JSSN 2016; 19 (2)

Original Article

Preoperative serum albumin level as a predictor of perioperative outcome in patient undergoing major gastrointestinal surgery

Tika Ram Bhandari[1], Sudha Shahi[2], Ramesh Singh Bhandari[3], Paleswan Joshi Lakhey[3]

[1]Department of General Surgery, Universal College of Medical Sciences, Bhairahawa, Nepal (Formerly Department of Surgery, Institute of Medicine ,Tribhuvan University Teaching Hospital, Kathmandu, Nepal)

[2] Department of ENT, National Academy of Medical Sciences, Kathmandu , Nepal

[3] Department of Surgical Gastroenterology, Institute of Medicine ,Tribhuvan University Teaching Hospital, Kathmandu, Nepal

Corresponding author: Dr. Tika Ram Bhandari, MS General Surgery (IOM, Nepal), Lecturer, Department of General Surgery,Universal College of Medical Sciences, Bhairahawa, Nepal

Email: tikanmc@hotmail.com

Abstract

Introduction: Hypoalbuminemia, as a marker of malnutrition and disease, is associated with higher risk of poor postoperative outcomes. However, no study has been reported from our country until now. Our aim was to identify the relationship between preoperative hypoalbuminemia and the development of complications after major gastrointestinal surgery.

Methods: A prospective study of 106 patients who underwent major elective gastrointestinal surgery between July 2012 to June 2013 in Department of Surgery, Tribhuvan University Teaching Hospital, Kathmandu, Nepal were considered for the study. Serum albumin was determined preoperatively in all patients. Hypoalbuminemia was defined as albumin less than 35 mg/dl. Thirty-day postoperative complications were analyzed.

Results: The patients were 70 males (66 %) and 36 females (34%) with a mean age of 50 years (23-81). Thirty-six patients (34%) had hypoalbuminemia. Overall complication rate was 32%. Hypoalbuminemic patients had a significantly higher rate of postoperative complications (26.4 and 5.6%; P<0.05). In multivariate analysis, age (>50 year), BMI (<18 kg/m^2), duration of surgery (>3 hours) and hypoalbuminemia (<35 mg/dl) were the significant risk factors for postoperative complications (P<0.05).

Conclusion: Preoperative hypoalbuminemia is an independent predictor of postoperative outcomes in patients with elective major gastrointestinal surgery. Identification and optimization of nutritional status prior to surgery may improve surgical outcomes.

Keywords: Gastrointestinal Surgery; Hypoalbuminemia; Postoperative Complication.

Introduction

Malnutrition is a common problem in patients with gastrointestinal disease, which adversely affects surgical outcomes[1–5]. There are many tools to assess patient's nutritional status. Decreased serum albumin is a good and simple predictor of surgical risk and has a close correlation with the degree of malnutrition[6,7]. Complications are defined as any deviation from the normal postoperative course[8]. Complications can be graded according to the postoperative complication grading system[9]. It has been maintained that hypoalbuminemia is associated with

higher rate of post operative complications[10–12]. However no study has been reported relating to hypoalbuminemia and outcomes in major gastrointestinal surgery in our part of world until now. We aimed to identify the relationship between preoperative hypoalbuminemia and the development of complications following open elective major gastrointestinal surgery in our institution.

Methods

This was a prospective study carried out from the period of July 2012 to June 2013 in the department of surgery, Tribhuvan University Teaching Hospital, Kathmandu, Nepal. The protocol was approved by the Institutional review board, Institute of Medicine, Tribhuvan University. All Patients undergoing major open elective gastrointestinal surgery were included in the study as shown in Figure 1. Patients with ASA grade more than II, pediatrics patients, patients having liver failure, cirrhosis, nephrotic syndrome, emergency surgery, laparoscopic surgery and those who lost on follow-up were excluded. Each patient had a pre-operative serum albumin assessment. Serum albumin less than 35 mg/dl was considered as hypoalbuminemia.

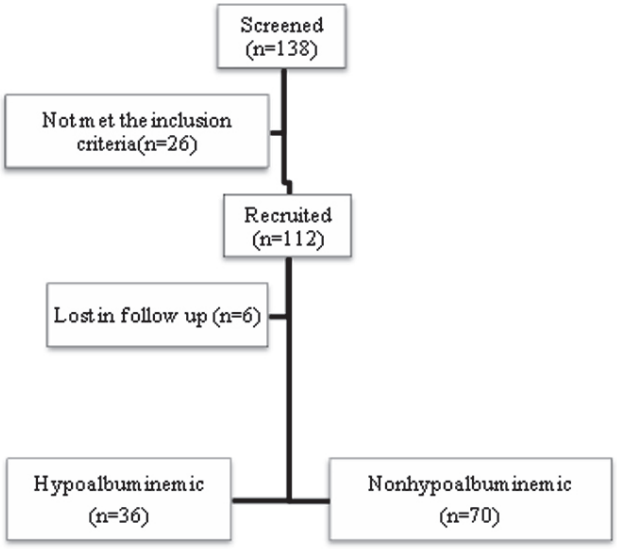

Figure 1: Work plan for the study

The patients were classified into two groups (non-hypoalbuminemic and hypoalbuminemic) in relation to level of preoperative serum albumin (<35 mg/dl or >35mg/dl). Patient's demographic details, diagnosis, operative details and intraoperative outcomes were registered. All perioperative complications within 30 days of surgery were recorded. Complications were graded according to the postoperative complications grading system[9] (Briefly, Grade 0 = no complication; Grade 1 = use of oral medications or bedside care; Grade 2 = use of intravenous therapy, TPN, or transfusion; Grade 3 = intubation, interventional radiology, or surgery; Grade 4 = organ dysfunction and Grade 5 = death).

Continuous variables were compared using the Student t-test or the Mann- Whitney U-test as appropriate. Categorical variables were compared using the chi-square test or the Fischer exact test as feasible. To recognize independent predictors of postoperative complications, statistically significant variables known by univariate analysis were analyzed further by multivariate logistic regression analysis. All of the data were analyzed using SPSS version 18. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 106 patients, who underwent major elective open abdominal surgery were studied (Figure 1). Out of 106 patients, 70 patients (66%) had normal albumin and 36 patients (34%) had hypoalbuminemia. Majority of patients were male (70%) with median age of 50 (23-81). There were no significant differences in different preoperative variables, when we compared these variables in nonhypoalbuminemic and hypoalbuminemic patients (P>0.05) as shown in Table 1.

Table 1: Preoperative data

Variables	Nonhypoal-buminemic (n=70)	Hypoal-buminemic (n=36)	P value
Age (year)	50(23-76)	53(24-74)	0.25
Gender			
Male	45 (64.2)	25(69.4)	
Female	25 (35.5)	11(31.6)	0.44
BMI (kg/m^2)	22(18-23)	18(16-22)	0.54
Hematocrit	33(27-40)	31(26-39)	0.86
Smoker	18(25.7)	28(77.7)	0.23
ASA			0.35
I	53(75.7)	14(38.8)	
II	17(24.3)	22(61.1)	
Comorbidity			0.34
Diabetes(DM)	5(7.1)	5(13.8)	
Hypertension	1(1.4)	3(8.3)	
DM with	1(1.4)	2(5.5)	
hypertension	1(1.4)	2(5.5)	
Others			

Values are presented as median (range) or number (%), ASA; American society of Anesthesiology

Table 2: Type of surgery on Nonhypoalbuminemic and Hypoalbuminemic patient

Type of surgery	Non-hypoalbumenemic (n=70)	Hypoalbuminemic (n=36)
Gastric surgery	12(17.1)	25(69.4)
Subtotal gastrectomy	7(10.0)	18(50.0)
Total gastrectomy	5(7.1)	7(19.4)
Hepatobiliary surgery	21(29.4)	9(25.0)
Hepatectomy	3(4.2)	1(2.7)
CBD exploration	7(10.0)	1(2.7)
Pericystectomy	1(1.4)	4(11.1)
Extended cholecystectomy	5(7.1)	2(5.4)
Completion cholecystectomy	5(7.1)	1(2.7)
Pancreatic surgery	10(14.3)	6(16.7)
Whipple's	3(4.2)	1(2.7)
Frey's	1(1.4)	2(5.4)
Modified Puesto's	2(2.8)	1(2.7)
Cystogastrostomy	2(2.8)	1(2.7)
Partial pancreatectomy	1(1.4)	0(0)
Splenorenal shunt	1(1.4)	1(2.7)
Colorectal surgery	11(15.8)	13(36.1)
Hemi colectomy	4(5.6)	1(2.7)
APR	1(1.4)	1(2.7)
Sigmoidectomy	1(1.4)	1(2.7)
Anterior resection	5(7.1)	2(5.4)

Values are presented as number (%), APR; Abdominoperineal Resection

Mean preoperative serum albumin level was 37 mg/dl and 32 mg/dl in nonhypoalbuminemic and hypoalbuminemic patients respectively. Operative procedures were classified as gastric (n=37), hepatobiliary (n=29), pancreatic (n=16) and colorectal (n=24) as shown in Table 2. Patients undergoing gastric surgery presented with the lowest albumin value (33.55+/-4.6 mg/dl) followed by pancreatic, colorectal and hepatobiliary surgery patients.

Overall postoperative complications were found in 34 patients (32%), out of which 6 (5.6%) belonged to nonhypoalbuminemic group while 28 patients (26.4%) to the hypolbuminemic group (P=0.001). The most common grade of complication was grade I in both the groups (11.1 and 44%). Out of four mortalities, three were in hypoalbuminemic group (Figure 2).

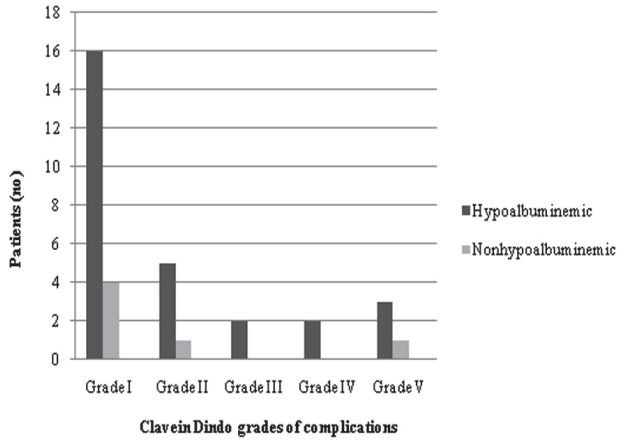

Figure 2: Albumin level and Clavien Dindo Grades of complication

The incidence of complications following gastric surgery was 13.2% followed by pancreatic(8.4%), hepatobilliary (4.71%) and small intestine-colorectal(4.71%) in both the groups. While comparing type of surgery between the groups, more complications had been noticed in hypoalbuminemic patients than nonhypoalbuminemic patients , however the difference was not statistically significant (P >0.05).

In univariate analysis gender, smoking, ASA status and presence of comorbidity were not associated with an increased risk of developing postoperative complications. However, in multivariate logistic analysis, age (>50 year), BMI(<18 kg/m^2), duration of surgery (>3 hours) and hypoalbuminemia were the significant risk factors for postoperative complications (P<0.05) as shown in Table 3.

Table 3: Association of variables and postoperative complications

Variables	Compli-cations (n=34)	Univariate P value OR (95% CI)	Multivariate P value, OR(95% CI)
Age			
50 or more	24	0.01; 1.1 (0.9-1.4)	0.001;1.037 (1.02-1.05)
Less than 50	10		
Gender			
Male	19	0.23; 1.3 (1.1-2.0)	NA
Female	15		
BMI(kg/m2)			
20 or more	9	0.02; 0.9 (0.7-1.4)	0.001; 1.7 (0.37-0.94)
Less than 20	25		
Smoking			
Smoker	24	0.30; 1.0 (0.9-1.7)	NA
Nonsmoker	10		
ASA			
I	14		
II	20	0.70; 1.1 (0.8-2.1)	NA
Comorbidity			
Yes	19	0.50, 1.3 (1.0-2.1)	NA
No	15		
Operative time (hr.)			
less than 3	25		
3 or more	9	0.02; 3.1 (1.9-.2.7)	0.001; 1.2 (1.03-2.02)
Hypoal-buminemia (mg/dl)	28	0.01; 4.5 (2.1- 7.6)	0.001; 5.2 (3.45-9.45)
Yes	6		
No			

NA; Not analyzed, OR; Odds ratio, CI; Confidence interval, ASA; American Society of Anesthesiology

Discussion

Complications after any surgery are inherent. Though it can be minimized, can never be eliminated. Many studies have shown that low preoperative serum albumin is a risk factor for postoperative complications[11–19]. In various other studies, different types of surgical procedures as a general or a specific type of surgical procedure has been considered in certain subclass of patients. There has been no distinction between elective and emergency surgical procedures in other studies. In the present study, we have established that preoperative hypoalbuminemia is an independent factor associated with postoperative morbidity and mortality in patients undergoing major elective gastrointestinal surgery. This study analyzed the different aspects of major gastrointestinal surgery in relation to hypoalbuminemic and nonhypoalbuminemic cohort. We also took advantage of the standardized Clavien Dindo classification system to assess postoperative complications[9] .

When we compared outcomes of major gastrointestinal surgery in the hypoalbuminemic and nonhypoalbuminemic cohort, we found statistical differences in the complications between the hypoalbuminemic and nonhypoalbuminemic groups ($P<0.05$).

Owing to the economic and social restraints characteristic of developing countries possibly preventing them from basics like good nutrition, lack of adequate knowledge about the health and poor access to health services, the rate of complications overall 32%, found is higher than 15.38% reported in a study from Portugal in a cohort of 117 patients undergoing major gastrointestinal surgery. Our hypoalbuminemic patients had a significantly higher rate of postoperative complications (26.4% vs 5.6%, $P=0.004$) consistent with that reported in the literature.[21-26] Hypoalbuminemic patients have higher risk of having postoperative complications (37.5% vs. 21.3%, $P = 0.014$) following rectal cancer surgery which is similar to that observed in our study.[11] In the present study , a multivariate analysis of the relationship of serum albumin and complications showed that a preoperative hypoalbuminemia increased the risk of complications by 5.2 fold which is comparable to 5.6 fold observed in the series of 524 patients undergoing gastrointestinal surgery in Ireland in 2010.[22] Grade I complication was the most common complication found in our series. This is consistent with the results of a study from Switzerland published in 2004 in a cohort of 6336 patients who underwent elective general surgery in a single institution.[27] Surgical site infection was the most common complication within grade I similar to reported in the literature. The mortality rate in the present study is comparable to other studies which were associated hypoalbuminemia.[26]

The incidence of complication following gastric surgery was the highest in our study similar to that observed from Spain in 2009 in a retrospective review of 158 patients undergoing elective gastrointestinal study.[21] A multicenter study of 54,215 patients following major noncardiac surgery in 1999 highlighted that a decrease in serum albumin from concentrations greater than 46 g/L to less than 21 g/L was associated with an exponential increase in mortality rates from less than 1% to 29% and in morbidity rates from 10% to 65% following non-cardiac surgery.[28] Recently, another retrospective study from Ireland in a review of 200 patients revealed decreased serum albumin concentration on the first postoperative day was also good predictor of poor surgical outcome following gastrointestinal cancer surgery. Patients with low preoperative albumin levels have an increased overall mortality and cancer-specific mortality risk than those with normal albumin levels. [29] Preoperative albumin levels <30 mg/dl increases the perioperative morbidity after gynecologic cancer surgery. [30]

We also analyzed the factors that affect postoperative outcome in major gastrointestinal surgey. Age (>50 years), BMI (<18 kg/m^2), duration of surgery (>3 hours) and hypoalbuminemia were the significant risk factors for postoperative complications ($P<0.05$) similar to reported in the literature[11]. We did not find any correlation between the gender of the patient, smoking, ASA status and presence of comorbidity with postoperative complications.

Low serum albumin is associated with poor wound healing, compromised collagen synthesis, and compromised immune responses . These elements collectively may clarify the higher risk of post-operative complications in hypoalbuminemic patients. Concerning the treatment of pre-existing low serum albumin level, few studies have shown no beneficial outcome with the administration of albumin infusions.[31-33] This could be due to inadequate albumin replacement or increased leakage of synthetic albumin into the extravascular spaces. However, recently some study highlighted that preoperative nutrition supplements may benefit the patient and improve surgical outcomes.[34,35]

We believe that this is one of the precise series clearly showing an association between preoperative serum albumin and significant complications after major elective gastrointestinal surgery. Limitations of our study are; single centered study design; small size study population with only 34% showing low preoperative serum albumin,

which could influence the ability to determine preoperative serum albumin as a predictor; serum albumin which itself is a multifaceted variable which could be altered broadly in various physiopathological condition. Despite all the limitations, preoperative serum albumin remained a significant predictor of postoperative complications and mortality in patients undergoing major gastrointestinal surgery. Hence, in order to validate our findings further appropriately designed studies are suggested.

Conclusion

Preoperative hypoalbuminemia is an independent risk factor for the development of postoperative complications. Surgeons should be aware of the consequences of low preoperative serum albumin and concern of nutritional optimization, which is likely to improve operative outcome in a surgical patient.

Acknowledgement : The authors are grateful to all the patients, staffs, colleagues who assisted in the study.

Conflict of study: The Authors declare that they have no conflict of interest .

Funding: None

Consent to participate: Informed and written consent were taken to participate in the study.

Consent to publish: Consent to publish was obtained from the patients.

The contribution of authors: All the authors contributed equally to drafting, literature search and writing.

References

1. Sullivan DH, Bopp MM, Roberson PK. Protein-energy undernutrition and life-threatening complications among the hospitalized elderly. J Gen Intern Med.2002 Dec;17(12):923–32. https://doi.org/10.1046/j.1525-1497.2002.10930.x PMid:12472928 PMCid:PMC1495141

2. Sungurtekin H, Sungurtekin U, Balci C, Zencir M, Erdem E. The influence of nutritional status on complications after major intraabdominal surgery. J Am Coll Nutr.2004 Jun;23(3):227–32. https://doi.org/10.1080/07315724.2004.10719365 PMid:15190047

3. Schneider SM, Hebuterne X. Use of nutritional scores to predict clinical outcomes in chronic diseases. Nutr Rev. 2000 Feb;58(2 Pt 1):31–8. https://doi.org/10.1111/j.1753-4887.2000.tb07809.x

4. Correia MITD, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. Clin Nutr Edinb Scotl.2003 Jun;22(3):235–9. https://doi.org/10.1016/S0261-5614(02)00215-7

5. McWhirter JP, Pennington CR. Incidence and recognition of malnutrition in hospital. BMJ.1994 Apr 9;308(6934):945–8. https://doi.org/10.1136/bmj.308.6934.945 PMid:8173401 PMCid:PMC2539799

6. Fuhrman MP, Charney P, Mueller CM. Hepatic proteins and nutrition assessment. J Am Diet Assoc.2004;104(8):1258–1264. https://doi.org/10.1016/j.jada.2004.05.213 PMid:15281044

7. Quinlan GJ, Martin GS, Evans TW. Albumin: biochemical properties and therapeutic potential. Hepatol Baltim Md. 2005 Jun;41(6):1211–9. https://doi.org/10.1002/hep.20720 PMid:15915465

8. Clavien PA, Camargo CA, Croxford R, Langer B, Levy GA, Greig PD. Definition and classification of negative outcomes in solid organ transplantation. Application in livertransplantation.AnnSurg.1994Aug;220(2):109–20. https://doi.org/10.1097/00000658-199408000-00002 PMid:8053733 PMCid:PMC1234350

9. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg.2009 Aug;250(2):187–96. https://doi.org/10.1097/SLA.0b013e3181b13ca2 PMid:19638912

10. Kuzu MA, Terzioğlu H, Genç V, Erkek AB, Özban M, Sonyürek P, et al. Preoperative nutritional risk assessment in predicting postoperative outcome in patients undergoing major surgery. World J Surg.2006;30(3):378–390. https://doi.org/10.1007/s00268-005-0163-1 PMid:16479353

11. Lohsiriwat V, Lohsiriwat D, Boonnuch W, Chinswangwatanakul V, Akaraviputh T, Lert-Akayamanee N. Pre-operative hypoalbuminemia

is a major risk factor for postoperative complications following rectal cancer surgery. World J Gastroenterol. 2008;14(8):1248. https://doi.org/10.3748/wjg.14.1248 PMid:18300352 PMCid:PMC2690674

12. Alves A, Panis Y, Mathieu P, Mantion G, Kwiatkowski F, Slim K. Postoperative mortality and morbidity in French patients undergoing colorectal surgery: results of a prospective multicenter study. Arch Surg.2005;140(3):278–283. https://doi.org/10.1001/archsurg.140.3.278 PMid:15781793

13. Putwatana P, Reodecha P, Sirapo-ngam Y, Lertsithichai P, Sumboonnanonda K. Nutrition screening tools and the prediction of postoperative infectious and wound complications: comparison of methods in presence of risk adjustment. Nutrition.2005;21(6):691–697. https://doi.org/10.1016/j.nut.2004.10.015 PMid:15925293

14. Ryan AM, Hearty A, Prichard RS, Cunningham A, Rowley SP, Reynolds JV. Association of hypoalbuminemia on the first postoperative day and complications following esophagectomy. J Gastrointest Surg.2007;11(10):1355–1360. https://doi.org/10.1007/s11605-007-0223-y PMid:17682826

15. Leite JF, Antunes CF, Monteiro JC, Pereira BT. Value of nutritional parameters in the prediction of postoperative complications in elective gastrointestinal surgery. Br J Surg. 1987 May;74(5):426–9. https://doi.org/10.1002/bjs.1800740538 PMid:3594145

16. Neumayer L, Hosokawa P, Itani K, El-Tamer M, Henderson WG, Khuri SF. Multivariable predictors of postoperative surgical site infection after general and vascular surgery: results from the patient safety in surgery study. J Am Coll Surg. 2007;204(6):1178–1187. https://doi.org/10.1016/j.jamcollsurg.2007.03.022 PMid:17544076

17. Pikul J, Sharpe MD, Lowndes R, Ghent CN. Degree of preoperative malnutrition is predictive of postoperative morbidity and mortality in liver transplant recipients. Transplantation.1994 Feb; 57(3):469–72. https://doi.org/10.1097/00007890-199402150-00030 PMid:8108888

18. Lai C-C, You J-F, Yeh C-Y, Chen J-S, Tang R, Wang J-Y, et al. Low preoperative serum albumin in colon cancer: a risk factor for poor outcome. Int J Colorectal Dis. 2011 Apr;26(4):473–81. https://doi.org/10.1007/s00384-010-1113-4 PMid:21190025

19. Chai FY, Jiffre D. Preoperative hypoalbuminemia is an independent risk factor for the development of surgical site infection following gastrointestinal surgery. Ann Surg. 2011;254 (4):665. https://doi.org/10.1097/SLA.0b013e318230631b

20. Leandro-Merhi VA, de Aquino JLB, Chagas JFS. Nutrition status and risk factors associated with length of hospital stay for surgical patients. J Parenter Enter Nutr. 2011;35(2):241–248. https://doi.org/10.1177/0148607110374477 PMid:20971940

21. Badia-Tahull MB, Llop-Talaveron J, Fort-Casamartina E, Farran-Teixidor L, Ramon-Torrel JM, Jódar-Masanés R. Preoperative albumin as a predictor of outcome in gastrointestinal surgery. E-SPEN Eur E-J Clin Nutr Metab. 2009;4(5):e248–e251. https://doi.org/10.1016/j.eclnm.2009.07.001

22. Hennessey D, Burke JP, Mealy K. Malnutrition and postoperative complications in abdominal surgery. Ann Surg.2011;254(4):666–667. https://doi.org/10.1097/SLA.0b013e318230647f

23. Jin S, Bochicchio GV, Joshi M, Bochicchio K, others. Admission serum albumin is predicitve of outcome in critically ill trauma patients. Am Surg. 2004;70(12):1099.

24. Garth AK, Newsome CM, Simmance N, Crowe TC. Nutritional status, nutrition practices and post-operative complications in patients with gastrointestinal cancer. J Hum Nutr Diet.2010;23(4):393–401. https://doi.org/10.1111/j.1365-277X.2010.01058.x PMid:20337847

25. Garg T, Chen LY, Kim PH, Zhao PT, Herr HW, Donat SM. Preoperative serum albumin is associated with mortality and complications after radical cystectomy. BJU Int. 2014 Jun;113(6):918–23. https://doi.org/10.1111/bju.12405 PMid:24053616 PMCid:PMC4203702

26. Kim J, Shim S-H, Oh I-K, Yoon S-H, Lee S-J, Kim S-N, et al. Preoperative hypoalbuminemia is a risk factor for 30-day morbidity after gynecological malignancy surgery. Obstet Gynecol Sci.2015;58(5):359–367.

https://doi.org/10.5468/ogs.2015.58.5.359 PMid:26430660 PMCid:PMC4588840

27. Dindo D, Demartines N, Clavien P-A. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004 Aug;240(2):205–13. https://doi.org/10.1097/01.sla.0000133083.54934.ae PMid:15273542 PMCid:PMC1360123

28. Gibbs J, Cull W, Henderson W, Daley J, Hur K, Khuri SF. Preoperative serum albumin level as a predictor of operative mortality and morbidity: results from the National VA Surgical Risk Study. Arch Surg.1999;134(1):36–42. https://doi.org/10.1001/archsurg.134.1.36 PMid:9927128

29. Lambert JW, Ingham M, Gibbs BB, Given RW, Lance RS, Riggs SB. Using preoperative albumin levels as a surrogate marker for outcomes after radical cystectomy for bladder cancer. Urology. 2013;81(3):587–592. https://doi.org/10.1016/j.urology.2012.10.055 PMid:23352372

30. Uppal S, Al-Niaimi A, Rice LW, Rose SL, Kushner DM, Spencer RJ, et al. Preoperative hypoalbuminemia is an independent predictor of poor perioperative outcomes in women undergoing open surgery for gynecologic malignancies. Gynecol Oncol. 2013;131(2):416–422. https://doi.org/10.1016/j.ygyno.2013.08.011 PMid:23962700

31. Cerantola Y, Grass F, Cristaudi A, Demartines N, Schäfer M, Hübner M. Perioperative nutrition in abdominal surgery: recommendations and reality. Gastroenterol Res Pract. 2011;2011:739347. https://doi.org/10.1155/2011/739347 PMid:21687620 PMCid:PMC3113259

32. Bromenshenkel J, Newcomb M, Thompson J. Continuous quality improvement efforts decrease postoperative ileus rates. J Healthc Qual Off Publ Natl Assoc Healthc Qual. 2000 Apr;22(2):4-7, 15.

33. Rubin H, Carlson S, DeMeo M, Ganger D, Craig RM. Randomized, double-blind study of intravenous human albumin in hypoalbuminemic patients receiving total parenteral nutrition. Crit Care Med. 1997 Feb;25(2):249–52. https://doi.org/10.1097/00003246-199702000-00009 PMid:9034259

34. Moskovitz DN, Kim Y-I. Does perioperative immunonutrition reduce postoperative complications in patients with gastrointestinal cancer undergoing operations? Nutr Rev. 2004;62(11):443–447. https://doi.org/10.1111/j.1753-4887.2004.tb00016.x PMid:15622717

35. Dempsey DT, Mullen JL, Buzby GP. The link between nutritional status and clinical outcome: can nutritional intervention modify it? Am J Clin Nutr. 1988 Feb;47(2 Suppl):352–6. PMid:3124596