Original Article

Evaluating Post Operative Prognostic Index in Liver Resection Outcomes

Rahman A[1], Ahmed A[2], Islam MJ[3], Hassan FU[4], Suma SA[5], Khan MS[6], Islam MJ[7], Parveen M[8]

Conflict of Interest: None
Received: 09.11.2024
Accepted: 17.11.2024
www.banglajol.info/index.php/JSSMC

Abstract: *Hepatic Resection is the first-line curative treatment in selected patients with benign as well as malignant liver lesion. Though due to refinement in surgical technique and peri operative care, the outcome of hepatic resection has been improved but mortality and morbidity still remains high in patient with chronic liver disease (CLD) specially post hepatectomy liver failure (PHLF). Various scoring system such as albumin bilirubin (ALBI), aspartate aminotransferase to lymphocyte ratio (APRI) has developed but they are difficult to calculate. Prognostic nutritional index (PNI) is calculated by serum albumin & total lymphocyte count. It is easy to calculate and cost effective, may not only reflect the nutritional status but also systemic inflammation. As a result, further research is needed whether prognostic nutritional index (PNI) is associated with the postoperative outcome after liver resection.*

Aim: *To evaluate the value of preoperative prognostic nutritional index (PNI) to predict the postoperative outcome after liver resection.*

Methods: *After receiving approval from the Institutional Review Board (IRB) of BSMMU, this study was conducted at the Department of Hepatobiliary, Pancreatic, and Liver Transplant Surgery, BSMMU, Dhaka. During the study period, a total of 34 consecutive patients were enrolled, who were undergone liver resection. After meeting inclusion and exclusion criteria, an informed written consent was obtained from each patient or from person authorized by the patient before their participation in this study. Prior to participation, all patients were evaluated using a combination of history, clinical examination, laboratory tests, and imaging techniques. Prognostic nutritional index (PNI) scoring was done after admission of patient selected for liver resection. Per operative information was collected. Routine hematological and biochemical investigations such as, white blood cell (WBC) count, hemoglobin percentage, serum albumin, serum bilirubin, serum creatinine, prothrombin time (PT), international normalized ratio (INR), serum glutamate pyruvate transaminase (SGPT), serum glutamate oxaloacetate (SGOT) and alkaline phosphatase (ALP) were measured during the early post-operative days. The outcomes of surgery will be assessed and any post-operative complications that may happen were graded according to Clavien-Dindo classification and dealt accordingly. The association of prognostic nutritional index (PNI) was evaluated by observing postoperative complications such as infectious complications, length of hospital stays and post hepatectomy liver failure (PHLF).*

Results: *It was observed that about 35% patients had hepaticolithiasis and 35% patients had GB mass followed by 5 (15%) HCC, 2 (6%) giant hemangioma, 2 (6%) FNH and 1(3%) simple hepatic cyst. Patients were divided into high PNI group and low PNI group. Demographic variables (age, sex, BMI) and associated comorbid conditions were similar between two groups of patients. There was no difference in types of liver resection between two groups. p value 0.859 per operative data showed operative time and whole blood transfusion were similar between two groups. On the other hand, amount of blood loss and FFP transfusion were different significantly showing p value 0.0475 and 0.0336 respectively. Comparison of postoperative outcomes and complications were similar between two groups. But in the length of hospital stay, we found significant differences between two groups. p value <0.01.*

Conclusion: *This study demonstrates a relationship between preoperative nutritional and inflammatory parameters with postoperative outcomes in patients undergoing LR.*

Key Words:
Liver Surgery, Liver Resection, prognostic nutritional index (PNI), Liver Cirrhosis, Outcome, Complication.

[J Shaheed Suhrawardy Med Coll 2024; 16(1): 43-48]
DOI: https://doi.org/10.3329/jssmc.v16i2.88306

Authors:

1. Md. Atiqur Rahman, Assistant Registrar, Department of Hepatobiliary Surgery, Shaheed Suhrawardy Medical College Hospital
2. Akhter Ahmed , Associate Professor, Department of Hepatobiliary Surgery, Shaheed Suhrawardy Medical College Hospital
3. Mohammad Jayedul Islam, Junior Consultant, Department of Hepatobiliary Surgery, Shaheed Suhrawardy Medical College Hospital
4. A.S.M Farhad-Ul-Hassan, Junior Consultant, Department of Hepatobiliary Surgery, Shaheed Suhrawardy Medical College Hospital
5. Sharmin Akter Suma, Lecturer, Department of Anatomy, Shaheed Suhrawardy Medical College
6. Mohammad Saifuddin Khan, Assistant Professor, Department of hepatobiliary and pancreatic Surgery, Shaheed Suhrawardy Medical Collegel,Dhaka.
7. Mohammad Jahirul Islam, Junior Consultant, Department of Hepatobiliary Surgery, Shaheed Suhrawardy Medical College Hospital
8. Maria Parveen, Junior Consultant, OSD, DGHS, Mohakhali, Dhaka.

Correspondence:
Dr. Md. Atiqur Rahman (Author), Assistant Registrar, Shaheed Suhrawardy Medical College Hospital, Sher-e-Bangla Nagar, Dhaka-1207.
Email: atiqss34hbps@gmail.com, Mobile: +880-1717753270

Introduction

Hepatic Resection is the first-line curative treatment in selected patients with benign as well as malignant liver lesion. In recent decades, refinements in surgical techniques and perioperative patient care have improved the outcome of liver resection. Hepatic resection has shown significant improvements in morbidity and mortality over the years, but it remains a challenging procedure in surgical practice (Andreatos et al. 2017) Despite significant advancement in surgical technique and perioperative care in recent decades, the mortality rate after hepatectomy remains high, especially in patients with chronic liver disease (Capussotti et al. 2005) i.e. with underlying advanced liver fibrosis and cirrhosis (Cescon et al. 2009).

Conventional scores, such as Child–Pugh score, Model for End Stage Liver Disease (MELD) score, Albumin-Bilirubin ratio (ALBI) score, and Aspartate Aminotransferase to Platelet Count Ratio Index (APRI), preoperative prognostic nutritional index (PNI) score are used widely for preoperative assessment of liver-function reserve. Some preoperative assessments had reported, such as preoperative portal pressure, technetium 99m-labeled asialoglycoprotein analog, indocyanine green (ICG) retention test, and computed tomography (CT), liver volumetry is useful for predicting prognosis before hepatectomy. It has been established that liver stiffness measurement (LSM) using transient elastography is a novel method for detection of liver fibrosis and cirrhosis with high accuracy. Nevertheless, liver stiffness measurement is not routinely assessed for liver resection all over the world for it is expensive (Vallet-Pichard et al. 2007).

Preoperative prognostic nutritional index (PNI) which is calculated by serum albumin level and total lymphocyte count (TLC) not only reflects nutritional status as well as systemic inflammation. Prognostic nutritional index (PNI) is one of the most cost effective noninvasive tool to evaluate nutritional as well inflammatory status. As prognostic nutritional index (PNI) is very cost effective than other scoring system, it can be checked in our patient as data on this aspect lacks in Bangladesh.

This study has been undertaken to see the association of prognostic nutritional index (PNI) with short term outcomes after liver resection such as infectious complications, length of hospital stay, post hepatectomy liver failure (PHLF).

Materials and Method

This is a observational comparative study done at Department of Hepatobiliary, Pancreatic and Liver Transplant Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU) over a period of one year one year (July 2023-June 2024) amongst the admitted patient in Department of Hepatobiliary Surgery. A total of 34 subjects (n=34) were chosen for purposive sampling. Patients who did not follow up are excluded from this study. After inclusion and assessment, all patients were interviewed by the research team for base line data like age, sex, socioeconomic status, BMI and co-morbid disease. Subjects were investigated for anesthetic fitness as well as to identify comorbidities.All patients underwent liver resection. Detail clinical and demographic history was taken along with thorough physical examination relevant investigations. All patients were evaluated preoperatively and post operatively at discharge, 1 month.

Results

This prospective observational study was conducted at Department of Hepatobiliary, Pancreatic and Liver Transplant Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU) on 34 patients with diagnosed case liver SOL for liver resection.

Table-1: Distribution of the study patients according to indications of hepatectomy.

Indication	Number of patient	Percentage
Hepaticolithiasis	12	35%
GB Mass	12	35%
HCC	5	15%
Giant haemangioma	2	6%
FNH	2	6%
Simple hepatic cyst	1	3%

This table showing distribution of the study patients according to indication of hepatectomy. Hepaticolithiasis (35%) and GB mass (35%) were most common indication.

Table 2: Comparison of Demographic and preoperative base line clinical characteristics of patient between two groups.

Characteristics	Low PNI Group (n=12)	High PNI Group (n=22)	P Value
Age (Mean+SD)	47.50+16.00	43.95+11.63	0.2297a
Gender Male- n(%) Female- n(%)	 4(33.3) 8(66.7)	 5(22.7) 17(77.3)	0.5831b
BMI	21.13+2.02	21.75+2.76	0.2483a
Associated disease- n (%) • Diabetes • Hypertension • Asthma/COPD • Hyperthyroidism • IHD	 3 (25) 2 (16.67) 1 (8.3) 1 (8.3) 0	 2 (9.1) 4 (18.2) 1 (4.5) 2 (18.2) 1 (4.5)	<0.8541b

This table shows the demographic and preoperative baseline clinical characteristics between two groups of patients.

Age , Gender , BMI and associated comorbid conditions were similar between two groups of patients.

Table 3: Comparison of pre-operative hematological and biochemical parameters of between two groups.

Laboratory data	Low PNI Group Mean±SD	High PNI Group Mean±SD	P Value
Hemoglobin, g/dL	11.25+1.28	10.99+1.70	0.3300
WBC, x109/L	4.75+7.93	6+7.67	0.2810
Total Lymphocyte count x109	4.75+7.93	6.2+7.67	0.001
Serum creatinine, mg/dL	1.27+0.79	0.99+0.54	0.1112
AST, U/L	40.42+62.90	50.05+70.89	0.3632
ALP, U/L	164.42+110.04	142.64+116.71	0.2981
PT, seconds	12.34+1.88	12.05+1.40	0.3050
INR	1.14+0.17	1.21+0.32	0.2420
Serum albumin, g/L	34.08+2.19	40.55+4.32	0.0001*
Serum total bilirubin, mg/dL	1.23+0.78	1.34+0.60	0.3264

This table showing comparison of preoperative hematological and biochemical parameters between two groups. Preoperative heamoglobin , WBC , serum creatinine , AST, ALP , PT , INR, serum bilirubin were similar between two groups. Difference of total lymphocyte count and serum albumin were statistically significant between two groups

Table 4: Comparison of per operative data between two group.

Liver Resection	Low PNI Group (n=12)	High PNI Group (n=22)	P Value
Resection procedure (Strasberg et al., 2000; Strasberg, 2005) • Right hepatectomy • Left hepatectomy • Left lateral sectionectomy • Bisegmentectomy • Extended cholecystectomy	 0(0) 1(8.3) 5(41.7) 1(8.3) 5(41.7)	 1(4.5) 3(13.6) 7(31.8) 4(18.2) 7(31.8)	0.859

This table showing comparison of types of liver resection between two groups. There was no differences in types of resection between two groups.

Table 5: Comparison of per operative information between two groups.

Operative data	Low PNI Group Mean±SD	High PNI Group Mean±SD	P Value
Operative time (minutes)	177.91 ± 77.66	170.5 ± 52.35	0.3707
Amount of blood loss (ml)	248.16 ± 91.17	204.21 ± 61.23	0.0475*
Whole blood transfusion (bag)	2.14 ±1.08	1.75 ± 0.75	0.1093
Fresh frozen plasma transfusion	2.18 ± 1.54	1.34 ± 1.11	0.0336*

This table showing comparison of per operative information between two groups. Operative time and number of whole blood transfusion were similar between two groups, Amount of blood loss was higher in low PNI group which was statistically significant, p value 0.0475. Fresh frozen plasma transfusion was higher in low PNI group which was statistically significant, p value 0.033

Table 6: Comparison of postoperative outcomes between two groups.

Variables	Low PNI Group (n=12)	High PNI Group (n=22)	P Value
No complications	07(58.3)	15(68.1)	0.634
Complications	5(41.7)	7(21.9)	
Minor complications, Clavien-Dindo complications	4(33.3)	6(27.3)	0.859
Major complications, Clavien-Dindo complications	1(8.3)	1(4.5)	

This table showing comparison of postoperative outcomes between two groups. Postoperative outcomes were found similar between two groups.

Table 7: Difference in the complications between two groups.

Complications	Low PNI Group (n=12)	High PNI Group (n=22)	P Value
Wound Infection	2(16.7)	3(13.6)	0.653
Pneumonia	0(0)	2(9.1)	
PHLF	2(16.7)	1(4.5)	
Wound discharge	1(8.3)	1(4.5)	

This finding indicates a significantly higher incidence of the Low PNI Group (16.7%) compared to the High PNI Group (9.1%) was not statistically significant, p value 0.653.

Table 8: Differences in the length of Hospital stay.

Length of hospital stay	Low PNI Group (n=12)	High PNI Group (n=22)	P Value
≤ 10 days	7(58.34)	13(59.09)	<0.01
11 - 20 days	4(33)	9(40.91)	
> 20 days	1(8%)	0(0.0)	

The table categorizes the length of hospital stay into three groups: ≤ 10 days, 11 - 20 days, and > 20 days. A higher proportion of patients in the High PNI Group (59.09%) had a hospital stay of 10 days or fewer compared to the Low PNI Group (58.34%). This difference was statistically significant ($p < 0.01$), indicating that patients with higher PNI tended to have shorter hospital stays.

Discussion

Preoperative nutritional index (PNI) is widely used to see the association of postoperative outcome after liver resection.Malnutrition is of particular concern in patients with HCC due to concomitant underlying cirrhosis. In addition, though liver resection is the mainstay of curative therapy for HCC, it can also result in a series of postoperative changes in metabolic, endocrine, neuroendocrine, and immune system function that increase the risk of complications and metastasis. Theoretically, malnutrition and immunological status may act as predictors of survival in patients undergoing curative resection for HCC (Schutte K et al, McMillan DC et al.)

Several studies had shown that the inflammatory scores are associated with prognosis in patients with HCC (Ishizuka et al.). The PNI was initially designed to assess the immunological and nutritional aspects of patients undergoing surgery of gastrointesintal tract, predominantly as an indicator of the nutritional status of any given patient (Nozoe et al., Kanda et al). Albumin is a widely used indicator of nutrition and has been shown to correlate with postoperative complications (Fujiwara et al, Ellis et al, Lai et al.).

Pinato et al. first demonstrated the usefulness of the PNI as a prognostic tool in HCC. Chan et al. identified PNI as a significant prognostic predictor of OS and DFS in patients with very early/early stage HCC receiving curative surgery. However, relatively few studies have dealt with PNI in HCC, and their results have been inconsistent, for example the findings of Yamamura et al.

The PNI value, which is a combination of albumin and the total lymphocyte count, may be used to evaluate the immunological and nutritional aspects of patients undergoing surgery. Ke M et al. reported that the PNI was established as an indirect measure of a patient's nutritional status, suggesting that the PNI may be associated with postoperative complications. Koike Y et al. suggested that the level of albumin and the lymphocyte count have been closely associated with the induction of the inflammatory response. Therefore, the PNI may not only reflect the nutritional status, but also systemic inflammation.

Ohtani H et al. reported that the PNI may reflect the immune-nutritional condition rather than tumor malignancy. Tumor-infiltrating lymphocytes (TILs) are a

specific histological feature of human cancers, reflecting an individual's immunological tumor response. Lee YY et al. reported that TILs may be associated with peripheral blood cells, such as the TLC and absolute neutrophil count. Okadome K et al reported in esophageal cancer, the PNI and TIL score have been reported to be associated with clinical outcomes. Considering the relationship between the PNI and TILs, nutritional status and systemic immune competence may affect patient prognosis through local immune response. Hanahan D et al. reported lymphocytes play an important role in the host immune response to eradicate the formation and progression of tumour.

In our study, we found that PNI correlated tightly with hepatic function index, the parameter of coagulation function white blood counts. In our present study the optimal cutoff value of PNI was set at 45. In lower PNI group patients were more likely to have postoperative complications, more blood loss, a longer surgery time and prolonged hospital stay after liver resection. Peroperative amount of blood loss were different between two group which had p value 0.0475 , was statistically significant. Amount of FFP transfusion and lenth of hospital stays between two groups significant containing p value 0.0336 and < 0.01 respectively. Mengyun Ke et al. and Yu Saito et al. also found almost similar results in their study.

Onodera et al. showed that PNI may be used as a predictor of patient prognosis and an indicator for preoperative nutritional management. Preoperative nutritional treatment may be important for patients with PNI lower than 37 to increase albumin level and lymphocyte count because prognosis was extremely poor in patients with preserved liver functional reserve.

Nishikawa H et al. suggested nutritional supplement by branched-chain amino acid granules has shown to improve hypoalbuminemia, preserve hepatic functional reserve, and prevent perioperative complications and tumor recurrence in patients with HCC undergoing surgery. Improvements in serum albumin level and/or peripheral T- lymphocyte count by these methods hence improve the PNI. So preoperative immuno-nutritional management should be required to increase PNI when surgical rescction is the sole curative treatment option.

Limitations

The study sample size is relatively small (n= 34) potentially limiting the generalizability of the findings to a broader population. The PNI score does not account for other factors such as comorbidities or patient specific condition that could influence postoperative outcomes.The study was single centered and duration period of study was short.Various indications of liver resection was included in this study.

Conclusion

In conclusion, PNI score less than 45 was associated with higher postoperative complications duration of hospital stay and blood loss during per operative period. PNI is associated with nutritional and immunological status of patient. Therefore, the PNI score is a practical and effective preoperative measure for assessing postoperative risks in liver resection patients.

Recommendations

Estimation of PNI score may be taken into consideration for patients who are planned for liver resection.

References:

1. Alleway, R. 2017. Classification of Intervention. [online] ncepod.org.uk. Available at: <http://www.ncepod.org.uk/classification.html>.
2. Andreatos, N., Amini, N., Gani, F., Margonis, G. A., Sasaki, K., Thompson, V. M., ..& Pawlik, T. M. (2017). Albumin-bilirubin score: predicting short-term outcomes including bile leak and post-hepatectomy liver failure following hepatic resection. Journal of Gastrointestinal Surgery, 21(2), 238-248.
3. Balzan S, Belghiti J, Farges O, Ogata S, Sauvanet A, Delefosse D and Durand F: "The 50-50 criteria" on postoperative day 5: An accurate predictor of liver failure and death after hepatectomy. Ann Surg 242:824-829,2005
4. Bataller, R., and Brenner, D, A. 2005. Liver fibrosis. The Journal of clinical investigation, 115(2), pp.209-218.
5. Capussotti, L, Muratore, A, Amisano, M, Polastri, R, Bouzari, H and Massucco, P., Cheng, J, Zhao, P, Liu, J, Liu, X and Wu, X. 2016. Preoperative aspartate aminotransferase-to-platelet ratio index is a predictor on postoperative outcomes of hepatocellular carcinoma. Medicine, 95(48).
6. Cescon, M., Vetrone, G., Grazi, G. L., Ramacciato, G., Ercolani, G., Ravaioli, M., ... & Pinna, A. D. (2009). Trends in perioperative outcome after hepatic resection: analysis of 1500 consecutive unselected cases over 20 years. Annals of surgery, 249(6), 995-1002.
7. Chan AW, Chan SL, Wong GL, Wong VW, Chong CC, Lai PB, et al. Prognostic nutritional index (PNI) predicts tumor recurrence of very early/early stage hepatocellular carcinoma after surgical resection. Ann Surg Oncol. 2015;22:4138–48.
8. Chen, Q. et al. (2018) 'Perioperative complications and the cost of rescue or failure to rescue in hepato-pancreato-biliary surgery', HPB: the official journal of the International Hepato Pancreato Biliary Association, 20(9), pp. 854–864.

9. Dindo, D, Demartines, N., and Clavien, P.A., 2004. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Annals of surgery, 240(2), p.205.
10. Fan, X., Chen, G., Li, Y., Shi, Z., He, L., Zhou, D. and Lin, H., 2021. The preoperative prognostic nutritional index in hepatocellular carcinoma after curative hepatectomy: a retrospective cohort study and meta-analysis. Journal of Investigative Surgery, 34(8), pp.826-833.
11. Fleiss, J.,L, Levin, B and Paik, M.,C. 2013. Statistical methods for rates and proportions. john wiley & sons.
12. Gilg, S. et al. (2018) 'The impact of post-hepatectomy liver failure on mortality: a population-based study', Scandinavian Journal of Gastroenterology, 53(10–11), pp. 1335–1339.
13. Goh BK, Kam JH, Lee SY, Chan CY, Allen JC, Jeyaraj P, et al. Signifcance of neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio and prognostic nutrition index as preoperative predictors of early mortality after liver resection for huge (≥10 cm) hepatocellular carcinoma. J Surg Oncol. 2016;113:621–7.
14. Horvath, B, Kloesel, B, Todd, MM, Cole, DJ and Prielipp, RC 2021. The evolution, current value, and future of the american society of anesthesiologists physical status classification system. Anesthesiology, 135(5), pp.904-919
15. Huang J, Xu L, Luo Y, He F, Zhang Y, Chen M. The infammation-based scores to predict prognosis of patients with hepatocellular carcinoma after hepatectomy. Med Oncol. 2014;31:883.
16. Jara, M. et al. (2015) 'Reductions in post-hepatectomy liver failure and related mortality after implementation of the LiMAx algorithm in preoperative work-up: a single-centre analysis of 1170 hepatectomies of one or more segments', HPB: the official journal of the International Hepato Pancreato Biliary Association, 17(7), pp. 651–658.
17. Ji F, Liang Y, Fu S, Chen D, Cai X, Li S, et al. Prognostic value of combined preoperative prognostic nutritional index and body mass index in HCC after hepatectomy. HPB (Oxford). 2017;19:695–705.
18. Katayama, H, Kurokawa, Y, Nakamura, K, Ito, H, Kanemitsu, Y, Masuda, N, Tsubosa, Y, Satoh, T, Yokomizo, A, Fukuda, H and Sasako, M 2016. Extended Clavien-Dindo classification of surgical complications: Japan Clinical Oncology Group postoperative complications criteria. Surgery today, 46(6), pp.668-685.
19. Kinoshita A, Onoda H, Imai N, Iwaku A, Oishi M, Fushiya N, et al. Comparison of the prognostic value of infammation-based prognostic scores in patients with hepatocellular carcinoma. Br J Cancer. 2012;107:988–93.
20. Lachin, J M 2000. Biostatistical Methods. John Wiley & Sons. New York ..Lin, ZH, Xin, YN, Dong, QJ, Wang, Q, Jiang, XJ, Zhan, SH, Sun, Y and Xuan, SY 2011. Performance of the aspartate aminotransferase-to-platelet ratio index for the staging of hepatitis C-related fibrosis: an updated meta-analysis. Hepatology, 53(3), pp.726-736.
21. Machin, D, Campbell, MJ, Tan, SB and Tan, SH 2011. Sample size tables for clinical studies. John Wiley & Sons.
22. Madoff, D.C. et al. (2020) 'Improving the Safety of Major Resection for Hepatobiliary Malignancy: Portal Vein Embolization and Recent Innovations in Liver Regeneration Strategies', Current Oncology Reports, 22(6), p. 59.
23. Mai, RY, Ye, JZ, Long, ZR, Shi, XM, Bai, T, Chen, J, Li, LQ, Wu, GB and Wu, FX 2019. Preoperative aspartate aminotransferase-to-platelet-ratio index as a predictor of posthepatectomy liver failure for resectable hepatocellular carcinoma. Cancer management and research, 11, p.1401.Mol, L, Ottevanger, PB, Koopman, M and Punt, CJA 2016. The prognostic value of WHO performance status in relation to quality of life in advanced colorectal cancer patients. European Journal of Cancer, 66, pp.138-143.
24. Morandi, A. et al. (2023) 'Predicting Post-Hepatectomy Liver Failure in HCC Patients: A Review of Liver Function Assessment Based on Laboratory Tests Scores', Medicina, 59(6), p. 1099.
25. Nagata, S., Maeda, S., Nagamatsu, S., Kai, S., Fukuyama, Y., Korematsu, S., Orita, H., Anai, H., Kuwano, H. and Korenaga, D., 2021. Prognostic nutritional index considering resection range is useful for predicting postoperative morbidity of hepatectomy. Journal of Gastrointestinal Surgery, 25(11), pp.2788-2795.
26. Okamura Y, Ashida R, Ito T, Sugiura T, Mori K, Uesaka K. Preoperative neutrophil to lymphocyte ratio and prognostic nutritional index predict overall survival after hepatectomy for hepatocellular carcinoma. World J Surg. 2015;39:1501–9.
27. Pinato DJ, North BV, Sharma R. A novel, externally validated infammationbased prognostic algorithm in hepatocellular carcinoma: the prognostic nutritional index (PNI). Br J Cancer. 2012;106:1439–45.
28. Rahbari, NN, Garden, OJ, Padbury, R., Brooke-Smith, M, Crawford, M, Adam, R, Koch, M, Makuuchi, M, Dematteo, RP, Christophi, C and Banting, S 2011. Posthepatectomy liver failure: a definition and grading by the International Study Group of Liver Surgery (ISGLS). Surgery, 149(5), pp.713-724.
29. Russell, M.C. (2015) 'Complications following hepatectomy', Surgical Oncology Clinics of North America, 24(1), pp. 73–96.
30. Ryan, TP 2013. Sample size determination and power. John Wiley & Sons.
31. Saito, Y., Imura, S., Morine, Y., Ikemoto, T., Yamada, S. and Shimada, M., 2021. Preoperative prognostic nutritional index predicts short and long term outcomes after liver resection in patients with hepatocellular carcinoma. Oncology Letters, 21(2), pp.11.Schuppan, D and Afdhal, NH 2008. Liver cirrhosis. The Lancet, 371(9615), pp.838-851.
32. Shiha, G, Ibrahim, A, Helmy, A, Sarin, SK, Omata, M, Kumar, A, Bernstien, D, Maruyama, H, Saraswat, V, Chawla, Y and Hamid, S 2017. Asian-Pacific Association for the Study of the Liver (APASL) consensus guidelines on invasive and non-invasive assessment of hepatic fibrosis: a 2016 update. Hepatology international, 11(1), pp.1-30.
33. Strasberg, SM 2005. Nomenclature of hepatic anatomy and resections: a review of the Brisbane 2000 system. Journal of hepato-biliary-pancreatic surgery, 12(5), pp.351-355.
34. Tasneem, H, Shahbaz, H and Sherazi, BA 2015. Causes, management and complications of ascites: a review. International Current Pharmaceutical Journal, 4(3), pp.370-377.
35. Wai, CT, Greenson, JK, Fontana, RJ, Kalbfleisch, JD, Marrero, JA, Conjeevaram, HS and Lok, ASF 2003. A simple noninvasive index can predict both significant fibrosis and cirrhosis in patients with chronic hepatitis C. Hepatology, 38(2), pp.518-526.
36. Wang Z, Wang J, Wang P. The prognostic value of prognostic nutritional index in hepatocellular carcinoma patients: a meta-analysis of observational studies. PLoS ONE. 2018;13:e0202987. https://doi.org/10.1371/journal.pone.0202987.
37. Yang, HJ, Jiang, JH, Yang, YT, Guo, Z, Li, JJ, Liu, XH, Lu, F, Zeng, FH, Ye, JS, Zhang, KL and Chen, NZ 2017. Stratified aspartate aminotransferase-to-platelet ratio index accurately predicts survival in hepatocellular carcinoma patients undergoing curative liver resection. Tumor Biology, 39(3), p.1010428317695944.
38. Zhang X, Li C, Wen T, Peng W, Yan L, Yang J. Postoperative prognostic nutritional index predicts survival of patients with hepatocellular carcinoma within milan criteria and hypersplenism. J Gastrointest Surg. 2017;21:1626–3