

World Journal of *Hepatology*

World J Hepatol 2024 March 27; 16(3): 300-489



EDITORIAL

- 300 Is there a need for universal double reflex testing of HBsAg-positive individuals for hepatitis D infection?
Abbas Z, Abbas M

REVIEW

- 304 Non-alcoholic fatty liver disease and sleep disorders
Bu LF, Xiong CY, Zhong JY, Xiong Y, Li DM, Hong FF, Yang SL
- 316 Amebic liver abscess: An update
Kumar R, Patel R, Priyadarshi RN, Narayan R, Maji T, Anand U, Soni JR

MINIREVIEWS

- 331 Advances in discovery of novel investigational agents for functional cure of chronic hepatitis B: A comprehensive review of phases II and III therapeutic agents
Lam R, Lim JK
- 344 Protein succinylation, hepatic metabolism, and liver diseases
Liu S, Li R, Sun YW, Lin H, Li HF
- 353 Hepatocellular carcinoma immune microenvironment and check point inhibitors-current status
Gupta T, Jarpula NS

ORIGINAL ARTICLE

Case Control Study

- 366 Associations of PNPLA3 and LEP genetic polymorphisms with metabolic-associated fatty liver disease in Thai people living with human immunodeficiency virus
Choochuay K, Kunhapan P, Puangpetch A, Tongsima S, Srisawasdi P, Sobhonslidsuk A, Sungkanuparph S, Biswas M, Sukasem C

Retrospective Cohort Study

- 379 Comparison of fungal *vs* bacterial infections in the medical intensive liver unit: Cause or corollary for high mortality?
Khan S, Hong H, Bass S, Wang Y, Wang XF, Sims OT, Koval CE, Kapoor A, Lindenmeyer CC
- 393 Lean body mass index is a marker of advanced tumor features in patients with hepatocellular carcinoma
deLemos AS, Zhao J, Patel M, Kookan B, Mathur K, Nguyen HM, Mazhar A, McCarter M, Burney H, Kettler C, Chalasani N, Gawrieh S

Retrospective Study

- 405 Prediction model for hepatitis B e antigen seroconversion in chronic hepatitis B with peginterferon-alfa treated based on a response-guided therapy strategy

Zhang PX, Zheng XW, Zhang YF, Ye J, Li W, Tang QQ, Zhu J, Zou GZ, Zhang ZH

- 418 Retrospective study of the incidence, risk factors, treatment outcomes of bacterial infections at uncommon sites in cirrhotic patients

Schneitler S, Schneider C, Casper M, Lammert F, Krawczyk M, Becker SL, Reichert MC

Observational Study

- 428 Palliative long-term abdominal drains *vs* large volume paracenteses for the management of refractory ascites in end-stage liver disease

Kaur S, Motta RV, Chapman B, Wharton V, Collier JD, Saffioti F

Basic Study

- 439 Comprehensive prognostic and immune analysis of sterol O-acyltransferase 1 in patients with hepatocellular carcinoma

Gan CJ, Zheng Y, Yang B, Cao LM

SYSTEMATIC REVIEWS

- 452 Update in lean metabolic dysfunction-associated steatotic liver disease

Sato-Espinoza K, Chotiprasidhi P, Huaman MR, Díaz-Ferrer J

META-ANALYSIS

- 465 Influence of nonalcoholic fatty liver disease on response to antiviral treatment in patients with chronic hepatitis B: A meta-analysis

Liu SY, Wang D, Liu J, Yang LP, Chen GY

- 477 Prognostic value of neutrophil-to-lymphocyte ratio in end-stage liver disease: A meta-analysis

Cai XH, Tang YM, Chen SR, Pang JH, Chong YT, Cao H, Li XH

ABOUT COVER

Editorial Board Member of *World Journal of Hepatology*, Marcello Maida, MD, Doctor, Gastroenterology and Endoscopy Unit, S.Elia - Raimondi Hospital, Caltanissetta, Caltanissetta 93100, Italy. marcello.maida@hotmail.it

AIMS AND SCOPE

The primary aim of *World Journal of Hepatology* (*WJH*, *World J Hepatol*) is to provide scholars and readers from various fields of hepatology with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJH mainly publishes articles reporting research results and findings obtained in the field of hepatology and covering a wide range of topics including chronic cholestatic liver diseases, cirrhosis and its complications, clinical alcoholic liver disease, drug induced liver disease autoimmune, fatty liver disease, genetic and pediatric liver diseases, hepatocellular carcinoma, hepatic stellate cells and fibrosis, liver immunology, liver regeneration, hepatic surgery, liver transplantation, biliary tract pathophysiology, non-invasive markers of liver fibrosis, viral hepatitis.

INDEXING/ABSTRACTING

The *WJH* is now abstracted and indexed in PubMed, PubMed Central, Emerging Sources Citation Index (ESCI), Scopus, Reference Citation Analysis, China Science and Technology Journal Database, and Superstar Journals Database. The 2023 Edition of Journal Citation Reports® cites the 2022 impact factor (IF) for *WJH* as 2.4.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: Yi-Xuan Cai, Production Department Director: Xiang Li, Cover Editor: Xiang Li.

NAME OF JOURNAL

World Journal of Hepatology

ISSN

ISSN 1948-5182 (online)

LAUNCH DATE

October 31, 2009

FREQUENCY

Monthly

EDITORS-IN-CHIEF

Nikolaos Pyrsopoulos, Ke-Qin Hu, Koo Jeong Kang

EXECUTIVE ASSOCIATE EDITORS-IN-CHIEF

Shuang-Suo Dang

EDITORIAL BOARD MEMBERS

<https://www.wjgnet.com/1948-5182/editorialboard.htm>

PUBLICATION DATE

March 27, 2024

COPYRIGHT

© 2024 Baishideng Publishing Group Inc

PUBLISHING PARTNER

Department of Infectious Diseases, the Second Affiliated Hospital of Xi'an Jiaotong University

INSTRUCTIONS TO AUTHORS

<https://www.wjgnet.com/bpg/gerinfo/204>

GUIDELINES FOR ETHICS DOCUMENTS

<https://www.wjgnet.com/bpg/GerInfo/287>

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH

<https://www.wjgnet.com/bpg/gerinfo/240>

PUBLICATION ETHICS

<https://www.wjgnet.com/bpg/GerInfo/288>

PUBLICATION MISCONDUCT

<https://www.wjgnet.com/bpg/gerinfo/208>

POLICY OF CO-AUTHORS

<https://www.wjgnet.com/bpg/GerInfo/310>

ARTICLE PROCESSING CHARGE

<https://www.wjgnet.com/bpg/gerinfo/242>

STEPS FOR SUBMITTING MANUSCRIPTS

<https://www.wjgnet.com/bpg/GerInfo/239>

ONLINE SUBMISSION

<https://www.f6publishing.com>

PUBLISHING PARTNER's OFFICIAL WEBSITE

http://2yuan.xjtu.edu.cn/Html/Departments/Main/Index_21148.html



Prognostic value of neutrophil-to-lymphocyte ratio in end-stage liver disease: A meta-analysis

Xiang-Hao Cai, Yun-Ming Tang, Shu-Ru Chen, Jia-Hui Pang, Yu-Tian Chong, Hong Cao, Xin-Hua Li

Specialty type: Gastroenterology & hepatology

Provenance and peer review:

Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification

Grade A (Excellent): 0
Grade B (Very good): 0
Grade C (Good): C
Grade D (Fair): 0
Grade E (Poor): 0

P-Reviewer: Shelat VG, Singapore

Received: November 12, 2023

Peer-review started: November 12, 2023

First decision: December 7, 2023

Revised: January 3, 2024

Accepted: February 6, 2024

Article in press: February 6, 2024

Published online: March 27, 2024



Xiang-Hao Cai, Yun-Ming Tang, Shu-Ru Chen, Jia-Hui Pang, Yu-Tian Chong, Hong Cao, Xin-Hua Li, Department of Infectious Disease, Third Affiliated Hospital of Sun Yat-sen University, Guangzhou 510630, Guangdong Province, China

Corresponding author: Xin-Hua Li, MD, PhD, Doctor, Department of Infectious Disease, Third Affiliated Hospital of Sun Yat-sen University, No. 600 Tianhe Road, Tianhe District, Guangzhou 510630, Guangdong Province, China. lixinh8@mail.sysu.edu.cn

Abstract

BACKGROUND

The neutrophil-to-lymphocyte ratio (NLR) is commonly utilized as a prognostic indicator in end-stage liver disease (ESLD), encompassing conditions like liver failure and decompensated cirrhosis. Nevertheless, some studies have contested the prognostic value of NLR in ESLD.

AIM

To investigate the ability of NLR to predict ESLD.

METHODS

Databases, such as Embase, PubMed, Web of Science, Cochrane Library, China National Knowledge Infrastructure, Weipu, and Wanfang, were comprehensively searched to identify studies published before October 2022 assessing the prognostic ability of NLR to predict mortality in patients with ESLD. Effect sizes were calculated using comprehensive meta-analysis software and SATAT 15.1.

RESULTS

A total of thirty studies involving patients with end-stage liver disease (ESLD) were included in the evaluation. Among the pooled results of eight studies, it was observed that the Neutrophil-to-Lymphocyte Ratio (NLR) was significantly higher in non-survivors compared to survivors (random-effects model: standardized mean difference = 1.02, 95% confidence interval = 0.67-1.37). Additionally, twenty-seven studies examined the associations between NLR and mortality in ESLD patients, reporting either hazard ratios (HR) or odds ratios (OR). The combined findings indicated a link between NLR and ESLD mortality (random-effects model; univariate HR = 1.07, 95%CI = 1.05-1.09; multivariate HR = 1.07, 95%CI = 1.07-1.09; univariate OR = 1.29, 95%CI = 1.18-1.39; multivariate OR = 1.29, 95%CI = 1.09-1.49). Furthermore, subgroup and meta-regression analyses revealed regional variations in the impact of NLR on ESLD mortality, with Asian studies demonstrating a more pronounced effect.

CONCLUSION

Increased NLR in patients with ESLD is associated with a higher risk of mortality, particularly in Asian patients. NLR is a useful prognostic biomarker in patients with ESLD.

Key Words: Neutrophil-to-lymphocyte ratio; End stage liver diseases; Prognosis; Meta-analysis; Mortality

©The Author(s) 2024. Published by Baishideng Publishing Group Inc. All rights reserved.

Core Tip: This meta-analysis examines the association between neutrophil-to-lymphocyte ratio (NLR) and mortality in patients with end-stage liver disease (ESLD). It finds that elevated NLR is correlated with higher risk of death. Specifically, NLR levels were higher in non-survivors than survivors, and high NLR predicted increased mortality risk as indicated by univariate and multivariate hazards ratios and odds ratios. Moreover, NLR had stronger prognostic value in Asian populations, suggesting it may be a useful biomarker for identifying high-risk ESLD patients, particularly in Asia.

Citation: Cai XH, Tang YM, Chen SR, Pang JH, Chong YT, Cao H, Li XH. Prognostic value of neutrophil-to-lymphocyte ratio in end-stage liver disease: A meta-analysis. *World J Hepatol* 2024; 16(3): 477-489

URL: <https://www.wjgnet.com/1948-5182/full/v16/i3/477.htm>

DOI: <https://dx.doi.org/10.4254/wjh.v16.i3.477>

INTRODUCTION

End-stage liver disease (ESLD) is defined as the final stage of liver disease caused by various factors. Globally, cirrhosis and liver cancer are ranked as the eleventh and sixteenth leading causes of death, respectively, accounting for 3.5% of all deaths each year worldwide[1]. The burden of ESLD is expected to increase in the future[2]. Because liver transplantation remains the only curative treatment for ESLD, it is crucial to identify predictors of ESLD prognosis to differentiate between patients who require immediate transplantation and those who can be managed with intensive medical care for a longer period.

The neutrophil-to-lymphocyte ratio (NLR) is a readily measurable parameter that has been shown to reflect disease severity[3]. NLR has been widely used as a biomarker for prognostic evaluation of patients with various diseases and has diagnostic value in distinguishing among certain conditions[4]. For example, NLR has shown promise in predicting poor prognosis in cancer patients[4]. Because Kupffer cells and inflammatory cells, such as macrophages, T lymphocytes, neutrophils, and dendritic cells, have been found to contribute to liver inflammation and fibrosis in patients with liver disease[5], NLR is often utilized as a prognostic factor in these patients. NLR has also been associated with prognosis in patients with hepatocellular carcinoma, suggesting its potential as a prognostic indicator after liver transplantation[6,7]. Moreover, NLR has been used to predict the prognosis of patients with other liver diseases, such as acute-on-chronic liver failure (ACLF) and decompensated liver cirrhosis (DC)[8-10], although the prognostic value of NLR in patients with ACLF and DC remains unclear. Most studies indicate that NLR is linked to poor prognosis in patients with ACLF or DC, although other studies have reported no association[11]. Most of these studies, however, focused solely on patients with ACLF or DC, with few examining whether NLR is a prognostic factor for ESLD, the broader condition.

The objective of this systematic review and meta-analysis was to thoroughly assess the correlation between NLR and prognosis in patients with ESLD. The aim was to identify a reliable and easily measurable parameter that could help identify patients in need of immediate liver transplantation.

MATERIALS AND METHODS

Literature search

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) 2009 statement guidelines[12] were followed to report the results of this systematic review. The protocol was registered in the Prospective Register of Systematic Review [CRD42022367423].

The databases OVID Embase, PubMed, Web of Science, Cochrane Library, China National Knowledge Infrastructure (CNKI), Weipu, and Wanfang were systematically searched for studies on the associations of NLR with ESLD published from 1 January 1980 to 30 October 2022 in English or Chinese. Search terms included “end-stage liver disease”tOR “liver cirrhosis”rOR “hepatic cirrhosis”rOR “liver fibrosis”bOR “liver failure”iOR “hepatic failure”iOR “liver transplantation”aOR “hepatic transplantation”aOR r liver transplant”aAND “neutrophil-lymphocyte ratio”lOR “neutrophil-to-lymphocyte”tOR ro-lympThe full search strategy is described in Appendix 1.

Study Selection

Studies were selected if they were (1) observational studies, including cross-sectional, cohort, and case-control studies; (2) included adults aged ≥ 18 years; (3) involved patients who were diagnosed with ESLD; and (4) measured NLR in both survivors and non-survivors or reported a hazard ratio (HR) or odds ratio (OR) reflecting the association between NLR and mortality. Conference abstracts, case reports, systematic reviews, dissertations, expert opinions, and editorials or commentaries were excluded, as were studies that included fewer than 100 participants and studied published in Chinese journals limited to the Chinese Scientific and Technical Papers and Citation Database, the Chinese Science Citation Database, and the Chinese core journal criterion of Peking University. If multiple studies involved the same dataset, the study with the larger number of participants was included. After removing duplicates, two authors (CXH and TYM) independently reviewed the titles and abstracts to remove irrelevant studies. The full texts of the remaining studies were examined with a record of reasons for exclusion. A third author (LXH) resolved disagreements when necessary.

Definition of ESLD

ESLD was defined as chronic or acute-on-chronic liver failure according to the standard criteria of the Asian Pacific Association for the Study of the Liver (APASL)[13] or the European Association for the Study of the Liver[14]. Included were patients with liver cirrhosis who were diagnosed pathologically or by clear ultrasound with at least an index clinical complication of decompensation and candidates for liver transplantation due to liver failure or cirrhosis. Patients aged < 18 years and patients with acute liver failure or other terminal diseases were excluded.

Data extraction

Data were extracted from included articles using a standardized form in Microsoft Excel. Data extracted from these studies included the name of the first author; the year of publication; the location of the study; the number of patients analyzed, as well as their sex and mean or median age; the etiology of ESLD; the mean or median NLR and NLR cutoff value; the primary outcome of the study; and univariate and/or multivariate HRs or ORs, along with their associated 95% confidence intervals (CIs). Two authors (CXH and TYM) independently extracted these data, with disagreements resolved by consensus.

Evaluation of study quality

Two authors (CXH and TYM) independently assessed the quality of each study using the Newcastle-Ottawa Scale. This tool consists of three items, selection, comparability and outcome/exposure, which included four, two, and three sub-items, respectively, to which star-based scores were assigned. Studies with scores ≥ 6 were considered high-quality studies, those with scores of 4-5 were regarded as having a moderate risk of bias, and those with scores < 4 were regarded as having a high risk of bias.

Statistical analyses

Statistical analyses were performed using Stata 15.1 (Stata Corp, College Station, TX, United States) and Comprehensive Meta-analysis software (2.0). The main pooled outcomes were the HRs or ORs with their 95% CIs of the associations between NLR and ESLD. HRs and ORs were analyzed separately, as were univariate and multivariate HRs and ORs.

The heterogeneity of the studies was assessed using I^2 statistics, with I^2 values of 25%, 50%, 75%, and $\geq 75\%$ indicating low, moderate, high, and very high heterogeneity, respectively[15]. If heterogeneity was high or very high, a random-effects model was used. Study heterogeneity and some potential moderators were explored using subgroup analyses and meta-regression. These variables included the mean age of the patients (categorized as < 50 or > 50 years), location (categorized as Asia or non-Asian regions), etiology, and duration of follow-up. Publication bias was assessed by visual inspection of funnel plots, and by Begg's and Egger's tests. When necessary, trim-and-fill analyses and sensitivity analyses were performed.

All statistical tests were two-sided, with the level of significance set at $P < 0.05$.

RESULTS

Literature search

A search of the databases yielded 5510 studies. Analysis using EndNote Version 9.0 software found that 1132 of these studies were duplicates. The remaining 4378 studies were screened by reading their titles and abstracts, resulting in the removal of 4247 studies. A full-text review of the remaining 131 studies resulted in the inclusion of 30 of these studies. The literature search strategy is described in a PRISMA flow diagram (Figure 1).

Characteristics of eligible studies

The 30 studies consisted of 21 published in English and nine published in Chinese. Table 1 shows the main characteristics of the included studies.

All studies were published after 2014, with the largest number, seven, published in 2021. The studies included were from three continents, with the largest number, 22, from Asia. Sixteen studies included patients with ACLF, 13 included patients with acute decompensation (AD), and one included patients with both ACLF and AD. Eighteen studies analyzed patients with hepatitis B virus (HBV)-related ESLD. The mean quality assessment score of the 30 studies was 7.4 (range: 5-9).

Table 1 Characteristic of included studies

Ref.	Year	Location	Population	Patient number (male)	Mean age	Outcome	Etiology	NLR cutoff value	Analysis	NOS scores
Agiastotelli <i>et al</i> [8]	2016	Greece	ACLF patients	108 (80)	60.5	30-d & 180-d mortality	Mixed	NR	HR (Univariate & Multivariate)	8
Bernsmeier <i>et al</i> [27]	2020	Britain	DCC & ACLF patients	617 (386)	NR	90-d mortality	Mixed	30	OR (Univariate & Multivariate)	8
Cai <i>et al</i> [28]	2018	China	ACLF patients	203 (151)	51.14	90-d mortality	HBV	5.09	HR (Univariate & Multivariate)	8
Cai <i>et al</i> [18]	2017	China	ACLF patients	637 (486)	54	6-month, 1-yr & 3-yr mortality	Mixed	5.7	HR (Multivariate)	8
Chiriari <i>et al</i> [29]	2020	Romania	ACLF patients	70 (49)	62	In-hospital mortality	Mixed	5	NR	7
Fan <i>et al</i> [30]	2017	China	ACLF patients	560 (487)	44.9	30-d mortality	HBV	NR	OR (Multivariate)	8
Gao <i>et al</i> [31]	2017	China	ACLF patients	573 (478)	43.5	90-d mortality	HBV	NR	HR (Univariate & Multivariate)	8
Guan <i>et al</i> [32]	2019	China	ACLF patients	174 (135)	49.60	Mortality	HBV	6.5	OR (Univariate)	6
Li <i>et al</i> [33]	2022	China	LC patients with UGIB	376 (235)	60.25	1-yr mortality	Mixed	3.76	OR (Univariate)	7
Li <i>et al</i> [10]	2020	China	DCC patients	174 (139)	53.6	28-d mortality	HBV	3.78	HR (Univariate & Multivariate)	8
Liang <i>et al</i> [34]	2020	China	ACLF patients	227 (202)	46.4	90-d mortality	HBV	5.38	HR (Univariate)	6
Lin <i>et al</i> [35]	2018	China	DCC patients	235 (133)	60	30-d mortality	Mixed	NR	HR (Multivariate)	9
Liu <i>et al</i> [36]	2014	China	ACLF patients	216 (183)	45.58	8-wk mortality	HBV	6.12	NR	8
Liu <i>et al</i> [37]	2021	China	ACLF patients	160 (145)	46.1	28-d mortality	HBV	4.5	OR (Univariate)	7
Maccali <i>et al</i> [38]	2021	Brazil	DCC patients	320 (235)	55.67	90-d mortality	Mixed	NR	HR (Univariate & Multivariate)	8
Moreau <i>et al</i> [39]	2018	Belgium	ACLF patients	105 (72)	58	90-d mortality	Mixed	6.2	HR (Univariate & Multivariate)	7
Oikonomou <i>et al</i> [11]	2020	Greece	DCC patients	132 (NR)	NR	10-month mortality	Mixed	NR	HR (Univariate)	7
Qi <i>et al</i> [26]	2021	China	DCC patients	144 (115)	54.0	30-d mortality	HBV	3.78	OR (Univariate & Multivariate)	8
Qiang <i>et al</i> [40]	2021	China	ACLF patients	577 (494)	48.20	90-d mortality	HBV	4.09	HR (Univariate & Multivariate)	7
Shi <i>et al</i> [41]	2022	China	LC patients with HE	402 (323)	52	30-d mortality	HBV	4	HR (Univariate & Multivariate)	7
Sun <i>et al</i> [9]	2021	China	ACLF patients	412 (351)	NR	28-d & 90-d mortality	HBV	4.79	OR (Univariate & Multivariate)	9
Sun <i>et al</i> [42]	2021	China	ACLF patients	290 (252)	44	90-d mortality	HBV	4.78	HR (Univariate & Multivariate)	9
Wang <i>et al</i> [43]	2019	China	ACLF patients	270 (228)	46.56	90-d mortality	HBV	NR	OR (Univariate)	6
Wang <i>et al</i> [44]	2020	China	ACLF patients	102 (75)	42.9	90-d mortality	HBV	4.22	OR (Univariate)	6
Wu <i>et al</i> [45]	2018	China	ACLF patients	100 (89)	47.3	28-d mortality	HBV	NR	NR	6
Xue <i>et al</i> [46]	2021	China	LC patients with HE	116 (74)	60	30-d mortality	Mixed	4.4	OR (Univariate)	6
Zhang <i>et al</i> [47]	2016	China	DCC patients	148 (118)	53.2	30-d mortality	HBV	5	HR (Univariate & Multivariate)	7
Zhang <i>et al</i> [48]	2018	China	ACLF patients	133 (108)	44.9	90-d mortality	HBV	2.06	OR (Univariate)	5
Zhang <i>et al</i> [49]	2022	United State	DCC patients	264 (122)	58.31	30-d & 90-d mortality	Mixed	10.6	HR (Univariate & Multivariate)	9

Zhou <i>et al</i> [50]	2022	China	LC patients with acute UGIB	676 (398)	62.29	6-wk mortality	Mixed	5.04	OR (Univariate)	9
------------------------	------	-------	-----------------------------	-----------	-------	----------------	-------	------	-----------------	---

ACLF: Acute-on-chronic liver failure; DCC: Decompensated cirrhosis; HE: Hepatic encephalopathy; UGIB: Upper gastrointestinal bleeding; LC: Liver cirrhosis; NLR: Neutrophil-to-lymphocyte ratio; NOS: Newcastle-Ottawa Quality Assessment Scale.

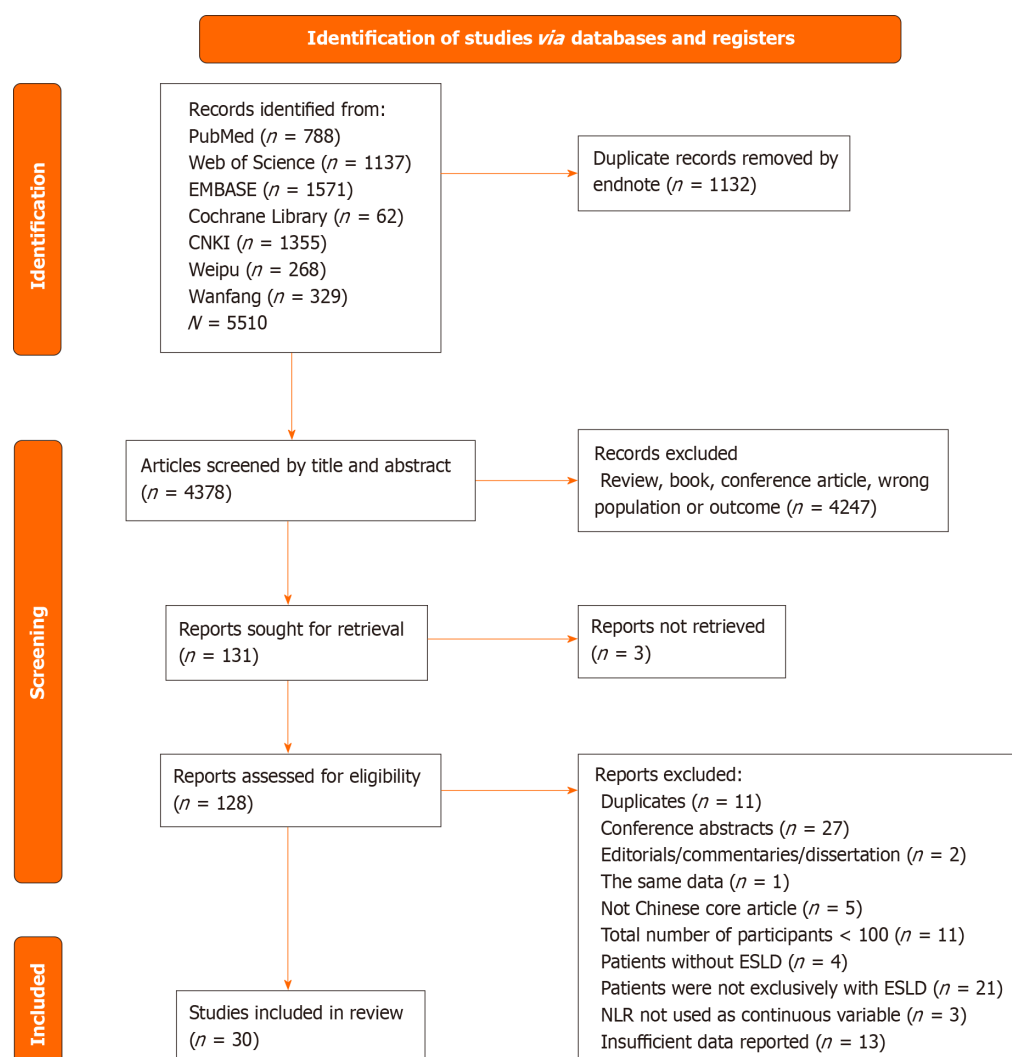


Figure 1 PRISMA flowchart outlining the study search. NLR: Neutrophil-to-lymphocyte ratio; ESLD: End-stage liver disease.

Eight studies provided NLR data for both survivors and non-survivors. Twelve studies used logistic regression analysis to determine the association between NLR and mortality in patients with ESLD, whereas 15 studies used Cox regression analysis to determine this association.

Effect of NLR

Univariate HR: Thirteen studies reported the association between NLR and mortality as univariate HR, with a meta-analysis finding that increased NLR was predictive of increased mortality (Figure 2, Panel A, HR = 1.07, 95% CI = 1.05-1.09). There was significant heterogeneity among these studies ($I^2 = 89.4\%$, $P < 0.001$). Subgroup (Table 2) and meta-regression (Supplementary Table 1) analyses showed that patient age, sex ratio, region, population, primary outcome, and etiology of ESLD did not affect the prognostic value of NLR. On publication bias tests, Begg's test was non-significant, whereas Egger linear regression indicated possible bias (Supplementary Figure 1, $P < 0.05$). Using trim-and-fill analyses, two studies were imputed into the meta-analysis, but this did not significantly change the results (Supplementary Figure 2, HR = 1.06, 95% CI = 1.04-1.08). Sensitivity analysis showed similar results when each study was excluded.

Multivariate HR: Thirteen studies also reported the association between NLR and mortality as multivariate HR, with a meta-analysis finding that increased NLR was predictive of increased mortality (Figure 2, Panel B, HR = 1.07, 95% CI = 1.04-1.09). There was significant heterogeneity among these studies ($I^2 = 89.1\%$, $P < 0.001$). Similar to the results of

Table 2 Subgroup analyses

	Number of subgroup data from studies	Effect size	95%CI	<i>I</i> ²	Q between subgroup
Univariate HR					
Mean age					
> 50	9	1.072	1.043-1.101	85.63 ^c	0.492
≤ 50	3	1.056	1.016-1.097	92.65 ^c	
Study location					
Not Asian	6	1.049	1.018-1.082	63.92 ^a	2.168
Asian	8	1.082	1.054-1.110	91.32 ^c	
Population					
AD	8	1.076	1.044-1.110	85.60 ^c	0.376
ACLF	6	1.062	1.032-1.093	92.03 ^c	
Primary outcome					
≤ 30 mortality	5	1.097	1.057-1.139	80.06 ^c	2.852
Long term mortality	9	1.057	1.034-1.080	90.95 ^c	
Etiology					
HBV	8	1.082	1.054-1.110	91.95 ^c	2.168
Mixed	6	1.049	1.018-1.082	63.92 ^a	
Multivariate HR					
Mean age					
> 50	12	1.082	1.051-1.113	90.10 ^c	0.621
≤ 50	2	1.052	0.986-1.121	83.28 ^b	
Study location					
Not Asian	6	1.030	1.000-1.061	70.153 ^b	7.728 ^b
Asian	11	1.087	1.061-1.113	87.451 ^c	
Population					
AD	11	1.046	1.038-1.054	91.00 ^c	3.472
ACLF	6	1.031	1.022-1.040	82.00 ^c	
Mortality					
≤ 30 mortality	6	1.087	1.044-1.131	77.08 ^c	1.297
Long term mortality	11	1.058	1.033-1.083	91.38 ^c	
Etiology					
HBV	7	1.069	1.030-1.110	78.04 ^c	0.864
Mixed	10	1.065	1.036-1.095	92.38 ^c	
Univariate OR					
Mean age					
> 50	4	1.323	1.077-1.625	78.80 ^b	0.036
≤ 50	5	1.289	1.080-1.538	85.73 ^c	
Population					
AD	4	1.329	1.058-1.669	78.80 ^b	0.095
ACLF	7	1.388	1.179-1.634	92.12 ^c	
Mortality					
≤ 30 mortality	3	1.329	1.127-1.567	87.61 ^b	0.301

Long term mortality	7	1.256	1.117-1.412	93.79 ^c	
Etiology					
HBV	8	1.375	1.247-1.515	90.93 ^c	3.558
Mixed	4	1.166	1.013-1.081	76.32 ^b	

^a $P < 0.05$.^b $P < 0.01$.^c $P < 0.001$.

AD: Acute decompensation; ACLF: acute-on-chronic liver failure; HR: Hazard ratios; HBV: Hepatitis B virus.

univariate HR analysis, subgroup (Table 2), and meta-regression (Supplementary Table 1) analyses showed that age, sex ratio, population, primary outcome, and etiology of ESLD did not affect the prognostic value of NLR. In contrast, subgroup analysis revealed that studies in Asia (HR = 1.87, 95%CI = 1.06-1.11) and studies not in Asia (HR = 1.03, 95%CI = 1.00-1.06) yielded significant effects ($P = 0.005$). Both Begg and Egger test showed possible publication biases (Supplementary Figure 3, $P < 0.05$). By trim-and-fill analyses, two studies were imputed into the meta-analysis, but this did not significantly change the results (Supplementary Figure 4, HR = 1.06, 95%CI = 1.04-1.08). Sensitivity analysis showed similar result when each study was excluded.

Univariate OR: Eleven studies reported the association between NLR and mortality as univariate OR, with a meta-analysis showing that increased NLR was predictive of increased mortality (Figure 2, Panel C, OR = 1.29, 95%CI = 1.18-1.39). There was significant heterogeneity among these studies ($I^2 = 91.3\%$, $P < 0.001$). Subgroup (Table 2) and meta-regression (Supplementary Table 1) analyses showed that age, sex ratio, region, population, primary outcome, and etiology of ESLD did not affect the prognostic value of NLR. In the publication bias test, Begg's test was non-significant ($p=0.81$). However, Egger's linear regression showed the possible presence of bias (Supplementary Figure 5, $P < 0.05$). No study was imputed into the meta-analysis by trim-and-fill analyses (Supplementary Figure 6). Because the number of studies was small, the possibility of publication bias could not be completely excluded. Sensitivity analysis showed similar results when each study was excluded.

Multivariate OR: Four studies reported the association between NLR and mortality as multivariate OR, with a meta-analysis indicating that increased NLR was predictive of increased mortality (Figure 2, Panel D, OR = 1.29, 95%CI = 1.09-1.49). There was significant heterogeneity among these studies ($I^2 = 93.4\%$, $P < 0.001$). Because the number of studies was not adequate, subgroup and meta-regression analyses were not performed. In publication bias tests, Begg test was not significant ($P = 0.81$), whereas Egger linear regression showed possible bias (Supplementary Figure 7, $P < 0.05$). No study was imputed into the meta-analysis by trim-and-fill analyses. Because the number of studies was small, the possibility of publication bias could not be excluded completely. Sensitivity analysis showed similar result when each study was excluded.

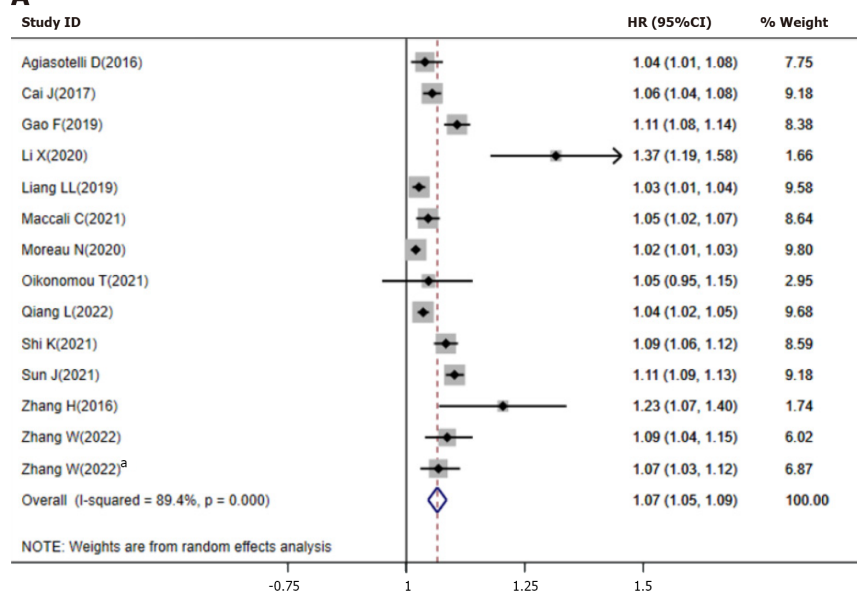
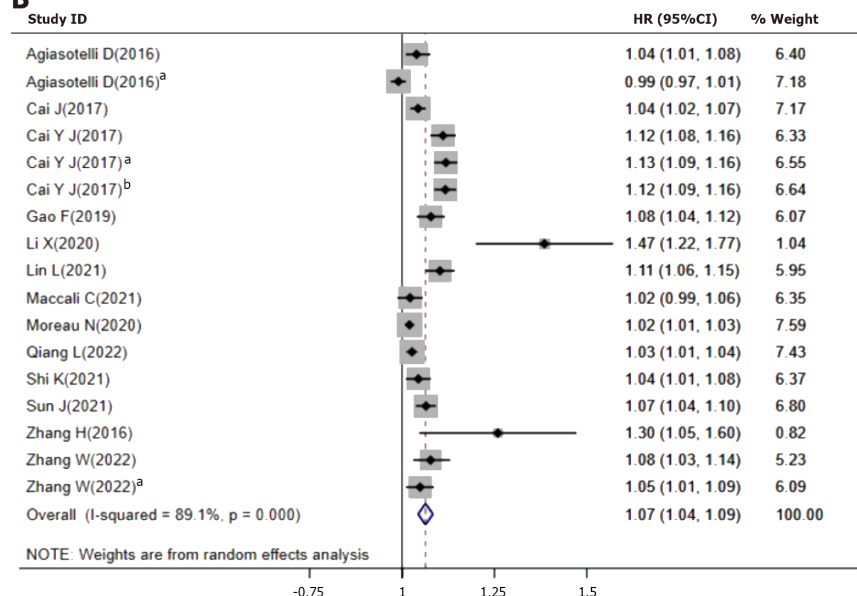
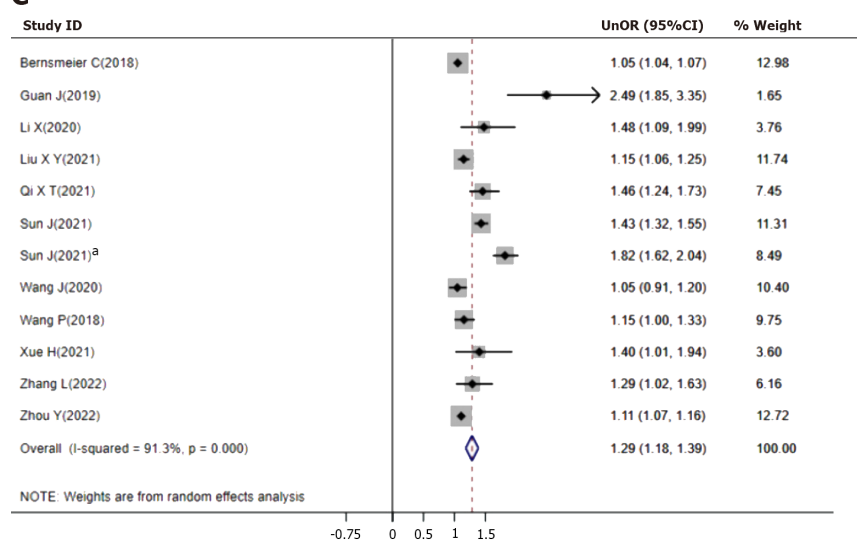
Comparison of NLR in survivors and non-survivors

Eight studies compared NLR in surviving and non-surviving patients with ESLD. A meta-analysis showed that NLR was significantly higher in non-survivors than in survivors (Supplementary Figure 8, random-effects model: SMD = 1.02 95%CI; 0.67-1.37).

DISCUSSION

To our knowledge, this systematic review is the first to report a relationship between NLR and mortality in patients with ESLD. The pooled results of this study indicated that NLR was associated with mortality (random-effects model; univariate HR = 1.07, 95%CI = 1.05-1.09; multivariate HR = 1.07, 95%CI = 1.07-1.09; univariate OR = 1.29, 95%CI = 1.18-1.39; multivariate OR = 1.29, 95%CI = 1.09-1.49). Furthermore, the pooled results of eight studies showed that NLR levels were significantly higher in non-survivors than in survivors with ESLD (random-effects model: SMD = 1.02, 95%CI = 0.67-1.37).

Mortality rates are high in patients with ESLD, such as liver failure and decompensated cirrhosis. Systemic inflammatory reactions are closely related to the severity and prognosis of liver disease in patients with severe cirrhosis, with the occurrence of systemic inflammatory response syndrome increasing mortality rates in patients with cirrhosis[16]. It is therefore crucial to identify and treat infections and systemic inflammation in patients with ESLD. Although routine tests, including measurements of C-reactive protein and procalcitonin (PCT) concentrations and white blood cell (WBC) counts, are commonly used to assess bacterial infection and systemic inflammation, these tests may not fully meet the demands of patients with ESLD. High serum total bilirubin concentrations in these patients can influence the diagnostic sensitivity of PCT[17]. Additionally, patients with ESLD often have lower baseline WBC counts, which can impair the predictive value of WBC in detecting infections. A study included in this review confirmed that NLR is superior to WBC or PCT for assessing infection in patients with ACLF[9]. NLR may also be a useful indicator of systemic inflammatory response syndrome or infection in patients with decompensated cirrhosis[18]. Taken together, these findings suggest that NLR

A**B****C**

D

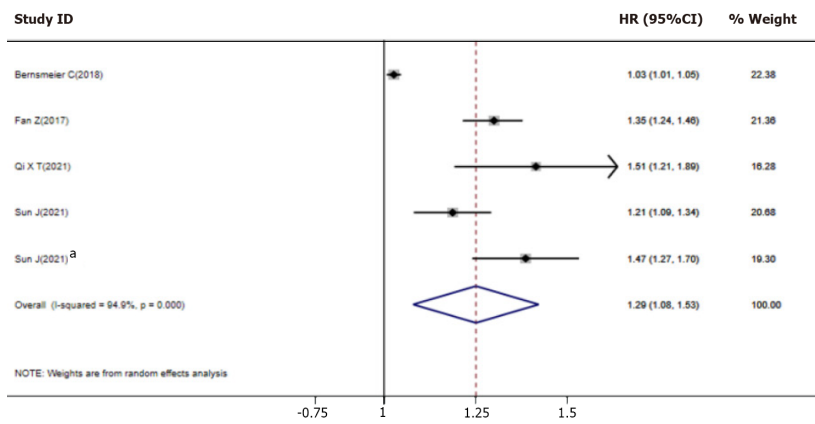


Figure 2 Forest plot of association between neutrophil-to-lymphocyte ratio and end-stage liver disease mortality. A: Univariate hazard ratios (HR); B: Multivariate HR; C: Univariate odds ratios (OR); D: Multivariate OR. Different subgroup data extracted in the same literature were distinguished using the letter (^a) and (^b).

strongly correlates with infection and systemic inflammatory response syndrome in patients with ESLD and that NLR may be predictive of mortality. These findings are consistent with the majority of the included studies and the final pooled results.

NLR has also been shown to be an indicator of inflammation in other conditions, such as colorectal cancer and myocardial infarction[19]. Peripheral neutrophil counts have been reported to serve as markers for both acute and chronic inflammation[20]. Activation of these neutrophils can inhibit T lymphocyte activation through the production of reactive oxygen and arginase[21]. Peripheral T-lymphocyte subsets were found to be significantly lower in ACLF patients than in healthy controls[22], and lower lymphocyte cell counts have been associated with poorer immune responses in patients with chronic liver disease[23]. These findings suggest that NLR may be a practical indicator that reflects the balance between inflammation and immune reactions. Furthermore, the inflammatory process has been shown to play a significant role in the development of liver fibrosis and cirrhosis. A meta-analysis suggested that NLR may be a marker of the degree of fibrosis and predictor of prognosis in patients with chronic liver disease[24]. NLR may also be predict of for prognosis in patients with ESLD.

Subgroup and meta-regression analyses revealed that the predictive value of NLR was not influenced by patient age, sex ratio, or the etiology of ESLD, suggesting that NLR is a reliable predictor of ESLD prognosis across different patient populations. NLR is considered a cost-effective and practical tool for predicting mortality in critically ill patients with liver failure and for screening patients with severe liver disease. Unlike other prognostic biomarkers, neutrophils and lymphocytes can be easily obtained and measured in clinical practice. Subgroup analysis of multivariate HR from 13 studies showed that NLR was strongly associated with mortality in Asian patients with ESLD, possibly due to the high prevalence of hepatitis B infection in Asian populations. HBV-ACLF patients exhibit lower levels of circulating lymphocytes and significantly higher levels of liver infiltrating lymphocytes[25]. Subgroup analysis, however, did not find significant differences in NLR between patients with HBV and those with mixed etiology. This may have been due to confounding factors and high heterogeneity in the mixed etiology group.

It is worth mentioned, the severity of the neutropenia and the overall status of the patient should be taken into account. Profound neutropenia may signify a more severe inflammatory or immunocompromised state, potentially affecting the NLR's ability to reflect the underlying inflammatory process accurately. In these patients, it can potentially impact the accuracy of NLR as a marker of systemic inflammation. Future research should focus on large-scale longitudinal studies to assess the predictive value of the NLR in ESLD patients with neutropenia, subgroup analyses to account for specific clinical characteristics, mechanistic studies to understand the underlying pathophysiology.

While NLR was identified as the strongest independent predictor in this study, other ratios such as platelet-to-lymphocyte ratio (PLR) and platelet-to-neutrophil ratio (PNR) have also been investigated for prognosis in liver diseases. However, study have shown that NLR had good predictive ability for mortality, higher than PNR[26]. In the setting of ESLD, PLR and PNR may be less reliable due to various thrombocytopenia mechanisms associated with advanced liver dysfunction. This is aruably a more direct assessment of the disease stage and prognosis in decompensated cirrhosis patients. For this reason, this article focused on NLR rather than PLR or PNR, though future studies could explore whether a combination of ratios provides even stronger predictive ability than individual markers alone.

The present review and meta-analysis had several limitations. First, there was high heterogeneity among the studies included in this analysis, similar to other prognostic reviews, despite the use of a random-effects model. Second, most of the included studies reported positive results, which may have introduced latent publication bias, although Begg's test and Egger's test did not show significant biases. Moreover, the number of studies that utilized multivariate OR analysis to assess the association between NLR and mortality was too small for determination of publication bias. Third, the critical cut-off value of NLR for determining prognosis remains unclear. Due to limitations in the original studies, the present analysis could not determine an exact ideal cut-off value.

CONCLUSION

This meta-analysis highlights the significance of NLR as a valuable prognostic biomarker in patients with ESLD, with higher NLRs indicating an increased risk of mortality. These findings especially emphasize the strong association between higher NLRs and prognosis in the Asian patients with ESLD. The continuing absence of a critical cut-off value of NLR for determining prognosis suggests the need for additional research to clarify this matter.

ARTICLE HIGHLIGHTS

Research background

End-stage liver disease (ESLD) carries a high mortality risk. Identifying reliable prognostic factors is important to guide management, but studies on the prognostic value of neutrophil-to-lymphocyte ratio (NLR) in ESLD have reported conflicting results.

Research motivation

To comprehensively evaluate the association between NLR and ESLD prognosis through a systematic review and meta-analysis of existing literature.

Research objectives

To establish whether NLR is a useful prognostic biomarker for predicting mortality in patients with ESLD.

Research methods

A systematic literature search was conducted through multiple databases. Studies evaluating the relationship between NLR and mortality in ESLD patients were selected and their data extracted. Pooled effect sizes were calculated using meta-analysis.

Research results

Higher NLR levels were associated with increased mortality risk in ESLD based on meta-analysis of 27 studies reporting hazard/odds ratios. NLR also distinguished survivors from non-survivors. The prognostic value of NLR was not influenced by patient characteristics but differed regionally.

Research conclusions

NLR is clinically useful for prognostic assessment in ESLD patients, especially Asian populations, but optimal cut-off values require further investigation.

Research perspectives

NLR represents a promising, readily available prognostic tool for risk stratifying ESLD patients. Future research should establish standardized NLR cut-offs and evaluate its utility accounting for potential confounders like severity of neutropenia.

ACKNOWLEDGEMENTS

We would like to express our gratitude to Professor Xing-Fa Zhang, the statistician who provided statistical support for this article.

FOOTNOTES

Co-first authors: Xiang-Hao Cai and Yun-Ming Tang.

Co-corresponding authors: Xin-Hua Li and Hong Cao.

Author contributions: Li XH and Cao H contributed to study concept and design; Cai XH and Tang YM contributed to drafting of the manuscript; and Pang JH collected data of including articles; Cai XH and Chen SR performed the analysis of the project; Pang JH compiled the figures and tables. Li XH and Cao H contributed to critical revision of the manuscript for important content; Chong YT, Li XH, and Cao H contributed to obtaining funding. Cai XH and Tang YM are co-first authors due to their significant involvement in drafting the manuscript and collecting data, showcasing their strong understanding of the research findings. Li XH and Cao H are likely the corresponding authors because of their significant contributions to the study's concept, design, and funding acquisition. The pivotal roles of Li XH and Cao H in shaping the study's foundation and ensuring its continued support position them as the lead corresponding authors in this collaborative effort. Chong YT and Li XH contributed to obtained funding. This collaboration between Li XH and Cao H is crucial for the publication of this manuscript. Their combined efforts reflect their shared responsibility for the scholarly work and ensure that their individual contributions are duly recognized and attributed. All authors approved submission.

Supported by the Science and Technology Planning Project of Guangdong Province, China, No. 2019B020228001; 5010 Project of Sun Yat-sen University, No. 2018024; and Science and Technology Program of Guangzhou, China, No. 202103000060.

Conflict-of-interest statement: All authors declare that they have no conflict of interest.

PRISMA 2009 Checklist statement: The authors have read the PRISMA 2009 Checklist, and the manuscript was prepared and revised according to the PRISMA 2009 Checklist.

Open-Access: This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <https://creativecommons.org/licenses/by-nc/4.0/>

Country/Territory of origin: China

ORCID number: Shu-Ru Chen 0000-0002-8433-9866; Yu-Tian Chong 0000-0001-8215-4393; Hong Cao 0009-0006-4252-8278; Xin-Hua Li 0000-0002-6748-9803.

S-Editor: Liu JH

L-Editor: A

P-Editor: Guo X

REFERENCES

- Asrani SK, Devarbhavi H, Eaton J, Kamath PS. Burden of liver diseases in the world. *J Hepatol* 2019; **70**: 151-171 [PMID: 30266282 DOI: 10.1016/j.jhep.2018.09.014]
- Mokdad AH, Forouzanfar MH, Daoud F, Mokdad AA, El Bcheraoui C, Moradi-Lakeh M, Kyu HH, Barber RM, Wagner J, Cercy K, Kravitz H, Coggeshall M, Chew A, O'Rourke KF, Steiner C, Tuffaha M, Charara R, Al-Ghamdi EA, Adi Y, Afifi RA, Alahmadi H, AlBuhairan F, Allen N, AlMazroa M, Al-Nehmi AA, AlRayess Z, Arora M, Azzopardi P, Barroso C, Basulaiman M, Bhutta ZA, Bonell C, Breinbauer C, Degenhardt L, Denno D, Fang J, Fatusi A, Feigl AB, Kakuma R, Karam N, Kennedy E, Khoja TA, Maalouf F, Obermeyer CM, Mattoo A, McGovern T, Memish ZA, Mensah GA, Patel V, Petroni S, Reavley N, Zertuche DR, Saeedi M, Santelli J, Sawyer SM, Ssewamala F, Taiwo K, Tantawy M, Viner RM, Waldfogel J, Zuhiga MP, Naghavi M, Wang H, Vos T, Lopez AD, Al Rabeeah AA, Patton GC, Murray CJ. Global burden of diseases, injuries, and risk factors for young people's health during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2016; **387**: 2383-2401 [PMID: 27174305 DOI: 10.1016/S0140-6736(16)00648-6]
- Zahorec R. Ratio of neutrophil to lymphocyte counts--rapid and simple parameter of systemic inflammation and stress in critically ill. *Bratisl Lek Listy* 2001; **102**: 5-14 [PMID: 11723675]
- Cupp MA, Cariolou M, Tzoulaki I, Aune D, Evangelou E, Berlanga-Taylor AJ. Neutrophil to lymphocyte ratio and cancer prognosis: an umbrella review of systematic reviews and meta-analyses of observational studies. *BMC Med* 2020; **18**: 360 [PMID: 33213430 DOI: 10.1186/s12916-020-01817-1]
- Koyama Y, Brenner DA. Liver inflammation and fibrosis. *J Clin Invest* 2017; **127**: 55-64 [PMID: 28045404 DOI: 10.1172/JCI88881]
- Wang Y, Peng C, Cheng Z, Wang X, Wu L, Li J, Huang C, Guo Q, Cai H. The prognostic significance of preoperative neutrophil-lymphocyte ratio in patients with hepatocellular carcinoma receiving hepatectomy: A systematic review and meta-analysis. *Int J Surg* 2018; **55**: 73-80 [PMID: 29787804 DOI: 10.1016/j.ijssu.2018.05.022]
- Al-Ameri AAM, Wei X, Wen X, Wei Q, Guo H, Zheng S, Xu X. Systematic review: risk prediction models for recurrence of hepatocellular carcinoma after liver transplantation. *Transpl Int* 2020; **33**: 697-712 [PMID: 31985857 DOI: 10.1111/tri.13585]
- Agiasotelli D, Alexopoulou A, Vasilieva L, Kalpakou G, Papadaki S, Dourakis SP. Evaluation of neutrophil/Leukocyte ratio and organ failure score as predictors of reversibility and survival following an acute-on-chronic liver failure event. *Hepatology Research* 2016; **46**: 514-520 [DOI: 10.1111/hepr.12582]
- Sun J, Guo H, Yu X, Chen J, Zhu H, Qi X, Zhang X, Han J, Liu X, Yang J, Wang J, Qian Z, Huang Y, Mao R, Zhang J. Evaluation of prognostic value of neutrophil-to-lymphocyte ratio in patients with acute-on-chronic liver failure or severe liver injury from chronic HBV infection. *Eur J Gastroenterol Hepatol* 2021; **33**: e670-e680 [PMID: 34074984 DOI: 10.1097/MEG.0000000000002207]
- Li X, Wu J, Mao W. Evaluation of the neutrophil-to-lymphocyte ratio, monocyte-to-lymphocyte ratio, and red cell distribution width for the prediction of prognosis of patients with hepatitis B virus-related decompensated cirrhosis. *J Clin Lab Anal* 2020; **34**: e23478 [PMID: 32666632 DOI: 10.1002/jcla.23478]
- Oikonomou T, Goulis I, Kiapidou S, Tagkou N, Akriviadis E, Papatheodoridis G, Cholongitas E. The significance of C-reactive protein to albumin ratio in patients with decompensated cirrhosis. *Ann Gastroenterol* 2020; **33**: 667-674 [PMID: 33162744 DOI: 10.20524/aog.2020.0534]
- Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol* 2009; **62**: 1006-1012 [PMID: 19631508 DOI: 10.1016/j.jclinepi.2009.06.005]
- Sarin SK, Choudhury A, Sharma MK, Maiwall R, Al Mahtab M, Rahman S, Saigal S, Saraf N, Soin AS, Devarbhavi H, Kim DJ, Dhiman RK, Duseja A, Taneja S, Eapen CE, Goel A, Ning Q, Chen T, Ma K, Duan Z, Yu C, Treeprasertsuk S, Hamid SS, Butt AS, Jafri W, Shukla A, Saraswat V, Tan SS, Sood A, Midha V, Goyal O, Ghazinyan H, Arora A, Hu J, Sahu M, Rao PN, Lee GH, Lim SG, Lesmana LA, Lesmana CR, Shah S, Prasad VGM, Payawal DA, Abbas Z, Dokmeci AK, Sollano JD, Carpio G, Shrestha A, Lau GK, Fazal Karim M, Shiha G, Gani R, Kalista KF, Yuen MF, Alam S, Khanna R, Sood V, Lal BB, Pamecha V, Jindal A, Rajan V, Arora V, Yokosuka O, Niriella MA, Li H, Qi X, Tanaka A, Mochida S, Chaudhuri DR, Gane E, Win KM, Chen WT, Rela M, Kapoor D, Rastogi A, Kale P, Sharma CB, Bajpai M, Singh V, Premkumar M, Maharashi S, Olithselvan A, Philips CA, Srivastava A, Yachha SK, Wani ZA, Thapa BR, Saraya A, Shalimar, Kumar A,

- Wadhawan M, Gupta S, Madan K, Sakhuja P, Vij V, Sharma BC, Garg H, Garg V, Kalal C, Anand L, Vyas T, Mathur RP, Kumar G, Jain P, Pasupuleti SSR, Chawla YK, Chowdhury A, Song DS, Yang JM, Yoon EL; APASL ACLF Research Consortium (AARC) for APASL ACLF working Party. Acute-on-chronic liver failure: consensus recommendations of the Asian Pacific association for the study of the liver (APASL): an update. *Hepatol Int* 2019; **13**: 353-390 [PMID: 31172417 DOI: 10.1007/s12072-019-09946-3]
- 14 Arroyo V, Moreau R, Jalan R. Acute-on-Chronic Liver Failure. *N Engl J Med* 2020; **382**: 2137-2145 [PMID: 32459924 DOI: 10.1056/NEJMra1914900]
- 15 Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ* 2003; **327**: 557-560 [PMID: 12958120 DOI: 10.1136/bmj.327.7414.557]
- 16 Thabut D, Massard J, Gangloff A, Carbonell N, Francoz C, Nguyen-Khac E, Duhamel C, Lebrech D, Poynard T, Moreau R. Model for end-stage liver disease score and systemic inflammatory response are major prognostic factors in patients with cirrhosis and acute functional renal failure. *Hepatology* 2007; **46**: 1872-1882 [PMID: 17972337 DOI: 10.1002/hep.21920]
- 17 Qu J, Feng P, Luo Y, Lü X. Impact of hepatic function on serum procalcitonin for the diagnosis of bacterial infections in patients with chronic liver disease: A retrospective analysis of 324 cases. *Medicine (Baltimore)* 2016; **95**: e4270 [PMID: 27472699 DOI: 10.1097/MD.00000000000004270]
- 18 Cai YJ, Dong JJ, Dong JZ, Chen Y, Lin Z, Song M, Wang YQ, Chen YP, Shi KQ, Zhou MT. A nomogram for predicting prognostic value of inflammatory response biomarkers in decompensated cirrhotic patients without acute-on-chronic liver failure. *Aliment Pharmacol Ther* 2017; **45**: 1413-1426 [PMID: 28345155 DOI: 10.1111/apt.14046]
- 19 Doğan M, Akyel A, Bilgin M, Erat M, Çimen T, Sunman H, Efe TH, Açikel S, Yeter E. Can Admission Neutrophil to Lymphocyte Ratio Predict Infarct-Related Artery Patency in ST-Segment Elevation Myocardial Infarction. *Clin Appl Thromb Hemost* 2015; **21**: 172-176 [PMID: 24322278 DOI: 10.1177/1076029613515071]
- 20 Kolaczowska E, Kubes P. Neutrophil recruitment and function in health and inflammation. *Nat Rev Immunol* 2013; **13**: 159-175 [PMID: 23435331 DOI: 10.1038/nri3399]
- 21 Müller I, Munder M, Kropf P, Hänsch GM. Polymorphonuclear neutrophils and T lymphocytes: strange bedfellows or brothers in arms? *Trends Immunol* 2009; **30**: 522-530 [PMID: 19775938 DOI: 10.1016/j.it.2009.07.007]
- 22 Lou YF, Dong W, Ye B, Lin S, Mao WL. Changes in peripheral T-lymphocyte subsets in acute-on-chronic liver failure patients with artificial liver support system. *Hepatogastroenterology* 2012; **59**: 814-817 [PMID: 22469725 DOI: 10.5754/hge10064]
- 23 O'Keefe SJ, El-Zayadi AR, Carraher TE, Davis M, Williams R. Malnutrition and immuno-incompetence in patients with liver disease. *Lancet* 1980; **2**: 615-617 [PMID: 6107408 DOI: 10.1016/s0140-6736(80)90284-6]
- 24 Peng Y, Li Y, He Y, Wei Q, Xie Q, Zhang L, Xia Y, Zhou X, Feng X, Chen K, Chen S, Chen W, Long Q, Chai J. The role of neutrophil to lymphocyte ratio for the assessment of liver fibrosis and cirrhosis: a systematic review. *Expert Rev Gastroenterol Hepatol* 2018; **12**: 503-513 [PMID: 29629626 DOI: 10.1080/17474124.2018.1463158]
- 25 Zou Z, Xu D, Li B, Xin S, Zhang Z, Huang L, Fu J, Yang Y, Jin L, Zhao JM, Shi M, Zhou G, Sun Y, Wang FS. Compartmentalization and its implication for peripheral immunologically-competent cells to the liver in patients with HBV-related acute-on-chronic liver failure. *Hepatol Res* 2009; **39**: 1198-1207 [PMID: 19788691 DOI: 10.1111/j.1872-034X.2009.00571.x]
- 26 Qi X, Wang C, Shan X. Peripheral Blood Cell Ratios as Prognostic Predictors of Mortality in Patients with Hepatitis B Virus-Related Decompensated Cirrhosis. *Clin Lab* 2021; **67** [PMID: 34910423 DOI: 10.7754/Clin.Lab.2021.210238]
- 27 Bernsmeier C, Cavazza A, Fatourou EM, Theocharidou E, Akintimehin A, Baumgartner B, Dhar A, Auzinger G, Thursz M, Bernal W, Wendon JA, Karvellas CJ, Antoniadis CG, McPhail MJW. Leucocyte ratios are biomarkers of mortality in patients with acute decompensation of cirrhosis and acute-on-chronic liver failure. *Aliment Pharmacol Ther* 2020; **52**: 855-865 [PMID: 32683724 DOI: 10.1111/apt.15932]
- 28 Cai J, Wang K, Han T, Jiang H. Evaluation of prognostic values of inflammation-based makers in patients with HBV-related acute-on-chronic liver failure. *Medicine (Baltimore)* 2018; **97**: e13324 [PMID: 30431619 DOI: 10.1097/MD.00000000000013324]
- 29 Chiriac S, Stanciu C, Singeap AM, Sfarti CV, Cuciureanu T, Trifan A. Prognostic value of neutrophil-to-lymphocyte ratio in cirrhotic patients with acute-on-chronic liver failure. *Turk J Gastroenterol* 2020; **31**: 868-876 [PMID: 33625999 DOI: 10.5152/tjg.2020.19838]
- 30 Fan Z, EnQiang C, Yao DL, LiBo Y, Hong L, Lang B, Ping F, Hong T. Neutrophil-lymphocyte ratio predicts short term mortality in patients with hepatitis B virus-related acute-on-chronic liver failure treated with an artificial liver support system. *PLoS One* 2017; **12**: e0175332 [PMID: 28426800 DOI: 10.1371/journal.pone.0175332]
- 31 Gao F, Sun L, Ye X, Liu Y, Liu H, Geng M, Li X, Yang X, Li Y, Wang R, Chen J, Wan G, Jiang Y, Wang X. Development and validation of a prognostic model for acute-on-chronic hepatitis B liver failure. *Eur J Gastroenterol Hepatol* 2017; **29**: 669-678 [PMID: 28195876 DOI: 10.1097/MEG.0000000000000854]
- 32 Guan J, Xu Y, Xian Y, Huang C, Lai R, Wang X, Xie J, Cai W, Xie Q. [Prognostic value of the neutrophil-lymphocyte ratio in peripheral blood in acute and chronic liver failure]. *Chinese Hepatology* 2019; **24**: 130-132 [DOI: 10.14000/j.cnki.issn.1008-1704.2019.02.008]
- 33 Li X, Ji Y, Sun Y, Gao Y. [The role of ALBI score combined with NLR in the prognosis of esophageal variceal hemorrhage in cirrhosis]. *Modern Digestion & Intervention* 2022; **27**
- 34 Liang L, Jin S, Du J, Hu T, Hu Y, Yan H. [Prognostic value of neutrophil-lymphocyte ratio combined with CLIF-OF scores in the short-term outcomes of patients with hepatitis B virus-associated acute-on-chronic liver failure]. *Modern Practical Medicine* 2020; **32**: 450-452+563
- 35 Lin L, Yang F, Wang Y, Su S, Su Z, Jiang X, Zheng Y, Deng Y, Lv H, Zhao J, Lin R, Wang B, Sun C. Prognostic nomogram incorporating neutrophil-to-lymphocyte ratio for early mortality in decompensated liver cirrhosis. *Int Immunopharmacol* 2018; **56**: 58-64 [PMID: 29353688 DOI: 10.1016/j.intimp.2018.01.007]
- 36 Liu H, Zhang H, Wan G, Sang Y, Chang Y, Wang X, Zeng H. Neutrophil-lymphocyte ratio: a novel predictor for short-term prognosis in acute-on-chronic hepatitis B liver failure. *J Viral Hepat* 2014; **21**: 499-507 [PMID: 24750274 DOI: 10.1111/jvh.12160]
- 37 Liu XY, He X, Cai M, Peng SQ. Prognostic Value of Complete Blood Cell Count-Derived Inflammatory Markers in Hepatitis B Virus-Related Acute-on-Chronic Liver Failure. *Clin Lab* 2021; **67** [PMID: 34655197 DOI: 10.7754/Clin.Lab.2021.210217]
- 38 Maccali C, Augustinho FC, Zocche TL, Silva TE, Narciso-Schiavon JL, Schiavon LL. Neutrophil-lymphocyte ratio predicts short-term mortality in patients hospitalized for acute decompensation of cirrhosis. *Arq Gastroenterol* 2021; **58**: 131-138 [PMID: 34287528 DOI: 10.1590/S0004-2803.202100000-23]
- 39 Moreau N, Wittebole X, Fleury Y, Forget P, Laterre PF, Castanares-Zapatero D. Neutrophil-to-Lymphocyte Ratio Predicts Death in Acute-on-Chronic Liver Failure Patients Admitted to the Intensive Care Unit: A Retrospective Cohort Study. *Shock* 2018; **49**: 385-392 [PMID: 28930918 DOI: 10.1097/SHK.0000000000000993]

- 40 **Qiang L**, Qin J, Sun C, Sheng Y, Chen W, Qiu B, Chen X, Chen Y, Liu F, Wu G. [Prognostic evaluation of a prediction model based on neutrophil/Lymphocyte ratio and red blood cell distribution width of inflammatory factors on hepatitis B virus-related acute-on-chronic liver failure]. *Journal of Chongqing Medical University* 2021; **46**
- 41 **Shi K**, Huang Y, Zhang Q, Ran C, Hou J, Zhang Y, Bi Y, Wang X. A dynamic nomogram to predict transplant-free mortality in patients with hepatitis B-related cirrhosis and overt hepatic encephalopathy. *Int Immunopharmacol* 2022; **108**: 108879 [PMID: [35623289](#) DOI: [10.1016/j.intimp.2022.108879](#)]
- 42 **Sun J**, Guo H, Yu X, Zhu H, Zhang X, Yang J, Wang J, Qian Z, Shen Z, Mao R, Zhang J. A neutrophil-to-lymphocyte ratio-based prognostic model to predict mortality in patients with HBV-related acute-on-chronic liver failure. *BMC Gastroenterol* 2021; **21**: 422 [PMID: [34758747](#) DOI: [10.1186/s12876-021-02007-w](#)]
- 43 **Wang J**, Cheng N, Xiang T, Li S, Xiao J, Wu X. [Establishment and evaluation of short-term prognostic model for hepatitis B virus-related acute-on-chronic liver failure]. *Journal of Clinical Hepatology* 2019; **35**
- 44 **Wang P**, Zhang Q, Li Y, Yan X, Ding Q. [Usefulness of red blood cell distribution width and neutrophil to lymphocyte ratio model for a short-term prognosis of patients with hepatitis B virus-induced acute-on-chronic liver failure]. *Journal of Practical Hepatology* 2020; **23**: 682-686
- 45 **Wu D**, Jin L, Gao Y, Ye J, Xia G, Li f, Zhou G. [Value of neutrophil-lymphocyte ratio in evaluating the short-time prognosis of patients with acute-on-chronic liver failure]. *Journal of Clinical Hepatology* 2018; **34**: 1945-1949
- 46 **Xue H**, Shen J, Ju L, Zhang X, Shao J, Bian Z. [Correlation between neutrophil/Lymphocyte ratio, platelet/Lymphocyte ratio and prognosis in patients with cirrhotic encephalopathy]. *International Journal of Laboratory Medicine* 2021; **42**
- 47 **Zhang J**, Hu Y, Gao G, Hu A, Dong F. [Evaluation of the neutrophil/Lymphocyte ratio and end-stage liver disease model for short-term prognosis in patients with chronic severe hepatitis]. *Modern Practical Medicine* 2016; **28**
- 48 **Zhang L**, Chen W, Sheng Y, Deng C. [Value of Model for End-Stage Liver Disease score combined with neutrophil-lymphocyte ratio in predicting the short-term prognosis of patients with HBV-related acute-on-chronic liver failure]. *Journal of Clinical Hepatology* 2018; **34**
- 49 **Zhang W**, Aryan M, Chen Z, Khan W, Thompson B, Kwenda E, Geller B, Morelli G. Prognostic value of neutrophil-to-lymphocyte ratio in cirrhosis patients undergoing transjugular intrahepatic portosystemic shunt. *Eur J Gastroenterol Hepatol* 2022; **34**: 435-442 [PMID: [34750323](#) DOI: [10.1097/MEG.0000000000002295](#)]
- 50 **Zhou YF**, Xu Y, Ding YF, Yu XJ, Wu YL, Chen P, Zou DW. Novel nomogram model for predicting 6-week mortality in liver cirrhosis patients with acute upper gastrointestinal bleeding. *J Dig Dis* 2022; **23**: 516-526 [PMID: [36208036](#) DOI: [10.1111/1751-2980.13137](#)]



Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA

Telephone: +1-925-3991568

E-mail: office@baishideng.com

Help Desk: <https://www.f6publishing.com/helpdesk>

<https://www.wjgnet.com>

