

HOW DO SURGICAL STRESS AND LOW PERIOPERATIVE SERUM PROTEIN AND ALBUMIN IMPACT UPON SHORT TERM MORBIDITY AND MORTALITY IN GASTRIC CANCER SURGERY?

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Abstract

Background. Patients undergoing surgery for gastric cancer may be expected to develop a certain range of postoperative complications. This retrospective cohort study determined if gauging the serum value of total proteins and albumins before and especially after surgery can predict an undesired short term outcome in patients with gastric resections for cancer, as we have not found studies debating the link between low postoperative total proteins or albumins and early postoperative morbidity.

Methods. A total of 195 patients with gastric cancer who had been subjected to gastric resection (83 patients) or total gastrectomy (111 patients), were subsequently arranged into study group pairs. In each of these group pairs, one group had a complication, while another was without said complication, or total vs. subtotal gastrectomy, etc. Each of these group pairs were compared between them in order to determine if total serum proteins and/or albumins, before and/or after surgery could predict the onset of certain complications or death. In the end, we performed ROC curves to determine the predictability value of variables for certain complications.

Results. preoperative serum albumin can predict an early onset of anastomotic leakage ($p=0.02$) as it can predict the occurrence of general complications ($p=0.018$) and surgical wound infections ($p=0.029$) as well as a higher risk of reoperation for the management of complications ($p=0.028$). Total serum protein may be tied to a higher surgical stress, like albumin, as it was significantly lower in patients undergoing total gastrectomy as compared to those subjected to subtotal gastrectomy ($p=0.0001$ total proteins, $p=0.0001$ albumins). Postoperative low total serum proteins and albumins translate in a risk of early postoperative death ($p=0.031$ total proteins, $p=0.001$ albumins).

Conclusion. We demonstrated the fact that total serum proteins and serum albumins, checked both before and after surgery, are of great value in helping predict a series of postoperative complications in gastric cancer surgery and that they can also be used as surgical stress markers.

Keywords: serum albumin; stomach neoplasms, gastrectomy, protein; gastric surgery; complications

Background and aims

Gastric cancer is a leading culprit in cancer-caused death all over the world. It is also a frequently occurring form of cancer, being the sixth most common type of cancer [1].

Apart from early gastric cancer and small benign tumors, most other forms of gastric cancer end up in a surgical clinic, either for curative treatment or for palliation. The complete surgical removal of the tumor and adjacent lymph node groups is the only hope in curing gastric carcinoma [2].

Even if more than a hundred years have passed since Billroth and Schlatter first performed a subtotal gastrectomy and a total gastrectomy for cancer, the optimal operation for tumors of the distal or middle stomach remains debatable [3,4]. Multicentric European studies, including thousands of patients, show that 44% (5) of surgeons opt for a total gastrectomy in case of an antral cancer. A US study based on data from the National Cancer Data Base [5] shows that total gastrectomy was only performed in 12.3% of patients with antral or pyloric cancer. One objective of this study is to determine whether these procedures differ in terms of outcome, while indirectly determining the surgical stress caused, comparing early postoperative complications and mortality of the two procedures.

Another objective of this study is to determine whether preoperative as well as early postoperative serum albumin and total serum protein values can predict the onset of surgical complications, such as anastomotic leakage, which is an important complication of gastrointestinal surgery. It leads to increased postoperative morbidity, being the main cause of mortality after intestinal resections. Identification of predisposing factors is paramount in the prevention of anastomotic leakage [6] We only found studies analyzing the connection between albumin and surgical complications such as anastomotic leakage in colorectal cancer surgery [7,8] and only preoperatively, while few other studies debated the problem of postoperative low total serum protein values in abdominal cancer surgery [9] and an unfavorable outcome.

We tried to search for a link between both preoperative and postoperative serum albumin and total serum protein levels and an unfavorable postoperative outcome in gastric cancer patients. We also tried to assess the predictability value of serum albumin and total serum proteins for the onset of surgical short term complications.

Methods

Our retrospective cohort study included gastric cancer patients admitted and operated in the 3rd Surgical Clinic of the Octavian Fodor Regional Institute of Gastroenterology and Hepatology from Cluj-Napoca, Romania, between 2009 and 2015. Only patients already present in the hospital database were included and their total number was 1058. We excluded from the study

group the gastric cancer patients who underwent palliative procedures. From the remaining 761 patients, we only selected patients with records of both preoperative and postoperative (first day after surgery) serum protein and albumin values in the database. Thus, the final number of patients was 195. Patients were aged between 21 and 88 years with an average of 64 years: 62 patients were female and 133 were male. Of these patients, 111 underwent total gastrectomy, 75 underwent subtotal gastrectomy and 8 underwent superior gastric resection. From the database we selected for analysis the following variables: haemorrhagic complications, duodenal stump leakage, anastomotic leakage, abdominal abscesses, surgical wound evisceration, surgical wound infection and general complications (such as cardiac arrest, pulmonary thrombembolism, pneumonia, bowel obstruction, etc.), preoperative serum total protein and albumin values, total protein and albumin values on the first postoperative day and deaths.

For the statistical analysis we used the IBM SPSS software, version 20. The patients were subsequently split into groups for statistical evaluation: two groups of patients, one with haemorrhagic complications versus the other without this complication (193 vs. 1); one group with duodenal stump leakage versus a group without duodenal stump leakage (187 vs. 7); one group with anastomotic leakage versus those without anastomotic leakage (177 vs. 17); a group with early abdominal abscesses versus a group without said abscesses (182 vs. 12); a group with general complications versus a group without general complications (165 vs. 29); a group with early postoperative surgical wound evisceration versus a group without surgical wound evisceration (192 vs. 2); a group with early surgical wound infection versus a group without surgical wound infection (181 vs. 13); a group without any complications versus a group with any complication (138 vs. 56); a group of patients who underwent total gastrectomy versus a group of patients who underwent subtotal gastrectomy (111 vs 83); a female versus male group (61 vs 133); a group of patients who underwent reoperation for the management of complications versus a group with no reoperation (21 vs. 173); a group of the deceased versus a group with no deaths (19 vs. 175). All these group pairs were checked for valid statistical correlations concerning preoperative total serum proteins and albumins and their decrement (preoperative-postoperative total protein), (first day) postoperative total serum proteins and albumins and their decrement (preoperative-postoperative total protein). For these analyses we used the Mann-Whitney and the Student test. Finally we used the ROC curves to try and find out if the general complications are predicted by the preoperative serum albumin levels and did the same for wound infection and preoperative serum albumin levels, as for the lack of complications and the serum albumin levels, deaths and first postoperative day total serum protein levels, duodenal stump leakage for patients undergoing total gastrectomy

and first postoperative day total serum protein levels, risk of death for patients over 45 years characterized through the first postoperative day's total serum protein levels, this final part conferring our study also an experimental nature.

Results

For the first group, comparing patients with haemorrhagic complications to those without such complications, after performing the T Student test and the Mann-Whitney test, no statistically relevant differences were found. This shows preoperative and postoperative total serum proteins and albumin values, have no apparent effect on haemorrhagic complications. However, since there was only one case of haemorrhage in our study group, this conclusion is of little significance (Table I).

The second group, comparing patients with duodenal stump fistula with those showing no such complication, after being subjected to the Mann-Whitney and Student test, no statistically relevant differences were found (Table II).

The third group pair (Table III), comparing patients with anastomotic leakage to those without anastomotic leakage, after being subjected to the Mann-Whitney and Student test, the only statistically relevant find is that lower preoperative serum albumin values impact negatively on the occurrence of anastomotic leakage, the average difference between the two groups, with and without leakage being 4.01 mg/dl versus 4.38 mg/dl, difference found to be statistically relevant ($p=0.02$).

The fourth group pair (Table IV) compared patients with postoperative abdominal abscesses to those without. The statistical analysis yielded no significant results concerning the influence of total serum proteins or albumin levels upon this type of complication.

The fifth group pair (Table V) compares patients with general complications (such as cardiac arrest, pulmonary thrombembolism, pneumonia, bowel obstruction, etc.) to patients without general complications. The patients in the general complications group showed statistically significant lower preoperative serum albumin levels, an average of 4.07 mg/dl vs. 4.32 mg/dl, $SD=0.64$ vs. 0.70 , $p=0.018$ (Mann-Whitney), with a $p=0.018$.

The sixth group pair (Table VI) compares patients with surgical wound evisceration to those without surgical wound evisceration. The Student and Mann-Whitney tests both showed no statistically relevant differences between the two groups regarding total serum protein and albumin levels.

The seventh group pair (Table VII) compares cases of surgical wound infection to those with no surgical wound infection. Two statistically significant differences between the two groups were found [10]. One was preoperative serum albumin. The mean value for patients showing the complication was 4.03 mg/dl versus 4.30 for the ones free of the complication. Comparing the two using the Mann-

Whitney test yielded a p value of 0.029, showing that patients with lower preoperative serum albumin levels are more prone to surgical wound infection; as are those with a greater intraoperative albumin loss.

The eighth group set (Table VIII) compares patients with no postoperative complications to those with any of the aforementioned complications followed by this study. Preoperative serum albumin levels of patients with no postoperative complications were significantly higher than those with any complication, the mean being 4.38 mg/dl (no complications) versus 4.06 (with complications). This shows again that lower preoperative albumin levels can predict a worse postoperative outcome. What is interesting is the fact that the postoperative serum albumin levels for patients with postoperative complications were also found to be lower, and the difference is statistically relevant. The total intraoperative albumin loss was also statistically lower for the patients showing postoperative complications.

A ninth group set (Table IX) was formed of patients undergoing a total gastrectomy compared to a group of patients undergoing subtotal gastrectomy. The statistically significant difference found between the two groups was the postoperative value of the total serum proteins. The TG group came out of surgery with a lower serum protein value than the non-TG group, showing that TG impacts heavier upon the patient's system than subtotal gastrectomy. For the TG group, the mean total serum protein value was 5.32 mg/dl, while the mean of the non-TG group was 5.78 mg/dl. The Student test found a p value of 0.0001.

Emphasizing the former statement, serum albumin values after surgery were also found lower for the TG group as compared to the non-TG group. Serum albumin mean value for the TG patients was 3.12 mg/dl versus 3.41 mg/dl for the non-TG group, with $p=0.0001$ (Student test).

The intraoperative total protein loss (PT) and total albumin loss (Alb) were also significantly lower for the patients who were subjected to total gastrectomy.

The tenth group set (Table X) compared female to male patients, in order to determine if there is any sex related difference in the way which gastric surgery impacts upon the system. The result shows a significantly lower postoperative serum total protein and albumin value for the female group. Total protein mean value for the females was 5.32 mg/dl and 5.60 mg/dl for the male patients ($p=0.035$, Student test) and the serum albumin mean for the female group was 3.12 mg/dl versus 3.29 mg/dl for males ($p=0.028$, Student test).

An eleventh group pair (Table XI) was made up of patients undergoing reoperations for the management of complications after gastric surgery versus patients without reoperation. Serum albumin levels both before and after the first surgery for patients suffering complications which required a surgical management, were lower than those of patients free of complications or with complications not needing a surgical approach. The mean values for serum

albumin before surgery for patients with reoperation were 4.01 mg/dl compared to 4.32 mg/dl for patients with no reoperation ($p=0.028$ Mann-Whitney). The postoperative serum albumin level mean for patients requiring reoperation was 3.03 mg/dl versus 3.27 mg/dl for patients not needing reoperation ($p=0.03$ Mann-Whitney).

The twelfth group set (Table XII) is composed of a group of patients who deceased in the short term postoperative period and a group of patients who survived. The total serum protein value after surgery was also significantly lower for the group of patients suffering deaths. The mean for these patients was 5.14 mg/dl compared to 5.56 mg/dl for patients who survived. The Student test in this case yielded a p value of 0.031. The same can be said for the serum albumin level after surgery. Patients who died showed a mean of 2.89 mg/dl vs. 3.28 mg/dl for the patients who survived ($p=0.001$, Mann-Whitney test).

A ROC analysis was performed to determine if the preoperative albumin value can be used as a predictive variable for the onset of general complications (Figure 1). The area under the ROC curve is 0.638, with a $CI_{95\%}=[0.531;0.745]$ ($p=0.018<0.05$), being different from an area of 0.5. This means that the preoperative albumin value can be used for diagnostic purposes for predicting the onset of general complications after gastric surgery.

We also performed the ROC curve analysis to assess the predictability value of the preoperative serum albumin concerning the onset of surgical wound infection (Figure 2). The area under the ROC curve is 0.707, $CI_{95\%}=[0.556;0.857]$ ($p=0.013<0.05$). It is statistically different from an area of 0.5, meaning that the preoperative albumin value can be used to predict the onset of surgical wound infections after gastric surgery.

This ROC curve (figure 3) was performed to verify the predictability value of the total intraoperative serum albumin loss in predicting surgical wound infection. The area under the ROC curve is 0.707, $CI_{95\%}=[0.556;0.857]$ with a $p=0.013<0.05$, this area being significantly different from an area of 0.5. This proves that the total intraoperative

serum albumin loss can be used as a predictor for surgical wound infections.

The following ROC analysis (Figure 4) characterizes deaths through the postoperative total serum protein values, considering the situation to be positive when death does not occur. The area under the ROC curve is 0.655, $CI_{95\%}=[0.528;0.783]$ with a $p=0.026<0.05$, and is different from the area of 0.5. This means that the first postoperative day's total serum protein value can be used as a predictive variable for the occurrence of death.

The ROC analysis of patients regarding the characterization of duodenal stump leakage through the total postoperative serum protein level for patients who underwent total gastrectomy (Figure 5), considering the situation as positive when there are no complications. The area under the ROC curve is 0.872, $CI_{95\%}=[0.732;1.000]$ with a $p=0.028<0.05$, and is different from the area of 0.5. This means that the first postoperative day's total serum protein value can be used as a predictive variable for the onset of duodenal stump leakage in patients who underwent a total gastrectomy.

The ROC analysis of patients regarding the characterization of deaths through the total postoperative serum protein level for patients over 45 years (Figure 6), considering the situation as positive when death does not occur. The area under the ROC curve is 0.658, $CI_{95\%}=[0.528;0.787]$ with a $p=0.025<0.05$, and is different from the area of 0.5. This means that the first postoperative day's total serum protein value can be used as a predictive variable for the occurrence of early postoperative death in patients over 45 years of age.

The ROC analysis of patients regarding the characterization of surgical reintervention through the postoperative serum albumin level (Figure 7), considering the situation as positive when reintervention does not take place. The area under the ROC curve is 0.645, $CI_{95\%}=[0.518;0.772]$ with a $p=0.03<0.05$, and is different from the area of 0.5. This means that the first postoperative day's serum albumin value can be used as a predictive variable for a possible reoperation.

Table I. Haemorrhagic complications vs. NO haemorrhagic complications.

Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	193	7.19	0.83	>0.05-T
	yes	1	7.7		
PT 1	no	193	5.51	3.03	>0.05-T
	yes	1	6.1		
PT	no	193	1.67	2.98	>0.05-T
	yes	1	1.6		
Alb 0	no	193	4.28	0.7	>0.05-MW
	yes	1	4.3		
Alb 1	no	193	3.24	0.51	>0.05-MW
	yes	1	3.6		
Alb	no	193	1.04	0.61	>0.05-MW
	yes	1	0.7		

PT0=preoperative total serum protein value;

PT1=postoperative total serum protein value;

PT=total intraoperative total serum protein loss;

Alb0=preoperative serum albumin;

Alb1=postoperative serum albumin;

Alb=total intraoperative serum albumin loss;

T=Student (t) test;

MW=Mann-Whitney test. Mean value in mg/dl.

Table II. Duodenal stump leakage vs. NO duodenal stump leakage.

Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	187	7.21	0.81	>0.05-T
	yes	7	6.6	1.06	
PT 1	no	187	5.53	0.84	>0.05-T
	yes	7	5.03	0.94	
PT	no	187	1.67	0.8	>0.05-T
	yes	7	1.57	0.55	
Alb 0	no	187	4.3	0.7	>0.05-MW
	yes	7	3.79	0.33	
Alb 1	no	187	3.26	0.51	>0.05-MW
	yes	7	2.96	0.39	
Alb	no	187	1.04	0.61	>0.05-MW
	yes	7	1.01	0.34	

PT0=preoperative total serum protein value;

PT1=postoperative total serum protein value;

PT=total intraoperative total serum protein loss;

Alb0=preoperative serum albumin;

Alb1=postoperative serum albumin;

Alb=total intraoperative serum albumin loss;

T=Student (t) test;

MW=Mann-Whitney test. Mean value in mg/dl

Table III. Anastomotic leakage vs. NO anastomotic leakage.

Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	177	7.21	0.85	>0.05-T
	yes	17	6.99	0.56	
PT 1	no	177	5.54	0.86	>0.05-T
	yes	17	5.26	0.66	
PT	no	177	1.66	0.8	>0.05-T
	yes	17	1.73	0.7	
Alb 0	no	177	4.38	0.71	0.02-MW
	yes	17	4.01	0.53	
Alb 1	no	177	3.26	0.51	>0.05-MW
	yes	17	3.05	0.47	
Alb	no	177	1.05	0.61	>0.05-MW
	yes	17	0.96	0.55	

PT0=preoperative total serum protein value;
 PT1=postoperative total serum protein value;
 PT=total intraoperative total serum protein loss;
 Alb0=preoperative serum albumin;
 Alb1=postoperative serum albumin;
 Alb=total intraoperative serum albumin loss;
 T=Student (t) test;
 MW=Mann-Whitney test. Mean value in mg/dl.

Table IV. Postoperative abdominal abscesses vs. NO postoperative abdominal abscesses.

Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	182	7.21	0.83	>0.05-T
	yes	12	6.93	0.84	
PT 1	no	182	5.53	0.81	>0.05-MW
	yes	12	5.36	0.76	
PT	no	182	1.67	0.8	>0.05-MW
	yes	12	1.58	0.61	
Alb 0	no	182	4.3	0.69	>0.05-MW
	yes	12	4.04	0.8	
Alb 1	no	182	3.25	0.51	>0.05-MW
	yes	12	3.14	0.59	
Alb	no	182	1.05	0.61	>0.05-MW
	yes	12	0.9	0.42	

PT0=preoperative total serum protein value;
 PT1=postoperative total serum protein value;
 PT=total intraoperative total serum protein loss;
 Alb0=preoperative serum albumin;
 Alb1=postoperative serum albumin;
 Alb=total intraoperative serum albumin loss;
 T=Student (t) test;
 MW=Mann-Whitney test. Mean value in mg/dl.

Table V. General complications vs. NO general complications.

Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	165	7.2	0.83	>0.05-T
	yes	29	7.12	0.8	
PT 1	no	165	5.53	0.83	>0.05-T
	yes	29	5.44	0.92	
PT	no	165	1.66	0.8	>0.05-T
	yes	29	1.68	0.66	
Alb 0	no	165	4.32	0.7	0.018-MW
	yes	29	4.07	0.64	
Alb 1	no	165	3.26	0.52	>0.05-MW
	yes	29	3.17	0.44	
Alb	no	165	1.06	0.62	>0.05-MW
	yes	29	0.9	0.51	

PT0=preoperative total serum protein value;
 PT1=postoperative total serum protein value;
 PT=total intraoperative total serum protein loss;
 Alb0=preoperative serum albumin;
 Alb1=postoperative serum albumin;
 Alb=total intraoperative serum albumin loss;
 T=Student (t) test;
 MW=Mann-Whitney test. Mean value in mg/dl.

Table VI. Wound evisceration vs. NO wound evisceration.

Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	192	7.19	0.83	>0.05-T
	yes	2	7	0	
PT 1	no	192	5.52	0.85	>0.05-T
	yes	2	5.3	0	
PT	no	192	1.66	0.8	>0.05-T
	yes	2	1.7	0	
Alb 0	no	192	4.29	0.69	>0.05-MW
	yes	2	3.65	0.21	
Alb 1	no	192	3.25	0.51	>0.05-MW
	yes	2	2.75	0.21	
Alb	no	192	1.04	0.61	>0.05-MW
	yes	2	0.9	0	

PT0=preoperative total serum protein value;
 PT1=postoperative total serum protein value;
 PT=total intraoperative total serum protein loss;
 Alb0=preoperative serum albumin;
 Alb1=postoperative serum albumin;
 Alb=total intraoperative serum albumin loss;
 T=Student (t) test;
 MW=Mann-Whitney test. Mean value in mg/dl.

Table VII. Surgical wound infection vs. NO surgical wound infection.

Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	181	7.21	0.84	>0.05-T
	yes	13	6.92	0.54	
PT 1	no	181	5.52	0.86	>0.05-T
	yes	13	5.47	0.74	
PT	no	181	1.68	3.07	>0.05-T
	yes	13	1.45	0.83	
Alb 0	no	181	4.3	0.07	0.029-MW
	yes	13	4.03	0.51	
Alb 1	no	181	3.24	0.5	>0.05-MW
	yes	13	3.34	0.66	
Alb	no	181	1.06	0.6	0.014-MW
	yes	13	0.69	0.5	

PT0=preoperative total serum protein value;
 PT1=postoperative total serum protein value;
 PT=total intraoperative total serum protein loss;
 Alb0=preoperative serum albumin;
 Alb1=postoperative serum albumin;
 Alb=total intraoperative serum albumin loss;
 T=Student (t) test;
 MW=Mann-Whitney test. Mean value in mg/dl.

Table VIII. Patients w/o any complication (yes) vs. patients with ANY complication (no).

Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	56	7.03	0.77	>0.05-T
	yes	138	7.25	0.84	
PT 1	no	56	5.41	0.81	>0.05-T
	yes	138	5.56	0.85	
PT	no	56	1.62	0.67	>0.05-T
	yes	138	1.69	0.84	
Alb 0	no	56	4.06	0.6	0.001-MW
	yes	138	4.38	0.71	
Alb 1	no	56	3.15	0.51	0.031-MW
	yes	138	3.28	0.51	
Alb	no	56	0.91	0.49	0.031-MW
	yes	138	1.09	0.64	

PT0=preoperative total serum protein value;
 PT1=postoperative total serum protein value;
 PT=total intraoperative total serum protein loss;
 Alb0=preoperative serum albumin;
 Alb1=postoperative serum albumin;
 Alb=total intraoperative serum albumin loss;
 T=Student (t) test;
 MW=Mann-Whitney test. Mean value in mg/dl.

Table IX. Patients who underwent total gastrectomy (yes) vs. patients who underwent subtotal gastrectomy (no).

Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	83	7.24	0.91	>0.05-T
	yes	111	7.15	0.76	
PT 1	no	83	5.78	0.78	0.0001-T
	yes	111	5.32	0.84	
PT	no	83	0.96	0.43	0.001-T
	yes	111	1.83	0.77	
Alb 0	no	83	4.34	0.72	>0.05-MW
	yes	111	4.24	0.68	
Alb 1	no	83	3.41	0.51	0.0001-MW
	yes	111	3.12	0.48	
Alb	no	83	0.93	0.61	0.031-T
	yes	111	1.12	0.59	

PT0=preoperative total serum protein value;
 PT1=postoperative total serum protein value;
 PT=total intraoperative total serum protein loss;
 Alb0=preoperative serum albumin;
 Alb1=postoperative serum albumin;
 Alb=total intraoperative serum albumin loss;
 T=Student (t) test;
 MW=Mann-Whitney test. Mean value in mg/dl.

Table X. Female patients (no) vs. male patients (yes).

Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	61	7.09	0.82	>0.05-T
	yes	133	7.23	0.28	
PT 1	no	61	5.32	0.92	0.035-T
	yes	133	5.6	0.8	
PT	no	61	1.76	0.92	>0.05-T
	yes	133	1.62	0.75	
Alb 0	no	61	4.19	0.66	>0.05-MW
	yes	133	4.32	0.7	
Alb 1	no	61	3.12	0.54	0.028-T
	yes	133	3.29	0.48	
Alb	no	61	1.07	0.65	>0.05-MW
	yes	133	1.02	0.58	

PT0=preoperative total serum protein value;
 PT1=postoperative total serum protein value;
 PT=total intraoperative total serum protein loss;
 Alb0=preoperative serum albumin;
 Alb1=postoperative serum albumin;
 Alb=total intraoperative serum albumin loss;
 T=Student (t) test;
 MW=Mann-Whitney test. Mean value in mg/dl.

Table XI. Patients with reoperation (yes) vs. patients W/O reoperation (no).

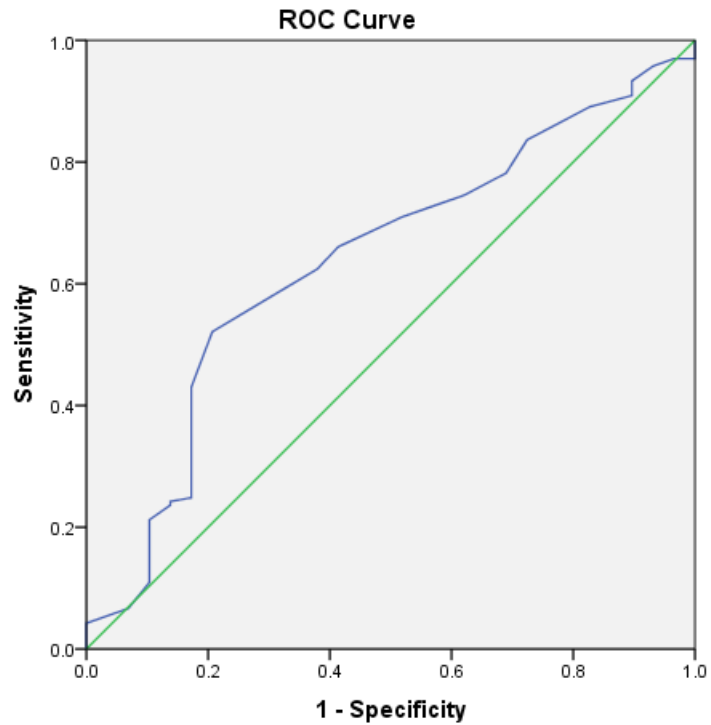
Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	173	7.21	0.85	>0.05-MW
	yes	21	7.02	0.61	
PT 1	no	173	5.54	0.86	>0.05-T
	yes	21	5.3	0.71	
PT	no	173	1.66	0.81	>0.05-T
	yes	21	1.71	0.57	
Alb 0	no	173	4.32	0.7	0.028-MW
	yes	21	4.01	0.57	
Alb 1	no	173	3.27	0.51	0.03-MW
	yes	21	3.03	0.51	
Alb	no	173	1.05	0.62	>0.05-MW
	yes	21	0.43	0.43	

PT0=preoperative total serum protein value;
 PT1=postoperative total serum protein value;
 PT=total intraoperative total serum protein loss;
 Alb0=preoperative serum albumin;
 Alb1=postoperative serum albumin;
 Alb=total intraoperative serum albumin loss;
 T=Student (t) test;
 MW=Mann-Whitney test. Mean value in mg/dl.

Table XII. Deceased patients (yes) vs. surviving patients (no).

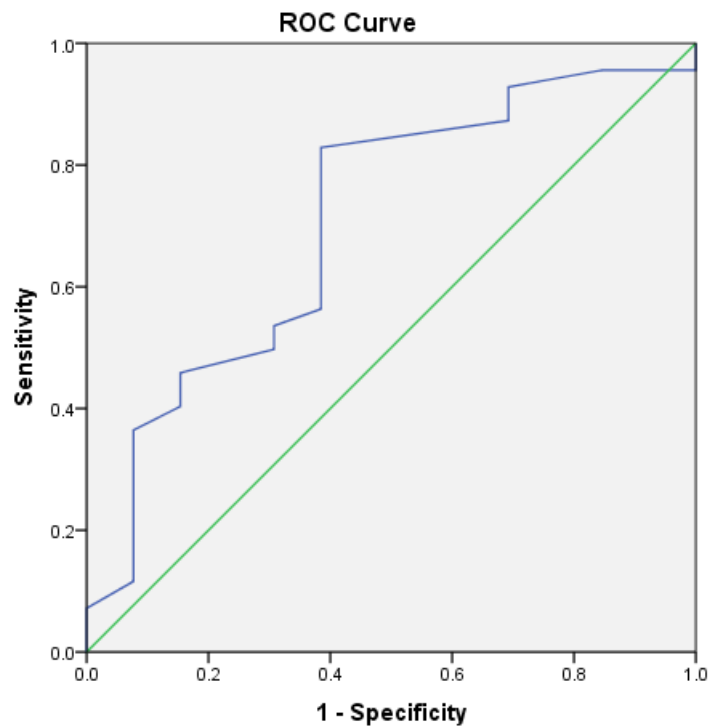
Variable	Presence	No.	Mean	Std. Deviation	P - value
PT 0	no	175	7.19	0.84	>0.05-T
	yes	19	7.14	0.69	
PT 1	no	175	5.56	0.85	0.031-T
	yes	19	5.14	0.75	
PT	no	175	1.63	0.79	>0.05-T
	yes	19	2	0.81	
Alb 0	no	175	4.31	0.7	>0.05-MW
	yes	19	4	0.59	
Alb 1	no	175	3.28	0.51	0.001-MW
	yes	19	2.89	0.43	
Alb	no	175	1.03	0.61	>0.05-MW
	yes	19	1.11	0.58	

PT0=preoperative total serum protein value;
 PT1=postoperative total serum protein value;
 PT=total intraoperative total serum protein loss;
 Alb0=preoperative serum albumin;
 Alb1=postoperative serum albumin;
 Alb=total intraoperative serum albumin loss;
 T=Student (t) test;
 MW=Mann-Whitney test. Mean value in mg/dl.



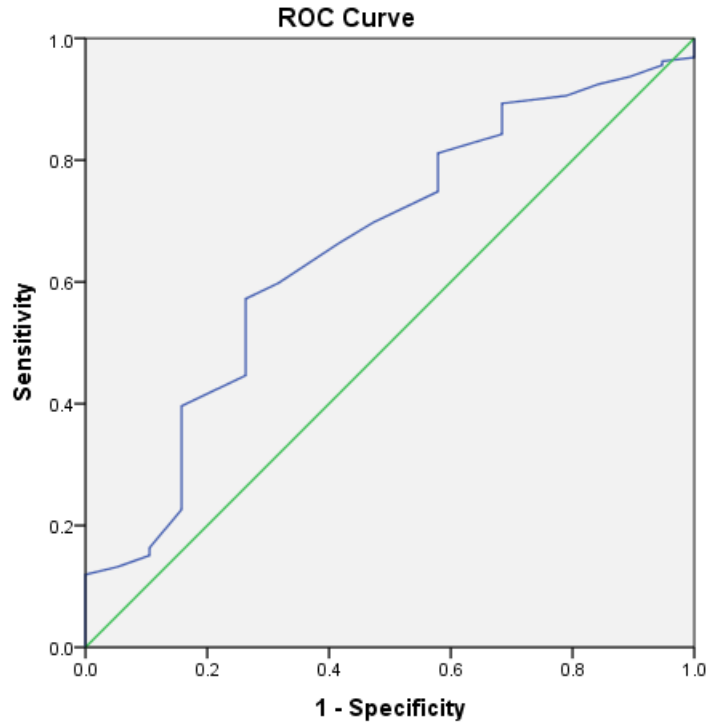
Diagonal segments are produced by ties.

Figure 1. ROC curve characterizing general complications by the preoperative albumin value.



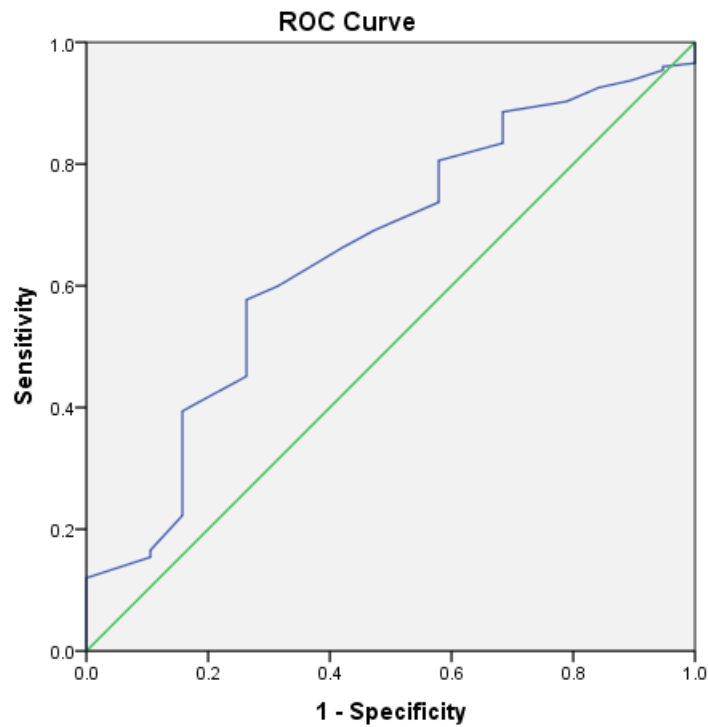
Diagonal segments are produced by ties.

Figure 2. ROC curve characterizing surgical wound infection by the preoperative albumin value.



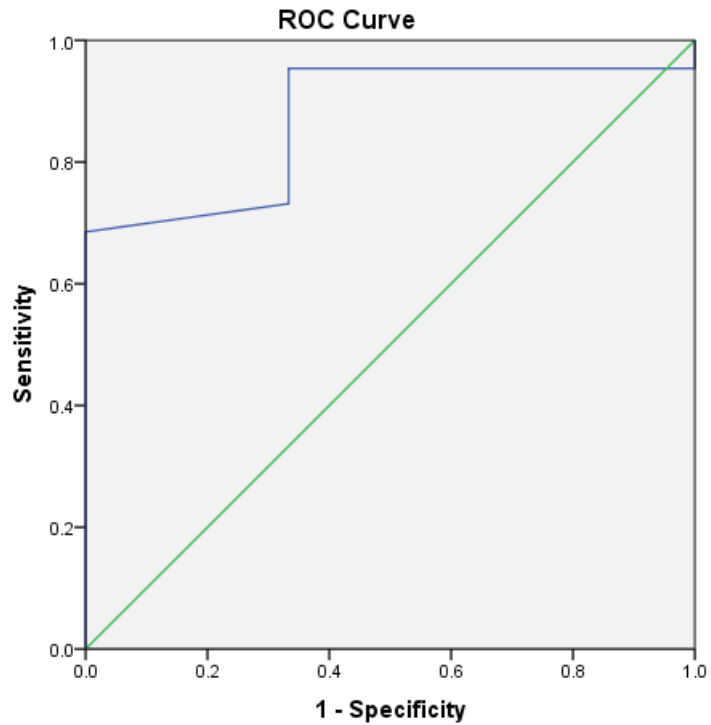
Diagonal segments are produced by ties.

Figure 3. ROC curve characterizing surgical wound infection by the total intraoperative serum albumin loss.



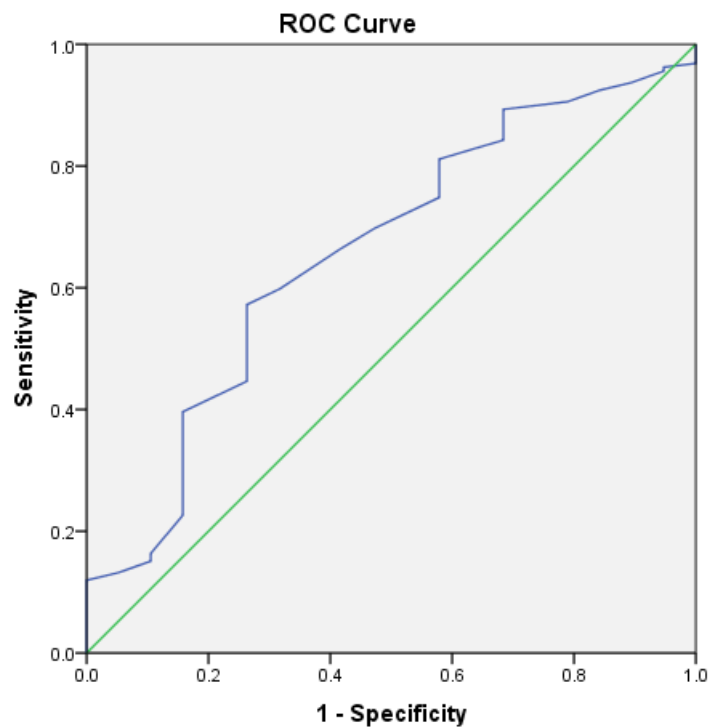
Diagonal segments are produced by ties.

Figure 4. ROC curve characterizing death through the postoperative total serum protein.



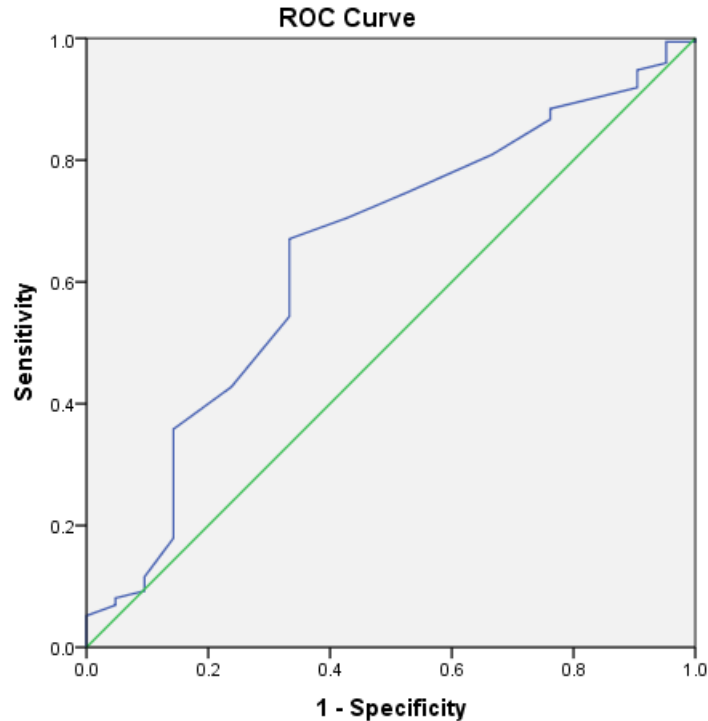
Diagonal segments are produced by ties.

Figure 5. ROC curve characterizing duodenal stump leakage by postoperative total serum protein levels for patients with total gastrectomy.



Diagonal segments are produced by ties.

Figure 6. ROC curve characterizing deaths through postoperative total serum protein levels for patients over 45 years.



Diagonal segments are produced by ties.

Figure 7. ROC curve characterizing reoperations through postoperative serum albumin levels.

Discussion

Our main goal was to determine whether we can use perioperative total serum protein and albumin values as predictive factors or for gauging surgical stress and predicting early postoperative complications in gastric cancer surgery. We found that a lower (~4.01 mg/dl) preoperative serum albumin value can foretell the possible onset of anastomotic leakage, the appearance of general complications, surgical wound infection and an increased reoperation risk. The ROC curve analysis performed for preoperative serum albumin proves that it can be used as a predictive test for general complications and surgical wound infection.

After surgery, determining the patient's serum albumin and total protein values can also be useful. Our study has shown that patients with lower serum albumin (<2.89 mg/dl) and total serum protein values (<5.14 mg/dl) in the first postoperative day have a greater risk of an early postoperative demise. The ROC curve analysis shows a high predictability value of total intraoperative albumin loss, total postoperative serum proteins for wound infection, early postoperative death, duodenal stump leakage and the risk of reoperations for the management of complications.

Serum albumin and total protein values can also be used to study the surgical stress response in gastric cancer surgery. This study shows lower values for female patients

in the first postoperative day as well as a statistically significant decrease in both values for patients undergoing total gastrectomy as compared to those undergoing subtotal gastrectomy.

Studying these values both before and after surgery can raise awareness or even alter the therapeutic point of view concerning the possibility of complications in patients undergoing gastric cancer surgery. After an apparently successful gastric surgery, most patients are sent directly to the ward, not to the ICU and are not subjected to any more tests if the clinical aspect looks normal. It might be prudent to pay closer attention to patients with low pre-/postoperative total serum proteins and/or albumins.

The questions raised are: would it be prudent to place a jejunostomy tube for patients with low preoperative serum albumins to safeguard the healing process of the anastomoses? Would it be prudent to investigate the abdomen of a patient with low postoperative serum albumin and total serum proteins routinely by performing early ultrasounds, CT scans or Gastrografin swallow tests [2] to detect early signs of anastomotic fistulas? Should we prolong the postoperative antibiotic therapy for patients with low preoperative serum albumin to prevent surgical wound infection? These may be matters for future studies to assess.

The limitations of this study are the small number

of cases and the fact that it only deals with cases from a single center.

Conclusions

We demonstrated the fact that total serum proteins and serum albumins, checked both before and after surgery, are of great value in helping predict a series of postoperative complications in gastric cancer surgery and that they can also be used as surgical stress markers.

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