Original Research Article

Role of pre-operative serum albumin level in predicting the post-operative outcomes in gastrointestinal surgery

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ABSTRACT

Background: The prevalence of protein-energy malnutrition in surgical patients is seen in 30-50% of surgical patients with gastrointestinal disease. Malnutrition and hypalbuminemia contribute to increased morbidity and mortality. Serum albumin level is a low-cost key element in nutritional assessment. Clavien-Dindo classification of post-operative complications enables stratification of post-operative complication.

Methods: We retrospectively analysed the prospectively maintained data of 136 patients who underwent major gastrointestinal procedures from October 2019 to March 2020. We assessed the pre-operative; intra operative parameters, outcome variables and the postoperative complications were graded according to Clavien-Dindo severity, length of ICU stay, length of hospitalization and mortality.

Results: Out of the 136 patients (M: F=3:2), the procedures were hepatopancreatobiliary (n=40), colorectal (n=39), small bowel (n=36) and esophago-gastric (n=19). Pre-operative serum albumin was identified to be single most statistically significant pre-operative variable predicting post-operative complication of Clavien-Dindo severity grade III and above. The ROC curve of the serum albumin level predicting the severe post-operative complication suggested optimal cut off value of 3.1 gm/dl (AUC=0.76; 5% CI=0.64-0.87; p<0.001). Linear regression analysis of serum albumin level predicting the severe post-operative complication suggested good correlation with both of these dependent outcome variables. The serum albumin level correlated inversely with the length of ICU stay and hospitalization.

Conclusions: Low pre-operative albumin (serum level <3.1 gm/dl) in patients undergoing major gastrointestinal surgery predicts severe post-operative complications, prolonged ICU and hospital stays.

Keywords: Gastrointestinal Surgery, Hypoalbuminemia, Postoperative complication, Clavien-Dindo

INTRODUCTION

The prevalence of protein-energy malnutrition in surgical patients is high and is seen in 30% of surgical patients with gastrointestinal disease and this can be up to 60% of the patients in whom the hospital stay has been prolonged as a result of post-operative complication.1 The data from an Indian study also reported that the malnutrition has a prevalence of 30-50% in hospitalized patients.2

Malnutrition and hypoalbuminemia causes a significant increase in the postoperative complications by impairing host immune function, causing muscle dysfunction, decreasing collagen synthesis, and delaying tissue healing and is generally considered to be detrimental to surgical outcomes.3-5

It is important to recognize the malnourished patients before surgical intervention to minimize the morbidity
and mortality of these patients. There are many tools to assess patient’s nutritional status. Serum albumin level constitutes a vital parameter for assessing adequate nutritional reserves. It is a low-cost key element in nutritional assessment and has been found to be closely correlating with the clinical outcomes. Serum albumin level has also been validated as a component of the Acute Physiology and chronic health evaluation III (APACHE III) score that is used to predict morbidity and mortality in critically ill patients.

Clavien-Dindo classification of post-operative complications has enabled stratification of post-operative complication of varying severity. In order to establish the relationship between the pre-operative serum albumin level and the degree of severity of post-operative complications, the latter need to be objectively stratified. The Clavien-Dindo classification has enabled the stratification of the post-operative morbidity according to the varying severity. Our study aims to find out the role of pre-operative serum albumin level in predicting the post-operative outcomes.

METHODS

The present study was a retrospective observational study carried out between October 2019 and March 2020 in Department of Surgical Gastroenterology and Liver Transplantation (SGE and LT) in Bangalore Medical College and Research Institute (BMC and RI), Bengaluru, India. All patients undergoing both elective and emergency major gastro intestinal surgery in Department of SGE and LT in BMC and RI were included in the study.

An estimated sample size of 130 was proposed at the time of study protocol. This was calculated with the formula used for testing multiple regressions. The sample size was calculated to establish a moderate correlation (r =0.40). The minimum sample size with type I error of 5% and power of 90% was found to be 130. All consecutive patients admitted in Dept. of Surgical Gastroenterology and Liver Transplantation who meets the Inclusion and Exclusion Criteria during the study period was included in the study.

Inclusion criteria

All consecutive patients undergoing both elective and emergency major gastro intestinal surgery in Department of Surgical Gastroenterology and Liver Transplantation of BMC and RI, Bengaluru.

Exclusion criteria

Patient’s with organ dysfunction- like chronic liver disease, chronic kidney disease, congestive cardiac failure, severe COPD etc., patients with BMI of 40 or of 35 to 40 with significant medical problems caused by or made worse by their weight, liver or renal transplant, donor or recipient, patients on immune suppression, patients on artificial nutrition, dialysis were excluded.

Pre-operative evaluations

In an attempt to reflect the true conditions of the major gastrointestinal surgery in our hospital, we used the Albumin value obtained together with other parameters determined preoperatively in actual clinical practice to assess the patient’s preoperative status. Pre-operative data obtained included age, gender, BMI, Charlson’s comorbidity score, current smoker within one year, alcohol abuse defined as more than 2 drinks per day within 2 weeks of admission, previous operation in 30 days, chemotherapy in last 30 days of operation, radiotherapy in last 90 days before operation, pre-operative serum albumin level, ASA grade and neoplastic/non-neoplastic condition.

Intra-operative evaluations

Nature of surgery (elective or emergency), type of surgery (laparoscopic/open), operation type (gastro esophageal, hepatobiliary, small bowel or colorectal), wound class (clean/clean contaminated/contaminated/dirty) duration of surgery, intra operative blood loss and need for blood and blood products.

A data was retrieved from the electronic database maintained for carrying out the proposed research programme.

Patients were categorised based on serum albumin level after calculating the cut off value following the data collection. Patients were followed up for 30 days post-surgery.

Post-operative evaluations

Four dependent variables related with the postoperative clinical course were studied. Post-operative complications are graded according to Clavien-Dindo classification, post op length of ICU stay, length of hospital stay and operative mortality.

Statistical analysis

Main outcome variables analysed were Clavien-Dindo complications grade, length of ICU stay, hospital stay and mortality.

Statistical testing conducted with the statistical package for the social science system version SPSS 17.0. Continuous variables presented as mean±SD or median (IQR) for non-normally distributed data. Categorical variables expressed as frequencies and percentages.

A receiver operating characteristics (ROC) analysis calculated to determine optimal cut-off value for pre-operative albumin in predicting the post-operative
complications in gastro intestinal surgery. The area under the curve, the sensitivity, and the specificity calculated to analyse the diagnostic accuracy of pre-operative albumin levels in predicting the post-operative complications.

The comparison of normally distributed continuous variables between the groups is performed using Student’s t test, otherwise Mann Whitney U test was used. Nominal categorical data between the groups compared using Chi-squared test or Fisher’s exact test as appropriate. For all statistical tests, a p value less than 0.05 taken to indicate a significant difference.15

RESULTS

From October 2019 to March 2020, one hundred & thirty six consecutive patients underwent major gastro intestinal surgical operations in Department of Surgical Gastroenterology and Liver Transplantation of BMC and RI that have been included in the study.

Operations were categorised into various organ system i.e. esophagogastric (n=19, 14%), hepatopancreatic biliary (n=40, 30%), small bowel (n=36, 27%), colorectal operations (n=39, 29%). Hepatopancreatic biliary operations constituted the majority; which is followed by colorectal, small bowel and esophagogastric procedures in that order.

Patient demographics and characteristics

There were 88 males and 48 females in the study group. The age group ranged from 12 to 89 years with the median age of 55 years. The BMI of the patients were 24.28±5.73 (mean±SD). About 74% of the patients in the study were having Charlson’s co-morbidity11 score less than 4. Majority of operated patients (72%) were of ASA grade ≥2.13 The history of smoking and alcohol consumption was present in 22% and 18% of patients respectively. Only 4 patients have undergone abdominal procedures within 30 days before the index surgery. None of the patients had history of chemotherapy or radiotherapy in the last 30 days of index operation (Table 1).

Intra-operative variables

Most of the patients underwent elective surgery (88%) and by open route (75%). The duration of surgery ranged between 20-680 min with a mean duration of 232.2±95.69 (mean ±SD) min. The mean±SD blood loss of 270.95±238.78 ml. 35% of patients needed intraoperative blood transfusion (Table 2).

Pre-operative serum albumin

Low pre-operative serum albumin level was associated with higher grade of post-operative complications. The area under the curve on ROC of 0.76 (Figure 1) was obtained with serum albumin level in predicting the of post-operative complication severity of Clavien-Dindo grade 3 to 5. Optimal cut off point of serum albumin level in predicting the post-operative complication severity was found to be 3.1 gm/dl (95% CI 0.64- 0.87; p<0.001) with a sensitivity of 42.85%, specificity of 89.23%.

Table 1: Distribution of pre-operative variables.

| Variables               | N   | Percentage |
|------------------------|-----|------------|
| Age (years)            |     |            |
| ≤ 50                   | 58  | 42         |
| > 50                   | 78  | 58         |
| Sex                    |     |            |
| Males                  | 88  | 65         |
| Females                | 48  | 35         |
| BMI (kg/m²)            |     |            |
| <18.5                  | 14  | 10         |
| 18.5-24.9              | 72  | 53         |
| 25-29.9                | 36  | 27         |
| >30                    | 14  | 10         |
| Charlson’s comorbidity index | |            |
| 0                      | 25  | 19         |
| 1-4                    | 75  | 55         |
| >4                     | 35  | 26         |
| ASA                    |     |            |
| ≤2                     | 98  | 72         |
| >2                     | 38  | 28         |
| Smoking                |     |            |
| Yes                    | 30  | 22         |
| No                     | 106 | 78         |
| Alcohol abuse          |     |            |
| Yes                    | 25  | 18         |
| No                     | 111 | 82         |
| Previous operation in 30 days | |            |
| Yes                    | 4   | 3          |
| No                     | 132 | 97         |

Table 2: Intra-operative characteristics of the patient.

| Intra-operative characteristics | Values     |
|---------------------------------|------------|
| Nature of Surgery               | Elective 119 (88%) |
|                                 | Emergency 17 (12) |
| Route of operation              | Open 102 (75) |
|                                 | Laparoscopic 34 (25) |
| Duration of operation (mins)    | Mean ±SD 232.2±95.69 |
|                                 | Median 240 |
|                                 | Range 20-680 |
| Blood loss (ml)                 | Mean ±SD 270.95±238.78 |
|                                 | Median 167 |
|                                 | Range 30-1500 |
| Requirement of blood transfusion| No 88 (65) |
|                                 | Yes 48 (35) |

Primary outcome variable

Majority of the patients (78%) had less than grade III complications; However about 22% of patients developed grade III or more severe post-operative complication. Seven patients in the study group died post-operatively; of which 4 were following elective and 3 were following emergency operations. Grade 0: 31 (23%), Grade1: 30 (22%), Grade II: 45 (33%); Grade III: 11 (8%), Grade IV: 10 (7%) and Grade V: 9 (7%).
Secondary outcome variables

The median length of ICU stay was 1 day (range 0-7 days) and median length of hospital stay was 9 days (3-27 days).

Pre-operative variables and severity of post-operative complications

The pre-operative variables like age, sex, BMI, Pre op serum albumin level, CCI score, ASA score, smoking, alcohol consumption, surgery in last 30 days and pathology (non-malignant or malignant) in predicting the severity of post-operative complications of Clavien-Dindo grade <3 or 3-5 were examined. Only pre-op serum albumin level was found to be statistically significant in predicting the severity of post-operative complications with p<0.001 (Table 3).

Correlation between organ system and the severity of post-operative complications

To establish the correlation between the different organ system and severity of the complications Pearson’s Chi square test was used. There was no significant correlation was found with p=0.397 (Table 4).

Correlation between intraoperative variables and the severity of post-operative complication

Of all the intra operative variables examined in the study the duration of surgery, blood loss and the need for blood transfusion were statistically significant in predicting the severe post-operative complications (Table 5).

Table 3: Pre-operative variables and post-operative complication severity grade.

| Pre-operative variable | Clavien Dindo severity grade <3 | Clavien Dindo severity grade 3-5 | P value |
|------------------------|---------------------------------|---------------------------------|---------|
| Age (mean±SD)          | 52±17                           | 58±8                            | 0.147   |
| Sex (M:F)              | 72:34                           | 16:14                           | 0.244   |
| BMI (mean±SD)          | 24.03±5.03                      | 25.17±0.43                      | 0.32    |
| Pre op serum albumin (mean±SD) | 3.42±0.69                  | 2.74±0.75                        | <0.001  |
| CCI score (median)     | 3                               | 3                               | 0.765   |
| ASA grade              | <2                              | 78                              | 0.651   |
|                        | ≥2                              | 29                              |         |
| Smoking                | Yes                             | 21                              | 0.208   |
|                        | No                              | 86                              |         |
| Alcohol                | Yes                             | 19                              | 0.98    |
|                        | No                              | 87                              |         |
| Previous operation in 30 days | Yes                           | 4                               | 0.872   |
|                        | No                              | 102                             |         |
| Pathology              | Neoplastic                      | 58                              | 0.152   |
|                        | Non-neoplastic                  | 48                              |         |

Table 4: Correlation between organ system and the severity of post-operative complications.

| Organ system      | Clavien Dindo severity grade <3 | Clavien Dindo severity grade 3-5 | P value |
|-------------------|---------------------------------|---------------------------------|---------|
| Hepatopancreaticobiliary | 31                              | 10                             | 0.397   |
| Colorectal        | 31                              | 8                              |         |
| Esophagogastric   | 12                              | 7                              |         |
| Small bowel       | 33                              | 4                              |         |

Table 5: Correlation between intraoperative variables and the severity of post-operative complication.

| Intra operative variables | Clavien Dindo severity grade <3 | Clavien Dindo severity grade 3-5 | P value |
|---------------------------|---------------------------------|---------------------------------|---------|
| Nature of surgery         | Emergency                       | 12                              | 5       |
|                           | Elective                        | 95                              | 24      |

Continued.
Intra operative variables

| Type of surgery          | Clavien Dindo severity grade <3 | Clavien Dindo severity grade 3-5 | P value |
|--------------------------|---------------------------------|---------------------------------|---------|
| Open                     | 76                              | 26                              | 0.264   |
| Laparoscopic             | 30                              | 4                               |         |
| Clean                    | 27                              | 8                               | 0.219   |
| Clean Contaminated       | 73                              | 16                              |         |
| Contaminated             | 6                               | 3                               |         |
| Dirty                    | 1                               | 2                               |         |

| Wound class              |                                 |                                 |         |
|--------------------------|---------------------------------|---------------------------------|---------|
| Clean                    | 27                              | 8                               |         |
| Clean Contaminated       | 73                              | 16                              |         |
| Contaminated             | 6                               | 3                               |         |
| Dirty                    | 1                               | 2                               |         |

| Need blood transfusion   |                                 |                                 |         |
|--------------------------|---------------------------------|---------------------------------|---------|
| Yes                      | 27                              | 19                              | <0.001  |
| No                       | 79                              | 11                              |         |

| Duration of surgery (mean±SD) | 219.62±86.8                     | 276.82±114.86                   | 0.035   |
| Blood loss (mean±SD)         | 236.35±194.56                   | 393.64±31.34                    | 0.02    |

Pre-operative serum albumin and severity of post-operative complication

At an optimal cut off of 3.1gm/dl the ability of pre-operative albumin level in predicting severity of post-operative complication is statistically significant with p<0.001 (Table 6).

Table 6. Post-operative complications.

| Serum albumin level (gm/dL) | Clavien Dindo severity grade <3 | Clavien Dindo severity grade 3-5 | P value |
|-----------------------------|---------------------------------|---------------------------------|---------|
| ≤ 3.1                       | 27                              | 20                              | <0.001  |

Linear regression to predict the complication grade using serum albumin level

On simple linear regression analysis (Table 7) there was statistically significant correlation between pre-op serum albumin level and severity of post-operative complications was established with R²=0.133 and β coefficient of -0.689.

Table 7: Complication grade.

| Variable      | R²       | β        | P value |
|---------------|----------|----------|---------|
| Serum albumin | 0.133    | -0.689   | <0.001  |

Correlation between the lengths of hospital stay, length of ICU stays using serum albumin level

The correlation between the pre-op serum albumin level and the secondary outcome variables (Table 8) like length of post op stay and length of ICU stay was examined with Spearman’s correlation test.12 There was statistically significant correlation between pre-op serum albumin level and both the secondary outcome variables were obtained.

Table 8: Correlation of serum albumin level with Length of hospital stay and ICU stay.

| Variable      | Length of hospital stay | Length of ICU stay |
|---------------|-------------------------|--------------------|
| Serum albumin | Correlation coefficient (r) | -0.417             | -0.308            |
| P value       | <0.001                  | <0.001             |
| N             | 136                     | 136                |

Pre-op serum albumin level and mortality

The ROC curve (Figure 2) of pre-op serum albumin level predicting the mortality showed an optimal cut off point of 3.56gm/dl with area under the curve of 0.70. However, this was not statistically significant with p=0.104.

Figure 2: Serum albumin level predicting the mortality.

DISCUSSION

Malnutrition is identified in 30 to 50% of hospitalised patients; serum albumin level is one of the pre-operative assessment tools for the nutritional status. In the current study 35% of the patients had serum albumin level less than 3.1gm/dl (cut off level obtained in the study to predict severe post-operative complication).
The negative influence of hypoalbuminemia may be attributed to poor tissue healing, decreased collagen synthesis, and granuloma formation in surgical wounds, ultimately delaying wound healing.14-16 Several studies have demonstrated the adverse influence of the hypoalbuminemia in trauma, cardiac and general surgical procedures.17,18

A systematic review of 15 studies on elderly general surgery patients (>65 years) from 1998 to 2008 revealed that weight loss and serum albumin concentration were predictive parameters for postoperative outcome.19 This has been confirmed in a recent cohort study of patients undergoing major upper gastrointestinal surgery.20

In our study, we have graded the post-operative complications according to the Clavien-Dindo classification. This has enabled the objective stratification of the post-operative complication severity. We have found out that serum albumin level was a lone statistically significant (p≤0.001) pre-operative predictor of post-operative severity of Clavien-Dindo grade 3 and above. The optimal cut off value of albumin level to predict the post-operative complication severity was found to be 3.1 gm/dl (AUC-0.760; 95% CI 0.649-0.870; p≤0.001). The regression analysis of the albumin level in predicting the severe complication has established a statistically significant correlation between the pre-operative serum albumin level and post-operative Clavien Dindo severity grade. A unit change in the grade of severity (i.e. say grade II to grade III) can completely change the patient’s post-operative course. Our study demonstrated that a 1gm decrease in the albumin level increased the risk of severity of post-operative complication by approximately 69% (β=-0.689).

The previous studies have identified the cut off level of the albumin to predict the postoperative complication to be in the range of 3 to 3.5 gm/dl.21-23 Similar to some of the other studies on hypoalbuminemia we have established statistically significant correlation between the pre-operative serum albumin level and the length of hospital stay, post op ICU stay with respective Spearman’s correlation coefficient of ‘r’ equal to -0.417 and -0.308.21,23,24

However, the current study failed to establish statistically significant correlation between the pre-operative serum albumin level and mortality. Although ROC curve on albumin level predicting mortality had an area under the curve of 0.7 which was found to be statistically not significant (p=0.104).21,25

Unlike the other studies the present study has failed to establish correlation between other pre-operative variables like BMI, ASA grade, pathology, surgical site. This can be explained by the fact that the study has attempted a correlation with the higher grades of severity of complication and not the mere occurrence.22,25

The present study has shown good correlation of pre-operative serum albumin level with post-operative Clavien Dindo complication severity grades, length of ICU stay and hospitalisation. Therefore a modest decrease in the serum albumin level can lead to a more severe grade of complication, prolonged ICU stay and hospitalisation.

According to the ESPEN (European Society for Parenteral and Enteral Nutrition) guidelines on clinical nutrition 2017, serum albumin level <3 gm/dl is considered to be one of the criteria for severe nutritional risk. The guideline recommends the pre-operative nutritional therapy in patients undergoing major surgery. The guidelines recommend the therapy even in those patients with cancer where operation has to be delayed. Appropriate duration of therapy recommended is 7-14 days.26

LIMITATIONS

There are certain limitations in the present study. The study comprised of a small sample size. The other limitation of the study is the existence of heterogenous procedures. The correlation between the pre-operative serum albumin and post-operative complication severity in the background of heterogeneity may not reflect the causal relationship. The study can be done on a homogenous group of patients with better matched population to establish the causal relationship. The study has not considered the other nutritional assessment tool other than BMI which directly or indirectly contribute to the severity of post-operative complications.

CONCLUSION

Low pre-operative albumin (serum level less than 3.1 gm/dl) in patients undergoing major gastrointestinal surgery predicts severe post-operative complications, prolonged ICU and hospital stays.

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REFERENCES

1. Macfie J. Nutrition and fluid therapy. Bailey and Love, Short Practice of Surgery 27th ed. CRC Press. USA. 2018: 278.
2. Chakravarty C, Goswami L, Hazarika B, Ramasubban S. Prevalence of malnutrition in a tertiary care hospital in India. Ind J Crit Care Med. 2013;17:170.
3. Studley HM. Percentage of weight loss e a basic indicator for surgical risk in patients with chronic peptic ulcer. JAMA 1936;106:458-60.
4. Van Bokhorst-de van der Schueren MA, van Leeuwen PA, Sauerwein HP, Kuik DJ, Snow GB,
Quak JJ. Assessment of malnutrition parameters in head and neck cancer and their relation to postoperative complications. Head Neck. 1997;19:419-5.

5. Durkin MT, Mercer KG, McNulty MF, Phipps L, Upperton J, Giles M, et al. Vascular surgical society of great britain and ireland: contribution of malnutrition to postoperative morbidity in vascular surgical patients. Br J Surg. 1999;86:702.

6. 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;57:469-72.

7. Zhou, J., Hiki, N., Mine, S. et al. Role of Prealbumin as a Powerful and Simple Index for Predicting Postoperative Complications After Gastric Cancer Surgery. Ann Surg Oncol. 2017;510-517

8. Fuhrman MP, charney P, Mueller CM. Hepatic proteins and nutrition assessment. J Am Diet Assoc. 2004;104:1258-64.

9. Knaus WA, Wagner DP, Draper EA, Zimmerman JE, Bergner M, Bastos PG, et al. The APACHE III Prognostic System. Chest. 1991;100:1619-36.

10. 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;250:187-96.

11. Charlson, M., Szatrowski, T., Peterson, J. and Gold, J. Validation of a combined comorbidity index. J Clin Epidemiol. 1994;47(11):1245-51.

12. Campbell M, Machin D, Walters S. Medical statistics. Chichester: John Wiley and Sons, Ltd; 2010.

13. Mayhew D, Mendonca V, Murthy BVS. A review of ASA physical status-historical perspectives and modern developments. Anaesthesia. 2019;74:373-9.

14. Ward MWN, Danzi M, Lewin MR, Rennie MJ, Clark CG. The effects of subclinical malnutrition and refeeding on the healing of experimental colonic anastomoses. Br J Surg. 1982;69:308-10.

15. Reynolds J V, Redmond HP, Ueno N, Steigman C, Ziegler MM, Daly JM, et al. Impairment of macrophage activation and granuloma formation by protein deprivation in mice. Cell Immunol. 1992;139:493-504.

16. Testini M, Margari A, Amoruso M, Lissidini G, Bonomo GM. The dehiscence of colorectal anastomoses: the risk factors. Ann Ital Chir. 2000;71:433-40.

17. Goiburú ME, Goiburú MMJ, Bianco H, Díaz JR, Alderete F, Palacios MC, et al. The impact of malnutrition on morbidity, mortality and length of hospital stay in trauma patients. Nutr Hosp. 2018;21:604-10.

18. Rich MW, Keller AJ, Schechtman KB, Marshall WG, Kouchoukos NT. Increased complications and prolonged hospital stay in elderly cardiac surgical patients with low serum albumin. Am J Cardiol. 1989;63:714-8.

19. van Stijn MF, Korkic-Halilovic I, Bakker MS, van der Ploeg T, van Leeuwen PA, Houdijk AP. Preoperative nutrition status and postoperative outcome in elderly general surgery patients: a systematic review. J Parenter Enteral Nutr. 2013;37:37-43.

20. Aahlin EK, Tranø G, Johns N, Horn A, Soreide JA, Fearon KC, et al. Risk factors, complications and survival after upper abdominal surgery: a prospective cohort study. BMC Surg. 2015;15:83.

21. Moghadamyaneghaneh Z, Hwang G, Hanna MH, Phelan MJ, Carmichael JC, Mills SD, et al. Even modest hypoalbuminemia affects outcomes of colorectal surgery patients. Am J Surg. 2015;210:276-84.

22. Hennessey DB, Burke JP, Ni-Dhonnchú T, Shields C, Winter DC, Mealy K. Preoperative Hypoalbuminemia is an Independent Risk Factor for the Development of Surgical Site Infection Following Gastrointestinal Surgery. Ann Surg. 2010;252:325-9.

23. Lohsiriwat V, Lohsiriwat D, Boonmuch W, Chinswangwatanakul V, Akaraviputh T, Lertakayamanee N. Pre-operative hypoalbuminemia is a major risk factor for postoperative complications following rectal cancer surgery. World J Gastroenterol. 2008;14:1248.

24. Kudsk K, Tolley E, DeWitt R, Janu P, Blackwell A, Yeary S, et al. Preoperative albumin and surgical site identify surgical risk for major postoperative complications. J Parenter Enter Nutr. 2003;27:1-9.

25. Gibbs J. Preoperative Serum Albumin Level as a Predictor of Operative Mortality and Morbidity. Arch Surg. 1999;134:36.

26. Weimann A, Braga M, Carli F, Higashiguchi T, Hübner M, Klek S, et al. ESPEN guideline: Clinical nutrition in surgery. Clin Nutr. 2017;36:623-50.