years, due to the popularity of laparoscopic surgery and the development of surgical equipment, such as ultrasound systems, the average amount of IBL has decreased and the demand for perioperative blood transfusion has also decreased (11).

Previous studies reported the value of IBL in predicting the prognosis and complications of patients with CRC. However, the predictive effect of IBL on complications and prognosis has been controversial. Tamagawa *et al* (7) reported that the reduction of IBL may improve the overall survival (OS) and disease-free survival (DFS) of patients with CRC. However, Egenvall *et al* (12) indicated that major IBL increases the risk of postoperative complications, but may not affect OS. Thus, the purpose of the present meta-analysis study was to evaluate whether postoperative complications and prognosis were affected by the amount of IBL in patients with CRC.

Materials and methods

Study registration. The present study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (13). The registration ID of the present meta-analysis on PROSPERO is CRD42022309536 (https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022309536).

Correspondence to: Professor Dong Peng, Department of Gastrointestinal Surgery, The First Affiliated Hospital of Chongqing Medical University, 1 Youyi Road, Chongqing 400016, P.R. China
E-mail: carry_dong@126.com

*Contributed equally

Key words: intraoperative blood loss, complications, overall survival, disease-free survival, colorectal cancer

Search strategy. The PubMed, EMBASE and Cochrane Library databases were searched from inception up to November 30, 2020. To find eligible studies, two key words were used: IBL and CRC. The search strategy was limited to the English language. For IBL, the search items were as follows: 'blood loss' OR 'intraoperative blood loss'. For CRC, the search terms were as follows: 'colorectal cancer' OR 'colon cancer' OR 'rectal cancer' OR 'colorectal neoplasm' OR 'colon neoplasm' OR 'rectal neoplasm' OR 'colorectal tumor' OR 'colon tumor' OR 'rectal tumor'. Subsequently, 'AND' was used to combine the two search items.

Inclusion and exclusion criteria. Studies were included in the present meta-analysis if they met the following criteria: i) The study included patients with CRC who underwent radical surgery; ii) the studies reported the comparison between a larger IBL group and a smaller IBL group; iii) postoperative complications and prognosis were reported. The exclusion criteria for this study were as follows: i) Conference abstracts, reviews, letters, comments or case reports, and duplicated publication data; ii) insufficient data for analysis. Data were extracted from graphs if required/possible. The lists of references of eligible studies were searched to retrieve any further articles missed in the original search. Any disagreements regarding inclusion and exclusion were resolved by discussion among all authors.

Study selection. The databases were searched by two authors (FL and XRL) independently. After removing duplicate records, the titles and abstracts were screened by QL, ZLW and XPS. Full texts were then evaluated for eligibility according to the inclusion and exclusion criteria by DP and ZWL. The final decision was made through discussion among all authors.

Definitions of outcomes. Postoperative complications were classified according to the Clavien-Dindo classification and severe postoperative complications were defined as grades ≥III (14). OS was defined as the time from diagnosis to death from any cause. DFS was defined as the time from diagnosis to the time of recurrence, death or last follow-up.

Data extraction. The following data of the present study were extracted: i) Publication year, first author's name, country, sample size, study design, and definition of larger IBL and smaller IBL; ii) baseline information, including sex, tumor location, tumor stage, tumor size and surgical approach; iii) surgery-related information, including IBL, operation time and operation approach; iv) postoperative complications; and v) survival outcomes (OS and DFS).

Quality assessment. The Newcastle-Ottawa scale (NOS), which has a score ranging from 0-9 points, was used to assess the quality of the enrolled studies (15). A study with a score of 9 points was considered to be of high quality, a study with a score of 7-8 points was considered of medium quality and a study with ≤6 points was considered to be of low quality.

Statistical analysis. Hazard ratios (HRs) and 95% confidence intervals (CIs) were calculated for the OS and DFS of patients with CRC. Odds ratios (ORs) and 95% CIs were calculated for the postoperative complications. Statistical heterogeneity was assessed by using the value of I^2 and the result of the chi-squared test. If I^2>50%, the random-effects model was used and P<0.1 was considered statistically significant. The fixed-effects model was used in this study if I^2≤50% and P<0.05 was considered statistically significant (16). The present study was performed with RevMan 5.3 (The Cochrane Collaboration).

Results

Study selection. A total of 5,398 studies were identified from the database, including 1,845 studies in PubMed, 3,261 studies in Embase and 292 studies in the Cochrane Library. After removing duplicate studies, 4,417 were left for record screening. After browsing the titles and abstracts, 42 studies were left for full-text scanning. Finally, 7 studies (7,12,17-21) were included in this study (Fig. 1).

Characteristics of the included studies. A total of seven studies (7,12,17-21) involving 10,540 patients were included in the present study. These studies selected were published from 2006 to 2021, including six retrospective studies and one prospective study. In two studies, the cutoff for the larger and smaller IBL groups was 200 ml, while it was 250 ml in two studies, 450 ml in one study, 200 ml in one study and one study did not include specific values. A total of four studies were assigned an NOS score of 8, one study scored 7 and two studies scored 6. The NOS scores are presented in Table I.

Comparison of characteristics between the larger and smaller IBL groups. Sex, tumor location, tumor stage and surgical approach were included in the baseline information. By comparing the baseline information, it was found that male sex (OR=1.47, 95% CI=1.30 to 1.66, P<0.00001) and tumor location in the rectum (OR=2.98, 95% CI=1.36 to 6.53, P=0.006) were associated with larger IBL. However, T1-T3 stage (OR=0.59, 95% CI=0.34 to 1.02, P=0.06), T4 stage (OR=1.69, 95% CI=0.97 to 2.92, P=0.06>0.05) and surgical approach (P=0.91) had no statistically significant association with the amount of IBL (Table II).

Comparison of survival outcomes between the larger and smaller IBL groups. A total of seven studies (7,12,17-21) reported on OS and two studies (7,19) reported on DFS of patients with CRC who underwent radical CRC surgery. The random-effects model was used to calculate the HR values. It was found that the smaller IBL group had better OS (HR=1.45, 95% CI=1.17 to 1.80, P=0.0007; Fig. 2) and better DFS (HR=1.76, 95% CI=1.40 to 2.21, P<0.00001; Fig. 3A) than the larger IBL group.

Comparison of complications between the larger and smaller IBL groups. There were two studies (12,20) reporting postoperative complications. After pooling up the data, it was found that the larger IBL group had a higher rate of postoperative complications than the smaller IBL group (OR=2.06, 95% CI=1.72 to 2.45, P<0.00001; Fig. 3B).

Table I. Characteristics of the studies included in the meta-analysis.

Author, year	Country	Study design	Study date	Sample size			Definition of larger and smaller IBL		NOS score	(Refs.)
				Larger IBL group	Smaller IBL group	Total	Larger IBL group	Smaller IBL group		
Tamagawa, 2021	Japan	Retrospective	2000-2019	489	1108	1597	≥200	<200	8	(7)
Shibutani, 2021	Japan	Retrospective	2012-2016	66	211	277	>100	≤100	7	(21)
Okamura, 2016	Japan	Retrospective	2003-2007	412	1142	1554	≥200	<200	8	(20)
Egenvall, 2014	Sweden	Retrospective	1997-2003	1398	445	1843	≥450	<450	8	(12)
Jiang, 2013	China	Retrospective	2005-2011	52	87	139	>250	≤250	6	(24)
Mörner, 2012	Sweden	Prospective	1997-2003	1588	1474	3062	≥250	<250	8	(18)
McArdle, 2006	UK	Retrospective+ prospective	1991-1994	NA	NA	2068	NA	NA	6	(17)

IBL, intraoperative blood loss, ml; NOS, Newcastle-Ottawa scale.

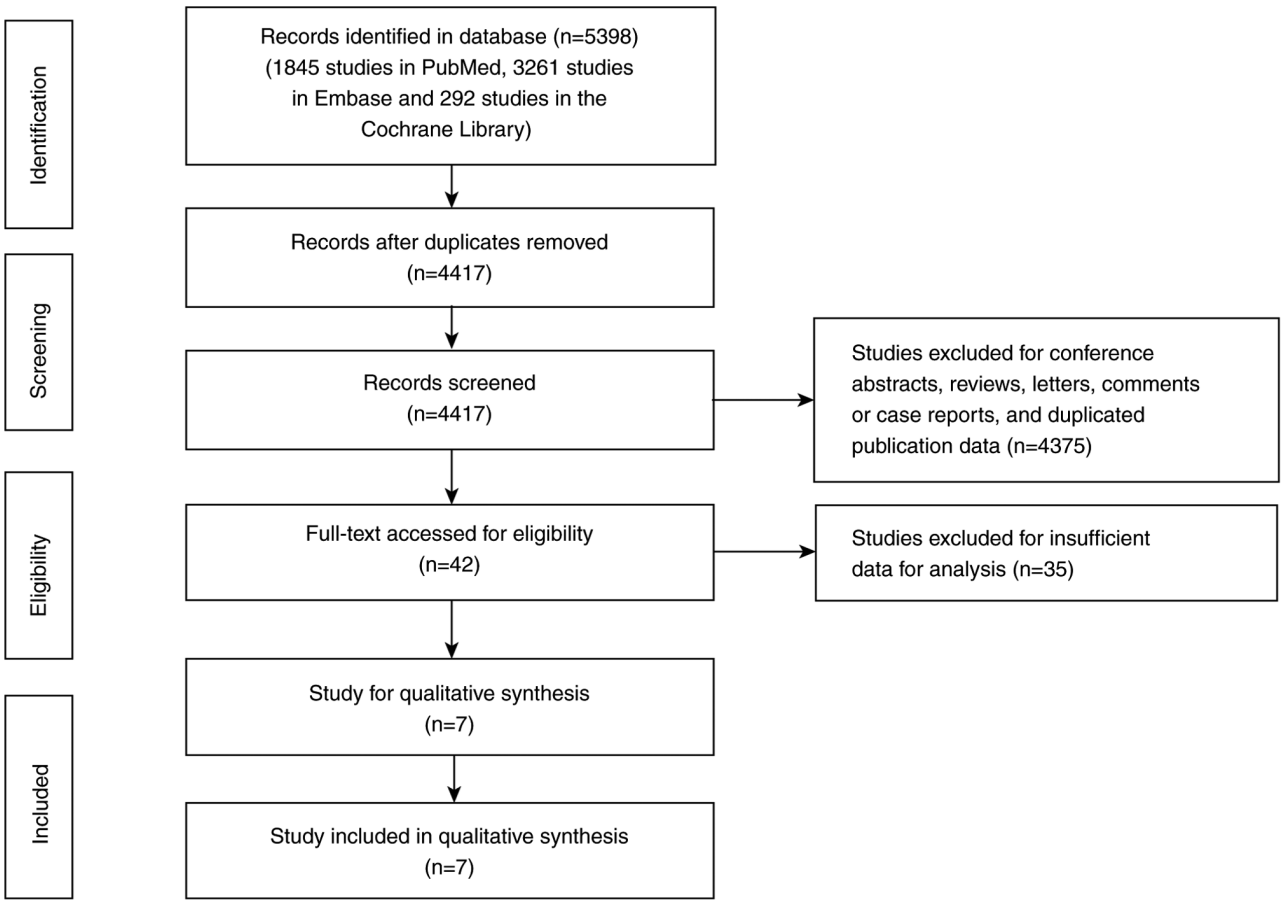

Figure 1. Flowchart of study selection.

Factor analysis of HRs for OS and DFS. There were further factors that affected OS and DFS. Thus, a subgroup analysis of factors, including age, sex, lymph node metastasis (LNM), surgical approach, tumor location, tumor stage and body mass index was conducted. It was indicated that LNM (HR=1.64, 95% CI=1.16-2.31, P=0.005; Fig. 4A) and higher tumor stage (HR=2.25, 95% CI=1.98-2.56, P<0.00001; Fig. 4B) were related to poor OS. However, no significant influence on DFS was found for age (P=0.66) or sex (P=0.66). The results of the subgroup analysis are presented in Table III.

Table II. Association of the different features with larger and smaller IBL groups.

Characteristic	Studies, n	Participants, n (larger/smaller IBL)	Mean difference/odds ratio (95% CI); P-value	Heterogeneity
Sex				
Male	5	2417/2993	1.47 (1.30, 1.66); P<0.00001	I^2=45%; P=0.12
Female	5	2417/2993	0.72 (0.64, 0.82); P<0.00001	I^2=0%; P=0.50
Tumor location				
Rectum	2	901/2250	2.98 (1.36, 6.53); P=0.006	I^2=95%; P<0.0001
Colon	2	901/2250	0.27 (0.19, 0.39); P<0.00001	I^2=76%; P=0.04
Tumor stage				
T1-T3	2	555/1319	0.59 (0.34, 1.02); P=0.06	I^2=65%; P=0.09
T4	2	555/1319	1.69 (0.97, 2.92); P=0.06	I^2=66%; P=0.09
Type of surgery				
Laparoscopic	2	1631/1520	0.83 (0.03, 24.16); P=0.91	I^2=100%; P<0.00001
Open	2	1631/1520	1.20 (0.04, 34.75); P=0.91	I^2=100%; P<0.00001

IBL, intraoperative blood loss, ml; T, tumor.

Table III. Factor analysis of HRs for OS and DFS.

A, Factors for OS

Factor	Studies, n	Model	HR (95% CI); P-value	Heterogeneity
Age	5	RE	1.14 (0.74, 1.77); P=0.55	I^2=98%; P<0.00001
Sex (male/female)	2	RE	1.12 (0.95, 1.33); P=0.17	I^2=69%; P=0.003
LNM	3	FE	1.64 (1.16, 2.31); P=0.005	I^2=0%; P=0.45
Surgical approach (laparoscopic/open)	2	FE	0.80 (0.63, 1.03); P=0.08	I^2=0%; P=0.47
Tumor location (rectum/colon)	2	FE	1.12 (0.86, 1.45); P=0.41	I^2=0%; P=0.96
Tumor stage (III/II/I)	2	RE	2.25 (1.98, 2.56); P<0.00001	I^2=72%; P=0.06
BMI (≥25/<25 kg/m^2)	2	RE	1.5 (0.37, 6.13); P=0.57	I^2=88%; P=0.004

B, Factors for DFS

Factor	Studies, n	Model	Hazard ratio (95% CI)	Heterogeneity
Age	2	RE	0.88 (0.51, 1.52); P=0.66	I^2=60%; P=0.12
Sex (male/female)	2	FE	0.82 (0.67, 1.01); P=0.06	I^2=0%; P=0.90

HR, hazard ratio; OS, overall survival; DFS, disease-free survival; LNM, lymph node metastasis; BMI, body mass index; FE, fixed effects; RE, random effects.

Discussion

Despite the improvement of the treatment level in recent years, the five-year survival rate of patients with metastatic CRC is still poor (6). It has been determined that risk factors such as age, type 2 diabetes mellitus, lymph node status and tumor stage may predict the postoperative survival rate of patients with CRC (8). In the present study, it was found that LNM and tumor stage were prognostic factors for patients with CRC. These results were similar to those of previous studies (7,12).

Various previous studies have discussed the relationship among IBL, postoperative complications and prognosis; however, the effect of IBL on complications and prognosis remains controversial. McArdle *et al* (17) reported that the mortality rate was higher and OS was worse after massive bleeding during CRC surgery. Mörner *et al* (18) supported the hypothesis that the degree of bleeding during colon cancer surgery affected long-term survival. However, Egenvall *et al* (12) indicated that larger IBL increases the risk of postoperative complications, but does not affect OS. Thus, in the present study, the effect of IBL on the

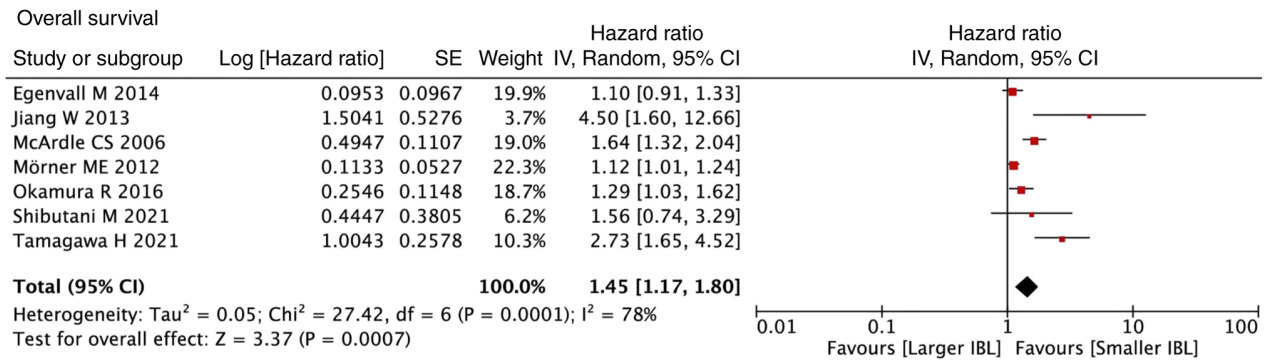

Figure 2. Overall survival analysis between larger IBL group and smaller IBL group. IBL, intraoperative blood loss; SE, standard error; IV, inverse variance; df, degrees of freedom.

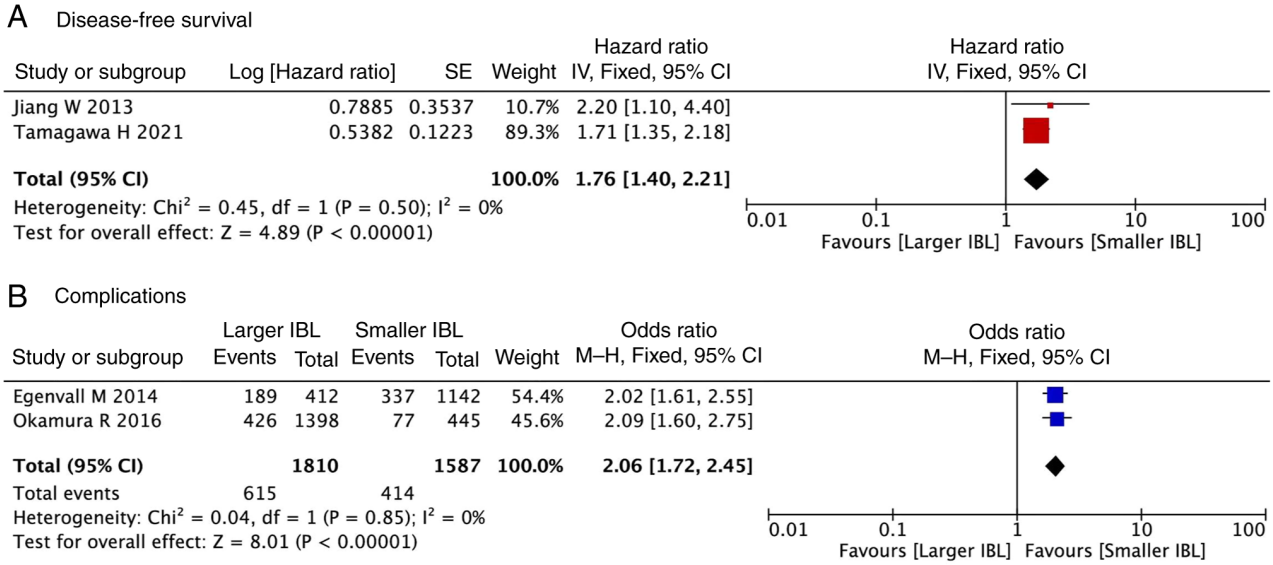

Figure 3. (A) Disease-free survival analysis between larger IBL group and smaller IBL group. (B) Forest plot showing complications between larger and smaller IBL group. IBL, intraoperative blood loss; SE, standard error; IV, inverse variance; df, degrees of freedom.

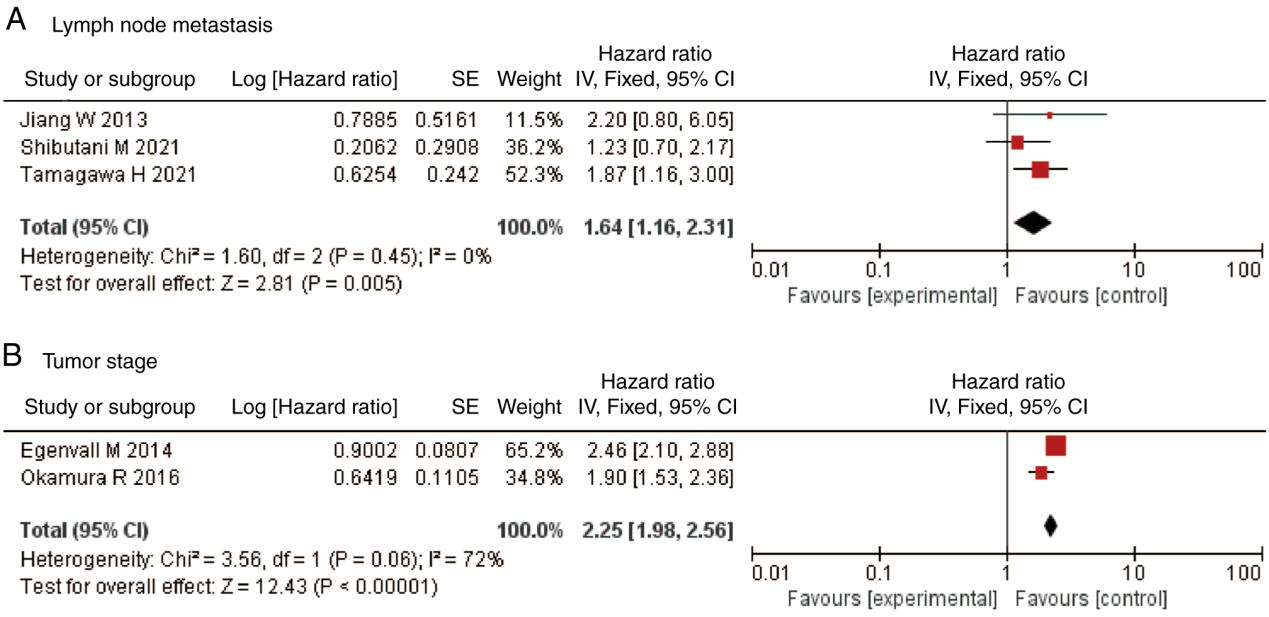

Figure 4. (A) Forest plot showing the association between lymph node metastasis and overall survival. (B) Forest plot showing the association between tumor stage and overall survival.

postoperative complications and prognosis of patients with CRC was explored.

Patients with early CRC have no obvious symptoms and they are already in the intermediate and late stages of the disease at the time of diagnosis (22). Previous studies demonstrated that in the late T-stage, the amount of IBL may be increased (7). Patients with advanced T-stage receive systemic chemoradiotherapy before the operation and may require more extensive anatomy for surrounding blood vessels and tissues during the operation (12). Furthermore, preoperative radiotherapy may increase IBL (23). In addition, metastasis was reported to be the main characteristic of advanced CRC (24), and the liver was the most common organ of CRC metastasis and liver metastasis was the main cause of death from CRC (25). Patients with advanced CRC were determined to have a 40-50% probability of secondary liver metastasis, which reduces OS (26). In addition, Jiang *et al* (19) found that the number of CRC liver metastases was a predictor of larger IBL, which was associated with worse OS in patients with CRC liver metastasis resection. However, in the present study, it was not found that the T-stage was associated with large IBL. Therefore, more data are needed for further research.

The incidence rate of CRC is higher in the elderly (27,28). Advanced age is an important risk factor for postoperative mortality and the elderly had poor performance status, recovery ability and comorbid diseases. Okamura *et al* (20) reported that elderly patients with CRC were more suitable for laparoscopic surgery. Compared with traditional open surgery, laparoscopic surgery had a smaller incision, less IBL, a shorter postoperative hospital stay and lower postoperative complications and postoperative mortality (29,30). However, in the present study, no significant difference in surgical approach was found between the larger and the smaller IBL groups. A high volume of IBL significantly affected the postoperative complication incidence rate, OS and recurrence in elderly patients with CRC (20). Furthermore, certain studies reported that men had higher IBL than women among patients undergoing CRC surgery (7,12,17). The reason may be that men have a narrower pelvis, making the operation more difficult. In the present study, it was found that male sex was associated with larger IBL.

A larger IBL increases the probability of blood transfusion and a blood transfusion would in turn increase the risk of postoperative mortality (10). The mechanism behind the effect of a larger IBL on prognosis remains elusive. The potential causes may be as follows: i) The amount of IBL indirectly represents the degree of tumor progression (21), and this would increase the scope of intraoperative anatomy; ii) a large amount of IBL would accelerate tumor overflow and hematogenous dissemination (31); iii) larger IBL leads to systemic hypoperfusion and insufficient oxygenation, promotes systemic inflammatory response and hinders antitumor immunity (32). Inflammation may increase the risk of postoperative infection, leading to poor prognosis.

Of note, there are some limitations to this study. First, the seven articles included in the present study were observational and most of these studies came from Asia, which may introduce bias into the analysis. Furthermore, the present study did not assess the potential impact of confounding variables and postoperative treatment on the relationship between IBL and outcomes. In addition, the amount of blood loss during the operation was an estimated amount, which may have some bias. As another limitation, the definition of IBL was inconsistent and different studies had different cut-offs for high and low IBL. In addition, the present study did not include the impact of other factors on postoperative complications. In addition, this study did not assess the potential impact of different surgical techniques or treatment regimens on the relationship between IBL and outcomes. Finally, no publication bias was assessed, and no sensitivity analysis was performed by excluding one study to determining the impact on the pooled effect. Therefore, comprehensive, prospective and high-quality randomized controlled trials should be performed in the future.

In conclusion, a smaller IBL was associated with higher OS and DFS and lower risk of postoperative complications compared with a larger IBL in patients with CRC, which reminded us that surgeons should pay more attention to the perioperative management and surgical operation to reduce IBL.

Acknowledgements

The authors appreciate the contribution of Professor Juan-Xiao Luo (Department of Endoscopy Center, The First Affiliated Hospital of Chongqing Medical University, Chongqing, China) to the revision of the manuscript and language modification.

Funding

This study was supported by the Chongqing Medical University Program for Youth Innovation in Future Medicine (grant no. W0190).

Availability of data and materials

The datasets used and/and analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

Data extraction, ZWL, QL, XYL, DP and ZLW; quality assessments, XRL, XPS, DP and FL; data analysis, XPS, DP and WZ; writing-original draft, ZWL; writing-review and editing, ZWL, DP and XPS. Confirmation of the authenticity of the raw data, DP and ZWL. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

1. Siegel RL, Miller KD, Fuchs HE and Jemal A: Cancer statistics, 2022. CA Cancer J Clin 72: 7-33, 2022.
2. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA and Jemal A: Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 68: 394-424, 2018.
3. Cheng YX, Tao W, Zhang H, Peng D and Wei ZQ: Does liver cirrhosis affect the surgical outcome of primary colorectal cancer surgery? A meta-analysis. World J Surg Oncol 19: 167, 2021.
4. Kobayashi N, Oike T, Kubo N, Miyasaka Y, Mizukami T, Sato H, Adachi A, Katoh H, Kawamura H and Ohno T: Colorectal cancer screening outcomes of 2412 prostate cancer patients considered for carbon ion radiotherapy. Cancers (Basel) 13: 4481, 2021.
5. Liu XY, Li ZW, Kang B, Cheng YX, Tao W, Zhang B, Zhang H, Wei ZQ and Peng D: Does preoperative waiting time affect the short-term outcomes and prognosis of colorectal cancer patients? A retrospective study from the West of China. Can J Gastroenterol Hepatol 2022: 8235736, 2022.
6. Wu QB, Wang M, Hu T, He WB and Wang ZQ: Prognostic role of the lymphocyte-to-monocyte ratio in patients undergoing resection for nonmetastatic rectal cancer. Medicine (Baltimore) 95: e4945, 2016.
7. Tamagawa H, Numata M, Aoyama T, Kazama K, Atsumi Y, Iguchi K, Sawazaki S, Sato S, Kano K, Ohshima T, *et al*: Impact of intraoperative blood loss on the survival of patients with stage II/III colorectal cancer: A multicenter retrospective study. In Vivo 5: 3483-3488, 2021.
8. Artinyan A, Orcutt ST, Anaya DA, Richardson P, Chen GJ and Berger DH: Infectious postoperative complications decrease long-term survival in patients undergoing curative surgery for colorectal cancer: A study of 12,075 patients. Ann Surg 261: 497-505, 2015.
9. Scott AR, Alore EA, Naik AD, Berger DH and Suliburk JW: Mixed-Methods Analysis of Factors Impacting Use of a Postoperative mHealth App. JMIR Mhealth Uhealth 5: e11, 2017.
10. Jagoditsch M, Pozgainer P, Klingler A and Tschmelitsch J: Impact of blood transfusions on recurrence and survival after rectal cancer surgery. Dis Colon Rectum 49: 1116-1130, 2006.
11. Ueda Y, Shiraishi N, Kawasaki T, Akagi T, Ninomiya S, Shiroshita H, Etoh T and Inomata M: Short- and long-term outcomes of laparoscopic surgery for colorectal cancer in the elderly aged over 80 years old versus non-elderly: A retrospective cohort study. BMC Geriatr 20: 445, 2020.
12. Egenvall M, Mörner M, Påhlman L and Gunnarsson U: Degree of blood loss during surgery for rectal cancer: A population-based epidemiologic study of surgical complications and survival. Colorectal Dis 16: 696-702, 2014.
13. Moher D, Liberati A, Tetzlaff J and Altman DG; PRISMA Group: Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLoS Med 6: e1000097, 2009.
14. Dindo D, Demartines N and Clavien PA: Classification of Surgical Complications: A New Proposal With Evaluation in a Cohort of 6336 patients and results of a survey. Ann Surg 240: 205-213, 2004.
15. Stang A: Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol 25: 603-605, 2010.
16. Ioannidis JP: Interpretation of tests of heterogeneity and bias in metaanalysis. J Eval Clin Pract 14: 951-957, 2008.
17. McArdle CS, McMillan DC and Hole DJ: The impact of blood loss, obstruction and perforation on survival in patients undergoing curative resection for colon cancer. Br J Surg 93: 483-488, 2006.
18. Mörner ME, Gunnarsson U, Jestin P and Svanfeldt M: The importance of blood loss during colon cancer surgery for long-term survival: An epidemiological study based on a population based register. Ann Surg 255: 1126-1128, 2012.
19. Jiang W, Fang YJ, Wu XJ, Wang FL, Lu ZH, Zhang RX, Ding PR, Fan WH, Pan ZZ and De-Sen Wan: Intraoperative blood loss independently predicts survival and recurrence after resection of colorectal cancer liver metastasis. PLoS One 8: e76125, 2013.
20. Okamura R, Hida K, Hasegawa S, Sakai Y, Hamada M, Yasui M, Hinoi T and Watanabe M; Japan Society of Laparoscopic Colorectal Surgery: Impact of intraoperative blood loss on morbidity and survival after radical surgery for colorectal cancer patients aged 80 years or older. Int J Colorectal Dis 31: 327-334, 2016.
21. Shibutani M, Maeda K, Kashiwagi S, Hirakawa K and Ohira M: The impact of intraoperative blood loss on the survival after laparoscopic surgery for colorectal cancer. Anticancer Res 41: 4529-4534, 2021.
22. Wang Z, Guo M, Ai X, Cheng J, Huang Z, Li X and Chen Y: Identification of potential diagnostic and prognostic biomarkers for colorectal cancer based on GEO and TCGA databases. Front Genet 11: 602922, 2021.
23. Kapiteijn E, Marijnen CA, Nagtegaal ID, Putter H, Steup WH, Wiggers T, Rutten HJ, Pahlman L, Glimelius B, van Krieken JH, *et al*: Dutch colorectal cancer Group. Preoperative radiotherapy combined with total mesorectal excision for resectable rectal cancer. N Engl J Med 345: 638-646, 2001.
24. Stella Tsai CS, Chen HC, Tung JN, Tsou SS, Tsao TY, Liao CF, Chen YC, Yeh CY, Yeh KT and Jiang MC: Serum cellular apoptosis susceptibility protein is a potential prognostic marker for metastatic colorectal cancer. Am J Pathol 176: 1619-1628, 2010.
25. Wang S, Zhang C, Zhang Z, Qian W, Sun Y, Ji B, Zhang Y, Zhu C, Ji D, Wang Q and Sun Y: Transcriptome analysis in primary colorectal cancer tissues from patients with and without liver metastases using next-generation sequencing. Cancer Med 6: 1976-1987, 2017.
26. Manfredi S, Lepage C, Hatem C, Coatmeur O, Faivre J and Bouvier AM: Epidemiology and management of liver metastases from colorectal cancer. Ann Surg 244: 254-259, 2006.
27. Kang B, Liu XY, Li ZW, Yuan C, Zhang B, Wei ZQ and Peng D: The effect of the intraoperative blood loss and intraoperative blood transfusion on the short-term outcomes and prognosis of colorectal cancer: A propensity score matching analysis. Front Surg 9: 837545, 2022.
28. Jeong DH, Hur H, Min BS, Baik SH and Kim NK: Safety and feasibility of a laparoscopic colorectal cancer resection in elderly patients. Ann Coloproctol 29: 22-27, 2013.
29. Song XJ, Liu ZL, Zeng R, Ye W and Liu CW: A meta-analysis of laparoscopic surgery versus conventional open surgery in the treatment of colorectal cancer. Medicine (Baltimore) 98: e15347, 2019.
30. Liu XY, Zhang B, Kang B, Cheng YX, Yuan C, Tao W, Wei ZQ and Peng D: The effect of complications on oncological outcomes of colorectal cancer patients after primary surgery: A propensity score matching analysis. Front Oncol 12: 857062, 2022.
31. Katz SC, Shia J, Liau KH, Gonen M, Ruo L, Jarnagin WR, Fong Y, D'Angelica MI, Blumgart LH and Dematteo RP: Operative blood loss independently predicts recurrence and survival after resection of hepatocellular carcinoma. Ann Surg 249: 617-623, 2009.
32. Fan ST, Lo CM, Liu CL, Lam CM, Yuen WK, Yeung C and Wong J: Hepatectomy for hepatocellular carcinoma: Toward zero hospital deaths. Ann Surg 229: 322-330, 1999.

Copyright © 2023 Li et al. This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) License.